IRSE

Institution of Railway Signal Engineers

Proceedings

2020-2021

IRSE///
Institution of Railway Signal Engineers

The Institution of Railway Signal Engineers

Proceedings for the year 2020-2021

Table of Contents

IRSE
Institution of Railway Signal Engineers

1. Introduction and summary of the year

The IRSE's Presidential Year started in April 2020 and will probably be remembered as the most challenging, yet innovative year in the history of the Institution. This year we were struck by the global COVID-19 pandemic, with most countries being forced into lockdown by their governments. As the United Kingdom went into the first of a series of lockdowns in March 2020, the AGM was postponed following appropriate legal advice provided enabling Council to do this, and the presidency passed from George Clark to Dr Daniel Woodland without a face-to-face handover.

The Annual Dinner and Members' Lunch were also cancelled. The Convention planned to be held in Canada during 2020 was postponed until 2021.

Innovation was necessary to enable the Institution to function 'virtually'. Having already trialled a very successful online seminar in 2019, the IRSE was able to live-stream Dr Woodland's Presidential address and deliver his full presidential programme on the theme of 'Challenges of Change in Complex command, control and signalling systems' online.

To avoid cancellation of the October 2020 IRSE Professional Examination, The E & PD Committee worked quickly to find a robust platform on which the exam could be delivered remotely and as a result for the first time, the Professional Examination was held online.

Dr Woodland was unable to carry out any of the international travel he had planned, and Section face to face meetings were suspended. Following Government sanctions, Head office was closed and all staff worked from home. The new Voice Over Internet Protocol (VOIP) telephone system, installed before the pandemic, enabled HQ staff to maintain a high level of service throughout.

Blane Judd, Chief Executive and General Secretary, IRSE

Lockdown provided the impetus for the Institution to enhance its digital capabilities delivering industry leading content online all recorded remotely. Dr Woodland led the first joint venture online seminar between the IRSE, IET, PWI and IMechE on the subject of Automated Railway. Held across two sessions in October and September, the highly successful, revenue generating webinar delivered 16 expert presentations to a global audience.

The IRSE's International Technical Committee (ITC) has 32 fully participating and ten correspondence members from across the world. During the year the ITC held four meetings virtually and produced six papers, three of which were delivered as part of the Presidential Programme.

The IRSE makes a number of awards each year to recognise, reward and encourage the professional development of engineers, particularly those in the early stages of their career. The purpose behind this is not simply to assist their career development, but to promote high standards of engineering excellence, thereby contributing to the public benefit objectives of the Institution.

The IRSE Signet Award was presented to Jonathan Farrell of Irish Rail for achieving 90% in module 1 (safety of railway signalling and communications). No candidates met the criteria this year to receive either the Thorrowgood Scholarship or the Dell Award Dell Award.

In 2020 due to travel restrictions imposed by the global pandemic, funds from the Frank Hewlett Bequest and Alan Fisher Memorial Fund paid for free places to be made available to younger members to on the virtual Rail Automation Seminar, run jointly by the IRSE, IET, IMechE and PWI. In total 32 places were provided to members from India, UK, Indonesia, Canada, Egypt, UAE, Australia, Nigeria, Hong Kong, South Africa and the Netherlands.

This year IRSE Merit Awards were presented to David Came MIRSE, Trevor Foulkes FIRSE and Mark Glover FIRSE. David was recognised for his continuous work and support for the Plymouth Section. Trevor played an important role in setting up the new South East and London Section and the award also recognised his ongoing support of the IRSE, presenting papers and supporting the IRSE Exam review. Mark received the award in recognition of the outstanding work he has done since 2014 in producing key IRSE publications including IRSE News, the Annual Report and sponsorship brochures for international IRSE events.

During this period, The Membership Committee met online to assess applications for IRSE membership and Engineering Council registration, and deal with procedural and policy matters. There were 305 successful membership applications, 130 for corporate grades and 175 for non-corporate grades, there have also been 72 members who have transferred to a different grade of membership. The total number of members has remained static over the last year, with 4,918 members on 31 December 2020. During 2020 the IRSE has also supported 29 engineers to achieve professional registration with the Engineering Council, the UK regulatory body for the engineering profession – 13 Chartered Engineers (CEng), 2 Incorporated Engineers (IEng) and 14 Engineering Technicians (EngTech).

In this extraordinary year, I would like to put on record the Institution's thanks to the President, staff, volunteers and members who, in the face of the huge and difficult challenge presented by the COVID-19 pandemic, pulled together to ensure we met the needs of the membership and fulfilled our continuing charitable aim to advance the science and practice of train control.

Blane Judd BEng FCGI CEng FIET
Chief Executive and General Secretary, IRSE
December 2021

IRSE
Institution of Railway Signal Engineers

2. Annual report and consolidated accounts for the year 2020

IRSE

Institution of Railway Signal Engineers

Annual Report

Number 108

1 January to 31 December 2020

Contents

This Annual Report briefly describes the activities undertaken by the Institution of Railway Signal Engineers (IRSE) throughout the world during 2020. Our President from April 2020 has been Daniel Woodland from the United Kingdom.

For up to date information about the Institution or its activities, or to download a membership application form, log on to the IRSE website **www.irse.org**.

Follow us on Twitter **@IRSEHQ**

IRSE, 4th Floor, 1 Birdcage Walk,
Westminster, London,
SW1H 9JJ, United Kingdom

IRSE///
Institution of Railway Signal Engineers

An introduction from our President

From March onwards, the 2020 year proved to be a difficult and most unusual one for many of our members, both in their personal and professional lives. With much of the world experiencing periods of COVID-19 related 'lockdown' and restrictions, our usual/familiar cycle of IRSE activities has also been impacted by this.

The AGM and annual dinner were the first IRSE event casualties, followed by the members lunch, convention and technical visits … along, of course, with my own plans to visit local sections around the globe. It could have been a very quiet year for the institution, but I have been delighted to see how our staff and many volunteers have rallied around to find new, innovative, ways to facilitate continuing service of our memberships needs and fulfilment of our charitable aim to advance the science and practice of train control.

Back in 2018 (as I was becoming a Vice-President) we began to work on a 'beyond 2020' vision for the IRSE, which you can see summarised in the section on strategy on page 4 and laid out in full at irse.info/strategy. This encapsulated our vision, to 'Deliver Safe and Sustainable Global Railways' and five pillars of activity, or goals, ENGAGE, GROW, NETWORK, DEVELOP and ASSURE on which that is based.

Through 2020 it has been my privilege to lead the institution into that 'beyond 2020' period and we have been working to embed this vision into our planning and delivery to achieve the aims outlined in our Articles of Association. To draw out some highlights (which are by no means all that we have been doing):

1. Engage (with the sector and community)

2020 saw our first use of Civica (formerly electoral reform services ERS) to facilitate and run our Council election process – with nominations and voting now possible electronically. This was a significant step forward in engagement with our membership and represents the first stage in a review of our governance processes to explore how we can further improve representation of our global membership. I anticipate further changes coming out of this review to be implemented in 2021 and beyond. Looking further afield, throughout the year we have developed closer ties with our fellow professional institutions, the UK Railway Industry Association and Rail Business Daily, amongst others.

"From March onwards, the 2020 year proved to be a difficult and most unusual one for many of our members"

2. Grow (increase our membership)

Recognising that the expertise and experience of IRSE members and prospective members are key to addressing many of the sectors challenges, our ability to support them in developing and applying their competence depends largely on getting them to engage and join. Delivering on the Grow pillar, the IRSE therefore launched working groups during 2020 to explore our value proposition (for members and licence holders) and fee structure – looking to explore how we can tune our offering to the industry and better market that globally. Expect to see changes arising from these working groups being implemented in coming years.

3. Network (facilitate interactions globally)

As with all aspects of life, we have moved into online forms of activity and have now all become familiar with the plethora of online meetings, seminar and webinar tools! Delivering to the Network element, the programme of Presidential lectures has been able to continue as planned (completing George's series on 'Delivering Change' and starting my own on 'Complexities of Change' in modern CCS systems), as have many local section events. By moving online, these have been able to attract wider audiences of both members and non-members. It has been pleasing to see higher attendances than we have for many years and participants joining from around the world, not just the area local to the event.

4. Develop (enhanced capability of the railway sector workforce)

The IRSE filled the void left by the decision to cancel the 2020 Convention in Toronto by proposing a joint institution seminar on 'Practical Integration of Automated Operation in Railways: A System of Systems Perspective'. I was personally delighted that the IMechE, IET and PWI joined with us in that event, enabling a far richer and more holistic review of the topic than we could have assembled alone, delivering a fantastic set of presentations and Q&A through September and October (and now available to all members via the IRSE website). With Presidential and Local Section presentations having continued online, we have seen a wealth of material become available to aid development of our members and the wider sector workforce. Our next challenge will be to find ways of conducting 'virtual' technical visits – a task which is already being worked on.

5. Assure (set and uphold standards for people and processes)

Probably the most significant development for the IRSE over this year has been the movement of the IRSE Exams to an online format. This was (at least for our conservative industry) a radical move which required a huge effort from our staff and members of the Education and Professional Development and Examination committees – given that they only had a couple of months from realising that a physical invigilated exam would not be possible to having an online solution up and running, this was a really amazing achievement.

These highlights barely scratch the surface of all that has been going on within the institution and you will find details of more within the full annual report. My heartfelt thanks go out to our staff and volunteers for their significant efforts in keeping the institution active, relevant, and forward looking through all the trials of the year and despite all of the extra work, re-planning and challenges that has caused.

Dr Daniel Woodland, 2021

The IRSE at a glance

IRSE

The
Professional Engineering Institution
for all those engaged or interested in
railway signalling, control and communications
and allied disciplines

Over 5000 members in locations across the world

Providing world-class presentations, seminars, conventions and conferences

Industry leading competence assessment and
licensing
scheme

The world's leading
professional examination
for railway signalling, control and communications

11 issues of
IRSE News
each year: our specialist railway signalling, control and communications magazine

21 Sections
representing the needs of members in their geographic region or specialism

Accredited by the Engineering Council to add
Chartered Engineers, Incorporated Engineers and Engineering Technicians
to the Professional Register

Vibrant
Younger Members
Section

Run by
engineers
for
engineers

Founded in 1912

Objectives of the Institution

The Institution's objectives are recorded in its Articles of Association. They can be traced back to the formation of the Institution in 1912 and are:

a) The advancement for the public benefit of the science and practice of signalling by the promotion of research, the collection and publication of educational material and the holding of conferences, seminars and meetings, and

b) The maintenance of high standards of practice and professional care amongst those working within the industry and the promotion of improved safety standards for the protection of the general public.

Although it might appear that the IRSE is concerned only with railway signalling, the full text of the objectives makes clear that all forms of train control and traffic management, and communications systems, are all within our scope of interest.

There is a clear emphasis in the objectives on 'public benefit'. This is most obvious in the sense of contributing to safety on the world's railways, where train control systems play a critical role. But we are also interested in ensuring that railways are efficient, cost-effective and sustainable (in the widest sense). We meet our obligations to the public through the following principal mechanisms:

- The dissemination of knowledge, experience and good practice in the fields of railway signalling, control and communications and allied topics, to help ensure that those working in the profession do so with the best available knowledge for the safe, efficient and cost-effective construction and operation of the world's railways.
- The provision and management of the IRSE Licensing Scheme to assure the competence of those working in the profession. The Scheme is focused predominantly, but not exclusively, on ensuring safety in the design, construction, testing and maintenance of signalling and telecommunications systems.
- Our Code of Professional Conduct, with which IRSE members are required to comply in the course of their work. It emphasises topics such as personal responsibility for work undertaken or managed by IRSE members, the importance of safeguarding the public interest (particularly safety), environmental management, the efficient use of resources, handling conflicts of interest etc.
- Undertaking specific initiatives to help ensure the safety and efficiency of railways. By bringing the IRSE Sections around the world together, we will facilitate the sharing of best practice and new initiatives to help engineers and others enhance their knowledge and professionalism. We will continue to reach out and grow our network of professionals around the world to harness the collective knowledge they possess for the benefit of all operators and users of railway transport.

The financial resources of the Institution are applied to achieve the objectives of the Institution, in addition to which members make a significant contribution to delivering the Institution's aims by their volunteer activities. The Institution has only a small number of full and part-time staff and most of the activities are organised by our members acting in a voluntary capacity.

Our Strategy

In 2020 we launched our new five-year rolling strategic plan 'Beyond a 2020 vision', details are available on the website at **irse.info/strategy**. The objective of making the IRSE accessible to members 24 hours a day seven days a week throughout the year, as long as you have an internet connection, was timed perfectly to address the challenges of the COVID-19 pandemic. You will read in this report how the Institution has swiftly responded to the challenges of maintaining services to the membership during this difficult time.

The rate of pace of change is testament to the commitment the staff and volunteers have made to continue to bring high quality information and services to you the membership.

Looking to the future the Council and its sub committees, as part of their governance activities have ensured that they continue monitor our progress ad growth in the value we provide to the signalling and telecommunications community around the world.

Progress had to be halted in developing the international dimension of the Institution, with plans for the Toronto Convention in 2020 and work on ASPECT 2021 severely hampered by the pandemic. We obtained several video conferencing licences to support the Local Sections, and the work of the Local Section Coordinator has been essential in helping to roll this out internationally.

As part of the focus on new entrants into the sector, the Institution is working with training providers in the area of apprenticeships. We continue to offer our services as an End Point Assessment service. There will be developments into 2021 to support candidates in completing their programmes.

The IRSE vision is to:
Deliver Safe and Sustainable Global Railways

IRSE ENGAGE GROW NETWORK DEVELOP ASSURE

To ENGAGE with and GROW a global NETWORK of railway signal and telecommunications engineers in order to DEVELOP and ASSURE high standards of ethics, knowledge, competence and safety in all aspects of train control.

The five key elements of the IRSE strategic plan are

Engage

Digital platform for a global professional body 24/7/365, early careers support, communicate best practice in ethics, diversity, inclusion, produce technical documentation, knowledge transfer activities.

Grow

Peer recognition, professional development, practice support and guidance, support in professional obligations, Advance profession.

Network

Industry Partnership Scheme, global local section development, International Technical Committee support, conferences, seminars and conventions, facilitate collaboration, latest information and news.

Develop

Signpost professional development, awards & bursaries, upskilling and re-skilling, examination, apprenticeships, promote benefits to the public.

Assure

International professional recognition, flexible pathways to professional registration, offer regulation in professional conduct, operate the licensing scheme.

Governance

Council

The IRSE is governed by an elected Council of twenty-one Corporate Members, led by the President, who are the Trustees of the Institution.

Six meetings of the Council were held during the year in which the business of the Institution was conducted. The Articles of Association permit the current Chairs of all local sections, both in and outside the UK, and also Country Vice-Presidents to attend Council meetings. During the year a number of Chairs and Country Vice-Presidents attended meetings using video conference facilities due to COVID-19 restrictions, with the exception of the meetings in February and March which were held in person.

In addition to conducting all the normal Council business during the year, Council discussions included the following topics:

- Adoption of the 'Beyond a 2020 vision' strategy and the associated Implementation Plan.
- Agreement to review the Governance documents.
- Implement a fees structure working group to start in 2021.
- Establishing a succession plan for the office of President.
- Consideration of changes to voting to facilitate greater representation of members around the globe.

Council also receives and reviews the annual report from each of the international Sections of the IRSE.

Committees

The Institution has a number of Committees which are accountable to Council, through which our activities are managed. The principal Committees and their relationships to Council are shown in the diagram below. In addition, ad-hoc working groups are formed from time to time which focus on specific tasks.

Audit

External audit

A number of areas of the Institution's business are audited on a regular basis by various external audit bodies:

- All areas of finance are subject to audit annually by independent external auditors who submit their report to the Annual General Meeting.
- The Licensing Scheme is subject to an annual external audit by the United Kingdom Accreditation Service (UKAS).
- As a registered Charity, the Institution is subject to periodic external review by the Charity Commission.
- As the Institution is licensed by the Engineering Council in the UK to register Chartered and Incorporated Engineers and Engineering Technicians, it is subject to a review every five years by the Engineering Council in order to ensure compliance with their registration standards.

Internal audit

The IRSE's internal Audit Committee undertakes independent audits to complement the external audits, in order to ensure the Institution is running efficiently and effectively. The audits focus primarily on the role and remit of each of the principal Committees of the Institution.

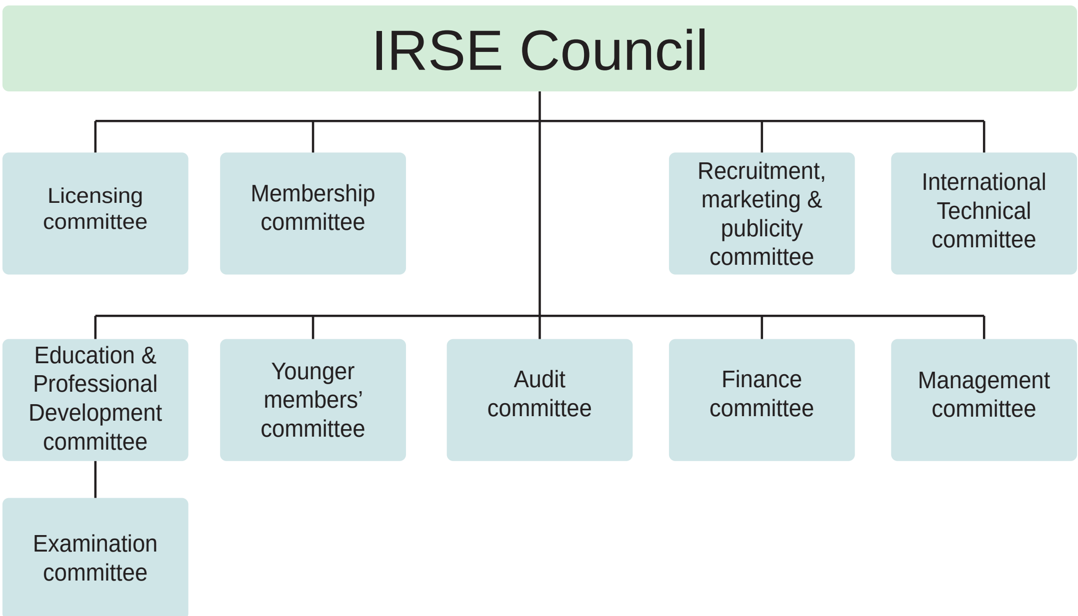
The Audit Committee normally performs two audits per annum. Each audit results in a report, which is presented to the Chair of that Committee and subsequently the Council, which uses the recommendations to improve the management of the Institution's affairs for public benefit and for the benefit of its members. The Institution maintains a Risk Register, which is reviewed annually by Council, and this is used as the basis for audit.

IRSE Enterprises

IRSE Enterprises Ltd is the trading company wholly owned by the Institution. The trading company handles a number of activities which are associated with but outside the direct scope of the charity. The Directors of the company appointed for the year April 2020 to April 2021 were:

- Chair (Immediate Past President): George Clark.
- President: Daniel Woodland.
- Senior Vice President: Ian Bridges.
- Junior Vice-President: Andy Knight.
- Council representative: Steve Boshier.
- IRSE Treasurer: Andrew Smith.
- Company Secretary (CEO): Blane Judd.

Any profits from the company are, where possible, gift-aided back to the Institution.



Sections

The IRSE Sections around the world exist by authority of the IRSE Council, and they operate in accordance with a set of Articles of Association (or Byelaws) that have been approved by Council. At the end of 2020 there were 23 sections in total. 15 Sections outside the UK in various parts of the world (Australasia, China, France, Hong Kong, India, Indonesia, Ireland, Japan, Malaysia, Netherlands, North America, Singapore, Southern Africa, Swiss, Thailand) and six of which are UK-based. The North America Section includes the USA, Canada and Mexico. The Ireland Section includes both Northern Ireland and the Republic of Ireland.

Two other Sections also exist – the Younger Members' Section and the Minor Railways' Section. These are not geographically based, although their activities are predominantly within the UK. Some geographical Sections also have younger members' groups.

Each Section has an organising Committee, with elected officers for key roles. Information about the activities of the Sections is provided elsewhere in this report.

Professional development

Supporting professional development of IRSE members and prospective members throughout the world is a key objective of the IRSE.

To do this, we have Judith Ward, our Director of Operations, the Education and Professional Development Committee and the Examination Committee.

IRSE Professional Examination

The IRSE professional examination is a Masters-level academic qualification which tests knowledge and understanding of railway systems with a particular emphasis on safety. A new module was introduced in October 2020, the Certificate in Railway Control Engineering Fundamentals, which covers all aspects of railway control engineering at a foundation level and is a stand-alone qualification.

To pass the full exam, to be known in future as the Advanced Diploma in Railway Control Engineering, candidates must pass four modules including a compulsory module on safety systems.

Passing the IRSE exam is one route to obtain either Associate Member or Member of the IRSE and it can 'top up' engineering or technology qualifications for professional registration with UK's Engineering Council. An accredited Bachelor's degree with honours plus IRSE exam may demonstrate knowledge and understanding for Chartered Engineer applicants and an accredited Higher National Diploma / Foundation Degree plus IRSE exam may demonstrate knowledge and understanding for Incorporated Engineer applicants.

Many volunteers run exam study groups, the independent exam forum website and support the Younger Members' exam workshops to provide support for prospective examination candidates.

To enable our exam candidates to sit the exam in 2020, Education and Professional Development Committee agreed to hold the exam remotely for the first time in the Institution's history, with 286 candidates sitting the exam on 3 October. This was an increase in the number of candidates, the majority of whom were sitting the new Certificate in Railway Control Engineering Fundamentals (module A). The quality of answers from candidates was similar to 2019, with the overall percentage of those achieving pass grade or higher was 57%. Candidates sat the exam across the globe, covering 16 geographic sections and several countries not covered by sections.

October 2020 was the final time candidates could sit numbered modules. From October 2021, four mandatory modules covering the whole syllabus to the same high standards will be available, the successful completion of which will be known as Advanced Diploma in Railway Control Engineering .

Continuing Professional Development (CPD)

The Engineering Council requires that as of 2020, those who do not engage in the CPD monitoring process are removed from their register.

Information about the importance of developing and maintaining members' professional competence through CPD has continued to be provided through IRSE NEWS and the website.

The IRSE recommends the use of the Mycareerpath system for CPD planning, recording, reflecting and reviewing. More information about Mycareerpath is available on the IRSE website.

Certified courses

The IRSE offers a process by which training providers can have their courses assessed and certificated by the IRSE.

This year ASAP Mobility Sdn (Malaysia), Signet Solutions (UK) and PM Training and Assessing (UK) gained IRSE certification for their courses covering railway signalling and telecommunications.

Other training providers are in the process of having their signalling and telecommunications courses assessed.

Professional Registration

The IRSE is licensed by the UK's Engineering Council to register suitably qualified members as Chartered Engineer (CEng), Incorporated Engineer (IEng) and Engineering Technician (EngTech).

The requirements for these are defined by the Engineering Council for knowledge, understanding, competence, relevant work experience and commitment. Brief definitions are that: Engineering Technicians apply proven techniques and procedures to practical problems; Incorporated Engineers maintain and manage applications of current and developing technology; Chartered Engineers develop solutions to engineering problems using new or existing technologies and/or have technical accountability for complex systems with significant levels of risk.

Apprenticeships

IRSE are End Point Assessment Organisation (EPAO) for two English apprenticeships: Rail Engineering Design Technician (Level 3) and Rail Engineering Technician (Level 3).

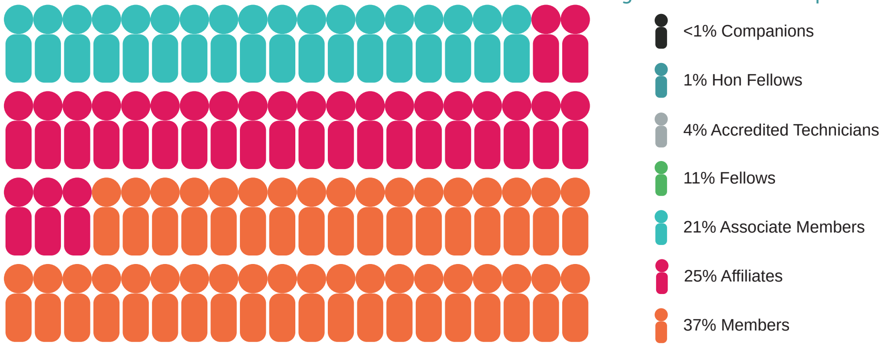
Membership and Registration

Remote working due to the COVID-19 issues has been both a challenge and an opportunity for the Membership and Registration activity of the IRSE. With the ingenuity and flexibility of both staff and volunteers we have succeeded in continuing to effectively process applications for both membership and professional registration.

From late March the Membership Committee has been meeting online to assess applications for IRSE membership and Engineering Council registration and deal with procedural and policy matters. There were 305 successful membership applications, 130 for corporate graded and 175 for non-corporate grades, there have also been 72 members who have transferred to a different grade of membership.

The total number of members has remained static over the last year, with 4,918 members on 31 December 2020.

During 2020 the IRSE has also supported 29 engineers to achieve professional registration with Engineering Council, the UK regulatory body for the engineering profession – 13 Chartered Engineers (CEng), 2 Incorporated Engineers (IEng) and 14 Engineering Technicians (EngTech).



The IRSE has around 5000 members worldwide. They belong to the following grades of membership:

We have been continuing to encourage our membership to engage with us electronically by email and through the IRSE website which has been vital during 2020 with the continued disruption caused by the COVID-19 pandemic. We are still hoping to pursue the development of a fully automated online application process for membership but the progress of this has not been possible over the last year.

The Institution was sad to report the deaths of the following members during 2020: Brian Foster, Denys Dyson, Paul Hepworth, Christopher Mitchell, Vivian Brown, Timothy Howard, Michael Hynd, Yoshio Ishihara, Stephen Harris, Walter Cooper, Paul Coulson, John Franklin, Michael Horne, Richard Stokes, Ray Weedon, Kevin Boyd, Derek Brown, David Norton and Ian Page.

Licensing

The IRSE Licensing Scheme continued to provide assurance for the competence of individuals to carry out technical safety critical or safety-related work on rail control systems throughout 2020. The Licensing Team was impacted by various factors relating to COVID-19 including staff working from home, a lack of access to the office and working with a slightly reduced team. Despite this, the team continued to deliver and the Scheme continues to provide a cross-industry accepted benchmark of competence for personnel.

Competence standards are reviewed at least five yearly and during 2020 nine licence standards were reviewed. Briefing notes were also published on a range of topics including:

- Revisions to 1.4.230 Signalling Maintainer and Fault Finder competence standard.
- Updates to 1.2, Signalling Installation Suite of Licences.
- Updates to the Licensing Standard, and a number of Licensing Procedures.
- Revisions to the Engineering Manager and Senior Engineering Manager suite of licences.
- Coronavirus (COVID-19) restrictions: extension to licence validity.

During the first half of 2020 the Scheme was managed by an interim Licensing Registrar, David Weedon, who stepped down from the role in November. Sarah Loutfi joined the Institution as the new Licensing Registrar in July working under the direction of the Licensing Committee, chaired by Colin Porter.

The Licensing Team was joined in December 2020 by a further Licensing Officer to assist with the processing of applications and will soon be joined by a Licensing Co-ordinator, providing an admin support function, a new role for the team.

During the year, a total of 1076 licences were issued, slightly lower than previous years.

There has been a significant impact of the COVID-19 situation on the number of licence applications received and issued. A six month extension to the validity of licences was agreed at the beginning of the lockdown period, and that has had an effect.

There are currently c.5816 active licence holders, which represents a slow decrease in the total no of licences held c.6800 at December 2019).

For operations within the UK, the Licensing Scheme continues to hold accreditation by the United Kingdom Accreditation Service against the competence standard for the certification of persons: ISO17024:2012, with four yearly re-accreditation successfully achieved during 2018.

IRSE Assessing Agents are approved and appointed for the purposes of performing assessments of candidates for licences, and they are an essential part of the Licensing Scheme. The number of approved assessing agencies remains at 26, with one new agency and one ceasing to operate during the year.

Awards

The IRSE makes several awards each year. The majority of these are to recognise, reward and encourage the professional development of engineers, particularly those in the earlier stages of their careers. The purpose behind this is not simply to assist their career development, but to promote high standards of engineering excellence, thereby contributing to the public benefit objectives of the Institution.

Frank Hewlett Bequest and Alan Fisher Memorial Fund

Frank Hewlett was an Associate Member of the Institution. He died in September 2008 and left a very generous and substantial bequest to the Institution. In 2009 the IRSE Council launched an appeal to establish a memorial fund for Alan Fisher, who died unexpectedly during his Presidency of the Institution. The intention was to use the fund to support the development of young S&T engineers, particularly those outside the UK.

In normal times the income from the two funds is used predominantly to provide a number of travelling bursaries for younger members from all over the world to support their attendance at major IRSE events. For 2020, as a result of the pandemic, the funds paid for free places to be made available to younger members to on the virtual Rail Automation Seminar, run jointly by the IRSE, IET, IMechE and PWI. In total 32 places were provided to members from India, UK, Indonesia, Canada, Egypt, UAE, Australia, Nigeria, Hong Kong, South Africa and the Netherlands.

Thorrowgood Scholarship

The Thorrowgood scholarship is awarded under a bequest of the late W J Thorrowgood (Past President) to assist the development of a young engineer employed in the signalling and telecommunications field of engineering.

The award is made to a candidate who has excelled in the IRSE professional examination and comprises an engraved medallion and funding for a study tour of railway signalling installations or signalling manufacturing facilities.

For the 2020 award no candidates achieved the necessary criteria in the 2019 examination.

Dell Award

The Dell award is made annually under a bequest of the late Robert Dell OBE (Past President). It is awarded to a member of the Institution employed by London Underground (or its successor bodies) for achievement of a high standard of skill in the science and application of railway signalling. The award takes the form of a plaque with a uniquely designed shield with an engraved plate being added each year with the recipient’s name.

No award was made in 2020.

IRSE-Signet Award

Jonathan Farrell

The IRSE-Signet award is the most recent of awards, introduced in 2016 and sponsored by Signet Solutions. This Award is given annually to the person who obtains the highest marks in any single module of the IRSE Examination.

The Award takes the form of the Signet logo ‘person’ on a small plinth, engraved with the name and year of the winner, and bearing the IRSE’s logo. The Award also comprises funding for the winner to attend the IRSE Convention.

This year’s IRSE-Signet Award was presented to Jonathan Farrell of Irish Rail for achieving 90% in module 1 (safety of railway signalling and communications).

IRSE Merit Award

David Came, Trevor Foulkes and Mark Glover

The Merit Award was introduced in 2007 In order to recognise exceptional service to the Institution by a volunteer or staff member anywhere in the world. The award is made by the Council following receipt of a nomination and takes the form of a plaque mounted on a rectangular plinth with an engraved citation.

In 2020 Merit awards were awarded to David Came MIRSE, Trevor Foulkes FIRSE and Mark Glover FIRSE.

David Came was recognised for his continuous work and support for the IRSE Plymouth Section, from inauguration to the 50th Anniversary. Trevor Foulkes played an important role in establishing the new London and South East section which he now chairs. He has been a good contributor to the Institution for many years, presenting a number of papers particularly on telecoms topics and supporting the IRSE exam review and development of the revised arrangements.

Since late 2014 Mark Glover has undertaken the production of key Institution publications. In all his work, Mark demonstrates a high level of commitment and workmanship, and the IRSE has benefited hugely from the professional image that his work portrays.

Presidential programme

As a result of the COVID-19 pandemic, after March 2020 no group gatherings could be held. The AGM was cancelled and IRSE history was made when incoming president Dr Daniel Woodland was the first to deliver his presidential address virtually.

Our President up to April 2020 was George Clark. His theme for 2020 was 'Delivering Change' and his series of presidential events looked at ways in which challenges faced by change could be addressed. His final three presidential programme events were: 'Delivering change – the race against obsolescence' presented by Wim Coenraad in Holland in January, in February Nicola Furness and Michel Ruesen presented their paper on 'Future reference CCS architecture' in London and in March Steve Allday presented 'Delivering metro travel' in Sydney.

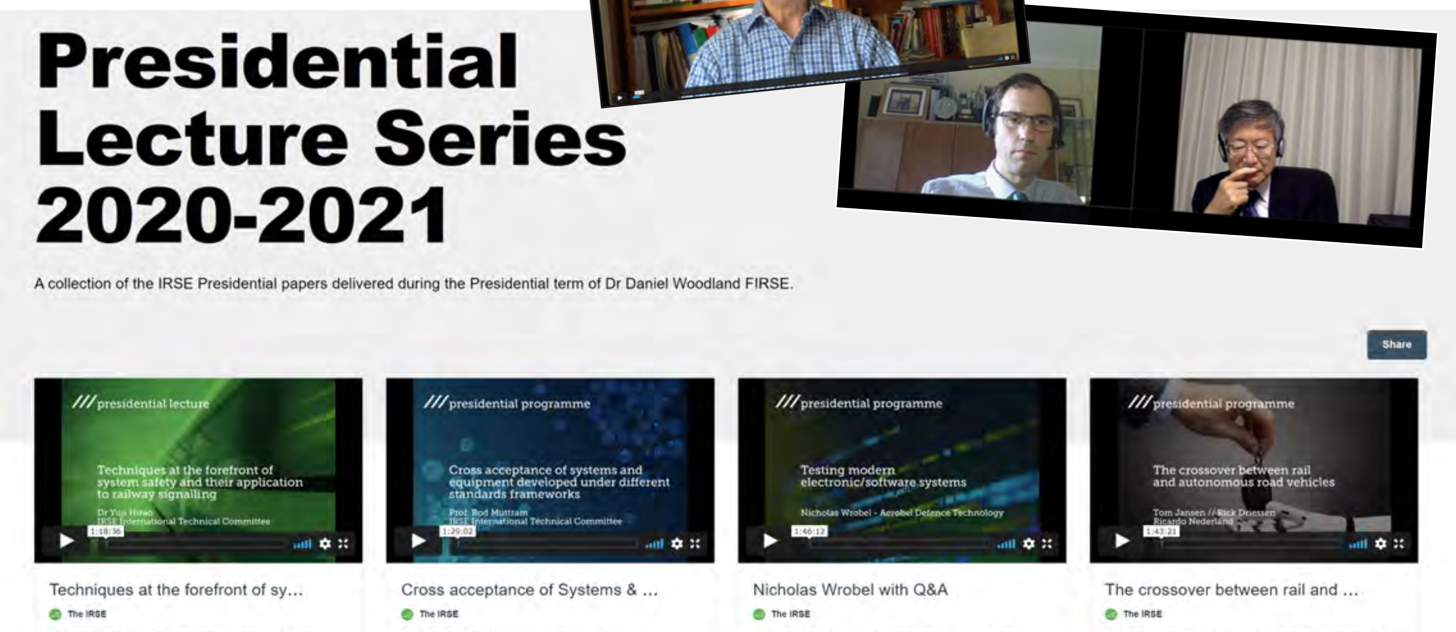
President Dr Daniel Woodland then faced a completely different challenge; how to carry out traditional presidential duties in the time of COVID-19.

Whilst extremely disappointed he would not be able to travel internationally to visit sections, he worked hard to deliver a full presidential programme on his theme of the 'Challenges of change in complex command, control and signalling systems' virtually. In addition to this programme of lectures, he was also the instigator of the first highly successful joint revenue-generating seminar between the IRSE, IET, IMechE and PWI. This online Automated Railway seminar held across two sessions on 1 September and 8 October, delivered 17 expert presentations to a global audience of over 200 attendees.

He also took part in the first ever online Rail Broadcast Week hosted by the Railway Gazette in September and was a panellist in the 'ERTMS & ETCS: The future of railway signalling' conference held in December.

Three Presidential Programme webinars were presented between June 2020 and December 2020, all followed by an interactive question and answer session. In June, Professor Yuji Hirao presented 'The forefront of system safety and its application to railway signalling'. Tom Jansen, delivered 'The crossover between rail and autonomous road vehicles' in October and in November Professor Rod Muttram presented 'Cross acceptance of systems and equipment developed under different standards frameworks'. Nicholas Wrobel, presented his paper on 'Testing modern electronic/ software systems' in December.

All presidential papers are published in our monthly journal, IRSE News, and the presentations are available to watch on the IRSE Vimeo channel irse.info/vimeo or on the IRSE website.



Section activities

In addition to the Presidential Programme, every year there is a programme of lectures, seminars and technical visits organised by the Institution's 22 sections across the globe. Our sections are in Australasia, China, France, Hong Kong, India, Indonesia, Ireland, Japan, Malaysia, Netherlands, North America, Singapore, Switzerland, Thailand, and Southern Africa. Within the UK, sections cover London & South East, Midland & North Western, Plymouth, Scottish, Western, York and Minor Railways.

The geographical sections vary considerably in size (from around 20 members up to several hundred), and in levels of activity. Each has its own organising Committee, elected officers and programme of events. They report annually to the Council on their work.

In 2020 sections were unable to meet face-to-face for the majority of the year. Some adapted and provided virtual meetings and others were unable to provide these opportunities due to technical difficulties and the workload of the volunteers. Paul Darlington (Chair Midland & North Western) and Trevor Foulkes (Chair London & South East) produced a guide for sections organising and running virtual meetings and many of the sections who ran these have reported record numbers of attendees. Several technical presentations were recorded and can be found on IRSE's Vimeo channel **irse.info/vimeo**.

The Council wishes to record its thanks to the officers, committee members and all others involved in the operation of the local sections, for the excellent work they undertake in organising technical meetings and other events particularly in this challenging year. Council also very much appreciates the help and support given by many companies in facilitating and supporting the events organised by the sections all over the world. Charles Page continues his excellent work in the role of Local Section Coordinator, supporting the sections.

Younger Members

2020 marked the spirited relaunch of the IRSE Younger Members Section chaired by Aaron Sawyer. This section exists to ensure that the activities of the Institution are relevant to the professional development of younger and less experienced members.

The expansion of the committee, and the revised energy imparted by its members, has enabled the section to grow in strength and significantly increase the benefits offered to the community. The section focused on five key areas for development: major events, attract & expand, digital initiatives, support development and sustain & improve.

Under these focus areas the section delivered on an array of existing and new initiatives with an agile shift to online events. The highlights included:

- Preparation for major events including a flagship competition and accident investigation weekend.
- The 'IRSE Super Train Challenge: A Journey Around the World' and associated online STEM webinar. The event followed the semi-fictional character Prerna the Great Inventor and her quest to build a Super Train.
- International outreach where the section worked closely with younger members around the world to facilitate future collaboration and increase diversity within our committee.
- A newly automated mentoring scheme that connects mentors with mentees in a simple self-managed system to be released in 2021, alongside improvements to the 'Maintain your Competency' system.
- A 12-week IRSE Cyber Academy course bringing together developing engineers within the field of railway cyber security.
- And of course, our continued support for the IRSE Exam through study events and over 24 hours of recorded material.

With the strength of the Younger Members section ever growing, there are now over 20 volunteers dedicated to bringing increased benefits our community. We welcome members from around the world to share in this experience and thank everyone who has supported the section in realising its ambitions.

International Technical Committee

The IRSE's International Technical Committee (ITC) has 23 fully participating and 11 corresponding members from many parts of the world, including Japan, the UK, Netherlands, Germany, Switzerland, Belgium, Finland, France, Australia, Spain, Singapore and Canada. The ITC's primary purpose is to provide thought leadership and disseminate learning on strategic or technical topics relevant to train control and communications systems in the railway environment, thereby providing value not only to IRSE members but to the wider rail industry. Its particular strength lies in its international membership at senior level, enabling engineering principles and practices from a diverse range of countries to be brought to bear upon the subjects that the ITC debates.

During the year, the ITC held four meetings. Due to COVID-19 measures all four were held as video conference meetings. The ITC experienced video conference meetings effective however live interaction in this international setting is essential. After lockdown the ITC will hold its meetings in a mix of video conferencing and live meetings. This will have also a positive effect on our carbon-footprint. The ITC produced six papers, all of which have been published in IRSE News, three of them were given as presidential papers. All ITC papers can be found on the IRSE website. The meetings are hosted by members in their country and minutes are produced for each meeting.

The ITC is aligned with the IRSE strategy. From this year the ITC has decided to keep in touch with the younger membership by having a Younger Member official position on the committee – the first Younger Member to join is Robin Lee. The ITC also focused on Safety – issues of cross-acceptance and standards as well as requirements management and system integration. The Junior Vice President and Senior Vice President are members of the ITC so that they can influence the choice of topics to be discussed, to align with the presidential theme. Papers in the pipeline also include Signalling Power Supplies and the Effectiveness of Security Measures.

London office and personnel

The Institution leases a small suite of offices on the 4th floor of the Institution of Mechanical Engineers, 1 Birdcage Walk, London, UK, from where the centrally organised activities of the Institution are managed – membership, licensing, events administration and financial administration.

The COVID-19 pandemic has meant that the offices have not been accessible since March 2020. As a result, all staff have had to make the transition to working from home. The Council and many members have on numerous occasions praised the efforts of the staff in maintaining a high level of professional service despite this significant disturbance to work patterns. It became apparent that there was a need to restructure in order to meet the differing demand of a distributed workforce and Council have overseen the work done by the Chief Executive and senior staff to effect these changes.

Chief Executive

The Chief Executive and General Secretary of the Institution is Blane Judd, a Chartered Engineer and Fellow of the Institution of Engineering and Technology. He is responsible for directing and managing the resources of the Institution in order to implement the decisions of Council in an efficient manner and in compliance with UK company and charity law. He is accountable to the Council. He also provides the focal point of contact for other Institutions and external organisations, including the UK's Engineering Council and the Royal Academy of Engineering, government agencies, the chief officers of other professional bodies, and the scientific, engineering and technology community. He is also responsible for ensuring compliance with the requirements of the Institution's Articles of Association, Companies House, the Charities Commission and relevant legislation.

Office team

The office team comprises:

- Polly Whyte, Head of Membership and Registration
- Hilary Cohen, Executive Assistant
- Judith Ward, Director of Operations (part-time)
- Sarah Loutfi, Licensing Registrar
- Karen Boyd, Deputy Licensing Registrar
- Roger Button, Licensing Assistant
- Caterina Indolenti, Membership and Registration Administrator
- Sophie Hunter, Membership and Registration Assistant (fixed term contract)
- Hannah Mueller, Finance Assistant (part-time)
- Swaathy Bhaskaran, Licensing Assistant (part-time)

October 2020 saw the departure of two members of the team – Anja Laitinen, after eight years with the IRSE and Laura Freeborn at the end of her temporary contract.

We also received the shock news that Hilary Cohen had been taken seriously ill and would be absent from work for some time. As many will know Hilary, who has been with the IRSE for more than ten years, is a key member of staff and is engaged in a number of member facing activities. We have appointed Deepka Kharaud to provide temporary cover for her position.

Contract support

The following members of the team work part time on a contract basis:

Marketing and Communication activities have been operated externally by Lindsay Jones of LJPR Ltd. Lindsay is a qualified journalist with a MSc in public relations and runs her own PR consultancy. She is successfully promoting the Institution to a much wider International stakeholder group. We are also receiving excellent support from Howard Elwyn-Jones of Prettybright on a wide range of social media activity, which includes the much-improved e-bulletin and video livestreaming of events.

Andrew Smith is the Institution's Treasurer, with responsibility for the production of the budgets and accounts, and for monitoring the health of the Institution's savings and investments.

Debbie Bailey, is the Institution's HR Manager. She is a Chartered Member of the CIPD and runs her own HR consultancy business. Debbie has provided HR services to the staff of the IRSE for more than eight years and has been much involved this year in supporting the staff through the pandemic and in particular the transition to remote working.

Annual General Meeting

The IRSE's intended 107th Annual General Meeting, which was to be chaired by the retiring President, George Clark, was initially postponed until July 2020 due to the COVID-19 pandemic, in accordance with the Memorandum and Articles of Association. It was hoped that by July the situation would have been sufficiently controlled to allow a normal AGM to take place. As the year progressed it became apparent, prior to the July date, that International lockdown restrictions would not allow a meeting to be held in person. After considerations of a number of options it was resolved by Council that there would be no AGM in 2020. All ordinary business was concluded by correspondence and it was resolved to appoint HPH Chartered Accountants for 2020.

The membership received copies of the Annual Report for 2019 (published on 1 April 2020), and there being no comments or questions received through correspondence this report was adopted.

The ballot for the election of members to Council had resulted in Harvinder Bhatia (UK), Gordon Lam (Hong Kong), Clive Roberts (UK), Rob Cooke (Singapore) and Firas Al-Tahan (N America) joining Council.

Grateful thanks go to Pierre-Damien Jourdain, Cassandra Gash and Lynsey Hunter all of whom retired from Council.

IRSE Council

IRSE Council 2020-2021	
President	Daniel Woodland
Vice Presidents	Ian Bridges, Andy Knight
Members of Council from the class of Fellow	Peter Allan, Ian J Allison, Harvinder Bhatia ,Steve Boshier, Bogdan Godziejewski, Yuji Hirao, Gordon Lam, Rod Muttram, Jane Power, Clive Roberts
Members of Council from the class of Member	Firas Al-Tahan, Rob Burkhardt, Rob Cooke, Martin Fenner, Ryan Gould, Paul McSharry
Members of Council from the class of Associate Member	Xiaolu Rao, Keith Upton
Co-opted Past Presidents	George Clark, Markus Montigel, Peter Symons
Chief Executive	Blane Judd
Treasurer	Andrew Smith

IT systems

The three major IT components that support the Institution's operations are the Membership and Licensing database, the website, and the London office IT systems.

The decision to migrate our office software systems to a more secure cloud-based server facility, could not have been taken at a better time. We could not have known that by the first quarter of 2020 we would be locked out of the offices and hence access to any IT-based systems located there.

After many years of support from Mike Tyrrell who single-handedly kept our old telephony system working, a decision to change the obsolete equipment was made in the first quarter of 2020. The initial discussions were to install a similar but more modern private automatic branch exchange (PABX). The lockdown however, made us rethink that decision and complete 'softphone' voice over internet protocol (VoIP) was adopted. This has facilitated us being able to make and receive calls while working from home, or on mobiles without interruption of service. The VoIP system also allows us to manage calls remotely from the office system, giving us a greater flexibility and improved communication service to members.

We have now had a year of operating with the new website which again has been extremely helpful in allowing us to maintain a high standard of service for the membership. The inclusion of video content has seen a significant increase in the number of visits to the site. Members are also able to us the site to update information, previously managed manually by staff in the office. Throughout 2021 there are plans to increase the functionality of the site in line with our vision to be accessible 24/7/365 wherever there is an internet connection.

Just after lockdown occurred, we acquired additional licenses for the online conferencing tool, GoToMeeting (GTM), which we had been using for many of the IRSE virtual meetings. Some of these licenses were offered free by LogMeIn, the company that owns GTM, as part of a support package for charities. We have been able to distribute these licenses to the sections that wanted to be able to run virtual meetings. As a result, all of the meetings that IRSE hold, both as part of its normal operational activities and with volunteers, have seen a large increase in membership engagement. We intend to continue to offer this service even once lockdown has been lifted.

The combination of GTM and Microsoft Teams has meant we have reached more of the membership that we have been able to achieve in the past.

You will read elsewhere in this report that we held IRSE examination online for the first time this year, through necessity. The platform we used, Moodle, has a lot of additional functionality which we will be looking to exploit as we become more familiar with its capabilities. The aim is to increase the educational offerings under the Knowledge, Skills and Behaviours initiative, started by Markus Montigel in his presidential year, using Moodle at the foundation for this development.

We cannot express our gratitude more strongly, to all those who work for or with the Institution, including the volunteer network. Their ability to adapt so well to the challenges that we have faced as a result of the pandemic has been a tremendous help. Hopefully 2021 will bring a better year and see us able to use much of what we have learnt during lockdown for the benefit of the membership, wherever they are in the world.

Publications and communications

Publications and communications

The global pandemic has impacted on every aspect of our lives. Sometimes out of necessity comes innovation, and this has certainly been the case for the IRSE.

Towards the end of George Clark's presidency, we successfully trialled the webinar format for his November presidential programme event. This learning was to prove invaluable in the months to come.

As it became clear that face to face meetings would not be possible for the foreseeable future, HQ staff, members and volunteers all stepped up to devise robust ways to keep the Institution running as normally as possible in the 'virtual' world. Section meetings were held via GoToMeeting or Zoom platforms and the presidential programme was delivered with outstanding success by GoTo Webinar. In all cases, a far higher number of members attended the events virtually than ever before from all over the world.

For the first time in the Institution's history, a paid-for joint online seminar on Automated Railway was held in partnership with the IET, IMechE and PWI. Not only did this event generate much needed revenue for the Institution but it was watched internationally by over 200 people.

We were able to build on the work carried out since 2018 to upgrade and improve our digital communications and as a result our digital platforms came into their own enabling us to keep members informed via frequent e-bulletins and enhanced content on www.irse.org.

IRSE News

IRSE News is published monthly, its purpose being primarily to inform IRSE members worldwide about industry news, technical developments, and the work and activities of the IRSE and its Sections. Papers that comprise the presidential programme are published in IRSE News, together with a wide range of other internationally sourced educational papers and articles. We'd like to extend our thanks to the dedicated and hard -working editorial production team and committee led by Managing Editor Paul Darlington for another excellent year.

Proceedings

The Proceedings provide a summary of the Institution's activities and have been produced annually since the very first issue in 1913. A hard copy of the Proceedings is supplied to the British Library and to the library of the Institution of Engineering and Technology and pdf versions of the Proceedings are available for all to read via our website.

Website

The website provides details of Institution events, Sections, information about the governance and operation of the IRSE, material for members taking the IRSE professional examination, how to become a member, as well as a wealth of information relating to professional development. Members (and registered non-members) can update contact details, book events, order publications, and pay their subscriptions online. This year almost 72 000 visitors from 137 countries viewed more than a million pages at **www.irse.org**.

Video

During 2020 the number of videos available on the IRSE website increased significantly as we uploaded content including presidential events, section meetings and study guides. As a result in the past 12 months we saw a 1700% increase in video views and more than 3000% increase in audience size. IRSE videos received over 15 000 views.

E-Communications

A monthly email bulletin is sent to all members, containing information about upcoming events and other topical information. In addition, we send out ad-hoc electronic communications to members highlighting key presidential events and other important information.

Social Media

The Institution has a social media presence on LinkedIn, Facebook and Twitter which play a key role in promoting our activities and signposting our content. Key events, presentations and topical news stories are posted on all these feeds on a regular basis to help keep members informed and raise the profile of the Institution amongst the wider railway industry.

LinkedIn has seen a 90% increase in engagement in the last 12 months, boasting almost 7000 followers. On average, IRSE posts on LinkedIn which linked to content were clicked over 58 times each (7400 clicks), while over 55% of our tweets were re-shared by other Twitter users. Link clicks on Twitter are up over 700% on 2019, while on Facebook, links to IRSE content were clicked 1600 times.

Rail Industry media

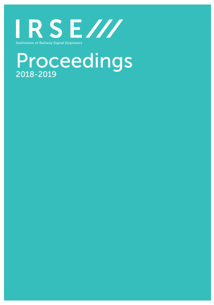
During this year we have developed our relationship with more key railway media. Until the lockdown, Modern Railway Magazine had included selected section events in their events section, and presidential events have been promoted in the online Railbusinessdaily.com e-zine.

Publications

The IRSE publishes a range of books on railway train control and communications systems, which provide a useful source of educational material for those relatively new to the profession, as well as providing a valuable record of the development of signalling. Extensive work continues to edit and modernise the Metro Signalling Handbook.

Library

Sadly, the IRSE Library which is housed in our London offices has been closed this year due to the pandemic. The building at Birdcage Walk which we share with several other professional engineering institutions has remained closed with all staff working from home.



Collaboration

The IRSE has formal and informal working relationships with a number of organisations in the UK and with organisations in other parts of the world. In China and South East Asia in particular, the IRSE's sections are forging closer links with other engineering and educational organisations, and with governments.

The Industry Partnership Scheme has been slow to get off the ground mainly due to the inability to engage with senior leaders during the COVID-19 lockdown period. That said, some dialogue with employers has started to highlight the areas that would be of interest and benefit to Industry. It is expected that as the restrictions on face-to-face engagement are lifted, more work will be able to be done to move this initiative forward.

An important element of our strategy, is to strengthen our engagement with external bodies, including rail industry companies and other relevant organisations. The Institution enjoys good working relationships and support from many companies, but our ambition is to grow this further. As a result, the development of the Future Integrated Rail Think Tank (FIRTT), a collaboration with WSP, KPMG, the Rail Delivery Group and IRSE, has focused on several key areas of railway operation, to debate key issues. The first two of these were held this year and the outputs were published on the IRSE website.

This is the second of the IRSE two-year term as chair of the Rail Engineers Forum (REF). The REF (**theref.org.uk**) is made up of representatives from the Professional Engineering Institutions who have a rail interest e.g., IMechE, IET, ICE, PWI, IRO, INCOSE, CILT, RCEA and the Young Railway Professionals. The chair, Andrew Simmons, a former President of the IRSE, continues to work with HQ to help focus on REF's aim, to harmonise the various strengths of the constituent Institutions to support the railway community. In normal times this would encompass conferences, seminars, lectures, training, information services, publications and statements of policy to Government and other regulatory bodies. This year has mainly focused on maintaining links across the sector.

Regular meetings are taking place with the UK's Railway Industry Association (RIA) to ensure that where possible the two bodies are working closer together to promote the principle of professional employees working in professional businesses. This working relationship is helping the IRSE and RIA identify where we can make a difference.

A closer relationship with the Royal Academy of Engineering and Engineering UK is helping us to gain better traction with activities focusing on encouraging young people into careers in science, technology, engineering and mathematics as a career opportunity. We are able to gain a better exposure working with these bodies than if we used our own smaller resources.

The UK's Engineering Council is responsible for the regulation of engineers, particularly in the UK. The IRSE is a licensed body of the Engineering Council and is thus licensed to register Chartered Engineers, Incorporated Engineers and Engineering Technicians. We work closely with them to maintain standards of engineering excellence.

Finances

The financial results are shown on pages 16 to 20. They are extracted from the consolidated accounts for the IRSE and its wholly owned trading subsidiary, IRSE Enterprises Limited. The term 'Group' at the top of a set of tables refers to the two companies combined, and 'Charity' to the IRSE alone. As far as possible, these extracted results use the titles and the format of the consolidated accounts.

Probably the headline figure from the 2020 financial results is the Total Charity Funds in the first table on page 16. Despite the outbreak of COVID-19 and its global consequences, the Total Charity Funds have increased by £186,750. This increase is entirely due to a significant increase in value of the investments, in the form of shares, shown in Note 1 on page 18. Our activities during the year made a loss which is not unexpected, given two major fundraising activities, the annual dinner and convention, did not take place, so IRSE Enterprises did not make a surplus to donate to the IRSE.

For part of 2020 because our activities were forcibly reduced by the pandemic we were able to furlough some members of staff under the UK Government's furlough scheme although as we introduced innovative new ways to deliver the service to our Members, by the end of the year all employees were back working as normal. During the year we took on two new members of staff, both of whom required training in order to take on their roles. However, as we have a very small workforce, to suddenly, if only temporarily, expand our expenses to cover them would have required a sudden, significant increase in income. We could have increased subscriptions or licence fees significantly, only to put them back down again for 2021, but we identified some of our reserves as being saved to cover for eventualities like this. As a consequence, during the year there was a transfer from investments to cover these additional costs.

An issue that has come to our attention can be seen by comparing Notes 10 and 12. Note 10 includes a figure which is the total income from our main activities whilst Note 12 is the cost of running the charity. It can be seen that for the last two years the charity's costs have been higher than the income. Historically this has been the case, but the surplus from IRSE Enterprises has topped up the income to cover the difference, and commonly led to a net surplus. However, in 2020, clearly, this didn't happen although additional unexpected income was realised through the Institution's first ever and highly successful paid-for online seminar held jointly between the IRSE, IET, PWI and IMechE. In addition, the introduction of the new Module A Exam Certificate in Railway Control Engineering Fundamentals created a surge in Exam income for 2020. We face a similar situation for 2021 as COVID-19 restrictions prevent us once again from holding either the annual dinner or a traditional convention. Whilst it is to be hoped these events will reappear in the IRSE's calendar as soon as possible, it has exposed a potential challenge for the future, especially if it continues to prove difficult to organise big events for several years. As a consequence work is currently underway considering how to increase the Charity's income. Naturally, given that most is from subscriptions, it is this area that is being particularly addressed. There are no conclusions so far, so they will have no impact on 2021, but will need to be included in the budget for 2022.

Consolidated accounts (extract)

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
CONSOLIDATED BALANCE SHEET AS AT 31st DECEMBER 2020

	Notes	Consolidated 2020 £	Consolidated 2019 £	Charity 2020 £	Charity 2019 £
Fixed Assets					
Tangible assets		19,558	31,227	10.395	16,871
Investments	1	2,055,844	1,812,394	1,488,776	1,342,570
		2,075,402	1,843,621	1,499,171	1,359,441
Current Assets					
Stocks	3	48,862	45,110	42,416	36,076
Debtors	4	207,530	194,705	290,623	269,580
Investments	5	209,668	209,205	209,668	209,205
Cash in hand		238,466	338,188	69,062	108,013
		704,526	787,208	611,769	622,874
Creditors: amounts falling due within one year	6	(422,469)	(438,934)	(228,440)	237,003
Net current assets / (Liabilities)		282,057	348,274	383,329	385,871
Total assets less current liabilities		2,357,459	2,191,895	1,882,500	1,745,312
Creditors: amount falling due after more than one year	7	(237,697)	(258,883)	-	-
Net assets		2,119,762	1,933,012	1,882,500	1,745,312
Funds	2				
Unrestricted funds		2,083,971	1,896,893	1,846,709	1,709,193
Restricted funds		35,791	36,119	35,791	36,119
Total charity funds		2,119,762	1,933,012	1,882,500	1,745,312

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
CONSOLIDATED CASH FLOW STATEMENT AS AT 31st DECEMBER 2020

	2020 £		2019 £	
Net cash (used in) operating activities		(124,790)		(78,758)
Cash flow from investing activities:				
Purchase of tangible fixed assets	(5,784)		(44,793)	
Purchase of fixed asset investments	(237,983)		(231,680)	
Sale of fixed asset investments	237,082		193,471	
Interest received	1,825		2,534	
Dividends received	29,928		36,371	
Net cash provided by / (used in) investing activities		25,068		(44,097)
Change in cash and cash equivalents in the year		(99,722)		(122,855)
Cash and cash equivalents at start of year		338,188		461,043
Cash and cash equivalents at end of year		238,466		338,188

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
CONSOLIDATED STATEMENT OF FINANCIAL ACTIVITIES AND INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER 2020

	Notes	Unrestricted £	Restricted £	Total 2020 £	Total 2019 £
INCOME AND ENDOWMENTS FROM:					
Charitable activities:					
Donations and legacies	9	19,092	-	19,092	41,708
Other trading activities:					
Non-ancillary trading income	10	354,592	-	354,592	425,921
Other activities	10	480,916	-	480,916	448,263
Investments:					
Investment Income	11	31,685	68	31,753	38,905
Total Income		886,285	68	886,353	954,797
EXPENDITURE ON:					
Raising Funds	12				
Other activities		3,857	-	3,857	8,567
Investment		8,008	-	8,008	7,865
Non-ancillary trading		422,322	-	422,322	438,884
		434,187	-	434,187	455,316
Charitable activities	12				
Awards		16,195	-	16,195	24,529
Promoting best practice		481,557	-	481,557	534,779
		497,752		497,752	559,308
Total Expenditure		931,939	-	931,939	1,014,624
Net Expenditure before (loss) / gain in investments		(45,654)	68	(45,586)	(59,827)
Net (loss) / gain on investments		232,732	(396)	232,336	280,451
NET INCOME / (EXPENDITURE)		187,078	(328)	186,750	220,624
RECONCILIATION OF FUNDS					
Total funds brought forward		1,896,893	36,119	1,933,012	1,712,388
TOTAL FUNDS CARRIED FORWARD		2,083,971	35,791	2,119,762	1,933,012

ANNUAL MEMBERS' REPORT WITH SUPPLEMENTARY MATERIAL

The tables set out on pages 16 to 20 are extracted from the full audited accounts of the Institution for the year ended 31 December 2020. They constitute supplementary material to this Annual Members' Report. Section 426A of the Companies Act 2006 requires the following statements to be made in respect of the supplementary material:

1. This annual report is only part of the company's annual accounts and reports prepared under the Companies Act.
2. A full copy of the company's annual accounts and reports may be obtained upon request from The Institution of Railway Signal Engineers, 4th Floor, 1 Birdcage Walk, Westminster, London SW1H 9JJ, UK.
3. The auditor's report on the annual accounts was unqualified.
4. The auditor's statement under section 496 of the Companies Act (whether the Trustees' Report is consistent with the accounts) was unqualified.

A P Smith
Treasurer

Approved by the Trustees on 11 March 2021.

D Woodland
President
Director and Trustee

I Bridges
Vice-President
Director and Trustee

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
NOTES TO THE CONSOLIDATED ACCOUNTS
FOR THE YEAR ENDED 31st DECEMBER 2020

1 Fixed Asset Investments (Group)

	Equities £	Government Securities £	Total £
Market value			
At 1 January 2020	1,602,145	210,249	1,812,394
Additions	237,983	-	237,983
Disposals	(211,545)	(25,537)	(237,082)
Revaluations	233,790	8,759	242,549
At 31 December 2020	1,862,373	193,471	2,055,844

2 Movement in Funds (Group)

Designated funds	At 1.1.20 £	Net movement in funds £	At 31.12.20 £
Scholarship fund	77,128	940	78,068
Alan Fisher / Frank Hewlett Fund	407,071	18,250	425,321
General Development	307,000	-	307,000
Future ASPECT Conference	10,000	-	10,000
International Convention	27,500	-	27,500
Textbook Preparation	7,500	-	7,500
General Fund - Unrestricted Fund	856,485	118,328	974,813
IRSE Enterprises - Non-charitable Trading Fund	204,209	49,560	253,769
	1,896,893	187,078	2,083,971
Restricted funds			
Dell Bequest	23,432	(305)	23,127
Thorrowgood Bequest	12,687	(23)	12,664
TOTAL FUNDS	36,119	(328)	35,791

The company holds 20% or more of the issued share capital of the following company:

Company	Country of incorporation	Share class	%age owned
IRSE Enterprises Limited	England and Wales	Ordinary	100

	Share capital and reserves	Profit for year
IRSE Enterprises Limited	£241,676	£49,590

3 Stock

	Consolidated 2020 £	Consolidated 2019 £	Charity 2020 £	Charity 2019 £
Stock	48,862	45,110	42,416	36,076

4 Debtors

	£	£	£	£
Trade debtors	122,910	58,801	-	-
Other debtors	12,017	9,707	12,017	9,707
Pre-payments and accrued income	6,422	78,555	-	-
VAT	66,181	47,642	53,571	35,995
Amounts owed by group undertakings	-	-	225,035	223,878
	207,530	194,705	290,623	269,580

5 Current Asset Investments

	£	£	£	£
National Savings	209,668	209,205	209,205	209,205
	209,668	209,205	209,205	209,205

6 Creditors: amounts falling due within one year

	£	£	£	£
Trade creditors	28,984	38,981	18,093	28,520
Deferred income and accruals	200,644	196,505	177,332	176,262
Other taxes and social security costs	-	-	-	-
Other creditors	192,841	203,448	33,015	32,221
	422,469	438,934	228,440	237,003

7 Creditors: amounts falling due after one year

	Consolidated 2020 £	Consolidated 2019 £	Charity 2020 £	Charity 2019 £
Deferred income	237,697	258,883	-	-

Representing the proportion of licence fees receive which will be credited to Income after more than one year.

8 Activities of IRSE Enterprises

	2020 £	2019 £
Turnover		
Donations	4	(10)
Proceeds - Conventions and Conferences	784	15,559
Proceeds - Dinners	-	51,466
Proceeds - Technical Visits and Seminars	13,008	35,453
Licensing - Licence Fees Received	205,404	194,321
Licensing - Audit Fees	45,042	56,022
Licensing - Assessing Agents Fees	82,306	62,564
Licensing - Technical Publications	8,044	10,546
	354,592	425,921
Cost of sales		
Costs - Conventions and Conferences	1,812	4,801
Costs - Dinners	(2,653)	31,285
Costs - Technical Visits and Seminars	13,929	35,354
Costs - Young Members’ Seminars and Visits	-	1,104
Licensing - Logbooks Opening Stock	9,034	4,721
Licensing - Engineer’s fees	14,503	14,081
Licensing - IRSE Administration Charges	162,753	122,032
Licensing - Audit Engineers	48,195	58,825
Licensing - Accreditation	5,385	10,980
Licensing - Logbooks Closing Stock	(6,444)	(9,034)
	246,514	274,149
GROSS PROFIT	108,078	151,773
Other income		
Dividends receivable	6,105	6,413
Bank interest receivable	119	367
	6,224	6,780
	114,302	158,553
Expenditure		
IRSE Admin Charges	48,561	18,990
Telephone	6,322	7,033
Post and Stationery	2,447	6,441
Officers’ expenses	-	-
Accommodation and Refreshments	675	3,584
Computer costs	33,598	34,522
Sundry expenses	2,910	2,975
Licensing - Treasurer’s, Chief Executive’s and Registrar’s Fees	73,201	71,500
Logbook Purchases	-	9,025
Investment Manager’s Fees	3,694	3,421
Auditor’s remuneration	2,000	4,000
Exchange rate variance	(2)	7
	173,406	161,498
Finance costs		
Licensing - Bank charges	2,402	3,238
Net figure	(61,506)	(6,183)
Gain / Loss on revaluation of assets		
Gain on revaluation of investments	111,066	77,292
NET PROFIT	49,560	71,109

9 Donations and Legacies (Group)

	2020 £	2019 £
Donations	19,092	41,708

10 Other Trading Activities (Group)

	£	£
Subscriptions	407,702	404,989
Professional Reviews	3,350	915
Advertising	12,555	9,075
Booklets and text books	18,730	7,138
IRSE ties, badges & cufflinks	26	26
Examination Fees and materials	38,553	25,413
Proceeds from members' lunch	-	707
Consultancy Income	-	-
IRSE Income	480,916	448,263
Trading income:		
Turnover of trading subsidiary - Note 8	354,592	425,921

11 Investment income (Group)

Equities and government stocks	23,824	29,958
Interest receivable	1,705	2,167
IRSE Enterprises Ltd	6,224	6,780
	31,753	38,905

12 Analysis of Expenditure

	Staff Costs £	Depreciation £	Other £	2020 £	2019 £
Raising Funds					
Other Activities	1,494	93	2,270	3,857	8,567
Investment	-	-	8,008	8,008	7,865
Non-ancillary trading - Note 8	126,654	8,170	287,498	422,322	438,884
Total raising funds	128,148	8,263	297,776	434,187	455,316
Charitable Activities					
Awards	5,977	371	9,847	16,195	24,529
Promoting best practice	141,955	8,818	330,784	481,557	534,779
Total charitable activities	147,932	9,189	340,631	497,752	559,308
Total Expenditure	276,080	17,452	638,407	931,939	1,014,624

13 IRSE Charitable Expenditure

	£	£
Raising donations and legacies		
Fund raising dinners	-	4,190
Consultancy	-	-
Charitable activities		
Proceeding: editing and printing	4,028	4,517
Newsletter: editing and printing	98,249	94,728
Booklets and textbooks	5,628	5,773
IRSE ties, cufflinks and badges	-	1,295
Prizes	39	1,111
Awards	767	7,020
Activities funded by country subscription supplements	5,974	8,821
Professional review costs	1,203	2,682
Support costs		
Staff costs	151,739	191,176
Office rent and services	18,524	20,202
Fees and honoraria	74,017	71,070
Membership database	-	8,420
Other administrative costs	128,160	127,100
Investment manager's fees	8,008	7,865
Fixtures and fittings	9,282	15,770
Governance costs		
Auditor's remuneration	4,000	4,000
Total Expenditure	509,618	575,740

v1.0, March 2021. Production, typeset and lay out www.polunnio.co.uk.

IRSE///
Institution of Railway Signal Engineers

3. Index to IRSE News from May 2020 to April 2021

IRSE News 266, May 2020

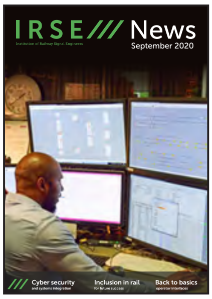
Article	Author	Page
Presidential address: The challenges of change in complex command, control and signalling systems	Daniel Woodland	2
Technology trends in mass rapid transit	Alan Rumsey	7
Converting a GoA1 commuter railway to a GoA4 driverless metro – The Sydney Metro Experience	Steve Allday	10
Back to basics: Interlocking Part 2	Francis How	20
Industry news		26
News from the IRSE		30
Creating video content: some advice		31
Working from home		32
Your letters		33
New books		34

IRSE News 267, June 2020

Article	Author	Page
Traffic management – the bigger picture	John Francis	2
Back to basics: Principles of railway safety engineering	David Nicholson	10
"It's only a relock"	Stephen Dapré	17
Industry news		22
News from the IRSE		25
Professional development: Future IRSE structures for Knowledge, Skills and Ability		26
Presidential programme		29
Younger Members: Railway telecom exam study day – via telecoms		30
North American International Conference – An overview of "Beyond CTBC" 2019		33
Past lives: Craig Longley		40
Past lives: Tim Howard		41
Membership changes		42

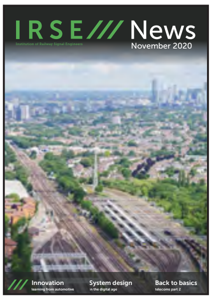
IRSE News 268, July/August 2020

IRSE News 269, September 2020



IRSE News 270, October 2020

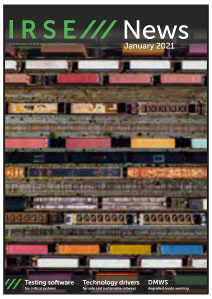
IRSE News 271, November 2020



IRSE News 272, December 2020

Article	Author	Page
Cross-acceptance of systems and equipment developed under different standards frameworks	Rod Muttram	2
Safety is no accident: lessons from a different railway	Karl Davis	14
Traction decarbonisation in Great Britain	David Fenner	18
C-DAS Connected Driver Advisory System	Paul Darlington	20
Zero disruption project delivery	Frank Heibel	22
Industry news		25
News from the IRSE		29
Professional development: Railway Automation Seminar		30
Past lives: David Norton		32
Past lives: Richard Stokes		33
Past lives: Michael Page		34
Your letters		36

IRSE News 273, January 2021



Article	Author	Page
Testing of software-based critical systems in railway applications	Nicholas Wrobel	2
Technology drivers for Safe and Sustainable Global Railways	Daniel Woodland	12
DMWS – Degraded Mode Working System	Chris Fulford	15
Configuring safe software driven systems	Rod Muttram	22
Industry news		30
News from the IRSE		34
IRSE News: Producing your magazine		37
Past lives: Graham Brown		39
Your letters		40
Membership changes		42

IRSE News 274, February 2021

IRSE News 275, March 2021

IRSE News 276, April 2021

IRSE

Institution of Railway Signal Engineers

4. Summaries of IRSE Presidential Programme technical papers

Each year the President of the IRSE invites keynote speakers to produce papers and presentations on selected topics. The papers for the Presidential Programme for April 2020 to March 2021 had the overarching theme of “Challenges of change in complex command, control and signalling systems”, selected by Daniel Woodland for his Presidential Year.

In 2020-2021 the speakers and papers were as follows, a summary of each appears on the following pages.

Techniques at the forefront of system safety and their application to railway signalling

by Yuji Hirao (on behalf of the IRSE International Technical Committee) on 16 June 2020

Automating our railways – lessons learned from bold automotive innovators

by Tom Jansen and Rick Driessen on 30 October 2020

Cross-acceptance of systems and equipment developed under different standards frameworks

by Rod Muttram on 19 November 2020

Testing of software-based critical systems in railway applications

by Nicholas Wrobel on 2 December 2020

Digital resilience maturity matrix for the railway sector

by Alzbeta Helienek and Mathijs Arends on 20 January 2021

Automation in railway control centres

by Ian Mitchell and Nora Balfe on 4 February 2021

Techniques at the forefront of system safety and their application to railway signalling

Yuji Hirao, Professor Emeritus, Nagaoka University of Technology, Japan
on behalf of the IRSE International Technical Committee (ITC)

Presented 16 June 2020, online

Published in IRSE News 268, July/August 2020

To cope with residual risks caused by the sophistication and the large-scale complexity of future railway signalling systems, entirely distinct safety technologies and risk management methods are required in addition to conventional ones.

For this purpose, we need to assimilate potential cutting-edge technologies with the aim of applying them to railway signalling. The following techniques used in system safety fields such as academia and aerospace, where a high level of safety is concerned, are applicable to our domain and can be expected to contribute to its improvement and enhancement. This paper describes the essence, rather than the details, of safety technologies and management techniques at the forefront from the viewpoint of their application to railway signalling.

The paper explores techniques including:

Goal Structured Notation (GSN) for defining system requirements;

Systems Theoretic Accident Model and Processes/System Theoretic Process Analysis (STAMP/STPA) – hazard analysis techniques for complex systems;

Data preparation techniques in use in the rail sector for design and testing, including SafeCap, RailTopoModel.

The paper also explores the challenges of using multi-core processors in safety-critical applications, and the application of artificial intelligence (AI) and machine learning in safety-related systems (autonomous systems), and briefly refers to the security aspects of systems.

Automating our railways – lessons learned from bold automotive innovators

Tom Jansen and Rick Driessen, Ricardo, Netherlands

Presented 30 October 2020, online

Published in IRSE News 268, July/August 2020

The global demand for passenger transportation is growing (disregarding the current short-term effects of the Coronavirus pandemic). In large parts of western Europe demand is outgrowing supply, with almost 3000km of track declared as congested, and with only conventional technologies the sector is struggling to keep up. Currently available technical solutions such as ERTMS have some potential to optimise the utilisation of the railway system, creating some breathing space, but on its own it is doubtful whether ERTMS will provide sufficient capacity increase in the long term.

Besides this challenge in capacity, the railway industry is facing potentially existential threats from innovative competing transportation modes. Since innovation in the railways has been very slow in recent history, the question that comes to mind is: How can the railway industry still be competitive and attractive enough in the mobility landscape of the future?

This paper highlights and discusses the key challenges for further automation of the railway industry, in order to stay competitive and to optimise the market share for rail transportation, while comparing these challenges with recent innovations in the automotive industry. The authors consider the potential benefits of replacing the train driver with computers, how the safety and integrity of a self-driving train and its software can be demonstrated, and whether the business case can be improved by making use of automation knowledge and products from other industries.

Cross-acceptance of systems and equipment developed under different standards frameworks

Rod Muttram, UK on behalf of the IRSE International Technical Committee (ITC)

Presented 19 November 2020, online

Published in IRSE News 272, December 2020

The subject of cross-acceptance is one that the ITC has visited before. Indeed, it was the subject of the first ever ITC Paper (Paper 1, what we would now call Topic 1) "Safety System Validation with regard to cross acceptance of signalling systems by the railways" in January 1992. The ITC wrote again about cross-acceptance as Topic 6 "Proposed Cross Acceptance processes for railway signalling systems and equipment" in April 2003.

The paper begins by considering what is meant by the term "cross acceptance", looking first to the definition in EN50129 and its shortcomings. The paper then moves on to acknowledge that there are two dominant approaches to safety approval in the rail domain:

The use of the safety case to demonstrate that failure rates will be commensurate with defined safety targets. CENELEC Standards in the EN5012X series (based on IEC61508) classify products by their assessed failure rates as being capable of supporting safety functions in 4 'bands' from SIL 1 to SIL 4. The CENELEC approach often involves gaining a 'one-time' approval for a Generic Product (GP) and then approvals for a Generic Application (GA) in each user environment followed by assessment of each Specific Application (SA) site/project within that environment.

The use of compliance against domain standards – evident in Europe in the form of TSIs and National Technical Rules (NTRs), and in the USA a suite of standards from AREMA (American Railway Engineering and Maintenance-of-Way Association), the IEEE, MIL-STDs and the railroads themselves.

The paper explores the progress made in Europe using TSIs, and the shortcomings in the CCS domain (e.g. with the approval of interlockings), and the evolution of the US approach.

TR50506-1 (a Technical Report that supports EN5012X, and due to be withdrawn at the end of 2020) sets out a well-structured seven step process for cross acceptance:

1. Establish a credible case for the native (baseline) application.
2. Specify the target environment and application.
3. Identify the key differences between the target and native cases.
4. Specify the technical, operational and procedural adaptations required to cater for the differences.
5. Assess the risks arising from the differences.
6. Produce a credible case for the adaptations adequately controlling the risks arising from the differences.
7. Develop a generic or specific cross-acceptance case.

The author looks back at some previous experiences with cross-acceptance, particularly in the UK (Bombardier on LUL sub-surface lines, Ansaldo ACC at Manchester South, and, in greater detail, Atkins' deployment of ElectrologIXS) and the lessons learned.

Testing of software-based critical systems in railway applications

Nicholas Wrobel, UK

Presented 2 December 2020, online

Published in IRSE News 273, January 2021

The purpose of testing software-based critical systems in railway applications is to find and fix as many faults as possible before releasing the software onto the railway and to demonstrate, within given confidence limits, the fitness-for-purpose of this software prior to its release onto the railway. This paper outlines the importance of system level testing of software-based critical systems before releasing the software onto the railway.

The paper is based on information gained on London Underground's Victoria line upgrade programme (VLUP) in the period 2003 to 2009. The line was the first Automatic Train Operation (ATO) metro railway in the world when it opened in 1968, with the full line opening in 1969.

The paper explores:

- The requirements for and benefits of system level testing
- The operating envelope
- Test coverage
- Levels of confidence
- A framework for off-the-railway system level testing using a test rig
- Application of this framework to the system level testing of a new train with a new ATO signalling system
- Development and validation of the test rig
- The benefits of system level parametric testing

The benefits of system level testing using an off-the-railway test rig include:

- Reduced access to the railway.
- Reduced delays to the delivery programme and consequential reputational damage, and hence reduced overall cost of the delivery programme.
- Increased operator confidence when passenger operations commence due to an increased test coverage.
- Reduced operational delays after commencing passenger operations due to fewer Service Affecting Faults (SAFs).
- Reduced number of software releases (and hence cost to the signalling contractor) after commencing passenger service.

One would imagine that these benefits, even if not all were actually realised, would be sufficient to persuade clients and contractors alike to maximise off-the-railway testing at system level. Surprisingly, the experience on the VLUP was that none of the parties involved, even the independent safety assessors, appreciated at the outset the magnitude of the benefits of using a system level test rig.

Digital resilience maturity matrix for the railway sector

Alzbeta Helienek and Mathijs Arends, Ricardo, UK and Netherlands

Presented 20 January 2021, online

Published in IRSE News 274, February 2021

Cyber security has become a critical part of delivering an efficient and safe railway, driven by ever more digitally connected systems and the evolving threat landscape. Much has been achieved over the last few years but even today the railway finds itself in various stages of cyber security awareness and readiness.

As an industry we range from having developed and integrated security assurance frameworks, allowing safe, secure R&D and project implementations through to no awareness at board level and lack of understanding of responsibility within engineering teams.

The Digital Resilience Railway Maturity Matrix set out in this paper presents a method to categorise, recognise and support organisations with their roadmaps to integrate security into daily operations. It provides a powerful benchmarking tool in a competitive landscape, which in a race to become more effective has also become more vulnerable to today's technological changes.

Automation in railway control centres

Ian Mitchell, UK and Nora Balfe, Irish Rail, Ireland

Presented 4 February 2021, online

Published in IRSE News 275, March 2021

When automation is considered in the context of transport, automatic driving of the individual vehicles first comes to mind. On railways we have over 50 years' experience of metro trains with a variety of 'grades of automation', and the highest grade GoA4 'unattended train operation' is now routine for new lines. This experience has clearly demonstrated that the combination of a high capacity signalling system such as ETCS with automatic train operation (ATO) is the way to maximise capacity, and this is increasingly seen as a 'game changer' for main line railway networks as well as metros.

The other side of transport automation is in the management and co-ordination of the vehicle movements, and again there is a long history of this in the railway industry. Automatic signalling systems to control train separation on plain track have been around for over 100 years, and these were followed by electro-mechanical systems that could be programmed to set routes through simple junctions. By the 1980s what we would now recognise as a modern railway control centre was emerging with automatic route setting (ARS) by an electronic computer. But even today, we still have a human in the loop, we may call him/her a signaller, operator, dispatcher or controller, and the human and the computers have to work together to manage the operation of the railway.

At the IRSE's ASPECT 2015 conference our current President, Daniel Woodland, was one of the authors of a paper with the title Automation in Railway Control Centres: avoiding the 'bridge too far'. For his Presidential Year, he has set us the challenge of looking in more detail at the current state of the art in railway control centres, and asking the questions "What should we automate?" and "How should we automate?". In doing this, we have been supported by the IRSE's International Technical Committee, whose members have completed a questionnaire about the state of the art in main line and metro control centres around the world.

IRSE
Institution of Railway Signal Engineers

5. Summaries of IRSE International Technical Committee (ITC) papers

The mission of the IRSE's International Technical Committee (ITC) is to provide a multi-national and independent perspective on Railway Control, Command and Signalling (CCS) topics. Membership is by invitation, and comprises industry experts from both suppliers and operators, drawn from more than a dozen countries around the world. It aims to inform and educate both IRSE members and the train control and communications community worldwide, principally by the production of reports on selected topics.

Listed below are the ITC papers published during 2020–2021 with a summary of the content given on the following pages. Presentations based on a number of these papers were also part of the Presidential Programmes for the years 2019-2020 and 2020-2021.

The race against obsolescence
by Wim Coenraad, paper published April 2020

Technology trends in mass rapid transit signalling
by Alan Rumsey, paper published May 2020

Techniques at the forefront of system safety and their application to railway signalling
by Yuji Hirao, paper published July 2020

Cross-acceptance of systems and equipment developed under different acceptance frameworks (2020)
by Rod Muttram, paper published November 2020

Configuring safe software driven systems
by Rod Muttram, paper published January 2021

Automation in railway control centres
by Ian Mitchell and Nora Balfe, paper published March 2021

Intelligent railways
by Paul Hendriks and Mark Witvoet, paper published March 2021

The many aspects of architecture and their impact on system performance
by Rod Muttram, paper published April 2021

The race against obsolescence (ITC Report 68)

Wim Coenraad, Netherlands

Published in IRSE News 265, April 2020

The world in which we do our signal engineering changes rapidly. We must deliver change more quickly as technology cycles speed up.

However, the demands for assurance and certification of railway control systems slow us down, which causes inertia in the development and deployment of systems, products and processes, and can lead to obsolescence.

Obsolescence is usually thought of as technical systems becoming life expired, no longer maintainable or losing relevance for the required functions in their operating environment. It can also refer to engineering processes that become out-dated or no longer fit for purpose. And it can apply to people – either when the skills to maintain old systems are in short supply, or when the workforce does not have (and cannot acquire) the knowledge and expertise required for new systems. Even a profession can become irrelevant and outmoded.

This paper explores obsolescence in its many forms in the rail industry, and the impact of ever changing (and faster changing) technology. The author also challenges us about our burdensome engineering processes, and asks how we as engineers (and IRSE members) can remain relevant as the industry changes.

Technology trends in mass rapid transit signalling (ITC Report 61)

Alan Rumsey, Canada

Published in IRSE News 266, May 2020

The mission of any mass rapid transit system is to provide for the safe, reliable and efficient movement of people. Signalling/train control systems play a critical role in delivering this mission. The evolution and availability of new technologies can influence the delivery of the above mission in two ways:

"Doing things better" i.e. by implementing the same functions as earlier technologies but in a safer, more reliable, more efficient, or cheaper, etc. manner; or

"Doing better things" i.e. by implementing new functions that were simply not feasible or affordable with earlier technologies.

In order to address how technology trends may enable signal engineers to "do things better" and/or "do better things", we first have to look at the trends with respect to future requirements and expectations for mass transit signalling and train control systems.

One trend that is clear is that the requirements will be increasingly passenger-centric, with an emphasis on minimising system life-cycle costs. In addition to ensuring the safety of all train movements and the safety of the passenger interchange at station platforms, user requirements will be focused more on improving system reliability/availability and on enhancing train operations. This will include optimising the movement of passengers by maximising the utilisation of the available rail infrastructure and adopting higher levels of automation.

In this paper the author explores the technology impact on things such as train location determination, movement authority determination and enforcement, interlocking architectures, and train service management.

Techniques at the forefront of system safety and their application to railway signalling (ITC Report 74)

Yuji Hirao, Japan

Published in IRSE News 268, July/August 2020

To cope with residual risks caused by the sophistication and the large-scale complexity of future railway signalling systems, entirely distinct safety technologies and risk management methods are required in addition to conventional ones.

For this purpose, we need to assimilate potential cutting-edge technologies with the aim of applying them to railway signalling. The following techniques used in system safety fields such as academia and aerospace, where a high level of safety is concerned, are applicable to our domain and can be expected to contribute to its improvement and enhancement. This paper describes the essence, rather than the details, of safety technologies and management techniques at the forefront from the viewpoint of their application to railway signalling.

The paper explores techniques including:

Goal Structured Notation (GSN) for defining system requirements;

Systems Theoretic Accident Model and Processes/System Theoretic Process Analysis (STAMP/STPA) – hazard analysis techniques for complex systems;

Data preparation techniques in use in the rail sector for design and testing, including SafeCap, RailTopoModel.

The paper also explores the challenges of using multi-core processors in safety-critical applications, and the application of artificial intelligence (AI) and machine learning in safety-related systems (autonomous systems), and briefly refers to the security aspects of systems.

Cross-acceptance of systems and equipment developed under different standards frameworks (2020) (ITC Report 72)

Rod Muttram, UK

Published in IRSE News 272, December 2020

Summary

The subject of cross-acceptance is one that the ITC has visited before. Indeed, it was the subject of the first ever ITC Paper (Paper 1, what we would now call Topic 1) "Safety System Validation with regard to cross acceptance of signalling systems by the railways" in January 1992. The ITC wrote again about cross-acceptance as Topic 6 "Proposed Cross Acceptance processes for railway signalling systems and equipment" in April 2003.

The paper begins by considering what is meant by the term "cross acceptance", looking first to the definition in EN50129 and its shortcomings. The paper then moves on to acknowledge that there are two dominant approaches to safety approval in the rail domain:

The use of the safety case to demonstrate that failure rates will be commensurate with defined safety targets. CENELEC Standards in the EN5012X series (based on IEC61508) classify products by their assessed failure rates as being capable of supporting safety functions in 4 'bands' from SIL 1 to SIL 4. The CENELEC approach often involves gaining a 'one-time' approval for a Generic Product (GP) and then approvals for a Generic Application (GA) in each user environment followed by assessment of each Specific Application (SA) site/project within that environment.

The use of compliance against domain standards – evident in Europe in the form of TSIs and National Technical Rules (NTRs), and in the USA a suite of standards from AREMA (American Railway Engineering and Maintenance-of-Way Association), the IEEE, MIL-STDs and the railroads themselves.

The paper explores the progress made in Europe using TSIs, and the shortcomings in the CCS domain (e.g. with the approval of interlockings), and the evolution of the US approach.

TR50506-1 (a Technical Report that supports EN5012X, and due to be withdrawn at the end of 2020) sets out a well-structured seven step process for cross acceptance:

1. Establish a credible case for the native (baseline) application.
2. Specify the target environment and application.
3. Identify the key differences between the target and native cases.
4. Specify the technical, operational and procedural adaptations required to cater for the differences.
5. Assess the risks arising from the differences.
6. Produce a credible case for the adaptations adequately controlling the risks arising from the differences.
7. Develop a generic or specific cross-acceptance case.

The author looks back at some previous experiences with cross-acceptance, particularly in the UK (Bombardier on LUL sub-surface lines, Ansaldo ACC at Manchester South, and, in greater detail, Atkins' deployment of ElectrologIXS) and the lessons learned.

Configuring safe software driven systems (ITC Report 82)

Rod Muttram, UK

Published in IRSE News 272, December 2020

Summary

The motivation for the IRSE's International Technical Committee (ITC) to produce this article was a letter to the IRSE News regarding another ITC article on human factors and automation that in part examined the circumstances leading to the two well publicised fatal Boeing 737 MAX crashes. The part played in those disasters by the Manoeuvring Characteristics Augmentation System (MCAS) has become infamous and the letter contended that the crashes would not have happened had the 2oo3 architecture of the Solid State Interlocking (SSI) been used.

Designing a computer based, software configured and operated system which is both safe and highly available can be challenging. They need to be able to safely handle both random failures (such as an electronic component becoming defective) and systematic failures such as errors (bugs) in the software. We cannot afford the historic interpretation of 'fail-safe', which a lot of older mainline railway infrastructure still utilises, based on 'right-side' and 'wrong-side' failures, where a wrong-side failure has immediate safety consequences but a failure that causes loss of function and stops the trains is classified as 'right-side' and thus to some degree acceptable.

Not only must no single fault cause an unsafe failure, but no single fault must cause a loss of functionality either, and the probability of multiple or 'cascade' faults must be acceptably low. Furthermore, all faults must be detectable even if they cause no immediate loss of functionality. Undetected dormant faults may compromise safety and/or reliability. The safety requirements will usually demand a lower failure rate, but availability targets are now often 99.99 per cent or even higher.

To service these potentially conflicting requirements a number of architectural solutions have emerged, each with their own advantages and disadvantages. Most of the approaches use multiple computers in some way cross checking one another and these are sometimes known as 'multi-lane' or 'multi-channel' safe computing platforms.

The use of multi-lane architectures does not guarantee safety or availability without a lot of other things also being correctly put in place. There are a number of 'pitfalls', sometimes quite subtle in nature, that can result in such systems failing to deliver these design objectives. In this article we try to explore some of those, based on real problems experienced by ITC members.

Automation in railway control centres (ITC Report 79)

Ian Mitchell, UK and Nora Balfe, Irish Rail, Ireland

Published in IRSE News 275, March 2021

When automation is considered in the context of transport, automatic driving of the individual vehicles first comes to mind. On railways we have over 50 years' experience of metro trains with a variety of 'grades of automation', and the highest grade GoA4 'unattended train operation' is now routine for new lines. This experience has clearly demonstrated that the combination of a high capacity signalling system such as ETCS with automatic train operation (ATO) is the way to maximise capacity, and this is increasingly seen as a 'game changer' for main line railway networks as well as metros.

The other side of transport automation is in the management and co-ordination of the vehicle movements, and again there is a long history of this in the railway industry. Automatic signalling systems to control train separation on plain track have been around for over 100 years, and these were followed by electro-mechanical systems that could be programmed to set routes through simple junctions. By the 1980s what we would now recognise as a modern railway control centre was emerging with automatic route setting (ARS) by an electronic computer. But even today, we still have a human in the loop, we may call him/her a signaller, operator, dispatcher or controller, and the human and the computers have to work together to manage the operation of the railway.

At the IRSE's ASPECT 2015 conference our President, Daniel Woodland, was one of the authors of a paper with the title Automation in Railway Control Centres: avoiding the 'bridge too far'. For his Presidential Year, he has set us the challenge of looking in more detail at the current state of the art in railway control centres, and asking the questions "What should we automate?" and "How should we automate?". In doing this, we have been supported by the IRSE's International Technical Committee, whose members have completed a questionnaire about the state of the art in main line and metro control centres around the world.

Intelligent railways (ITC Report 56)

Paul Hendriks and Mark Witvoet, Netherlands

Published in IRSE News 275, March 2021

The economy is highly dependent on the modern railway as we know it. People commute daily to their work and during the weekend they use these trains for leisure. Freight carriers also use the railway heavily during the day and night.

Due to demographic and economic development it is to be expected mobility will grow by more than 50 per cent over the next 30 years. Additionally, the Paris Climate Agreement and the European Green Deal call for urgent action to further reduce the carbon footprint. As railway transport is one of the most sustainable ways of travelling, the expectation is that the demand will rise even more. For the Netherlands it is expected that within ten years from now the railway demand will grow by 27-45 per cent. The predicted increase in demand is accompanied by an increased need for highly reliable and available railway infrastructure. These high requirements for railway transportation mean there must be a high reliability and availability of the infrastructure. Unplanned equipment downtime will significantly impact daily operations and reduce asset performance, which must be avoided. At the same time, a discrepancy is observed in the increase in transportation demand and the available budget. This forces the rail sector to increase operational efficiency. We need to make use of new ways of working within the sector to ensure that our infrastructure and assets can still deliver the promised and demanded performance.

To attain the necessary capacity we can choose high capacity trains (double decker, longer), or more track and higher availability of infrastructure (less disturbance, less maintenance, fewer trackworks). Control command and signalling can play a role and we need to think of different ways to monitor our infrastructure and assets while keeping costs low. We must go from corrective (and preventive) maintenance to an "intelligent" predictive maintenance way of working within the railway sector.

Combining intelligent predictive maintenance and advanced ways of analysing data can help to reach this target. This intelligent predictive maintenance can be delivered by new technologies such as Internet of Things (IoT), big data and data analytics. This paper explores the use of sensors for monitoring both trains and infrastructure, and how the information from sensors can be combined to create a more intelligent picture of the railway's performance. Examples are used for level crossings, for train speed and braking, and for freight wagons.

In the railway sector, there are endless possibilities to monitor the assets by connecting all kinds of sensors with each other and thereby creating a digital twin. For example combining data from smart sleepers with sensors on trains we can predict where on the track long-term degradation takes place. This long-term degradation is not visible by a visual inspection of a location once or twice a year but with the help of sensors this could be possible. It may even be possible for these sensors to be used for train detection, or as a fall back for when the existing track circuits or axle counters fail. Multiple sensors providing a large amount of data could be combined with sufficient statistical methodology resulting in the required safety level.

The many aspects of architecture and their impact on system performance (ITC Report 83)

Rod Muttram, UK

Published in IRSE News 276, April 2021 (Part 1)

The dictionary defines architecture as the process of planning, designing and constructing buildings or systems. Most lay people would associate architects with buildings or structures. But it is not 'civil' structures that are the subject of this paper; it is intended to focus more on the structure of control, communications and power systems – the 'systems' element of the definition.

'Architecture' in that context exists at several levels. There is the design and architecture of individual components and subsystems and then the overall architecture of the system, or 'system of systems' that delivers the desired service or outputs.

It is the second of these facets that tends to be more thought of as the 'system architecture' but such 'big systems' are critically dependent on the first element being correct if they are to deliver the reliability and safety performance required.

The ITC therefore decided to split the paper into three parts. The first part covers aspects related more to the good design basics of components and sub-systems, focusing on hardware; the second covering software, normally distributed throughout the hardware of a bigger system but also having critical architectural dimensions; the third covering the bigger system and system of system issues. That said, the three parts interact and are interdependent so those distinctions may not always be strictly maintained.

IRSE
Institution of Railway Signal Engineers

6. Results of the IRSE Examinations held in October 2020

The IRSE is pleased to announce the results of the 2020 IRSE Professional Exam modules and to congratulate all those listed, especially those who have now achieved the IRSE Professional Exam and the Advanced Diploma in Railway Control Engineering.

2020 was the first year that candidates could sit the Certificate in Railway Control Engineering Fundamentals (Module A) and the last year they could sit up to four modules from the numbered module exam structure. All modules were sat remotely for the first time in the history of the IRSE Professional Examination.

Thank you to all those who have supported candidates through their studies by organising study groups, acting as sponsors, and running the exam forum. Thanks also to the examiners for the considerable amount of time involved with setting and marking the papers.

The successful candidates for each module are identified in the tables below. In each case 'P' indicates a pass, 'C' a credit and 'D' shows that the candidate passed with distinction.

Certificate in Railway Control Engineering Fundamentals and Advanced Diploma in Railway Control Engineering results

The table below details the candidates who have not only successfully passed the Certificate in Railway Control Engineering Fundamentals (Module A) but who have now completed their exam journey, having previously passed a combination of three numbered modules. These candidates have therefore achieved the Advanced Diploma in Railway Control Engineering, the new name for the IRSE Professional Examination. Jehad Mahmoud and Matthew Slade had previously passed the IRSE Professional Examination before taking this module.

Name	MA
Emily Bramble	P
Robert Gunn	P
Tsz Yin Law	C
Andrew Laz	C

Name	MA
Jehad Mahmoud	C
Matthew Pylyp	C
Matthew Slade	D
David Snelling	P

Name	MA
Kwok On Wong	C
Feng Zhang	P

The table below details those who have successfully passed the Certificate in Railway Control Engineering Fundamentals (Module A), a stand-alone qualification and the start of the new Advanced Diploma in Railway Control Engineering journey.

Name	MA
Shalini Aithal	P
Osama Ali	P
Mozahir Anwar	P
Divya Aramalla	P
Daniel Barton	C
Robert Baxter	P
Muhammad Komail Bin Akram	P
Daniel Bowen	P
Peter Briton	P
Michael Brouder	P
Ewan Burns	P
Scott Cao	P
John Chaddock	D
Ching Yin Chan	P
Cho Yee Cheung	P
Tsz Hei Cheung	C
Ka Kwan Chu	P
William Clark	C
Martin Cooper	C
Agnes Darazsi	C
István Darázsi	C
Chetan Devikar	P
Malcolm Dobell	C
Neal Dodge	C
Philip Dubery	C
Veera Duggirala	P
Richard Fisher	P
Dominic Fleming	P
Gareth Fussell	P
David Gardner	P
Emily Glover	C
Stephen Goodwin	C
Russell Grinham	P
Paul Gueneau	C
Harry Hammond	C

Name	MA
Stephen Hatton	C
Hongyang He	C
Anthony Hewitt	P
Ming Hsia	P
Dani Indrianto	P
Joe Inniss	P
Mukul Jetmalani	C
Christopher Johnson	C
Rhiannon Jones	P
Manroshan Singh Jusbir Singh	P
Akash Reddy Kankanala	C
Gaurav Kaushik	C
Jonathan Kelly	P
Timothy Kelman	C
Atif Khan	P
Yiu Nam Kwok	P
Yung Ho Lam	P
Chun Yeung Law	P
Tsz Ki Lee	P
Man Cheng Lei	P
Joseph Little	P
Hiu Tung Lo	C
Virun Lokavirun	P
Stuart Maddock	C
Oliver Marshall	D
Gregory Martin	P
Diatta Mbaye	P
Ian McNerlin	P
Paul McSharry	P
Israel Mendez Tovar	P
Paul Morris	D
Stanley Mudyawabikwa	C
Ashley Murray	C
Mehmet Narin	P
Paul Naylor	C

Name	MA
Siamak Nazari	C
Alfred Ng	P
Daniel Oakes	P
Henry Pang	P
Stuart Park	P
Toby Parker	P
Karthik Raja	P
Simon Read	C
Aneurin Redman-White	D
David Roebuck	P
Nicholas Rook	C
Ian Ross	P
Daniel Scourfield	P
Davelia Sihombing	P
Shashi Singh	P
Trevor Stevens	P
Mark Styles	P
Arvind Kumar	P
Vangelis Tsiapalas	P
Tajamal Tuffail	C
Ayberk Ustaoglu	P
Ben Vallely	P
Tanay Verma	P
Vikrant Vishal	C
Robert Watson	C
Robert Wheeler	P
Bill Raymond Wilkinson	P
Hiu Tung Wong	C
Man Lok (Wilson) Wong	C
James Wood	C
John Woods	P
Richard Wright	C
Li Xie	P
Rui Zou	C

Results for the IRSE Professional Exam and passes in numbered modules

Candidates in the table below have successfully passed the IRSE Professional Exam by being successful in Safety of Railway Signalling and Communications (Module 1) and three other modules from the numbered module exam structure available up to and including October 2020. We would particularly like to congratulate Ewan Campbell, Kin Sum Lee and Hey Man Joshua Ma for not only passing the examination, but also successfully passing five modules. Colin Hamilton-Williams had previously passed the exam but has also now passed five modules, and Aaron Sawyer who had also passed the exam previously, has now been successful in six modules.

Name	M1	M3	M4	M5	M6	M7
Martin Allen	C			P		
Ewan Campbell		P		P		
Clare Crooks		P				
Colin Hamilton-Williams			P			
Kauser Ismailjee	D					P
Elliott Jordan	P			P		
Peter Kelly						P
Michael Kingston		P				P
Praveen Kumar				P		
Ching Yin Lau	P					C

Name	M1	M3	M4	M5	M6	M7
Kin Sum Lee		P		P		
Hey Man Joshua Ma	C			P		P
Aaron McConville		P				
Rory Mitchell		P				
Michael Murphy		P				
Gabor Nemeth	P	C				P
Aaron Sawyer			P		P	
Phuoc Tran						P
Susannah Walker						P
Jordan Wallis	C					P

The table below shows those who have successfully passed modules in 2020 but have not yet achieved sufficient passes to complete the exam. Candidates will be able to continue their exam journey by passing a combination of new modules.

Name	M1	M3	M4	M5	M6	M7
Kevin Banks		P				
Paven Bhatti	P					
Arjun Chauhan	P					
Chong Lam Cheong			P		P	P
James Darlington				P		
Shane Dowling		P				
Thomas Franklin	P					
Sean Gorman		P				
Alex Grant	P					
Kieron Hadlington	D					
Oliver Hains	P					
Jordan Harris		C				
Ho Ka Man	P					
Harshvardhan Kodam						P
Dabi Laniyan						P

Name	M1	M3	M4	M5	M6	M7
Ka Seng Lio		P				
Samuel Loveless						P
Sam Mitchell		P				
Aisling O'Connor		P				
Antonis Phasouliotis						P
Andrew Plumb		P				
Hiu Chun (Jack) Pun		P				
Suhanya Saenthan	C					
Chou Tek Sam Ti			C			C
Ming-Tak Shum	P					
James Stanley	D					
Natcha Sujaritworakun	P					
Mark Williamson						P
Hai Tao Wu				P		

IRSE
Institution of Railway Signal Engineers

7. Reports from Local Sections outside the UK

The following reports were originally prepared by the UK's international (non-UK) sections as a means of reporting their activities to the Institution's Council. The reports reflect the activities and plans of each section at the time they were submitted to Council. They have been edited slightly for the purposes of providing a permanent record as part of the Proceedings 2020-21.

The international sections in existence in 2020-21 (in alphabetical order) were:

- Australasian
- China
- French
- Hong Kong
- Indian
- Indonesian
- Irish
- Japanese
- Malaysia
- Netherlands
- North American
- Singapore
- Southern Africa
- Swiss
- Thailand

Australasian Section

Report produced by: Georgina Hartwell
Les Brearley

Date: April 2021

1. Introduction

The Covid pandemic caused considerable disruption to the Technical Meeting programme of the Australasian Section in the past year. No face-to-face national technical meetings were able to be held with two online meetings held.

The four-day AGM and technical meeting scheduled for Adelaide in late March 2020 was postponed and eventually cancelled.

The AGM in June 2020 was held using GoToMeeting as was the AGM held in March 2021.

A small subcommittee has been set up to coordinate the running of the local technical meetings throughout the States as webinars and these are advertised throughout the region.

The Graduate Diploma in Railway Signalling course has operated effectively for the past twelve months with intakes in January, May and August each year. Intakes are restricted to 30 students.

In spite of multiple reminders from the Section, a significant number (approximately 50) of IRSE members in the region failed to meet the 1 April 2021 deadline for payment of their subscriptions. Steps have also been taken to increase the number of IRSE members residing in the region also joining the Section.

Please note that the Local Technical Meeting information in Section 3.2 covers the period from January 2020 until December 2020.

Date of last Annual General Meeting	26 March 2021.
Were annual accounts presented at the AGM?	Yes Motion to accept financial statements was passed at the AGM.
Were officers elected/re-elected at the AGM?	Yes Nominations matched Officer positions. An electronic ballot was held for vacant committee member positions.
Have minutes of the last AGM been produced?	Yes Draft 2021 AGM Minutes have been produced.
How many IRSE members are in the section?	746 members in the region of which there were 558 IRSE Australasian Section Inc members as of 1 April 2021.
Is your page on the website up to date?	No Officer position correct.

2. Section officers (at time of writing report)

Chair	G Hartwell
Vice Chair	D Woodcock
Secretary	L F Brearley
Treasurer	M Guruji
Country Vice-President	R Baird
Communications/website	N Hughes

3. Main activities during the past 12 months

As explained above no face-to-face National technical meetings were able to be held with two online meetings. In addition, five face to face Local technical meetings were held with the remaining eleven meetings held on line.

3.1 National technical meetings

These meetings are typically held in each state and New Zealand on a rotational basis. The AGM meeting (March or April) is held over three days. The other meetings are two days. With Covid restrictions these meetings were held on line and consisted of three technical papers and question and answer sessions.

3.1.1 Technical meeting – Sydney Online 17 July 2020

The theme was 'Signalling Technology Supporting Growing Cities and Transport Needs'.
Three papers were presented:

- CBTC101 – Concepts and Architecture
- ETCS Based Door Control System for Passenger Rollingstock.
- Signalling Design for Performance and Safety

Online attendance was 175.

3.1.2 2020 AGM

The AGM was held online as a GoToMeeting on 4 June 2020 and was opened at 11:30 am by the Chairperson K P Sundareswaran. There were 36 members online. In the election associated with the AGM Ms. G Hartwell was elected as Chairperson and so became the first female Chairperson of the Section in its 73 year history.

3.1.3 2021 AGM

The AGM was held online as a GoToMeeting on 26 March 2021 and was opened at 2:00 pm AEDT by the Chairperson Ms. G Hartwell. There were 27 members online.

3.1.4 Technical meeting – Brisbane Online 26 March 2021

Three papers were presented:

- CBTC in a Brownfield. But is there any guidance?
- Matching Changing Technology with the Right Resources
- A Progress Update on Inland Rail

Online attendance was 175.

3.2 Local technical meetings in 2020

Local technical meetings are held in capital cities. Typically, they involve two 30 minute presentations followed by light refreshments and networking. Technical papers are not usually provided. Note this information is for the 2020 calendar year which is the most recent detailed information available. These meetings started in the usual pattern in 2020, however the meetings were then halted due to the regulations associated with Covid. They were then restarted as webinars or online meetings.

3.2.1 Queensland

- 11 February 2020, attendance 73
  - The Biggest Robot in the World – Dr Anthony Macdonald (Hitachi Rail STS)
  - Open and Closed Communication Networks – What do we really mean? – Chris Jones (Hitachi Rail STS).
- 11 June 2020, online attendance 46
  - Rail Safety and Signalling Assessment Management – Andy Webb (ONRSR).
- 8 September 2020, online attendance 59
  - Signalling Modernisation for New York City's Subway – Aron Fraser (WSP). Unfortunately, due to technical difficulties the meeting was closed after 30 minutes.
- 27 October 2020, online attendance 72
  - Rescheduled from 8 September. Signalling Modernisation for New York City's Subway – Aron Fraser (WSP).

3.2.2 South Australia

- 3 September 2020, joint meeting IRSE, RTSA & PWI attendance 45
  - Advanced Train Management System (ATMS) – Whyalla Line Commissioning - Peter Rogers (ARTC) and Mike van de Worp (Lockheed Martin)
  - Mobility – Asset Management Innovation at ARTC –Vincent Lammerse (ARTC) and Daniel Cappello (ARTC).

3.2.3 Victoria

- 19 February 2020, attendance 81
  - RSA's application of a switch-over facility for testing – Ferry (Rail Systems Alliance).
  - Signalling Trains under Failure Conditions –Jim Warwick (Metro Trains Melbourne).
- 17 June 2020, online attendance 40
  - Building careers in the rail industry – Catherine Baxter (Metro Trains Melbourne).
- 15 July 2020, online attendance 51
  - Sharing the experiences of past CQU graduate diploma participants via a panel discussion
  - Cassandra Gash (Rail Projects Victoria), Aaron Fraser (WSP), Subhajit Dey (WSP), Jeanette Aitken (Competency Australia).
- 12 August 2020, online attendance 73
  - Updates to the ALCAM pedestrian model to incorporate human factors risks – Darren Quinliven (Metro Trains Melbourne) and Simon Meiers (Systra Scott Lister).

- 14 October 2020, online attendance 90
  - A review of headway modelling fundamentals from an operational modelling viewpoint – Moe Goitsemang (WSP) and Rick Singleton (WSP).
- 11 November 2020, online attendance 109
  - The practicalities of retrofitting ETCS onto existing trains – Tom Godfrey (ARUP).

3.2.4 New South Wales

- 27 February 2020, attendance 25
  - ETCS Level 2 Signalling Principles – Daniel Oakes (Asset Standards Authority).
- 30 April 2020, online attendance 62
  - Safety in Design – Trevor Moore (JMDR).
- 24 September 2020, online attendance 82
  - Signalling Equipment: Type Approval Processes – Trevor Moore (JMDR).
- 10 December 2020, online attendance 45
  - The (Real) Lasting Legacy of Major Infrastructure Projects – Matko Spadina,(UGL) and Andrew Baker, (UGL).

3.2.5 Western Australia

Event planned for April 2020 was cancelled due to Covid restrictions.

3.2.6 New Zealand

- 6 October 2020. Combined meeting with RTSA. Attendance 30 plus 150 attended via webinar
  - Auckland EMU CAF Signalling ETCS Onboard equipment introduction, assurance and commissioning process – Martin Tompkins (KiwiRail) and Paul Barnsley (freelance consultant).

3.3 ARIA Virtual Presentation, 15th October 2020. (attendance 500+)

The Australasian Rail Industry Awards (ARIA) were held on 15 October 2020 via a virtual platform. There were no nominations for the IRSE Systems Engineering award and therefore there was no presentation by the IRSE, although the IRSE's support to the overall event was acknowledged. For 2021, the award will be called the IRSE Signalling and Systems award to potentially invite more nominees.

3.4 AUSRAIL Live and On Demand 1-3 December 2020

AUSRAIL is an event held by the Australasian Railways Association (ARA) and is a three-day conference with more than 380 exhibitors and typically approximately 5000 attendees. In 2020 AusRail was held as a "Live and On Demand" conference. The IRSE participated with two streams of papers in the conference with a total of six papers presented. We were able to provide free access passes for nine of our members including four younger members.

3.5 Insight into Railway Signalling Courses

In conjunction with ARA, the IRSE delivers the "Insights into Railway Signalling" course in the various states of Australia. Due to the pandemic no courses have been run in the past twelve months.

4. Plans for the next 12 months

4.1 Events

The program of technical meetings, both national and local, will be maintained as far as possible given the restrictions associated with the Covid pandemic. The next National technical meeting is proposed to be a webinar to be held in July. A decision in relation to the following National technical meeting scheduled for October/November will be made by the end of April. It is hoped that normal meetings are able to be resumed in 2022.

Local technical meetings will continue to be arranged as webinars with face-to-face meetings recommencing in the major capital cities where possible.

The biennial CORE (Centre on Railway Excellence) Conference will take place in Perth between June 21-23, 2021. The IRSE will manage two technical streams during this conference.

IRSE will be holding three streams of presentations in the AusRail Plus conference to be held in Brisbane from 30 November to 2 December 2021.

The Australasian Section is scheduled to host ASPECT in Melbourne in 2023.

Our joint delivery of the Insight into Railway Signalling courses with the Australasian Railway Association (ARA) is planned to recommence with two courses in Sydney planned for 2021.

4.2 Other Initiatives

One major focus is to continue setting up the processes obtaining feedback and the ongoing reviewing the material for the Graduate Diploma in Railway Signalling as well as reinstating the 'Appropriate Equivalent Qualification' status from HQ for the course.

Another major focus is to establish a coordinated set of technology platforms to enable the committees to operate more efficiently, to provide an improved window to our members via an updated website and provide the e-commerce systems to provide efficient data transfer from the website to our accounting systems. The current systems in place are not sufficiently automated and integrated.

China Section

Report produced by: Yinghong Wen
Date: February 2021

1. Introduction

Date of last Annual General Meeting	10 January 2020
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	102
Is your page on the website up to date?	Yes

2. Section officers (at time of writing report)

Chair	Tao Tang
Secretary	Yinghong Wen
Treasurer	Wei Jiang
Country Vice-President	Chaoying Liu, Yan Qin, Weizhong Shi, Weizhong Huang, Fang Ma

3. Main activities during the past 12 months

IRSE China Section AGM

The IRSE China Section 2020 Annual General Meeting (AGM) was held in January 2020 in Beijing with the kind support of Beijing Jiaotong University. The president of IRSE China Section, Professor Tao Tang, gave a warm welcome to all attending IRSE members and presented an annual report to all members in terms of the main activities during the past 12 months and the plans for 2020. Followed by the secretary, Prof Yinghong Wen who gave a short report in terms of the important notice of membership affairs, including membership subscription payment, website updating, social media communication methods, etc. Member delegates also expressed the opinions and suggestions of the expected development of IRSE China Section. The new IRSE China Section committee was elected at the AGM.

The elected IRSE China section committee is,

- Committee Chair: Tao Tang (Beijing Jiaotong University)
- Committee Vice-Chairs:
  - Chaoying Liu (China Railway Corporation)
  - Yan qin (China Railway Corporation)
  - Weizhong Shi (China Academy of Railway Sciences)
  - Weizhong Huang (China Railway Signal & Communication Corporation Limited)
  - Fang Ma (China Academy of Railway Sciences)
- Secretary General: Yinghong Wen (Beijing Jiaotong University)
- Executive Committee Members:
  - Yu Cao (China Railway Corporation)
  - Zhisong Mo (China Railway Corporation)
  - Yong Cui (China Railway Test & Certification Center Limited)
  - Zhijie Yang (China Academy of Railway Sciences)
  - Baigen Cai (Beijing Jiaotong University)
  - Chunhai Gao (Beijing Traffic Control Technology Co. Ltd)
  - Chunming He (Beijing HollySys Automation Technologies Ltd)
  - Wei Li (Beijing Jiaoda Signal Technology Co. Ltd)
  - Jiangtao Wang (Beijing MTR Company)
  - Jianhua Jiang (CASCO Signal Ltd)
  - Wenhong Liu (Beijing Jiaxun Feihong Electrical Co. Ltd)
  - Lei Chen (Anhui-Birmingham International Research Institute in Rail Transportation)
  - Xiaohong Yu (Beijing MTR Company)
  - Min Zhang (Beijing Jiaoda Signal Technology Co. Ltd)
  - Yang Zhao (China Academy of Railway Sciences)
- Treasurer: Wei Jiang (Beijing Jiaotong University)

IRSE Membership Application

In 2020, IRSE China Section considered and approved 17 membership applications and submitted these to the IRSE Council.

The IRSE China Section also updated the application form and the membership routes flowchart in Chinese and submitted to IRSE committee. The translated version has also been uploaded to IRSE China Section website to help member applicants fill in the English/Chinese application form.

Online technical seminar

The IRSE China Section and Beijing Jiaotong University hosted the technical workshop on "Advanced Transportation – Telecommunication and Signalling Control". Prof Dongqin Feng from Zhejiang University, Prof Huayan Pu from Shanghai University, Bo Ai from Beijing Jiaotong University, and Fuchun Sun from Qinghua University made the technical report. More than 50 delegates attended the workshop, and each presentations was followed by a lively Q&A session.

4. Plans for the next 12 months

Annual General Meeting 2021

In 2021, IRSE China Section plans to conduct the Annual General Meeting according to the bye-law. The Annual General Meeting will be held in OCT, chaired by the President Tao Tang.

The Annual Dinner will be held at Beijing, on October 2021, followed by the Annual General meeting. The IRSE China Section would invite president Tao Tang to give an annual report of IRSE China Section to all members.

Executive Committee meeting 2021

The Executive Committee meeting is planned to be chaired by the president Tao Tang in June, held in Beijing Jiaotong University. The meeting aims to discuss the membership application to IRSE China Section, and recommend the outstanding member to the IRSE council.

The second Executive Committee Meeting is planned to be chaired by the President Tao Tang, held in Beijing Jiaotong University. This meeting is scheduled three weeks prior to the AGM,and aims to support the preparation of the AGM 2021.

Training and courses

The IRSE China Section will conduct a series of domestic and international trainings and courses in 2021 to assist members to develop their professional skills.

The courses will include but not limited to:

Signalling Principles

The course provides a thorough understanding of signalling principles and systems to ensure that you can apply this knowledge in a safe and cost efficient manner. Students will be able to understand and address the issues that may arise from combining multiple and diverse units of equipment.

Signalling Systems, Management and Engineering

The course assists students with further development of engineering skills in railway signalling, control and communication systems including integration of many subsystems and diverse equipment in a professional manner. Students are introduced to Systems Engineering and learn how to transform an operational need into a set of requirements to system performance, produce the most suitable configuration and recommend system design, select the equipment, implement and then validate the system.

French Section

Report produced by: Cédric Blin and Thibaut de Piedoue
Date: February 2022

1. Introduction

The local section, keeping the management as simple as possible, has taken the decision that no Annual General meeting is to be organised as such. Regarding financial matters, IRSE French Section has decided to organise free events (around four per year among which conferences and technical visits) each individually sponsored by companies who have members.

Given the covid period, the technical conferences are organised remotely as video conferences and gather around 100 participants each time.

Presentations and/or an article cover all events, which are systematically published on the IRSE webpage.

The IRSE French section is willing to write articles linked to the technical conferences that could be issued in the IRSE News, but none of our requests have been successful over a year.

The French section has been increasing its number of members from 45 (minimum for the creation of the section) to 71 members of the IRSE today. We also attracted the interest of 300 other professionals, potentially future members of the IRSE.

Minutes of all meetings are written and available in native language.

Date of last Annual General Meeting	N/A
Were annual accounts presented at the AGM?	N/A
Were officers elected/re-elected at the AGM?	N/A
Have minutes of the last AGM been produced?	N/A
How many IRSE members are in the section?	71
Is your page on the website up to date?	Yes

2. Section officers (at time of writing report)

Chair	Christian Sevestre
Secretary	Thibaut de Piedoue and Cédric Blin
Treasurer	N/A
Country Vice-President	Jacques Poré
Communications/website	Cédric Blin

3. Main activities during the past 12 months

Meetings

The French section has held five regular committee meetings within 2021.

The committee meetings are well attended with physical or online presence of our eight committee members, namely Christian Sevestre (Consultant ex SNCF), Jacque Poré (Alstom), Cédric Blin (Hitachi), Thibault De Piedoue (Alstom), Hugh Rochford (SNCF Réseau), Philippe Lebouar (SNCF Réseau), Gilbert Moens (ex SNCF), Gilles Pascault (Hitachi), Pierre Damien Jourdain (Alstom) and François Xavier Picard (SNCF Réseau).

The agenda consists of decisions to be taken regarding the section's development (visiting major railway companies for IRSE promotion) and preparation of events (contacts and coordination of the event).

Events

The events attracted around 100 individuals at each conference, among them members and non-members.

Technical conferences

Because of Covid19, major disruption in the conference planning occurred, the conferences were pushed to better days which did not come and ended up being presented in a webinar format.

The events focused on national and international signalling presentations such as:

- 25 March 2021, High Speed Line in Morocco : The first High Speed line on the African continent!
- 16 November 2021, Sharing about a new type of market for innovative signalling systems : ARGOS

The interest and satisfaction of attendees is good and increasing in the number of attendees, experience shows that the answer rate is still high and that replies are sent shortly after reception of the invitation.

4. Plans for the next 12 months

Plans for the future are uncertain due to the pandemic, especially for technical visits, however the IRSE French Section will organise new events towards the beginning of year 2022:

- The Autonomous Train under lateral signalling.
- Cybersecurity for railways.
- Laboratories validating the interoperability.
- The use of telecoms for railways.

Feedback of our events is always analysed during the meetings, and we already see the fruit of our efforts to promote contacts and discussion across the French sector.

Hong Kong Section

Report produced by: Anthea Ngai
Date: February 2022

1. Introduction

Despite the coronavirus pandemic causing lots of disruptions to local events, the Hong Kong Section reacted actively. With the use of technology, our Chairman, John William Manho led committee members to strengthen the established Hong Kong section and cope with the "new normal". The Hong Kong Section continues to organise technical forums, technical visits, study groups, etc., both in traditional face-to-face format and online. The Hong Kong Section continues to support and develop young engineers to become signalling (or rail systems) professionals in the railway industry.

Date of last Annual General Meeting	17 November 2020
Were annual accounts presented at the AGM?	Yes The account was in a good financial position with the income of the CPD course.
Were officers elected/re-elected at the AGM?	Yes There are 21 official committee members elected.
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	188 (2020)
Is your page on the website up to date?	Yes Brand new IRSE(HK) website (**irse.org.hk**) was launched on 10 November 2020 that provides more user-friendly online services to support the dynamic environment under Covid.

2. Section officers (at time of writing report)

Chair	John William Manho
Secretary	Yuen Fat Sung
Treasurer	Timothy Tai
Country Vice-President	Kam Ming Luk (Country Vice President) Gordon Lam (Vice Chair) Henry Cheung (Vice Chair) Timothy Tai (Vice Chair)
Communications/website	Kim Chung Lam (Webmaster)

3. Main activities during the past 12 months

Annual General Meeting

The 25th Annual General Meeting was successfully held on 17 November 2020 in the auditorium at MTR Headquarters. The event was chaired by KW Pang (immediate past Chair 2018-2020) and it attracted 23 members. Mr Pang presented the detailed bi-annual report, highlighting the impacts of government Covid 19 restrictions, institutional matters and a detailed report of continuing professional and exchange activities. The new committee was declared, and John William Manho was elected as the new Chair. Mr Manho acknowledged the contribution made by the committee over the last two years and delivered his plan for 2020-2022. He emphasised "technology" as a new dimension in IRSE(HK) objectives and encouraged all members to explore the technological opportunities and issues in operating IRSE(HK).

Committee meetings

Hong Kong is one of the fastest moving and dynamic cities, and quickly adopted the technology to conduct committee meeting over teams when restrictions were in place over the last 12 months.

- 16 June 2020 (Face-to-face).
- 10 Dec 2020 (Teams call).
- 9 March 2021 (Teams call).
- 13 March 2021 (Face-to-face for IRSE document review workshop).

Continuing Professional Development programme

The Hong Kong Section has been working closely with Beijing Jiaotong University in China over the last ten years to deliver a three-year distance learning BEng Program in Traffic and Transport (BJTU-TT). Over 400 people graduated from this programme. In February 2020, online video conferencing class replaced face-to-face lectures due to the restrictions of social distancing. The feedback was generally satisfactory.

Other than the degree program, IRSE(HK) also offered a professional short course in Railway Basic Signalling and an Intermediate Signalling course with the MTR Academy. Again, with the efforts of the committee members, and after multiple rescheduling, IRSE(HK) was able to deliver one face-to-face Intermediate Railway Signalling course in August 2020 with 15 enrolments. The students rated the course highly at 9 out 10 and said that they would highly recommend it. Yet, the compressed revised schedule to catch-up following the cancellation due to restrictions was not welcomed. The course was considered too intensive and compressed, not allowing students the opportunities to fully comprehend the topics. The IRSE(HK) panel valued the feedback and will carefully plan future courses.

Online event

Though Covid continues to impact the activities delivered by the IRSE(HK), a lot of the activities planned were rescheduled or cancelled. The Hong Kong Section has successfully run a webcast technical forum – AFC Cardless Solution on 30 March 2021 – to overcome the restrictions imposed by Covid. The response from local members was very positive and even members working overseas now could benefit and attend the forum without geographical constraints. Members regarded this to be a very convenient and effective channel. Our committee members are considering arranging more webcast technical forums in the future to provide diversity of the event.

Review of IRSE(HK) official documents

As the IRSE(HK) is a professional institution registered in Hong Kong, the new committee members conducted a new phase of review and update of the internal documents to ensure the governance framework is consistent and compliance with statutory regulations.

Newsletter and Website

A brand new IRSE(HK) website was launched on 10 November 2020 to provide more user-friendly online services to support the dynamic environment under Covid. A quarterly newsletter was issued to members, and all these are now available on the website.

4. Plans for the next twelve months

IRSE(HK) aims to deliver courses, technical forums and visits as far as possible given the restrictions associated with the Covid pandemic. We will continue to provide professional development opportunities to our members and support younger people in the industry.

Our plans include:

- Developing IRSE exam study group supporting plan.
- Developing award scheme for the IRSE exam.
- Continuing to deliver the three-year distance learning BEng Program in Traffic and Transport (BJTU-TT) with Beijing Jiaotong University in China.
- Continuing to deliver Basic Signalling Course and Intermediate Signalling Course jointly with the MTR Academy.
- Collaborating with MTR to provide staff development and training, for signal maintenance staff, in particular reviewing competency and training approach to provide customised support.
- Cooperating with Asia Pacific Rail 2021 to deliver presentation and participates in panel section to gain mutual promotion (15-16 September 2021).

Technical forums (face-to-face or webcast) planned

- Light railway S&C systems on 17 May 2021.
- Commissioning the longest metro line in Hong Kong – Tuen Ma Line (TML) – January 2022.
- EAL MFO 2022, Tuen Ma Line – September 2021.
- Signalling changes on the Disneyland Resort Line – November 2021.
- Experience sharing for gaining professional registration through IRSE – November 2021.
- Airport APM Upgrade – 2022.

Technical visits (when restrictions allow)

- MTR-Light Rail and Express Rail Line in Tuen Mun Depot – October 2021.
- High Speed Rail OCC and depot in Shek Kong – 2022.
- Macau Light Rail and Guangzhou hump yard – on hold due to cross boundary restrictions.

Other activities to be delivered

- Organising 26th Anniversary Dinner in Nov 2021.
- Organising Christmas gathering and spring dinner for members.
- Arranging IRSE-HK 2021 souvenir.
- Providing online services platform for members services and newsletter.
- Attending IRSE Convention 2022 – Glasgow in Autumn 2022.

Indian Section

Report produced by: Anshul Gupta
Date: June 2021

1. Introduction

The Indian Section has planned a number of activities but due to the continued Covid scenario, no technical visit could be undertaken.

Date of last Annual General Meeting	28 July 2020
Were annual accounts presented at the AGM?	Yes (Income Tax returns as per IT act of India also filed).
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	412
Is your page on the website up to date?	Yes

2. Section officers (at time of writing report)

Chair	A K Misra
Secretary	Anshul Gupta
Treasurer	Anshul Gupta
Country Vice-President	Arun Saksena
Communications/website	Ajay Singh

3. Main activities during the past 12 months

The following webinars were held in association with IRISET, Indian Railways:

- 16 June 2020 – University of Birmingham digital twin based simulation model for capacity assessment on a section of Indian Railways.
- 28 July 2020 – TMS/ CTC for Indian Railways.
- 14 August 2020 – Train Collision Avoidance System (TCAS) developed by Indian Railways.
- 2 September 2020 – Surge protection and earthing – railway signalling installation.
- 28 September 2020 – TCAS – planning & execution.

Each of these were attended by about more than 200 participants, which included members of the IRSE as well as Signal Engineers from Indian Railways.

4. Plans for the next 12 months

Due to the Covid situation we shall be continuing with our online/webinars and workshops.

- 22 May 2021 – IOT based, Artificial Intelligence based predictive maintenance system for signalling assets.
- 3 June 2021 – 3 GPP based LTE system for TCAS in place of GSM-R.
- 2 July 2021 – Designing a fifth-generation mission critical mobile train radio communication system for Indian Railways.
- 6 August 2021 – Automatic Block Signalling – designing without line side signals for capacity enhancement.
- 20 September 2021 – Signalling and communication systems inside long tunnels on Indian Railways.
- 10 October 2021 – Signalling systems for Light/Neo metro.
- 12 November 2021 – OFC acoustic sensing based intrusion detection and warning system.
- 23 to 25 February 2022 – Hosting IRSE's convention in India.

Indonesian Section

Report produced by: Toni Surakusumah
Date: June 2021

1. Introduction

Date of last Annual General Meeting	2015
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	84
Is your page on the website up to date?	No

2. Section officers (at time of writing report)

Chair — Adi Sufiadi Yusuf
Secretary — Toni Surakusumah
Treasurer — Yunanda Raharjanto

3. Main activities during the past 12 months

- Monthly online coordination of IRSE membership in LEN Group (to renew and activate membership).
- Every two months: Online coordination of the IRSE Indonesia Section, to discuss activities in light of the Covid situation.

4. Plans for the next 12 months

- 24 July 2021. Online seminar (IRSE membership and sharing experience).
- End September 2021. General meeting of the committee and election. We will reactivate the IRSE Indonesia Section, hold a new committee election and open new membership.
- August/October 2021. IRSE campaign and open recruitment for university students. We plan to give lectures at Stadium General Programme in several universities (ITB, Tel-U, Itera, API Madiun, UP).
- November 2021. IRSE Mentoring. On the topic of latest signalling issues around the world.

Irish Section

Report produced by: Mark Neilan
Date: January 2021

1. Introduction

Date of last Annual General Meeting	6 February 2020
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	108
Is your page on the website up to date?	No

2. Section officers (at time of writing report)

Chair	Peter Cuffe
Secretary	Mark Neilan
Treasurer	Huw Bates
Country Vice-President	Colin McVea

3. Main activities during the past 12 months

Nothing to report due to Covid pandemic.

4. Plans for the next 12 months

AGM planned for 4 February 2021.

Nothing planned face-to-face due to Covid pandemic.

Online seminars are being discussed at present.

Japanese Section

Report produced by: Yuji Hirao
Date: November 2020

1. Introduction

Date of last Annual General Meeting	26 November 2020
Were annual accounts presented at the AGM?	No
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	77
Is your page on the website up to date?	No

2. Section officers (at time of writing report)

Chair	Prof Yuji Hirao
Vice Chair	Dr Masayuki Matsumoto
Secretary	Dr Takashi Kawano
Treasurer	Hideki Komukai

3. Main activities during the past 12 months

3.1 8th Study Meeting, 16 January 2020

Attended by IRSE President and 51 members.

The 8th Study Meeting was held with the honour of the attendance of IRSE President, George Clark, at JR East Headquarters. Three subjects were discussed as follows:

1. The presentation entitled "Delivering change" was given by the President, which focused on revolutions of railway signalling and their key factors for success to realise good public transportation systems. Japanese members were really interested in the situation in the UK.
2. The presentation entitled "Toward future digital signalling systems" was given by Mr Tosihaki Sasaki as the first of lectures by well-experienced engineers, which was decided at the second Annual General Meeting in 2019, aiming at technology experience transfer to the next generation/younger engineers. The presentation started with his experience on single rail track circuits and an electronic token block, and extended into his expectations of train detection by fibre-optic cables, a new mechanism of point machines and AI application to railway signalling.
3. The presentation entitled by "My job activities" was given by Mr Hideki Komukai as the first of presentations by younger engineers, which was also decided at the second Annual General Meeting, aiming at sharing experience and mutual understanding among them. His presentation focused on foreign affairs including standardisation of railway signalling systems and human resource development.

Following the Study Meeting, a networking meeting was held and 43 members attended.

Japanese Local Section members with IRSE President.

3.2 Study group leaders' meetings, 27 February, 12 June

Proactive involvement of each member was thought to be crucial for Japanese section. In July 2018, the section decided to set up five study groups which discussed the following fields of railway signalling: (a) management and strategy, (b) technology in general, (c) technology in details, (d) cost and (e) certification and standards. Each study group consists of younger and middle-ranking members.

As they accomplished their objectives to some extent by the end of 2019, study group leaders discussed what themes were appropriate for the next stage of study groups. As new themes, the leaders proposed four subjects (management, new technologies to railway signalling, safety assessment, cost), which were obtained through PEST analysis. These results were reported to the Committee.

3.3 9th Study meeting, 22 May 2020, 10 July 2020, postponed owing to Covid

We tried to hold the 9th Study meeting twice, i.e. on 22 May and 10 July. However, it was not possible owing to the Covid epidemic, and we decided to postpone it until November, at which point the Annual General Meeting would take place.

3.4 Third Committee meeting, 25 August 2020

Attended by 12 Committee members.

The third Committee meeting was held at JR East Headquarters.

The draft of the Committee meeting agenda and its documents were prepared, and the Committee discussed what should be reported and proposed at the Annual General Meeting to be held in November.

3.5 Third Annual General Meeting, 26 November 2020

Attended by 47 members (including 29 via web) and 12 proxies).

The third Annual General Meeting was held at Head Office of the Kyosan Electric Manufacturing Co.,Ltd. The following matters were reported/proposed, and all were approved.

1. Report on local section activities after the Annual General Meeting on 14 November, 2019.
   - Minutes of the last Annual General Meeting (14 November 2019).
   - Report on local section activities after the Annual General Meeting.
   - Report on Committee activities.

2. Approval of action plans for 2020-2021 (Proposal by Committee).

- Proposal of action plans for 2020-2021.

  - Study groups of younger engineers.

    New themes (management, new technologies to railway signalling, safety assessment, cost).

    Publication of study group activities .

  - Study Meeting.

    Presentations of key technologies for railway signalling by experts.

    Presentations of activity results of study groups.

    Lectures by well-experienced engineers.

    Presentations by younger engineers.

  - Introduction of Webinar to local section activities.

3. Approval of Committee Members (Proposal by Committee).

- Proposal of Committee members for 2020-2021.

  Chair, Vice-chair, Secretary, Treasurer, 10 Committee members (an increase from 9).

3.6 9th Study meeting, 26 November 2020

Attended by 56 members (including 35 via web).

Following the third Annual General Meeting, the 9th Study Meeting was held. Three subjects were discussed as follows:

1. As a lecture by well-experienced engineers, the presentation entitled by "From fault tolerance to dependability" was given by Dr Katsuji Akita, which focused on application of computers to railway signalling and its key technologies. The presentation started with his experience on developments of the traffic control system for Shinkansen and electronic interlocking systems, discussed safety technologies, and extended into dependability which covers GoA3 and Mobility as a Service.
2. Mr Satoshi Nishida and Dr Tossaporn Srisooksai made a presentation of "Development CBTC". In their presentation, safety data transmission by radio was explained on the basis of their experience in developing CBTC, including hindsight.
3. Treasurer of the local section, Mr Hideki Komukai explained the details of new themes of the study groups which were approved at the Annual General Meeting, and invited applications for members of study groups (management, new technologies to railway signalling, safety assessment, cost). Applications are requested to be addressed to Mr Komukai by 15 January 2021.

4. Plans for the next 12 months

Three or four Study Meetings are to be held.

Malaysia Section

Report produced by: Sri Viknesh
Date: January 2021

1. Introduction

Date of last Annual General Meeting	17 June 2019 (2020 AGM not conducted)
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	91
Is your page on the website up to date?	Yes

2. Section officers (at time of writing report)

Chair	Shahrizaman Zamhury
Secretary	Sri Viknesh
Treasurer	Hazwan Rahman
Country Vice-President	Aniket Mukhopadhyay

3. Main activities during the past 12 months

- 20 January 2020, Committee progress meeting and event planning. 6 members participated
- 19 November 2020, Evening Talk, online, 105 participants. Speakers on:
  - Main Line FAO
  - Railway operation and TCS

4. Plans for the next 12 months

- February 2021, Evening Talk – Sharing session. Online.
- March 2021. Partnering with C3 Rail : Command, Control & Communications (Asia Pacific) seminar. Online
- May 2021, Evening Talk – Sharing session. Online
- August 2021, Evening Talk – Sharing session. Online
- November 2021, Evening Talk – Sharing session. Online

Netherlands Section

Report produced by: Ben van Schijndel
Date: January 2021

1. Introduction

The year 2020 started very ambitiously for the Dutch section. We had gatherings planned, project visits organised and also some socials were foreseen. In March 2020 everything changed, as for many sections. We had to reorganise our planned meetings and find (new) ways of keeping in touch with our members.

This was not an easy period, as the essence of IRSE is the exchange of knowledge via meeting other members. We decided to postpone our AGM, which was planned in May 2020 first to September 2020, still hoping that after the summer we could do a live event. When it was clear, during the summer holidays that this was not feasible, we decided to organise a Microsoft Teams meeting in October 2020.

In the meantime, we gave ourselves the target to organise every month a webinar with a technical subject, followed by an enquiry in order to keep track of the perception and appreciation of our members. The response was incredibly positive. Everybody understood that we were doing the maximum we could do and this was very much appreciated. This can also be seen in the attendance rates.

For this year 2021, we will keep on organising these monthly webinars, but as soon as we have the opportunity to get together in a safe and controlled way, we will organise a big barbeque with all our members and we will again enjoy the essence of our IRSE membership: "bringing people and knowledge together"

Date of last Annual General Meeting	Originally 14 May, postponed to 8 October 2020.
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	212
Is your page on the website up to date?	No

2. Section officers (at time of writing report)

Chair	Alwin van Meeteren
Vice Chair	Wendi Brandt-Mennen
Secretary	Ben van Schijndel
Treasurer	Wilbert Eijsink
Country Vice-President	Wim Coenraad/Paul van de Ven

3. Main activities during the past 12 months

- 7 January 2020. Presidential visit to the Netherlands, including presentation on Obsolescence. 50 attendees.
- 8 January 2020. Visit of the IRSE CEO including visit to ProRail/ERTMS programme management.
- 12 March 2020. Visit to EMC chamber lab and Rail@Dekra, Arnhem. 35 members (cancelled).
- 6 October 2020. Webinar on Crossrail, 70 attendees.
- 8 October 2020. Webinar Annual General Meeting. 32 attendees.
- 3 November 2020. Webinar on overlap lengths (Doorschietlengte). 66 attendees.
- 1 December 2020: Webinar on cyber security. 69 attendees.

4. Plans for the next 12 months

2021 started with a new year's KaHooT! Quiz on 12 January. Members were invited to join the highly competitive quiz after a short introduction about the planned activities in 2021.

These activities are listed below. Of course this planning is made under the condition that we can have physical meetings again around April, but this is not the most likely scenario. In order to anticipate this, we are continuing with the technical webinars, which are so much appreciated by our members.

- 2 February 2021, Webinar on EULYNX.
- 2 March 2021. Webinar on OCORA.
- April 2021. Visit, ATO/ERTMS L3 Wuppertal Germany.
- 13 May 2021. AGM.
- September 2021. Visit to LWR Rotterdam Harbour.
- October 2021. Visit to Infrabel including presentations. Antwerp Central Station.
- November 2021. Lecture on GSM-R/GPRS/FRMCS. Nyenrode University.
- December 2021. Close out IRSE Netherlands Section year event.
- Special. Diversity/inclusion event.

North American Section

Report produced by: Rob Burkhardt
Date: February 2022

1. Introduction

Date of last Annual General Meeting	17 December 2020
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	110
Is your page on the website up to date?	Yes (January 13 2021)

2. Section officers (at time of writing report)

Chair	Rob Burkhardt
Secretary	Ray Rizman
Country Vice-President	Dave Thurston

3. Main activities during the past 12 months

The past 12 months have not seen much activity due to the effects of the worldwide pandemic. The AGM planned for the 2020 Railway Interchange Convention was cancelled. Travel restrictions prevented any in-person gatherings.

A virtual AGM was held on 17 December. The meeting was well attended, but only the business of the section was handled.

4. Plans for the next 12 months

The AGM is tentatively scheduled to be held during the 2021 Railway Interchange to be held 26-29 September in Indianapolis, Indiana. A technical visit is planned to be held following the AGM.

The 2021 IRSE Convention is tentatively planned for November in Toronto.

A Presidential Programme Technical Paper is scheduled for December. Both the location of the paper and its subject are to be determined.

Singapore Section

Report produced by:	Lim Chee Siong
Date:	November 2020

1. Introduction

Date of last Annual General Meeting	5 November 2019
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	59

2. Section officers (at time of writing report)

Chair	Robert Cooke
Secretary	Lim Chee Siong
Treasurer	Ian Tomlins
Country Vice-President	Mark Appleyard
Communications/website	Lim Chiau Koon

3. Main activities during the past 12 months

In year the 2020, the following presentation was facilitated by the IRSE Singapore Section:

- 11 February 2020. Software system testing. Lam Lai Yin.

Our presentations are open to both IRSE Members and non-Members.

In March 2020, we held a lunch for our retiring secretary, Martin Philip White, with members of the IRSE Singapore Section Committee.

4. Plans for the next 12 months

Following the government guidelines to avoid the resurgence of Covid cases, events and activities involving large numbers of people continue to be restricted and will take more time to resume. The international travel restrictions have also impacted the number of IRSE presentations as we are highly dependent on speakers who are visiting Asia or transiting in Singapore.

We plan to continue to hold IRSE presentations at approximately quarterly intervals over the next year once the local situation permits.

Southern Africa Section

Report produced by: Ryan Gould
Date: November 2020

1. Introduction

Date of last Annual General Meeting	10 October 2019 (the most recent AGM relative to the reporting period of September 2019 to August 2020)
Were annual accounts presented at the AGM?	Yes The accounts as presented were approved.
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	57

As would be expected for the IRSE Head Office as well as all the local sections of the IRSE, this past year has been truly different. Not so much in terms of the established processes and procedures, but rather in terms of the processes and procedures specific to the day to day running, format of events, activities and operation of both the Head Office and the local sections. Most of this is as a result of the sudden occurrence of the Covid epidemic.

The signalling industry in the Southern Africa Region remains depressed, with a further decline in specifically the amount of new works planning and implementation.

The activities within the South Africa signalling industry during this period has focused on the following:

- The ongoing re-signalling project in the Gauteng, Durban and Cape Town metropolitan areas. This remains the most significant project in progress. Meaningful further progress has been achieved during the past 12 months, but with the extent of the progress varying from region to region.
- The planning and implementation of signalling changes to various selected freight rail corridors, to either increase or in some cases decrease (typically associated with theft and/or vandalism) the infrastructure and capacity of the general freight network.
- Efforts to combat the occurrence and impact of what appears to be a more rapidly growing trend in theft and vandalism, especially in certain areas of the metropolitan infrastructure. The levels of theft and vandalism has further increased in the past 15 months and is having a significantly greater negative impact on the commuter and freight rail service quality and projects, with the commuter rail sector being more affected.
- Essential train control system developments, enhancements, maintenance and repair to ensure, as far as possible, continued train operations on existing commuter and freight rail networks.

As reported last year, the IRSE Local Section was granted Voluntary Association Recognition by the Engineering Council of South Africa (ECSA) in August 2018. Significant progress has been made in the past 15 months regarding the processes and procedures required for IRSE Local Section members to claim continuous professional development (CDP) points from ECSA for attending the Local Section Technical Meetings and any other qualifying events. These CPD points form part of the requirements for re-registering every five years with ECSA as a Professional Engineer. Some of the IRSE members have already been successful in logging these events with ECSA.

Financial support from the local industry players for the IRSE Local Section remains a mixed bag, with good support from some industry players and limited to no support from others. Despite this, the SA IRSE Section has improved on its financial reserve during this period.

Unfortunately, some difficulties were experienced regarding the regular inclusion of the IRSE colleagues from Botswana in the South African events. Efforts to resolve these problems were unsuccessful. The need for us to change to virtual technical meetings, as dictated by the Covid epidemic, now creates the opportunity for the Botswana members to dial into the Local Section meetings. Initiatives to achieve this are currently under way.

2. Section officers (at time of writing report)

Chair	Nikesh Hargoon
Secretary	Ryan Gould
Treasurer	Johan van de Pol
Country Vice-President	Louis Beukes
Communications/website	Selection still to be finalised – shared role currently.

3. Main activities during the past 12 months

On 19 September 2019, at the 8th Technical Meeting of 2019, Nkululeko Gobhozi from Transnet delivered a presentation titled “Artificial Intelligence and Machine Learning in context for Railway Engineers”. He postulated that the Fourth Industrial Revolution (4IR) is characterised by an emergence of various technologies that have become accessible to industry. The actual value however that can be realised in the short term is dependent on the maturity of the environment within which it is explored. His paper sought to demystify one of the technology areas that are in the forefront of the 4IR, namely Artificial Intelligence, and more particular, Machine Learning for advanced analytics.

On 22 October 2019, at the IRSE 2019 Annual General Meeting (AGM)and 9th IRSE 2019 Technical Meeting, the AGM focused on the report of the Chairperson and the report of the Treasurer for the 2018-2019 session, the election of members to the General Committee for the 2019-2020 session and any other matters relating to the IRSE AGM.

The Technical Presentation title “Electronic Interlocking Development and Application – the Actom Approach” was delivered by Leon Pienaar from Actom. The presentation focused on a comparison between existing versions of relay interlocking and electronic interlocking as well as the advantages and disadvantages of each type. He also addressed the reasons why IVPI was chosen by Actom as the basis for the interlocking development, the different configurations that can be used with the IVPI, the improvements and additions developed locally to enhance the IVPI application and the performance of the system over the last four years.

On 26 October 2019, relating to the presentation of 22 October 2019, the IRSE Local section arranged a Technical Visits to the Actom IVPI installation that they had installed approximately four years back. The focus was on viewing and learning more about the electronic interlocking, the diagnostics and the interfaces to the adjacent stations.

On 14 November 2019, at the 10th Technical Meeting of 2019, a Technical Presentation was delivered by Kameshini Pathar (Kamy) of Transnet. The presentation related to a subject pertaining to signalling/train control systems within Transnet. A constraint was placed on further distribution of the detail.

On 20 February 2020, at the 1st Technical Meeting for 2020, the presentation took the form of a brief feedback for each of the two technical visits that took place towards the end of 2019 (one in Johannesburg and one in Cape Town), followed by a discussion. The intention was to expose a wider group of the membership to the feedback and discussion re the two 2019 Technical Visits (as referred to above and the other in Cape Town (not reported on)). It was hoped that doing this would whet the appetite of more members and guests for future technical visits.

For March, April, May 2020, in the advent of Covid 19, it was initially decided to suspend both the committee and technical meetings. We then discovered the world of virtual meetings.

On 18 June 2020, the IRSE local section held its 1st virtual meeting and 2nd Technical Meeting in 2020. The topic was presented jointly by Berend Ostendorf and Johan Todkill and was titled "Testing of Electronic Interlocking". The testing of an electronic interlocking is significantly different to that of an electro-mechanical interlocking, although they both largely perform the same function. It also requires different test methods. The presentation outlined the methodology used to test electronic interlockings. It addressed two examples of electronic interlocking used for the new PRASA systems in Gauteng and Western Cape respectively.

On 16 July 2020, the 2nd virtual and 3rd Technical Meeting was held. The topic pertained to the PRASA ETCS Pilot installation and was presented by Athanacious Makgamatha from PRASA. PRASA has embarked on a modernisation programme comprising a re-signalling system, train communications systems and new rolling to improve asset life cycle, safety and capacity for commuter rail services. The Pilot is setup to test and commission all systems and subsystems within Signalling, Rail Bound Telecommunications and Trains. The Pilot involves validation of trackside equipment and on-board in-cab signalling based on the European Railway Train Management System (ERTMS)/ETCS System. The technical presentation was followed by a discussion session.

On 20 August 2020, the 3rd virtual and 4th Technical Meeting, the current IRSE President, Daniel Woodland delivered to us his Inaugural Presidential Address, updated slightly based on how things had emerged subsequently. We in South Africa again express our thanks to Daniel for a very interesting and relevant presentation. We did not foresee such a successful event happening at the start of the Covid 19 challenges.

4. Plans for the next 12 months

The current focus areas for the Southern Africa Section for the balance of 2020 and for 2021 are captured below. These will however be reviewed and refined at and after the AGM in October or November 2020 and when the newly elected committee for 2020-21 is in place. Accordingly, these focus areas/plans may change later.

- To inform of and promote to the South Africa IRSE members the processes required to fully and successfully implement and benefit from achieving ECSA recognition as a Voluntary Association.
- To promote this as a tool to persuade non IRSE members in the industry to become members and thereby be able claim ECSA CPD points for IRSE events attended.
- Strive to further identify possible approaches and enhance ongoing efforts to encourage our guests and others in the train control systems arena to become IRSE members.
- To strive to provide the best possible programme for the 2020-21 session.
- As an ongoing effort, finding more innovative ways to approach the captains of the railway and signalling industry in South Africa to promote the IRSE and to provide a better understanding of how the IRSE can contribute to the success of the industry. Conversely, to also promote the concept that the industry can in turn support and assist the IRSE. There is still meaningful room for improvement in this regard.

Swiss Section

Report produced by: Daniel Pixley
Date: January 2021

Date of last Annual General Meeting	6 March 2020
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	69
Is your page on the website up to date?	Yes

2. Section officers (at time of writing report)

Chair	Daniel Pixley
Secretary	Henrik Roslund
Treasurer	Rolf Seiffert
Country Vice-President	Rolf Seiffert
Communications/website	Beatrice Müller and Henrik Roslund

3. Main activities during the past 12 months

3.1 Events

Like everywhere worldwide, our plans for the calendar year 2020 were substantially impacted by the Corona virus. Nevertheless, we managed to hold a number of events.

Overview:

6 March 2020, Technical visit, Bär interlocking, Châtel-St-Denis FR

6 March 2020, Annual General Meeting, Bulle FR

24 June 2020, Get-together, Olten SO

6 September 2020, Technical visit, Ride on ATO test train from S. Gallen to Winterthur

30 October 2020, Paper session, The crossover between rail and autonomous road vehicles (presidential programme), video conference only

All events were well attended, generally by close to half of the section members. Reports of the events have been submitted to the IRSE News. The selection of interdisciplinary subjects demonstrates once again one important element of the strategy of the section.

For organising the events and get-togethers we have continued to utilise the online scheduling service of doodle.com, so that all participants could sign up and also see, who else was joining. Although not mandatory for most events this was well utilised. It has proven to be a very lightweight but powerful way to organise our events.

3.2 Annual General Meeting

On 6 March 2020 the 9th regular AGM was held together with a technical visit. The annual accounts 2019 and the budget 2021 were approved.

All members of the committee were re-elected. As a main topic, the AGM discussed the communication strategy for the local section.

3.3 Participation at international level

The Swiss section also remains involved at the international level:

- With Markus Montigel as the past IRSE president and Xiaolu Rao as re-elected council member the Swiss section is well represented in the governing body of IRSE.
- Two active members of the Swiss section, Beat Keller from Siemens Mobility and Jens Andreas Schulz from the Swiss Federal Railway SBB, are active members of the International Technical Committee (ITC).
- Companies being increasingly restrictive on travel and of course the limitations due to the Corona virus have been compensated by the well-received possibility to join many IRSE sessions by video link.

3.4 Committee

The committee met four times during the year and dealt with strategic subjects, the organisation of the events, membership and other matters. Due to Corona restrictions, all committee meetings except the first one were held by video conference.

This year's priority was to begin to execute on the communication strategy for the local section.

3.5 Development of membership

We were able to increase the number of members to 69 members. Five candidates are currently in the application process to become IRSE members.

There are a number of guests that have been actively participating in the section events, so we are hopeful they will join as member this year. The potential to grow to 100 members mid-term remains, given the number of guests and prospective members. The largest obstacle remains filling in the application form in English correctly and completely.

We have therefore assigned a member of the committee with the specific experience to motivate and coach prospective members individually when filling in the application form. This has proven valuable and necessary.

4. Plans for the next 12 months

For 2021 the committee has set the following priorities for the Swiss section:

- Organise the usual four yearly events:
  - Q1: paper session
  - Q2: AGM and technical visit
  - Q3: technical visit
  - Q4: technical visit

The events will be published on the irse.org web site as the dates are defined and we very much welcome international participation.

- As soon as the Corona situation allows, we will take up the get-togethers again.
- It remains our goal to grow the number of members and develop membership.
- Continue to implement the communication strategy for the local section. We plan to improve the communication between members of the Swiss section by taking advantage of state-of-the-art social media tools.

Thailand Section

Report produced by:	Vasuwee Euanchita/Wichai Siwakosit
Date:	September 2020

1. Introduction

The IRSE Thailand Section was opened at the inaugural meeting on 27 July, 2016. Currently there are 3 fellows, 9 members, 7 associate members, and 4 affiliate members in the section with 8 committee members.

Due to the global pandemic situation, the activities for 2020 had been greatly affected since March 2020 according to Thai government restrictions. Thailand has still not opened its borders and international travel restrictions are enforced. Mass gatherings and conferences are generally adapted to social distancing norm and the emergency law is still in effect. Asia Pacific Rail 2020, an international event planned in Bangkok with IRSE TS involvement was postponed twice and finally cancelled. However the annual general meeting for IRSE TS was held on 29 January 2020 just before the pandemic and it was the only event held by the section this year. An on-line technical meeting is planned in early November this year and IRSE TS will present at Rail Asia 2020 event in 27 November 2020. The section is hopeful that the situation will be improved due to the availability of mass vaccination, and next year's activities are planned accordingly.

Date of last Annual General Meeting	29 January 2020
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	No
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	23

2. Section officers (at time of writing report)

Chair	Wichai Siwakosit
Secretary	Vasuwee Euanchita
Treasurer	Vasuwee Euanchita
Country Vice-President	Paul Harland
Communications/website	Vasuwee Euanchita

3. Main activities during the past 12 months

Due to the global pandemic situation, IRSE TS achieved only an AGM held on 29 January 2020 at Bombardier Transportation Thailand head office. There were 33 participants in the event. Presentation topics were CBTC technologies applied to MRTA monorail lines in Bangkok, WiFi 6 protocol with applications to signalling and telecommunications, and roles of safety assessment in railway projects.

A photograph of the event is shown overleaf.

4. Plans for the next 12 months

The section expects that the pandemic situation in Thailand will be markedly improved without a substantial recurrent wave of infection, hence our plan is as follows.

- Second week of November 2020. Technical meeting.
- 25 November 2020. Rail Asia 2020 conference and exhibition at SRTET Makkasan station.
- First week of March 2021. Annual General Meeting.
- Third week of May 2021. Asia Rail Summit including presentation by IRSE Thailand Section.
- Third week of July 2021. Technical meeting.
- Second week of September 2021. Committee meeting.

IRSE
Institution of Railway Signal Engineers

8. Reports from Local Sections in the UK

The following reports have been received from the IRSE's UK sections to report their activities over the Presidential Year 2019-20. They have been edited for consistency and to provide a permanent record for the 2019-20 Proceedings.

The UK sections in existence in 2020-21 (in alphabetical order) were:

- London & South East Section
- Midland & North-Western Section
- Minor Railways Section (submitted in non-UK Section format)
- Plymouth Section
- Scottish Section
- Western Section
- York Section
- Younger Members' Section

London & South East Section

Report produced by: Mike Brouder
Date: September 2021

1. Introduction

Date of last Annual General Meeting	27 May 2021
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	808
Is your page on the website up to date?	Yes

2. Section officers (at time of writing report)

Chair — Trevor Foulkes
Secretary — Mike Brouder
Treasurer — Adrian Vyse

3. Main activities during the past 12 months

All meetings have been held online using GoToMeeting and have been well attended, with on average more than 100 participants. The presentations were all recorded along with live questions and stored on the IRSE section of the Vimeo web site for later viewing

Crossrail signalling

Presented by Tom Godrey of Bombardier and Rory Mitchell of Crossrail this presentation discussed the development of Crossrail and some of the challenges faced in its deployment.

Docklands Light Railway

Geoff Mitchell discussed the Docklands Light Railway and its evolution from its inception to the present day. This fully automatic passenger railway went into traffic in August 1987 and has had many extensions and upgrades since then.

Industry 4.0 – Delivering digital transformation for a transport revolution

Presented by Mike Hewitt, this talk was about new technologies and how they can be applied to railways.

Degraded Mode Working System

Chris Fulford is the technical lead overseeing the development of the Degraded Mode Working System (DMWS) (formerly known as COMPASS). Chris has been leading this development since the feasibility studies undertaken in later 2015.

Chris talked about the DMWS project, its development history thus far and the challenges posed in developing a completely new system to be used to safely and efficiently control train movements when the primary signalling has failed.

A key objective of Chris' work on DMWS was borne out of TPWS, to maintain simplicity and avoid over-specifying functionality, utilising as much of existing systems as possible.

Certification of interoperable systems

Pradip Roy from Siemens gave a presentation on the new compliance process for interoperable systems that have been carried out of TSIs in connection with obtaining NoBo/DeBo certification for Thameslink.

ETCS interlocking principles on the Paddington to Heathrow Project,

Presented by Aidan McGrady, the talk was about the ETCS interlocking principles on the Paddington to Heathrow project in West London.

London managed stations security information systems improvements,

Steve Peckham, Senior Project Engineer (Telecoms) for Network Rail delivered a presentation to the London and South East Section, outlining the development of the technology renewal of Station Information and Security Systems at London Managed Stations.

LSE 4G radio coverage in London Underground's Tunnels,

The presentation covered Transport for London's recently deployed 4G/LTE capable neutral host radio infrastructure on the Jubilee line, outlining some key facts regarding the build while presenting the architecture, challenges and performance statistics. It also discussed the current status of cellular technologies and Standards (5G-NR/4G-LTE) and the use of these for mission and safety critical services/applications such as FRMCS which will be the successor to GSM-R. Lastly, it showed how signalling renewal programmes could utilise such critical services and take advantage of a 4G/5G capable neutral host infrastructure.

Negative Short Circuit Devices,

NSCDs are equipment which are generally installed at TPHs (Track Paralleling Huts) and substations across the Southern Region. They are a switching device which is able to be controlled remotely by an operator which places a short circuit on an electrical section, increasing safety and in turn possession time availability. The amount of safety incidents Network Rail has on the DC network which are related to isolation support staff placing straps in the wrong possession and not testing the conductor rail prior to applying straps is scary.

This was presented by Neil Clegg, who has worked for Network Rail for the last 15 years, leading the safe delivery of NSCDs across Kent and Sussex Routes.

Croydon Area redevelopment

A lecture by Adrian Vyse and Tajamal Tuffail on the development of the redevelopment scheme at Croydon. Adrian covered the development of the thinking behind the Brighton Mainline Upgrade Programme (BMUP) from 2010-2015.Adrian ran through the methods used to develop options with due consideration of constraints that led to the outputs of the feasibility study stage.

Taj then talked through the key design decisions made at the option selection phase of the CARS project – in particular the signalling elements that have helped further the design maturity of the scheme to support the public consultation process. He gave an overview of how the design has evolved and also what the upcoming challenges and opportunities are for the scheme going forward.

We were additionally fortunate to be presented a virtual tour of Bombardier's new Old Oak Common Depot hosted by its Depot Manager, Mark Coleman, where a significant proportion of the Crossrail train fleet is stabled and maintained. The Depot was also the first deployment into operational service of Atkins' ElectroLogIXS interlocking.

4. Plans for the next 12 months

Below is the planned programme of events for the next year, the current plan is to hold these events virtually until suitable venues can be found to hold face to face events, COVID permitting.

- 24 June 2021, Schweizer automatic track warning system and level crossing Controller.
- 22 July 2021, Goal structured notation.
- 23 September 2021, Piccadilly line interim control upgrade.
- 28 October 2021, My career by Leslie Biggs.
- 25 November 2021, High Speed 2.
- 27 January 2022, Gatwick redevelopment and additional layout changes part of BMUP programme.
- 24 February 2022, Northern line extension.
- 24 March 2022, Crossrail 2.
- 28 April 2022, Level crossing developments (subject to confirmation).
- 26 May 2022, Annual General Meeting and East Coast Main Line ETCS.

Midland & North Western Section

Report produced by: Ian Mitchell
Date: April 2021

1. Introduction

Date of last Annual General Meeting	4 August 2020
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	780
Is your page on the website up to date?	Yes

2. Section officers (at time of writing report)

Chair — Ian Mitchell
Secretary — Bill Redfern
Treasurer — Clive Williams
Communications/website — Ian Fury

3. Main activities during the past 12 months

The M&NW Section covers a large geographical area and has traditionally organised technical meetings at different locations throughout the year. Due to the Covid restrictions, in 2020-2021 we have instead been holding all meetings online using GoToMeeting. There have been eight meetings since the previous report to Council.

- 28 May 2020. Merseyrail fleet replacement. 70 attendees.
- 4 August 2020. Human factors in signalling operations. 75 attendees.
- 13 October 2020. Obsolescence management for railway systems. 118 attendees.
- 18 November 2020. Suitable and sufficient risk assessment at level crossings. 151 attendees.
- 9 December 2020. Infrastructure data for ETCS. 141 attendees.
- 13 January 2021. Crewe, Basford Hall and independent lines re-signalling project. 136 attendees.
- 10 February 2021. Developing the timetabling system for the UK railway network. 149 attendees.
- 17 March 2021. Signal sighting using Unreal Engine. 120 attendees.

The migration to online events has had a spectacular effect on the number of participants. Whereas we typically achieve attendance of 20-40 people at our traditional meetings, we are now regularly getting 130-150 participants online, with many of the audience outside our traditional catchment area. The talks are also recorded to allow later viewing on the IRSE Vimeo channel, and a summary is reported in IRSE News.

In a normal year, we would also have organised a number of technical visits and social events, but this has not been possible in 2020-2021 due to the pandemic.

4. Plans for the next 12 months

The 2021 Annual General Meeting is planned for 21 April as an online event, linked to a talk from the project operations interface manager from Network Rail's North West Route.

A programme of talks for 2021-2022 is under development, but the timing and format (online or face to face) is subject to review depending on the level of Covid-19 restrictions going forward. Given the success of the online talks this year, we will certainly want to retain this format for a proportion of meetings, but we are also keen to give members the chance to meet one another face to face again.

We will also be running a presentations competition for developing engineers. This was launched in the March 2021 IRSE News, with entrants invited to submit a synopsis via the IRSE website. Three finalists will be selected to make a presentation at the finals event on 24 November.

Something we wish to develop going forward is to better understand who are the non-members that are joining our online talks, and to see what can be done to attract them to join the institution.

Minor Railways Section

Report produced by: Dominic Beglin

1. Introduction

Whilst 2020 has prevented the Institution's Minor Railways Section from visiting our colleagues, their signalling and telecommunications and operational railway infrastructure, the section has not been sitting still.

During August, the section had its 2020 AGM, whilst the physical ability to meet had been curtailed by the pandemic, the opportunity was undertaken to facilitate this via the medium of the internet and so the section sent out invites to interested attendees of the section to attend virtually.

The AGM went reasonably well, with some learning curves made from the perspective of digital technology and online meetings, how to access this and holding virtual Meetings with questions and answer sessions.

Following the AGM it is usually the sections time to visit an operational signalling or telecommunications installation and again the section proposed to undertake a virtual visit to the Churnet Valley Railway's project at Cheddleton, with Emma Haywood the Railway's head of signalling undertaking the first portion of the virtual visit giving a brief upon the project itself.

This was then followed up by myself giving the second portion of the virtual visit on site with a walk around of the works being undertaken.

From the reports back, this virtual visit appears to have been received well by all the online attendees.

The section has also regularly been undertaking regular updates to its Facebook pages. These cover the various members' signalling projects, other museums and railways signalling projects of which many railways signalling departments have started regular updates on their respective works for all to see, we have also managed to provide some small "how it works" videos to the pages bringing regular interest to the section.

As part of this, we will try to keep this regularly updated and certainly would like to see more Telecommunications based updates as well as signalling from the minor railways section, as well as bringing the wider world of minor railways Worldwide into the pages if possible.

Many of the section's members update these pages and the availability to all the minor railways to be part of this information exchange is desired.

Lastly I would like to thank Ian Allison our outgoing chairman for all his hard work and input over the last few years, Ian is a driving force in many fields and I hope to follow in his footsteps with as much fervour.

Plymouth Section

IRSE
PLYMOUTH SECTION

Report produced by: Dave Came
Date: November 2020

1. Introduction

This report covers the period from after the 2018-2019 Annual General Meeting until the present day. Normally this report would end with the Annual General Meeting for the period in question (2019-2020 in this case), which would have been held in May 2020. However, as a result of the Covid pandemic all section activities ceased in March 2020. As a result of this, section officers have remained unchanged from the previous year with the proposal to keep it that way until the end of the 2020-2021 period in order to maintain some continuity.

Included within this period was to have been the celebration of the 50th anniversary of the formation of the section. At the above AGM it had been agreed that the Section should celebrate this occasion, but no detail had been discussed except at a general level.

Date of last Annual General Meeting	15 May 2019
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	At the time of the meeting it was estimated that there were approximately 20 members local to Plymouth. This did not take into account many who reside in Devon and Cornwall but who rarely attend meetings.

2. Section officers (at time of writing report)

Chair — Richard Belli
Secretary — Dave Came

3. Main activities during the past 12 months

As a result of Coronavirus lockdowns none of the activities planned for 2020-2021 took place.

4. Plans for the next 12 months

There have been no meetings of any sort during the various lockdown periods, thus no plans are in place, except that the 50th anniversary celebration will go ahead when possible.

Scottish Section

Report produced by: Gerry Loughran
Date: January 2021

1. Introduction

This year's session has like all other sections within the institution, been heavily affected by the Covid pandemic. To ensure our members' safety, we were forced to cancel our Annual Dinner and postpone the various presentations we had organised from March onwards until we ascertained the level of government restrictions put in place for social events etc.

Now that the 'new normal' revolves around computer-based meetings and conferencing, we managed to reschedule some of our planned presentations which will be detailed below from September until the end of 2020. Any future technical visits or family days have been put on hold until further notice while we await nationwide progress on the Covid issues.

Date of last Annual General Meeting	29 May 2020
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	130
Is your page on the website up to date?	Yes

2. Section officers (at time of writing report)

Chair	Frazer Howie
Secretary	Gerry Loughran
Treasurer	Brian McKendrick
Communications/website	Gerry Loughran

3. Main activities during the past 12 months

January lecture: Level Crossing Developments

The first lecture of 2020 was given by Ken Vine, Technical Head of Level Crossings at Network Rail.

The presentation looked at the recently published Network Rail Level Crossing Safety Strategy 2019-2029 with the key aims to reduce safety risk to the public, passengers and the workforce, increase rail capacity and performance across the network and reduce operational and financial risk.

Ken also discussed the CP6 plan for level crossing technology research and development activities and covered other technology developments currently in progress such as revised User Working Crossing Signage and the advancements in the Mark 2 Obstacle Detection system with the first commissioning planned for mid-2021.

February lecture: Very High Throughput Satellite (VHTS) communications for Rail'

Our next lecture was given by Dr Robert Gardner and Richard Varnden of Network Rail.

Robert and Richard explained the cost of deploying infrastructure along the rail corridor to support enhanced and traditional wireless telecoms use cases (ETCS, passenger broadband etc.) is a constant challenge. The imminent arrival of Very High Throughput Satellite communications via Medium-/Low-Earth Orbit constellations is allowing us to look at some interesting alternative solutions.

Robert and Richard presented the existing satellite connectivity in use on the railways, and advancements in such technology and how it could affect the way the railway operates.

A strong local attendance from a research team from Herriot-Watt University who were involved in the development of these technologies helped a very informative Q&A session following the presentation.

October Microsoft Teams lecture: Westrace Trackside System (WTS)

Our first rescheduled lecture following the restrictions was given by Ben Pugh of Siemens Mobility.

The presentation looked at how WTS has been applied to several projects across the UK in very different environments, from Thameslink to Huddersfield to Bradford, from brand new builds to relocking the existing trackside equipment.

Ben discussed the capabilities of WTS and how it has been applied, with a detailed look at the overall system architecture and a case study overview presented from the Sutton to Wimbledon project. Comparisons to free-wired and SSI interlockings show the benefits in the WTS system with overall costs and equipment space requirements saved.

Ben then went on to discuss his viewpoint on the challenges to come as the railway deploys into new environments such as ETCS.

November Microsoft Teams lecture: Reasonable Opportunity

The last presentation of the year was given by a past Scottish Section Chair, Lynsey Hunter of Network Rail.

The topic is often open for debate; however reasonable opportunity cannot be ignored. We have a legal obligation to ensure we are not missing critical elements because of the blinkered view that 'I'm only instructed to renew the cables, not the cases'

Lynsey discussed the main drivers for reasonable opportunity becoming an integral part of the project lifecycle as we see now, with a review of the fatal accident at Moreton on Lugg level crossing in 2010 and the opportunities to improve the crossing functions and safety benefits that were missed or discounted in various years that would have prevented the accident from occurring.

Lynsey made mention to the recent updates to NR/L2/SIG/30009 Module E810 and Notice Board 123, but reiterated to the attendees the importance of the members of the single project taking cognisance of the overall railway and their impact on it as they carry out their works, and taking responsibility to ensure the safety, reliability, availability and maintainability of the railway is a priority once the works are completed.

4. Plans for the next 12 months

The Scottish section has agreed to carry on organising presentations using Microsoft Teams until further notice as per local guidelines. Until we see an improvement in Covid restrictions, all social events will remain postponed/cancelled.

Western Section

Report produced by: Sam Loveless
Date: August 2020

1. Introduction

The 2019-2020 season was a troubled one for the Western Section. Meetings were subject to frequent cancellation and/or last-minute alteration due to problems with external stakeholders. As this happened frequently, and with most committee members occupied with high workloads in their day jobs, meetings ended up being arranged on a meeting-by-meeting basis. Plans for new summer activities were abandoned due to the Covid pandemic.

Date of last Annual General Meeting	2 October 2019
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	Yes
How many IRSE members are in the section?	375

2. Section officers (at time of writing report)

Chair	Simon Cooper
Secretary	Sam Loveless
Treasurer	Andy Scarisbrick

3. Main activities during the past 12 months

October debate: Competency Management

This was the second time the section had used the debate format, following the successful debate on the Digital Railway the previous season. This session focused on the competencies used in the signalling industry.

The session began with an exploration of how competencies had originated, developed over time and what keeps them relevant. Ownership of competence management was discussed as a collaboration between companies and individuals to reflect what each party needs from the system. The comments then proceeded to reflect that individual companies drives what competencies are needed, and although the IRSE licence has an underpinning commonality it is not an equivalent system. There was also concern raised that the existing competency systems were suitable for conventional signalling systems but were not ready for ETCS-style systems.

The debate then moved onto the differences between jobs/roles and competencies and, as an extension, how Network Rail's changing processes changed the relevance of mainline competencies, especially in maintenance. Supplier companies management systems were discussed and by extension how the continual addition of new technologies placed pressure on the competency system. Concerns were also expressed at the difficulties involved in some colleagues switching between licensable and non-licensable work, and the associated degradation in competency. It was observed that the different company systems could be translated by qualified individuals without difficulty.

Technology was a key issue, with the introduction of technologies and revolution of systems creating knowledge obsolescence amongst the key items. The use of technology to keep people off track also led to discussions about rounded experiences in engineers, and whether a fragmented industry was leading to a shortage in multi-disciplinary skills sets. The evening concluded on discussions predominately centring around the licence complaints process and whether it was being used effectively.

Attendance: 16 Members, 2 Guests

November lecture: The Waterloo Incident. Richard Brown, RAIB

An inspector from the RAIB walked the section through one of its most recent reports. He focused on the lead-up to the commissioning, including the complexity of the project, an incomplete design process and a late change to the possession arrangements. The immediate cause and underlying issues as described in the report were then walked through, including an extraordinary section on comparisons with previous incidents. The evening ended with a spirited Q&A.

NB. This event was very popular: there were requests afterwards for the RAIB to conduct more presentations on major incident reports. This will be followed up for future seasons.

Attendance: 45 Members, 14 Guests

December lecture: Developing cyber resilience together. Alexander Patton, Siemens Mobility

The presentation for this session was an extended and updated version of the ASPECT 2019 paper of the same name. Throughout the evening, he described the problems with cybersecurity on an international level, and what must be done by railway suppliers to make signalling systems resilient to the modern environment. A general conclusion drawn is that whilst physical security is at a reasonable level, network security is still not very well understood, with too much emphasis on products and not enough on process. This was followed by information on what can be done to improve on this state of affairs.

An informative Q&A focused on migration strategies and the risk-reward balance in availability.

Attendance: 10 Members, 3 Guests

March lecture: The obsolescence of GSM-R and other telecoms updates. Paul Darlington, IRSE

The session served as a history of telecoms development and what might come next. The speaker covered the use of GSM-R, and its use in the context of ongoing telecoms development, and its predicted remaining lifespan. This segued into explanations of successor technologies, with a focus on 5G as the most likely long-term replacement candidate. The importance of spectrum was raised throughout the talk, as was the protracted development time of GSM-R and any replacement system. This was followed up on in the Q&A, where questions were asked concerning the use of obsolete technologies in planned projects and the risks involved in the current planned timescales the UK are working to.

Attendance: 20 Members, 2 Guests

Abandoned Activities

The February presentation was intended to be a joint session with a local branch of the IET, the arrangement for which has been in place for some years. This season, the quality of response communication from the IET was poor, culminating in the section being informed of the cancellation of the speaker at the last minute.

The annual pub quiz/social event was also abandoned due to issues with the venue.

The April session was planned as a series of short presentations conducted by younger member of the institution. This was cancelled due to the pandemic. The pandemic also resulted in the abandonment of plans for a technical visit and social event in the summer.

4. Plans for the next 12 months

The current pandemic means that, in the view of the section committee, the vast majority of meaningful events the section can put on are not viable. The current plan is to put on a couple of presentations in 2021 using the HQ GoToMeeting licence and gauge the reaction to them. It is currently too early to tell if a full programme can be planned for 2021-2022.

In the absence of activity, there is work in the background to create new ties with other local institutions, so that more joint events can be held when we are able to resume normal service.

York Section

Report produced by: Rhianon Jones
Date: May 2021

1. Introduction

Date of last Annual General Meeting	11 April 2019. (Planned AGM for 2020 could not take place due to pandemic).
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	No AGM held but officers agreed to stay in post due to pandemic.
How many IRSE members are in the section?	360

2. Section officers (at time of writing report)

Chair Rhiannon Jones
Secretary Rebecca Radnage
Treasurer Tony Kornas

3. Main activities during the past 12 months

The section delivered six technical papers, all on Zoom, from October through March, these were all really well attended both in number and diversity of location and background, highlighting the opportunities presented by a hybrid delivery approach when the pandemic was over.

No technical visits were possible due to the pandemic.

4. Plans for the next 12 months

Due to the ongoing pandemic, it is not possible to plan a robust future programme of events, although we will continue to deliver papers by Zoom until we are able to meet face-to-face again.

Younger Members Section

Report produced by: Aaran Sawyer
Date: November 2020

1. Introduction

Following the successes of 2019, including the attendance of many Younger Members (YMs) to ASPECT 2019, the YM Section experienced a significant and positive reorganisation of the committee in February 2020. The introduction of new members within the committee and the revised energy imparted by its members has enabled the expansion of the Section's activities over the past 12 months; however, it is noted that in person activities have been prohibited due to the global pandemic and government restrictions. The committee is comprised of 15 YM delivering content for the community.

Date of last Annual General Meeting	3 March 2020
Were annual accounts presented at the AGM?	Yes
Were officers elected/re-elected at the AGM?	Yes
Have minutes of the last AGM been produced?	No
How many IRSE members are in the section?	980. General members under the age of 35.

2. Section officers (at time of writing report)

Chair	Aaron Sawyer
Secretary	Robin Lee
Treasurer	John Chaddock

3. Main activities during the past 12 months

The previous Younger Members' Section Committee conducted a survey of the Younger Members, to identify what they want their committee to focus on. The results of this survey were analysed by this year's committee. Based on this feedback the YM section committee developed ideas for new events, to facilitate more participation and networking with the wider IRSE. A focus on international responses was also made, and in combination with the new requirements driven by Covid-19, study days were held online, with material then made available through the IRSE's Vimeo channel.

This year the IRSE YM committee developed a strategy which focused on five focus areas:

- Flagship competition;
- Attract and expand;
- Digital initiatives;
- Support development; and
- Sustain and improve.

Flagship competition

The Flagship competition was an initiative that has seen many of the YM committee planning a competition event targeted towards giving its committee the opportunity to compete in a signalling related design competition. The specifics of the event are still in their infancy; however, it is hoped that the event will grow into a large annual event targeted specifically at our YM community.

Out of this workstream, the committee founded another initiative. An initiative which was not appropriate for a flagship competition; however, worth developing for the benefit of the Section. This initiative is the Accident Investigation event whereby attendees are invited to a heritage railway to conduct a railway accident investigation into a mock scenario. The scope of this event has been set and the team is working to form strategic partnerships to deliver the event.

Attract and expand

Attract and expand saw the delivery of the IRSE STEM programme. This saw four members of the YM committee produce an IRSE STEM workbook titled "IRSE Super Train Challenge: A Journey Around the World" – and associated online webinar. The event followed the fictional character "Prerna the Great Inventor" and her quest to build a Super Train. The webinar was attended by 30 participants in which the YMs introduced themselves, their careers, the Super Train challenge and hosted a quiz. The event also featured within the IRSE magazine. This was a brand-new initiative created by the committee, the second event is in development.

Following feedback provided to the YM committee expressing a desire for more international input within the YM activities, the committee has a dedicated International Outreach role. The aim of which is to move away from a UK centric operation. We have been working closely with key younger members of the IRSE around the world allowing for collaboration with future event planning. In 2020 we now have representation from both the Swiss and Netherlands Sections. The advent of remote working and virtual events has allowed the IRSE to offer many events from around the world to all members regardless of geographical location. We are currently working closely with Australia as pilot region to coordinate future events and advertisement. We are also utilising the advertisement outreach of the UK section to help promote younger sections to a wider reach of members across the globe.

The committee's interaction with the other sections has further increased with active YM interface with the International Technical Community.

We are further supporting the Railway Control and Digital Systems course at Birmingham University. It is hoped that through our visibility at such events and audience targeting, we will create greater exposure and attract new volunteers and members into our community.

Digital initiatives

Due to prohibition of in-person events, all IRSE YM events occurred on a digital platform. Beyond this we also created and actively managed the IRSE YM social media platforms. This enabled increased communication channels between the committee and its members, contributing to the advertisement and positive attendance of events of interest to our members.

Support development

The section increased its presence across the Institution, including its active relationship with E&PD committee through a permanent YM/E&PD interface role. The development of this interface was considered a key priority as many of the committees' initiatives are aligned to YMs of the institution. Beyond providing updates and input within discussions, representatives from the YM Section led two collaborative projects between the committees.

Firstly, the YM Section has developed and is working to rollout a new automated mentoring scheme that connects mentors with mentees in a simple self-managed system that reduces administration overheads and ensures low maintenance. Regaining access to the mentoring IRSE email address was a positive first step.

The second activity has seen the YM Section conduct a review of the "Maintain your competency" system. This work is identifying and proposing updates to the website to improve the navigation of the site to simplify the information provided to Chartership candidates and improve the MyCareerPath system. The YM section is working to define the full scope of the improvements and produce and implementation plan.

Sustain and improve

This focus area covered activities already delivered under previous YM Sections or the wider Institution. These include ASPECT, IRSE Exam Study Days and the YM Conference.

Following ASPECT 2019 in Delft, Netherlands, and the attendance of many Younger Members from around the world, the YM Section further developed its relationship with the event providing active YM representatives at the ASPECT organisation committee. It was the roles of these individuals to speak on behalf of the YM Section and represent our community to the organising committee.

The section has always been committed to supporting the preparation for the IRSE exams; however, 2020 saw a significant increase the support provided by the YM Section. Several members of the Section played lead roles in the organisation and logistical planning of the events. Following the Exam review in March, online exam preparation events were held with the assistance of the normal tutors:

- Telecommunications day.
- Modules 2, 3, 5 & A preparation day.
- A series of three Module 2 events.
- Safety and Systems Engineering day.
- Signalling equipment (Module 5) event.

These were recorded and now form a permanent study resource, consisting of over 24 hours of content: **irse.info/vimeo**

A 'Cyber Academy' was run consisting of a small group working through the CompTIA Security+ textbook practice questions.

4. Plans for the next 12 months

The YM section committee intends to run a survey again early in the new year to attain general feedback on the activities of the committee in 2020 and what improvements could be made for 2021.

The following events are planned:

- Exam review and AGM (following exam results).
- Online YM conference, planned for 13 March 2021 (a series of YM papers).
- Further exam study events.
- STEM.
- Cyber Academy.

It is our goal to further increase international presences outside of the UK within the YM committee and to continue our close working relationship with the Australia section as a pilot region to coordinate future events and advertisement.

Planning is to continue for the Flagship Competition and Accident Investigation Events.

The Section will continue to develop relations with other IRSE Sections and deliver improvements in collaboration with E&PD committee.

It is also the intention to develop improved committee handover documentation to aid future committee changes.

Institution of Railway Signal Engineers

9 IRSE News issues 266 (May 2020) to 276 (April 2021)

The issues of IRSE News that follow are also available in the archive on the IRSE website.

Please visit irse.info/newsarchive

IRSE News

Institution of Railway Signal Engineers

May 2020

Daniel Woodland
our new president

Going driverless
the Sydney experience

Back to basics
interlockings part 2

KEEP CALM

AND

CARRY ON-LINE

Signet is following government guidelines and putting our staff and clients safety first. You can still call us and we are busy identifying courses that we can deliver on-line. We have already completed some existing courses so please call or email for more details and above all please keep safe!

+44 (0)1332 343 585

enquiries@signet-solutions.com

www.**signet-solutions**.com

Signet Solutions

Raising the Standard in Development

IRSE///
Institution of Railway Signal Engineers

Issue 266
May 2020

In this issue

Feature articles

News and opinion

From the IRSE

Enhancing competence

The UK Engineering Council requires engineering registrants to commit to maintaining and enhancing their competence through Continuing Professional Development (CPD) activities. Canadian engineering regulators require that licence holders meet the requirements of a CPD programme. The Institution of Engineers (India) require professional engineers to maintain CPD at a satisfactory level. Engineers Australia require chartered members to undertake at least 150 hours of CPD over a three-year period. I could go on, but hopefully this makes the point that CPD is seen by professional bodies around the world as a key element of maintaining professional competence, and a key requirement for continuing recognition as a professional engineer.

CPD includes formal structured training, courses and distance learning programmes, but it can also be: informal learning through new work based tasks and challenges; interaction with colleagues, customers and suppliers; private study; relevant voluntary work; preparation of papers, lectures and presentations; mentoring... basically anything that helps you expand your knowledge and maintain up-to-date technical skills.

To get the most out of CPD it is best to take time to plan (considering your career goals and what CPD will assist in achieving them) and reflect (reviewing the learning you have achieved to consider how to apply it in your work and to help plan your next steps).

The IRSE puts on a lot of activities to assist with maintaining your CPD. The annual presidential programme lecture series and technical seminars (generally live streamed and available later as webcasts via **www.irse.org**) and our major conferences and conventions provide some excellent opportunities, as do local section events. Reading IRSE News, as you are doing now, engaging in institution committees and tackling one or more modules of the IRSE Exams are other ways that you can use the IRSE to support your CPD.

If you need further advice and inspiration on CPD, why not take a look at the IRSE guidance document "Maintaining and developing your professional competence" or my own ASPECT 2017 keynote paper on "Training and Development for Signalling, Control & Communication Engineers" – both available at **www.irse.org**.

Daniel Woodland, president

Cover story

A Class 220 Bombardier Transportation Voyager 125mph (200km/h) diesel-electric multiple-unit approaches a set of clamp lock operated points at Durham railway station on the East Coast Main Line (ECML) in the UK. Durham is 254 miles north of London King's Cross on the way to Edinburgh.

Network Rail is to introduce in-cab ETCS signalling on the southern section of the ECML from London King's Cross to just north of Peterborough, which will be the first intercity in-cab signalling railway in the UK. Siemens are the train control and traffic management partner and Atkins rail systems the integration partner, working with Network Rail to deliver the East Coast Digital Programme.

Photo Paul Darlington.

Presidential address: The challenges of change in complex command, control and signalling systems

Daniel Woodland
Head of command, control & signalling
Ricardo Rail, UK

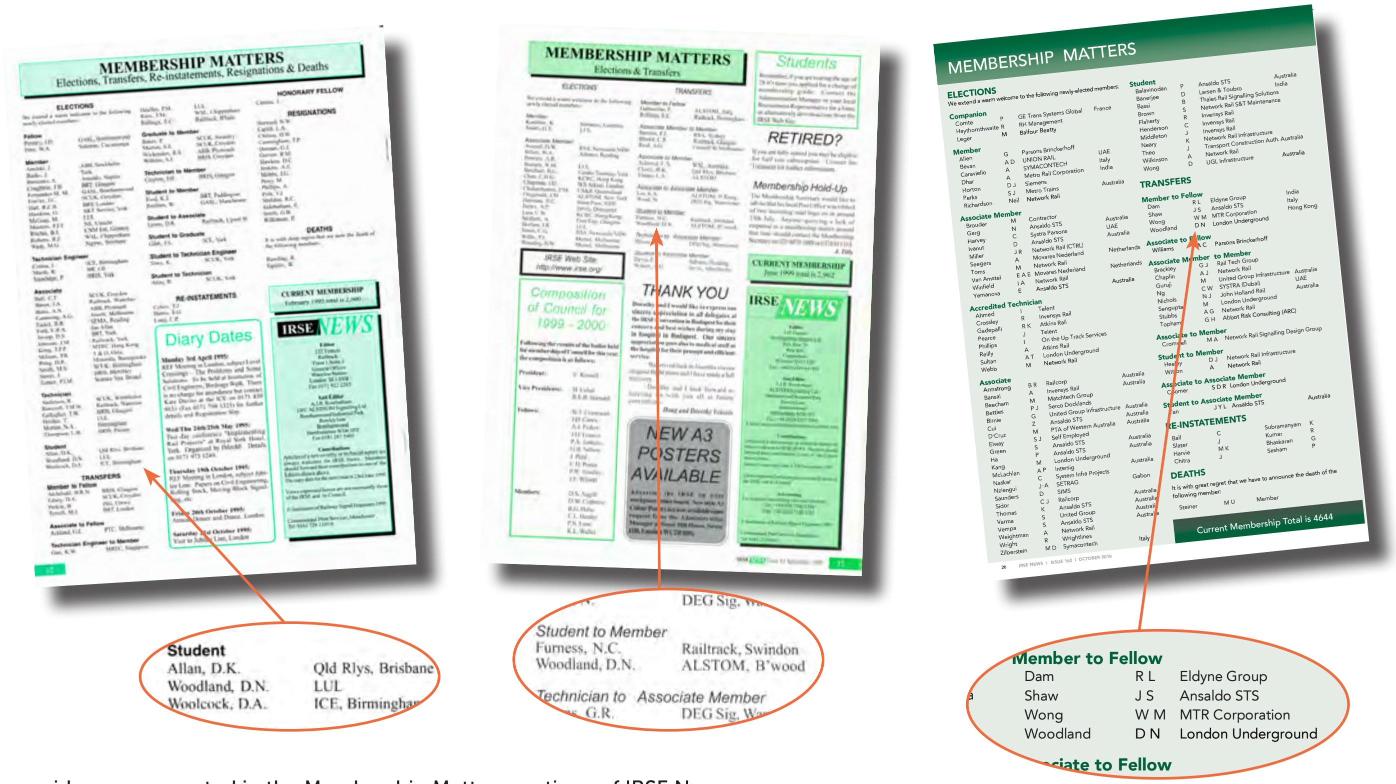
On 23 April, Daniel was confirmed as IRSE president for 2020-2021.

My engagement with railway signalling began with some confusion over terminology, back in 1993. London Underground advertised a graduate training scheme in 'Communications and Control Systems', which seemed perfect for my mix of university course communications and control theory final year options. It wasn't until final selection that I realised exactly what they meant by 'control' when George Clark, my predecessor as president, gave a talk to the candidates about signalling for the Jubilee Line extension.

It was quite an eye opener – I had no idea how complex the control of a railway could be, or that it was all about communication systems, software and automation. From that stumble into the industry, I soon discovered a keen interest in signalling principles – and realised that most railway signalling implementations were not actually software based and included only rudimentary automation.

Following completion of my MEng in Electronic and Electrical Engineering at Loughborough University, I managed a few months with London Underground before being handed an IRSE membership application form by my mentor, Jim Irwin. A few minutes later I was marched around the corner to obtain a signature from Eddie Goddard (then senior vice-president). During those few months I had gone from novice to signalling engineer, by attending an intensive London Underground signalling principles course, and was already gainfully employed in the signalling design office – my first 'job' being to review a mechanical locking chart for Edgware Road, illustrating the lesson that some signalling technology was rather old!

I set about learning all I could of both legacy and emerging systems, with much help from the IRSE and London Underground's IRSE exam study group. Sitting and passing the IRSE Exams certainly gave a boost to my knowledge and confidence, and subsequent receipt of the 1996 Dell Award boosted my profile in the industry. On completing my graduate training, I settled to work in the London Underground signalling design office, developing a specialisation in scheme plans and control tables. However, with a proposed Public Private Partnership on the horizon work began to dry up and I was forced to seek alternative opportunities with the GEC Alstom design office at Borehamwood. So far, my career had been in 'conventional' signalling, but in 2000 I obtained a transfer to the (then Alstom) 'systems' team to work for the first time on the 'new' systems – with a role as a systems engineer looking at principles development and operational scenarios for ETCS on the West Coast Main Line. At the same time, I commenced a part-time PhD at Sheffield University on "Optimisation of Automatic Train Protection Systems", enabling me to explore some of the theory and implications further. Most of my career since then has been involved in some way with ETCS, CBTC and similar systems. As projects and opportunities came and went, I moved to Rail Link Engineering as system integration engineer for Channel Tunnel Rail Link section 2, then back to my roots at London Underground as a signalling asset engineer and later head of signalling for the Sub-Surface and then Deep Tube upgrade programmes. That led on to joining Lloyd's Register Rail, which later became Ricardo Rail, in 2013 as professional head of signalling and train control and later head of command, control and signalling. My responsibilities with Ricardo have included activities to enhance and monitor technical integrity, staff and business development, alongside project works as independent competent person, lead assessor for ISA/Assessment Body projects and as a technical expert for consultancy activities in the UK, Ireland, Europe, the Middle East and Asia.



Path to presidency as reported in the Membership Matters sections of IRSE News. Elected a Student April 1995, Member September 1999 and Fellow in October 2010.

My IRSE engagements did not end with passing the exams. The ink was barely dry on the certificate when I was invited to join the Younger Members section committee. I quickly found myself organising lectures, seminars and conferences, going on to chair first a two-day conference and then the section. This role led to me joining Management Committee as Younger Members' representative, the Publications Committee, Professional Development Committee, Recruitment & Publicity Committee and ASPECT Committee. It also led indirectly to my standing for Council as a Member (2003-2011) and later as a Fellow (2013- present). Shortly after joining the Younger Members I was also invited to become secretary of the Exam Committee, which I stayed with for 20 years – moving on to roles as examiner for Modules 1 and 7 and a time as chair of the committee. During and since that time I have been involved in three reviews of the examination format, content and administration, and chairing two of the reviews. Since being co-opted as junior vice-president in 2018 I have also participated in meetings of the Membership Committee and International Technical Committee (ITC). For those of you who don't know, the ITC is a collection of international experts who, on behalf of the IRSE, prepare papers and articles on topics of significant global interest. I see the ITC as a key element in the IRSE's delivery of its charitable aim for "The advancement, for the public benefit, of the science and practice of signalling by the promotion of research, the collection and publication of educational material…". As such ITC will be featuring repeatedly through my Presidential Programme.

This selection of IRSE engagements has proved an excellent preparation for my impending role as the institution's president. I haven't served on every committee, but I've had a fair stab at it. So why, you may ask, did I bother doing all of that? Well,

Daniel served on the Younger Members Committee for some time. In this photo from IRSE News in April 1996 he is standing second from the right in the back row. We use a somewhat different journalistic style for our headlines today.

Daniel, second from the front on the right hand side of the table, at a Council meeting in 2017.
Photo Colin Porter.

With members of the Scottish Section during a visit in 2019.
Photo Peter Ramsay.

through my IRSE activities I have discovered that it is true that 'you get out what you put in'. I have been able to shape the direction of institution activities, meet with peers, mentors and mentees, develop both my technical and management abilities, raise my industry profile and – I hope – along the way have also enabled my fellow members to benefit, along with the wider industry, from these activities. I would therefore prefer to turn the questions around and ask why all IRSE members are not clamouring to get more involved in the institution's activities and how come so many committees had a space free that I could slot into?

Besides work and the IRSE, I also became engaged with academia during my PhD studies, and have lectured ever since on the (initially Sheffield University, but now University of Birmingham) Railway MSc programmes. In so doing, I believe I have become the ultimate systems engineer – having completed my first degree in an Electrical Engineering department, my PhD in a Mechanical Engineering department and now lecturing on a course (and having been appointed as an honorary senior research fellow) with a civil engineering department. That just goes to show that railway signalling and control truly encompasses multidisciplinary engineering and that the badge doesn't necessarily define who you really are.

So, coming back to the 2020/21 Presidential Programme. Over my 25 years in the industry, reality has gradually moved closer to that initial introduction to signalling that I received from George, and through roles working with ETCS, TVM430, Invensys DTG-R, Bombardier Citiflo-650 and Ansaldo STS CBTC, I find myself with a good working knowledge of the 'modern' systems he was describing back then. However, along with that knowledge has come awareness that the industry struggles sometimes with understanding the opportunities and implications associated with new technologies; and particularly with the changes in approach required to manage safety in complex, generally software based, systems. I now find myself with the great honour of serving as the president of the Institution and, on looking back through the themes of my predecessors, note that I am not alone in noticing the industry's difficulties in grappling with new technology. So, building on Markus Montigel's "Winds of Change" and George Clarke's "Delivering Change", I intend through the 2020/21 programme to look at the "Challenges of Change" in complex command, control and signalling systems. These challenges encompass:

- The ongoing technology evolution (with increased use of computers, 'radio' based communications and software)
- Changes in deployment of technology (with signalling and control equipment and the 'intelligent' system features moving from the traditional localised trackside locations to centralised locations and increasingly on-board trains).
- Increased globalisation of solutions (where global standards are not always the same).
- Increasing use of automation (for all aspects of system development and operation) and
- A general move away from provision of command, control and signalling systems solutions by lifelong rail specialists to the use of specialist service providers for the technology and software development.

This is obviously too large a topic to cover exhaustively through the year, but I hope that the programme will highlight key points and assist members in preparing themselves for their contribution to our changing industry. The challenge of achieving this has become harder with the unprecedented pandemic that is currently seeing much of the world 'locked down' and practicing 'social distancing' to limit the spread of novel coronavirus disease 2019 (COVID-19). This virus will have a big impact on all aspects of our lives through 2020/21, including the IRSE and my presidential programme. Unfortunately, the AGM and my public inauguration have had to be postponed (currently rescheduled until later in the year) whilst the Annual Dinner and Members Lunch have been cancelled. It remains unclear at the time of writing how much else will be impacted and we are busily planning a shift from physical to web-based meetings such that, at very least, the presidential lecture programme will be able to proceed. I will outline my aspirations for the year in this address – time will tell how close we are able to get to that!

In 2004 the then IRSE president, John Corrie, asked me to present one of his presidential lectures, on "The Philosophy of Railway Control". John was concerned that the 'basic principles' of what we as railway signalling, control and telecommunications engineers do was not well documented and wanted something 'on the record' in the IRSE proceedings for his year. I wrote the requested paper and a second part looking at some of the issues with our traditional approaches. During my career I have authored (if I have added up correctly) 55 papers that have been presented to, or published by, professional institutions and societies, mostly railway related (the first one having marginally preceded my joining the IRSE and been on the topic of spatial modulation in Rogowski Coils – which, although I have come across several examples of use by others in the rail environment, I have yet to find an excuse to apply myself). In all, 28 of these were through the IRSE. It could, therefore, be argued that I have had ample opportunity to 'have my say'. So, having set the theme and selected the topics, authors and organisers, I am sure that you will be relieved to know that delivery of the programme is in the hands of others.

This year's presidential programme will start on 16 June with a webcast paper on 'The forefront of system safety and its application to railway signalling' by Professor Yuji Hirao. This paper has been developed by the IRSE's ITC to capture approaches at the forefront of safety technologies and management, both in rail and related industries. In order to realise sophisticated railway signalling systems which contribute to the enhancement of traffic service quality, as well as cost reduction, whilst ensuring safety, we need to assimilate potential cutting-edge technologies with the aim of applying them to our systems. The need for this topic to be considered is driven by changes in technology, with systems becoming increasingly large-scale and complex 'system-of-systems', based on software, multi-core processors and even Artificial Intelligence. Safety requirements and safety cases for the above systems, their completeness to the point of assurance, and relations between safety and security are topics of great importance to the future of our industry. I think that Yuji and the ITC have been quite heroic in taking on such a large topic and I am greatly looking forward to the resulting paper.

The Institution's convention in Toronto was due to follow in September, looking at developments across rail in North America. Such a large international gathering is not currently feasible, so we are considering options for deferral to a later date – details will be announced as soon as we have a clear way forward.

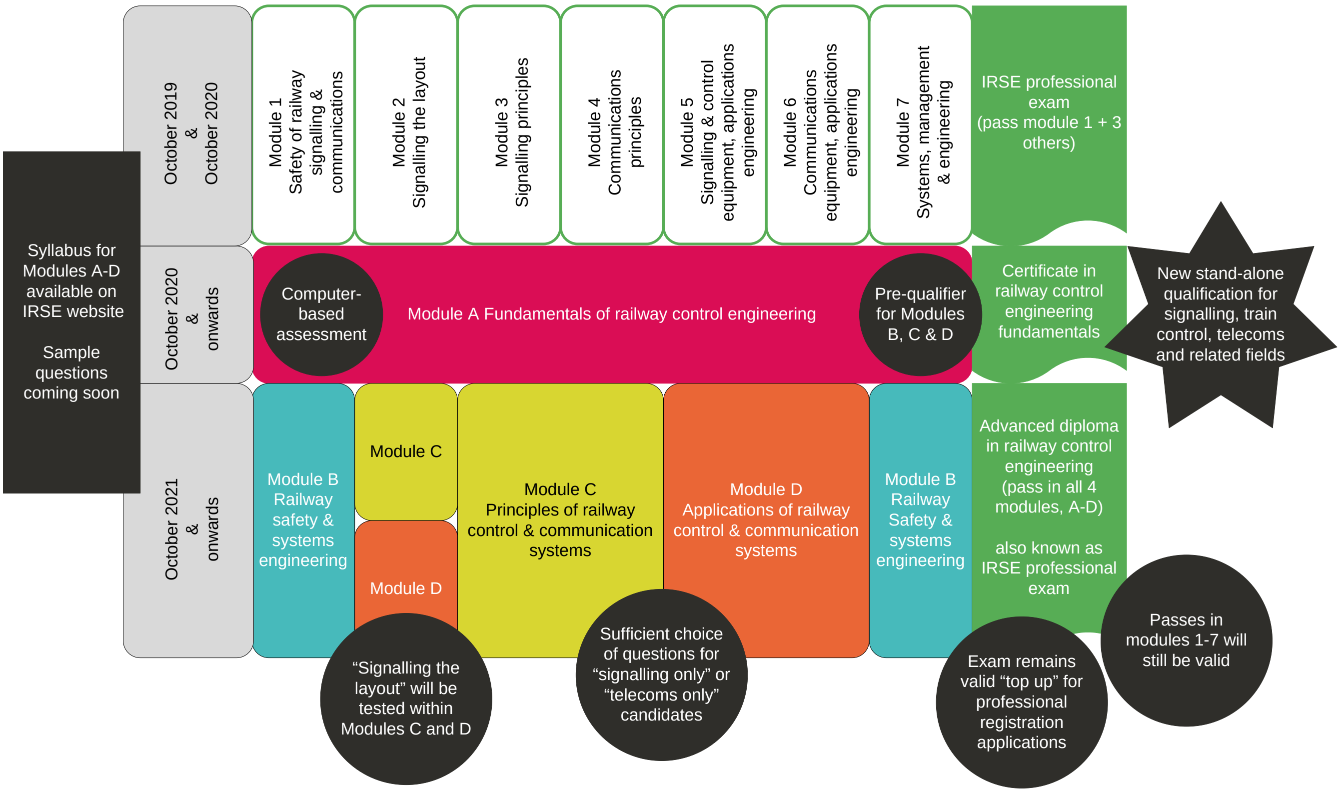
The second paper will be in Switzerland/webcast on 30 October, exploring crossover between rail and autonomous road vehicles, led by Tom Jansen. Our traditionally efficient railway networks are nearing their maximum capacity and whilst currently available technical solutions such as ERTMS have some potential to optimise railway system utilisation, creating some breathing space, they are not likely to provide sufficient increase in capacity. The railway industry is also facing potentially existential threats from increasingly innovative competing transportation modes. Recent history has seen the introduction of advanced driver-assistance systems for cars, and in the more distant future self-driving cars and even urban air mobility are seen as a welcome addition to the transportation ecosystem. In the near future major choices will have to be made regarding the strategies to tackle these challenges and one of the major areas of interest has recently focussed on the topic of automation. Tom will be exploring what benefits we get by replacing the driver by computers, how we can demonstrate the safety and integrity of a self-driving train and its software, and how we can improve our business case by making use of automation knowledge and products from other industries. Again, no small topic.

The third paper will be another ITC outing, by Rod Muttram, in York/webcast on 19 November. The topic will be cross acceptance of systems and equipment developed under different standards frameworks. Within the rail domain there are two dominant approaches to securing safety/safety approval: In Europe and Commonwealth countries the 'safety case' approach has prominence with technical approval and acceptance of products following standards in the CENELEC EN5012X series. This approach often involves approvals for a generic product, generic application in a particular environment and then specific site/project application within that environment. In the USA and associated countries similar approvals are carried out against a suite of standards from AREMA, the IEEE and MIL-STDs. Equipment safety requirements are generally split into 'vital' and 'non-vital' i.e. supporting safety function delivery or not involved in safety. Whilst a 'safety report' is required, the safety evidences of the generic product are rarely mandatory standalone deliverables within that, and individual pieces of equipment tend to be assessed against specific standards based on long established custom and practice. This paper will re-visit earlier ITC guidance based on recent experience of product introductions and attempted introductions in both directions.

The University of Birmingham will host/webcast the fourth paper on 2 December, by Nicholas Wrobel and Robin Hirsch, on testing modern electronic/software systems. This paper will outline the importance of system level testing of critical systems before releasing the software on to the railway and capture the benefits of system level testing in terms of access, safety, confidence, reputation, operational reliability and cost. The authors will consider factors such as: the requirements and typical operating envelope; a framework for system level testing; key elements of the test rig; a methodology to determine the test scenarios; metrics to measure the software's fitness for purpose', achievable levels of confidence and the number of test runs required to achieve a given confidence level and to satisfy the engineering safety & assurance case.

Paper five, by Alžbeta (Betty) Helienek will be hosted by the Scottish Section in Glasgow/webcast during January 2021. Cyber security has become a critical part of delivering an efficient and safe railway, driven by ever more digitally connected systems and the evolving threat landscape. Much has been achieved over recent years, but even today the railway finds itself in various stages of cyber security awareness and readiness. As an industry we range from having developed and integrated security assurance frameworks (allowing safe, secure R&D and project implementations), through to no awareness at board level and lack of understanding of responsibility within safety engineering teams. The paper will propose a digital resilience railway maturity matrix, presenting a method to categorise, recognise and support organisations with their roadmaps to integrating security into daily operations. It provides a powerful benchmarking tool in a competitive landscape, which in a race to become more effective has also become more vulnerable to technological changes.

That brings us on to the final paper of the series, hosted by the Irish Section in Dublin/webcast on 4 February 2021 and again developed by the IRSE's ITC. Ian Mitchell will take the lead, supported by a guest author from outside our institution, Nora Balfe (a human-factors expert). They have agreed to tackle traffic management systems and automation in control centres. We usually think of railway automation in terms of replacing some or all of the functions undertaken by a train driver, but there are other aspects of railway operations where replacement of human operators by automatic systems can reduce costs or improve reliability, performance, capacity or safety. With this in mind, what is the appropriate level of automation in a railway control centre? How far can the tasks traditionally undertaken by staff with job titles such as 'signaller', 'controller' or 'dispatcher' be partially or fully automated? What are the benefits and what are the risks? The ITC are currently engaging with railways around the world to determine their experience of automation, its benefits, risks, problems and limitations, in order to add to the existing knowledge base of the ITC members and inform this paper.



One of the biggest changes during Daniel's presidential year will be the major revisions to the IRSE examination.

In between these events I also hope to arrange some technical visits and seminars, and to visit sections across the globe. Fortunately, as some of you will know, the visits started two years ago. We now have far too many sections to get around in three years, let alone one – a feature of the IRSE that provides much of its depth and character. The early start means that even if I can't travel much this year, I have managed to meet with some of you – and I do hope it will be possible to meet with more, even if it's only via video conference.

I am very excited that the first significant change to the IRSE exam format for 25 years will begin to roll out during this presidential year. A new 'Module A' foundation level paper has been developed and a trial exam run with nearly 100 volunteers from across the world. The first real version is planned for October 2020.This represents a significant evolution for the IRSE, being computer (rather than paper) based and leading to a new qualification "Certificate in railway control engineering fundamentals". As well as acting as a pre-qualification for candidates wishing to sit the full IRSE professional exam in future, the 'certificate' will also provide an opportunity for a wider range of industry professionals (such as project managers, project planners and software developers) to demonstrate a broad knowledge of railway control and communications systems engineering. Further changes will follow to the existing modules, simplifying the exam structure and promoting more cross-discipline (signalling/telecommunications) learning. Modules B, C and D will be launched in 2021, leading to the qualification 'Advanced diploma in railway control engineering' for those who pass all four of the new modules A to D.

Over the last few years, the IRSE has made considerable efforts to improve our offering and accessibility to global membership, with webcast of lectures, webinars and electronic voting. This has given us good experience to assist continuing engagement with members in these difficult times. However, there remains much more that we could, and need to, do. It is our intent through the 2020/21 year to begin a detailed review of our value proposition, 'how we do things', our governance and election approaches and consider how to better engage with and support our global membership. This review, which will likely take longer than a year to complete and implement, will move us from discussing the 'Challenges of Change' to effective 'Delivery of Change' for our members. The challenges of COVID-19 highlight the necessity for this and the Institution of the future will likely be unrecognisable from that of today as it evolves in response.

Embarking on this year as president of the IRSE, I am aware of the debt that I owe to my predecessors and mentors. I would not have achieved this position without their support and guidance. Recognising that I can't mention everyone whose influence has been material in my journey, I would still like to highlight a few key individuals: My mentor, Jim Irwin (IRSE Fellow and past Council member); PhD Supervisor Professor Felix Schmid (IRSE Fellow); industrial supervisor Bob Barnard (IRSE Hon Fellow and past president); general IRSE guide and font of wisdom Colin Porter (IRSE Hon Fellow, past president and past CEO) and, unfortunately too late for him to know of this acknowledgement, Eddie Goddard (past president) whose calm and knowledgeable influence was an inspiration to all who knew him. Many thanks to all of you, and all of the other IRSE members who have in both significant and subtle ways helped me to become the engineer that I am today.

I hope during the coming year to meet as many IRSE members as possible in the circumstances, to make a positive contribution to the Institution, its future direction and the benefit that it offers to both its membership and the wider society.

Technology trends in mass rapid transit signalling

Written and edited by Alan Rumsey on behalf of the International Technical Committee of the IRSE

The mission of any mass rapid transit system is to provide for the safe, reliable and efficient movement of people. Signalling/train control systems play a critical role in delivering this mission.

Providing for the safe movement of people requires a signalling/train control system that includes, for example, interlocking protection, safe train separation assurance and overspeed protection; all of which require knowledge of the location of all trains operating within the mass transit rail network.

Providing for the reliable movement of people requires a signalling/train control system that has a high level of system availability, achieved through the use of 'service proven' components and equipment, the provision of appropriate levels of redundancy, the ability to support degraded modes of working in the event of equipment failures, and effective maintenance and diagnostic provisions.

Providing for the efficient movement of people requires a signalling/train control system that can optimise line capacity, provide operational flexibility, and that includes appropriate levels of automation.

Role of technology

The evolution and availability of new technologies can influence the delivery of the above mission in two ways:

1) "Doing things better" i.e. by implementing the same functions as earlier technologies but in a safer, more reliable, more efficient, or cheaper, etc. manner; or
2) "Doing better things" i.e. by implementing new functions that were simply not feasible or affordable with earlier technologies.

Influence of technology to date

The origins of railway signalling and train control systems can be traced to the development of the basic principles upon which the safe movement of trains is assured, such as the interlocking of points and signals to prevent conflicting moves, and the use of absolute blocks to separate successive trains operating on the line. Initially, these principles could only be satisfied through purely manual rules and procedures, as the technology to implement these signalling functions was not available. This subsequently led to the development and deployment of new technologies to "do better things" such as:

- Mechanical interlockings.
- Track circuits for train detection.
- Block telegraph instruments.
- Means to automatically apply the train brakes.

In the intervening years, as signalling/train control systems have evolved, the primary influence of technology has been focused on 'doing things better'; implementing the same signalling principles in a way that further enhances safety, and/or improves reliability/availability, and/or reduces life cycle costs.

For example, while the basic interlocking functions have generally remained unchanged over the years, interlocking functions have been implemented differently as newer technologies have become available, with mechanical interlockings being replaced with relay-based interlockings; relay-based interlockings being replaced by solid-state interlockings; and then by processor-based interlockings, in which the interlocking logic can now be either distributed or centralised.

Similarly, while the basic function of track circuits, to establish block occupancy, has generally remained unchanged, the technology for implementing track circuits has also evolved from DC track circuits, to audio frequency track circuits, and to jointless track circuits. Alternative technologies for block occupancy detection have also been developed, such as wheel/axle counters.

The more recent development of train-based (as opposed to track-based) technologies for train location determination has led to a transition from a fixed block method of control to a moving block method of control. This is an example of where newer technologies have enabled signal engineers to "do better things"; to implement functions that were not feasible with earlier technologies. Other examples of "doing better things" are where the evolution of technology has supported higher levels of train automation, up to and including unattended train operations.

The evolution of communications technology, and specifically train-to-wayside and wayside-to-train data communications, has also enabled signal engineers to "do better things" as the datalink bandwidth has increased and as the reliability/availability of data communication systems has improved. For example, the means of communicating movement authorities to a train has evolved from wayside signal aspects to cab

Photo Shutterstock/sevenke.

signals (either in the form of fixed speed codes or profile-based movement authority telegrams). The communication medium for cab signals has also evolved from communications through the running rails, to communications through inductive loops, and now to radio-based communications.

An overarching trend in the evolution of signalling/train control systems has been the move from hardware-based to software-based solutions, and this trend can be expected to continue.

Technology trends

In order to address how technology trends may enable signal engineers to "do things better" and/or "do better things", we first have to look at the trends with respect to future requirements and expectations for mass transit signalling and train control systems.

One trend that is clear is that the requirements will be increasingly passenger-centric, with an emphasis on minimising system life-cycle costs. In addition to ensuring the safety of all train movements and the safety of the passenger interchange at station platforms, user requirements will be focused more on improving system reliability/availability and on enhancing train operations. This will include optimising the movement of passengers by maximising the utilisation of the available rail infrastructure and adopting higher levels of automation.

Key requirements for any future mass transit signalling/train control system are summarised below, with examples as to how these requirements may influence, or be influenced by, technology trends.

Train location determination

Requirements to safely and reliably determine the position of every train operating within the rail network, with an accuracy and precision to meet both the safety and operational requirements, will continue to be the foundation of any signalling/train control system solution.

The current state-of-the-art in train-based train location determination relies on the detection of wayside transponders (balises) as an absolute position reference, supplemented by tachometers to establish train location between transponders (based on axle/wheel rotations), with other devices such as Doppler radar or accelerometers used to detect and compensate for wheel slip/slide conditions. Such train location determination subsystems are implemented using redundancy and diversity techniques, with multiple sensors, to achieve fail-safe design characteristics while at the same time providing high levels of system availability and accurate/precise train location information.

Similarly, the various autonomous road vehicle systems now being developed and deployed typically do not rely on a single sensor technology to establish a vehicle's location and detect obstructions ahead, but rather integrate multiple sensor technologies – such as cameras, radar and LIDAR, for example – to overcome any weakness or limitation of any one sensor type. The advances in sensor technology being driven by autonomous road vehicle applications are now opening up opportunities for signal engineers to potentially develop alternative means of train location determination that may offer superior safety, availability and performance capabilities, with reduced installation and life-cycle costs.

Camera technology, for example, is now mature, reliable and relatively inexpensive, and when coupled with infra-red lighting can perform to some extent even under night-time and poor weather conditions. When used as a means of determining train location and/or obstruction detection, however, cameras do require complex image processing.

LIDAR (light detection and ranging) technology uses laser light to measure the distance to objects in a similar way to radar and can build up a detailed 3D view of the environment around the sensor. LIDAR technology can detect objects 100 metres or so away and can measure distances at an accuracy of a few centimetres. It is claimed that LIDAR is also unaffected by adverse weather conditions such as wind, rain and snow. Such technology could potentially eliminate the need for track-based transponders and associated train-based transponder readers, tachometers and other sensors. LIDAR technology is not without its own set of specific limitations, however, as it requires a huge amount of processing power to interpret millions of measurements every second, and then translate these measurements into actionable data. The LIDAR sensors themselves are also complex devices.

UWB (ultra-wideband) communications is an example of another promising technology for high precision train localisation determination utilising time-based range estimating between train-based UWB radios and UWB radios installed periodically along the right-of-way. UWB is a wireless technology capable of transmitting large amounts of digital data (that would be required for 'time-of-flight' calculations), for short distances, over a wide spectrum of frequency bands; all with very low power.

Thales, for example, is currently testing and evaluating a UWB-based train positioning subsystem, integrated with its CBTC product, at New York City Transit.

Interlocking protection

Requirements for interlocking protection, to prevent conflicting routes through interlocking areas, will also continue to be fundamental requirements for any signalling/train control system.

The trend to move away from interlocking logic being distributed along the right-of-way to centralised interlockings is expected to continue, with advances in computer-based and communications-based technologies now capable of supporting 'cloud-based' interlockings where the interlocking logic is capable of being performed off-site. While cloud-based interlocking may be more applicable to long distance rail, with interlocking logic for the entire rail network centralised at one location, there may also cost-saving opportunities in mass rapid transit applications.

Siemens, for example, is one supplier already working on these advanced technology alternatives.

Movement authority determination/enforcement

Requirements to establish limits of movement authority for every train operating in the network and to enforce compliance with these authorities (including enforcement of speed limits within these authority limits), will also continue to be key requirements for any signalling/train control system.

The traditional/historical approach to achieving these requirements has been wayside-focused. Equipment on the wayside, which today is typically a network of processor-based wayside controllers, collects data on the location of trains within its control zone, and the limits of a safe route for each train. These wayside controllers then utilise this information to establish movement authority limits for each train. The movement authorities are then communicated to each train and train-borne equipment is responsible for ensuring compliance with the movement authority limits.

Technology trends are however moving more and more of the signalling/train control intelligence to the trains, in order to minimise requirements for wayside and track-based equipment. This specifically includes direct train-to-train communications, and autonomous train control techniques, where the train could determine its own limit of movement protection, based on its knowledge of its local environment, rather than having to rely on a movement authority calculated and communicated from the wayside.

In the Alstom Urbalis Fluence product, for example, a train receives its mission from central control, but it is the train itself that computes the track resources needed for its movement, The train then requests the wayside controller/interlocking to set and lock the required route, and when route status has been confirmed, communicates directly with the train ahead to establish its own movement authority limit.

With direct train-to-train communications, revisions to traditional safe braking models may also become practical to support 'relative braking' and 'train platooning' concepts.

Train service management

Requirements to better manage and regulate train movements, utilising optimisation algorithms and decision support systems to ensure stability of network operations even in cases of operations at the capacity limit, can be expected to increase.

The trend is to move more and more of the train service management intelligence to central control, specifically to include the optimisation of train movements in a way that provides maximum benefits to the passengers and maximum life cycle benefits to the operator e.g. through dynamic train scheduling that is responsive to actual passenger demands (that becomes feasible when train timetables are no longer constrained by crew schedules in fully automated driverless systems). This could also likely include conflict prediction and automatic regulation capabilities to resolve such conflicts.

Technology trends will also support the seamless integration of signalling/train control systems with other operating elements of a mass transit system to include platform edge doors, traction power systems, tunnel and station ventilation systems, passenger information systems, etc. in a manner that exploits the operation and safety capabilities of the train control system.

Summary

In summary, we can see both trends towards 'smarter trains', with more and more of the basic signalling intelligence moved to the trains, as well as trends towards "smarter network control", with more and more of the train management control intelligence moved to central control. Both of these trends have as one underlying objective eliminating or minimising track-based and wayside-based equipment which is seen to be a major system cost driver, both from an installation perspective and a life-cycle cost perspective.

An integration/convergence of these two trends may also be possible where (for example) optimised network management can be achieved through the more sophisticated control centre systems while autonomous train control concepts could be utilised to support degraded mode of operation, if communications with central control were lost.

With the evolution of communications technology to provide increased bandwidth, lower latencies and higher levels of system availability, with the evolution of computer technology to provide increasing levels of processing power in smaller and smaller packages, and with the evolution of sensor technologies, technology itself is no longer a significant constraint on the evolution of signalling/train control systems. The question is no longer "what does the technology enable me to do?", but rather "what is the business case I am looking to the technology to deliver?".

Given the endless possibilities that new technologies now offer, without a clear focus on "what is the problem we are trying to solve", and "what are the requirements we are seeking to satisfy", there is a risk that new technology will result in a significant divergence in possible signalling/train control system designs, leading to an increase in supplier-specific and agency-specific solutions that in turn will result in a continued reliance on proprietary, non-interoperable systems. If the industry desires to move towards more standardised, global solutions, with a convergence, rather than divergence, in signalling/train control solutions, then this can only be achieved if there is first a convergence in user requirements that will in turn provide business-case benefits to both the operators and the system providers.

Finally, while the availability of more sophisticated, software-based technologies may offer a range of potential benefits to signal engineers and mass transit operators, the historical challenges associated with the introduction of any new computer-based and communications-based solution will remain. These include achieving a solution that is both reliable and maintainable within a mass transit operating environment, the development of the safety case for the increasingly complex systems, protecting against ever more sophisticated cyberthreats, managing and controlling the inevitable software updates and addressing issues of system obsolescence.

Converting a GoA1 commuter railway to a GoA4 driverless Metro – The Sydney Metro Experience

Steve Allday

This is the sixth and final paper of the 2019/2020 presidential programme.

The Sydney Metro is the first driverless passenger carrying railway to be built in Australia, the first stage having been introduced into service in June 2019 between Tallawong and Chatswood (Sydney Metro Northwest). The second stage of the project involves an element of new build railway and the migration of an existing Grade of Automation (GoA) 1 operated line from Sydenham through to Bankstown to a GoA 4 operation.

The business requirement for the extension from Chatswood and the building of the Sydney Metro City & Southwest is multi-faceted. It is to provide greater connectivity into the city from the northwest, which is an expanding growth area, to alleviate existing traffic congestion in the south, thus enabling Sydney Trains to provide enhanced services on the City Circle line and at the same time increase economic development opportunities along the southwest corridor.

"This paper describes the systems engineering challenges of achieving the project"

The Sydney Metro City & Southwest project has differing challenges. The City section involves the introduction of 'integrated station developments' and the Southwest section requires conversion of an operational railway, with a key objective being to minimise the time between the cessation of existing operations and introduction of the new GoA 4 operation.

This paper concentrates on the Southwest section and describes the systems engineering challenges of delivering the project. These challenges span the spectrum of time, logistics, design, integration, construction, assurance and not least innovation.

Background

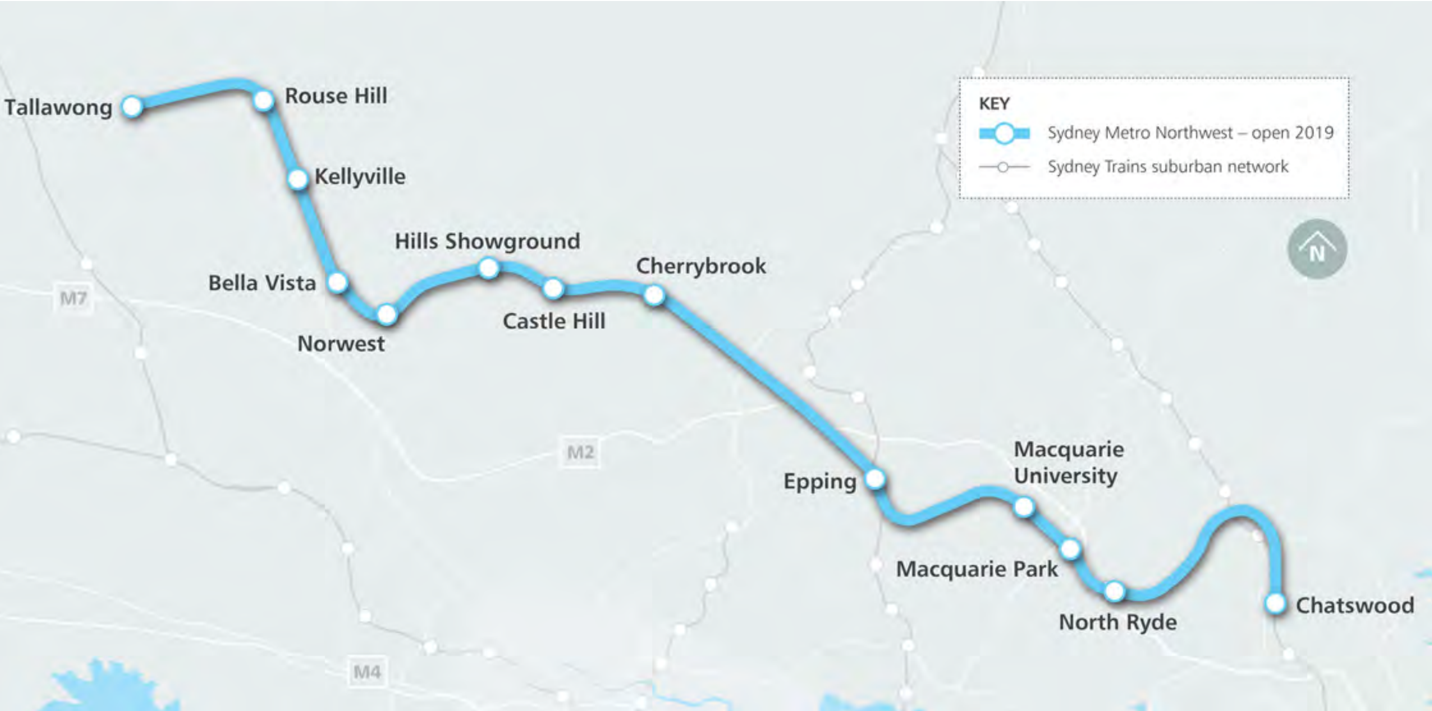
The Northwest section of the new route entered service in June 2019. This included eight new stations and the conversion of five existing Sydney Trains underground stations. The alignment is predominantly 'grade separated' with the exception being the depot and the Operational Control Centre (OCC) located at the end of the line in Tallawong. It has a total length of 36km, comprising 23km new build and 13km conversion of an existing underground network.

A second section of Sydney Metro, the City and Southwest section, which effectively doubles the size of the network (See Figure 2) was announced in 2016. This extension will be commissioned in two phases, the first being the City section in December 2023 and the second being the Southwest section in November 2024.

The City & Southwest section runs from Chatswood, in tunnels beneath Sydney harbour and the city and emerges at-grade from Sydenham to Bankstown. The first phase is a greenfield new build and the second phase a brownfield conversion of an existing Sydney Trains commuter line.

Augmentation (City & Southwest integrated with Northwest)

As the Northwest and City & Southwest sections are to form a vertically integrated, operated and maintained railway, it was considered that there would be advantages in extending selected elements of the Northwest section to reduce integration complexity of both the systems and OCC and ultimately cost (Although this was required to be demonstrated due to the scale of 'sole sourcing' involved). The elements considered to be of benefit to be retained/extended were; rolling stock, Communication-based Train Control (CBTC)/signalling, Centralised Control System (CCS) and radio systems.



Top, Figure 1 – Sydney Metro Northwest.

Right, Figure 2 – Sydney Metro City and Southwest.

"The Bankstown line has been in operation for over 100 years"

The Platform Screen Doors (PSDs) and communications systems were competitively tendered which resulted in a different supplier of PSDs from the Northwest section. The communications contract was also re-tendered but resulted in the continuation of the Northwest section with the same supplier of station and network communication systems.

The PSD supplier for the Bankstown Line could potentially be different to both the Northwest and the City sections, due to the need to develop and integrate Mechanical Gap Fillers (MGFs) and Obstacle Detector System (ODS), the responsibility and delivery risk for which equipment rests with Sydney Metro (covered later in the paper).

In addition to all of the above, as part of the tendering process the existing operator for Northwest will also operate the Augmented Sydney Metro and as part of their responsibility to ensure consistency, they are the overall systems integrator during the design, development and construction phases.

Converting the Bankstown Line (Back-drop)

The Bankstown line has been in operation for over 100 years and many of the stations are heritage listed which severely constrains the amount of civil and structural changes that are allowed to take place. A result of this is that eight of the ten station curved platforms are to be retained. This constraint, along with the commitment of Transport for NSW to make the metro system fully Disability Discrimination Act (DDA) compliant, with the metro rolling stock 150mm narrower than the current trains operated by Sydney Trains, has added to the complexity of the conversion in the station areas.

Belomore station.

“This means that a significant amount of the existing infrastructure in the corridor has to be retained and made to operate under Metro operations”

The line runs parallel with the Australian Rail Track Corporation freight corridor for approximately 50% of its length before reverting back to two lines for the remaining 7km. The line also experiences a significant amount of trespass.

Additionally, there is a requirement from government that the Sydney Trains operations on the line continue for as long as possible, while implementing many of the changes required for metro working in advance of the final shutdown and conversion. However, the programme must maintain the commitment to go live in 2024.

All of this means that a significant amount of the existing infrastructure in the corridor has to be retained and made to operate under metro operations whist at the same time meet the required operational and customer service performance measurements.

Whilst a new traction supply system is being provided, much of the existing Overhead Line Equipment (OLE) and all of the structures will be retained, using a SFAIRP (So Far As Is Reasonably Practicable) argument and adopting a process that proves the assets to be meeting both standards and performance measures as set out in the contracted Scope and Performance Requirements (SPRs). The same argument and process is also being adopted for track, cuttings, embankments and retaining walls.

Other retained assets are managed through differing mechanisms (see residual assets, p18).

All of this when considered alongside the objective of achieving a minimal period of conversion presents a number of challenges, covering aspects including technical, design, logistics, construction, operations and safety.

Ensuring integration at all stages of the project is a critical requirement in achieving both conversion and the final formation of a ‘vertically integrated railway’.

The following sections seek to explain in more depth those challenges, breaking them down into pre- and post-installation works, testing and commissioning, the management of residual assets and finally assurance. Although many of the challenges could be classified as ‘business as usual’ project activities, there are others that are more complex in their nature some of which have never been attempted elsewhere. However, in delivering these, the project seeks to set a precedent for future conversions of at grade GoA 1 to GoA 4 corridors in Australia and potentially for other railways around the globe to follow.

Pre-conversion works

The pre-conversion activities involve installation, testing, performance proving of systems, plus specialised product development, acceptance and approvals together with early integration testing.

Installation activities – stations

The following will be carried out with the cooperation of Sydney Trains Maintenance and Operations Divisions with Sydney Metro providing all necessary technical, engineering and safety evidence to demonstrate no impact to the existing rail systems or operations. Due to the nature of the activities involved there will be a mix of partial and fully completed installation works.

During the period between mid-2020 through to December 2022 all platform rebuilds and station refurbishments will be carried out. These involve raising the platforms to ensure horizontal alignment (this will also improve the current arrangements for Sydney Trains) and facilitating the dropping in of the developed and approved MGF cassettes at identified locations .

At the eight stations that have curved platforms, the existing ballasted track will be replaced with slab track necessary to manage the train to platform interface in future operations and to ensure DDA compliance. Other station work that can be completed is the installation of new lifts

Lakemba station.

"Activities will continue up to the Christmas period of 2022"

and systems such as Public Address (PA), visual information systems, CCTV and help points, plus the installation of Building Management Control Systems (BMCS) and fire systems. The exception is Bankstown which cannot be completed due to the need to physically separate Sydney Trains from Sydney Metro at the station and install a new at grade concourse between the two operations.

Sydney Metro is also providing a new 11kV High Voltage (HV) distribution system which will provide the low voltage necessary to be distributed to all stations, main equipment rooms located in the station vicinity and along the corridor. This system will be installed, tested and brought into operation in advance of the conversion period and will supply the needs of Sydney Trains in the interim period as well as the end state requirements for Sydney Metro.

Installation activities – corridor

Within the corridor some activities have already commenced and will continue up to the Christmas period of 2022. During the Christmas and New Year period of 2019/2020, the current lines from Bankstown were diverted to arrive in platforms 3 and 4 at Sydenham Station, thus freeing platforms 1 and 2 for future metro operations. The remaining corridor works planned are;

Common Services Route (CSR) – Commenced in late 2019, the installation of the required cable containment for high voltage (33kV and 11kV), signalling, communications and radio, both end-to-end and localised will continue until mid-2022. There are challenges however associated with the provisioning of the CSR which require close liaison and agreement between Sydney Trains and Sydney Metro due to the scale of the route (circa 2.5m high) which severely impedes access to existing operational assets. The impact of the CSR is partially alleviated between Campsie and Bankstown as the access to the corridor can be achieved from both the up and down direction. However between Sydenham and Campsie access is only on the down side due to the existence of the Australian Rail Track Corporation (ARTC) freight lines and the necessity to provide a segregation fence between the two operators, this means the cable route can only be constructed on the down side.

Solutions have been identified which provide a reduced but acceptable level of access to Sydney Trains through the burial of the CSR at strategic locations. In many cases these also align with Sydney Metro's access needs in the future.

Turnouts – Sydney Metro require three new turn-outs located at Bankstown, Campsie and Sydenham, plus two existing Sydney Trains turnouts at Campsie to be renewed and retained.

Operating rules dictate that the new turn-outs must be clamped, locked and detected by the Sydney Trains signalling system. They do not however need to be integrated to provide Sydney Trains control.

During 2022 static testing of the metro operational systems (signalling, communications, radio and station systems) will be carried out. The period of 2023 through to the final conversion date in 2024 is reserved for dynamic testing of the rolling stock with these systems. This will require a very effective and efficient method of transferring control to Sydney Metro, with a lot to be done in a three to five hour window. In order to reduce the level of integration complexity during the testing period, renewal of the existing turnouts will be completed during the third quarter of 2022, following which they will not be returned to Sydney Trains operation (an agreement reached with their operations staff).

There are further turn-out works to be carried out at Sydenham. Temporary works will enable Sydney Metro trains from the now vacated platforms 1 and 2 to transition onto the Sydney Trains network to facilitate the dynamic testing. Permanent work will be completed at final conversion to separate the two railways when the Metro goes live.

Corridor Systems – All operational systems are to be overlaid onto the Sydney Trains infrastructure, commencing mid-2021 and to be completed by the third quarter of 2022. The equipment to be installed includes, balises, axle counters, Wi-Fi antennas for the CBTC and transmission of train CCTV, radio masts and antenna and the communications requirements for access into the corridor (CCTV, electronic access control and centralised control system connections).

Due to the fact that Sydney Trains operations must continue, the design of the CBTC system must ensure there are no clashes between the existing track circuit Insulated Rail Joints (IRJs) and the axle counters.

"The terrain provides logistical challenges making the masts for the Wi-Fi antennas difficult to position and install"

The terrain of the Bankstown Line equally provides logistical challenges making the masts for the Wi-Fi antennas difficult to position and install, a decision has therefore been made to fit these on the existing (retained) OLE structures and to locate the associated cabinets near the base of the structures, due to cable length limitations.

Five new traction supply sub-stations are being installed along the corridor for the new Sydney Metro operations, these will be made live in preparation of being used and tested, however they cannot be connected until the final conversion period.

The intent is to maximise the use of the existing OLE, however there will be the need to provide additional sectioning arrangements at the location of the new turn-outs. Following further modelling to demonstrate the capability of the system to meet the end state operational needs, some changes may be required on the Sydney Trains traction control system in preparation. Additionally (and covered in more detail in the pre-testing section later in this paper), there will need to be temporary sectioning installed on both the Sydney Metro City section traction control system and the Sydney Trains system at Sydenham to facilitate the safe transitioning of Sydney Metro's rolling stock onto the Bankstown Line in order to carry out dynamic testing.

Corridor Access Control and Intrusion Detection – In order to comply with IEC 62267 (Safety Requirements for an automated GoA 4 railway), access control into the corridor needs to be in place between Sydenham and Campsie. This is particularly challenging as it will require a boundary fence (2.4m high security type fencing) to be constructed in the 10ft between the Sydney Trains and ARTC lines. It is anticipated that it may not be possible to fully construct the fence prior to conversion due to signal sighting issues.

Other security works are also intended to take place during the period between late 2020 through to late 2022. Between Sydenham and Campsie this will consist of 2.4m high security type fencing installed on the down side of the alignment (up side mentioned previously). The fencing is to be installed on both sides of the alignment between Campsie and Bankstown.

A number of risk/hazard workshops have taken place to assess the adequacy of the protection proposed on the corridor (e.g. high security fencing), which has identified the need to provide additional intrusion detection systems at known locations where trespass occurs regularly. There is also the need to detect any potential objects that could fall from the ARTC freight trains.

The form of these intruder detection systems is yet to be fully determined, however whatever is finally decided upon will be subjected to significant testing for reliability as they will be directly linked into the signalling system. Systems employed for a very short section on the Sydney Metro Northwest section (CCTV) have proved to be unreliable and generate false alarms. Investigation has commenced into the potential use of lidar

Canterbury station platform.

sensors and vibration detection using optical fibre sensors. Other corridor protection activities to be carried out prior to the final conversion include the installation of anti-climb and anti-throw screens on bridges.

Development works

In addition to the corridor protection (intruder detection) development works, which in reality is an exercise to prove existing technologies, can be adopted and applied to a GoA 4 railway application, there is the need to design and develop an integrated PSD/MGF/ODS system.

DDA compliance demands the gap between the train door and the platform edge shall not exceed 40mm in the horizontal plane or 12mm in the vertical plane. Due to the curvature of the platforms and the existence of three door thresholds on each carriage, horizontal gaps of up to 200mm (after 100mm of fixed frangible gap fillers have been installed) have been identified. This has triggered the need to utilise a MGF mechanism at strategic locations where the fixed gap filler alone will not meet the compliance requirements.

Sydney Metro has conducted a number of risk/hazard workshops specifically looking at the risks associated with the retention of curved platforms, the need to use MGFs for DDA compliance and the failure scenarios that would need to be managed.

"Sydney Metro has conducted a number of risk/hazard workshops specifically looking at the risks associated with the retention of curved platforms"

A technical and performance specification attracted interest from a number of suppliers and in January 2020 Sydney Metro selected three companies to take forward a development contract.

The development phase is an 85-week process where each supplier will be required to demonstrate compliance to the technical specification and also prove reliability (RAMS) of the integrated product and its robustness to meet the harsh and varying weather conditions associated with being exposed in an outdoor Australian environment.

Detailed discussions with the signalling supplier on Sydney Metro highlighted the development difficulty and complexity associated with making any changes to their systems hardware and software in order to provide additional control signals to and from the PSD for the MGF and ODS. Sydney Metro therefore recognised that the interface between the PSD/MGF/ODS and the signalling system must not differ from that presented between a traditional PSD/signalling arrangement as provided on the rest of Sydney Metro. This means all safety requirements to ensure that the MGFs deploy in advance of opening PSD and train doors, that obstacles (objects or people) between doors are detected and to ensure that the MGFs do not retract if something is present and the MGFs are fully retracted prior to the train being allowed to depart. All of these safety features are required to be carried out within the PSD/MGF/ODS integrated system and the timing of the door synchronisation, dwell times, etc. are accounted for and to fall within the specified period to enable adequate egress and access for passengers, whilst at the same time meeting committed journey time for the line.

Following the trial period (mid-2021) Sydney Metro will choose a single supplier to design, install, test and handover to the systems integrator for integration and acceptance in the final conversion period.

Due to the nature and uniqueness of the PSD/MGF/ODS system Sydney Metro is working in close collaboration with the future operator and the Office of the National Rail Safety Regulator (ONRSR) to ensure acceptance from both a technical and safe working perspective.

Corridor Southwest Metro.

Testing

During the period between 2021 through to the end of 2022 a series of testing activities will be carried out, Operational Control Centre (OCC), stations, corridor systems and corridor security works.

Operational Control Centre – The OCC systems installed for Sydney Metro Northwest are required to be expanded to incorporate both the City Section and the Bankstown Line operational and stations systems. The systems affected are CBTC/CCS, communications systems, Power Control System (PCS), Fire Control System, BMCS, depot control, radio and the expansion of the operations floor.

"Testing is broken into Operational Control Centre, stations, corridor systems and corridor security works"

The expansion of these systems will need to be carried out 'off line', whilst the systems are in operation. Testing will be staged through agreed possessions and during the 'maintenance period' each evening with the cooperation of the Operator, using 'over and back' arrangements until the commissioning phases for the depot expansion, City Section and Bankstown Line Section.

Changes are also required at the back-up control centre (BOCC) to facilitate the new functional and operational arrangements transferring station management from the BOCC to newly introduced group station management rooms (further detailed later in this paper).

Corridor systems static testing – A temporary OCC is to be installed and located in the stabling depot at Sydenham. This will facilitate the static testing of the signalling and train control systems along the Bankstown Line during the third and fourth quarters of 2022, prior to preparation for the start of dynamic testing in 2023/2024. At the end of 2022 the Bankstown Line will be connected to the OCC (which at this point will have already been upgraded in preparation of the required integration testing). As per the arrangements agreed when extending the systems in the OCC, the static testing of the signalling system when connected to the OCC will be done during 'out of hours working' of the Sydney Metro Northwest and City operations.

"The expansion of these systems will need to be carried out 'off line' whilst the systems are in operation"

Corridor systems dynamic testing – The PCS has to be configured to monitor and control all of the HV distribution equipment (33kV, 11kV, critical low voltage including uninterruptible power supplies) and the 1500V DC traction supply. As mentioned previously, there is the need to be able to move Sydney Metro rolling stock from the City Section (which will be in operation) onto the Bankstown Line under full power conditions to carry out dynamic testing. This needs to take place from the beginning of 2023 (prior to the conversion) and as such will need to utilise the Sydney Trains traction system. A temporary arrangement will need to be implemented (and later removed). This will necessitate changes on both the Sydney Trains and Sydney Metro PCS systems and an agreed operational process to be in place such that control of the traction supply sectioning is transferred in a safe manner.

In advance of the Metro rolling stock being allowed to enter the Sydney Trains corridor a series of tests will be required to ensure that it does not introduce EMC and stray current issues onto the existing operational systems. This testing will be carried out during 2020 and is part of the 'residual assets' process explained later in the paper.

At the commencement of dynamic testing all track works will have been completed, including slewing into the final end state. It should be noted that not all corridor access and detection systems will be completed in advance of the final conversion, as such there will be a mix of operational procedures in place as well as physical testing completed.

The dynamic testing will be carried out progressively from Sydenham to Bankstown and will demonstrate functionality and systems integration between the train and the infrastructure. This will culminate in proving the end-to-end journey time between Sydenham and Bankstown.

A level of headway testing will be carried out, however this will be limited to the constraints in place on the Sydney Trains traction supply system.

Stations – The station control system topology at the OCC breaks the Sydney Metro network into three group station management systems which, when the OCC has failed and/or been taken off line, transfers the control of groups of stations to three specified locations, Macquarie University in the northwest, Barangaroo in the City and Sydenham in the southwest (Bankstown Line). The group station functionality is to be tested prior to conversion and for the Bankstown Line requires a temporary server to be installed at Sydenham to test the Bankstown Line in isolation of the rest of the network and then later back to the OCC in preparation of the final switch-over.

With all station systems centralised equipment having been expanded in advance at the OCC, the Bankstown Line stations can be tested in readiness of the final conversion. The systems that are affected by this are CCTV, PA, help points, telephony, visual information, emergency evacuation control system, building management and control, fire and CCS interfaces.

Additionally, in order to reduce risk and also test interface functionality, the MGFs will be installed at the stations and the electronic and physical interface will be tested. A signalling emulator will be provided by the signalling supplier and fitted into the PSD control room. This functionality of the PSD deployment and retraction along with the physical proving of the train to platform gap interface will be demonstrated.

Post conversion works

In this section we look at those elements that can only be achieved in the final shutdown. The post conversion activities again involve installation, testing, performance proving of systems, plus final end-to-end railway testing and acceptance.

Willey Park station seen from the railway and, below, from the street.

Post conversion installation works

There are a number of activities that can only be carried out in the period where Sydney Trains is finally closed down and Sydney Metro commences its services (the conversion period). The following works are the main activities to be completed in this period;

"Elements that can only be achieved in the final shutdown"

Stations works – these include change out of all furniture and signage, the removal of Sydney Trains systems and equipment (help points, PA, CCTV, and information screens), a station 'deep clean', 'un-bagging' the Sydney Metro station systems and the installation of PSDs and ODSs (noting MGFs will have already been installed and part tested).

The new at grade concourse at Bankstown will need to be installed once the two rail networks have been separated. Signalling changes to Sydney Trains systems will need to be implemented, buffer stops installed on both railways and the installation and testing of the associated station systems will also need to take place.

Corridor works include – completion of outstanding security fencing in the 10ft between ARTC and the Metro corridor, completion of the associated fencing and intruder detection systems and testing of these, decommissioning Sydney Trains traction system and completing the connections of the Sydney Metro traction system and testing.

It should be noted that included in the traction systems activities is the separation of the two systems at Sydenham, the cutting and separating of the two systems at Bankstown and the removal of the temporary sectioning arrangement on the Sydney Metro City Section and reinstating the final arrangement.

Other works include bonding over IRJs (these will later be removed once the Metro is operational as a planned maintenance activity), removal of the detection arrangements on all turn-outs with Sydney Trains signalling system and also the removal generally of any "Metro operational impacting assets" that belong to Sydney Trains and the completion of the corridor security fencing, including the installation of gates, Electronic Access Control System (EACS), CCTV and CCS equipment.

Testing and commissioning – having carried out a significant amount of testing (both systems acceptance and systems integration) in advance of the final conversion period, the most critical elements to be tested and accepted are the PSD/MGF/OSD systems.

Although there is the requirement to cut-over the new traction system, the bulk of this will have already been tested as will the majority of the other corridor systems and outstanding station systems at Bankstown.

The largest period of time required prior to going into service will be that necessary to do operational readiness testing, along with final headway, end-to-end performance and journey time testing.

In the final shutdown and conversion window the Bankstown Line will require the 'cutting over' of the systems in the OCC, which will previously have been tested and readiness commissioned in advance in line with the agreed transition plan.

Residual assets

A significant proportion of the existing corridor's assets is intended to be retained. However, in order to do this Sydney Metro must prove to the incoming operator that the assets are fit for the purposes for operating a GoA 4 railway, that they meet the required standards and the agreed performance requirements (including RAMS) such that no renewals will be required for the length of the term. The residual assets are broken into different categories, these being;

"Sydney Metro must prove to the incoming operator that the assets are fit for the purposes of operating a GoA 4 railway"

Baseline residual assets – these are considered to be operational performance impacting systems. The assets are, track system (excluding the track bed), OLE (wire, insulators, droppers and structures), embankments, cuttings and retaining walls;

Specified assets – these are also assets that can affect operational performance; however, Sydney Metro retains the risk of these meeting requirements. The assets are bridges, culverts and station structures;

Track bed – this can affect operational performance and Sydney Metro retains the risk of this meeting requirements, however there is an obligation on the operator to monitor and provide early warnings of any deterioration in advance of implementing any operational controls.

Lifts – an agreed position will be taken as to the performance of any retained lifts and the operator must continue to meet ; and

Retained assets other – these are non-operational impacting assets such as retained station canopies, buildings, and station drainage .

The critical retained assets are considered to be the "Baseline residual assets" and in order for these to be accepted by the operator into the performance regime these are to be subjected to a process of 'evidence proving measures'.

The evidence proving measurements include a number of activities which require surveys and tests to be carried out, evidence of maintenance regimes being adhered to by Sydney Trains and the provision of failure records for the previous five years enabling RAMS analysis to be carried out through reverse engineering techniques. All of this will culminate in a report for each asset that provides a fully populated engineering assurance register. The report will contain the appropriate verification and validation (V&V) evidence of compliance with appropriate Asset Standards Authority (ASA) standards, references to specific V&V evidence documentation, including technical reports, reference to evidence to be verified through testing and commissioning activities and reference to other deliverables as outlined in baseline specification verification process.

To further support the baseline residual assets process as-built drawings will be collated along with asset condition reports, known defect reports and other relevant information received from Sydney Trains. These will be related to the track system and OLE only, along with the inclusion of safety assurance reports.

In addition to the above, a schedule of amendments, derogations or departures to the Scope and Performance Requirements (SPR), as applicable, and details of SPR requirements that are unable to be satisfied will be provided.

All of the above will be subject to an Independent Checker (IC) compliance verification.

Systems engineering and safety assurance

The necessary systems engineering and safety assurance case will be built up through evolution and is the responsibility of the systems integrator to collate and present to the operator, who along with the operational readiness plan will seek approval from the rail regulator to enter service.

The overarching systems engineering and safety case will consist of the individual evidences and arguments present by the stations, line wide systems (including tunnelling), operational systems (including rolling stock) and the baseline residual assets. All of these will have been subjected to an Independent Safety Assessor (ISA) review and certification, supporting each element and the overarching case.

Summary and conclusion

Systems integration is the key activity in order to achieve a successful implementation and introduction into service of the Sydney Metro City & Southwest. This has been recognised at the outset, taking lessons from the challenges witnessed on Crossrail in the UK. Through the introduction of a project wide systems integrator looking at all interfaces both physical and technical, Sydney Metro has seen huge benefits in risk reduction. Sydney Metro has introduced a number of working groups, all under the

"Systems integration is the key activity in order to achieve a successful implementation and introduction into service"

review and in many cases control of the Systems Integrator. These working groups look at:

- RAMS across all delivery packages seeking an 'end-to-end' approach to this critical element and ensuring that interfaces between contracts address this;
- Fire and Life Safety (FLS) ensuring the requirements of the operator's FLS Strategy are being met;
- Earthing, bonding, stray current and EMC, ensuring compliance both within packages and at interfaces between them;
- Safety assurance, monitoring the evolving evidences and cases from each delivery package and ensuring consistency in development and compatibility to meet the overarching requirements necessary to satisfy the operator and rail regulator;
- Systems integration and operational readiness ensuring that designs (and later construction) consider the requirements of the operator's intent to operate and maintain the Metro; and
- Requirements management, providing continuous rigour throughout the whole project life cycle (concept, through design, into construction and finally testing). Monitors traceability of requirements in each delivery package and reports on deviations and/or approved derogations (this includes residual assets).

In addition to the above Sydney Metro have a governance structure that provides a mechanism for all of the above working groups as well as the individual delivery groups to be able to escalate evolving issues and ensure a timely intervention and direction, providing risk mitigation and management.

Noting all of the above, the conversion of the Bankstown line brings with it additional complexity, requiring integration at a systems level and provisioning of evidence of 'no impact' to Sydney Trains systems and operations during the construction and pre-conversion testing phases.

It also requires strong cooperation between the two operators prior to conversion, ensuring the safe operation of the existing railway is maintained throughout the period leading up to the final shutdown and introduction of Metro services.

There are also the technical challenges associated with the introduction of new solutions necessary to meet both DDA compliance and corridor protection all of which will require development and proof of safe and reliable application as well as development of individual safety cases.

Add to all this the additional requirement to preserve heritage and maximise the use of existing assets and it can be seen that this project provides for an interesting case study.

Although the conversion of the Bankstown Line brings with it the challenges mentioned above, it is also recognised that with these come huge potential opportunities for the future.

Examples of these benefits are the ability to convert and expand GoA 4 operations on other parts of the Sydney Trains network in a cost efficient manner, and with the development of the PSD/MGF/ODS product it is seen that this can be adapted for use on parts of Sydney Trains network where the issue of a train to platform gap safety concern presents itself.

Other benefits include the development of a reliable intrusion detection system to assist with future conversions, as well providing the ability to develop new at grade GoA 4 metros that can demonstrate compliance to the requirements of International Standards of safety.

The Sydney Metro City & Southwest project and specifically the Bankstown line conversion, provides both a case study and evidence for other railways around the globe to consider how the approach being taken by Sydney can be applied in a positive way on their operational railways. The success of this project will set the way for other railways to enjoy the benefits that come with GoA 4 railways sooner and in a cost-effective and efficient manner.

About the author ...

Steve, originally from the north of England, is currently an executive director for ARCS (International) in Australia. He is an experienced rail and transportation executive who has been involved with rail infrastructure projects, asset management, maintenance, systems, operations and management throughout Australia, Asia, India, Europe, Middle East and North America.

With a background in railway telecoms Steve has a broad depth of railway engineering knowledge including signalling, and encompassing heavy rail, metro, light rail and freight.

What do you think?

What is your experience of converting a railway to a higher grade of automation?

Do you have a different experience to that explained by Steve in this article? Have you found or developed a technology that offers protection of the guideway that is different to those described? Do you even think there is a case for upgrading to higher levels of automation?

We'd love to hear about your experience, why not let us know what you think, email **editor@irsenews.co.uk**.

IRSE
Institution of Railway Signal Engineers

Back to basics: Interlocking Part 2

BACK TO BASICS

Francis How

Last month in IRSE News there was the third in a series of articles on 'back to basics' themes, looking at the essentials of 'interlocking', focused on the technology used. This month we are going to look at the functions that an interlocking performs, and how these ensure the safe movement of trains.

This article is no more than an introduction to the subject, intended for IRSE members new to the industry rather than those who are experienced in specifying, designing and testing signalling systems.

The functions of a modern interlocking

We saw in last month's article that interlockings have used a variety of mechanical, electrical, electronic and software-based technologies over the years. But regardless of what technology is used, a route-setting interlocking must perform essentially the same functions in order to ensure the safe movement of trains. These functions, which are defined in the railways' signalling principles and application rules, must be compatible with the operational rules/regulations for the movement of trains, under both normal and failure conditions.

"Signalling principles vary from country to country but are similar in their basic requirements"

The signalling principles and application rules for the interlocking functions vary somewhat from country to country but are similar in their basic requirements. The descriptions of the principal functions in this article are based on the current signalling principles used for colour light lineside signalling of passenger railways on the mainline railway in Great Britain and in some other countries (they are relaxed somewhat for shunting, permissive and freight movements, but these are not covered in this article). Where some railways adopt significantly different practices, these are noted but are not described in any detail.

Checking route availability

When a request to set a route is sent from the control panel/desk/VDU (or from the Automatic Route Setting system, where one is provided), the interlocking first checks that the route can be set in its entirety, and that the request does not conflict with any other routes that have already been set or are in the process of being set. Without this check, the interlocking might start moving points to set the route but fail to complete the process because one or more points are locked in the wrong position by routes that are set for other train movements. The check is also vitally important for 'directly opposing' routes, for trains travelling in the opposite direction to the route whose availability is being checked, and for which the point settings are identical.

If the whole of the route is not available for setting at the time the request is received by the interlocking, it is rejected or ignored, rather than being stored until the route can be set. This is a feature known as 'anti-preselection'. Not all railways include it, but it is often regarded as good practice to prevent a route request from continuously trying to make the interlocking set a route that cannot (yet) be set.

Route setting and locking

When the route availability check is successfully completed, the interlocking starts moving the points in the route to their required positions. It may also be necessary to move other points that are not in the route itself, to protect the route from other trains in the event that they pass a signal that is displaying a stop aspect.

When the points are correctly positioned, route locking is applied to all the track detection sections that form the route, thereby reserving each section for the route being set, preventing the points from being moved and ensuring that no conflicting routes can be set.

Interlocking has been an underpinning concept for railway safety since the 1850s, although the technology upon it depends has changed phenomenally during that period. Areas of points and crossings are the most complex part of any interlocking design. *Photo Paul Darlington.*

"Some railways don't use overlaps at all"

Overlaps

Many countries and railway administrations also lock and protect a short section of track beyond the exit signal as part of the route-setting process. This is called the 'overlap', and it is typically between 50m and 200m in length. The provision of overlaps is not a universal practice, however. Some railways do not use overlaps at all and, at the other extreme, some have overlaps which comprise, in effect, all the track from the exit signal to the next signal beyond that. Even on railways that use overlaps, they are not necessarily required for all types of routes. Where railways do use overlaps the rules for setting and locking them vary from one railway administration to another, so it is worth emphasising that this description applies to main line railways in Great Britain and is not necessarily true of other railways.

The purpose of an overlap is that if the exit signal is at danger (stop) and the train fails to come to a stand at the signal because of inadequate deceleration, it is likely to stop within the overlap distance and so avoid risk of collision with other legitimate train movements. Of course, it is not guaranteed that the train will stop within the overlap, and an overlap is of no help at all if the train brakes have not been applied or the adhesion conditions are very poor. It should also be noted that with cab signalling, overlaps have an additional purpose, to do with the accuracy with which the train location is known.

Trailing points in an overlap are set to the correct position and locked when a route is set. Where there are facing points ahead of the exit signal there may be more than one overlap that can be used. These facing points must be set to the position required for the selected overlap, and they may also be locked. The reason for not locking the facing points in all circumstances is that in complex areas such as stations, the interlocking may permit the overlap to be changed after the entrance signal has been cleared (a feature known as 'swinging overlaps') by moving the position of the facing points to create a new overlap. This provides signallers with greater operational flexibility. The facility to swing an overlap is inhibited by the interlocking as the train approaches the exit signal so that a safe (locked) overlap exists in case the train passes the signal at danger. Designing the circuits or data for swinging overlaps can become very complex indeed, however, and their provision should be limited to that which is considered necessary for operational purposes.

The setting of an overlap happens only if the exit signal is at danger (stop), of course. If a further onward route is set for the train, from the exit signal to the next signal beyond, then that route is itself set and locked in the same manner as described above.

Clearing the entrance signal

When the route has been set (as described above), all relevant train detection sections must be proved 'clear' (i.e. no train or vehicles present) before the entrance signal is permitted by the interlocking to show a proceed aspect. This includes:

- All the track that forms the route between the entrance and exit signals.
- All the track that forms the overlap ahead of the exit signal (if an overlap is provided).
- Any other sections of track on which a train or individual rail vehicle could stand and be 'foul' of the route (i.e. with which the authorised train could collide).
- Any 'flank' sections of track, which are included to provide early detection of another train passing its own exit signal at danger (SPAD) and thereby intruding onto the route of the authorised train.

In the case of lineside signalling, other checks may also be required before the signal is permitted

Interlocking design is based on the avoidance of conflicting routes, allowing for a wide range of combinations of possible events. *Photo Paul Darlington.*

"There may be other requirements that have to be satisfied before the interlocking will permit the entrance signal to clear"

to clear, including the following. Not all railways apply these checks, and the specific rules for applying them vary from one railway to another:

- The exit signal must be alight (i.e. displaying a visible aspect), to avoid the risk of the driver failing to see it.
- If the entrance signal is required to display a route indication for the route set, that indication must be proved alight before the entrance signal is permitted to display a proceed aspect.
- If the train is being routed over a diverging junction ahead of the entrance signal, that signal may be held at a restrictive aspect (stop or caution) by the interlocking until the train has slowed down sufficiently for the diverging points and the route beyond.

There may be other requirements that have to be satisfied before the interlocking will permit the entrance signal to clear, for instance for level crossings or train protection systems (the latter to stop, or mitigate the risk of, the train passing its exit signal at danger).

The actual aspect displayed by the entrance signal when it clears, including any speed or route indications, depends not only upon the route immediately ahead, but also on whether a further route has been set for the train beyond the exit signal. The sequence of aspects seen by a driver at successive signals as he or she approaches a signal at danger (stop) varies from one railway to another and is not dealt with in this article.

On most railways that use colour light signalling, the entrance signal will revert to danger (stop) if the conditions that permitted it to clear are no longer fulfilled. So, for instance, if a track circuit in the route fails, or there is a loss of detection on a set of points, the entrance signal will automatically revert to danger. This is a safe arrangement but can be worrying for a driver who unexpectedly encounters a signal at danger (stop). Some railways do not include reversion – and of course, with mechanical signals there was no possibility of doing so!

Route holding and release

When the train passes the entrance signal (showing a proceed aspect), the interlocking returns the entrance signal to danger (stop) but maintains the locking ahead of the train to prevent points from being moved and conflicting routes from being set. In order to maximise capacity and flexibility it is, however, desirable for the locking to be removed as soon as it is safe to do so after the passage of the train, in order that other routes may be set which make use of the same track (or some of it).

Before the locking can be released after the passage of the train, the route request must first be cancelled. Traditionally this would be done by the signaller using the control panel/desk. However, to ease the signaller's workload and to enable the locking to be released as soon as possible, many modern interlockings include a function called 'train operated route release' (TORR), which cancels the route request from the control panel/desk when the train has passed the entrance signal, without any action by the signaller. The interlocking normally does this by checking that the first two or three train detection sections beyond the signal show 'occupied' and then 'clear' in the correct sequence with the passage of the train (this minimises the risk of a train detection failure leading to the premature release of the route). Although the route request is cancelled by this process, the route locking is maintained to ensure the safe passage of the train.

The interlocking may also have a function which permits individual portions of the route to be unlocked as soon as possible after the train has passed, rather than having to wait until the train has passed through the whole route. This is known as 'sectional route release'. As the train passes clear of each train detection section in the route, the locking on that section is released, provided that:

- The entrance signal has returned to 'stop' (danger).

- The route request has been cancelled (either by the signaller or by TORR).
- All the route locking from the entrance signal up to the start of the section has already been released.

Route locking ahead of the train continues to be maintained.

Approach Locking

There is a further category of route release, applicable only where the route has to be cancelled **before** the train passes the entrance signal. Clearly this is an unusual set of circumstances – for instance if the signaller needs to change the order of two trains at a junction after the route has been set for one of them, or if there is an emergency and it is necessary to try to stop the train. In such circumstances the signaller cancels the route on the control panel/desk, which has the effect of setting the entrance signal to stop (danger). This action does not necessarily immediately release the route locking ahead of the entrance signal, however, in case the train cannot brake sufficiently to stop at the signal and consequently enters the route beyond it.

"There are many other functions that may feature in an interlocking"

The interlocking function that determines when the route locking ahead of the entrance signal is released in the circumstances described above is known as 'approach locking'. In its more comprehensive form, it maintains the locking of the route ahead of the entrance signal (which is displaying stop/danger) until one of the following conditions is satisfied:

- The train has come to a stand at or before the signal, or
- The train has sufficient braking distance to come to a stand at or before the signal.

With lineside signalling the first of these conditions is usually achieved by using a timer in the interlocking, rather than directly confirming the train is at a standstill. When it has finished timing, the train is assumed to either have come to a stand at the signal or to have passed it, being unable to stop in time (in the latter case the route locking holds the route safe for the train). The second condition consists of a check by the interlocking that the train has not yet occupied any of the train detection sections between the sighting point of the first signal displaying a caution aspect and the entrance signal displaying stop. With cab signalling, the speed and location of the train are usually known and can be used to check the two conditions, which is a more accurate method of checking whether the conditions are fulfilled.

Releasing the overlap

If the exit signal is at danger (stop), and the train has safely stopped at it, then it is necessary to release the locking of any points in the overlap beyond the signal. The reason for this is that the points may either not be set correctly for the train's onward route, or because another train needs to use some of the track and points in the overlap.

With lineside signalling, the interlocking times the train's occupancy of the last train detection section on the approach to the signal. When the timer finishes, and provided that the train detection section immediately beyond the signal has not been occupied, the interlocking will release the points in the overlap. With cab signalling, the speed and location of the train are usually known and can be used directly to check the train is at a standstill at the signal.

When the interlocking determines that the train is stationary at the exit signal, the locking of the overlap is released and the track and points in it can be used for setting the onward route, or for routing other trains.

Other interlocking functions

This article describes only the basic interlocking functionality of a signalling system. There are, of course, many other functions that may feature, including:

- The role of the interlocking in displaying speed information via lineside signals. This is of particular importance on 'speed signalled' railways, as distinct from 'route signalled' railways.
- Interlocking the signalling system with protection systems for personnel working on the track.

Interlocking design has to consider many factors including the speed of the trains using the railway and interfaces to other equipment such as level crossings. *Photo Shutterstock/ VanderWolf images.*

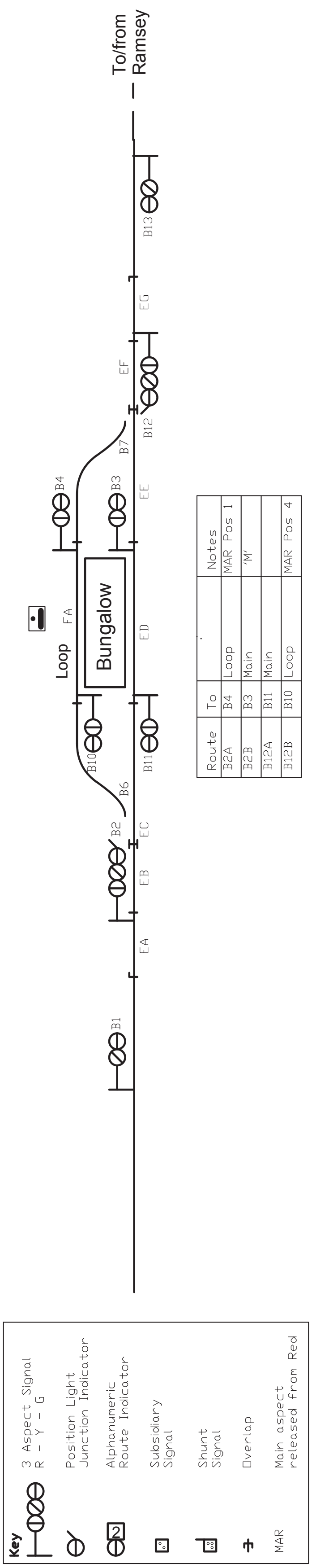


Figure 1 – Simple Scheme Plan, showing the signals, train detection sections, points, overlap etc. This example was used in a recent IRSE examination.

Route Information			Points Free to Go or Release		Route Normal	Opposing Route Locking Locked after route set until		Points Called, Locked and Detected			Tracks		Aspect Sequence			Approach Locked when		Approach Locking Released			Special Controls
Entrance signal / Route	Exit signal	Class	Normal	Reverse		Tracks Clear	Tracks Occupied for time (sec)	Normal	Normal or Reverse	Reverse	Proved Clear	Proved occupied for time	Aspect	Indication	Signal Ahead Aspect	Signal Cleared/ Route set	Unless tracks clear	First Condition	Second Condition	or Time (secs)	
B12A	B11	Main	B7, B6	-	B3	EE	-	B7, B6 #10	-	-	EE#11, ED, EC	EG #12	Y	-	B11 Red#13	B12	-	EF occ, EE occ	EF clr, EE occ	180	#15, #16, #17
					B2	EE [EB, EC, ED ……or …..	ED for 40]						G #14	-	Green						

Assumes

- Modern Network Rail practice, including:
  - TPWS train protection designed to stop train within overlap length
  - Route locking incorporates track bob protection
- Sufficient standage in the loops that the longest trains may pass; therefore special controls are not necessary.
- No special controls relating to the method of single line working are necessary (method is unspecified on the plan but would appear not to be Track Circuit Block, Token Block nor One Train Working- No Staff).

Special Notes

#10 Point set and locked, but not detected

#11 Stick track - returns signal to red (danger) when occupied when signal off and berth track also occupied

#12 Only applies when Temporary Approach Control Facility selected by technician

#13 Includes proving that associated TPWS loops energised

#14 AWS electro live when signal at green and alight, AWS suppressor energised after route set from B3 or B4 provided that no Up direction movement from Ramsey is possible.

#15 TPWS energised whilst signal controlled to Red

#16 Route cancelled by triggering of Pre-Defined Overrun Protection Group by a SPAD detected at B2

#17 Route cancelled by activation of Signal Group Replacement Control

Figure 2 – Example of a signal/route control table for the route from signal B12 to B11 (as shown in Figure 1). Our thanks to Peter Woodbridge for creating this example.

However functional and complex the interlocking is, it's important to ensure that the information relayed to the driver is clear and easily understood, as an aspect indicating safe speed (left) or route based signalling. *Photos Shutterstock/ Miles Schofield and Paul Darlington.*

- The provision of train protection systems (which will be covered in another 'Back to Basics' article, soon to be published in IRSE News).
- Interlocking with level crossings or other moveable infrastructure (e.g. swing bridges).

Specifying interlocking requirements

The process for specifying the interlocking requirements for a particular track layout is strictly governed by railway administrations (or in some cases their regulatory bodies), because of the safety implications of an error.

Ideally, the starting point for the signal engineer is to be provided with details of the proposed track layout and the operational requirements. The first of these includes knowledge of the location of points and associated critical dimensions. The operational requirements include the frequency of trains, their maximum speeds and braking capabilities, the required headways and the specific train movements (main line, shunting, permissive etc).

In practice, this ideal starting point is not always the reality! Signal engineers may, for instance be told to replicate the existing signalling arrangements in modern form (which is itself an ambiguous statement), without being given any explicit statement of operational requirements.

The signal engineer also needs to know the signalling principles applicable to the railway for which the design is being prepared. These are the high-level generic rules for ensuring the safe movement of trains, and they cover all the requirements relating to route setting, locking and release – and more.

The knowledge of the track layout, the operational requirements and the signalling principles enables the signal engineer to produce two key sets of documents. The first is the Scheme Plan, and the second are the Control Tables.

Scheme Plan

The Scheme Plan depicts the layout of the track, showing points, signals, train detection sections, level crossings, stations, permissible speeds etc. Each track is usually shown as a single line, not a pair of lines. Each signalling object is allocated a unique identity (numbers and/or letters). The plan also shows the routes that each train can take from each signal. Each route is given a unique identity. Other relevant information may also be shown on, or be associated with, the Scheme Plan. A simple Scheme Plan is shown in Figure 1, for a single line with a passing loop at a station. The symbols shown are used by many railways around the world, but are not universal.

Control Tables

The Control Tables state all the conditions that must be fulfilled for each route before a train can be given a movement authority to use it. The route information is derived from the Scheme Plan– the position of points, the train detection sections that must be clear, other routes that must not be set etc. Approach locking release conditions are also specified, as are requirements for functions such as the delayed clearance of signals at diverging junctions, and the aspect sequence for successive signals. A simple example of a signal/route control table is shown in Figure 2, for a route from signal B12 to B11 on the Plan in Figure 1. The requirements are based on current British (Network Rail) signalling practice and include some features (such as train protection proving and technician controls) that we have not dealt with in this article.

Control Tables are also prepared for each set of points, stating the conditions that must be fulfilled before a set of points is free to move. This includes the routes that require the points to be normal or reverse, dead-locking train detection sections and point-to-point locking.

It is in the preparation of the Control Tables that the signal engineer's knowledge of the signalling principles and application rules is of vital importance. From the Control Tables, the circuit diagrams for relay interlockings (based on standard circuits) can be produced, or the data in the case of a computer-based interlocking.

The production of the Control Tables is, therefore, a critical step in the design and configuration of the interlocking. Nevertheless, the gradual automation of the design process means that it is possible to go directly from Scheme Plan to detailed design, with the Control Tables being a by-product of the process for later use (e.g. for recording tests performed on the interlocking), rather than being a key stage in the design process.

Closing remarks

This article and last month's have provided an introduction to railway interlocking – and if you want to know more, some of the IRSE textbooks cover the subject in greater detail. For many signal engineers the specification and design of interlockings is at the heart of their careers. It requires knowledge, experience and expertise – and it is vital to the safety of the railway. But if you are new to the industry, don't let that deter you. Instead, take every opportunity to learn from those who have the experience and knowledge.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

High speed collision in Italy

Italy: On February 6 a Trenitalia ETR 1000 derailed on the high-speed line south of Milan. Two people were reported to have died and around 30 injured. The train departed Milan Central Station at 05.10 with the accident occurring at around 05.30 on a four-track section of the high-speed line around 50km southeast of Milan, near Casalpusterlengo in the province of Lodi.

It is believed the train derailed at a set of points, crossing the adjacent line and four sidings. The leading driving car colliding with two freight wagons and came to rest on its side facing the opposite direction of travel. The rest of the train derailed and continued between the two tracks, with the second coach also coming to rest on its side and the rest of the train remaining upright.

The investigation of the derailment will be carried out by the public prosecutor in Lodi, Domenico Chiaro. He confirmed that the train had derailed on a turnout, adding that human error may have been to blame. Initial investigations suggested that a set of facing-points had been incorrectly set and this had not been detected by the train control system. Track maintenance work had been taking place in the area overnight, and investigators will examine both the work carried out and the details of communications between maintenance staff and the line control centre in preparation for reopening the line.

ETCS for East Coast Main Line

UK: Network Rail has appointed Siemens Mobility Limited and SNC-Lavalin Atkins as its partners to introduce in-cab ETCS signalling on the southern section of the East Coast Main Line (ECML). Known as the East Coast Digital Programme (ECDP) it will be the first intercity in-cab signalling railway in the UK. Siemens Mobility is the train control partner (TCP) and traffic management partner (TMP), and Atkins rail systems integration partner (RSIP).

The section of the East Coast Main Line, which covers from King's Cross to just north of Peterborough, currently operates with colour light signalling that is reaching the end of its life. Staged migration to ETCS level 2 with no lineside signals will be provided along with 300 passenger and freight trains to be installed with ETCS.

As TCP Siemens Mobility will play a central role in deploying and sustaining a high-performance train control infrastructure based on ETCS, and incorporating design, build and maintenance of ETCS together with associated infrastructure for the lifetime of the assets on the ECML. The role includes the technical integration of an end-to-end system, including with other existing or proposed systems. The £900m contract covers more than the ECDP.

The TMP has a wider remit than just East Coast Digital Programme deployment, and will see Siemens Mobility working in both the Eastern and North West and Central regions, developing traffic management for the TransPennine route as well as the East Coast Main Line, worth £108m (€123m, $134m) and £72m (€82m, $89m) respectively.

As RSIP SNC-Lavalin Atkins will support the route and coordinate industry to deliver the ECDP. They will be responsible for managing the integration activities and establishing collaborative relationships with the route, its technology partners (TCP and TMP) and stakeholders including government, passengers, freight operators and train owners. They will also provide governance and assurance to the programme via the £55m (€63m, $68m) framework contract.

A third of the population lives within 20 minutes of an ECML station, and together produce 41% of the total UK's GDP. The line carries in excess of 80 million passenger journeys, and tens of millions of freight tonnes worth £30bn (€34bn, $37bn)every year.

Federal Railroad Administration approval for New Jersey PTC

USA: The Federal Railroad Administration (FRA) has approved New Jersey Transit (NJT) to begin Revenue Service Demonstration (RSD) of its Positive Train Control (PTC) system. The federally mandated deadline for full PTC certification is 31 December 2020.

NJT will initiate the RSD on the Morristown Line between Summit and Denville, New Jersey. Field testing has been conducted on non-revenue trains that did not carry customers. NJT's existing Automatic Train Control (ATC) system will remain active and will not be affected by the testing, said NJT.

The FRA's interim December 31, 2018 PTC deadline was met by installation of onboard equipment on 282 locomotives and cabs, equipping 326 miles with lineside infrastructure and transponders, and training 1,745 employees.

Ceneri Base Tunnel testing

Switzerland: Approval has been granted for test operations in the Ceneri Base Tunnel, connecting Camorino near Bellinzona with Vezia near Lugano. The 15.4km long Ceneri Base Tunnel is the final major structure to complete the new railway link through the Alps. The construction of the tunnel was visited by the IRSE during the 2018 convention.

To enable ETCS Level 2 control system testing SBB have permission to also start testing the new electronic signal box in Vezia. The tunnel opening ceremony is currently scheduled for 4 September with the formal opening taking place in December 2020.

ETCS train fitment in Finland

Finland: A contract has been awarded to Hitachi Rail STS by Stadler to provide onboard train control equipment for 60 diesel-electric locomotives to the national railway VR. The equipment will be compatible with ETCS Baseline 3.6 as well as the national train protection system.

The first five are expected to enter service in 2022, with the rest delivered by the end of 2025.

ETCS train fitment in the UK

UK: Porterbrook, Siemens Mobility and Bombardier have agreed a new way of fitting ETCS equipment trains. To provide the best way of providing ETCS to existing fleets, train manufacturers will seek to take a more active role in fitting on-board ETCS systems to rolling stock they originally manufactured.

Heathrow Express Class 387 will be first fleet to benefit from the new approach. The trains were originally built by Bombardier, so parties recognised that Bombardier are best placed to provide and fit ETCS to this class of trains.

Siemens Mobility will also look to take an active role in fitting on-board ETCS equipment on the trains they originally manufactured. The objective of the initiative is better systems integration, fleet availability and reliability.

ETCS fitment in Germany

Germany: A contract has been awarded to Alstom by Deutsche Bahn to retrofit 19 ICE1 high speed trainsets with Baseline 3 compliant ETCS onboard.

The 19 ICE1 sets which operate into Switzerland were the first to be fitted with ETCS in 2007. The €10m (£8.4m, $10.8m) contract announced on 12 February is an option on a €23m (£19m, $25m) agreement announced in 2014 for Alstom to equip 40 ICE1 trainsets with ETCS for operation on the high speed corridor, connecting Berlin, Leipzig/Halle, Nürnberg and München.

Czech ETCS

Czech Republic: The European Commission has approved a €134m (£115m, $148m) extension to the country's state aid project to support the installation of ETCS on rolling stock. The grant will help to achieve the European Union's (EU) objectives including increasing the interoperability of the EU's rail network and supporting the shift of freight from road to rail. Under the Czech national ETCS implementation plan, trains not equipped with ETCS will not be allowed to operate on ETCS-equipped routes from 1 January 2025.

Fehmarnbelt Fixed Link consultancy contract

Denmark: SNC Lavalin Atkins have been contracted to provide consultancy services for the Fehmarnbelt Fixed Link railway that will run through the 18km Fehmarnbelt tunnel between Denmark and Germany.

Running under the Baltic Sea and connecting the Danish island of Lolland and the German island of Fehmarn, the Fehmarnbelt tunnel will provide for two 200km/h electrified railway tracks and a four-lane highway. The tunnel is planned to open in 2028.

Throughout the project Atkins will deliver railway consultancy services for signalling, train control system, telecoms, track, overhead catenary, and power supplies. German elements of the new railway will be delivered in collaboration with GAUFF Engineering from Germany.

Wherry Lines new signalling

UK: The Wherry Lines on the Greater Anglia network have had new signalling systems installed by SNC-Lavalin Atkins. At the end of February, the Norwich to Yarmouth line opened following completion of work to introduce new Atkins ElectroLogIXS signalling system. A section of the East Suffolk line from Beccles to Lowestoft also reopened. The work replaced Victorian mechanical signals which have been in place for over 130 years.

Works on the Norwich to Yarmouth line took place at level crossings including Brundall, Lingwood Chapel Road and Station Road to introduce full barriers and crossing lights along with upgrade work to several user worked crossing such as Acle Marshes to improve crossing safety. The work also saw the new signals powered up along the lines and transfer of the last of the local signal box controls to Colchester as part of the programme.

Storm-proof signalling on stilts

UK: A storm-damaged section of the UK's West Coast main line in Cumbria was reopened in less than 24 hours, helped by raised signalling equipment location housings. A similar storm in 2015 forced closure of the main line to Scotland for 14 days.

In the months that followed the storms in 2015, Network Rail raised the signalling equipment using three-metre-high stilts. When the recent storm hit the line again, the railway fared far better than 2015, and was reopened to trains within 24 hours. Although the signalling system in the location housings remained intact, the point motors which sit beneath the track were damaged and needed replacing. The route however was reopened in a day and not two weeks.

Level crossing safety video

USA: A new safety video by Operation Lifesaver, Inc. (OLI) is targeting professional drivers of lorries and their employers to prevent collisions between such vehicles and trains at railway crossings across the US Preliminary statistics from the Federal Railroad Administration (FRA) show there were 506 crossing incidents involving lorries in 2018, compared with 449 incidents in 2017 and 443 incidents in 2016.

The new 3½-minute video "Rail Safety for Cement, Dump and Garbage Truck Drivers"—shows drivers the steps to take to avoid a devastating crash with a freight or passenger train, including details on how to use the crossings. The video can be seen at irse.info/zhnlt.

Level crossing AI

Japan: Nokia's artificial intelligence (AI)-based SpaceTime scene analytics for railway crossing safety is being trailed by Odakyu Electric Railway. The trial is taking place at Tamagawa Gakuenmae No 8 railroad crossing in Machida City, Tokyo and may identify potential improvements for rail crossing safety.

SpaceTime scene analytics applies machine-learning-based AI to available camera images and can detect abnormal events. It analyses available image feeds generated by the existing crossing cameras and identifies potential issues in real-time. Edge computing resources minimises the required bandwidth at remote sites with limited connectivity.

New heavy-duty fold down post

UK: Unipart Dorman Heavy Duty Assisted Lift Trunnion (HD ALT) has been approved by Network Rail. The new HD ALT builds on the original Assisted Lift Trunnion (ALT) product and allows the majority of signal configurations to be provided with tilting structures, and for heavier more complex head types, together with taller posts.

The HD ALT uses a double spring configuration delivering the same lifting force characteristics as the original ALT, but adds another 53 heavier head types to the range of fold down signals in a combination of up to 5 separate LED modules. It will also support much taller posts for applications such as level crossing CCTV mounting and signal offset posts.

The design reduces the amount of support equipment required to install and maintain lineside signals, whilst retaining the increased worker safety element of removing working at height risks. See irse.info/sx26q.

CFR railway upgrade contract

Romania: A consortium led by Alstom, known as Asocierea RailWorks, has been awarded a contract by state rail infrastructure manager CFR to provide digital train control, traffic management and electrification infrastructure for the Rhine to Danube corridor. The project aims to upgrade nearly 170km of railway infrastructure to enable passenger train speeds of up to 160km/h, including electrification, signalling, GSM-R and civil works. Alstom will also provide a traffic control centre in Brasov, digital interlocking and ERTMS Level 2, customer information systems, catenary upgrades and electric traction substations.

City railways and light rail

ATO testing in Japan

Japan: West Japan Railway has tested automated train operation ATO on a section of the Osaka Loop Line. The tests were completed using an eight-car Series 323 EMU and undertaken at night with no commercial services operating.

A driver was present in the cab during the test runs but did not intervene. JR West's principal aim is to automate the acceleration and braking of the train, and to ensure precise stopping at stations. Wireless automatic train protection technology was also being tested. It was also assessed that the EMU entrance doors were aligned with the platform markings.

The operator hopes to introduce ATO first on the 27.7km 1.5kV DC electrified Osaka Loop Line with 19 stations, together with the 4.1km Sakurajima branch line with three stations. The objective is to improve performance and capacity, and to increase operational safety, where trains currently run at average headways of 7 minutes in each direction.

New York CBTC and new trains

USA: MTA New York City Transit have announced plans to provide up to 949 new R262 subway trains with an open-gangway configuration. The trains are for the numbered lines and to increase passenger flow and to allow customers to move freely between cars, with the potential to improve dwell times at stations and increase capacity.

The announcement builds on the plans for CBTC (communications-based train control) on the Lexington Avenue 4, 5, 6 lines and the planned retirement of the R62 and R62A fleets that have been in service for more than 30 years.

Singapore LTA simulation facilities

Singapore: Singapore Land Transport Authority (LTA) has announced it is to build simulation facilities for all its railway lines, allowing locally run simulation scenarios and testing of signalling software enhancements before being rolled out. They will feature all hardware and software systems similar to the actual signalling equipment installed. Similar systems services will also be developed for the North-East Line at Sengkang Depot and Circle Line at Kim Chuan Depot

LTA has previously established simulation centres at Gali Batu Depot and Mandai Depot for the Downtown Line (DTL) and Thomson-East Coast Line (TEL) respectively in collaboration with Siemens and Alstom.

Communication and radio

Wi-Fi data leak

UK: Station Wi-Fi service C3UK has exposed personal data of about 10 000 people who signed up for the free wi-fi service at locations such as Waltham Cross, Harlow Mill, and London Bridge stations. It was reported by the BBC that the database was not password protected and contained 146 million records, including contact information and dates of birth.

Researcher Jeremiah Fowler, who discovered the unsecured database, said "Many of the records I personally saw contained customer email addresses, age range, device data, IP and reason for travel," He warned that some of the available information, such as "IP addresses, ports, pathways, build and version, and storage information" could be used by hackers to "access deeper into the network". He also added that the free wi-fi provider "took immediate action" to secure the user data and internal records and restricted public access before he could "fully analyse the millions of records inside the database".

£65 million for 5G trials

UK: The Department for Digital, Culture, Media & Sport has announced winners of a funding budget to help unlock the potential of 5G.

Rural areas will benefit from a series of government-funded trials. Nine projects across the country will receive a share of £35m (€42m, $45m) from rural and industrial 5G competitions, and a new £30m (€36m, $39m) open competition – 5G Create – will look at how 5G can create new opportunities in industries including film, TV, video games, logistics and tourism.

Sherwood Forest in Nottinghamshire visitor experience will be enhanced via virtual and augmented reality using 5G networks. New robotic environmental management will also be tested alongside live monitoring of the health of Sherwood Forest to preserve the site for future generations. Funding will also go to 5G trials in air and sea search and rescue in Dorset using terrestrial and satellite connectivity. This project will also trial 5G connectivity for remote farms to track crop growth, monitor livestock and reduce water pollution using 5G.

5G Create will fund for seven research and development projects across the UK. This includes five in England, one in Wales and one in Scotland with plans to expand into Northern Ireland. Test sites will be set up in Yorkshire, Gwent, Monmouthshire, Orkney, Wiltshire, Nottinghamshire, Dorset, Shropshire and Worcestershire. More than £5 million of funding will be awarded to two industrial projects, led by Ford Motor Company and Zeetta Networks, to test the benefits of using 5G in the manufacturing sector.

The Mobile Access North Yorkshire (MANY) project will support the development of future rural connectivity in the county by developing new technologies, apps and services tailored for rural areas. These will focus on tourism, mental health, coverage for emergency services and environmental management. The project will build small mobile phone networks in areas that have no mobile coverage. It aims to understand how the public, private and community sectors can work together to reduce the cost of delivering mobile access in rural areas.

Operating in the rural area where the counties of Shropshire and Worcestershire meet, 'West Mercia Rural 5G' will explore infrastructure challenges when planning, building and operating a rural 5G network and look at how 5G can enhance services for the benefit of residents, particularly researching 5G enabled health and social care applications.

Trial deployments will utilise unused mobile spectrum, using the new Ofcom-issued Local Access licencing procedures to offer a service that is both technically and financially possible in areas where conventional coverage solutions are not commercially viable or cannot scale to cover small areas.

5G is expected to be the technology used for Future Railway Mobile Communication System (FRMCS).

5G Release 16

The FRMCS (Future Radio Mobile Communications System) requirements are being incorporated into the 5G system. The 5G standard is published by 3GPP and Release 16 incorporates the outline FRMCS requirements along with others.

Release 16 is known as "5G phase 2". As well as FRMCS, Release 16 features; enhancement of Ultra-Reliable Low Latency Communications (URLLC), 5GS enhanced support of vertical and LAN Services; cellular IoT support and evolution; advanced V2X support; location and positioning services; radio capability signalling optimisation; satellite access; enablers for network automation architecture; wireless convergence enhancement; mission critical services for public warning, railways and maritime; streaming and TV; and (network) slicing.

The most notable enhancements to existing 5G features in Release 16 are in the areas of multiple-input, multiple-output (MIMO) and beamforming enhancements, dynamic spectrum sharing (DSS), dual connectivity (DC) and carrier aggregation (CA), and user equipment (UE) power saving. DSS provides a solution for enabling a smooth transition from 4G to 5G by allowing LTE and NR to share the same carrier. Additional mobility enhancements enable reduced handover delays, in particular when applied to beam-management and deployments in GHz frequency bands. Release 16 also includes a wake-up signal to reduce UE power consumption, along with enhancements to control signalling and scheduling mechanisms. More 5G system enhancements will follow in Release 17, scheduled for release in 2021 which will further cater for railway FRMCS requirements.

UK PSTN "switch off"

UK: Ofcom (the UK telecoms regulator) has announced 2025 will be the date for the "switch-off" of the UK public switched telecoms network (PSTN). BT Openreach has already launched a digital subscriber line (DSL) broadband service that doesn't include a voice service frequency running within the DSL frequency range. The new 'naked' product is called Single Order Generic Ethernet Access (SOGEA). Any voice telephony service will be provided via either VoIP or as a mobile service.

5G EMF emissions and health

UK: Ofcom (the UK's communications regulator) has been carrying out radio frequency electromagnetic field (EMF) measurements near mobile radio base stations for many years. The measurements have consistently shown that EMF emissions are well within the internationally agreed levels published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Despite this assurance there have been health concerns raised in some popular press and social media, and in particular for 5G frequencies.

Ofcom has now undertaken EMF measurements for the specific frequency bands for 5G. EMF measurements were taken at 16 locations in 10 cities across the UK, including Belfast, Cardiff, Edinburgh and London. The tests targeted areas where there are likely to be high levels of mobile phone use, including in and around major transport hubs and shopping centres.

The results so far indicate that in all cases, the measured EMF levels from 5G-enabled mobile radio base stations are at small fractions of the levels identified in the ICNIRP Guidelines (the highest level being approximately 1.5 per cent of the relevant level); and the contribution of 5G to the total emissions level observed in the band used for 5G was just 0.039 per cent of the reference level. The full report can be found at **irse.info/az6gk**.

In the UK, Public Health England (PHE) leads on public health matters associated with radiofrequency electromagnetic fields and has a statutory duty to provide advice to government on any health effects that may be caused by EMF emissions. On 5G, PHE's view is that "the overall exposure is expected to remain low relative to guidelines and, as such, there should be no consequences for public health".

Universities and Research

Data Platform to tackle data accessibility within the rail industry

UK: The UK Rail Research Innovation Network (UKRRIN) Data Platform has been launched by the Birmingham Centre for Railway Research and Education (BCRRE) to create the largest single source of data, both historic and real-time, covering railway operations in the UK and internationally. The platform, has been created in collaboration with transport technology specialist Zipabout.

BCRRE has developed the platform to offer the rail industry an opportunity to extract greater value from data, utilising a model designed to support the manipulation, understanding and application of data within their research programmes. The platform will allow UKRRIN partners to contribute their datasets specifically for research purposes. The data will come from a number of sources, e.g. trains, trackside sensors and infrastructure assets, as well as other railway sources, allowing partners to explore and analyse their real time and historic data, leverage big data technologies and use the platform's in-built data science capability.

Along with supporting the UKRRIN Data Platform, Zipabout in partnership with Kx and Amazon Web Services (AWS) has developed its own multi-source, big-data and communications platform that combines static, operational and behavioural data to better predict and manage the flow and capacity of transport networks.

At the launch of the Platform, the University of Birmingham and Siemens Mobility Limited also announced a new, academic framework research collaboration; to deliver a pipeline of innovation for the rail industry, developing the application of fundamental research by working with a range of industry partners across the rail supply chain.

Companies

CERTIFER acquire AEbt

Europe: CERTIFER has acquired AEbt Angewandte Eisenbahntechnik in Germany. CERTIFER is a testing, inspection and certification body based in Valenciennes, France, providing NoBo, DeBo and ISA services to more than 50 countries, to infrastructure, control-command-signalling and rolling stock.

AEbt, based in Nuremberg, Germany with offices in Olten, Switzerland, is a i-DeBo, AsBo, BOStrab verifier, as well as testing railway vehicles and organising training and seminars. AEbt also hold 70% of ERC Ltd (NoBo in Austria). With the acquisition CERTIFER say they are now able to provide DeBo/i-DeBo, NoBo, AsBo, ISA body services in France, Belgium, Netherlands, Spain, Italy, Switzerland, Luxembourg, Austria and Germany.

A Notified Body (NoBo) inspects the conformity of a product with the requirements of the Technical Specifications for Interoperability (TSI) on interoperability. A Designated Body (DeBo) or Interim Designated Body (i-DeBo) investigates if a product complies with the specific national rules and that safety requirements are taken care of in a systematic and controlled manner. An Independent Safety Assessor (ISA) is a person who carries out independent safety assessment, independent from system design, development or operational personnel, and checks the safety requirements are appropriate and adequate for the planned application. An Assessment Body (AsBo) assesses the risk management process of an applicant, and BOStrab (Verordnung über den Bau und Betrieb der Straßenbahnen), is a German regulation governing tramway, metro and light rail operations.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE

Blane Judd, Chief Executive

At the time of writing in mid-April, the world is trying to come to grips with the unprecedented coronavirus infection (COVID-19) pandemic which is impacting on all of us. Here at IRSE HQ the health and wellbeing of our staff, members and licence scheme members is an absolute priority with all staff remote working. We are dedicated to delivering the highest possible standard of service to our members and licensees during this period.

We are working on new innovative ways to ensure that whilst physical events cannot take place, industry-leading content will continue to be available to our global membership through video-streaming of presidential papers and speaker presentations recorded remotely.

We urge international members to follow the coronavirus safety guidelines laid down by their own jurisdictions. The latest information on the Institution's response to coronavirus is available on our dedicated page at **irse.org/coronavirus** which will be updated regularly as the situation unfolds.

Changes to the 2020/2021 programme

As advised by governments it is with regret that all forthcoming presidential and section events for the next few months across the world have been either postponed, cancelled, or held remotely. This of course is very disappointing for us all, but health and safety is paramount.

To summarise some of the major changes that have taken place:

- The April suite of governance meetings are planned for 23 April, with our incoming and outgoing Council members. At this meeting Daniel Woodland will be confirmed as president for the year 2020-2021. Ian Bridges will become senior vice president and Andy Knight junior vice president.
- The IRSE Annual General Meeting did not take place on 23 April and is postponed until later in the year, if restrictions on travel and meetings allow.
- The 2020 Annual Dinner has been cancelled and a provisional booking has been made for 23 April 2021.
- The 2020 Members' Luncheon has been cancelled.
- The 2020 International Convention in Toronto is under review.

Professional exam – October 2020

Sign ups should continue for the October IRSE professional exam. The Education & Professional Development Committee will keep the exam date under review as the current situation unfolds and will keep all candidates informed should changes be required.

Council changes

We are delighted to welcome to the IRSE Council Firas Al-Tahan, Harvinder Bhatia, Rob Cooke, Gordon Lam and Clive Roberts.

Pierre-Damien Jourdain, Cassandra Gash, Lynsey Hunter and Charles Page stepped down from Council on 23 April, we would like to thank them all for their contributions.

Does your country/company need you?

There have been a number of requests for assistance during this current health crisis including from infrastructure owners looking for key skills. If you have recently retired and believe you have the necessary competences and may be able to assist, please contact your former employer to offer your services. Many 'key worker' IRSE members will still be working 'on site' to keep trains moving safely at this challenging time, with other IRSE members working from home. On page 32 we have provided some guidance to assist members in this situation.

Quick links

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

Creating video content: some advice

Where sections have speakers already lined up, we are encouraging sections to consider asking speakers to record their presentation in the safety of their own homes or offices. HQ can then add associated slides or graphics to the recording and create a presentation which can be viewed safely by other members via the Vimeo channel on **www.vimeo.com/irse**. Some general advice on creating video content is given below. This guide is designed to help you create content using your own equipment. Raw footage and presentations can then be shared with the Institution using services like WeTransfer.

Audio is key

Most modern smartphones house excellent cameras, but good audio is most important. Ensure you're in a quiet room, with limited background noise. You may be able to source an inexpensive microphone which will help.

Lots of light

A bright space will yield the best results for clear video. Indirect light is best and avoids harsh shadows.

Backlight

Light shouldn't come from a bright screen or light source behind you.

Settings

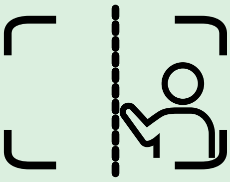
Your device should be set to capture video at as high a quality setting as possible. 1080p D video is our default standard, but 4K or 720p footage is absolutely fine.

Working with presentations

If there is a presentation to accompany your talk, don't worry about trying to get it in shot. This should be uploaded along with your video and our production team will handle the rest. We'll need a clear signal from you when it's time to change the slide, so if your hands are in shot, it's good for us to be able to see you reach for a clicker or mouse when it's time to change.

Framing your shot

If you use slides, frame your shot with you occupying only half the frame as shown below. When you film yourself, we suggest just talking to the lens of your device, like you're looking a person in the eye.



Managing mistakes

The great thing about a pre-recorded video is that it can be edited later, should this be necessary. If people try to edit as they go along, they end up sitting back down in a different position, or something else changes to make the video look odd and jumpy. If you make a mistake, it's less disruptive to your flow to pause for a second, say "cut" and then start the phrase you made the error in over again. Give a clear couple of seconds after "cut" to help the team edit around it.

In your email, include the play time at which any error occurs in your video. This will speed up the editing process. For help and support contact: **howard@prettybright.co.uk** or **communications@irse.org** if you require further assistance on this or any other aspect of communications.

Please don't keep us in the dark!!

Do we hold the correct email address for you? If you have just joined the digital community or recently changed your email address you will not be receiving important membership information or IRSE e-communications.

Don't miss out. Please email your new contact details to membership@irse.org to enable us to update our database.

Working from home

With the current world wide coronavirus infection (COVID-19) situation many non-key workers are now working from home wherever possible around the world. This provides new challenges for both employees and employers. If you can, rather than working in a bedroom or living room (spaces that are associated with leisure time) consider using a specific room or space dedicated to work. A private office space is ideal, but it could be a certain table, chair, room, shed or garage as a consistent 'work space.'

Having a reliable telecoms connection is important for remote working. If the connection is not fast enough, see if your broadband provider can configure your data connection to a better server, or if you can 'boost' the Wi-Fi signal to your computer, especially if others are using it for streaming in another room!

If broadband is not available and your computer does not have a mobile data connection it may be possible to 'pair' the data connection on your mobile phone to your computer. Some Internet browsers allow multiple accounts with a toolbar for home and a separate toolbar for work. This can help to separate work from the domestic environment. Social media can be a detriment to productivity, and removing social media browser shortcuts can help. You might also consider working primarily in a different browser window to a normal 'home' browser to lessen distraction. Make sure your home network does not use default passwords, and company security measures must be complied with.

It can be difficult to make a start on a task if distracted by domestic issues. Planning to do things over the course of the day may help. Background music may help some and unlike working in an open plan office it is the employee's choice and there may be more flexibility available when specific tasks are undertaken. It may help to start the day as if preparing for an office role, such as setting an alarm, taking breakfast and taking a short walk. Consider planning work when you're at your most productive, saving harder tasks for when you know you'll be in the right frame of mind and using 'slower' points in the day to address easier, logistical tasks.

Some people find the most productive times of the day are early in the morning or late at night. Others find it useful to start with the solitary tasks in the morning saving phone calls, virtual meetings, and other collaborative work for later in the day. Working from home might help some to focus better on work than in an office, but it can also make others feel cut off from the larger operation happening in the company. Instant messaging and video-conferencing tools can help to keep in contact with colleagues and the rest of the business. Apps are available to share desktops to multiple users along with a video conference facility.

You might have other people in the house, so make sure your space is respected during 'work' hours. However, do not let working from home prevent you from taking time to relax and it is important to see another face during the day. Use breaks to get away from your desk and go for a walk outside or spend some time with others in the house, catching up with them for a tea/coffee/lunch or watching the news together. Breaks are important and you do not need to be working 100% of the time to be more productive.

You may lose track of time, as you will not have others leaving for the day to remind you to do the same. Setting an alarm to indicate the end of your normal work day may help. You don't have to stop at exactly that time, but knowing the work day is technically over can help the process of moving to home life and leisure time. Packing up your laptop is also a help to switching over to leisure time and is particularly important if you are using the same space to work and relax in.

In many countries including the UK, employers have the same health and safety responsibilities for home workers as for everyone, and there are a number of issues to consider and manage. These include: How will people keep in touch with one another? What work activity will be undertaken? Can it be done safely and what control measures should be in place? Do lone remote workers have all the tools and information they require? Is it necessary to get things delivered and collected? Do they need to go into work, say to do tests in a lab? If so, will they be safe on their own or do they need support?

There will always be greater risks for lone workers with no direct supervision or anyone to help them if things go wrong. So, measures should be in place to keep in touch and ensure regular contact to make sure they are healthy and safe. If contact is poor, workers may feel disconnected, isolated or abandoned. This can affect stress levels and mental health. Email or instant messaging alone should not be relied on as not talking to people can cause loneliness. So, use verbal communications when possible and appropriate.

There is no increased risk from display screen equipment (DSE) when working at home, however people should be advised on completing their own basic assessment. A practical workstation checklist can be found at **irse.info/z20ks**.

Other simple steps to reduce the risks are: breaking up long spells of work with breaks or changes in activity; avoiding awkward, static postures by regularly changing position; getting up and moving or doing stretching exercises; avoiding eye fatigue by changing focus, staring out of the window for a few minutes or blinking from time to time.

Specialised equipment needs should be provided where possible, so for some tasks this could mean allowing such equipment to be taken home. For other larger items (e.g. ergonomic chairs, height-adjustable desks) other ways of creating a comfortable working environment can be tried, for example using supporting cushions.

Home working can cause work-related stress and affect people's mental health and being away from managers and colleagues could make it difficult to get proper support. Procedures should be in place so managers can keep in direct contact to recognise signs of stress as early as possible. It is also important to have an emergency point of contact and to share this so people know how to get help if they need to.

What do you think?

What is your experience of working at home? What are benefits and disadvantages? Have you any advice to share? If so let us know what you think, email **editor@irsenews.co.uk**.

Your letters

Re Back to Basics, Interlockings

This is a beautiful article (IRSE News April 2020) on the basic concept of interlocking – not only for the new comers to the signalling family, as the author had in mind, but also for the seasoned signal engineers to appreciate how the basic concept of interlocking is carried through the generations of mechanical to electromechanical and finally to processor-based systems.

With reference to various architectures of CBI explained in Figure 6 of the article, I fully agree that common cause failures are the biggest enemy of redundancy and we should take care that, while replicating the resources, be they hardware or software, we should insist on use of diverse resources, e.g. hardware chips from different manufacturers and software developed by independent teams as far as possible. The author has mentioned a genuine problem faced in the use of diverse resources, that is, synchronisation of outputs of the two resources. However, given that our signalling systems are much slower than the processors, this problem can be overcome by waiting for the slowest system to generate the output at some specified breakpoints in the program.

Still many signalling systems today use identical hardware/software for redundancy. Replication of identical hardware will no doubt eliminate failures due to random faults in the components which are caused by ageing or environmental conditions. However, this type of redundancy will not help in overcoming systematic failures caused for example design errors.

Most of us would remember the design fault in Intel Pentium microprocessor, which was released in 1992 and the fault detected in 1993 randomly when someone got bizarre results in Excel calculations under a given set of conditions. The fault was repeatable for the same conditions. Intel had come out with explanation that probability of such data combination to create the fault was infinitesimally small, and that since microprocessors are not 100% testable, the possibility of a fault in the microprocessor could not be ruled out. The fault was wrong programming in some of the memory locations of the chip.

The point is, had we designed a CBI using identical Pentium microprocessors, no matter how many chips we replicated, all of them would have agreed with a wrong output under a given set of conditions. The problem has only aggravated with time in the modern microprocessors. Due to the race for speed, they use several features for enhancement of speed such as parallel execution, out of order execution, and speculative execution. These features no doubt help in speeding up the execution of the programs, but they make it more and more difficult to test the chip. Therefore, there is a strong case for hardware diversity.

If identical resources are used in redundancy, be it 2oo2, 2x2oo2 or 2oo3, mere comparison of the outputs is not adequate for detection of systematic faults, as explained above. Effective self-check or cross-check capabilities should be built up in each unit for fault detection. In the recent air crashes of Boeing 737 Max, as per the accident investigation report, one of the contributing factors was reliance of the flight control system on a defective 'Angle of Attack (AoA)' sensor. The aircraft is equipped with two AoAs, out of which, one was defective.

IEC 61508 sets a quantitative requirement for 'Fault diagnostic coverage' and 'Architectural constraints' for the quantum of fault detection capability provided in the system, but CENELEC, which is a descendant of IEC 61508, does not set any such quantitative target; this must be for a good reason.

Mukul Verma, India

Re March IRSE News

Another interesting March issue and a lovely front cover of the train in Western Australia. "Should we forget the driver?" I like the detail on the Society of Automotive Engineers (SAE) Levels of Driving Automation and railway Grades of Automation (GoA). I think driverless trains will arrive, as in Docklands Railway in the UK. Even new people enjoyed seeing out the front of the train without worrying why there was no driver's head in the way! I'm not sure I could ever cope with a pilotless plane though. It inspires confidence that a paid employee is happy with the vehicle to risk his own life.

"Accessibility article" I don't drive; cycling and trains get me around. Drivers forget how much they know, saying things like, we'll just "go there"! There are occasionally programmes on TV about motorists going by train. It's a bit unfair on them, I would like the TV to make the reverse programme for me say(!) Obviously I would need a chauffeur who would have to do what I told him apart from the basic driving, stop here, go this way etc. would be my decision.

How often have we seen passengers who are 'railway virgins'? Typically, a male sits arms folded for the entire journey, he doesn't have anything to do as he is usually driving. Partner/wife often a bit bored as she's not worrying about being a SatNav. Then they don't know where they are, how far away is their station, whether destination or change. They might have food, but coats for the 'outside' bit of the journey they may not even possess. On boarding the train, they just go with everyone else and don't know where the less loaded parts of the train are. They are surprised that when on the train, those people from the platform are taking up just as much space! Often, they lose their ability to read, it's only a reservation and it matches the seat numbers. Ah, you're in the wrong coach or even the 1410 not the 1440 you've booked.

More positively new lines often do well. I can't believe people have been twiddling their thumbs whilst awaiting Mansfield or Tweedbank to re-open, they are new travellers for whom the car has not been a universal family option. Trams, such as the Manchester Metrolink near to myself have been wildly successful. You only have to blink and a new line is built! As I look forward to Trafford centre line opening for a 'bash', a Stockport line is being cogitated. New or reopened (like Bathgate in Scotland) lines seem to fit every day travellers need for something 'new'. I remember a film from the 60's. Steam trains were dirty and clean new cars would do the job; how wrong they were. New trains will always attract the 'virgins' who will repeat their journey.

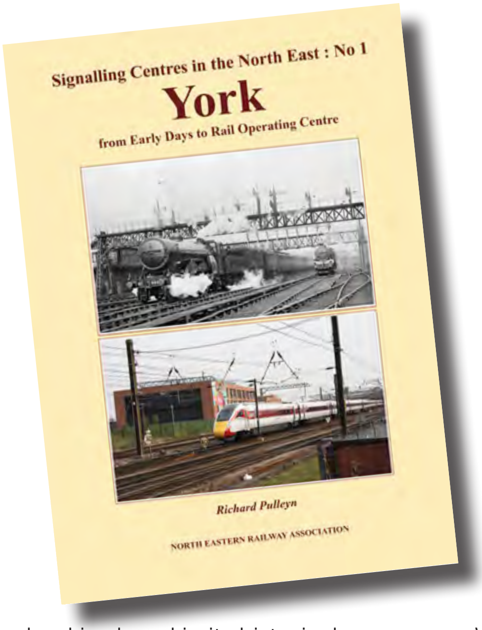
Dave Stuttard, Warrington, UK

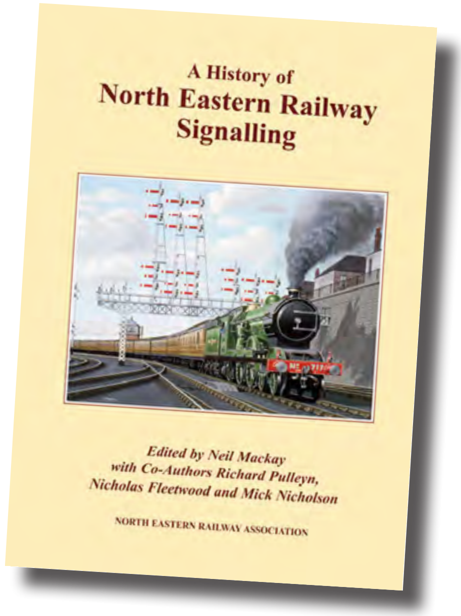
Don't fence me in

To drive or not to drive, Noel Burton's article, IRSE News March issue, is a very good summary of the issues in and around ATO. I would however take issue with the statement that "Railway corridors are generally fenced in most countries.....". This is not my experience, other than in the British sphere of influence. In most countries I know, fencing is mostly confined to high speed lines and urban areas.

J R Batts, UK

New books





Two recent books on UK signalling history have been published by the North Eastern Railway Association.

Signalling Centres in the North East: No 1 – York by Richard Pulleyn, (ISBN 978-1-911360-25-4). Subtitled "From Early Days to Rail Operating Centre", the book records how York's signalling infrastructure developed from pointsmen at strategic locations, through the gradual introduction of interlocked signal cabins, to the world's longest mechanical lever frame. Modernisation in the early 1950s took the form of a Westinghouse OCS relay interlocking, replaced in 1989 by an IECC as part of the East Coast Route electrification.

With 136 A4 size pages, the publication is printed on gloss art paper throughout with a gloss colour card cover, with over 170 colour & monochrome photographs, together with numerous specially drawn signal box diagrams, many contributed by IRSE member Charles Weightman. The price including UK postage and packing is £18.50.

A History of North Eastern Railway Signalling, edited by Neil Mackay (ISBN 978-1-911360-19-3). From its rudimentary beginnings the development of railway signalling in north-east England is placed in its historical context. The sceptical attitudes of the NER management towards signals, interlocking and the block system are examined and contrasted with the views of the Board of Trade and the public. An account is provided of the development of relevant signalling rules & regulations and descriptions of telegraph and block signalling equipment, mechanical and power lever frames, and the wide variety of signals. There are numerous diagrams illustrating signalling techniques at a representative cross-section of locations, from simple block posts and wayside stations to centres such as York and Newcastle.

With 320 page A4 size gloss art paper throughout with a casebound colour cover, there are 450 illustrations, of which 95 are colour, with numerous line drawings, diagrams, tables and appendices. The book is published by the North Eastern Railway Association and has been reprinted. The price including UK postage and packing is £27.

Orders for either or both books may be placed using the NERA website shop **irse.info/a6bnd**. Payment on-line may be made using PayPal, or by post (cheques payable to "NERA" to accompany orders) from: The Sales Officer, NERA, 31 Moreton Avenue, Stretford, Manchester, M32 8BP.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

IRSE News

Institution of Railway Signal Engineers

June 2020

Traffic management
the bigger picture

Back to basics
railway safety engineering

It's only a relock
the return of Ruth

Signet Solutions are continuing to follow government guidelines, keeping our staff and clients safe by delivering courses online. We're all in this together, so our aim is to support our industry by keeping us all connected. We've had great success with our courses so far and we've been so overwhelmed by the willingness of our staff and clients on adapting to this new way of training. So from all of us thank you and stay safe!

IRSE///
Institution of Railway Signal Engineers

Issue 267
June 2020

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

Exam success

Congratulations to all who have passed modules in October 2019's exam, in particular those who have now completed all four modules. Our successful candidates, listed in April's IRSE News, have put in many hours of study with the support of their mentors, colleagues, study group leaders and loved ones. I hope all have shared in the celebrations.

Many are now working towards our next exam day, 3 October. This date is under review due to the COVID-19 restrictions across the world and an announcement will be made as soon as possible. All those who have registered to date will be informed directly, otherwise please keep an eye on the exam web pages.

Besides those studying for Modules 1-7 and the new Module A, our office team and a very large number of volunteers are working hard behind the scenes. Many of our volunteers are writing the questions for the exams; covering the syllabus and ensuring questions are suitable for the global breadth of our candidates in main line and metro, whilst ensuring the high standards our professional exam requires. Other volunteers are obtaining suitable exam rooms and sufficient invigilators, whilst others are running exam study groups and workshops. All are invaluable to the IRSE professional exam.

The introduction this year of Module A, "Fundamentals of railway control engineering", is an excellent opportunity for the IRSE to help a wide range of people demonstrate their technical knowledge to employers and colleagues. Candidates for Module A do not need to be members of the IRSE or have a sponsor, unlike the other modules. Questions will cover the principles, applications and terminology of railway control and communications, its equipment and interfaces and interactions with related systems. In other words, it is much more than 'just S&T' engineering. A pass will result in a new qualification, the Certificate in Railway Control Engineering Fundamentals, as well as being a mandatory starting point for those planning to complete the full IRSE exam.

Being an exam candidate or one of the many volunteers is a great way of showing that you are maintaining your professional competence.

Judith Ward, director of operations

Cover story

A Class 175 Alstom Coradia leaves Crewe for South Wales in the UK, having arrived earlier from Manchester.

Crewe is a busy junction on the West Coast Main Line and the Manchester to South Wales trains have to cross the main line from north east to south west. The proposed HS2 high speed rail link from London to Manchester is planned to run underground at this point, but with links into the existing station.

Ahead of the train can be seen the floodlighting to enable night time inspection of the busy Crewe South Junction layout.

Photo Paul Darlington.

IRSE

Institution of Railway Signal Engineers

Traffic management – the bigger picture

John Francis

Great Britain's main line railway sees 23 500 trains run each week day. They cover 900 000 track miles, make 220 000 station stops and react to 1.5 million signals. This is no mean feat but service performance has continued to drop over a number of years. There is much talk of and various attempts being undertaken, to introduce Traffic Management Systems (TMS) in order to get greater capacity from parts of the rail network. Railway capacity is dictated by many factors meaning a TMS could be handicapped from the outset. A fundamental question is whether TMS is envisaged as a means to exploit capacity or as the instrument through which an already busy network is kept running with the least deviation from the timetable.

A timetable is a daily project

Delivery of a train service has many similarities to the delivery of a project. The promise, or scope, is embodied in the timetable. It is this which then drives the resources required to deliver it, such as rolling stock and train crew. The timetable may be constrained by the infrastructure that is available and the way in which this is signalled. As a plan, the timetable is very clearly based on the 'Just in time' principle meaning it is constantly vulnerable to influences that might materialise at any time throughout its implementation. The timetable is really just the starting point because it is a statement of intent that relies upon a host of assumptions, all of which must be satisfied. Just as with a project, there are many events that can interject to extend time, raise cost, reduce scope and even prevent complete delivery. Fortunately, except for the overnight services, the plan is largely 'zeroed up' during the early hours of each day and, except when catastrophic infrastructure or rolling stock issues intervene, a whole new attempt at delivery can be started each morning.

Thousands of people waiting for trains at a crowded London Waterloo station in 2017. Do they want TMS to exploit capacity, or to run the network to the timetable?
Photo Shutterstock/Bikeworldtravel.

Any project plan must have clear objectives, clear responsibilities and sufficient resources. It must also recognise dependencies and risks whilst crucially including credible mitigation against them to provide resilience. It is in fact the assumptions that introduce most of the risk, not just for a single train but for the entire service. These include:

- The availability of suitable rolling stock in the right place.
- The availability of a crew for the commencement of the journey and at relief points.
- The route for the journey being intact and available with no technical infrastructure issues or other incidents that lead to its degradation or result in its closure.
- Trains will move when given a movement authority.
- No on-board train technical or human issues occurring.
- Weather conditions not becoming extreme.
- The train being driven at its optimum performance.
- No other train getting in the way.
- No preceding trains failing in service and blocking the route.
- No incidents occurring at station calling points.

Each assumption can be impacted by a myriad of influences which could prevent it from being realised and that is why it is essential to be aware of each. That awareness then allows contingency and remedial plans to be created which, when enacted, can recover a situation in order to minimise distress to the timetable. Important also is the recognition that certain dependencies, particularly where rolling stock and crew are concerned, need to be given sufficient float to avoid propagation of delay into subsequent services.

For significant issues written contingency plans containing reactive strategies that seek to respond in a timely, decisive and rehearsed way are most appropriate. For minor issues and degradation then a more agile and adaptive response is appropriate, often achieved by regulation of the service, either at a local level or by intervention from a higher authority.

Where flaws in the timetable are identified once it is put into action it is crucial that schedules are able to be tweaked or altered speedily so as to rectify or improve the plan, thereby avoiding repetition for the duration of the timetable. This requires a suitable process, with interaction between parties involved, that is flexible enough to ensure a rapid response, outside of, and regardless of when, the next timetable update is due and unencumbered by industry structure.

Conflicts – simple or far reaching

Whilst it is possible to categorise the adverse events that prevent an assumption from being realised, it is of course usually impossible to forecast when an event will occur. A few, such as impending adverse weather and special events may be foreseen, allowing mitigating action to be taken prior to the issue materialising. Once an unforeseen event does occur then its impact can be assessed. A points failure, broken rail, trespass, suicide or train failure that is yet to happen cannot be factored into an earlier or immediate regulating decision, whereas an already known incident or indeed one that is developing can be.

Thus, if a disturbance has occurred or is in the course of unfolding that will bear upon a train further into its journey, this can be taken into account when making a regulating decision in the 'here and now'. Similarly, the consequence of an event on approaching traffic can be predicted quite easily. So, for example, rather than rush a subsequent train towards taking its place at the end of a queue of delayed trains awaiting their turn to proceed through or past a disturbance, such a train can be given lower priority compared with others it may conflict with. This will ensure the other trains, for which the disturbance in question is immaterial, will not be adversely impacted by the said train which, as a result merely takes longer to arrive on the end of the queue. The overall delay it encounters will be no greater whilst the perception of the journey for the passengers may actually be more favourable through spending less time at a stand. It may also be prudent to detain a train in a station platform awaiting the ability for it to progress rather than hold it further along at a signal in an isolated location.

Regulation is not always just a response to an incident but is an ongoing process reacting to minor deviations in train relationships, caused by all manner of things; weather, traction and driver variabilities, passengers, trespassers, rail adhesion, etc. It must take account of the track layout and available speeds, both of the layout and trains concerned, of the type of train, its route, its stopping places, its next working and often what the crew do next. Part of the decision making process must also be aware of the limitations imposed by the signalling, whether this be headways, point to point locking, overlaps, approach control, time of operation locking, alternate routes, etc. Therefore, to undertake intelligent regulating requires knowledge of many factors.

Real-time one-on-one conflicts are simple to spot and equally simple to resolve in isolation, given that the knowledge factors and providing agreed rules and guidance are available

upon which to base a desirable outcome. Such rules can even include preferences according to the time of day, it often being important to recognise directional flow. In some situations it is difficult to predict the downstream results of an individual regulating decision as it is far from straightforward to determine the positional relationship between the regulated train(s) and other trains further on in time and space. Such prediction can also be thrown into disarray by subsequent regulating decisions elsewhere or by an event, however minor, that has yet to take place. Such minor event might be poor railhead adhesion, a longer station dwell time dealing with an unexpected wheelchair user or technical difficulty achieving the train door interlock requiring multiple attempts. In some cases, the probability of a potential repercussion can be calculated allowing this to be factored into the decision at hand.

Resolution of a simple conflict will often have no further impact except to the trains concerned, but at times may have far reaching implications on how other downstream trains become affected. For example a decision taken at Peterborough could have a knock-on effect at Newcastle or Edinburgh – but is it feasible that a complete line of route be considered whenever a regulating decision is made, let alone connected routes? The sphere and magnitude of influence can be significant from what might be considered a simple decision and one which might therefore have been better resolved in a different way. Future influences might generate multiple permutations so it is unrealistic to think that all these can be assessed because, as well as numeracy, future unknown yet to evolve situations will materialise. A decision at a specific moment in time can actually result in a less desirable outcome later on when the train or trains concerned become exposed to further situations. So how far along the line and what future timescale should be considered if a sensible set of options is to be determined? The plan must be continually monitored so that when issues arise that will, or even might, affect delivery. Appropriate intervention can be taken to avoid impact or minimise deviation.

"A moving train is a happy train"

The question of passenger comfort and journey perception, both of which feed into satisfaction, are rarely considered in the realms of regulating. A journey subject to braking or stopping for conflicts, especially just short of an individual's destination, will detract from a passenger's overall experience. Then there are the environmental and cost implications of additional braking and acceleration, particularly in the case of freight trains. As a former colleague of mine would regularly say when making decisions: "A moving train is a happy train". This statement makes a lot of sense, not just in terms of passenger perception, cost and the environment but in terms of a moving train being highly likely to keep moving whereas there is no guarantee that a stationary train will resume its journey.

There are hundreds of cases every day of stationary trains being given preference over moving trains because that is what the timetable plan or the regulating rules demand. When the stationary train declines to move for whatever reason the result is two stationary trains. Unless informed in some way that a train will not move, today's signalling operators in their centralised, remote locations have no direct means of knowing.

On-time running

A train might run on-time for hundreds of miles only to be delayed for some reason close to its final destination. Being on-time throughout to this point will be of no assistance for a right-time arrival, whereas a delay encountered earlier in its passage has potential to be reduced or eliminated by spirited running for the remainder of the trip and through the judicious injection of recovery margins in the original plan.

Incidents which take place early on in a timetable day often result in greater overall impact across a large number of trains and wide area compared with those that manifest later. This of course is dependent upon the type of railway, and the level of service. For instance, disruption during a morning peak period on a suburban railway is likely to have a higher impact than disruption which occurs during the middle of the day.

The inclusion of what is often referred to as 'charter time' at the end of a journey results in on-time trains frequently having to wait outside their destination stations, either for their assigned platform to become available or for a right-time conflicting departure to pass clear. Whether this time allowance should be inserted at this particular final point in a train's progress is debatable. Its purpose is to extend the lapse time of the journey on paper in order to achieve a higher record of on-time arrivals at the destination, a measure which features in train company performance metrics; the Public Performance Measure (PPM). PPM is the percentage of trains which arrive at their terminating station 'on time' compared to the total number of trains planned. Whilst this purpose undoubtedly contributes positively to the metrics it turns a 'happy train' into an 'unhappy' stopped train.

The impact of the track layout

Track layouts have a significant impact on how a railway can be operated, often making the difference between ease of movement and in-built conflict. In the days when large terminal stations were segregated into arrival and departure sides, the instances of arriving trains having to wait outside for an available platform or for a departure were rare as such conflicts were minimised by design. Such a change in arrangement is just one example of where track layout and station facilities act as a significant constraint to timetabling which leads to the need for a higher degree of active regulation.

The simplification of layouts, together with a reduced number of platforms at many key stations, then requires bi-directional working to solve capacity issues but introduces, additional conflict opportunities. Once, most main stations followed the up and down segregation of lines giving discrete directional use of platforms thereby separating traffic flow. Today, the flows have become entangled. Point work constructed from standard configurations tends to result in layouts being spread out and preferably located on straight alignments. This, together with suitable placing of the approach signals, extends the length of railway that becomes part of the conflict zone. The result is to increase the distance and hence time over which conflicts are encountered. Such drawbacks are recognised leading to some key locations having platforms reinstated or added, junctions remodelled to enable parallel working, grade separation and re-quadrupling. This is, naturally, expensive but ultimately the most effective solution.

Just as there should be contingency in the plan to recover from matters such as the positioning and availability of train crew and rolling stock there should be contingency in the infrastructure, whether this be an additional platform, an alternative set of points or an alternative route. The more assets there are the more that can fail, but availability of these in terms of their installation and maintenance is a completely different argument when it comes to how a railway should be configured and operated. The lack of contingency will certainly reduce component failures but when one does occur the trains will become very 'unhappy'.

Establishing suitable practice

Regulating practice must be appropriate to the type of railway and service in question. A busy suburban route with regular interval trains of a similar characteristic requires a different approach to a mixed traffic main line as do both to a rural single line. Then there is the matter of how success or otherwise of a train service is measured and how this influences regulating decisions. Fundamental rules need to be established to enable appropriate, but above all sensible, regulating decisions to be made. Whilst many of these may be general the need for specific rules for individual trains and places can also be appropriate.

Should right-time start of one train overrule the late arrival of another or should the late arrival delay the right-time start? One side of the argument would say that by departing on-time a service is not handicapped from the word go, whereas the other side could say that a small late start will be recoverable during the journey and the late arrival should not be subjected to further delay. The reality of how such decisions are made is often based on whether the arriving train terminates at the location concerned, if given preference, it will achieve its PPM measure of arriving within 5 or 10 minutes. Should a late train be sacrificed, such that it is not given preference over other on-time trains and so become even later, or should the pain be shared so that a few trains are a little late rather than one being very late? Should passenger traffic always take precedence over freight? Should a class 1 train always take precedence over other classes? Clearly not, it could be argued, if a class 3 or 5 empty stock has to be at a certain station to begin a passenger working from there on-time.

Is it correct the train should be the unit to be measured or would the summation of its contents be more appropriate? Weighting a train by the collective impact on the passengers affected could result in a completely different regulating decision being made when a conflict presents itself. Take a short local train running 10 minutes late which has 25 passengers on board. This could crudely be weighted as 25 x 10 = 250 person minutes. Compare this with a five-minute late long distance express passenger carrying 400 people that would equate to 400 x 5 = 2000 person minutes. Which train deserves the greater priority if they clash at a junction?

Measurement always drives behaviour

With a trend over the years of increasing delays, during the 2018/19 year the total recorded minutes of delay to passenger trains on the GB railway, according to the Office of Road and Rail (ORR), was 16 747 590, equivalent to 11 630 days or, to put it another way, 31.86 years. As staggering a figure as this is it must be remembered that delays of two minutes or less are generally not included in this figure. Whilst 40% of the delays can be attributed to train company causes, over 59% were the responsibility of the network operator. The financial penalties driven by the attribution should focus minds on sharpening attention to the day job so as to avoid incident re-occurrence but the figures suggest this is not the case.

The way a process and its outcomes are measured will always drive how that process is undertaken and so it is with the regulation of the train service; regulating behaviour is driven by the performance measurement regime. Sadly, this culminates in a greater amount of delay being accrued than could otherwise have been the case. Primarily this is because in the GB network those making the regulating decisions are employed by the network operator, albeit on some occasions with input from train operators. In the event of an incorrect decision, whether made in good faith or not, or one that pans out to be less optimal as the situation unfolds then the ensuing delay, once measured, together with any reactionary delay that follows will be attributed to the network operator. Compensation in the form of money will then flow from the network operator to the train operator. Worse still are those decisions that would derive the least delay but which result in the network operator having to pay the compensation despite not being responsible for creating the initial conflict.

Avoiding such situations can discourage good regulation so that simplistic actions, or in fact inactions, are taken so as to avoid question. A prime case is keeping trains in booked order regardless of the lateness of the first train, the second being recorded as 'following late' and hence dependency and any compensation remaining an issue solely within or between train companies. There are situations where for example the use of station stop time, timetable allowances and alternative regulating points could enable the eventual total delay of a conflict to be reduced or even eliminated. But, any delay that first occurs to set up the more favourable outcome will be attributed at the point of occurrence, regardless of the fact it will result in less total delay than any alternative . Hence an operator faced with such a decision could choose the solution that causes the most delay and so avoid the minimised delay being attributed to themselves as the network operator.

To understand how this action is driven it is useful to illustrate some straightforward examples. In the first instance imagine the layout in Figure 1 which is continuously signalled under track circuit block principles and where a 750m long freight train travelling via route A is timetabled to arrive in Loop 1, with no contingency for lateness in its train plan. It runs directly ahead of a passenger train, also destined for route A, which is gradually catching up, and which is due to pass and call at the adjacent station. If the freight train is running only a couple of minutes late it will not get 'in clear' inside the loop before causing delay at previous signals to the following passenger, bearing in mind the approach control on the loop entry signal, the slow speed of the turnout and the length of the train. The subsequent delay to the passenger through stopping and starting behind the freight amounts to five minutes. Late arrival of the passenger at the station will be attributed to following the freight with the original reason for the freight being late having the passenger minutes added to it.

The freight train is then pathed to follow the passenger train. The five minute delay compounds back onto the freight train when it departs the loop. However, a second passenger train, which is to travel forward via route B after calling at the station, is timetabled to follow the first after a gap of 10 minutes. This

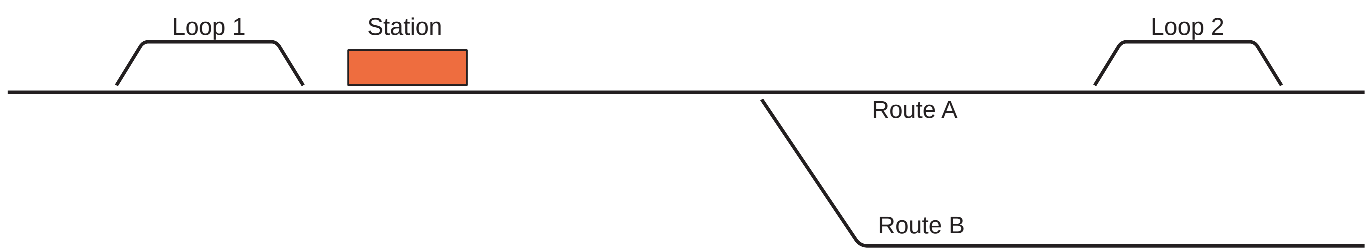


Figure 1.

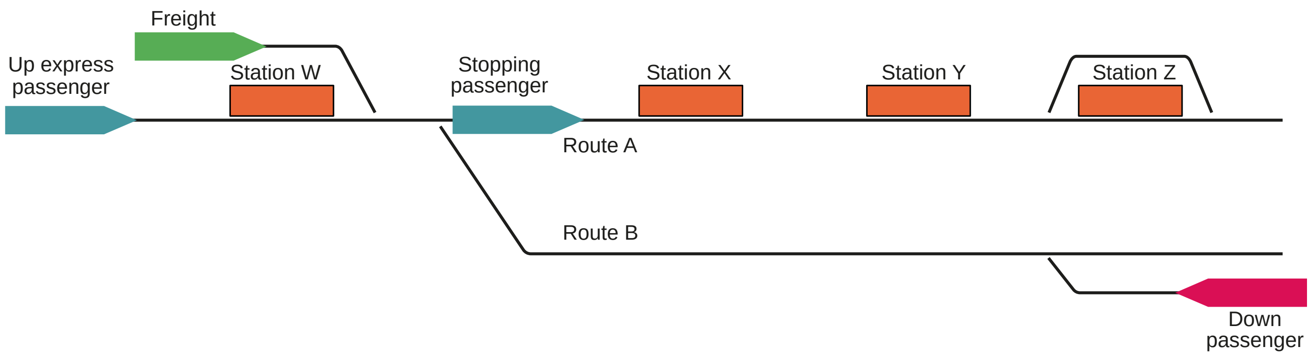


Figure 2.

train is running on-time which means if the freight is allowed to leave in its booked path it will begin drawing out of the loop at best only four minutes in front of this train (having allowed one minute for the first to pass clear beyond the station, the route to be set, the driver to respond to the signal and the brakes to have released).

The second passenger will receive adverse signals on approach to the station as the freight train pulls away and begins to accelerate its heavy load, resulting in a loss of two minutes which, once again, will be attributed to the original reason for lateness of the freight. The total delay up to now is therefore 2+5+5+2 = 14 minutes, 7 minutes to the freight and 7 minutes combined to the two passengers. With experience, prediction of this aggregate delay by the operator could identify two other outcomes that might be chosen.

One option would be to hold the freight until the second passenger has passed it, the total delay would then be 2+5+0+10 = 17 minutes, 5 minutes to the first passenger, no delay to the second passenger and 12 minutes delay to the freight. Alternatively, the operator could choose not to put the freight into Loop 1 as booked but instead run it to Loop 2. By not being subject to slowing for the approach control and entering Loop 1 it will recover its two minutes of lateness and actually pass the station early at full speed. The following passenger will not now approach close enough to receive adverse signals, thereby arriving and departing the station on-time. Similarly, the second passenger train will also enjoy a clear run. However, although the freight gains ground on the first passenger thanks to the slowing down, dwell time and acceleration associated with the station stop, the difference in speed between the two means the passenger train will encounter adverse signals as the freight enters Loop 2 ahead of it. This results in a 3 minute delay providing a total of 2+3+0+3 = 8 minutes, 3 minutes to the first passenger, no delay to the second and 5 minutes to the freight made up of the original two plus a further three caused by having to regain line speed from a start at Loop 2, despite having arrived there early. The problem with this, what might be regarded as the best option because delay is minimised, is that the three minutes of delay to the first passenger is now caused by the freight being allowed to run early to Loop 2 through the action of the network operator and so having to be attributed to them. The subsequent three minutes delay to the freight from having been side-lined at Loop 2 waiting to follow will similarly be allocated. So, reducing a 14 or 17 minute delay, which would be apportioned only between train operators to an 8 minute delay, will find the instigator of the reduction becoming liable for 6 minutes of it. Hardly an incentive to undertake sensible regulating.

In arriving at the best decision, it may be that a train which otherwise would not be delayed at a particular location is in fact subjected to delay to minimise the overall impact of an emerging situation. As before, attribution of such delay becomes critical to ensure that the reason is fully understood so as to avoid incorrect penalty to a particular train or freight company or the network operator. To illustrate this approach take a look at Figure 2.

Consider an up express passenger train running late that, having missed its path, is now following but catching up with an up stopping passenger that has departed station W. Both trains will be going forward over route A, the stopping train calling at stations X, Y and Z. It cannot be overtaken by the express train until station Z. The freight is due to follow the stopping train as far as the junction where it will take route B which is single line for some distance. If it does not leave on-time it will fail to reach the end of the single line before a down passenger is due in the opposite direction but letting the freight depart on-time will stop the express train outside the station.

Here is a situation where the correct regulation is to allow the freight train to follow the stopping train in its booked path and delay the express train. This is because the express train, if allowed to proceed first, will still incur delay on the approach to stations X, Y and Z whilst following closely behind the stopping train. The delay it incurs at W and whilst following the freight train to the junction means the stopping train will get further ahead such that the express train only begins to catch it up on the approach to Z. Its total delay will remain the same and no delay will be incurred by any other train.

Regulation by the human operator is often based upon accumulated experience. Just looking at the developing relationship between trains on a visual medium, such as a panel or VDU, is sufficient for a skilled operator to know the outcome and so intervene to achieve the most appropriate action to either avoid conflict or minimise delay. Such ability is learnt over time. To put it into action requires attentiveness and a desire to do a good job. In support of TMS, a properly programmed system will continue to make optimum decisions without getting tired, without being distracted and without personal preference. Distraction for the human operator is a significant impediment to good regulating because certain safety critical demands are placed in real-time that reduce and often prevent multi-tasking. In particular those tasks associated with incidents on the line and in responding to the increasing requests for staff protection to undertake routine work require precise focus that takes the operator away from focus on running trains.

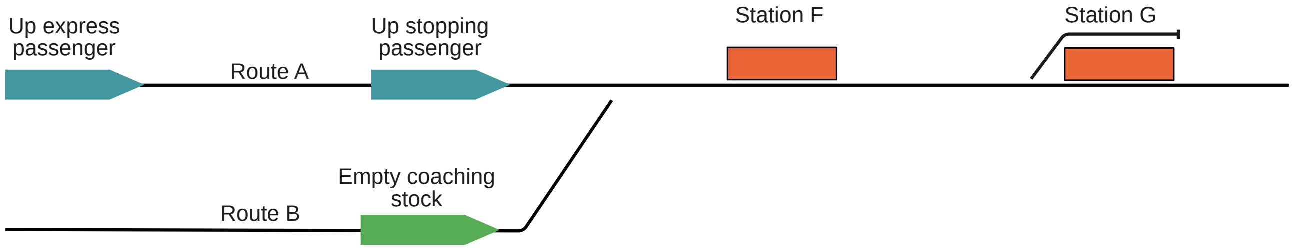


Figure 3.

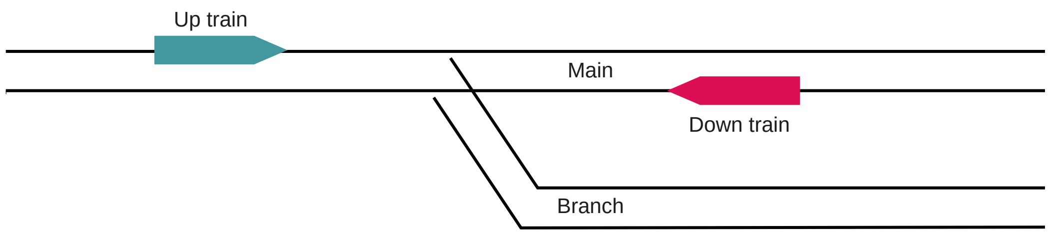


Figure 4.

Now take the situation depicted in Figure 3. An up passenger train coming from route A which calls at stations F and G is running 7 minutes late. Approaching on route B is an on-time up Empty Coaching Stock (ECS) train which terminates at G to form a down passenger service but which has a layover there of 15 minutes before it is due to depart. It is timetabled to pass over the junction 7 minutes behind the passenger train. Clearly it would not be sensible to let the empty train precede the late passenger train and so it is held at the junction to follow. The delay to it is attributed to the original reason for the passenger train being late. Had the operator allowed the empty train to run first the passenger train would have been delayed by a few more minutes whilst it followed. Such action would have not garnered any criticism of the operator and the extra delay would have gone down as "following an on-time" (in this case empty) train – bizarre.

Due to arrive at station G some 10 minutes after the first passenger train is another up passenger service that does not stop at station F. Allowing the empty stock to follow the first passenger train will now cause a clash with this second passenger train. Again the operator will encounter no criticism if he does this and so keeps the trains in booked order. All of the delay, including that now imposed on the second passenger train will be deemed attributable to the first passenger train and the second passenger train may now be the cause of a further conflict later in its journey. However, if the empty train is held for the second passenger train this will arrive at G just on-time . The total delay will be no greater but no other passengers have been inconvenienced and the arrival of the late empty stock will not impact on its next working.

Hitting the target but missing the point

The higher authority of route control, with input from train operators, will often seek to recover the downstream plan of a particular train by commanding that it run fast to its destination beyond a certain point, or 'skip stop' by missing out lesser used stations, or be turned back short. A better performance measure results on paper, helping to achieve or get closer to an overall target. That's all well and good for hitting the target but completely misses the point for the customers left stranded. Also, in many cases, this higher input often only looks at the train concerned, failing to recognise other trains that may negate the benefit of the decision. This might include catching up with a slower train which is now in front, so it might as well have not missed out stops; or being in the way at a platform where it turns back so preventing another train from progressing.

The influence of pathing and recovery allowances

Schedules often have a few minutes of recovery time inserted as an allowance at specific locations over a stretch of line to enable trains to regain their correct time should they encounter an unavoidable conflict or be subject to a temporary speed restriction. They may also have time inserted to recover from a conflict that the timetable has created or been unable to avoid. If there is no such restriction or the source of the conflict is itself running late then the train will run early to its next stopping point or new, subsequent, conflict. This is a situation that an experienced operator can take advantage of. The situation depicted by the junction in Figure 4 is a case in point. The up train is pathed onto the branch two minutes before the down train, leading to a slight conflict. The signalling provides approach control on the junction signal and so the up train will receive an aspect sequence commensurate with having to stop until such time as the junction signal clears. After this it will continue through the junction at the turnout speed.

The down train has a three minute allowance inserted in its plan because of this conflict and therefore if it is on-time can pass over the junction three minutes early and one minute ahead of the up train just as that train is arriving at the approach controlled signal. If, as is perfectly acceptable by the measurement regime, the trains are kept to booked order the conflict situation remains requiring the down train, travelling at line speed, to be presented with adverse signals. This results in the train having to approach and possibly even come to a stand at a red signal before finding it changes directly to green. Rather than arrive at the next station early it now barely achieves a right-time arrival. Passenger comfort, environmental impact and SPAD mitigation have all been sacrificed. Remember, a moving train is a happy train.

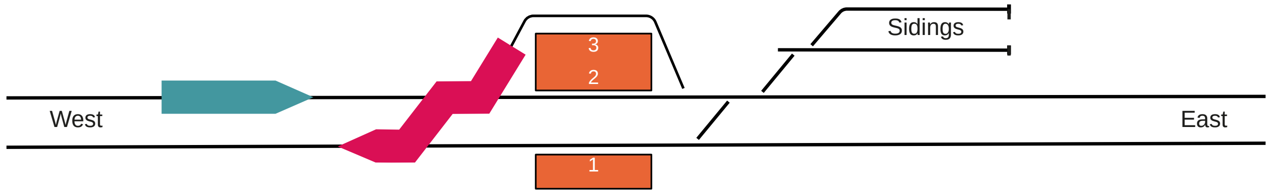


Figure 5.

Each train driver is isolated, unaware of their train's relationship with others. In the instance above, the driver of the down train might easily surmise the presence of the up train and that it has been given preference at the junction, especially if this is a regular occurrence. The provision of Driver Advisory Systems (DAS) can assist in keeping trains on schedule, but if fitted as unconnected devices can undermine regulating decisions. In the situation described, an unconnected DAS might encourage the driver to slacken speed and so not pass over the junction three minutes early, thereby causing the up train to have to stop at the junction signal. Operators make their decisions based upon the current position and progress of a train, expecting it to continue in the same manner. They have no knowledge of what unconnected DAS may be presenting to a driver and whether this may be at odds with the regulating decision they have made. Connected DAS brings the benefit of ensuring that drivers are encouraged to drive to a profile that supports a regulating decision.

It is also interesting to note that the Automatic Route Setting (ARS) tool used at many control centres in the UK does not recognise pathing time, hence making decisions that are not always optimal.

Timetabling to avoid conflict and dependencies

Timetabling has a part to play both in avoiding conflicts and in minimising dependencies whilst ensuring separation not just between trains but between service groups. The goal should be a zero defect timetable otherwise the front line operator who is dealing with real time delivery will not have the optimum basis for doing so. Reduction in journey time to make travelling by train more attractive has powerful outcomes in terms of marketing and ridership yet can be a contributor to unreliability. Extracting maximum speed from rolling stock and permanent way will certainly reduce point to point timings but unless an allowance for planned or unforeseen occurrences, including conflict with late trains, is included in the overall timings any occurrence during the journey will not be recoverable resulting in the train running late.

If recovery minutes are added to station dwell times at intermediate stations then a late arrival can be followed by a right-time departure but those people leaving the train at such a stop will be late whilst the performance regime will record such. If recovery allowance is added on the approach to the station then a minimum dwell time can be tabled and both a right-time arrival and departure recorded and that is why the allowance is on the approach.

The issue is when such recovery is not required and an early arrival creates conflict or a driver reduces speed to avoid early arrival and then on nearing the station encounters or creates a conflict that would otherwise have been averted. Better to arrive early and delight the passengers. Of course it then goes without saying that the station must have sufficient platforms to ensure the correct one is vacant for the arrival, even if a little early. Key to success is also establishing the right relationship between public and working timetables. The working timetable can allow for an arrival that is early compared with the public version and so be the means of achieving delight.

Many ways in which the railway is operated introduce conflict. Some of these are as a result of the limited infrastructure and the way in which it is used. Take for example a through station at which some services terminate and start back as depicted in Figure 5. The layout is minimal without the additional point work that would enable trains to start back from platform 2 whilst another arrives in parallel at platform 3. Schedules that decline to include the shunting of trains at such locations result in the creation of otherwise avoidable conflicts.

Trains terminate from the West in platforms 2 and 3, layover for periods of between 20 and 50 minutes before returning West again. Their departure conflicts both with any other such terminating service and with those travelling through from west to east. The classic right-time start versus late arrival situation mentioned earlier is created to which can be added the late departure (for whatever reason) to the right-time and late arrival conflict. On arrival the driver abandons the train, either to take a scheduled break or to book off at the end of their shift.

Making the correct decisions to keep freight trains moving without wasting fuel or impeding passenger trains is a major traffic management requirement. *Photo Shutterstock/Kev Gregory.*

Barnetby, Lincolnshire in the UK, and a rake of empty bogie tanks need to move across the complex junction. Since the photo was taken in 2014 the signalling has been replaced with colour lights – the change of technology hasn't removed the complexity of the move. *Photo Shutterstock/Kev Gregory.*

However, there are sidings used for the stabling of stock at night but which remain largely empty during the day.

Terminating trains could be shunted to the sidings between other arrivals and through traffic then reach the station using platform 1 at a convenient time to pick up their return path. Departure from platform 1 will be a parallel move to trains coming from the West. Obviously there is a cost to this in terms of drivers' hours, probably even requiring the provision of a shunt driver to perform the manoeuvres. The cost of not doing this is the certainty of conflict that will arise a number of times a day. The answer is simple.

Achieving Traffic Management

Is the quest for Traffic Management actually a reaction to what amounts to a host of problems and if so is it therefore just tackling symptoms whilst some of the root causes of disruption remain unresolved? Some causes are created by track layouts, operating practices and signalling functionality. Attention to these can eliminate many conflicts. Then there is the recognition of incidents, whether these be on the infrastructure, with rolling stock, with train crew or with station staff. Reduce these along with the impact of those that do occur by timely intervention and significant strides in performance can be gained. That's not to say there is no place for a TMS to assist in dealing with those other day to day unavoidable situations that do arise.

When considering a TMS there should be no doubt as to the complexity of its task. Just how far into the future and what geographic limit is placed on its predictions are important factors as is the way in which the train service punctuality is measured. The TMS could be configured to minimise overall delay or perpetuate a set of rules that result in a higher level of delay based on direct train on train impact. To be successful it must have a more flexible, braver set of rules by which it calculates its decisions and be able to demonstrate neutrality whilst showing what decisions are available and what their outcomes are. This will allow for correct attribution, preferably automatically by the TMS itself thereby improving the consistency and robustness of the data. Off-line analysis should then allow for improvement, not just of the TMS but of individual schedules and indeed of individual train companies highlighted by the results.

Just as an experienced operator learns from the situations presented to them, so too should a TMS by harnessing artificial intelligence and machine learning so that its performance can improve over time and, when timetables change, it can continue to operate seamlessly.

Then, what the operator needs from the tool is a form of visual presentation of the future based on calculations of the unfolding scenario that clearly shows the options available together with their outcomes. If it is to be connected directly to the route setting then it must be explicit in its intentions and capable of transparency in order that these can be justified. Importantly its decisions need to be fed to DAS and it must also be able to be circumvented by the operator who must remain in ultimate control.

About the author ...

John is a signal engineer with hands-on experience in railway operations, enabling him to understand in depth the relationship between these two related disciplines. A past president of the IRSE who has worked for network operators and supply companies he has contributed to a number of textbooks whilst accumulating 48 years in the profession engaged in various roles that have seen him work on engineering projects and studies both in the UK and abroad. As well as undertaking project engineering and design management he has been responsible for significant market intake for a major contractor and both led and contributed to the development and introduction of new technology.

What do you think?

Do you agree with the points raised in John's article? Have you had different experiences in operating the railway? Does TMS offer all the solutions on our crowded railways, or does it fall short of our expectations?

Perhaps your railway has had particular success in using the technology to improve passenger experience, or maybe you believe that humans will always have an overriding position in running the network.

Let us know what you think, email **editor@irsenews.co.uk**.

Back to basics: Principles of railway safety engineering

David Nicholson

This article continues the 'back to basics' series, looking at the principles of safety engineering as applicable to a railway, particularly hazard and risk assessment, identification and analysis techniques. Previous 'back to basic' articles have touched on the safety inherent in each of the systems discussed; this article considers how safety is achieved.

Definitions

Before we begin, it is necessary to be clear on definitions and what is meant by the different terms used.

- Safety: Freedom from unacceptable risk.
- Risk: The combination of the likelihood of occurrence resulting in harm and the degree of severity of that harm.
- Harm: Physical injury, material damage.
- Severity: A measure of the amount of harm.
- Accident: An unintended event or series of events that results in harm.
- Hazard: A condition that could lead to an accident; a potential source of harm; an accident waiting to happen.
- Cause: Any event, state or other factor which might contribute to the occurrence of a hazard.
- Safety measure: An action reducing the risk of a hazard.

The definition of 'safety' introduces the concept that some risk is acceptable. This might seem surprising at first reading, but there are plenty of people who indulge in activities that others consider too dangerous (e.g. bungee jumping or flying). Others can see the benefits that it brings to them (e.g. thrills or speed of travel).

This raises the question of who determines whether a risk is acceptable or not. Sometimes this is purely personal (whether to bungee jump or fly), but when a service (such as rail travel) impacts on the general public, it is usual for governments to establish legislation with which those providing the service must comply. The legislation is usually aimed at reducing the amount of potential harm to the general public and workers, whether that harm is shock, injury, permanent damage (e.g. loss of a limb or hearing loss) or fatality.

This is not a simple action for governments to achieve as the public they are seeking to protect is not consistent in their perceptions of acceptable levels of risk. There is often a large outcry from the public when a single train accident results in several deaths, but the very many single deaths that occur each day on the roads is felt tolerable. This inconsistency is something that railway, and other, engineers have learnt to live with.

"If we wish to avoid harm, we should seek to reduce risk"

From the definition of 'risk' we can see that if we wish to avoid harm, we should seek to reduce risk. This is achieved either by reducing the likelihood of occurrence of harm, reducing the severity of the harm, or both. Putting it another way, we can reduce risk through two different approaches: the first is to reduce the likelihood of an event happening where the outcome may be harm; the second is to reduce the amount of harm should that event take place.

The definition for a hazard can also be expressed as 'an accident waiting to happen'. No accident has taken place, but there is a dangerous situation where if something else happens, it can lead to an accident. Thus, for any given hazard, all that is needed is a trigger event to start the process which ultimately leads to the accident. An example hazard is a level (or at grade) crossing with no form of protection. The hazard (the accident waiting to happen) occurs when a train is approaching. There has not been any accident, but one could happen if there was a car approaching (the trigger event). An approaching car may now collide with the train resulting in an accident with consequences beyond the railway boundary.

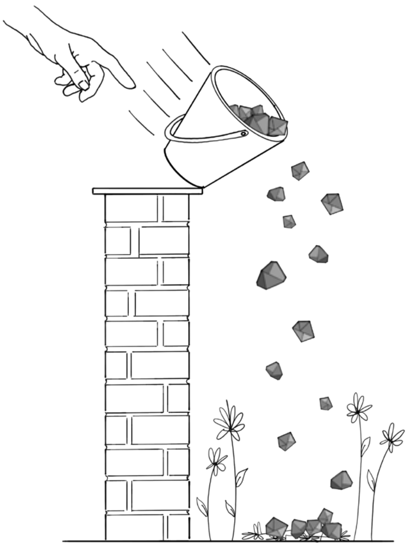


Figure 1 – Hazard to accident.

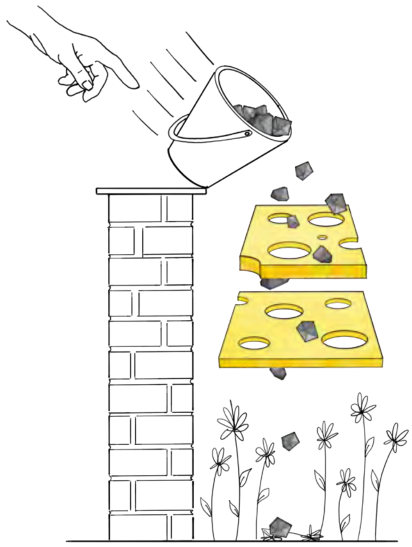


Figure 2 – Hazard to accident – reduced risk.

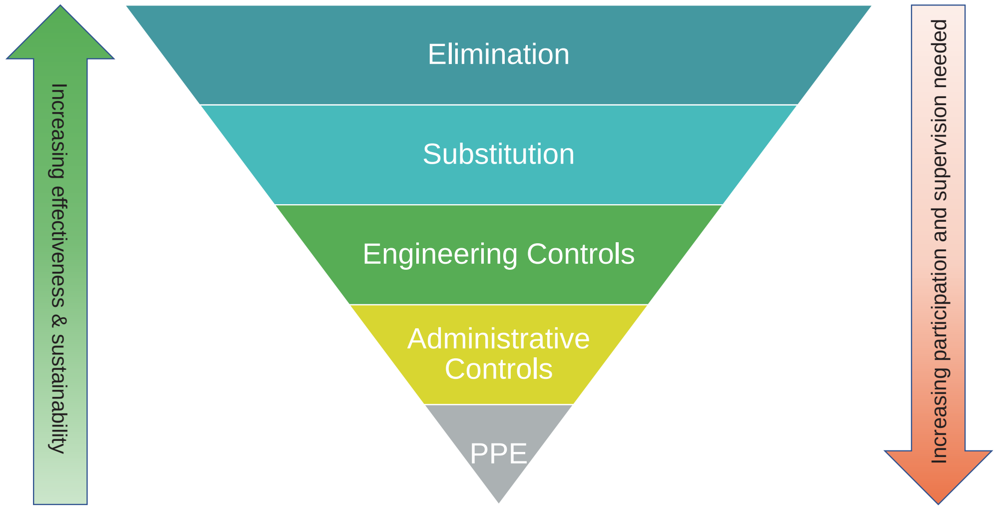


Figure 3 – Hierarchy of control.

"Risk reduction measures are sometimes expressed in a hierarchy of control"

This sequence of events is illustrated in Figure 1 where: the level crossing is the wall; the hazard is shown as the bucket of stones on top of the wall; the trigger event is the hand knocking the bucket over; and the accident is the stones falling onto the flowers.

Risk reduction

From the diagram, we can see the accident can be prevented, or limited, quite simply by:

- Removing the hazard: Design the railway without a level crossing.
- Reducing the frequency with which the hazard occurs: Reduce the number of trains that use the crossing.
- Reducing the frequency of the trigger event: Reduce the number of cars that use the crossing, for instance by providing an alternative and more attractive route for car drivers to use).
- Reducing the likelihood of a collision: Design a level crossing system that warns of an approaching train; install barriers and road traffic lights to stop road traffic; provide railway staff to stop traffic; have the train sound its horn on approach; ensure good sight lines.
- Reducing the severity of a collision: Reduce the speed of approaching trains; provide space for a car to divert into at the last minute; design cars to survive the impact of a train. This last point about car design is outside the scope of railway projects but indicates how solutions can lie outside of the expected areas of interest as shown in Figure 2.

Trying to limit the number of falling stones in our illustration in Figures 1 and 2 is not a perfect solution. Any of the examples given above can fail. If the means to limit the falling stones is shown as barriers with holes, it is obvious that some stones still make it through the holes in both layers and crush the flowers underneath. But the impact, or severity, of that accident is (hopefully!) smaller than it might have been if no protection was put in place – fewer flowers are crushed!

Risk reduction measures are sometimes expressed in a hierarchy of control. This is shown in Figure 3.

Substitution may see a level crossing replaced with a bridge, although bridges bring their own set of hazards.
Photo Shutterstock/ Ivonne Wierink.

"The temptation is to rely on the lower levels of risk reduction"

"Determining the safety benefit over the lifetime of the safety measure is a little harder and, at times, controversial"

The explanation of the different levels is as follows:

- Elimination: design out the hazard (e.g. remove the need for the road to cross the railway).
- Substitution: replace the hazard with something less hazardous. For instance, we could replace the level crossing with a bridge. While in this example this might seem very close to elimination, bridges bring their own set of hazards due to bridge strikes, or vehicles or objects falling onto the railway from the bridge thereby blocking the line).
- Engineering: use work equipment or other measures to help separate people from the hazard. Examples are warnings, alarms, guarding dangerous machinery from human incursion (e.g. for level crossings, provide lights and audible alarms as the train approaches).
- Administrative Controls: Identify and implement procedures necessary to work safely with the hazard. For example, we could provide instructions and training both for train driver and road users on how to use the different types of level crossing.
- Personal Protective Equipment (PPE): This is why motorcyclists wear crash helmets. Or why people erecting scaffolding are tethered. There is no example here for a level crossing. But it is, for example, why many railway administrations require their trackside staff to wear high-visibility clothing. This makes them more visible to the train driver, who can sound the train's horn, thereby giving the trackside staff more time to get clear of the approaching train.

The temptation, because it's both inexpensive and quick to implement, is to rely on the lower levels of risk reduction, namely administrative controls or PPE. People are unreliable at carrying out instructions and obeying alarms, particularly under stressful conditions. Therefore, the reliance on these lower levels of control should only be used where elimination, or substitution or the use of engineering controls cannot be achieved.

Safety benefits and costs

It is expected that the engineering and operations teams will implement good practice and adopt the hierarchy of controls from the outset. Choosing which control in the hierarchy to apply introduces the concept of calculating the costs involved to introduce a safety feature and then comparing that with the safety benefit.

Calculating the costs is relatively straightforward by asking questions such as: How much will it cost to provide this extra design feature? How much do any extra parts or items of equipment cost to purchase? How much more will it cost to operate and maintain the railway with this safety feature implemented?

Determining the safety benefit over the lifetime of the safety measure is a little harder and, at times, controversial, not least because in addition to fatalities, there are so many different types of injury (both physical and mental). Does the age of the individual matter? Or the number of their dependants? Does the number of injuries or fatalities in any one incident make a difference?

A number of countries have adopted a method of converting injuries and fatalities into a common measure. One method is shown below as a Comparable Fatality Score (CFS) (note that other countries and other railway administrations may have different conversion rates):

- 10 major injuries to 1 fatality.
- 100 minor injuries to 1 fatality.
- 1000 negligible injuries to 1 fatality.

Each CFS is converted into a monetary value, a figure that is set independently, usually at a national level, typically with a figure around £1.5m to £2m per comparable fatality. By comparing the risk to life without the safety measure to the risk with the safety measure, a reduction in the CFS can be calculated. This benefit can then be compared to the cost of implementing the safety measure. This allows for a simple Cost-Benefit Analysis (CBA). If the cost of implementation is much higher than the reduction in CFS, then the project does not have to implement the safety measure. In the UK, for example, a project is obliged by law to reduce risk to As Low As Reasonably Practicable (ALARP) and it is this process of comparing project costs with a reduction in CFS that enables the project team to justify its decisions.

The demonstration of sufficient safety level is a complex and challenging process. Different countries will have different approaches to demonstrate what is acceptable and what is not. Adopting good practice through adherence to standards or qualitative arguments may be sufficient, with a CBA only used in the more complex situations. However, CBA on its own is not sufficient to demonstrate acceptable safety levels. It cannot, for example, be used to claim that adherence to statutory duties is not required, or that intolerable risks are somehow acceptable just because they offer a good CBA. Legislation often weights the decision towards safety, requiring risk reduction measures that may not seem necessary when judged by a CBA alone. And it should be noted that benefits may not be limited to safety. There may, for example, be efficiency or environmental benefits as well.

“Demonstration of sufficient safety level is a complex and challenging process”

Defence in depth

How do we design systems that are ‘safe’? We consider a process known as ‘Defence in depth’. This consists of seven sequential steps as discussed below.

Error avoidance: We work to prevent design errors occurring in the first place by:

- Keeping the design simple. An overly complicated system makes it harder to detect errors in the design of the system. Safety and non-safety elements of the design should be kept separate. Avoid novel design features and the use of subtle techniques that are not clearly understood by others. Don’t provide functionality that isn’t required in case it is inadvertently activated. This is particularly pertinent for software where complex subroutines and self-modifying code can result in faults in operation.
- Adherence to standards: People have spent a lot of time documenting how things should be done so that those who follow can benefit from their experience. It also ensures that people adopt a common approach to their understanding of functional operation.
- Configuration Management: We need to ensure that people are working from the correct design information, and that the final design drawings are marked correctly so that the installation, test and commissioning engineers can have confidence they are installing, testing and commissioning the correct design.
- Competence: Ensure those designing the system know what they are doing! Competence is defined as the combination of knowledge and experience, which can be grown through training, mentoring, observation and assessment.

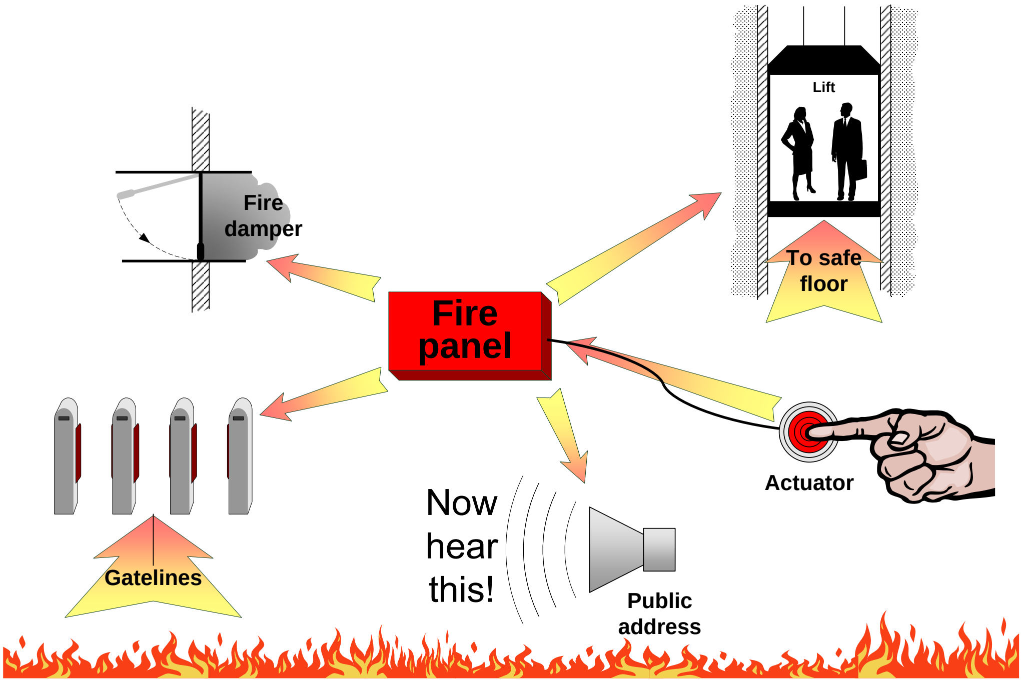
Error detection: If there is an error in the design, we want to find it and remove it before it is installed. This means designing for testability and validation, checking and reviewing designs, performing simulations, doing software code walkthroughs and undertaking development testing.

Fault avoidance: Even where the design is error-free, faults can occur in operational service, and so controls must be applied to minimise the risk. These controls include:

- Design for reliable operation, by ensuring components are not stressed when in service (e.g. too much current through electrical components, or too much load for mechanical elements) and by choosing reliable components.
- Perform proactive maintenance when in service by maintaining at regular intervals or by having systems that alert the maintainer when in need of maintenance.

Personal Protective Equipment is important, but cannot guarantee workers’ safety. *Photo Shutterstock/ Ian Stewart.*

Figure 4 – Simplified station fire panel interface diagram



"How are hazards identified before they result in accidents?"

Fault detection: We are dealing with real-life mechanical and electrical systems which will wear and fail. So we want to ensure that faults can be detected and rectified before any life-threatening situation arises. We do this through:

- Specifying appropriate testing and maintenance intervals and thresholds.
- Where there are several similar items, these can be compared to determine where their behaviour diverges.
- Provision of in-service self-diagnostic facilities.
- For software, the use of watchdog timers or plausibility checks on data.

Fault tolerance: Knowing that faults will occur, we can design our systems to tolerate certain levels of faults. Examples include:

- Redundancy: Providing more than one channel for the same information or control flow. A common approach in computer-based systems is to have three computers undertake the same calculation and a voting system checks that at least two of them agree. This is known as a 2-out-of-3 voting system). Note this protects against random hardware failures (one channel may fail) but not against systematic faults where there is a software fault which causes all three channels to produce the same wrong output.
- Diversity: This is similar to redundancy except that the channels use different hardware and/or software to avoid many systematic errors. This can be through design diversity (the 2-out-of-3 voting system uses different microprocessors), functional diversity (e.g. automatic braking, but with a driver on board to act in case the automated system fails), manufacturing diversity (procure the same product but from different suppliers).

Failure handling: We can ensure that we can handle failures well through:

- Using known physical or electrical properties to ensure that should a fault occur, it fails to a known state (e.g. gravity returns a signal arm to the stop position).
- Provision of alarms or other warning indicators.
- Instructions for people to follow in the event that something does go wrong.

Hazard mitigation: Finally, given the system may fail in an unsafe way despite all the above best efforts, we consider implementing other measures to reduce the overall risk such as crash worthiness of vehicles.

Hazard identification and analysis

This is all good theory. But how are hazards identified before they result in accidents? There are three areas we need to consider:

1. The functions the system has to perform.
2. The users of that system and how they are expected to interact with it.
3. Interfaces with other systems.

In order to do this, the system you are analysing needs to be comprehensively defined and understood. Consider the introduction of a station fire panel in an underground station as shown in Figure 4.

The fire panel has one function: upon receipt of an input from the actuator, it sends a control signal via each of its interfaces to external systems, so they can perform their functions.

In this example, there are three groups of people: firstly the one who presses the actuator who may need some instruction or guidance on when to press the actuator and what to expect next; secondly station staff who need training in the

Guideword	Definition
No or not	No part of the intended result is achieved or the intended condition is absent
More (higher)	Quantitative increase
Less (lower)	Quantitative decrease
As well as	Qualitative modification/increase (e.g. additional material)
Part of	Qualitative modification/decrease (e.g. only one of two components in a mixture)
Reverse/opposite	Logical opposite of the design intent (e.g. backflow)
Other than	Complete substitution, something completely different happens (e.g. wrong material)
Early	Relative to clock time
Late	Relative to clock time

Table 1 – Hazard identification guidewords.

Likelihood category	Classification term	Time frame	Midpoint likelihood estimate	Description
5	Frequent	Less than 1 year	1 in 6 months	The event is likely to occur frequently (probably annually).
4	Probable	1 year to 5 years	1 in 5 years	The event is likely to occur often.
3	Occasional	5 years to 10 years	1 in 10 years	The event is likely to occur several times.
2	Remote	10 years to 100 years	1 in 50 years	The event can be expected to occur during the lifecycle.
1	Improbable	100 years or greater	200 years	The event is unlikely but may by exception occur.

Table 2 – Likelihood categorisations.

Severity category	Classification term	CFS equivalence	Description
1	Negligible	0.001	Non-reportable injury
2	Minor	0.01	Minor injury
3	Major	0.1	Major injury or multiple minor injuries
4	Critical	1	Single fatality or multiple major injuries. Equivalent to 1 CFS
5	Catastrophic		Multiple fatalities

Table 3 – Severity categorisations.

“A HazID involves systematically considering each function, user operation and interface”

event of an alarm; thirdly members of the public who are expected to evacuate the station when the alarm is activated. Designers and maintainers are also important for any system but are not considered in this particular scenario.

Five separate interfaces are identified, each of which will have electrical, mechanical, physical and functional properties. These are:

1. The actuator input.
2. The fire damper which closes the damper to restrict the flow of oxygen to a fire.
3. The ticket gates, designed to open to permit the quick and safe exit of passengers.
4. Automated public address system which initiates announcements alerting passengers to the need to evacuate the station.
5. Lifts which must move people to a deemed safe floor.

It is quite usual to hold a Hazard Identification (or HazID) workshop. It is important to get representation from people who are experienced in the system being considered, the environment in which it will operate and how things might go wrong. A HazID involves systematically considering each function, each user operation (or reaction in the case of members of the public) and each interface. The conversation is seeded with guidewords to encourage the meeting to think about how the function, user or interface might not work as intended. An example of potential guidewords and their meanings are shown in Table 1.

The workshop members can consider whether each deviation from intended operation represents a genuine hazard. Once all reasonably foreseeable hazards are identified, the hazards can be analysed to determine their likelihood and severity of outcome. This aids understanding of the risk and enables effort to be focussed on those with the highest risk. This analysis is often done qualitatively, and it is usual to see categorisations of likelihood and severity similar to Tables 2 and 3.

Likelihood		Severity 1 Negligible	2 Minor	3 Major	4 Critical	5 Catastrophic	Risk classification
5	Frequent	Medium	High	High	High	High	**Intolerable risk:** Activity not permitted. Hazard to be avoided or reduced.
4	Probable	Medium	Medium	High	High	High	
3	Occasional	Low	Medium	Medium	High	High	**Tolerable risk:** Control measures to reduce risk rating to a level which is as low as reasonably practicable (ALARP).
2	Remote	Low	Low	Medium	Medium	High	
1	Improbable	Low	Low	Low	Medium	Medium	**Negligible or low risk:** Control measures to be maintained and reviewed to control residual risk as far as reasonably practicable.

Table 4 – Risk matrix.

This allows a matrix of risk classification to be developed where particular combinations of likelihood and severity can yield a risk that is intolerable, tolerable or negligible. An example is shown in Table 4.

Note that all of the above tables are examples. Different railway authorities may have different categorisations and different acceptable levels of risk. All such categorisations and levels must be justified, and this is typically done in a safety plan. In extreme cases, likelihood and severity may need to be calculated quantitatively; this is much harder to do.

Now the hazards are identified and their risk has been considered, safety measures can be designed to reduce those risks to a more acceptable level. A project may need to bring together a number of representatives to determine if a risk is acceptable based on proposed measures.

"There will always be engineering failures"

Causes vs hazards

A common mistake in this process is to confuse causes of hazards as hazards. This can result in a long list of so-called hazards to manage, increasing the time and cost involved to complete the design. Avoiding this confusion is achieved by being clear about the functions of the system being developed, its users and its interfaces. This usually entails developing a diagram showing all the possible interfaces, making sure this includes the human interactions as well as technical interfaces. In the fire panel example, the function of providing an alert to each of its interfaces could have a hazard of 'No alert to the interfaces'. This could happen because the power supply to the panel was faulty. The failing power supply is a cause of the hazard.

Be alert!

Samuel C Florman was a Civil engineer who started his career in the 1950s. In his book, "The Civilised Engineer" he writes (p149):

"There will always be engineering failures. But the worst kinds of failures, the most inexcusable, are those that could readily be prevented if only people stayed alert and took reasonable precautions.

"...experience teaches us that society requires a cadre of concerned citizens – engineers foremost among them – to urge proper action and to persist when rebuffed.

"Engineers, being human, are also susceptible to the drowsiness that comes in the absence of crisis. Perhaps one characteristic of a professional is the ability and willingness to stay alert while others doze. Engineering responsibility should not require the stimulation that comes in the wake of catastrophe."

Staying alert requires the engineer to identify, then assess the risks arising from the works being undertaken. As engineers, we need to be alert to how the design will be operated and how the system will be maintained. We must foresee changes in the operating environment that will affect the system's operation and consider how that design will eventually be decommissioned. Risks can arise through many areas. This includes the physical aspects, human behaviours, the processes which govern how tasks are performed, and the ability of people to perform a task when under pressure. Having assessed the risks, the engineer must design the system (consisting of people and processes as well as the products themselves) to mitigate against those risks.

About the author ...

David is the professional head of discipline for Engineering Management in SNC-Lavalin Atkins and works to grow the skills and knowledge of those who provide the technical leadership of projects. Beginning with an understanding of the operational needs, he specifies, designs and changes railways to make them safe, operable and fit for purpose.

As a railway systems engineer with a broad knowledge of rail systems, disciplines and operations, coupled with experience across the whole development lifecycle, David has taken projects from initial concept through design and development through to implementation.

He is currently working in the Engineering Management Office of the East Coast Digital Programme, bringing digital railway techniques to Network Rail's main line from London to Edinburgh.

"It's only a relock"

Stephen Dapré

We first met Ruth in IRSE News issue 250 "It's only data", with two further episodes in IRSE News issue 254 "It's only an 'Off' indicator" and 258 "It's only passive provision". This episode may make slightly more sense if you've already read the previous ones; for any new readers Ruth lives in a fictional world where the railway has been divided geographically into Communities.

"Ruth, we've just been asked to look at doing just a relocking rather than a full resignalling. Can you summarise what we would need to do please?"

Ruth thought for a moment. Relocks in her world had a somewhat mixed reputation: if done well, they appeared to be an elegant solution to rectify specific local issues, however each Community had their own views on when and how to do them. Nonetheless, Ruth was always up for a technical challenge and preferred to consider a blend of contrasting views as part of her optioneering, whereas many of her peers tended to rush headlong towards one technical solution.

"Actually, it's probably best if we do some fact-finding first – perhaps contact some other Communities, see what lessons they have learnt, see how relevant they are."

"Excellent idea! We can arrange some visits and travel around to see them all."

Ruth was unsure whether the project manager's sudden enthusiasm was driven by the desire to successfully deliver a well-scoped project, or just having a good excuse to visit and stay in hotels in interesting places in other Communities. Either way, she was relieved that her wish to do some proper research was being supported on this occasion, rather than just being told there was an unrealistic fixed end date and budget.

The Broad Minded way

Ruth and the project manager were on the train to visit the Community of the Broad Minded (CBM): when she had spoken to the CBM previously about interlockings and data they had also mentioned doing some relocks, so it seemed a good place to start.

Ruth was looking forward to a peaceful journey to enable her to prepare, however she could see that the project manager had other ideas.

"Ruth, I think it would be helpful for today's meeting if you could explain to me in more detail how interlockings work."

Fortunately, Ruth was prepared for this eventuality: by a remarkable coincidence her professional institution had just published a "back to basics" introduction to interlockings in their latest magazine which she had thoughtfully brought with her in her bag.

"Here we go, try reading this" she said, handing over the magazine, and smiling at the parent on the table across the aisle who had just given their child a colouring book and crayons.

Some time later they arrived at the CBM office.

"Welcome back to our Broad-Minded Community, I believe you want to know about why our approach is best practice for others to use?"

Ruth noted that they were as broad-minded as always.

"I've been asked to do some research into relocks, so I was wondering how yours are going?"

The CBM engineer explained how it was suddenly announced that their main line was to be electrified in impressive timescales, hence all their homebuilt 1960s relay interlockings would need to be renewed quickly because the equipment was not compatible with AC electrification. To save time it was decided to renew the interlockings and lineside equipment whilst keeping the existing signals in the same place, instead of following a traditional resignalling approach with new signals positioned to suit current standards.

Ruth was intrigued.

"Why didn't you want to move any signals?"

"We didn't have time to do all the necessary design development and signal sighting sorcery, and in any case we knew the existing layouts worked safely so there was no reason to change anything."

"Surely the signals won't last another whole lifecycle?"

"Fair question, however, we were told that Binary Railway would be introducing UTCS (Universal Train Control System) here to deliver improved capacity, so all the signals would be swept away within 10 years."

"So how did it go?"

Relock and recontrol: Reading

Reading is a major station and junction on the Great Western main line (GWML) between London and the west. The previous signalling was 1960s Western Region E10k relay interlocking technology, controlled from Reading Panel Signal Box (PSB) on the north side of the station.

A major enhancements scheme was proposed with several new platforms, junctions and a viaduct. This triggered extensive signalling work for three distinct reasons:

- The local interlocking for the immediate station area would have to be relocked because the Power Signal Box (PSB) – which also contained the station interlocking downstairs – was being demolished to make space for the new platforms. The station layout also required major alterations, so relocking allowed data changes rather than relay wiring alterations for the subsequent remodelling stages.
- Several adjacent interlockings also had to be relocked because of the additional running lines and junctions on the approaches.
- All the other remote interlockings had to be re-controlled by diverting and renewing the TDMs because the Entry/Exit (NX) panel and associated "office end" Post Office relays were situated in the PSB building.
- In a later plot twist, 25kV electrification of the GWML through Reading was announced towards the end of the Reading remodelling. The relocked areas near the station already included passive provision for electrification, however many of the remote E10k interlockings only recently re-controlled now had to be relocked for AC immunity as a subsequent "Reading Outer" project.

Therefore, the former PSB area is now controlled from Thames Valley Signalling Centre at Didcot. It uses Resonate IECC Scalable mostly controlling Siemens Trackguard Westlocks, plus a few remaining re-controlled E10k interlockings beyond Newbury (the limit of the electrification scheme) towards Westbury.

"Well, at the time we thought it made good sense, however it hasn't quite worked out like that."

This wasn't the first time in her career that Ruth had heard a sentence approximately like this.

"How do you mean?"

"Several things really: firstly, one of the old signal structures fell over which highlighted their poor condition, so we are now having to replace quite a few of them even to last 10 more years. Most of the gantry signals needed full replacement anyway to give clearance for the overhead line equipment, so we had to build some significant structures. The testers also said that reusing the old signals and four-foot equipment had made commissioning changeovers slower and harder than if we'd simply installed new equipment and powered it up for testing beforehand."

"Understandable. What about the longer-term strategy?"

"Ah, now that seems to have evolved: Binary Railway changed their national rollout plans. We won't get UTCS in our Community until much later, so we will now have to keep our old signals going for considerably longer. In the meantime, we are being asked to run more train services on signalling layouts designed several decades ago. It's quite disappointing that the electrification also proceeded much more slowly than first planned, so we probably would have had time to do a full re-signalling instead!"

Ruth could genuinely feel their pain: they had made decisions based on the information available, only to find that promises from others were not delivered and they were now faced with ongoing work to keep older assets going even longer. If this had happened in her local Community, the hindsight engineering department would have been swarming all over it...

Like-minded

Their next visit to a Community started with a bold statement.

"We have kept this area going for over 60 years without having to do a complete resignalling, avoiding the major cost and disruption of full renewals."

This Community was clearly proud of how they had prolonged the life of their signalling systems.

"That's interesting. So how many times have you renewed the lineside equipment?"

"Depends – some components such as signal heads only once, whereas the cables have been replaced several times. Actually, some of our signal structures are more than 60 years old, with newer heads fitted since then."

"What about the interlockings – are they still RRI (Route Relay Interlocking)?"

"Well, they were each rewired many years ago, then we had to rebuild new relay racks in new buildings alongside because the original relay rooms had leaking flat roofs which had damaged the equipment inside."

"Anything else?"

"Let me think: the first TDM (Time Division Multiplex) was renewed once due to obsolescence, then the second one was refurbished with new cards and racks two years ago. Last year we diverted the TDM circuits to recontrol the whole area from a VDU system at our new Community Operations Centre instead of the original NX panel. That also required a new interface unit to ensure the TDM could talk to the control system."

"So really the whole system has been fully renewed?"

"Absolutely not! All we've done is change individual subsystems over the years. Next year we are planning to replace each RRI with a Standard Computer Interlocking (SCI), interfacing to the existing lineside cables."

Ruth's mind started to wander: she vaguely recalled a story about a philosopher with an axe where the wooden handle and steel blade had each been changed several times, yet the owner was insistent it was the same axe. Or maybe it was a broom? She was also struggling to remember whether she'd seen it in an academic paper or just in a sitcom on TV – but it didn't really matter.

At this point the Community's own project manager intervened:

"Of course, our strategy is also highly cost-efficient, as it means we never have to pay for a 100% renewal."

Ruth looked curious, so the PM continued:

"Well, our funding is based on percentages of full renewal rates: a lineside renewal is funded at only 62%, a relay rack renewal is 49%, a TDM renewal 8% and a recontrol is a bargain at 14%."

After what Ruth considered to be some nimble mental arithmetic she responded:

"Isn't that 133% overall?"

"Yes, but you don't have to pay it all at once, we can spread it throughout the lifetime."

This was now reminding Ruth of her brother's approach to his personal finances using the full headroom of his credit card. She asked another question:

"What about the interfaces? Each time you renew one part, you have to connect it to the residual parts being retained, which surely creates extra work in design and testing?"

"True, although for simplicity we exclude the interfaces from our funding calculations – we have a separate contingencies pot to cover the interfacing work."

A very deep pot, Ruth thought. It didn't take a qualified accountant or an elaborate whole life costs financial model to work out that this was probably costing considerably more longer-term than regular full renewals. Nonetheless Ruth recognised that this approach might sometimes have advantages, such as when some parts of the system have a much longer life than others.

Ruth's gaze returned to the Community engineer.

"How do you accommodate changes to the layout, if you are only relocking what is already there?"

"We don't allow any changes during our relocking work, otherwise that would make it an enhancement. That would be dreadful – we might have to apply modern standards, and the testers would want to retest the whole system. The whole point is that we keep the layout the same so that we can argue it's only a relock and treat it like a like for like project."

After a short delay while Ruth processed whether that final phrase was grammatically correct (which of course it was), she was able to move on to consider what it meant. Most railway lines she had encountered had inevitably been prone to minor alterations over the years, whether to remove redundant facilities no longer required or to add new functionality; how could this Community keep the same layout forever? She wanted to explore this further.

"What happens when there is a new operating requirement for train services?"

"Ah, that's easy – we do those as standalone enhancement projects in between, so they do not distract from the like for like scope during our targeted asset refurbishments."

"Oh I see, so do you apply modern standards for the enhancements?"

"Of course not! It would be impractical and disproportionate to apply modern standards when making localised layout alterations to a legacy system."

"But it isn't a legacy system if it's being continually renewed piecemeal!"

"As I said before, only certain elements are renewed at any time."

Ruth could see that this engineer was fully committed to their Community strategy, however she could see the assistant engineer in the corner was starting to look uncomfortable. Ruth decided to try probing in a different way, so she turned towards the assistant engineer.

"Hi, I can see you brought some scheme plans with you, please could I see some examples?"

"Er, yes, if you want – they are for our RRI to SCI conversion project next year. How about this one?"

The assistant engineer spread the scheme plan along the table in front of them. There was very little to see apart from some notes in red, which was presumably the idea – it supported the like for like approach by minimising the design and testing. Ruth soon found her attention drawn to a major junction.

"I don't know this area that well, but those turnout speeds seem quite low when lots of trains weave across here?"

"Ah yes, the track department wanted to relay it for higher speeds about 10 years ago, but we said at the time it wouldn't be practical to alter the legacy equipment for such a major change."

"OK, but presumably once you've installed your interfaced SCI next year that would open up the chance for the track department to renew the junction for higher speeds at their next renewal?"

"I suppose so, although that would require them to plan a data change which

Signalling archaeology

A plethora of location cases of varying vintages. This is Leamington Spa in the UK Midlands, site of the trial SSI scheme in the 1980s. The trial was a relock that retained the existing signals, point machines and track circuits. Since then there has been an upgrade to SSI Mark 2, changes for TPWS retrofit, fringeworks for the Cherwell Valley scheme southwards, then another trial, this time for the first Siemens Trackguard Westlock which thus replaced the trial SSI. The latest cases have sun shields to protect the trackside functional modules inside. Meanwhile, the signals are new LED heads on a much older structure.

would be hard for them to justify as part of their track renewal."

Ruth was simultaneously sympathetic (she knew how irritating it could be when people kept saying "It's only data"), yet frustrated that this blinkered approach seemed to prevent any ongoing improvements to the railway. She cast her eyes further along the plan.

"Oh, now this is a strange station layout, what's that short platform for?"

"Ah yes, well spotted – that was for the milk trains."

"Milk trains..?! When did they last run?"

"Hmm, can't remember – not since I joined the industry. Perhaps 40 years ago? The platform has been out of use for a long time."

"So why is it still shown on the plan?"

"It's just easier to leave it in the interlocking so we don't have to do any wiring recoveries on site."

"But the SCI will use brand new data!"

"We still need the data to match the lineside equipment otherwise we would have to alter that at the same time, which wouldn't be like for like. In any case, we would need permission from the train companies and they said they wouldn't agree to it in case they might want to use it again sometime."

Ruth realised she wasn't going to learn much more from this Community. She quietly amused herself with her unspoken sentence that they didn't like like for like being challenged, then decided it was time to go.

Other Communities are available

Their next visit was to a Community that was the polar opposite of the previous one.

"Relocks, why on earth would you want to do one of those? If the signalling assets are getting old, it's much better to resignal so that everything is the same age, it is far more efficient."

"What if some bits aren't life-expired, doesn't it seem wasteful?"

"Nonsense, by the time you've faffed about altering all the interfaces and brought everything up to modern standards to be compliant you'll need to retest the whole system. Far better to build a new system, soak test it beforehand and scrap the old stuff completely. Also means our railway is always compliant with the latest standards."

"Have you ever considered the retention of older principles and standards using a risk-based approach?"

The blank look answered her question.

Ruth continued her quest for sensible ideas, and meetings with other Communities gave a range of opinions between the extremes. One conversation was with a Community

Thinking outside the (power signal) box

Reading PSB looking gloomy alongside the Goods Loops in the final years prior to demolition. This entire area is now covered by new platform lines.

with a large population of the first generation of SCIs. The person they met introduced themselves as being their SCI expert and went straight into a deep technical discussion.

"Firstly, do you know what re-platforming is?"

Before Ruth could open her mouth, her project manager quickly jumped in:

"Oh absolutely, it happened to us yesterday evening when we were changing trains on the way here, our train was due to depart from platform 2 but it got changed to platform 5 at the last moment. It can be quite annoying can't it?"

Some things can definitely be annoying, thought Ruth. She and the Community engineer shared a knowing look, then she indicated to them to continue.

"What we intend to do is upgrade our original SCIs with newer versions from our suppliers that run faster and have better diagnostics. We prefer the computer industry term re-platforming rather than relocking because it better reflects what we are doing. All we have to do is copy and paste the data across with minimal testing…"

"… Aha of course, I know why: because it's only data!" said the project manager. Ruth closed her eyes and started thinking of plausible reasons why she might need to travel home on her own on a different train that evening…

Locking down the scope

After a few weeks Ruth had gathered a wide range of opinions from different Communities. For her own peace of mind (and amusement), she had also listened to her Uncle Bob recounting barely credible tales from his career, and explained to Grandpa Harold that her relocking project was unlikely to involve grease, tappets and hammers. Ruth now had to decide what to recommend to her own Community, however she had gradually realised during her research that she wasn't really that clear why they wanted the relock in the first place. She therefore asked the project manager to go back and clarify this.

A few days later the project manager came to find her.

"Ruth, I've now had a response about why they wanted a relock."

"Great. Is it based on asset condition, or are they planning to transfer control somewhere – or perhaps there's a layout upgrade coming? This area could do with a good remodelling to allow more capacity!"

The project manager sighed and then looked away, knowing Ruth wasn't going to like the answer.

"Actually, it turns out it was all because our director had heard from another Community director that relocks were cheaper and quicker than re-signallings; they thought it would be good to try out a relock here to demonstrate to others how our Community is becoming more efficient. They didn't really understand what they were asking for."

It was times like this that Ruth felt her professional CPD records needed a special section entitled something like: "Excellent technical experience gained from projects that never got built."

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

ETCS for Heathrow Express Class 387s

UK: Train leasing company Porterbrook has confirmed the completion of a series of test runs of Class 387 EMUs with ETCS on the Great Western Main Line.

The tests were undertaken by Porterbrook, Heathrow Airport Ltd, Bombardier, the Department for Transport, and DB Cargo UK, using sections of the main line east of Reading and the branch from Hayes & Harlington to Heathrow Airport.

Great Western Railway (GWR) are transferring 12 four-car Class 387 EMUs from Thames Valley commuter services to the airport shuttle route. Once ETCS Level 2 has been commissioned on the branch between Hayes & Harlington and the airport, the Class 387s will replace the current Class 332 trainsets.

The Heathrow Express service is not part of the national franchising system, but owned and managed by Heathrow Airport Ltd. However, train operations are outsourced to GWR under a management contract running from 2018 to 2028.

PTC for Metro-North

USA Metro-North Railroad have confirmed Metro-North's full Harlem and Hudson lines are operating Positive Train Control (PTC), bringing Metro-North's total of PTC-equipped route miles to 189 and 68% of its mileage.

The coverage includes all trains along the Hudson Line's 74 miles (120km) from Grand Central Terminal to Poughkeepsie, and the Harlem line's 82 miles (132km) from Grand Central Terminal to Wassaic, including Amtrak and CSX freight. Metro-North full implementation of PTC will be completed by the federally mandated deadline of 31 December 2020.

ETCS onboard for eastern Denmark and southern Sweden

Europe: Alstom will supply and install its Atlas ETCS onboard equipment for the X31 Contessa electric multiple-units used on Öresundståg services in eastern Denmark and southern Sweden. The integrated system will enable the trains to use legacy ATC-2 in Sweden and ZUB 123 in Denmark, along with ETCS Level 2 in both countries. The project will be led by Alstom Sweden, from its ERTMS centre at Charleroi in Belgium, with the installation undertaken in Copenhagen. An initial 77 vehicles will be fitted by the end of 2023, with an option for the remaining 34.

Transitio in Sweden has now procured ETCS onboard systems across its newer fleet, with Bombardier Transportation covering the Regina and Itino units, with Stadler double-deck and Alstom Coradia X62 units fitted from new. There are currently no plans to equip the older X11, X12 and X14 units.

ERTMS on third Danish line

Denmark: ERTMS has been fully commissioned on the 73.6km single-track line between Thisted and Struer in northwest Jutland. Infrastructure manager Bandanmark has been commissioning ERTMS on the line since mid-February. Banedanmark said "Everything has gone according to plan, and Arriva, the train operator, has now started to run using ERTMS on the entire route between Thisted and Struer".

Banedanmark expects to see 80% less delays due to signalling faults as ERTMS is rolled out. This is the third line in Denmark where ERTMS has been installed as part of the national rollout, following Vendsysselbanen from Lindholm to Frederikshavn in northeast Jutland and between Roskilde and Køge on the main island of Zeeland. Banedanmark has also launched CBTC on two S-Bane lines in Copenhagen.

Real-time warnings of potential rail switch failure

Finland: The Finnish Transport Infrastructure Agency, Väylävirasto and the national railway's VR FleetCare subsidiary are undertaking a pilot project to use real-time data to provide warnings of potential switch/points failure. IoT specialist Vire Labs is being used to monitor 80 switch/points locations across the network. The data collected is analysed to detect any abnormal performance so that action can be taken before any failure occurs.

City railways and light rail

Dublin metro advisory contract

Ireland: SNC-Lavalin Rail & Transit, Britain, have been appointed as an operations advisor for MetroLink, the planned north-south automated metro line in Dublin. The scope is to lead the development of an operational strategy for the project, to construct a 19km metro from Swords to Charlemont via Dublin Airport. SNC-Lavalin will also review the design of rolling stock and provide consultancy services, together with the development of a business case for a Grade of Automation (GoA) 4 signalling system. Construction on the largely underground project is planned to start in 2021 with completion in 2027. The line will have 15 stations and an end-to-end journey time of 25 minutes is planned.

Czech tram obstacle detection

Czech Republic: Tram operator DP Ostrava has awarded a KC26.9m (£0.9m, €1m, $1.1m) contract to Stadler Bussnang to provide the city's Tango NF2 trams with obstacle detection. The contract includes the upgrading of two vehicles by September as a trial, with the remaining 38 vehicles upgraded by 2024.

The trial vehicles are expected to operate for six months as a test bed for the detection system, which will be based on cameras and radar sensors to detect foreign objects up to 80m away when travelling at up to 80km/h. If a collision risk is detected, the system will alert the driver using audible and visual warnings. If the driver doesn't react the system will automatically operate the tram's electromagnetic emergency brakes.

Communication and radio

Impact of COVID-19 on telecoms network and working from home

UK: Communications Chambers has written a paper on the impact of COVID-19 on broadband traffic with more people working from home, and why the network is coping well, at least in the UK (see irse.info/6807k).

The report concludes that COVID-19 has had a significant impact on data traffic, but for the UK fixed network this has so far not been a problem. The network already had extra capacity, and is designed for growing and occasionally high demand traffic.

COVID-19 has caused surges in use for certain applications, and in some cases has overloaded the servers for these applications, rather than the fixed network. However, application providers are generally able to upgrade capacity relatively quickly, similar to the fixed network. COVID-19 has significantly disrupted many aspects of life – but the report demonstrates the public fixed telecoms network is currently performing well.

LTE for ATO on three Grand Paris Express metro lines

France: Société du Grand Paris (SGP) has appointed a consortium of Nokia and Engie Solutions to install an industrial grade LTE private wireless network for ATO on three Grand Paris Express metro lines. This is in line with the metro market trend in China and supports LTE being suitable to handle all reasonable communications requirements of a high-performance railway system.

The project will involve lines 15, 16 and 17 covering more than 200km of new lines, 68 stations, depots and trains and will provide high-speed 4G broadband wireless connectivity for both operational and maintenance, as well as emergency and security requirements. This will include voice, data (file transfer and multimedia) and video services including onboard CCTV. Engie Solutions will be responsible for construction, testing and commissioning of the Nokia system.

6GHz Wi-Fi 6E trial

USA. The Wireless Broadband Alliance (WBA), Broadcom and Intel have announced the first phase trial of Wi-Fi 6E, In San Jose, California, which suggest that the 6GHz band could provide more capacity than all the other Wi-Fi bands put together. Wi-Fi 6E is not to be confused with Wi-Fi 6 which is currently positioned in the 5GHz band, but according to WBA the Wi-Fi 6 standard and the 6GHz spectrum will work in combination together to deliver even greater Wi-Fi performance.

The tests also claim Wi-Fi 6E could deliver connections with speeds equivalent to 5G mobile networks, with Wi-Fi in the 5.925-7.125 (6GHz) band complimenting 5G, as it could be deployed inside buildings where 5G will struggle. WBA also claim the trials prove that Wi-Fi 6E can also support the low-latency levels required for virtual and augmented reality (VR/AR) applications, and Industry 4.0 solutions. During the trials speeds of 2Gbps and a consistent 2ms low-latency were achieved.

It's envisaged the technology will be especially suitable for location such as subsurface stations and testing in such places is planned over the coming months, along with in-house testing. WBA say several regulators are to release 6GHz spectrum bands for unlicensed use, including FCC in the US, Ofcom in the UK and regulators in the EU.

Öresund train Wi-Fi

Denmark/Sweden: Nomad Digital Limited has been awarded a contract by Öresund train fleet to provide their Nomad Connect Wi-Fi solution for 111 trains. Öresund train fleet is also known as OTU option holders – OTU is a cooperation between, in Denmark DSB, and in Sweden AB Transitio, Region Skåne through Skånetrafiken, Region Blekinge through Blekingetrafiken and Hallandstrafiken AB.

The scope includes the supply, design and delivery of a complete onboard passenger Wi-Fi solution, along with maintenance and operational services. The Wi-Fi solution is built on Nomad's R5001 router platform using Nomad Connect software. The delivery program is already underway with the contract valid until August 2024.

Crossrail driver only CCTV maintenance

UK: telent Technology Services Limited have been awarded a contract to support and maintain the Elizabeth Line driver-only operation CCTV system by Transport for London. telent has been maintaining the CCTV since May 2017 when the eastern section of the Crossrail service from London Liverpool Street to Shenfield was launched running over existing lines. The new five-year contract is in addition to the seven-year contract with TfL to manage a wide range of communication assets across the London transport network.

Swiss 1900MHz FRMCS radio frequency trial

Switzerland: Nokia and Swiss Federal Railways (SBB) have completed a trial to help define the radio frequency for the new Future Railway Mobile Communication System (FRMCS) replacement for GSM-R.

LTE 1900MHz radio frequency testing has been completed in the Swiss cantons of Fribourg and Neuchâtel. However, 1900MHz for rail is not universally available in all countries, for example the UK, and will require more fixed radio sites than the current GSM-R 900MHz radio frequency.

Subway to trial 5G project

Scotland: Strathclyde Partnership for Transport (SPT) has announced plans to trial a project to install 5G within the subway tunnels in Glasgow. The trial is part of a collaborative agreement signed between SPT and partners Cisco, the University of Strathclyde and the South Korean Transport Agency. The project is being part-funded by the UK Government Department of Digital, Culture, Media and Sport, and industry partners.

The pilot will test the viability and practical operation of 5G within a section of the subway tunnel between Buchanan Street and St Enoch. It is believed this is the first subway railway to test the viability and practical operation of 5G within a subterranean system. SPT say the results of the trial will be shared with other underground networks where appropriate.

5G driverless train

Germany: A trial of a driverless train using remote control has taken place at the Smart Rail Connectivity Campus in Erzgebirge, Germany. Thales Transportation used its Lucy laboratory train, supported by a Vodafone 5G network. The trial operated via a separate 5G network from the public network, with one of the first 5G base stations installed in the Erzgebirge region of Saxony, Germany,

Mobile Edge Cloud (MEC) was used, with the data processed directly on-site in a small data centre near the mobile base station, reducing delay as it does not have to travel to the 5G core. The 5G technology enables bandwidths greater than 500 Mbps on the test track and reduces the latency to less than 10ms. Thales provided the control and safety systems for the trial, along with a remote-control system for the train in cooperation with the German Aerospace Centre (DLR) and Railergy.

Lyon Metro real-time video surveillance

France: Syndicat mixte des transport pour le Rhône et l'agglomération Lyonnaise (SYTRAL) in the city of Lyon has implementing a real-time wireless video-surveillance system, providing continuous video streams from metro trains to the main control room. The system uses a Fluidmesh provided wireless ground to train connection, integrated with Cisco MPLS fibre infrastructure.

The new surveillance system contains more than 1000 new cameras installed on 48 Line D and 36 Line B trains. Security personnel can monitor any camera from the main control room in real time. Fluidmesh claim the MPLS-based trackside wireless deployment provides a broadband wireless link that reliably connects each on-board network and associated camera, regardless of the relative position and speed of any train. They say the infrastructure is robust, redundant and fault-tolerant, and can accommodate potential failures in milliseconds by re-routing traffic and re-connecting trains through alternative or redundant devices.

800Gbps over 950km

USA: Infinera have completed a trial of 800 gigabits per second (800G) single-wavelength data transmission over 950km, across a long-haul link in a major North American network.

Conducted over a third-party optical line system carrying live multi-vendor traffic, the trial was implemented using Infinera's Groove (GX) Series equipment over industry-standard G.652 fibre. The Infinera vertically integrated ICE6 optical engine features second-generation Nyquist subcarriers and per-subcarrier dynamic bandwidth allocation.

Making rail more user friendly

UK: Realtime Trains is partnering with ScotRail to provide "Know Your Train". This will provide customers all the information they require on the train operating their journey via an app.

The app is able to show a picture of an approaching train to show its type and length and what facilities are, and where they are located. The information may include important information such as onboard Wi-Fi, bicycle spaces, disabled access, toilets, first class, power and USB sockets.

If the train is formed of multiple units, common facilities throughout the train are shown on the top right of the picture. The app currently supports selected services operated by ScotRail running class 158, 334, 380 or 385 multiple units. Further ScotRail rolling stock types will follow.

Transport for London's Jubilee Line 4G pilot

UK: Mobile network operators EE, O2, Three and Vodafone, along with Capita, Nokia and Installation Technology have worked with Transport for London (TfL) to deliver the first publicly available 2G, 3G and 4G mobile services on the London Underground. The pilot project covers the tunnels along the Jubilee Line between Westminster and Canning Town and the platforms from Westminster to North Greenwich. Ticket halls and corridors within stations are also covered, except for London Bridge and Waterloo stations where the service will be solely available on their Jubilee Line platforms.

The 'neutral host' network routes signals from the mobile network operators to servers situated in a purpose-built room. The signal is then disseminated to the other stations via equipment on the platforms and along the tunnels through leaky feeder antennae. Capita will have responsibility for operating the network over the lifecycle of the pilot project.

Ofcom shine a light on interference issue

UK: Ofcom (the UK telecoms regulator) spectrum assurance team were contacted by National Air Traffic Services to inform them that aircraft flying in and out of Glasgow airport were being affected by interference when they were between 6000 and 10 000 feet (1800m to 3000m) in the air. The interference was affecting voice communications between the controllers on the ground and the aircraft.

The interference was traced to a house directly underneath the flightpath of the aircraft with the cause being four 'vintage' lightbulbs that the homeowner had recently bought online. Due to the construction of the bulbs, they were found to be radiating a 'noise' when they were switched on that affected a wide range of licensed spectrum.

The bulbs were removed from the sockets and checks with NATS and aircraft operators confirm that the area is now free of interference. The lightbulb suppliers were contacted to make sure the bulbs are not sold to any more unwitting customers. In the case of any interference to operational train radio equipment the radio spectrum manager should always be informed to carry out an investigation.

Huawei radio contract in question

Australia: The West Australian government is revising a contract with Huawei to build a mobile data network for Perth's public train system. It said trade restrictions imposed by the United States on the company had created a force majeure event under the contract, which could not be overcome and that the decision had been taken before taking into account disruption caused by the COVID-19 crisis.

Huawei was to build 80 LTE radio sites along Perth's railway corridors in a consortium with UGL. The government public transport authority would now attempt to complete the project without breaching US trade restrictions. They say this could include a range of outcomes, from withdrawal of Huawei Australia from the contract to termination of the contract with the consortium. The original requirement for the PTA to vacate the analogue radio spectrum by May 2020 has since been extended to beyond 2021.

Safety

Near miss using radio-based lookout operated warning system incorrectly

UK: At around 09:00 hrs on 14 November 2019, three members of Network Rail staff had to jump clear of a train travelling at a speed of 125mph (200km/h) near Kirtlebridge, Dumfries and Galloway in Scotland. The staff had just begun work under the protection of the radio-based Lookout Operated Warning System (LOWS) when the train approached unexpectedly round a bend. The train driver sounded the horn and applied the emergency brake. The staff jumped clear less than one second before the train passed. Fortunately, there were no injuries. While the system had been tested as working, work had commenced without the lookout being instructed to give a warning of approaching trains.

This incident demonstrates the importance of staff reaching a clear understanding when communicating messages affecting the safety of people on the track, and that safety critical communication protocols are concise and easy to apply by those working on site. LOWS lookouts should always treat the system as live following a successful test, and to always start giving warnings of trains unless the LOWS controller has specifically instructed them not to. The full report can be found at irse.info/he9o7.

Government and regulators

Delay in ORR study

In January 2020, the Office of Rail and Road (ORR), the UK rail regulator, opened a formal study into the UK signalling market in order to explore whether there were any competition issues affecting the supply chains, and to determine if any action was needed as a result.

The ORR has now announced that given the impact of the ongoing COVID-19 outbreak, they have taken the decision to close the market study. They were making sound progress and had reached a critical point in gathering information, having identified a number of issues warranting further close investigation. The ORR says the signalling market remains a key focus, and re-opening the study when the railway returns to a 'steady-state' will be a high priority.

News from the IRSE

Blane Judd, Chief Executive

For some time, some Council members (and in particular non UK-based members) have attended the London HQ based Council meeting by video conference. However, on 23 April the suite of governance meetings and the entire Council, including new and retiring Council members, all met via video conference. During the meeting Daniel Woodland was confirmed as president for the year 2020-2021, Ian Bridges senior vice president and Andy Knight junior vice president. George Clark was warmly thanked for his year as president and he in turn wished Daniel well for what will be a challenging year ahead.

The meeting went well and it is possible that video conferencing may continue to be used for such meetings after the coronavirus infection (COVID-19) pandemic. No doubt the IRSE will not be the only organisation or company who will adopt new ways of working.

For the first time in our history the April Council meeting was held entirely virtually.

Since the 'lockdown' Blane and the team have been busy and meetings have been held remotely with Network Rail to explore the possibility of making the recording of evidence more accessible to operatives in the field for the Licence scheme and to progress recommendation 1 of the report into the collision at London Waterloo 15 August 2017. This is to ensure the competence of staff includes the attitudes and depth of understanding that is needed to properly appreciate the importance of applying all the relevant design, installation and testing processes.

Council endorsed the postponement of Convention 2020 – Toronto, to September 2021. ASPECT 2021 in Melbourne will also be postponed, with the viability of moving it to March 2022 being explored. At the moment the Convention in Glasgow September 2022 is to continue planning as originally envisaged. Further updates will be provided as soon as possible.

Licensing

The role of Licensing registrar continues to be undertaken by David Weedon. However, Sarah Loutfi has been appointed on a permanent basis, with a start date of 1 July 2020. OSL has been approved as an IRSE Licensing Assessing Agent and Rao Training & Placement Services has satisfactorily completed their initial desktop review to be an Assessing Agent.

As a result of Covid-19 a six-month extension to licence validity has been agreed, along with extensions, where appropriate, to the timescales for various parts of the assessment process. General acceptance has been given for assessments to be carried out remotely where there is not a requirement for direct observation of tasks. Full information on the arrangements can be found on the IRSE website within the licensing pages.

The health and wellbeing of staff, volunteers, members and Licence scheme members of course remains the absolute priority and at the time of writing the HQ building in London remains closed with all staff remote working. The remote working arrangements are working well. All normal committee meetings taking place, professional registrations are being held remotely (as they have for some applicants for many years) and IRSE membership applications and changes are still being processed. All telephones at HQ have been diverted, however it has not been possible to divert mail. Therefore, when communicating with HQ for membership, professional registration, licence matters or any other subject please use email.

Sections have been provided with a video conference tool and we encourage all sections and members to embrace new innovative ways to network whilst physical events cannot take place. We will also be arranging video-streaming of HQ key events, such as the presidential address (see **irse.info/buhq3**) and presidential papers, along with making recordings available.

Subscription payments

Council noted the list of lapsed members to be removed from membership due to non-payment. Several payments were received late, after a number of reminders had been instigated. Council wishes to remind all members that the membership year is 1 July to 30 June and that fees are due at the beginning of the membership year (with the exception of the first year of membership), not on the anniversary of joining. Late or delayed payment of subscriptions is not the behaviour of those wishing to be recognised as professional members of the Institution. It puts an undue strain on the finances of the Institution, increased burden on the resources in chasing late payments and places an unfair expectation on their colleagues who pay promptly and therefore underwrite that behaviour.

Minor Railways competency management

Council was pleased to endorse publication of guidance for the competency management of S&T volunteers supporting Minor Railways. An article covering the development of the guidance is planned for a future IRSE News.

Professional development

Future IRSE structures for Knowledge, Skills and Ability

Markus Montigel, Blane Judd and Francis How

The Presidential World Tour 2019 has shown the world's almost desperate need for well-educated signal engineers. Management Committee and Council have adopted the view that the IRSE's role in education and Continuous Professional Development (CPD) should be substantially strengthened in the IRSE's future strategy.

The importance of signalling and telecommunications in delivering a safe and efficient rail system cannot be underestimated. Advances in train control have significantly contributed to the safety of the public when using rail as a transport medium. Movement of passengers and freight rely on effective and efficient signalling and telecommunications systems linked to rolling stock and track. Looking forward the boundaries between the three elements of train, track and signalling are becoming increasingly homogeneous. The IRSE must play its part in collaborating with others to provide expertise that will have a positive, global impact across the industry.

If we are to be successful in our ambition, our strategy must set a bar which outlines the frameworks, mechanisms and collaborative spirit where members are supported to assist in advancing the Institution's aims. Emerging from the last strategic plan many of the building blocks have been put in place — but to fully realise our vision we must work to draw on the skills, knowledge and ability of those in our sector who have not yet fully embraced the IRSE, engaging with them to augment the existing expertise of the global membership who are core to our success.

Our vision is to deliver safe and sustainable global railways.

To do this our mission statement is:

"The IRSE will ENGAGE with and GROW a global NETWORK of railway signal and telecommunications engineers in order to DEVELOP and ASSURE high standards of ethics, knowledge, competence and safety in all aspects of train control."

This clearly shows the important role which knowledge, skills and abilities will play in the future IRSE's strategy and business.

Consequently, a workstream, IRSE Knowledge, Skills and Abilities (KSA) has been created, aiming at investigating the current status and identifying the future goals of the IRSE in this area. This article summarises the results of this workstream so far.

Terminology

The use of language in this domain is not commonly defined. Different parties use different terminology and define the relevant terms in different ways, even in the sciences which work in this domain.

K S A

Knowledge Skills Ability

In particular, there is a level of disagreement on the meaning of the "A" in KSA, namely "Attitude" or "Ability" [irse.info/z1a08]. In this article the point of view is adopted that both qualities are required, especially in a safety-related field, and hence both terms are subsumed under the "A".

Hence, the following definition is used for the purpose of this article:

Competences (C) = Knowledge + Skills + Attitude/Ability (KSA)

The definitions of the terms as agreed on in the KSA workstream and as used in this article are as follows:

Knowledge: the theoretical or practical understanding of a subject, for example knowledge of the CENELEC standards for safety case.

Skills: The expertise required to undertake a task, acquired through training or hands-on experience. An example may be properly developing and applying a safety case based on CENELEC standards for a specific product or project.

Attitude: The way of thinking about something, often reflected in behaviours, for example being honest in addressing gaps in the safety case, even if the safety authority would be unlikely to detect them.

Ability: Having the aptitude and talents required to carry out a job to the required standard. An example would be the ability to comprehend the deeper meaning of the philosophy of safety and choose the appropriate interpretations of normative regulations.

Competence: The combination of related knowledge, skills, attitude and ability. The display of the correct behaviour, even if 'no one is looking', considered to be an innate behaviour (something from birth, a natural attribute). An example would be possessing the KSA for ensuring the safety of a product or project.

In general, two phases of acquiring KSA can be distinguished:

- Initial professional development up to, and potentially including, undergraduate level.
- Higher/continuing professional development later on.

Typically, knowledge is acquired during the initial professional development, while skills are primarily obtained in the first years of an occupation in the field. The "A" capacities are thought to be largely inborn, i.e. either they are present in a person, or not, from an early age, although they must be further developed during the career. It is clear that these explanations are generalisations, and not necessarily true of every individual.

The IRSE's current KSA activities

The IRSE's current areas where KSA activities happen include the following.

Academic education. Graduate Diploma being developed with University of Queensland with involvement of IRSE Australasian Section. Some course work of universities. Coordinated with IRSE exam syllabus and involving Education and Professional Development Committee, local sections and individuals. IRSE Exam. Maintaining the syllabus, mentoring, holding exams, involving the Education and Professional Development and Exam Committees.

Licensing. The IRSE Licensing Scheme run by the Licensing Committee.

CPD. Events (ASPECT, Convention, technical visits, seminars); publications (IRSE News, articles in other publications, books); involving Education and Professional Development Committee, HQ, local sections, ITC, IRSE News authors and editors, mentoring scheme.

Knowledge. "Body of Knowledge" (2003). Web-based knowledge base for members. Publications (IRSE News, articles in other publications, books).

The distribution of the IRSE's current KSA activities is shown in Figure 1.

While it is clear how to classify the IRSE's activities in relation to knowledge and skills, it is less easy to do the same for attitude/abilities.

What should the scope of KSA provided by the IRSE be in the future?

The KSA workstream members held several very lively discussions on the question: "What should the scope of KSA provided by the IRSE be in the future?" A number of ideas and potential activities have been proposed and these are reflected in Table 1 overleaf.

Proposals

Future KSA structure

A possible future IRSE KSA structure is proposed in Figure 2, which is much refined compared with the one shown in Figure 1.

Underpinning principles associated with the proposed KSA structure

The following principles should be observed in relation to the proposed KSA structure:

1. The IRSE doesn't aim at providing 'everything', but works in a specific domain indicated by the red border. It recognises that other organisations are better placed to provide some elements of the KSA structure.
2. General and specialised engineering content is to be provided by higher and further education establishments.
3. Specialised training content may be provided by external providers, but the IRSE may on occasion choose to do so as well (see CPD in the IRSE domain).
4. A core activity in the IRSE domain is to maintain a readily searchable knowledge base, and to enhance its usefulness by including content that raises awareness of KSA.

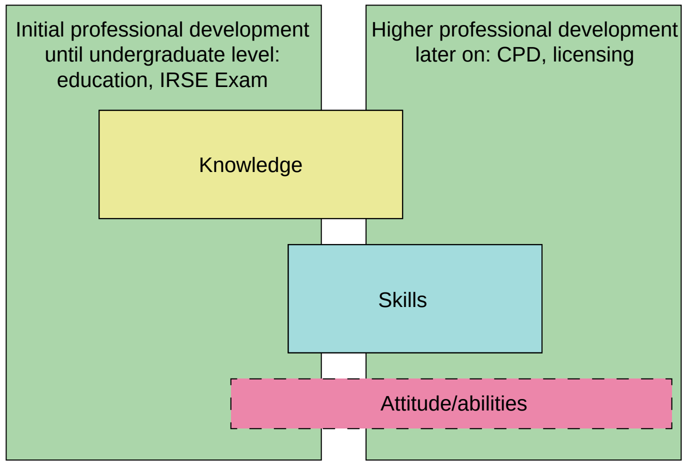


Figure 1 – Main emphasis of the IRSE's current KSA activities (qualitative).

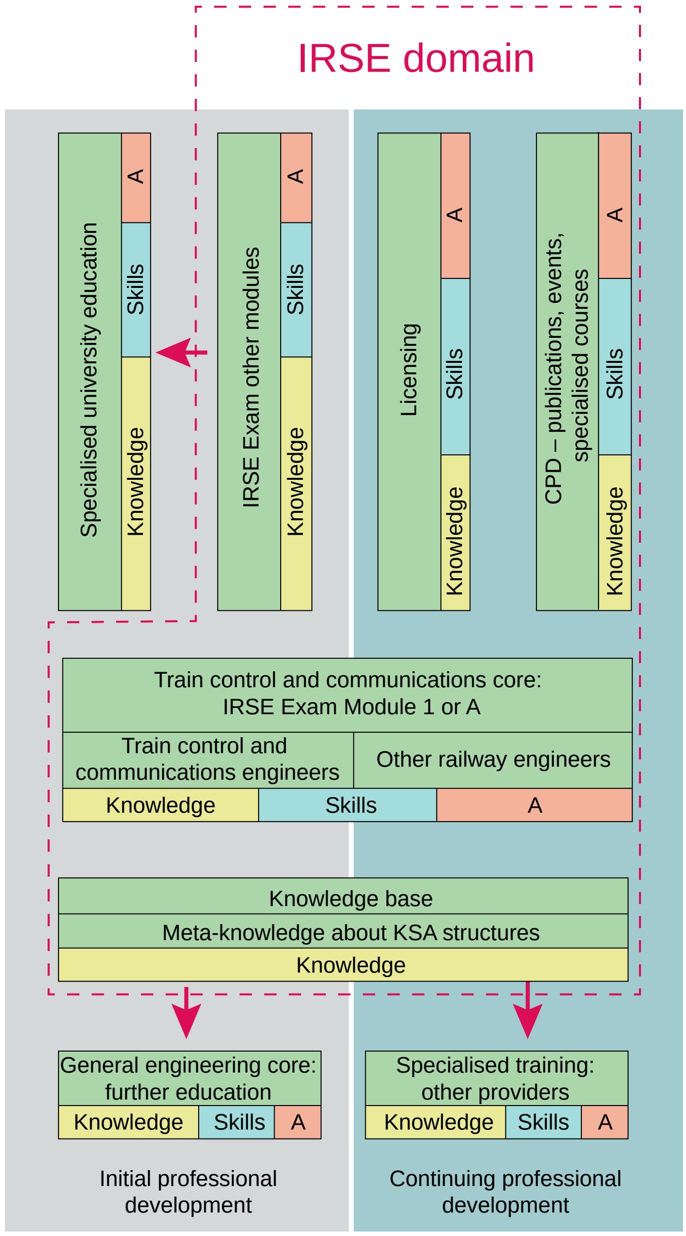


Figure 2 – Proposed IRSE KSA structure.

No	Idea/Activity	Main actor
1	Review existing knowledge bases [**irse.info/kbase**, the IRSE Body of Knowledge 2003 and Railway Signal Engineers' Signalling Philosophy Review (Francis How, updated by IRSE's Education and Professional Development Committee 2013/14] and define requirements of a future knowledge base.	IRSE
2	Separate out long-term the engineering basis (the basic and specialised train control & communications "constant" knowledge which does not change significantly over time) from engineering knowledge that changes as technology is developed and applied.	IRSE
3	Provide a comprehensive description of competences (KSA) which a train control and communications engineer should demonstrate on various levels of expertise: Potential sources: • Exam definitions • Guide to membership application • Requirements in job advertisements • Discussion with employers • Existing IRSE Knowledge Bases.	
4	Provide a textbook or comprehensive references to textbooks for Module A.	IRSE
5	Define levels of expertise of a train control and communications engineer, and consider how these align with IRSE membership.	IRSE
6	Define competences (in basic engineering and specialised train control and communications engineering) and the outputs to be provided by educational institutions.	IRSE
7	Provide initial education in basic engineering.	Universities
8	Provide initial education and assessment of KSA in the field of train control and communications engineering. (The current work to re-structure the IRSE exam, and in particular the development of the new Module 1 (offering a certificate qualification), is an excellent step in the right direction to cover the core knowledge required by train control and communications engineers.)	Universities, IRSE Exam
9	Provide highly specialised education and educational content in train control and communications engineering.	IRSE
10	Define career pathways and professional development routes.	IRSE
11	Strengthen the common basis and coordination for all the activities related to KSA in the IRSE.	IRSE
12	Improve structure and interlinking of the IRSE materials, tools and services already out there so that they can be readily accessed by members.	IRSE
13	Raise awareness that current IRSE KSA activities must not be independent of each other, but must be based on a common under-lying structure in order to maximise their usefulness and effectiveness.	IRSE
14	While this underlying structure may not be so much about extracting common content, it is mostly about providing the structure (framework) for finding the relevant content by offering intuitive alternative responses, similar to other search engines.	IRSE

Table 1 – Domains of activity proposed by KSA workstream.

IRSE signal engineering knowledge base

Existing knowledge bases are:

1. IRSE body of knowledge.
2. Railway Signal Engineers' Signalling Philosophy Review, which led to the IRSE Fundamental Requirements [**irse.info/lta6g**].
3. IRSE online Knowledge Base [**irse.info/kbase**].

These offer a solid basis for the future provision of an improved IRSE Knowledge Base. Ideas for the future development of the Knowledge Base include (but are not limited to) the following:

- It is acceptable for the Knowledge Base to have its own stand-alone website, but there should be a memorable link to it, such as irse.org/ksa. The site should be prominently accessible from the IRSE website.
- The Knowledge Base needs an improved and well-explained meta structure, which could be based in part on the proposed KSA structure.
- There should be an improved multi-dimensional access structure that classifies the content of the Knowledge Base along the following lines:
  - Basic engineering (references) vs specialised engineering.
  - Fundamentals of signalling vs advanced, define levels of expertise.
  - Stable knowledge vs ever changing.
  - Technical topics.
  - Category of source of knowledge (IRSE News, exam, licensing, events, books).
  - Strategic current subjects (according to that structure).
- IRSE News articles referenced in the Knowledge Base should be available as individual items (not as links to whole editions of IRSE News).

- The sources providing elements of KSA should be also referenced (University courses, research, training material, ITC etc).
- Consideration should be given to the introduction of a pay-per-use scheme for the access to the Knowledge Base by IRSE non-members and by non-affiliated organisations, thus providing a strong incentive for becoming a member or affiliated organisation.
- There should be a process describing the management and operation of the Knowledge Base (who adds content to it, etc). The IRSE News team could be best suited for this role, as they are closely linked to many of the sources of content for the Knowledge Base, both within and outside the IRSE.
- The IRSE should update its existing drafts of the definition of careers pathways and professional routes.

Conclusion

As stated in the introduction, the IRSE's future KSA structures are intended to play a fundamental role in its strategy and business. This is work in progress. Council, Management Committee, the CEO and his staff will take the decisions on how to implement the next steps. Most importantly, IRSE members are invited to contribute to this process with ideas about how to make the KSA structure and elements as useful as possible.

It remains to express many thanks to Les Brearley, Colin Porter, Felix Schmid, Rod Muttram, Hedley Calderbank and Anthony Kornas, who contributed to this paper.

Presidential programme 2020-21

IRSE
Institution of Railway Signal Engineers

The theme for the president's year is "The challenges of change in complex Control Command and Signalling (CCS) systems".

The planned programme shown below is itself very much subject to change as a result of the emerging picture of the COVID-19 pandemic, with some presidential papers and seminars delivered via on line webinar. Please consult the IRSE web site for the latest information.

16 June 2020: "Techniques at the forefront of system safety and their application to railway signalling", ITC (Yuji Hirao).

Webinar.

This paper has been developed by the IRSE's ITC to capture approaches at the forefront of safety technologies and management, both in rail and related industries.

30 October 2020: "Crossover between rail and autonomous road vehicles", Tom Jansen, Ricardo Nederland.

Switzerland location to be confirmed or webinar.

Exploring what benefits we get by replacing the driver by computers, how we can demonstrate the safety and integrity of a self-driving train and its software, and how we can improve our business case using knowledge and products from other industries.

19 November 2020: "Cross acceptance of systems and equipment developed under different standards frameworks", ITC (Rod Muttram, Fourth Insight Ltd).

York, UK location TBC or webinar.

This paper will re-visit earlier ITC guidance based on recent experience of product introductions and attempted introductions against different standards frameworks than those used for the product development

2 December 2020: "Testing Software-based Critical Systems on the Railway", Nicholas Wrobel, Aerobel Defence Technology Ltd and Robin Hirsch, Kingdom Technology Partnership.

University of Birmingham, UK or webinar.

Will outline the importance of system level testing of critical systems before releasing the software on to the railway and capture the benefits of system level testing in terms of access, safety, confidence, reputation, operational reliability and cost.

January 2021, date to be confirmed: "Cyber security", Alžbeta (Betty) Helienek, Ricardo Rail UK.

Glasgow, UK or webinar.

This paper will propose a digital resilience railway maturity matrix, presenting a method to categorise, recognise and support organisations with their roadmaps to integrating security into daily operations.

4 February 2021: "TMS and further automation in control centres", ITC (Ian Mitchell, IRSE and Nora Balfe, Irish Rail).

Dublin, Ireland or webinar.

Will discuss the appropriate level of automation in a railway control centre. How far can the tasks traditionally undertaken by staff with job titles such as 'signaller', 'controller' or 'dispatcher' be partially or fully automated? What are the benefits and what are the risks?

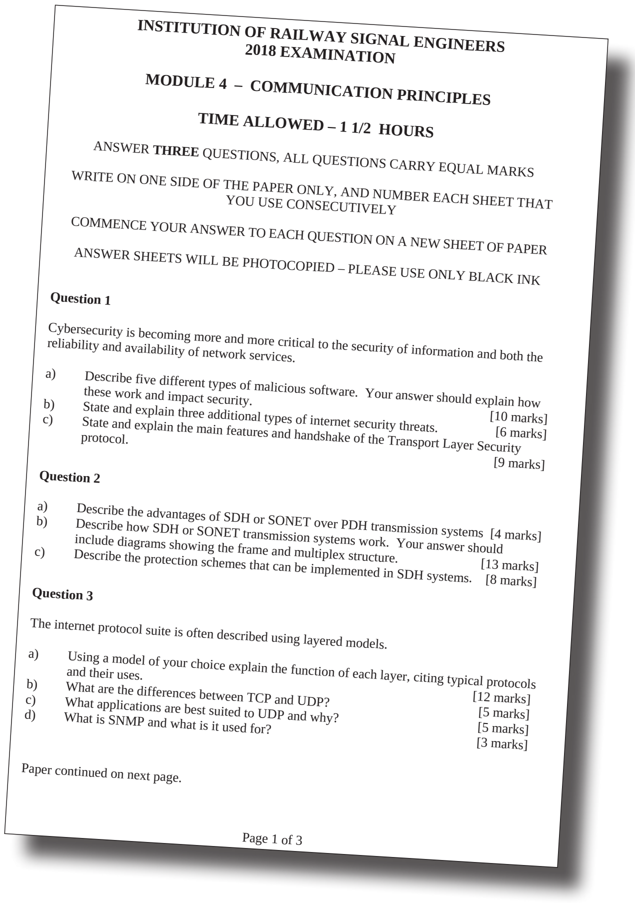
Younger members section

Railway telecom exam study day – via telecoms

Report by Paul Darlington

IRSE
Institution of Railway Signal Engineers
YOUNGER MEMBERS SECTION

On Saturday 4 April the IRSE Younger Members Section held its inaugural 'on line' railway telecommunications study day, to prepare candidates for the Institution's professional examination and to expand the telecommunications knowledge of seasoned railway engineers. Over 40 people participated, and the feedback received has been very positive and will hopefully set the model for other similar study days. The day consisted of several short on-line presentations by some very impressive experts, followed by a group Q&A and a discussion of past paper questions, to identify hints and tips and provide exam practice.


INSTITUTION OF RAILWAY SIGNAL ENGINEERS
2018 EXAMINATION

MODULE 4 – COMMUNICATION PRINCIPLES

TIME ALLOWED – 1 1/2 HOURS

ANSWER **THREE** QUESTIONS, ALL QUESTIONS CARRY EQUAL MARKS

WRITE ON ONE SIDE OF THE PAPER ONLY, AND NUMBER EACH SHEET THAT YOU USE CONSECUTIVELY

COMMENCE YOUR ANSWER TO EACH QUESTION ON A NEW SHEET OF PAPER

ANSWER SHEETS WILL BE PHOTOCOPIED – PLEASE USE ONLY BLACK INK

Question 1

Cybersecurity is becoming more and more critical to the security of information and both the reliability and availability of network services.

a) Describe five different types of malicious software. Your answer should explain how these work and impact security. [10 marks]
b) State and explain three additional types of internet security threats. [6 marks]
c) State and explain the main features and handshake of the Transport Layer Security protocol. [9 marks]

Question 2

a) Describe the advantages of SDH or SONET over PDH transmission systems [4 marks]
b) Describe how SDH or SONET transmission systems work. Your answer should include diagrams showing the frame and multiplex structure. [13 marks]
c) Describe the protection schemes that can be implemented in SDH systems. [8 marks]

Question 3

The internet protocol suite is often described using layered models.

a) Using a model of your choice explain the function of each layer, citing typical protocols and their uses. [12 marks]
b) What are the differences between TCP and UDP? [5 marks]
c) What applications are best suited to UDP and why? [5 marks]
d) What is SNMP and what is it used for? [3 marks]

Paper continued on next page.

Page 1 of 3

Ayo Obitayo, SNC-Lavalin Atkins opened the day with a presentation on telecoms network assets and earthing and bonding. He described telecoms cables, including copper twisted pair, co-axial, single and multimode fibre. Frequency Division Multiplex (FDM) over single mode fibre using Coarse Wavelength Division Multiplexing (CWDM) and Dense Wavelength Divisional Multiplexing (DWDM) were covered and how 18 to 160 wavelengths of light are used to greatly improve data transmission rates. Ayo also explained Ethernet twisted pair cabling along with telecoms earthing and bonding. The group then went through module 4 question 5 from the 2018 exam, discussing protective and functional earthing and the differences between typical TN, TT & IT earthing arrangements, followed by the role of surge protectors and their key specifications. It was noted that IRSE News issue 257 July/August 2019 covered the TN, TT & IT earthing arrangements and IRSE News is always a good place to find study information.

A list of articles which may be of use to members wishing to improve their telecoms knowledge can be found at irse.info/vaw7p. There is also additional material for Module 4 on the web site irse.info/13b2z.

Cyber security

Lucia Capogna, AEGIS covered cyber security and described the threats, sources (national governments, terrorists, industrial spies, organised crime, hackers, business competitors, disgruntled insiders, and human errors) and vulnerabilities. She illustrated some of these using examples such as the WannaCry ransomware cryptoworm – which targeted DB computers running the Microsoft Windows – and a 14-year-old hacking into the control system of a tram in Poland for fun! Lucia described the types of cyber security attacks which may be experienced by railway networks and the mitigations that need to be in place, based on threat identification and risk assessments. She emphasised the importance of constant defence upgrades and "defence in depth" with ensuring several layers of measures are in place. Module 4 question 1 from the 2018 exam was discussed. The group answered the first part of the question, but then discovered part of the answer formulated was the answer to another part of the question later on. This illustrated the importance of carefully reading questions all the way through before formulating an answer.

Duncan Robb, SNC-Lavalin Atkins presented the telecoms systems supporting ERTMS. Duncan made the group aware of GSM-R information that is available from ETSI/3GPP. European Telecommunications Standards Institute (ETSI) is a European Standards Organization (ESO) and deals with telecommunications, broadcasting and other electronic communications networks and services throughout Europe. This includes supporting European regulations and legislation through the creation of harmonised European Standards. 3rd Generation Partnership Project (3GPP) is the international standards body for all mobile radio including 5G. Only standards developed by European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (CENELEC) and ETSI are recognised as European Standards (ENs). ETSI also represent Europe at the 3GPP.

ETSI's standardisation activities for the Global System for Mobile Communications – Railway (GSM-R) focuses on the application of GSM for railway telecommunications. This includes numbering and addressing, configuration and system aspects as well as any additional features and services required by railways, including IP-based protocols such as General Packet Radio Service (GPRS) for ETCS. ETSI is also involved with the successor to GSM-R, Future Railway Mobile Communication System (FRMCS) and incorporating the railway requirements into the 5G mobile radio specifications managed by 3GGP.

Duncan demonstrated the information available on the ETSI website see ETSI standards (irse.info/m79cw) and discussed the SRS – System Requirement Specification and FRS – Functional Requirement Specification for GSM-R, along with the Euroradio ERTMS requirements and detailing the channel and timeslot configurations.

2017 Module 6 question 7 was reviewed and discussed and the first observation was that the question was about train radio, but did not specify or require the answer to be about GSM-R. Therefore, the answer could have been with regards to a Long Term Evolution (LTE), Wi-Fi or narrow band Ultra High Frequency (UHF) radio solution. The important point made was that exam candidates should always state any assumptions in exam answers. Do not assume the examiners know about your particular railway – and it could be they are not even from your country. Similarly, always write any abbreviation out in full as this demonstrates your knowledge and the same abbreviations can be used for different things in railways all over the world. An abbreviation may be commonly used and known by everyone in your railway, but not someone from outside.

"Assessing the security of ERTMS" by Richard Thomas – University of Birmingham was another presentation covering cyber security, but from a different angle. Richard explained that communications systems provide a vital link between two or more systems and the rail sector relies on these as part of the safety-critical operations and undertaking. With the shift towards digital solutions cybersecurity is something that cannot be ignored. The industry must be in a position to provide guarantees about the safety and security of all aspects, in particular communications which relay safety-critical information.

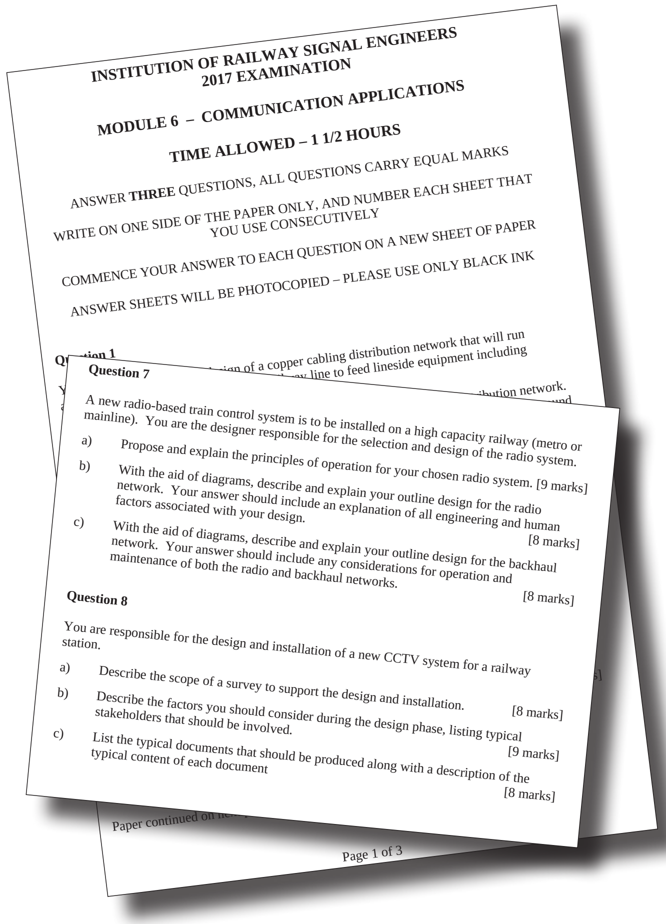
The European Rail Traffic Management System (ERTMS) is a wholly-digital solution, using GSM-R which is already deployed in a number of railway undertakings for voice communications, and developing new transport and application protocols which run above GSM-R, such as ETCS. Whilst GSM-R is an extension of the conventional GSM standard, its security 'roots' lie in the 20-year-old plus GSM standard. Design decisions made then continue to live on today, in particular those which govern the protection of data 'in-flight' where attacks allowing an adversary to decrypt communications exist. While it is not currently possible to 'inject' messages, this risk transfers into the railway. ERTMS, likewise is over 20 years old, where a number of the cybersecurity aspects, such as cryptography and authentication are based on limitations, such as memory and processing power that existed in the 1990s. These limitations brought justifiable decisions then, but today they do not hold where newer proven solutions can be deployed.

When new standards and protocols are developed, they should attempt to use standard technologies and components, for example the AES cryptographic scheme. Where non-standard components are used, they must be proven, especially when deployed in safety-critical contexts. As an example, the EuroRadio layer in ERTMS has its authentication, message transfer, and entity authentication developed as part of the standards, but with no verification to ensure that an adversary could not influence a train or radio block centre.

Formal Methods is a technique widely used in the rail sector, especially in signalling, to demonstrate safe operations of systems. The same process can be applied in a cybersecurity context to assure protocols, such as EuroRadio and its application layer to ensure that a train and RBC correctly authenticate and prove their identities to one another, messages sent between the train and wayside cannot be modified by an adversary, and to test partial compliance to EN50159 (Railway applications – Communication, signalling and processing systems – Safety-related communication in transmission systems).

One limitation of formal methods is if cryptography is used the application can be modelled, but the scheme itself might be flawed with the formal model showing the protocol is secure. Therefore, cryptanalysis is another function which must be carried out. The EuroRadio MAC was a modified variant of an ISO-specified scheme to assure message integrity and authenticity, but these modifications had not been verified, where flaws existed which, given sufficient traffic, an adversary could forge their own message to the train. This flaw shows how previous design decisions must be reviewed and challenged.

Finally, the operational lifespan of systems deployed must also be challenged. ERTMS will be here for a number of decades. Each component, therefore, must provide security into the future. One important point to note is safety cases do not change over time unless changes are made. Cybersecurity, however, is constantly changing where barriers to an adversary may be overcome given time. We must therefore be willing to re-evaluate decisions made as part of a continuous improvement to standards to deliver safe, secure railways.


INSTITUTION OF RAILWAY SIGNAL ENGINEERS
2017 EXAMINATION

MODULE 6 – COMMUNICATION APPLICATIONS

TIME ALLOWED – 1 1/2 HOURS

ANSWER THREE QUESTIONS, ALL QUESTIONS CARRY EQUAL MARKS

WRITE ON ONE SIDE OF THE PAPER ONLY, AND NUMBER EACH SHEET THAT YOU USE CONSECUTIVELY

COMMENCE YOUR ANSWER TO EACH QUESTION ON A NEW SHEET OF PAPER

ANSWER SHEETS WILL BE PHOTOCOPIED – PLEASE USE ONLY BLACK INK

Question 7

A new radio-based train control system is to be installed on a high capacity railway (metro or mainline). You are the designer responsible for the selection and design of the radio system.

a) Propose and explain the principles of operation for your chosen radio system. [9 marks]

b) With the aid of diagrams, describe and explain your outline design for the radio network. Your answer should include an explanation of all engineering and human factors associated with your design. [8 marks]

c) With the aid of diagrams, describe and explain your outline design for the backhaul network. Your answer should include any considerations for operation and maintenance of both the radio and backhaul networks. [8 marks]

Question 8

You are responsible for the design and installation of a new CCTV system for a railway station.

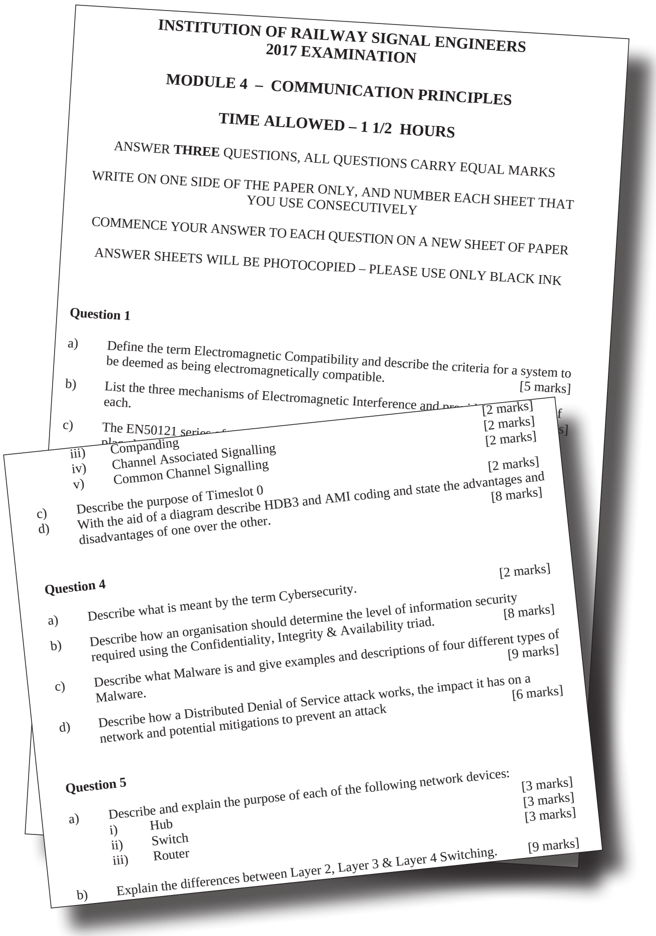
a) Describe the scope of a survey to support the design and installation. [8 marks]

b) Describe the factors you should consider during the design phase, listing typical stakeholders that should be involved. [9 marks]

c) List the typical documents that should be produced along with a description of the typical content of each document [8 marks]

Page 1 of 3

2017 Module 4 question 4 was reviewed and discussed with regards to cybersecurity, including the confidentiality, integrity and availability triad, what malware is and how a distributed denial of service attack works, along with the impact it has on a network and potential mitigations to prevent an attack.



INSTITUTION OF RAILWAY SIGNAL ENGINEERS
2017 EXAMINATION

MODULE 4 – COMMUNICATION PRINCIPLES

TIME ALLOWED – 1 1/2 HOURS

ANSWER **THREE** QUESTIONS, ALL QUESTIONS CARRY EQUAL MARKS

WRITE ON ONE SIDE OF THE PAPER ONLY, AND NUMBER EACH SHEET THAT YOU USE CONSECUTIVELY

COMMENCE YOUR ANSWER TO EACH QUESTION ON A NEW SHEET OF PAPER

ANSWER SHEETS WILL BE PHOTOCOPIED – PLEASE USE ONLY BLACK INK

Question 1

a) Define the term Electromagnetic Compatibility and describe the criteria for a system to be deemed as being electromagnetically compatible. [5 marks]

b) List the three mechanisms of Electromagnetic Interference and pro... each.

c) The EN50121 series ...

iii) Companding [2 marks]
iv) Channel Associated Signalling [2 marks]
v) Common Channel Signalling [2 marks]

c) Describe the purpose of Timeslot 0 [2 marks]

d) With the aid of a diagram describe HDB3 and AMI coding and state the advantages and disadvantages of one over the other. [8 marks]

Question 4

a) Describe what is meant by the term Cybersecurity. [2 marks]

b) Describe how an organisation should determine the level of information security required using the Confidentiality, Integrity & Availability triad. [8 marks]

c) Describe what Malware is and give examples and descriptions of four different types of Malware. [9 marks]

d) Describe how a Distributed Denial of Service attack works, the impact it has on a network and potential mitigations to prevent an attack [6 marks]

Question 5

a) Describe and explain the purpose of each of the following network devices:
i) Hub [3 marks]
ii) Switch [3 marks]
iii) Router [3 marks]

b) Explain the differences between Layer 2, Layer 3 & Layer 4 Switching. [9 marks]

Signal Post Telephone

Harry Hall, SNC-Lavalin Atkins presented "What could go wrong with installing an SPT?" A Signal Post Telephone (SPT) is mainly provided in the UK and is a 'direct line' telephone to enable a train driver or line side person to communicate with a signaller in a safe and secure manner. Despite its name an SPT nowadays is not located on a signal post, but on a separate post in a safe location to allow a user of the SPT to see the signal aspect. Not all signals require an SPT and they will be provided on a risk basis in accordance with guidance from an industry standard. The exact location of any SPT provided will be determined by a signal sighting committee. Harry explained how an SPT can be connected to the signalling centre by either a twisted pair cable or with the addition of a digital multiplex/IP (Internet Protocol) telecoms transmission network. Voice over IP (VoIP) telephones are now being used for SPTs, but as the distance VoIP will work to is limited to 100m such SPTs are normally located no more than 90m from an IP node. As SPTs are used to instruct drivers to pass signals at danger it is vital SPTs are labelled correctly and present the correct signal number to the controlling signaller. This must be tested as part of the commissioning of the SPT system and regular maintenance activity.

Trevor Foulkes, chair of the LSE Section and previously programme engineering manager for the GB GSM-R programme, concluded the day with the "Role of telecoms on the railway". He began by explaining the telecoms bearer network is the heart and veins of the railway. It provides links for: signalling, wide area data networks, level crossing telephones, SPTs (UK), GSM-R, business voice systems, electrification control, customer information systems, help points, remote condition monitoring/intelligent infrastructure, and applications that are growing all the time.

Voice communications are important for the following situations:

- **Routine**. For example, normal day to day communication to allow a train movement, to protect a work site or to allow a vehicle to use a crossing. If there is a misunderstanding then there is a hazard. Sometimes the location of the driver/track worker when the communication is made may put them at risk. This needs to be managed.
- **Prevention**. For when a hazardous situation has been identified and quick action is required to mitigate the hazard before an accident occurs. While obviously not widely publicised there have been a number of potentially serious incidents avoided by the use of emergency communications facilities.
- **Loss**. An accident has occurred and steps need to be taken to reduce the loss caused by the accident. For example, the "Investigation into the King's Cross Underground Fire" in London by Desmond Fennell and known as "the Fennell report" (**irse.info/u1inf**) identified many inadequacies in sub surface railway communications which added to the loss.

Commercial telecoms networks have a place in supporting an operational railway, in particular for providing link diversity for both voice and data services. However commercial networks cannot provide all the telecoms requirements for a railway, which often have difficult access and operational restrictions. For example, a GSM-R network must have continuous radio coverage including all tunnels and deep cuttings, but a commercial mobile network operator will have coverage optimised for maximum revenue generation and focused where people are located. They will not necessarily provide coverage for remote rural locations and railway tunnels and cuttings. A commercial telecoms network provider will want the ability to upgrade or change their network at short notice. This could mean an outage in the middle of the night with no notice, which may be the time an operational railway may be doing engineering work and needs all communication services. When investigating failures or making safety assessments the infrastructure manager may require detailed information of the telecoms network, which some commercial telecom operators may be unable to provide, and when major failures occur with commercial telecoms services the railway may find itself 'back of the queue' with service restoration.

The final exam question discussed was Module 6 question 7 regarding a major sub-surface railway refurbishment with the station telecommunication systems requiring renewal, with the opportunity to make enhancements to functionality. The group discussion identified and explained the typical telecom systems required, and the factors needed to be considered and why, together with integrating an adjacent shopping centre/main line railway station. These included Low Smoke Zero Halogen (LSZH) cabling, equipment and cable diversity for CCTV, PA, help points, radio, automatic fire detection, standby power systems and escape routes.

The study day was a big success and the IRSE would like to make a special thanks to all the presenters, to Andrew Love as chair and to Ayomide Obitayo, John Chaddock and Robin Lee for superb organisation – including the rapid and successful change of format from a physical event in London to an online study day. A recording of the day can be found at **irse.info/f6klx**.

International IRSE Conference

An overview of "IRSE CBTC and beyond" 2019

Report and photos by Yousef Kimiagar

IRSE
Institution of Railway Signal Engineers
NORTH AMERICAN SECTION

The fourth "CBTC and Beyond" conference was held in Toronto, Canada on 28-29 November 2019 at Fairmont Royal York and visited Eglinton Crosstown – the largest transit project under construction in Ontario.

Over 110 advanced train control and industry experts from more than 40 companies, organisations and agencies around the globe came together to share and exchange their knowledge, technology advancements and the lessons learned in deploying the advanced train control systems around the world. Twenty speakers from North America, Europe and Australia delivered the conference agenda.

Day 1: Thursday, 28 November

Yousef Kimiagar, the chairman of the conference, welcomed everyone and thanked attendees, speakers and sponsors and emphasised the key role that the sponsors play in keeping the conference affordable to young professionals. Yousef thanked the organising committee and the IRSE management especially president, George Clark, who travelled to Canada from the UK to attend. Yousef apologised for this year's conference overlapping the American thanksgiving holiday – leading to most of the interested individuals in the US not being able to attend – but the conference sell-out, long before the event, was an indication of the continued success of the event.

In his opening remarks, Yousef touched on two presidential themes: the "Winds of Change" by Markus Montigel, president 2018 and "Delivering the Change" by George Clark, president 2019. In reviewing these themes, Yousef asked the question "What is changing and why?". He then continued by a quote from Thomas Friedman that in year 2000, the world became flat. That's when the outcome of the 3rd industrial revolution brought computers to our offices and homes and cheap fibre optics connected everyone. That was the beginning of a global collaboration. But major changes happened in 2007 and the world became fast – the future generations will remember this year as a single technological inflection point in the history of humanity. This is the year that we experienced the 'easy touch' for interacting with the machines. First Apple iPhone, first cognitive computer IBM Watson, Google Android, YouTube became a global university, Amazon introduced Kindle, the Cloud was born and cloud computing platform took off to the point that today is capable of 12 T calculation/second, Big Data exploded and now 44 Zettabytes of data exist, the Internet users passed 1 billion and on and on.

And now, we are going deep with 'no touch' human-machine interface – just talk to the machine. And what is next? not even talking to the machines!? – yes – machines are learning, predicting and making decisions on our behalf.

IRSE president George Clark attended the event in Canada.

Yousef reflected on the transit industry and the fact that digitalisation is a reality and is happening much faster than anticipated. Faster and more flexible manufacturing is bringing smarter and more sustainable products. Factories are extended beyond their walls and products remain connected to the manufacturers. This is the 'new ecosystem' that demands the collaboration of all parties. Yousef went on showing some of the emerging intelligence in our industry and pointing to the fact that "self awareness" and "situational awareness" are becoming new characteristics of products and the survival strategy is to reimagine the workforce. He explained that the structured, routine and repetitive jobs are ideal candidates for replacement by machines and AI, therefore, the resources in this category must upgrade their skills and qualifications to undertake new jobs.

Historically, human adaptability used to be above the technological advancements, but in the last decade, things have changed and the average adaptation has fallen behind and our responsibility is to ensure the new generation of workforce is aiming towards filling the jobs that will be highly in demand in the near future, but also training the existing workforce to elevate their knowledge and capabilities to remain competitive.

Yousef ended with a quote from Albert Einstein who said: "It has become appallingly obvious that our technology has exceeded our humanity".

Phil Verster gave the keynote address.

President of the IRSE, George Clark welcomed the attendees. George is director of engineering at Transport for London and the 95th President of the Institution. George has more than 30 years of experience with London Underground and Transport for London and he now leads over 1,500 engineers across all disciplines and transport modes. George welcomed the audience and spoke about his presidential theme "Delivering the Change". He continued by stating that the winds of change, as was the presidential theme of the year before should continue by delivering it. George emphasised that in order to succeed in this journey, as the president of the IRSE, he needs to ensure the Institution takes the lead and supports the industry. As part of his presidential programme, George has planned seminars and conferences for the industry experts to discuss the issues, skills gaps and explore the opportunities that exist.

Keynote address

Phil Verster, president and chief executive officer of Metrolinx, delivered the keynote address. He oversees a team committed to transforming transportation in the Greater Golden Horseshoe. Prior to joining Metrolinx, Phil managed train operations, infrastructure builds and infrastructure management for passenger rail systems in England, Scotland and Ireland. Phil began his career in his native South Africa in the electricity sector. He then spent several years in the UK at Bombardier Rail and at Irish Rail. In 2011, Phil joined Britain's Network Rail where he managed the second largest route in the system. He then ran Scotland's ScotRail passenger rail service, and served as Managing Director of Network Rail's East West Railway. Phil joined Metrolinx in October 2017. His comprehensive knowledge and extensive transit background have equipped him with the necessary tools Metrolinx requires to continue working towards delivering an integrated, regional transportation system that will serve the needs of residents and businesses for years to come.

Phil talked about 1920s interlocking technology that still exists in the Metrolinx network its replacement with advanced signalling solutions to increase the network throughput, with some 60 out of 64 interlockings needing replacement. Phil further explained the associated business benefits and how GO Transit services have been expanded in the last two years leading to a significant and unprecedented growth of 40% in capacity. Phil continued by saying how fundamental is what we as a railway do and praised the audience for their crucial role in maintaining a safe operation while adding real economic value by increasing system capacity.

Projects in New York

The first four presentations were about New York CBTC.

Pete Tomlin, of MTA New York City Transit (NYCT), has decades of signalling experience in roles such as project manager of Jubilee Line Extension with London Underground, site manager of West Rail and Ma On Shan line projects with KCRC in Hong Kong, Manager of T&C for all projects at TTC, project director for the ATC and now vice president of Signals and Train Control Engineering for NYCT. Pete provided an introduction to NYCT subway network – the seventh largest in the world with 1.7 billion annual ridership, 11 subway corridors, 473 stations and the 10-Year capital plans to improve passenger journeys by 90% covering 47 of the 50 busiest stations. He portrayed a picture that in the past 22 years, only 43 miles of the network has been equipped with CBTC and the future $7.1 billion capital plan is to modernise and deploy an interoperable CBTC in accordance with the Interoperability Interface Specification I2S, on 220 miles by 2027. All this is expected to be performed in parallel with maintaining a safe operation 24 hours a day, 7 days a week.

Gregoire Sulmont, New York operations director, Thales, started his career as an electronic designer followed by joining the industry with Matra Transport in France where he led the digital electronic group and the development of the Digisafe platform for the Météor Project in Paris. He continued with the Canarsie CBTC project in New York, headed projects for Invensys in the Asia-Pacific region before moving to Systra in New York. He is currently with Thales managing New York operations. Gregoire talked about the Flushing Line with 500 000 daily ridership and how CBTC has been a game changer for the operation and the performance of the line. He touched on the fact that the track mounted equipment drives the cost and schedule, complicates the systems, constrains the operation, limits the performance and remains a maintenance burden. He explained about adopting new technologies and the new positioning system that is based on Ultra Wide Band (UWB) Inertial Measurement Unit (IMU) radar. This would eliminate the undercarriage installation and substantially reduce the track installation, and is currently under evaluation and functional demonstration.

Francois-Xavier Beau (Fix): head of integrated systems – Siemens, has developed vital software and on-board and wayside train control systems. Fix has worked on test and commissioning of the first CBTC line in New-York, the Canarsie (L Train) Line. He has also led the R&D team in France in charge of developing Siemens Trainguard MT CBTC software for driverless systems such as Budapest M4, San Paulo L4 and Paris Line 1. He is now responsible for the CBTC business for Siemens

Yousef, centre, with the speakers on the subject of projects in New York.
From left to right Mototsugu Kozaki, Francois-Xavier Beau, Gregoire Sulmont and Pete Tomlin.

in the US. Fix presented the New York Queens Boulevard Line (QBL). The CBTC route spans 39 track miles, 22 stations, 10 route miles, 9 relay-based interlockings and 309 CBTC equipped cars. He continued explaining that the transition between Thales and Siemens wayside areas is seamless to the operation, and Thales and Siemens equipped trains can be coupled together and run in Automatic Train Operation (ATO). In compliance with NYCT CBTC I2S, a Thales train can run on Siemens wayside area and vice versa. The interoperable ATS for the entire B division is also part of this project. A single user interface combines territories in a different state of renovation. The monitoring and control over five servers – each controls one of the five operational corridors of the B division. The territory under the ATS consists of 271 stations, 680 platforms, 8147 track circuits, 1950 home signals, 559 switches, 1491 approach signals and 3329 automatic signals. Fix also noted that there are two yards, each with one test rack fully equipped with CBTC on which trains can run in Automatic Train Protection Manual (ATP-M) mode and with ATO. To minimise the track time, an interoperable lab is developed and equipped with real onboard and wayside CBTC, radio and automatic train supervision equipment, and can be configured for each CBTC deployment. The multi supplier integrated test facility for Thales, Mitsubishi and Siemens is the key to a more efficient system integration and field testing. Three CBTC training facilities have been equipped with simulators and 54 train operators can be trained every week without requiring track access.

Mototsugu Kozaki, manager of train control & signalling systems, Mitsubishi Electric has over 20 years' experience designing systems with Mitsubishi Electric in Japan. He is currently responsible for the international CBTC business for Mitsubishi Electric. Mototsugu has also worked on technical research for state-of-art CBTC technologies and been the technical project manager for the NYCT Morris Park SSI project, and project manager for the NYCT CBTC equipment supplier interoperability project. He talked about Mitsubishi as a key supplier of signalling system in Japan and their progress towards CBTC qualification in New York becoming the third supplier of an interoperable CBTC train control system for New York. Mototsugu highlighted the huge challenge that Mitsubishi had faced making significant changes to their CBTC base product and reallocate functions to be compliant with the I2S requirements that were still being changed and amended – a moving target changing six times.

To overcome these challenges, the V&V testing time was minimised by automating the testing system. Another challenge outlined was limited access to Interoperability Testing Facility (ITF) that were heavily used by the other suppliers. Mototsugu outlined the opportunities to use advanced technologies and innovations such as UWB , cloud based solution, highly reliable radio system and intelligent ATS for train management and predicting the train movements. He also suggested making I2S a standard similar to IEEE.

At this point, Alan Rumsey, Fellow of IRSE and member of the IRSE International Technical Committee continued the conference by moderating the sessions.

The next presenter was David Dimmer, director, product strategy, Urban Rail Signalling Business Line – Thales. David has played a leading role in the design of the SelTrac™ MS radio-based product, which has been installed on more than 20 lines in China including five lines in Shanghai and Beijing, and in Kuala Lumpur, New York, Doha, Hyderabad, Santiago, Disney World, and the Ottawa LRT. He participates in international standardisation work and is the Canadian representative on the International Electrotechnical Commission (IEC) Working Group 40, which is developing the IEC 62290 standards for CBTC systems. David is also representing Thales on the IEEE WG2, which is currently updating the IEEE 1474 standards.

He was also the technical leader for the recently completed Next Generation Train Control (NGTC) research project in Europe, led by UNIFE, which investigated synergies between ETCS and CBTC systems. David talked about Light Rail Transit (LRT) projects and how they are flourishing around the world, especially in North America and in particular in Canada. He reviewed the signalling technologies that are available for the different types of LRT systems – fully segregated guideways, partially segregated guideways, and street running systems. He outlined the benefits of CBTC for LRT systems requiring ATP along with technology for street running sections not requiring ATP. In addition, he looked into emerging technologies leading to autonomous light rail vehicles and North American case study examples of the application of signalling technology.

Geert Schroeder, project director, Siemens Mobility, talked about the Copenhagen S-bane project and why a CBTC system is best fit for a commuter rail. Geert is a project director with an international remit for Siemens Mobility based in Germany, and has over 20 years of experience developing and

Clockwise from top left: Alan Rumsey, David Dimmer, Geert Schroeder, Thijs Teunissen, Bogdan Godziejewski and Crystal Cole.

delivering CBTC and ETCS systems on some of the world's most challenging commuter lines. During his career Geert has worked with a wide range of international commuter and main line rail stakeholders. He presented an overview and current state of a brownfield refurbishment project in Copenhagen – 170km doubletrack commuter rail system and specific brownfield issues needed to be tackled to obtain mixed operation and change in operational rules. He also provided some measures to overcome brownfield issues related to technical, stakeholder management and project agreement.

Crystal Cole, global discipline director – delivery governance development with Hatch, has over 26 years of international project management and consulting experience in the infrastructure, rail signalling, and construction industries. Crystal has an MBA and is a certified risk management leader and a project management professional. She talked about common impacts to future signalling project delivery from a project management perspective, and provided an overview of recurring causes and lessons learned from various international rail projects including scope for rail signalling or systems. Crystal discussed how these causes have the potential to impact future projects and the importance of exploring and understanding the common causes and associated impacts on rail signalling projects, from a project management perspective. This allows for insight and awareness of risk areas and potential recurring delivery challenges while providing the opportunity to discuss areas of improvement for delivery of future rail signalling projects.

"Challenges of Implementing Advanced Train Control Systems in a Brownfield Environment – a Global Perspective" was delivered by two speakers:

Bogdan Godziejewski, senior rail manager – Mott McDonald has over 30 years of international experience with railway signalling engineering, planning and research. He is a member of the IRSE specialising in technical and strategic advice with focus on advanced train control systems. Bogdan is active as external evaluator, reviewer and assessor of ETCS/CBTC projects as well as related European research & innovation projects of Shift2Rail.

Thijs Teunissen, project manager – Mott McDonald rail & transit has been involved in strategic advisory projects on advanced train control systems for national and regional authorities, operators and infrastructure managers in Belgium, the Netherlands and Denmark.

Bogdan and Thijs talked about major upgrade activities of various advanced train control systems emerging in both transit and heavy rail environments. Many transit networks, like TTC (Toronto), BART, WMATA, NYCT and MMRA decided to implement the CBTC systems. In Europe and Australia, large, often network-wide, deployment of ETCS is underway. All these projects are undertaken in a brownfield environment, causing further challenges to the implementation. They continued by identifying and comparing major implementation challenges and lessons learned at various stages of the project lifecycle. These included how projects cope with the technological progress and the development of new standards during implementation; how operational and technical needs can be specified properly; and how adequate solutions and suppliers can be selected. They also highlighted areas of concern about how to arrange technical migration and organisational change resulting from advanced train control systems; how to deal with technical and organisational project complexity; how to align the advanced train control system project development with a wider strategy and objectives of transit/railroad organisations; and the right choices for ensuring a successful project.

The Caltrain Commuter Positive Train Control System case study was presented by Mohsen Shafeie, technical project manager and co-authored by Alireza Edraki, senior director programme management – Wabtec Electronics Group. Mohsen has over 15 years of engineering experience in automation and control systems with ABB in the Netherlands, large-scale projects with Royal Dutch Shell and DuPont and CBTC system operation and design with Thales Canada. Alireza has more than 22 years of experience in the system engineering and independent safety assessment and held positions as systems specialist, principal engineer, director of engineering and vice president of operations.

Caltrain is a class 1 commuter railroad operating 160 locomotives and cars on 125km of track (80km owned) along California Bay Area. Caltrain, interoperates with UP, ACE and AMTRAK and in 2011 started deploying Positive Train Control (PTC) system to improve safety. Mohsen talked about the Interoperable Electronic Train Management System (I-ETMS) which is a communications based train control system developed to meet the PTC requirements in accordance with FRA 's mandated regulations and timelines.

The system utilises GPS, cellular and wireless radio communication along with advanced computing to send live visual and audible information to train crew. The standard four segments of the PTC are Locomotive, Wayside, Communication and Back Office that works with wayside equipment, back office solution and communications equipment from other vendors and provides incremental protection. It integrates new and existing technologies including the conventional crossing technology. Mohsen outlined some of the challenges experienced along the project deployment. Wabtec joined the programme halfway through the implementation with an unknown condition of the incomplete infrastructure, aggressive schedule, regulatory requirements, and most importantly, integrating the solution provided by different suppliers – lineside by Alstom, communication by Meteorcomm and CAD by ARINC.

To mitigate and overcome these challenges, a proactive customer collaboration approach was adopted, and the project delivery teams were collocated. An informal peer to peer communication and involvement of the customer in daily activities expedited the progress of work saving much-needed time. Early assessment of the infrastructure along with agile and flexible management and the integration lab at Caltrain facility were the key factors in timely completion of the project.

Andrew Lee, senior project manager ATC Implementation with Parsons talked about "Rail System Engineering Perspective to Cybersecurity". Andrew has more than 15 years of engineering and management experience in telecommunication and rail industries. He is a radio frequency specialist and has worked for Thales and Siemens in the areas of data communications system and system engineering for signalling and train control deployment. He is also an advocate of enhancing cybersecurity awareness within the rail industry. He talked about the rapid technological advancements since the 1970s leading to all types of automation and other technological trends that we have seen in recent years. There is no doubt about the benefits of a more connected community and a more connected infrastructure, but the convenience of connectedness might have clouded our judgement over the cybersecurity risk.

Andrew continued with some questions on what has been done in the rail industry towards cybersecurity and whether we have done enough to protect our connected infrastructure. What is our risk tolerance and what can we do to enhance our protection and our awareness towards cybersecurity risks? In response to these questions, Andrew provided some guidelines starting with the assessment of the condition, threats and vulnerabilities followed by evaluation of the risk, prioritisation and recommendations. The outcome of these steps must be considered throughout the design and build stages so that system specifications and design architecture are taken into account and develop solutions to mitigate the identified risks. Sustaining the systems resiliency is by continuously detecting threats and redefining the mitigations as required. He also recommended the development of the security concept of operation in parallel with the system Concept of Operation.

This would allow some trade off analysis to increase the system safety. Additional provisions were categorised as related to integrity, availability and confidentiality. Some examples were presented as firewalls, disabling unused ports, disconnecting unnecessary internet connections, encryption, strict policies, raising awareness, regular audits, monitoring intrusion, and controlled access. Some cyber standards were also recommended: PPD-21 Critical Infrastructure Security and Resilience, ISA/IEC62443 Cybersecurity Certificate Programs, NIST Cybersecurity Framework, Computer Security (SP 800), APTA (Control and Communications Security, Enterprise Cyber Security), ISO 27001, 27002, 22301, 27032, FIPS 140-3 and NERC CIP.

"Optimal Tunnel Ventilation System and Fire Life Safety Operations and Control Using CBTC/ATP Functionality and Integration" was presented by Nima Eslaminasab, senior engineer TVS and FLS and Yan He, technical director rail systems engineering from WSP.

Nima has more than 25 years of experience in multi-disciplinary design engineering, construction supervision, and project management in the field of transportation, Fire Life Safety (FLS), Underground and Tunnel Ventilation Systems (TVS), fire protection and fire alarm systems. Yan He has over 22 years of experience focused on systems engineering and systems integration. He has worked on large international transit projects and has taken the technical design and systems integration leadership roles in engineering disciplines, including traction power, OCS, signalling and train control, communications, SCADA, and operations and maintenance.

The two presenters talked about the importance of using CBTC functionality to improve the system's performance during emergency operations and evacuation. While the IEEE1474 standard establishes a set of performance and functional requirements necessary for enhancing performance, availability, operations, and train protection using a CBTC system, the standard is mainly focused on the normal operational safety of the signalling and train control system. CBTC increases the number of trains in the network and as a result, the number of

Mohsen Shafeie, Andrew Lee and Yan He.

Nima Eslaminasab, Derel Wust and Walter Kinio.

trains in specific ventilation zones could increase, leading to more complexity and risk in a fire emergency scenario.

They continued with some innovative ideas and methodologies to utilise CBTC and ATP capabilities to improve and optimise TVS controls and FLS operations, and the improved systems' performance. These included selective vehicle door operation, safe train separation during an emergency, and proper communication of disabled train location with first responders. The presenters talked about fire scenarios in the tunnel and NFPA130 standard, mapping fire ventilation zones and integration of the SCADA with CBTC. This would make it possible for early detection and prevention of train encroachment into the ventilation zones. Selective door operation can significantly reduce the Fire Heat Release Rate (FHRR) and as a result, help contain the spread of the fire during the crucial initial moments. Reduction in occupant load and reduction in evacuation time were also considered other benefits that could be realised. These could be achieved through reversing the travel direction under ATO.

Derel Wust, Managing Director 4Tel presented "Next-Generation Rail Systems using Artificial Intelligence and Machine Learning". He has Bachelor of Engineering and Graduate Diploma in Management Studies and started his own business 4Tel in Australia specialising in railway technology. Products include a virtual-block train control system for improving rail operations safety and productivity in remote and regional areas, GPS tracking of rail mobile users, internet-of-things infrastructure monitoring software, multi-modal passenger information displays. Most recently he has been developing expertise in artificial intelligence and machine learning for application to train control operations.

Derel talked about the rapidly evolving autonomous car technology and the opportunity for the rail industry to improve the safety, efficiency and cost-effectiveness of on-board driver advisory systems, next-generation train control systems, and rail systems generally. He presented the progress made on applying artificial intelligence and machine learning technologies to rail operations in Australia and demonstrated that a modern digital railway is not simply a digitised version of an analogue railway using distributed infrastructure for train control, rather a next generation digital railway can alternatively use network-centric, virtual-block software techniques to allow more efficient ways of working safely and productively.

He provided the background, starting in 2016 when 4Tel got engaged with University of Newcastle (Australia) Robotics Laboratory (NUBots) to develop rail-specific artificial intelligence and machine learning algorithms. The work has developed a deep learning processing pipeline as specific to rail operations that includes detection, localisation, awareness, dynamic and monitoring. Derel presented a few video clips

showing how artificial intelligence and machine learning can provide the capability for a rail system to autonomously identify objects and safety hazards when there is uncertainty, rather than simply act to pre-set logical software rules which are insufficient in complex systems with varying weather, light and environmental conditions.

The final presentation was "Beyond CBTC" delivered by Walter Kinio, vice president, research and innovation with Thales. He is responsible for all research activities for Thales Urban Rail Signalling and works closely with the product, engineering and strategy teams to create new and innovative solutions. Since 2016, he has led the train autonomy research and new product introduction activities, and worked on CBTC Systems since 1983 in a progression of engineering and management roles. He is recognised as a senior CBTC expert by Thales. Walter is the author of a number of patents related to train autonomy and has presented in conferences explaining the benefits of this new technology.

In this presentation, Walter talked about new technology trends appearing that will have a great impact on urban transportation. The introduction of artificial intelligence and train autonomy capabilities will result in greater flexibility, availability, reliability and quicker deployment for transit operators. He talked about challenges such as a processing power of about 1 Gigabit/second that is beyond the current embedded processor, high performance LIDARs that won't be available earlier than 2021, high performance communication networks and safety certification.

Walter indicated that current state of the art neural networks can produce results that are better than a person can achieve, however there is a large gap to bridge for SIL4. In order to use neural networks in critical functions, the AI needs to be able to distinguish when there is sufficient input information to produce a plausible output as opposed to when there is insufficient information. The ability to bound the results will allow other safety techniques to be used to build SIL 4 functions. Despite these significant challenges to overcome, Walter stated that autonomous trains are coming and sooner than it might be thought and before autonomous cars are on the roads.

Group 1 enjoying the presentation at the start of the second day.

Day 2: Friday, 29 November

On the second day, the technical tour was arranged to visit Metrolinx's largest transit expansion, Eglinton Crosstown LRT. The construction of this line started in 2015 by Crosslinx Transit Solutions (CTS) – a consortium of ACS-Dragados, AECON, EllisDon and SNC-Lavalin. It is over 19km of new light rail – 65% twin bored tunnels with 10 underground and 15 at grade stops. The train control system is CBTC GoA2 for the exclusive section, ATP-M for the at grade and GoA4 Unattended Train Operation (UTO) for the maintenance and storage facility. At different stages of the visit, CTS provided presentations to the attendees outlining the design, the construction and the progress made to date. The award of this contract followed the Alternative Funding Procurement (AFP) model.

The author would like to thank technical tour partner Crosslinx Transit Solutions – Platinum Sponsors SNC-Lavalin, Thales, WSP – Gold Sponsors AECOM, Hatch, Parsons, Green Aspects, CBTC Solutions – Silver Sponsor LTK Engineering for their support to CBTC and Beyond.

Below, all of our attendees at the technical visit on the second day of the event.

Past lives: Craig Longley

Craig Longley started a successful railway career in 2002 as a fast-track trainee, working from the Knottingley depot in West Yorkshire, England. After his initial training, he worked through the technician grades, and in 2009 he was recognised as a future leader, during which time he completed many signalling asset performance projects.

His first management position was as the section manger (signals), Wakefield, quickly progressing to the position of assistant signalling & telecoms maintenance engineer, based at Holbeck Depot, Leeds. He was further promoted to signal engineer, Leeds in March 2013.

In the face of a crisis, Craig was known to be unflappable (similar to many in the world of maintenance) and always took time to explain the technical detail to senior figures in terms they could easily understand, and with patience, often more than once!

Craig loved using new technology to make maintenance work easier and safer, and he was the cornerstone of making technical advances in the field of remote condition monitoring to improve signalling asset performance in the busy commuter area of Leeds. Leading the regional "Predict & Prevent" working group, pulling ideas and people together from across the industry and above all having a truly positive affect on the daily commute of thousands of people in and out of Leeds every day.

Away from technology and innovation, Craig influenced many new maintenance leaders, not only in signalling, but in track and overhead line. The years that Craig worked in Leeds saw a new level of excitement, diversity and an alternative approach to an extremely traditional field of engineering. Craig's technical expertise and enthusiasm moved maintenance into the 21st century. Railway companies from Singapore, Hong Kong, and Japan all visited Leeds maintenance depot to understand Craig's secrets for success.

Craig's passion was innovation. He is pictured in his Leeds depot replacing points machines using a specially adapted road rail vehicle.

Following a short illness, Craig passed away at the age of 36. He leaves a wife and two children, and a vast number of inspired railway engineers.

Quick links

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

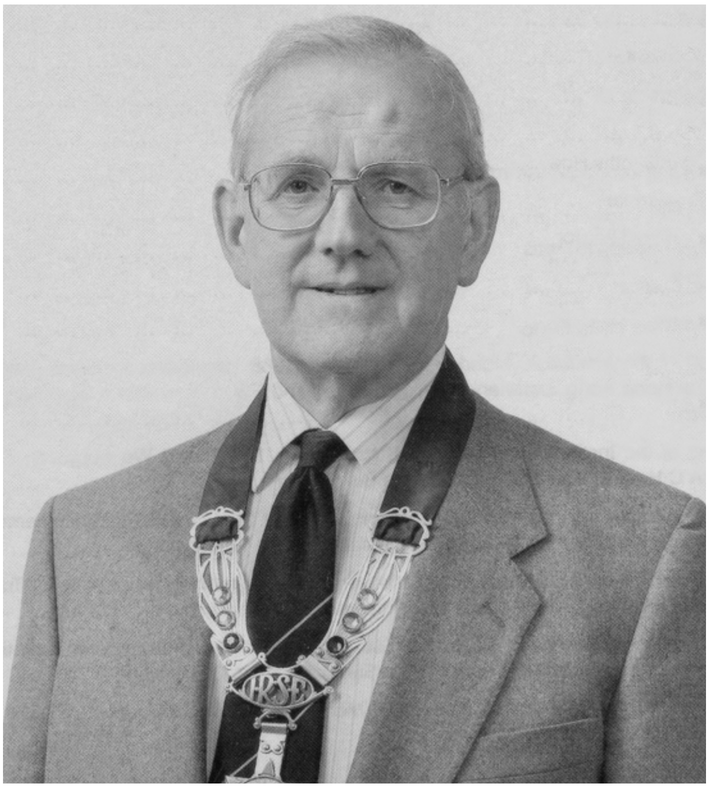
Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

Past lives: Tim Howard

Timothy Stratford Howard CEng, HonFIRSE, MIEE was born on 15 August 1929 and educated at Hurstpierpoint College in Sussex. He studied Electrical Engineering at Northampton Polytechnic in London (now City University) and after graduating with a BSc degree in 1953 he joined Westinghouse Brake & Signal Company in Chippenham as a graduate apprentice. A year later he joined the Contracts Engineering Department in the Westinghouse head office at York Way, Kings Cross, London, where he worked on many signalling projects for British Rail and overseas railways, becoming chief contracts engineer in 1969. In 1971 he became chief signal engineer for Westinghouse and head of the department responsible for all aspects of signalling contracts including project management, design and installation. Under his direction the company carried out numerous contracts in the UK and abroad including work on the Southern, London Midland, Eastern and Scottish Regions of British Rail. Noteworthy during this time was signalling for the electrification of the West Coast main line, signalling at Doncaster and for Irish railways, and for marshalling yards at Tyne, Tees and Perth.

In 1974 Tim was appointed export manager for Westinghouse and later became their marketing manager. In these posts he travelled extensively overseas in search of work for the company. He was involved in both main line and mass transit signalling projects in the Far East, Australia, the Indian sub-continent, the Middle East, Africa and North America. His abiding memory of things he did on behalf of the company during this period was eating sheep's eyes in a Bedouin tent somewhere in Arabia.

Tim was a Chartered Engineer and Member of the Institution of Electrical Engineers. He joined the IRSE as an Associate Member in December 1962; from 1965 to 1969 he was secretary of the General Purposes Committee, he was elected a Fellow in April 1971 and served on Council from 1978 before becoming the IRSE president for 1988-89. It was Tim's noteworthy and foresighted reference in his presidential address to the lack of protection against train driver error, then the custom in Britain and elsewhere, that led to the presentation in London in November 1988 of Tony Howker's seminal paper "Have We Forgotten the Driver". With Tim's connections in the Far East he was able to lead a very successful IRSE Convention in May 1988 to Hong Kong, the first time in the Institution's history the Convention had been held outside Europe. A record number of 332 attended, they visited installations on the KCRC, MTRC, the Tuen Mun light railway and at Guangzhou in China.



Timothy Stratford Howard, 1929-2020.

His main interest outside work was gardening and, somewhat perversely for a railway engineer, an interest in old London buses. The large garden attached to his house at Cherhill, where he lived with his wife Stella, was a blaze of colour and filled with flowers and vegetables. He was an excellent raconteur, mimic and amateur thespian who regularly had the audience in stitches particularly when performing in the very popular annual Cherhill pantomimes.

Tim was a highly respected professional railway signal engineer and after a long and successful career he retired in 1990. In recognition of his exceptional services to the profession he was appointed an Honorary Fellow of the IRSE in January 1992. He passed away peacefully on Wednesday 8 April 2020 and our sincere condolences are extended to his sons Peter and Colin. He will be remembered as a self-effacing person, with a quiet manner and a ready wit, a loyal friend and colleague.

Ken Burrage
(additional material from Tony Howker and Mike Harding)

Membership changes

Current Membership: 5169

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Fellow

Keiichi Katsuta, Hitachi, Japan

Member

Muhammad Amjid, Volker, UK
Michael McWilliams, Alstom, Australia
Chia-Ming (Paul) Teng, Oriental Consultants Global, Philippines
Fred Toshack, Gannett Fleming Transit & Rail, Canada

Associate Member

Maheswari Chekkapalli, WSP, India
Kapil Kumar Goley, AECOM, India
William Stevens, Transport for London, UK
Clifford Wilson, Northern Ireland Railways, UK

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following level:

EngTech

Donald Phillips, Network Rail , UK
Jonathan Roseveare, SNC-Lavalin Atkins, UK

Resignations: Stuart Doyle.

Past lives

It is with great regret that we have to report that the following members have passed away: Denys Dyson, Paul Hepworth and Christopher Mitchell, Tim Howard and Craig Longley.

Promotions

Member to Fellow

Yat-Sang Simon Chung, Transport for London, UK
John Gardner, Network Rail, UK
Mazli Mustaffa, Sarawak Metro, Malaysia
Shahrizaman Zamhury, Malaysia Rail Link, Malaysia
Bhajaman Singh, Network Rail, UK

Associate Member to Member

Ian Fury, IDFRAILSYS Consultant Services, UK
Yatin Arun Pathak, London Underground, UK
Trevor Stevens, London Underground, UK

Accredited Technician to Member

Mohammad Shahir Iqbal, Docklands Light Railway, UK
Jason Malschuk, Malschuk Rail, UK

Affiliate to Associate Member

Donald Phillips, Network Rail, UK
William Richardson, Amey, UK

New Affiliate Members

Basheer Ahmed, Alstom, Saudi Arabia
Neil Bradbury, Schweizer Electronic, UK
Jamie Brooker, Network Rail, UK
Callan Camp, Alstom, UK
Tsz Hin Wilson Chan, University of Birmingham, UK
Michael Coghlan, Siemens Mobility, UK
Tom Hatfield, Linbrooke Services, UK
Rayko Kostov, Network Rail, UK
Yiu Nam Kwok, Thales, Hong Kong
Nathan Murphy, Omada Rail Systems, Australia
Matthew Otton, Affiliated Computer Services, UK
Sameer Patel, SNC-Lavalin Atkins, UK
Nicolas Soilleux, Omada Rail Systems, Australia

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk
Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk
Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za
David Thurston (N America)
e-mail: thurston@temple.edu
Mukul Verma (Asia)
e-mail: mrverma@gmail.com
Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com
Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com
David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

IRSE News

Institution of Railway Signal Engineers

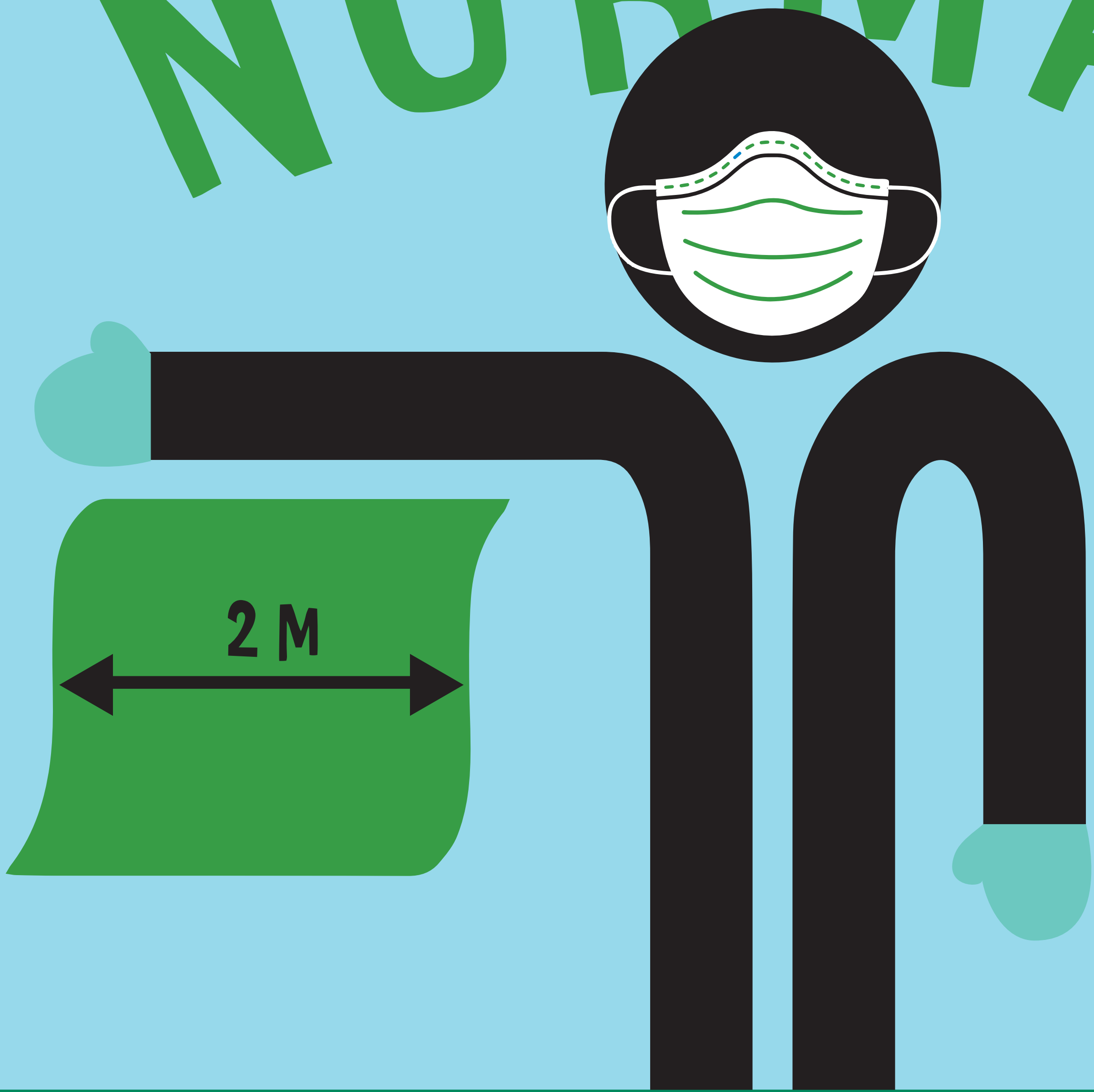
July/August 2020

System safety
techniques at the forefront

Train protection
back to basics

Interoperability
does it matter for CBTC?

THE NEW NORMAL



Signet Solutions continue to follow government guidelines, keeping our staff and clients safe by delivering courses online. We're also now starting to assess how we can get back to our training school. We'll be altering class sizes that complies with social distancing measures, we can also use bigger classrooms if required. We're adapting, maintaining safety and delivering learning in the 'New Normal'. Please look out for re-opening announcements in the near future. From all of us thank you for your support and stay safe!

IRSE ///

Institution of Railway Signal Engineers

Issue 268
July/August 2020

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

Challenge for the future

I am writing this introduction to IRSE News at a time when there is much uncertainty in the world. Only weeks ago our Institution had a stable plan for the next three presidential years, and I was still attending face to face meetings in London, York and elsewhere. The outlook is now very different. However, the different committees that undertake the business of the Institution are inventing new ways of working and innovative ways to serve its members without being able to physically meet. A very successful Younger Members telecommunications day was held by remote conferencing on 4 April, demonstrating how modern technology can be used to provide informative and educational experiences.

In the few weeks since I became senior vice president, and with under a year until my year as president starts, I am heavily involved with the planning of the events that will take place after April 2021. The one thing that will remain unaffected by the world situation is my vision for the IRSE. During my tenure, I want to explore how the railway industry can learn from other industries around the globe. This has been exemplified recently by the pandemic, where businesses that normally have no connection with the health and welfare of people have been making ventilators, protective equipment and other essential equipment to help fight the virus.

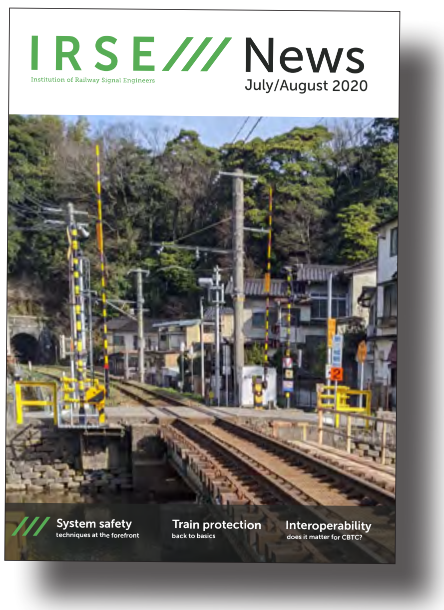
Our industry can also take a lead from this type of innovation. As future railway projects have ever more complex systems, the technology becomes more important to support those systems. Some of that technology exists in other industries and I am sure there are transferable applications available to help provide solutions in the railway environment. Collecting and storing data is now relatively easy but being able to interpret and make use of it is still a challenge, especially when different levels in organisations need different depths of detail. I hope that during my year we can all explore how that can be achieved and how the Institution and its members can help reach this goal.

Ian R Bridges, senior vice president

Cover story

A railway bridge in a 1300-year-old Japanese onsen town: Kinosaki Onsen. An onsen is a Japanese hot spring and Kinosaki is famous for its seven different public hot springs. This bridge is on the Sanin Main Line, operated by the West Japan Railway Company (JR West). In the background is a standard Japanese level crossing, easily identifiable by its yellow and black barriers. There are around 34,000 level crossings in Japan, most have red flashing lights, alarms and barriers to warn of an incoming train. In IRSE News this month on page 30 we report on the Young Rail Tour visit to Japan with 21 young rail professionals.

Photo Keith Upton.



Techniques at the forefront of system safety and their application to railway signalling

Yuji Hirao on behalf of the International Technical Committee

This paper, the first of the 2020-2021 presidential programme was presented 'on-line' on 16 June.

To cope with residual risks caused by the sophistication and the large-scale complexity of future railway signalling systems we need to assimilate potential cutting-edge safety technologies and risk management methods from outside the railway domain with the aim of applying them to railway signalling.

The introduction of electronic interlockings began between the late 1970s and the middle 1980s within the domain of railway signalling. Since then microelectronics has been applied to a wide variety of railway signalling systems, and their sophisticated functionalities realised by microcomputers have indeed contributed to the enhancement of transportation service quality as well as cost reduction, which is concretely accomplished by systems mainly for high-speed and high-density train operations as well as CBTC and ETCS/ERTMS.

It is, however, almost 40 years since the safety technologies and the risk management methods of these railway signalling systems began development, and now there are some important and urgent subjects to be considered for the future railway signalling systems. In particular, although future sophisticated railway signalling systems with their novel functions will become more complex, and although their software safety requirements are crucial, there is a limit to the ability of conventional software development methods based on Fault Tree Analysis (FTA) and Failure Mode and Effects Analysis (FMEA) to guarantee the completeness and correct implementation of the safety requirements. Consequently, the ensuring of the completeness of safety requirements and safety cases to achieve sufficient assurance is difficult. With regard to hardware, multi-core processors which can execute several software applications at the same time, even though that could cause delays by time interference between applications, are currently in the process of introduction in the domain of commercial avionics. To railway signalling systems too, multi-core processors should be advantageous, and their application is therefore to be expected in the railway domain.

Furthermore, Artificial Intelligence (AI) is a key technology which has the capability to attain revolutionary applications, and it is obviously being developed in autonomous road vehicles. In the railway signalling domain too, AI should be discussed with consideration of safety processes and principles sooner rather than later, as this is going to be a distinct feature of future railway signalling systems.

Consequently, to cope with residual risks caused by the sophistication and the large-scale complexity of future railway signalling systems, entirely distinct safety technologies and risk management methods are required in addition to conventional ones. For this purpose, we need to assimilate potential cutting-edge technologies with the aim of applying them to railway signalling. The following cutting-edge techniques in those system safety fields, such as academia and aerospace, where a high level of safety is concerned, are applicable to our domain and can be expected to contribute to its improvement and enhancement.

This paper describes the essence, rather than the details, of safety technologies and management techniques at the forefront from the viewpoint of their application to railway signalling.

GSN for clarifying system safety requirements

In all complex systems, system safety requirements, especially software safety requirements are crucial. There is, however, no mechanism which guarantees the completeness of safety requirements. Among software researchers, to define software safety requirements more clearly, Goal Structuring Notation (GSN) has been widely discussed [1].

GSN is a graphical argumentation notation as shown in Figure 1. In GSN, an argument is defined as a connected series of claims intended to establish an overall claim, and the elements and structure of an argument and the argument's relationship to evidence is explicitly documented. The claims about the system are described as goals in GSN, and the principal purpose of GSN is to show how goals are dissected into their sub-goals and how eventually they are supported by evidence, i.e. they become solutions.

Although FTA, which is widely used as a hazard analysis technique, might appear to be a similar form of graphical notation, the distinct feature of GSN is that, in addition to goals

Figure 1 – Principal elements of GSN.

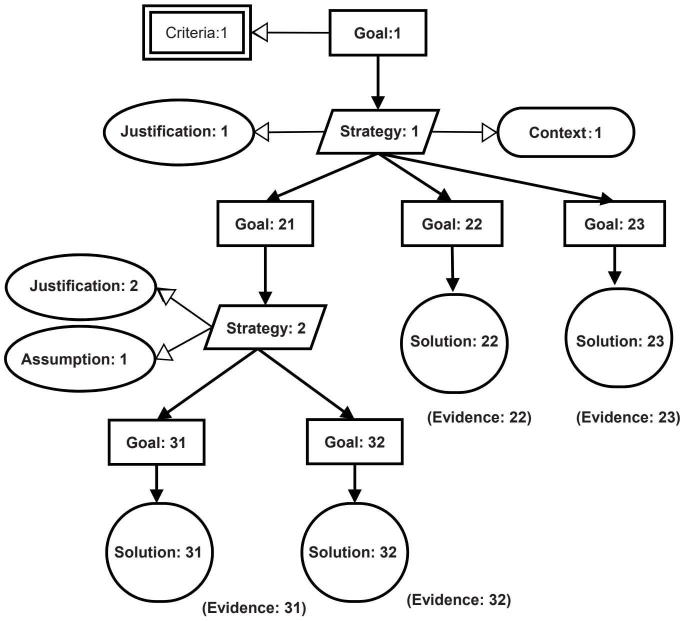
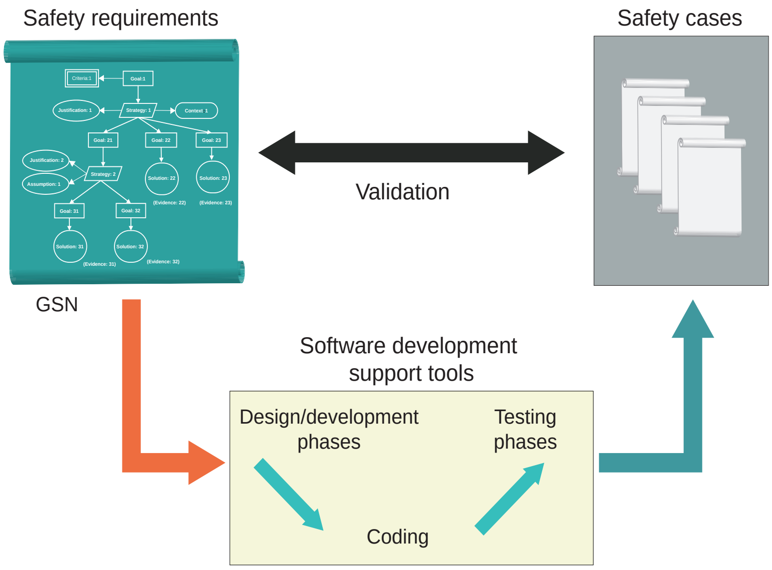


Figure 2 – GSN and safety cases in the software development lifecycle.



and solutions, clear documentation of explanatory elements, i.e. strategies, assumptions, justifications and context are required. This leads to the rationale of GSN: that inappropriate GSN argument development (e.g. logical contradiction or inconsistency) should be potentially avoidable if strict explanatory elements are explicitly documented.

Meanwhile, some powerful software development tools for embedded safety-critical systems are available, and these support software development mainly from the software architecture and design phase to the software/hardware integration phase. In these tools, several model-based software environments are provided by formally-defined bespoke language, and testing and documentation for safety cases is carried out to a certain extent. In particular, in formal methods, it is possible to avoid errors in the software coding process by means of formal proof and subsequent code generation. Indeed, these approaches are valid when the system and its functions targeted in the development are not complex. However, there is no guarantee that there are no errors at the level of requirement specifications, and in the case of complex systems with sophisticated functions, individual functions are interrelated and even if each one is formally defined, it becomes more difficult to clarify the system as a whole. Although, to cope with the deficiency in formal methods at the level of requirement specifications, a new formal approach through tooled validation by proof and animation is recently being adopted aiming at ensuring safety of systems in the railway domain [2], GSN has a wider potential to contribute to the sufficiency of the safety requirements.

As a matter of fact, GSN for the presentation of safety arguments was developed by York University during the 1990s, just after the Piper Alpha Disaster in the North Sea in 1988, which led to the introduction of Offshore Installations (Safety Case) Regulation 1992 in the UK just as the Railway (Safety Case) Regulations 1994 followed the accident at Clapham. The motive for this development is that a key recommendation of the public inquiry into the offshore disaster required the preparation of a safety case and its acceptance. With regard to safety cases, which are defined as “the documented demonstrations that the product complies with the specified safety,” GSN is, as mentioned above, an effective method to deal with these matters because it clarifies how individual requirements are supported by specific claims, and how claims are supported by evidence, which is at the heart of safety cases as shown in Figure 2. Now assurance cases, which extend their scope to a system, service or organisation, are being discussed from the viewpoint of risk, confidence and conformance arguments mainly in the academic domain in UK. A current attempt is modular assurance cases by Structured Assurance Case Metamodel (SACM), which aims at a scalable solution with re-use benefits to future large complex systems, by introducing modularity in assurance.

The advantage of GSN extends to hazard analysis and risk assessment of complex systems, and it is expected that items overlooked by conventional methods can be identified and included, which leads to reviewing/systematizing safety management as well as better technology transmission to younger signal engineers. This also applies to all RAMS lifecycle phase activities, where explicit and logical documentation is required.

The author of reference 3 (Kawakami with some guidance from myself) has applied GSN to safety analysis of chemical plants with complexity, where there is a limit to the ability of conventional safety analyses based on Hazard and Operability Study (HAZOP) [3]. It has been revealed that GSN is advantageous for the identification of hazards as well as of causes of chemical explosions, and it is expected that safety measures against hazards and explosion causes leads to safety enhancement of chemical plants.

STAMP/STPA as a new hazard analysis for complex systems

Systems Theoretic Accident Model and Processes/System-Theoretic Process Analysis (STAMP/STPA) is a hazard analysis technique for complex systems, which was proposed by Nancy Leveson (MIT) in the 2000s on the basis of her experience of accident-cause analyses made by NASA [4].

Whereas conventional hazard analysis techniques, such as FTA and FMECA, focus on the basis of failures of system components and their design errors, STAMP/STPA regards the system as a system-of-systems of which components are mutually connected through safety constraints, and it emphasises that, in addition to system component failures, accidents can also happen by unsafe interactions of components even if none of the individual parts has failed. Unsafe Control Actions (UCAs), which are those inappropriate interactions between components which may lead to accidents, are a specific feature of STAMP/STPA, and we will be able to advance countermeasures against latent complex system hazards by analysing causal factors of UCAs.

STAMP/STPA is carried out through the following steps: (i) Define the purpose of the analysis, (ii) Model the control structure, (iii) Identify UCAs and (iv) Identify loss scenarios. Defining the purpose of the analysis is the first step, and it identifies the losses and hazards to prevent in the system being discussed, and the system boundary. In the next step, it builds a model of the system called a control structure, which consists of controllers and controlled processes, and actions and feedback as their interactions, as shown in Figure 3. The third step is identifying UCAs, and they can be induced by applying the following four guidance phrases on the control structure:

(a) not providing the control action leads to a hazard,

(b) providing the control action leads to a hazard,

(c) providing a potentially safe control action but too early, too late, or in the wrong order,

(d) the control action lasts too long or is stopped too soon.

In the last step, it reveals the causal factors of individual UCAs by utilising the conventional hazard analysis techniques and the domain knowledge. These UCAs and their causal factors are the key to safety measures, as well as to safety requirements,

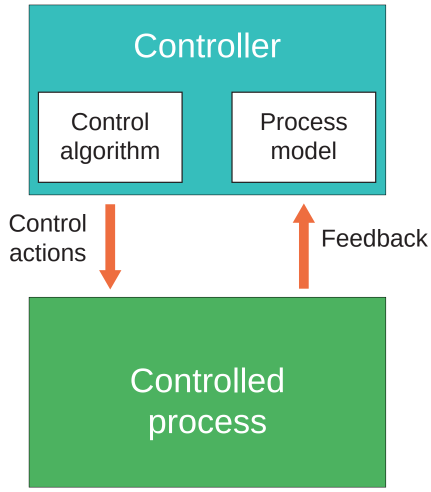


Figure 3 – Control loop of STAMP/STPA.

against the latent hazards of complex systems, which could hardly be found by the conventional hazard analyses. This is, as mentioned above, the specific feature of STAMP/STPA.

In similarity with the case of GSN, there is no guarantee that all hazards of complex systems can be identified by applying STAMP/STPA. However, this technique does provide a new viewpoint of hazard analysis which the conventional techniques have not resolved so far, and it is expected that this viewpoint will contribute to hazard analysis by complementing what conventional techniques could not resolve.

Now STAMP/STPA has accumulated its application results to a wide variety of safety-related systems, which reveals its effectiveness as a hazard analysis method for complex systems. Each year a STAMP Workshop is held at MIT, featuring tutorials and presentations from industry, government and academia.

In Japan for an experimental purpose, its application to hazard analysis of level crossings for single track lines has been carried out, and the result shows that the new hazard analysis technique is effective even if the railway signalling domain knowledge is not necessarily deep [5]. In this level crossing control, the train detection information at the points A and C initiates / terminates the warning by signal and sound, and lowers / raises barriers at the crossing for a train from the left side respectively, as shown in Figure 4. And, as the crossing is bidirectionally controlled, the point B has to be masked for the train from the left side. For the train from the right side, these similarly apply by exchanging points A and B. STAMP/STPA analysis can be applied to the level crossing control by taking steps explained above, and its results are as follows:

(1) Losses and hazards of level crossing: (L1) collisions of trains with pedestrians or vehicles in the crossing are identified as loss, and (H1) the crossing is not closed as a train is approaching the crossing and (H2) the crossing re-opens while a train is passing over the crossing are hazards.

(2) Control structure: taking into account the actual physical and functional structure of the level crossing control, the control structure is built as Figure 5.

(3) UCAs: UCAs can be induced by applying the four guidance phrases (a) to (d) on the control structure. The result is shown in Table 1.

Figure 4 – Level crossing control for single lines. The figure is simplified from the reference.

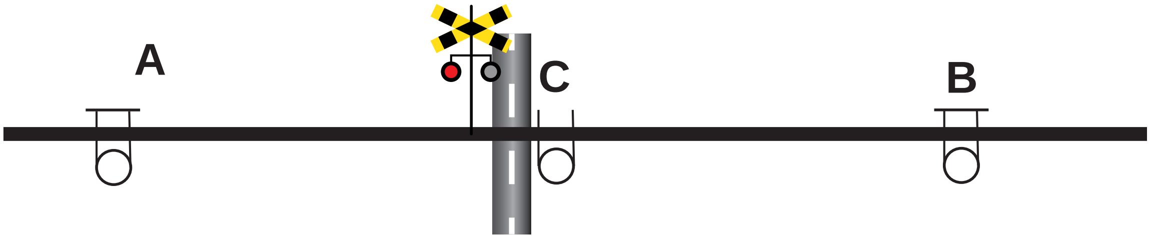


Figure 5 – Control structure of the crossing.

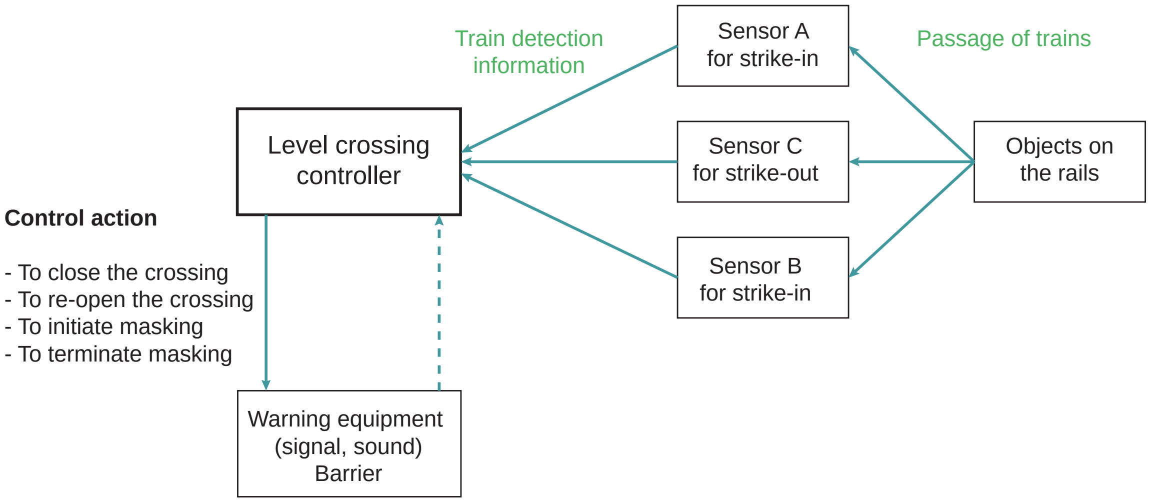


Table 1 – Identification of UCAs of level crossing control for single lines and their hazards.

	Control Action	Not providing	Providing causes hazard	Too early/too late	Stop too soon/ applying too long
1	To close the crossing	(UCA1) Not to close: the train passes over the open crossing	-	(UCA2) To close too late: before the crossing is closed, the train reaches the crossing	-
2	To re-open the crossing	-	(UCA3) To wrongly re-open: while the train is passing over the crossing, the crossing re-opens	(UCA3) To re-open too early: before the train is passing over the crossing, the crossing re-opens	-
3	To initiate masking	-	(UCA4) To wrongly mask: the crossing is not closed when a train is approaching the crossing	(UCA5) To mask too late: if masking is not activated before the train passes at the point B, the train from the opposite direction passes over the opening crossing	(UCA6) To mask too long: if masking continues until the train passes at the point B, the train from the opposite direction passes over the open crossing
4	To terminate masking	(UCA7) Not to terminate masking: the train from the opposite direction passes over the open crossing	-	-	-

(4) Causal factors: the causal factors of individual UCAs are identified, by utilising the conventional hazard analysis techniques and the domain knowledge as well as with the help of additional hint words for elements of control structure. Some of the causal factors are (CF1-UCA1) an opposite direction train movement after reaching the point B, (CF2-UCA1) timing conflict of commands to re-open the crossing and to close by another train, (CF3-UCA1) no information from the point A or B to the crossing controller owing to the sensor failure of the point A or B, and (CF6-UCA3) wrong information from the point C during the train running between the points A (or B) and C.

JR East is now studying a new level crossing control for single secondary lines, aiming at cost reduction by applying radio and Global Navigation Satellite System (GNSS) instead of conventional wayside equipment, i.e. short track circuits for strike-in and strike-out as well as cables connecting level crossings and wayside equipment [6]. This system consists of a control centre, interlocking systems of each station, onboard equipment of each train and level crossings. In this system, level crossings are controlled by departure signal conditions and a timer, which is set to a predetermined value on the basis of maximum train speeds, while conventional level crossing control utilises strike-in and strike-out short track circuits. For constant warning time control, train position information gained by odometers and GNSS, which is obtained onboard and transmitted to the control centre, is used for adjusting the timer value through radio command from the control centre. Although the study is still at preliminary stage hazard analysis, five UCAs and 17 causal factors have been identified by application of STAMP/STPA to the control, and four causal factors out of the 17 cannot be found by FMEA, a conventional analysis method. In Japan, other applications to the systems such as for train protection and interlocking have been studied.

In the railway signalling domain, we can see two kinds of new attempts on STAMP/STPA in the papers presented at ASPECT 2019. One is the paper about the combination of Unified Modelling Language (UML) sequence diagrams and the STAMP/STPA control structure, which is applied to the risk analysis of closer train running at less than the full braking distance [7]. This extended UML is useful for clarifying STMP/STPA control structure by means of information flow. Another is about an optimised causal scenario search method at the next step of identification of UCAs, which is applied to safety assurance of a fully automated train operation [8]. This method provides a systematic approach by eliminating inappropriate scenarios in stages from all possible combination of failure elements whereas analysing causal factors even by experts with domain knowledge is rather complicated.

It is expected that STAMP/STPA will contribute further to the extraction of residual risks in sophisticated and complex signalling systems.

Data safety similar to software development

Whereas there are a lot of safety standard requirements for software development, those requirements for data are generally fewer and non-specific compared with software, though mistakes introduced in both software and data have been factors in serious accidents. In fact, in the railway domain, the data requirements in EN 50128 (software) including EN 50129 (electronic systems) are indeed fewer and less specific, though some requirements are prescribed in the sections covering support tools and development of application data.

In this circumstance, a working group of the Safety-Critical Systems Club (SCSC) has built data safety guidance [9]. One of the motivations behind this guidance is an incident involving a Turkish Airlines Airbus A330 in Nepal in 2015, which touched down with its left main landing gear off the paved surface, and was subsequently written off, because of its inaccurate navigation database, i.e. not properly updated. Including the above incident, 26 cases of incidents and accidents of safety-related systems are described from a data perspective in the guidance.

This guidance aims to reflect the emerging best practice on how data should be managed in a safety-related context. As a data safety management process, the following four phases have been developed: (i) establish context, (ii) identify risks, (iii) analyse risks and (iv) evaluate and treat risks.

In the first phase, organisational and system context as well as intended use are established, and key stakeholders and interfaces are identified. Data artefacts, which are defined as items that provide a useful perspective on data, are also identified, and to support their identification data types such as requirements and interfaces are introduced corresponding to software development phases. In the second phase, risks are identified in the light of reviewing historical data-related incidents / accidents. Furthermore, data properties, which establish what aspects of the data need to be guaranteed for safety, such as integrity, consistency and traceability are introduced for analysing correlations between functions and data errors. Data Safety Assurance Level (DSAL) is, in the third phase, decided by evaluating the consequences and likelihood of each risk identified in the preceding phase. In the fourth phase, recommended data safety risk mitigation techniques are finally decided by combining conditions of elements of data types and data properties, and DSAL, which are described in tables.

The data safety guidance by the SCSC makes its points in phases concretely as described below. Depending on the systems under consideration the level of content may be different and the guidance tailored.

(1) Establish context: this phase involves the context within which the system development occurs, the system requirements and system design. These factors lead to the risk identification, analysis, and evaluation and treatment in the following phases. As data types that provide a useful perspective on data, a total of 25 items are listed, such as requirements, interface, design and development, performance, and justification.

(2) Identify risks: risk identification by some insight gained by reviewing historical accidents and incidents, for which 26 cases are provided from a data perspective, is carried out. To analyse how data can cause problems, 20 data properties are listed, and it is considered what data properties the system functions depend on and where a required data property is not exhibited. Typical data properties are integrity, completeness, continuity, traceability and timeliness.

(3) Analyse risks: this phase involves DSALs, which are an indicator for the level of rigour that an assurance argument required. They are decided on a scale of DSAL0 (lowest-assurance) to DSAL4 (highest-assurance) by the combination of likelihood and severity of risks.

(4) Evaluate and treat risks: the decision is made what action, i.e. treatment should be taken for each of the risks identified in the preceding phase. This involves reviewing each risk, including the associated DSAL, and implementing and verifying treatments as well as considering Organisational Data Risk (ODR) assessment. Treatment methods are tabled through the data lifecycle, and, for each DSAL, tables indicate whether techniques are highly recommended

Technique	Data types	DSAL				Notes	Data property
		1	2	3	4		
Data process definition	VIDPJ	-	R	HR	HR	Documented and agreed process definitions for how data is handled	...T..U..
Data flow diagram	VIDPJ	HR	HR	HR	HR	To describe the data flow in a diagrammatic form	......U..
Data model	VIDPJ	HR	HR	HR	HR	To articulate how data is organised	...N.O...
Client sign-off	VI.PJ	R	R	HR	HR	Agreement from the client that the data is appropriate	....R.V....
Data quality correction mechanisms	..P.	-	R	HR	HR	A process, strategy and tooling for data that breaches a given data quality criteria	IC.Y...

Data types: V: Verification, I: infrastructure, D: Dynamic, P: Performance, J: Justification

Data properties: I: Integrity, C: Completeness, N: Consistency, Y: Continuity, O: Format, T: Traceability; U: Intended Destination/Usage, R: Resolution, V: Verifiability

Table 2 – Example of data design.

(HR), recommended (R) or not recommended (-), as well as their relations to data types and data properties, as shown in Table 2.

With regard to data for signalling systems, some advanced projects have already been discussed. Automated testing of SSI data by SafeCap formal method tool-based approach [10], and data preparation for EULYNX by the RailTopoModel (RTM) [11] are new attempts on the basis of formal and model theories, and meanwhile the ISO 8000 standard has been proposed as a solution for data quality management [12]. Although these all submit solutions to specific issues indeed, the data safety guidance provides a wider perspective on data safety.

For safety systems, data is as important as software since the functions of safety systems are realised by common software by preparing designated data for individual conditions. So far signal engineers observe software safety standards, but data safety deserves greater attention.

Multi-core processors for hardware characteristics enhancement

In the domain of commercial avionics, multi-core processors for software airborne systems are in the process of introduction, though single-core processors are generally used for aviation and defence sectors [13]. In the background, multi-core processors are now common in the private and commercial sector because of their energy efficiency and performance improvement, which will probably result in single-core processors gradually becoming obsolete.

In the case of multi-core processors, a major difficulty in their application to safety-critical systems is the delays that are caused by contention for shared resources (e.g. a single memory controller) between multiple software applications, which are concurrently executed on different cores. This means that multi-core processors could interfere with timing functions and could have an impact on any Worst-Case Execution Times (WCETs), which are vital for completing the execution of their safety-critical functionality.

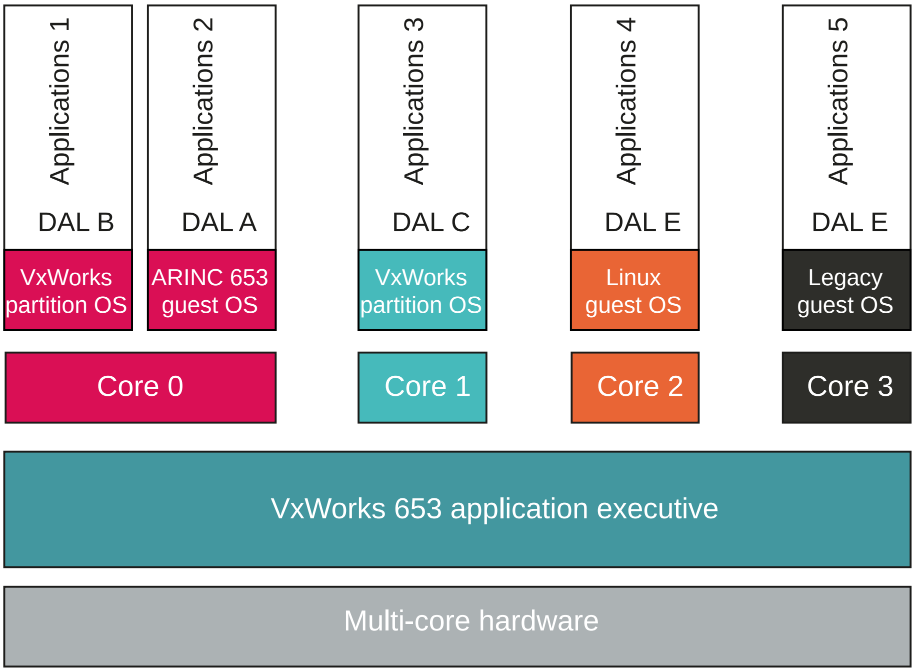
Meanwhile, with regard to single-core processors, Real Time Operating Systems (RTOSs) for multi-tasking avionics applications were developed by decoupling the real time operating system platform from the application software as well as by providing time and space partition for each application software, which enables execution of multiple software with different Development Assurance Levels (DALs), which are software safety levels and correspond to SIL, in compliance with ARINC 653 (Avionics Application Standard Software Interface). Microprocessors have typically two privilege levels, namely User Mode for user application context and Supervisor Mode generally for the operating system kernel, and RTOSs of single-core processors utilise Supervisor Mode with Application/Executive (APEV) interface.

As mentioned, interference caused by conflict for shared components is a main concern for multi-core processing systems in avionics. In addition, multiple Guest Operating System (GOS) support, enabling reuse of previously developed applications as well as third-party OS on the multi-core platform, is a most important requirement to reduce system integration cost. Many modern multi-core processors implement a third privilege level, which is known as Hypervisor Mode and achieves full hardware virtualisation, and this enables an operating system to run containing GOSs and applications. Hypervisor manages the actual physical hardware interactions with GOS. Single platform for multiple applications at different DALs is also important similar to single-core processors. Taking all the above into account, a safety-critical avionics real time operating system multi-core edition architecture has been developed as shown in Figure 6.

The Federal Aviation Authority (FAA) Certification Authorities Software Team published Position Paper CAST-32A guidance for multi-core processors in 2016. The certification of the multi-core processors by CAST-32A and other guides or standards such as DO-178C (Software Considerations in Airborne Systems and Equipment Certification, RTCA inc., December 2011) and DO-254 (Design Assurance Guidance for Airborne Electronic Hardware, 2000) should be at completion.

Certification, or more generally qualification of multi-core processors for application to safety-critical systems is, however, still a challenge. Difficulties in obtaining design details of multi-core processors are aggravated as the complexity of their hardware architecture as well as the software increases, and this leads to implementation and qualification complexity of

Figure 6 – VxWorks 653 multi-core edition architecture [13]. This figure is simplified from the reference.



multi-core processors for safety-critical system applications. For these complexities, a practical implementation and qualification strategy for multi-core processors on a safety-critical system within a UK airborne system is proposed, in terms of recommendations based on development and assessment activities undertaken [14].

Meanwhile, in the USA multi-core processor risk for not 'hard' but 'firm and soft' real-time systems is being discussed [15]. It is explained that most of the Department of Defense (DoD) safety-critical systems are not hard real-time, and even if performance may degrade in firm and soft real-time systems, missing some deadlines can be tolerated and catastrophic consequences can be prevented. It is also pointed out that there are limitations of current approaches to safety analysis of multi-core processors for real-time systems, and their ineffectiveness of cost. As a strategy for broad, safe and beneficial use of multi-core processors, the baseline metric and test of the multi-core processor operational clock speeds are being developed. At the slower speed, more processes of the multi-core processor are queued to execute at any time, and internal buffers, cache and hypervisor, as well as process management, are more stressed. Raw test output includes factors relevant to safety, without the detailed knowledge of multi-core processor internals.

To cope with future sophisticated functions with complex system structures, perhaps we need to reconsider hardware safety systems for railway signalling from a holistic perspective somewhat more urgently, and the progress in the domain of avionics provides a clue.

AI application for safety-related systems

The most widely recognised autonomous systems are perhaps self-driving cars, and AI is seen as being the critical technology for achieving autonomy. Whereas the commercial applications of AI mainly focus on analyses, one of the main concerns with the application of AI to autonomous systems is whether or not safety is ensured, as autonomy systems are, in general, safety-related. Demonstrating the safety of autonomy and AI is not a mature discipline.

Although the AI community recently has shown more interest in AI and safety, the Safety of Autonomous Systems Working Group (SASWG) of the SCSC is perhaps at the forefront of the safety issues of autonomous systems. This working group published a document of good practice for the safety assurance of autonomous systems last year [16]. Focused on the computation-level, it provides a small set of objectives expected to be met in any necessary safety argument for autonomous systems.

Concretely, the computation-level framework consists of six projections, which are (a) adaptation, (b) experience, (c) task, (d) algorithm, (e) software and (f) hardware, and objectives associated with each projection are provided. For instance, for the algorithm projection the following objects are provided together with discussions and examples; (d-1) an appropriate algorithm type should be used, (d-2) typical errors should be identified and shown to be protected against, (d-3) the algorithm's behaviour should be explainable and (d-4) the algorithm should support post-incident analysis.

The main concern about AI and safety issues is the result of the transparency problem in machine learning (ML). The problem with self-learning systems based on deep neural networks is that without special measures we will not know what the machine has learnt and why it makes certain decisions, and the machine may make an incorrect decision leading to an accident. Although in order to overcome or mitigate this problem, it is necessary to build transparency features into their designs, which is also discussed at the above-mentioned algorithm projection, it has not yet been possible to find evidence of such techniques being effective. As an advanced attempt, the IEEE has set up a "Global Initiative on the Ethics of Autonomous and Intelligent Systems". This is drafting a set of standards (the P7000 series), one of which (P7001) addresses the Transparency of Autonomous Systems, and the IRSE International Technical Committee (ITC) has a member in the drafting group. Their results are certainly expected to contribute to greater transparency. An alternative approach, which fulfils accumulation of data and system validation by means of trial and error on the premise of the transparency problem, is perhaps not practical in the railway signalling domain.

Furthermore, several challenges confront the application of AI to safety-related systems [17]: the sufficiency of safety requirements, the definition of exceptional circumstances, and verification, as well as the supporting evidence. The steadily advancing front line of developments in these areas needs to be appropriately noted in the railway signalling domain.

Security for complex safety-related systems

Security is a new issue, and integrated safety and security assurance for complex systems is an enormous challenge. With regard to analysis methods for this, STAMP/STPA is also applicable, by extending its safety processes to security considerations. Meanwhile a Safety-Security Assurance Framework (SSAF) is now being developed as a meta-model for safety and security assurance based on SACM, which certainly appears to be promising [18].

Conclusion

As discussed above, to cope with residual risks caused by the sophistication and the large-scale complexity of future railway signalling systems, we need to find ways to assimilate potential cutting-edge technologies, in addition to conventional ones, with the aim of applying them to railway signalling.

References

[1] Goal Structuring Notation Community Standard Ver 2, The Assurance Case Working Group (ACWG), Safety-Critical Systems Club, 2018. irse.info/i973u.

[2] Maarten Bartholomeus, Bas Luttik, Tim Willemse, Dominik Hansen, Michel Leuschel, Paul Hendriks, The use of formal methods in specification and demonstration of ERTMS Hybrid Level 3, IRSE News, Issue 260, 14-17, 2019.

[3] Tomoo Kawakami, Safety analysis of chemical plants applying GSN, IEICE Technical Report, Vol 199, No 182, SSS2019-12, 1-6, 2019 (In Japanese).

[4] Nancy G Leveson, John P Thomas, STPA Handbook, 2018. irse.info/ftujw.

[5] Information-technology Promotion Agency (IPA), Introduction to STAMP/STPA, 2016 (In Japanese).

[6] Takashi Kawano, Application of STAMP/STPA in Safety Analysis of Railway Signalling System, The Journal of Reliability Engineering Association of Japan, Vol 41, No 2, 1-7, 2019 (In Japanese).

[7] Hongsin Kim, Felix Schmid, Phillip Dakin, Shuxia Lu, Closer Running Magic Potion or Deadly Poison?, ASPECT 2019, 2019.

[8] Fei Yan, Chunhai Gao, Ru Niu, Tao Tang, Train Control Uncertainty Treatment and Safety Assurance Shifting from Manual Driving to Fully Automation, ASPECT 2019, 2019.

[9] Data Safety Guidance Version 3.0, The Data Safety Initiative Working Group (DSIWG), Safety-Critical Systems Club, 2018.

[10] Formal Verification of Signalling Programs with SafeCap, Proceedings of SAFECOMP 2018, 91-106, 2018.

[11] Bob Janssen, How the EULYNX Data Pre standard can improve railway robustness, ASPECT 2019, 2019.

[12] Tim King, Davin Crowley-Sweet, Data quality management systems Network Rail, IRSE News, Issue 220, 2-8, 2016.

[13] David Radack, Harold G Tiedeman Jr, Paul J Parkinson, Civil Certification of Multi-core Processing Systems in Commercial Avionics, Proceedings of the 27th Safety-Critical Systems Symposium, 295-308, 2019.

[14] Mark Hadley, Mike Standish, A Practical Assurance Approach for Multi-Cores (MCs) Within Safety-Critical Software Applications, Proceedings of the 28th Safety-Critical Systems Symposium, 167-184, 2020.

[15] Gary Warren, Stuart Whitford, Robert Alex, Addressing Multicore Risk for Firm and Soft Real-time Safety Critical Systems, 37th International System Safety Conference, 2019.

[16] Safety Assurance Objectives for Autonomous Systems, The Safety of Autonomous Systems Working Group (SASWG), Safety-Critical Systems Club, 2019.

[17] James McCloskey, Chris Allsopp, David Smith, Elizabeth Lennon, Towards a Safety Argument for Autonomous System that Use Machine Learning, Proceedings of the 28th Safety-Critical Systems Symposium, 329-353, 2020.

[18] Nikita Johnson, Tim Kelly, An Assurance Framework for Independent Co-assurance of Safety and Security, Journal of System Safety, Vol 54, No 3, 32-38, 2018.

About the author ...

As professor and dean of the Graduate School of Management of Technology, Nagaoka University of Technology in Japan from 2007 to 2018, and now as professor emeritus, Dr Yuji Hirao has been deeply concerned in education and research of functional safety. Yuji started his career at Japanese National Railways and moved to the Railway Technical Research Institute in 1976 where he was engaged in research and development of railway signalling systems for the MAGLEV (magnetically levitated transportation system) and for conventional railways.

In 1998 he was appointed as laboratory head of train control with responsibility for safety assessment of railway signalling systems and the development of radio-based train control systems, and afterwards in 2003 director of the Railway Signalling and Communications Research Division at the Institute.

Yuji has been a member of the IRSE for over 30 years, being proactive in advancing its activities, for instance, as a member of the Council for four years and a member of the International Technical Committee for over twenty years. He is chair of the Japanese section of the IRSE.

Back to basics: train protection

David Fenner

This, the fifth article on 'back to basics' themes, covers the subject of train protection. The fundamental requirement of a railway signalling system is to ensure a train movement can be completed with the minimum of risk from human error, while at the same time allowing as many trains as possible to run on a given infrastructure. Much of the focus of a signalling engineer is on the design of the infrastructure control system that ensures safe routing of the trains and supports the person responsible for that activity, the signaller. But the other key operative is the driver.

The history of railway signalling is very often about the development of systems to prevent the wrong signal being given to a driver and the evolution of the technology that underpins that function. Relatively little relates to supporting the driver, although it would be wrong to assume there is none. It is worth considering the different roles to see if there is any underlying reason for this. The signaller is dealing with a fixed set of equipment that has a limited range of states and thus a limited set of options. The requirement is to set specific routes at given times to permit the safe passage of a train, and to be reminded which of those actions have yet to be completed. The driver on the other hand is constantly making judgments about the safe movement of the train based on information from their own route and train performance knowledge, signs at the trackside and the signals seen. And in the case of signals seen these can and often will be changing minute by minute as other traffic moves. So the computational task of assisting a driver is significantly more sophisticated than that required to support a signaller. Maybe this is why train protection systems seem to have evolved more slowly, with the sophistication of train protection requiring computing power akin to a processor not a logic box.

> "The driver is constantly making judgements about the safe movement of their train"

Supporting the driver starts with providing clear and concise signal indications so there is no confusion in the meaning and limited opportunity to read the wrong one. One can wonder how drivers could see a dim oil lamp flickering behind a coloured lens as they approached many of the mechanical signals still in service, at least in the UK until as little as 15 years ago. Many years ago, drivers had the advantage of a dark sky with the general absence of town and street lighting. Now of course most signals are colour lamps but often against a much brighter background. The problem is how do we help the driver respond to those signals and what other support do we need to give them to limit the number of accidents. There are two main errors a driver can make:

- Failure to control the speed of the train correctly.
- Failure to stop at the defined End of Authority (EoA).

It is these functions a train protection system must address.

The remainder of this article will start by examining the various types of train protection and how those may affect the performance of the railway. It will then provide a generalised review of the development of systems to outline the key requirements with examples of systems from the UK and other countries.

Warning or protection

Within the overall scope of train protection there are two main sub divisions, warning systems and protection systems. A warning system will normally be associated with the location at which braking should commence whereas a protection system will aim to stop the train at or soon after the End of Authority (EoA). A warning system will alert the driver to take note of information presented from the trackside and may initiate

Supporting the driver by relaying accurate information in the cab and reducing the possibility of mistakes being made has been a long running focus of the command, control and signalling industry. The view may have improved from the steam era to the modern day (as shown above) but increased speed and traffic complicates the situation.
Photos Westinghouse B&S Archive/ Chippenham Museum and Shutterstock/aapsky.

"Train stops reduce capacity because extended overrun distance increases the headway between trains"

braking action if the driver fails to acknowledge the warning. After acknowledgement the train is usually solely under driver control. A protection system will enforce a brake application should the system detect the train is being driven outside safe parameters. There are several sub-divisions of protection systems. It should be noted there is overlap between some of these classifications.

Train stops

Probably the most basic but effective form of train protection, train stops are typically mechanical devices that trigger a brake application if passed when in the 'protecting' position. They are usually associated with a stop signal. A train stop will ensure the train comes to a halt at braking distance beyond. To be effective in eliminating accidents they require an extended protected length of track beyond the signal, which limits application to lines with relatively low top speeds (around 80km/h) and good brake performance – typically metros. There are two fundamental weaknesses with such systems; firstly, they reduce capacity because the extended overrun distance increases the headway between trains, and secondly, they do not address the issue of overspeed at other locations. There have been applications where timed release of train stops is used to monitor speed, especially approaching buffer stops or high-risk junctions, but they are difficult to implement successfully.

Intermittent train protection

Intermittent train protection is provided at those locations assessed to pose significant risk. These are usually junctions with substantial traffic or a particular layout that creates additional risk, for example where there is a chance of head-on collision. As a train approaches such sites it passes through a speed trap and if above a pre-set speed will experience a forced brake application.

In more recent systems it will be fed information about the current conditions and then calculates the safe speed profile to be followed.

Modern systems of this type usually require the fitment of an Automatic Train Protection (ATP) system to the trains but avoid expensive investment in a comprehensive trackside ATP installation. Many of the systems introduced prior to the turn of the century (2000) can be considered to be of this form.

Train protection with intermittent update

These systems continuously monitor the movement of the train to ensure it is within the safe envelope. The driver is provided with an indication of the current maximum safe speed but otherwise drives to the signals and signs observed at the trackside. The train picks up information about the infrastructure ahead including the traffic conditions at intermittent intervals, usually from a balise or beacon or from inductive loops laid in the track. The intermittent intervals are usually associated with a signal, to facilitate the inclusion of information about the extent of any current movement authority and any speed limits associated with that authority.

These systems provide full supervision of the driver at all times and will intervene to reduce the train speed back within the safe envelope prior to returning control to the driver. The exception to this is in the event of a Signal Passed at Danger (SPAD) when a 'trip' state is entered and the train is brought to a halt. The systems normally include roll back protection, a function of most ATP systems, to prevent the train rolling away when brakes are released but traction power is not applied.

Because the system only receives intermittent updates, the system may restrict track capacity because the train must be driven according to the last update received and may thus continue to enforce a reducing speed even though the signal ahead has changed to a less restrictive aspect. A means of partially overcoming this constraint is to have 'infill' in the form of loops or additional balises which augment the update frequency, especially approaching critical signals.

One advantage of such ATP systems is, because the train is being driven on conventional signals, the system can be overlaid on the railway to enhance safety. It is thus possible to partially equip either or both track and trains with only selected portions of the route and chosen trains being protected. One disadvantage with this is that an unfitted train which SPADS, may encroach on the path of a fitted train, resulting in a serious accident. Thus, this arrangement would ideally only be used as a migratory configuration.

Train protection with continuous update

These systems have the facility to provide updated movement authority information at any time. Consequently, they are often part of an in-cab signalling system because the driver is continually fed information on the current safe speed and is no longer required to watch for lineside signals or signs. There may be other reasons, outside the scope of the signalling system, for the driver to watch the passing trackside and one of the challenges is to ensure the right balance is struck between watching the displays in the cab and watching the line.

Another challenge with these systems is that the driver is given advice on the safe speed profile based on the train parameters encoded in the system. If these parameters are wrong the driver may be advised to brake later in the journey than is desirable, with the risk of passing the End of Authority (EoA) – the equivalent of a SPAD. This is of particular concern for variable formation trains, especially locomotive-hauled freight trains, but is also relevant at times when adhesion is poor.

“If these parameters are wrong the driver may be advised to brake later than is desirable”

The major advantage of such systems is the ability to enhance the capacity of the infrastructure. Because the train and infrastructure are in regular contact, and with a safe speed display in the cab, the limitations of fixed lineside signalling with a limited number of aspects can be removed. Thus, a fixed block railway is no longer limited to say four or five aspect signals, meaning closer running is possible and, more importantly, release of trains held at a converging junction can happen significantly earlier with very short block sections. This form of protection is a corner stone of moving block systems and the heart of Communication Based Train Control (CBTC). Metro railways have been able to gain significant uplift in service frequency as a result of such application, for example the Victoria line in London increased from around 30 to 36 trains per hour in the peak as a result of implementing CBTC. Continuous update train protection thus offers enhanced performance and options for reduced trackside equipment as well as improved safety, making the business justification measurably easier.

The advantages of in cab signalling and increased capacity by removal of lineside signals usually means either all trains must be fitted with a suitable system or the configuration of existing signals needs to be amended to allow changes in operational rules. This poses a significant cost hurdle before such benefits can be gained.

Warning systems

Warning systems are usually designed and positioned to alert the driver to the presence of a signal or sign at the trackside. The Automatic Warning System (AWS) in the UK and used elsewhere is a typical example. If a distant signal is approached with a clear indication the driver receives a bell (or gong) sound and is free to continue. Should the signal be at caution the sound is a buzzer (or horn) and the driver must acknowledge this both to turn off the sound and prevent a brake application. After acknowledgement the driver is responsible for the continued motion of the train. These basic functions are almost identical to the French “Crocodile” system.

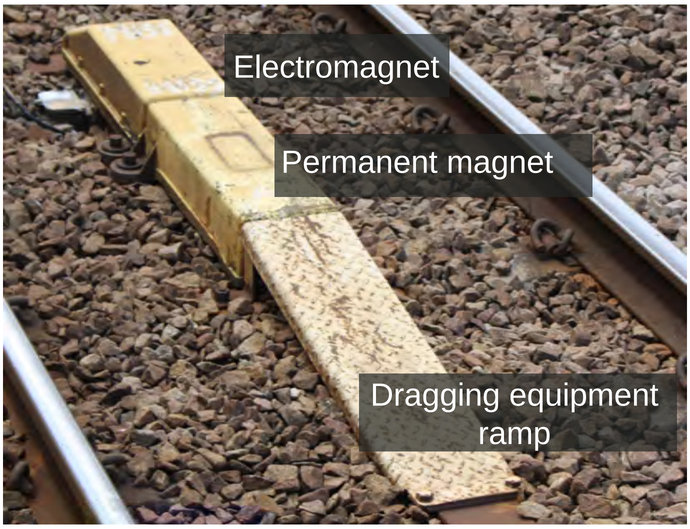
It is interesting to note how the technology of this system has changed. The basic system was developed by the Great Western Railway, trialled in 1906 and implemented shortly afterwards across their network. Initially the communication between track and train was a ramp in the track with an electrical feed to indicate clear and no electrical charge when at caution. This follows the “fail safe” principle because the absence of electricity could arise in several failure situations whereas the mechanical lifting of the contact shoe would fail much less often. The problem with a mechanical contact system is wear and tear especially as speed and frequency of use increases as was inevitable when Multiple Aspect Signalling (MAS) became common. The form of AWS implemented by British Railways from the 1950s uses magnetic induction to convey the signal status to the train. During the 1950s when the system was being installed, semiconductor devices were new so the equipment on the train used relays. Today the logic is performed by a PLC and the magnetic field detected by a Hall Effect sensor.

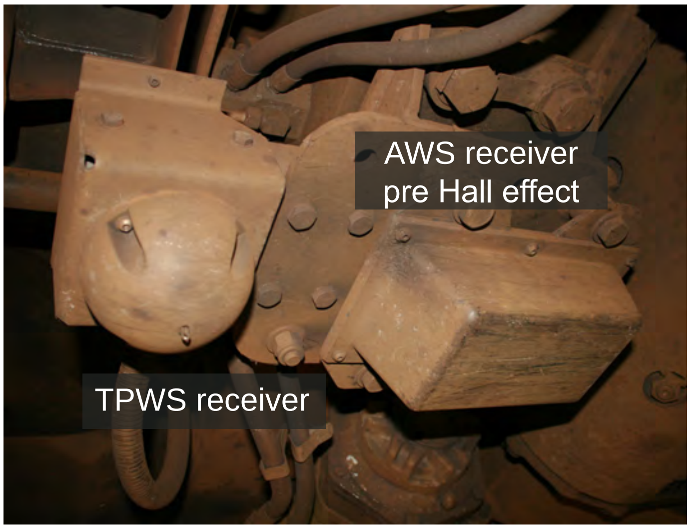
AWS uses a permanent magnet centrally located between the rails to initiate the onboard system and provide the driver with a warning if the signal is at caution or stop. An electromagnet is positioned immediately afterwards where a signal may show a line clear aspect. This second magnet is energised when the signal is clear (green) and effectively cancels the warning, instead sounding a bell in the cab (see Figure 1). The French “Crocodile” system conveys the two messages from the infrastructure to the train by different voltages applied to the “Crocodile” ramp collected by a wire brush on the driving vehicle mechanically contacting the ramp.

To ensure the two successive magnets are detected at low speed the system delays output to the driver for approximately one second after passing the permanent magnet. This provides time for a slowly moving train to detect the electromagnet prior to initiating the warning sequence. It then gives the driver around three seconds to acknowledge a warning and observe the signal. If no acknowledgement is received the brakes will be applied. On passing the signal displaying the caution aspect the train should stop at or before the associated stop signal. Thus the AWS trackside installation is placed around 4 seconds before the signal, which is normally interpreted as about 180m.

A key technical challenge for AWS arose with its application to third rail electrified infrastructure.

The “Crocodile” system conveys two messages to the train by different voltages fed to the ramp. The right hand photo shows Eurobalises, TBL antenna and Crocodile together in a Belgian application.
Photos Wikimedia CC-BY-SA Charlotte Noblet (left) and François Melchior.





AWS. Left trackside magnets, right, train-carried equipment.
Photos David Fenner.

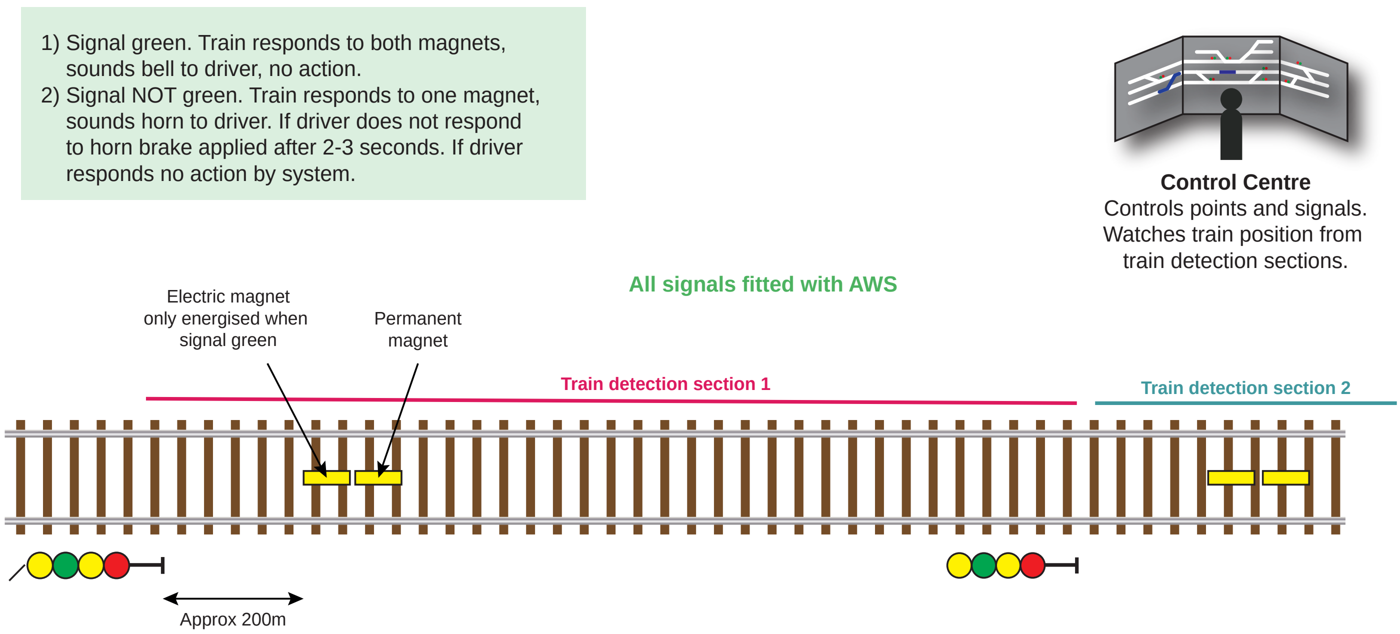


Figure 1 – AWS application Trains with AWS or full TPWS can share the line.

"Another challenge is the increasing use of bi-directional signalling"

"Train stops are still a mitigation measure rather than a control system"

Where high current DC traction systems are used there is a risk of cross track cables creating 'stray' magnet fields. In this case the AWS detectors on the trains were desensitised and extra strength magnets provided for the trackside AWS functions to minimise the risk of false AWS information from the stray fields.

Another challenge is the increasing use of bi-directional signalling. With the magnets in the centre of the track, trains in either direction will detect the fields. Thus, trains passing over an installation intended for the opposite direction of movement will experience a warning since the permanent magnet will be the last item passed. On tracks where this is an infrequent occurrence a sign may be installed to remind the driver this warning does not apply to them. In locations where such movement is more frequent or would result in the need to regularly acknowledge irrelevant AWS warnings, the permanent magnet is surrounded by an electromagnet coil which suppresses the permanent magnetic field when a reverse direction movement is signalled. Thus, outputs are required from the interlocking system not just to indicate when the signal is showing a green aspect but also when a reverse direction route is set. Occasionally the signalling arrangement may enable one AWS installation to be used for two signals reading in opposite directions. In this case the permanent magnet will have two electromagnets one either end associated with the relevant signal.

Multiple aspect signalling has resulted in most signals being equipped with AWS meaning the need for driver acknowledgement can become a semi-automatic reaction, especially when operating a congested railway on restrictive aspects. Indeed, this caused the Southern Region of British Rail to experiment with a more sophisticated form of Signal Repeating AWS (SRAWS) during the early 1970's but in the end this was not adopted. The problem of instinctive response is exacerbated by the application of the system to severe permanent and all temporary speed restrictions. These requirements arose after accidents caused by excess speed. The need to continue to reduce the harm caused by accidents together with these human factor weaknesses subsequently resulted in the development of the Train Protection Warning System (TPWS).

A feature of AWS and many similar systems is they give the driver one of two indications at every signal. Thus, any failure of the train borne equipment is quickly revealed to the driver and can be managed through appropriate procedures. In the case of AWS, the use of a permanent magnet ensures that a complete failure of the trackside installation is very remote and similarly the driver will note a wrong indication. It should be understood, AWS is not a fail-safe system with a high SIL rating. It is therefore important that faults are reported promptly and suitable measures taken to operate safely after discovery.

Basic protection systems

The earliest protection systems were train stops placed on the track at the location of a stop signal, as previously described. When the signal is showing a stop aspect an arm is raised typically 50-60mm above rail height. This engages with a trip cock on the train which opens a vent on the brake pipe forcing a brake application. The train will be passing the signal at danger before the brakes are applied in which context this is a SPAD mitigation measure rather than prevention. When the signal is clear the trip arm is lowered below rail level. Train stops were normally provided on metros operating in tunnels because of the significant risk of a collision in such locations. Extension to other locations has followed. To gain full protection requires a long enough overrun to bring the train to a halt from the maximum attainable speed prior to the brake application. For metros this is usually an associated design constraint limiting capacity and creating some operating constraints such as restricting speed through closed stations when the overlap at the next signal is based on the maximum attainable speed from a standing start. For main line railways the concept is often not practicable due to higher speeds and extended braking distances.

"Classic" trainstops on the Berlin S-Bahn, photo taken in 2007.
Photo Kabi/Wikimedia.

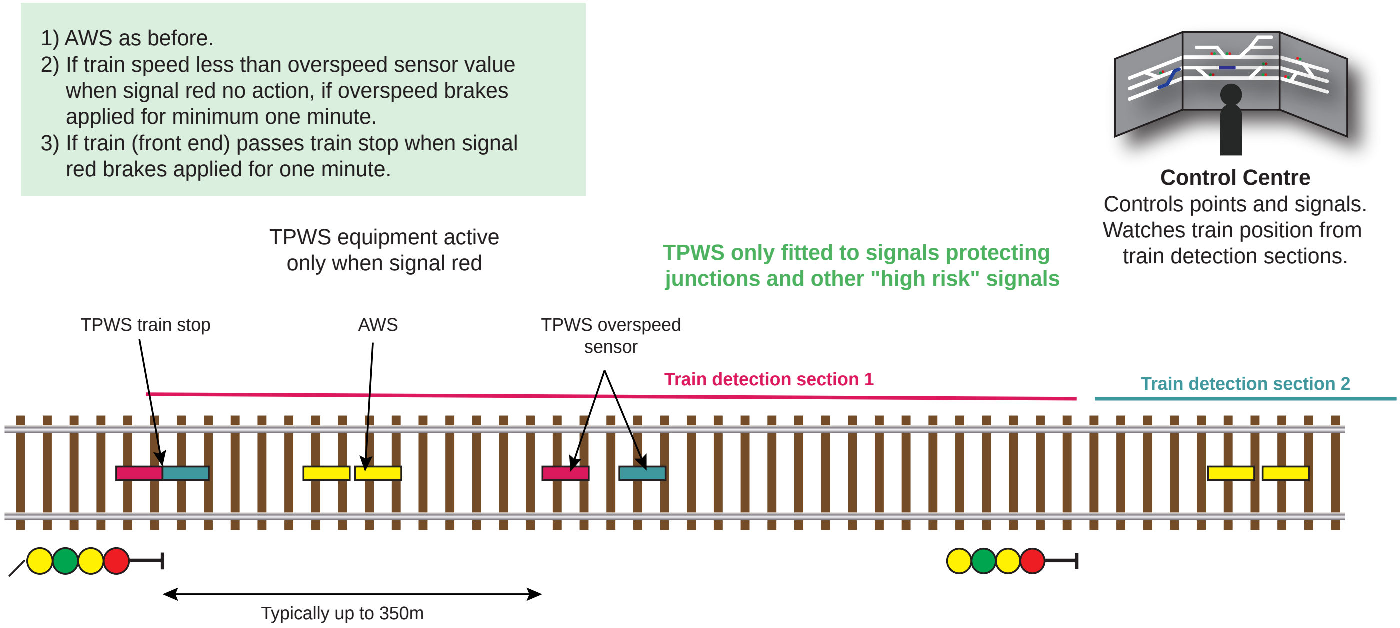


Figure 2 – Typical TPWS installation.

"TPWS is only provided at locations that are deemed high-risk"

Train stops have moved on significantly from this technology, but they are still a mitigation measure rather than a control system. An early advance on mechanical contact train stop systems was "Indusi", first installed in Germany and surrounding countries in the 1930s and revived in the 1950s. Several enhancements have subsequently occurred leading to the system known as PZB90. Three tones are generated on the driving vehicle and interact with passive tuned coils mounted as required trackside. The tuned coils cause the relevant frequency on the motive unit to resonate resulting in an impedance change and thus activating the required action. The 2000Hz tone is a train stop forcing a brake application and is will typically resonate on passing a red signal. The 1000Hz tone is typically associated with a caution signal and requires a driver acknowledgement followed by a speed reduction within a set time whilst a 500Hz tone requires a lower maximum speed and is often placed shortly before a red signal.

Indusi tuned coils are installed on the sleeper ends so they are naturally only detected by a vehicle travelling in one direction and do not need suppression for opposite-direction movements. TPWS in the UK has related functionality in that tones, in this case six of them around 65kHz, are transmitted by track mounted loops this time centrally mounted in the track. Three frequencies, two arming and one trigger, are used for the normal direction of movement and the other three for trains in the opposite direction on bi-directional track. These provide the functions of a 'speed trap' for a train travelling faster than deemed safe and a train stop (Figure 2). Should either the speed trap or train stop function be activated a full brake application is initiated and maintained for one minute, bringing the train to a stand. The location at which the train stops is a function of the train brake performance and the initial speed prior to the brake application. There is no certainty this will be in a safe location.

TPWS is considered to have a high probability of stopping a passenger train within the overlap provided the approach speed is not greater than 75mph (120km/h) and adhesion can deliver the braking effort of the train. Where approach speeds are greater than 75mph and risk is assessed to be high additional overspeed loops may be provided earlier on approach to the signal (Figure 3 overleaf). The system substantially mitigates the risk with a SPAD but does not eliminate it.

The speed trap function of TPWS is determined jointly by the train and the infrastructure. The train has a preset on board timer. At the trackside the arming and trigger loops are separated by a predetermined distance corresponding to a defined speed based on the standard timer setting. Current implementations assume two standard timer settings, one for passenger trains and a longer setting for freight trains. Thus, the speed trap will activate if a train passes above a predefined speed based on its 'type'. This gives rise to not infrequent cases where a marginal overspeed results in a heavy brake application that was probably 'unnecessary' in terms of the train being able to stop where required. This can cause drivers to dislike the system which is a concern as it may lead to misuse.

TPWS is an intermittent train protection system because it is only provided at locations that are deemed high-risk. Those are defined as signals protecting a convergent junction and selected other signals (where the SPAD risk is assessed as high), buffer stops and severe speed reductions where the approach speed is or exceeds 60mph (approximately 100km/h).

The TPWS system is active to stop a train so a key requirement is confirming the trackside equipment is functioning when required. This is done by monitoring the current fed to the transmitting loops. Should this fall outside the intended parameters an indication is given to the supervising signaller and the signal in rear held

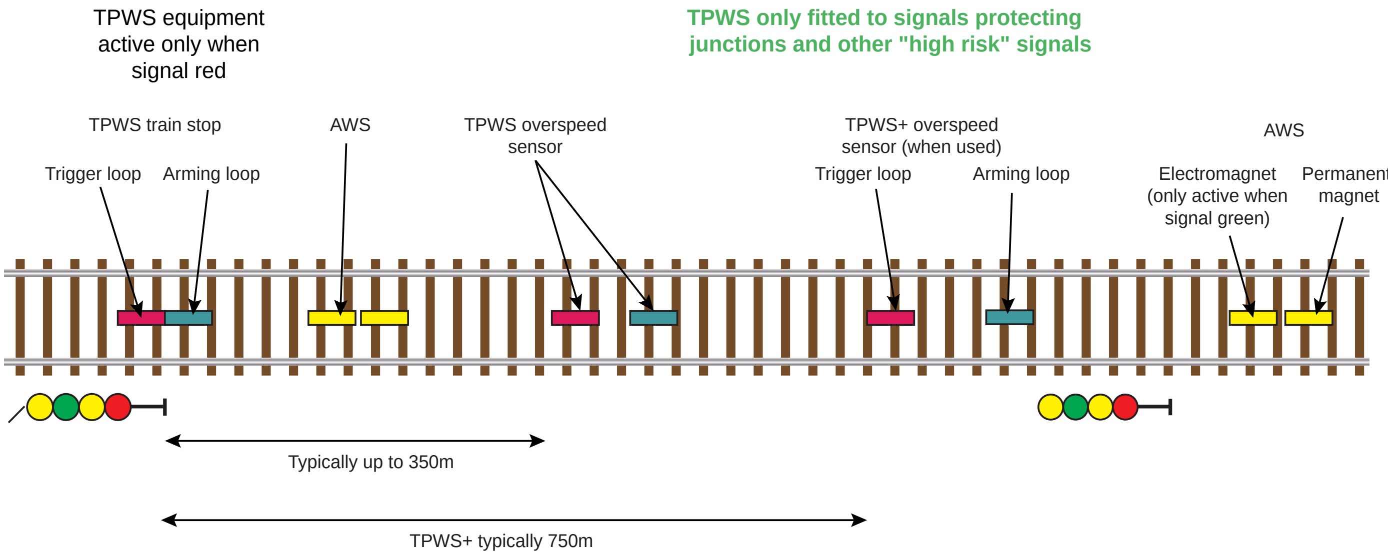


Figure 3 – Typical TPWS installation including AWS.

at danger. Similarly, the on-board equipment is self-diagnostic to confirm it is functional at the start of a journey and in some cases intermittently thereafter. As with AWS this system was not designed in accordance with SIL 4 requirements, so safety needs to be controlled by suitable procedures in the event of a fault.

Neither PZB90 nor TPWS can prevent all accidents as they are intermittent systems. Both systems are provided with facilities to allow the driver to reset the system after a brake intervention and continue with the journey. Such reset is required to be conducted under controlled circumstances involving communication with the signaller or a controller. In both cases there is evidence of drivers sometimes resetting without following the correct procedure, with the potential for a serious accident.

Full ATP systems with intermittent update

"Full ATP systems continuously monitor the movement of the train"

Full ATP systems continuously monitor the movement of the train and intervene with a brake application should the speed go outside the safe envelope. An indication of a suitable speed is given to the driver, this speed usually having a small margin beneath the safe speed envelope. These systems are normally designed in accordance with SIL 4 requirements.

To enable the train to continuously calculate and monitor the safe speed profile information is needed about several parameters:

- Infrastructure profile.
- Distance to the end of the movement authority (i.e. stop signal) (EoA).
- Current speed of the train.
- Distance travelled.
- Braking performance of the train.
- Maximum train speed.

The infrastructure profile must reflect the permitted speed, including any temporary speed limits, covering at least the distance within the current movement authority. This includes speed limits over junctions which may vary depending on the route allocated. It also needs to include the gradient profile over the same distance as changes to gradient can have a significant effect on stopping distance.

The location of the EoA either needs to be known or at least it is beyond the range that currently needs to be considered (e.g. when driving on green signals or the equivalent). To calculate the ongoing speed profile, it is obviously necessary to know the current speed and how far the train has travelled to enable the remaining distance to any speed change to be determined.

The braking performance of the train is a key parameter in performing the safe speed envelope calculation.

The data about the infrastructure including route set and signal status is usually fed to the train intermittently as data telegrams by balises or beacons, most of which will be associated with a signal (Figure 4). Some systems use inductive loops laid in the track to pass the relevant telegrams. Infill may be provided where the intermittent transmission of data has a significant impact on operational capability.

The need to know speed and distance travelled results in some fairly complex configurations of equipment on board the train. The wheel to rail interface is notoriously challenging with relatively low adhesion. This makes simple odometry inadequate for the purposes of ATP especially as the objective is a system with high safety integrity. Slip (during acceleration) and slide (during braking) are relatively likely, both creating erroneous information if reliance is placed on wheel rotation. Some systems use an unpowered and under braked (or unbraked) axle as the sensor input.

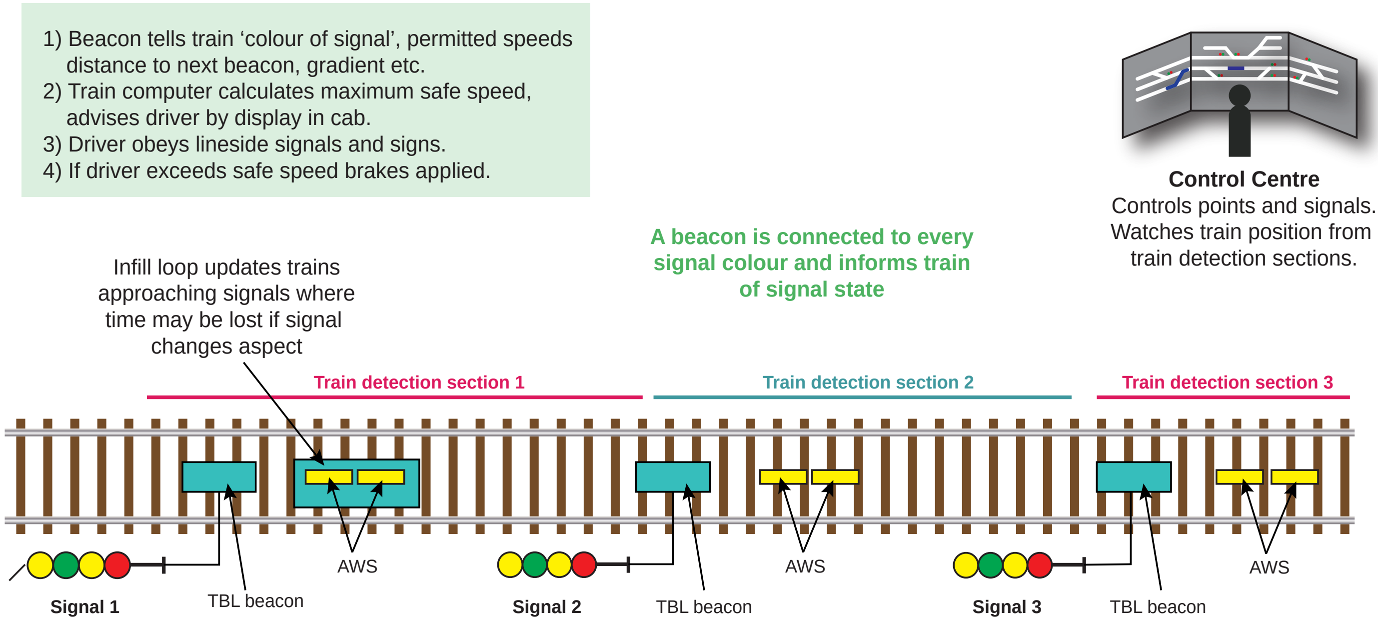


Figure 4 – ATP with intermittent update (as used by Network Rail between London and Bristol).

"Odometry for ATP is often a mix of systems to counteract the weakness of any one of them"

Another risk with wheel rotation is the slow but steady change in size as the wheel wears. Doppler radar is sometimes used, but is not without challenges especially in damp or snowy conditions and of course like wheel rotation it is subject to a steady build-up of position error unless corrected. Use of a Global Navigation Satellite System (GNSS) offers another means. However, it rarely covers all conditions, examples being tunnels and urban or other 'canyons' where lost or reflected signals can affect the calculated position. Thus, odometry for ATP is often a mix of systems to counteract the weakness of any one of them and to support the determination of the margin of error on the actual estimated position which will tend to increase over time and distance travelled. Balises or beacons on the infrastructure are frequently used as a reference point to correct accumulated error. Not surprisingly odometry problems are potentially the biggest cause of train equipment failure for some ATP systems.

A further result of the challenge with odometry is the need for a "release" speed with many ATP systems. Because the train cannot know exactly where it is the ATP system will assume worst case error and therefore bring the train to a halt a short distance prior to the current EoA. This is a significant problem if the next update function is located close to the EoA and in the case of the EoA being at the end of a station platform when, for station purposes, it is important to get close to the platform end. To counteract these challenges, it is normal for the ATP system to return full control to the driver on final approach to the EoA provided the train is then operated below a low "release" speed. This of course means there needs to be a short safe overrun beyond the EoA should the train pass beyond the EoA, when a "trip" state will be entered to bring the train to a stand.

Braking capability is the final parameter the system needs. This is generally relatively simple for fixed formation multiple unit trains, although a given axle may under-perform due to a maintenance issue. It is a far more complex challenge for variable formation locomotive hauled trains, especially freight trains. The usual arrangement is to request the driver to enter or select brake data as part of train preparation. One challenge in defining the brake performance is whether the system needs one or both the service brake and emergency brake parameters, and ensuring the rolling stock and signal engineer are discussing the same function! The rolling stock engineer will often regard the emergency brake as the brake of last resort (i.e. a vented air pipe) which may result in a lower deceleration rate because electric braking and wheel slide prevention systems may be disabled. If the emergency brake rate is lower than the service brake rate it will tend to dominate the operating profile because it will require the train to be slowed earlier than the service brake. Thus, it is important to be clear between parties exactly what the parameters mean and how they will be used.

The inputs from the above data sources are typically fed to a multi-channel processing system prior to being presented to the driver as a permitted speed indication and when necessary to the brake activation interface.

Full ATP systems with continuous update

These systems have the same basic functionality and challenges as described for intermittent update systems, but the data about infrastructure condition is able to be updated at any time. Such systems allow in cab signalling as the driver can be informed of an update to signalling conditions via the cab display.

Early systems achieved continuous update by transmitting codes to the train via track circuits. In practice the number of codes capable of transmission this way is severely restricted. So usually the train was given a maximum running speed and a target speed to achieve at the end of the section. Information such as speed restrictions

Opposite ends of the coded track train protection speed spectrum:
Left, the LGV-Est line in France, equipped with TVM430.
Right, London Underground's Central Line.
Photos Shutterstock/olrat, Shutterstock/Ttatty.

or gradient would have to be used as part of the design process when configuring the system for the railway. This method of providing continuous update is limited to lines using rolling stock with very similar brake performance, or at least has to be based on the worst brake performance train permitted. It was the backbone of the original London Underground Victoria Line automatic train operation system from 1965 until recently and is the basis of the signalling on many of the French LGV lines signalled using TVM 430. A significant challenge with such systems is the need to ensure the train can detect the track circuit code prior to shorting the track circuit current as part of the train detection role. Thus, assuming the detector is at the front of the train, it is necessary for all track circuit feeds to be ahead the train which means that reversal of feed and detector functions is necessary for any lengths of track used reversibly.

Another early method of providing continuous update was via a loop usually between the rails which radiates data to the train. The German LZB system is perhaps the best known of this form and is also the parent system for several others of this type (e.g. SELTrac). In this particular case the data rate is low by modern standards (1200 baud up link to the train; 600 baud down link). Thus, the data volumes handled between track and train are relatively low (circa 85 bits per telegram). As a result much of the calculation is performed in the LZB control centre and limited target speed data is passed to the train. The loops in the four foot are crossed every 100m which both reduces interference and provides a distance monitoring function to the train by reversing the phase of the radiated signal.

"CBTC systems incorporate continuous ATP protection using radio communications"

The system is in relatively widespread use through Germany and Spain, especially on high speed lines, with other applications in Austria and elsewhere.

The most recent systems in this category are urban CBTC train control systems and ETCS Level 2 and above, both of which use radio systems to transmit data between track and train.

The major advantage of mobile data packet systems is the much larger and reliable data bandwidth, meaning more of the processing can be performed on the train and be relevant to the specific train, resulting in better optimisation. They also both open the way for the train to inform the infrastructure of its position and its operating performance.

CBTC

Many current resignalling projects for metro railways are based on Communications Based Train Control (CBTC). As the title suggests this is a highly integrated form of train control covering all the important functions of train movement including route setting, train location, movement authority often based on moving block, train supervision and train driving. In the latest systems CBTC is often used on a railway working under Automatic Train Operation (ATO) or a higher grade of automation with the objective of providing the maximum achievable capacity on the routes fitted.

CBTC systems incorporate continuous ATP protection using radio communications between the train and the trackside installation. The actual form of the radio link, which is also used for other aspects of the CBTC system, varies between both supplier and application and may include Wi-Fi and 4G/LTE, although the majority of new systems are likely to use 4G/LTE. The detailed methods of implementation are proprietary to the manufacturer.

Most systems of this type have been implemented on individual lines of a metro or on people mover systems (e.g. at airports). This has the advantage of a limited range of rolling stock making the train parameters consistent and thus maximising the capacity gain from moving block.

Two disadvantages are the need, especially on a high capacity metro, of having a highly reliable system requiring layers of redundancy, and the proprietary nature of the systems from each manufacturer which for commercial reasons restricts the use of such systems on a large network of lines.

ETCS

Until the around the 1990s most EU countries had their own train protection systems as well as signalling and communications arrangements. This resulted in relatively closed markets for signalling products and required different systems to be available on any driving vehicle that might cross from one country to another. The advent of through international trains such as Eurostar required the trains to be fitted with multiple train protection and communication systems and for the drivers to be trained in the differing signalling arrangements. The opening up of markets prompted the EU to propose a common standard for rail traffic management and especially signalling, train protection and radio communications across the EU states which culminated in the definition and development of ERTMS including ETCS and GSM-R for track to train communication.

"The advent of through international trains such as Eurostar required the trains to be fitted with multiple train protection and communication systems"

ETCS provides three primary levels of implementation together with others to suit specific needs.

Level 1 is essentially an intermittent update ATP system associated with existing lineside signals with the same facilities and restrictions in terms of 'infill'. The primary track to train communication media is the balise with infill loops an option.

Level 2 adds a Radio Block Centre (RBC) and provides continuous update of movement authority and all associated infrastructure data by radio. For ETCS the currently specified radio link is via a continuously open GSM-R call. However, this is likely to change as train radio moves to packet switched (4G/LTE or 5G). In the interim GSM-R may be supplemented with General Packet Radio Service (GPRS), a 2/3G packet oriented mobile data standard, to support ATP in busy areas. It therefore has the functions of a continuous update ATP system. Lineside signals can be removed but Level 2 retains trackside train detection and interlocking functions. Such a system can provide the basis for Automatic Train Operation (ATO) and has been implemented on the Thameslink core through central London.

Level 3, which is not yet fully developed, will enable train detection to be based on data received by the RBC from the trains in the area. It will therefore facilitate the reduction or removal of lineside train detection equipment and facilitate the introduction of short virtual blocks or perhaps moving block. A significant challenge at present is from variable formation trains (e.g. freight and locomotive hauled passenger trains) and proving they are complete at all times.

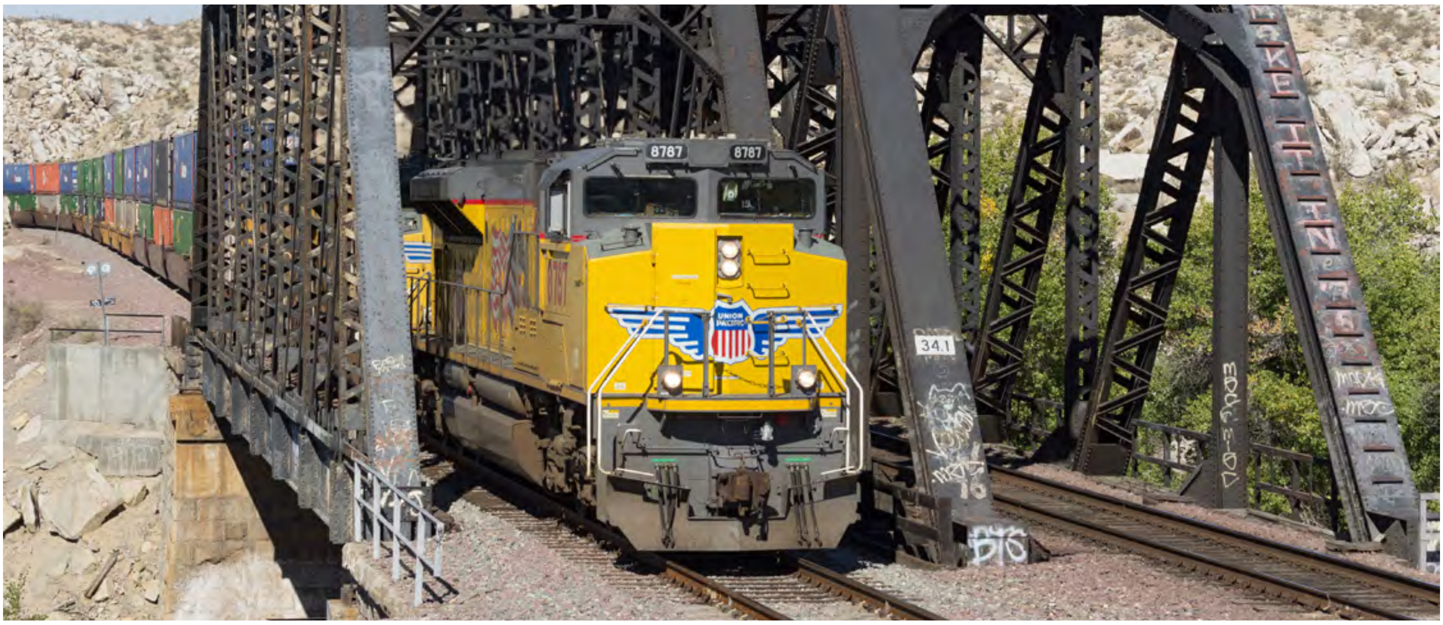
Other ETCS levels also exist, including those working with a national ATP system through a Specific Transmission Module (Level STM), and Level 0 when an equipped train is operating over unfitted infrastructure and is thus subject only to train ceiling speed supervision.

In addition to these primary levels there also exist options for Limited Supervision which effectively provides train protection only at critical locations and thus corresponds to intermittent train protection. Finally, there are proposals for ETCS Hybrid Level 3 which provides virtual blocks as well as conventional train detection, delivering capacity benefits for trains that are Level 3 enabled, without having to bar the route to Level 2 or unfitted trains. An article about ETCS Level 3 and Hybrid Level 3 was published in the April 2017 issue of IRSE News.

Positive Train Control (PTC)

In North America there is currently a programme to implement Positive Train Control (PTC) on all intercity passenger lines, and on freight lines carrying more than 5 million tons per annum of inhalable toxic substances. PTC is a form of ATP in that it requires the prevention of collision due to passing the end of authority or passing through misaligned points and speed supervision to prevent derailment at speed restrictions whether permanent or temporary. There is no one mandated solution but there is the requirement of interoperability between systems as many vehicles travel over several networks. It also requires provision of arrangements to protect track workers. Whilst several systems were proposed most installations have settled on one of three systems and all will operate with each other.

China's CTCS system shares many concepts with ETCS but has developed very quickly in order to keep up with infrastructure developments across the country. *Photo Shutterstock/ kikujungboy.*



In a similar way that CTCS was created to meet the needs of China, PTC was developed to meet the specific needs of North America's railroads. Union Pacific has been one of the adopters of this technology. *Photo Shutterstock/ AngelDiBilio.*

The PTC system was mandated by law signed in 2008. The original law required the system(s) to be in place by 2015 but costs and challenges in implementation mean this date has been pushed back to the end of 2020. The range of operating conditions from metro and commuter railways to long heavy haul freight lines means variety of solutions is too great to discuss here and could well be the subject of a separate article.

Conclusion

In this article I have attempted to summarise the scope of train warning and protection systems and to highlight some of the major issues the implementation of ATP faces as well as giving an insight into some of the systems that exist.

About the author ...

David joined the S &T department of the Southern Region of British Rail in 1968 as a student engineer, with his first appointment in the telecommunication design office. He supported the testing and commissioning of passenger information systems, including the automatic operation of platform indicators at London Bridge and Waterloo East and setting a career profile linked with development of new systems.

In the 1980s David led a team involved with train describer development and a new system to distribute train location information via the national teleprinter network, followed by the development of the Integrated Electronic Control Centre (IECC) including automatic route setting. He was also involved in improving electromagnetic compatibility between train detection and new rolling stock.

Moving to Railtrack in 1994 he was involved with the development and implementation of TPWS and the development of ERTMS in Europe, his work including the implementation strategy for the UK. Before retirement David managed the safety assurance process for the Cambrian ERTMS pilot. David is one of the contributing editors of IRSE News.

"Back to Basics" and the IRSE Exam

We hope our 'Back to Basics' series is interesting to all members, bringing topics that underpin our profession into focus in a simply understood, yet comprehensive way, making continuing professional development straightforward.

We particularly hope the articles are interesting to those of you who are new to the industry and are working to build up your knowledge. For those considering taking the IRSE exam, these articles should be particularly relevant for your studies.

As an example, why not think about how you would answer this question from the 2019 Module 5 of the exam, based on what you've learnt from the article?

"Describe a system which provides train protection for a stop signal or limit of movement authority. Using a diagram, clearly describe each of the following:

(i) How the speed of a train approaching a stop signal or a limit of movement authority is monitored and controlled;

(ii) How a train is prevented from ignoring a signal displaying a stop aspect or a limit of movement authority; and

(iii) The necessary interfaces to the signalling system including the interlocking and control system."

CBTC interoperability

Frank Heibel

This article was first published as a three-part series in the "High Performance Signalling Newsletter", available at docfrank.com.au. This version has been edited to enhance the flow when presented as a single piece.

Communications-Based Train Control (CBTC) is recognised as the global 'gold standard' for high-performance railway signalling technologies. As such it has become arguably the most popular advanced signalling technology, controlling city metro railways in way over a hundred cities around the world.

One major shortcoming of contemporary CBTC products is their proprietary nature. They don't 'play well with others', or more technically they lack interoperability. For metro operators with very intertwined rail networks that poses a major problem and makes interoperability the holy grail of CBTC technology. This article looks at historically developed reasons for that missing interoperability and at latest trends in that area.

Any form of interoperability between comparable products from different suppliers is usually governed by standards, most importantly including precise interface specifications between subsystems. It is therefore prudent to look at existing standards for CBTC to understand the current state of the industry.

IEEE 1474 – The original

The Institute of Electrical and Electronics Engineers (IEEE) has overseen the first set of CBTC standards that ever existed, labelled IEEE 1474. The "first set" means that in the meantime there have been two further sets of CBTC standards. One set was published by the Europe-based International Electrotechnical Commission (IEC) and is labelled IEC 62290, one could say the European equivalent of the North American IEEE 1474. And the other one, not openly published as far as I know, is a Chinese CBTC standard. More on those later.

IEEE 1474 was first published in 1994 I believe. At that time there were already different CBTC products from multiple different suppliers in commercial service, so the standard came too late to specify how different suppliers' CBTC systems could interoperate. The result of that situation was a rather high level and non-prescriptive pair of "standards" for performance and functional requirements (IEEE 1474.1) and for user interface requirements (IEEE 1474.2). Two more documents supplement the suite of IEEE 1474, so called "recommended practices" for system design & functional allocations (IEEE 1474.3) and for functional testing (IEEE 1474.4).

Image Shutterstock/ProStockStudio.

Those four documents were updated by an IEEE working group of CBTC subject matter experts in 1999 and 2004. Further five-yearly revisions in 2009 and 2014 confirmed the previous version. In other words, the content of those standards has not changed for the last 15 years. The upside is that a number of signalling suppliers have CBTC products that have been well and truly compliant with IEEE 1474 over many years, with many reference projects. Therefore, any metro railway procuring CBTC compliant with IEEE 1474 today will likely receive a number of technically compliant responses with very comparable functionality and performance. The downside is that IEEE 1474 does not address the shortcomings of existing CBTC over that 15-year timeframe. And one very prominent shortcoming of current CBTC is lack of interoperability.

For early CBTC projects, interoperability was not required. Vancouver Skytrain has a single CBTC supplier, as have airport people movers in several US cities, or Docklands Light Rail in London. However, some metro networks are strongly interconnected and too large to leave them to a single CBTC supplier. That is where interoperability requirements come in, and the supply industry struggles or fails to meet them.

Back to IEEE 1474. It seems the IEEE missed the due update for 2019 as they are working on a revision right now, in 2020. Well, better late than never as the saying goes. The more pressing question is, what will be changed from previous versions of these standards? And more specifically, will the ambition of an additional part IEEE 1474.5 finally become reality? As you may guess, that part 5 was meant to cover interoperability.

There are reasons why the development of an interoperable CBTC standard could become quite critical for the established 'western' (mainly American/Canadian and European) CBTC suppliers which rely on IEEE 1474. But before we get to that, let's have a look at another set of established CBTC standards.

IEC 62290 – The alternative

There is an alternative set of CBTC standards which was developed in Europe by the International Electrotechnical Commission (IEC), labelled as IEC 62290. It consists of two parts. Part 1 covers system principles and fundamental concepts. Part 2 provides a functional requirement specification (FRS). There are two other parts planned, much more substantial but not yet existing. Part 3 would be the system requirements specification (SRS), arguably much more specific and prescriptive than the FRS of part 2. And Part 4 was meant to be interface specifications which, if done properly, would allow for, of course, interoperability.

So, the situation with IEC 62290 is quite similar as for IEEE 1474. The parts needed for specifying interoperability are "considered" but have not been developed. Why is that?

Are CBTC suppliers interested in interoperability?

Every one of the established CBTC suppliers (mainly, in alphabetical order, Alstom, Bombardier, Hitachi Rail STS, Siemens and Thales) has a proprietary CBTC product. While the high-level architectures are comparable, the detailed functional allocation between the different subsystems is often quite different. That means communication between subsystems, which would have to be standardised for interoperability, differs not just in language or data format, but often in fundamental content of the transmitted data. The consequence? Standardising the communication interfaces between subsystems from different suppliers would require substantial change to the existing CBTC products, not just for the interfaces but for the core functions of the subsystems themselves. Obviously, none of the current CBTC suppliers is interested in doing that if they can keep selling their existing products instead.

Interestingly, even in cases where one railway customer has enforced interoperability between two CBTC suppliers (New York is the most notable example) those suppliers show no interest whatsoever to market their interoperable solution to other metros with interoperability needs, not even to stand out from the other non-interoperable CBTC suppliers. It just seems that interoperability of established CBTC products is either unachievable or virtually unaffordable (as the New York example demonstrated - the two most costly CBTC projects in global history, by a mile and a half).

However, that status quo of the established CBTC market is about to be disrupted. And it was not that hard to guess where such disruption may come from.

What happens in China?

By far the biggest country market for CBTC in the world is China. A few years ago, at a CBTC conference in London, one of the thought leaders for CBTC in China announced the ongoing development of a Chinese CBTC standard. That was a smart move in two regards. One, it would allow much larger numbers of Chinese engineers to read and understand CBTC standards in their native language, compared to the standards published in English by the IEEE and the IEC. That wider and deeper understanding would boost the prospects of CBTC product development made in China. Secondly, as a new CBTC standard started on a blank canvas, without existing divergent CBTC products and with very high compliance of local suppliers, the Chinese standard could eliminate several major shortcomings of contemporary CBTC, including (of course) lack of interoperability. The two other focus areas for improving the Chinese CBTC standard were radio communication (by specifying LTE/4G which has distinct advantages with interference over the traditionally used Wi-Fi) and unattended train operation which requires interfaces to CBTC-external systems e.g. for obstacle detection.

The power of the huge Chinese metro railway market, with more concurrent CBTC projects than the rest of the world combined, and the Chinese government's strong support of local suppliers allowed for a strategic plan that had multiple Chinese signalling companies developing CBTC based on the interoperable Chinese standards, and also for a clear roadmap towards in-service proof of interoperable CBTC made in China. The key year for that proof is … 2020. The first application of truly interoperable CBTC between three different Chinese suppliers is planned in Chongqing Metro for this year. Meanwhile, there is no indication that established 'western' CBTC suppliers would work towards interoperable CBTC, at least by agreeing on expanded standards which could pave the way for it.

All this will eventually have consequences on the world market. Following previous experience from other railway disciplines (telecommunications and rolling stock), Chinese suppliers will start seeking export markets for their CBTC products. And when they do, they can offer interoperability with other (likewise Chinese) suppliers which traditional suppliers cannot. I do not think that will lead to immediate bulldozing of the established western CBTC industry. But over time it will certainly make a dent in their market share, and maybe that dent gets bigger faster than they would like.

The signs are on the wall. Will there be a response from the rest of the world? And how will it look?

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

SNCF remote driver for ATO back up

France: SNCF has set a target to deploy Automatic Train Operation (ATO) on the main line network by 2025 to unlock extra capacity and improve the predictability of services. This major project has many issues to overcome and multiple research elements are required as part of SNCF's Autonomous Train Project.

TC-Rail is an initiative to develop and prove a remote driving solution to enable a driver to control and drive a train safely from a remote site. The system will support operation in the event of a failure of the ATO system as well as provide last mile coverage for trains travelling between stations, maintenance centres and yards.

SNCF is developing and coordinating the project in partnership with French Railway Technological Research Institute (Railenium), which is leading the human factors study, safety analysis, 5G telecommunications development, and oversight of testing. Thales, Actia Telecom and France's National Centre for Space Studies (CNES) are all involved in the telecommunications element of the system.

Advanced Train Management System

Australia: Deputy prime minister Michael McCormack has announced the establishment of a cross-industry oversight group to assist with the introduction of the Advanced Train Management System (ATMS) on the 1435mm gauge interstate freight rail network. The oversight group is intended to streamline the implementation process and to bring together representatives of Australian Rail Track Corp (ARTC) and nine major rail freight businesses.

Developed for ARTC by Lockheed Martin and under development since 2005, ATMS is expected to increase capacity as well as reliability and safety. The federal government has allocated A$110m (£58m, €66m, $72m) to fund the introduction of ARTC, which uses a combination of Global Navigation Satellite System, Global Positioning System (GNSS, GPS) and mobile data communications. The system is intended to reduce lineside signalling infrastructure, particularly in remote areas.

A pilot installation between Port Augusta and Whyalla in South Australia is already operational, and is in the final stage of being certified as the primary safe working system. Once the technology has been authorised for regular operation, it will be deployed on other parts of the ARTC network, starting with the trans-Australia main line between Tarcoola and Kalgoorlie.

ATMS is claimed to improve rail safety by allowing freight trains to be remotely controlled during an emergency, including automatic braking. It will boost the efficiency of services both on dedicated freight lines and shared rail networks. The Australasian Railway Association welcomed the announcement and has long supported the implementation of ATMS on the inland rail corridor as well as the interstate network, but acknowledged that other train management systems were in use across Australia, notably on the passenger networks in metropolitan areas.

South Kirkby re-signalling

UK: Network Rail has awarded Alstom a contract to re-signal South Kirkby in West Yorkshire, England. This will be the first operational main line deployment of the Alstom SmartLock 400GP interlocking (installed with EuroRadio+) with SMART I/O object controllers using the Internet Protocol (IP) Fixed Telecommunications Network (FTN-x) transmission network. The South Kirkby scope includes the renewal of the Interlocking, lineside signalling equipment, alterations within York Rail Operating Centre and associated fringe alterations.

Alstom says that the equipment will be 'digital ready' and can be interfaced directly with future European Train Control System (ETCS) – futureproofing the railway and offering greater value to passengers and freight services. The design will also reduce the need for copper cabling, with signals and points served by a digital, distributed network of object controllers. The project commissioning date is December 2022.

New Italian barrier machines

Italy: Ferrovie Emilia Romagna (FER) is a railway company serving the Emilia-Romagna region in Italy. FER has awarded WEGH Group a contract to supply a further 300 Type TD96/2 level crossing barrier machines. These will replace older equipment across the 364km regional network with more modern, more reliable and easier to maintain machines, which will be installed on the Ferrara-Suzzara, Reggio-Guastalla, Reggio-Sassuolo and Bologna-Portomaggiore lines. The two-year contract includes theoretical and practical training for maintenance staff.

City railways and light rail

Artificial Intelligence tram vision system

China: Urban rail signalling system provider FITSCO and Cognitive Pilot have partnered to develop an Artificial Intelligence (AI) based computer vision system for trams, with options to provide autonomous tram control and movement. Cognitive Pilot is a joint venture of Russia's Sberbank and Cognitive Technologies Group for autonomous driving technology.

Support for Urbalis CBTC driverless operation

Singapore: SMRT Trains Limited is a rail operator in Singapore and has signed a services support agreement with Alstom covering their Urbalis CBTC, which provides driverless operation on the Circle Line. The contract covers the provision of spare parts, repairs, obsolescence management and technical support until 2035. Alstom is currently supplying signalling and 69 Metropolis metro cars for Stage 6 of the Circle Line.

São Paulo Metro's Line 17

Brazil: BYD SkyRail São Paulo and São Paulo Metro have signed a contract for BYD to provide its driverless SkyRail system for the Line 17 (Gold Line) project. BYD Company Ltd is one of China's largest privately-owned enterprises and SkyRail is a straddle-type monorail system. The contract includes the provision of 14 five-vehicle trains, switches, conductive rails, signalling system, central control system, engineering vehicles, vehicle washing machines, and technical services, including engineering integration, installation, commissioning and training.

The first phase of the 17.7km Line 17 project will extend from São Paulo's Congonhas Airport to other central parts of the city, connecting business districts, the University of São Paulo, and densely populated areas in the city's east. The Gold Line will connect with Line 1 (Blue), Line 4 (Yellow), Line 5 (Lilac), and Line 9 (Emerald) and will be designed for a daily 250 000 passengers, and a service frequency of 80 seconds.

ETCS approval for Crossrail EMUs

UK: The Office of Rail & Road (ORR) has approved ETCS onboard equipment for the Bombardier Class 345 EMUs, for introduction on services to Heathrow Airport. The 70 nine-car EMUs are intended to operate Crossrail Elizabeth Line services to the airport and will replace Siemens Class 360 EMUs currently operating stopping services between London Paddington and Heathrow Airport.

The approval allows operation of the ETCS onboard equipment in levels 0, 1 and 2, but the ORR has placed three restrictions based on non-compliance with notified national technical rules, one affecting the TPWS and the other two relating to the ETCS Driver-Machine Interface. The authorisation is also subject to 84 areas of non-conformity with the Technical Specifications for Interoperability (TSI), many relating to ETCS functionality not used in the UK.

Communication and radio

Inmarsat rail telemetry and satellite communications

UK: Inmarsat, a British satellite telecommunications company has launched a new Rail Telemetry and Communications Solution. The system aims to provide real-time data transfer and push-to-talk (PTT) communications for rail operators working in remote areas, connecting drivers and railway staff. The solution uses a satellite based Broadband Global Area Network (BGAN), with a claimed reliability of up to 99.9%. Low form factor satellite terminals, such as the Cobham EXPLORER 323, are mounted on trains to provide real-time GPS, telemetry and PTT capabilities.

Inmarsat claim an important feature is the integration with existing equipment on board a train, with the system switching between connectivity types such as UHF or VHF, 3G/4G and satellite. They say the switching process is seamless and offers an economical approach to voice communications.

Security for 5G mission critical data

UK: The UK5G Testbed & Trials Working Group have launched a SecuritySub Group to address 5G security challenges. UK5G see the 5G Testbeds and Trials testing involving both mission critical data (such as between high speed vehicles or factory machines) and personally sensitive data (such as in a health or social care setting), which will need to have security at the heart of the design.

Mark Hawkins, QinetiQ Fellow and 5G technical lead, will chair the Security Sub-Group, which will include representatives from Toshiba Research, Spirent Communications, Utility Technology Council, Colt Technology Services, National Technical Assistance Centre (NTAC), Systematics Consulting Inc, British Standards Institution (BSI), University of Strathclyde, Ofcom and Department for Digital, Culture, Media & Sport (DCMS).

The Security Sub-Group, along with consortia teams and UK5G's associate partners, will identify security gaps, solve security problems and showcase good end-to-end security practices,ultimately, leading to higher confidence in 5G networks and support the rollout of 5G.

Wi-Fi 6 Spectrum

USA: The Federal Communications Commission has made 1,200MHz of spectrum in the 6GHz band (5.925–7.125GHz) available for unlicensed use in America for Wi-Fi 6, which will be known as Wi-Fi 6E for "extended" Wi-Fi 6E will be over two-and-a-half times faster and increase the amount of spectrum available for Wi-Fi by nearly a factor of five. Different power levels are specified for indoor and outdoor use and with the use of "automated frequency controllers" to protect existing fixed-wireless and satellite connections that use the 6GHz frequency band.

Europe may see the lower half of the 6GHz band allocated for unlicensed use. The upper 6GHz band may be used for exclusive-licensed national use for 5G and the ITU is also considering the band for possible 5G use at the next WRC conference in 2023.

The Wireless Broadband Alliance (WBA), the body leading development of next generation Wi-Fi services, supports the decision by FCC to open up the 6GHz frequency band for use by Wi-Fi 6 technology and confirmed that WBA early trials of Wi-Fi 6E achieved speeds of 2Gbps as well as consistent two-millisecond low latency.

5G mobile spectrum for private licensing

World: Spectrum licences are normally reserved for Mobile Network Operators (MNOs) but many countries are looking to allocate 5G mobile spectrum for private licensing, which could include railways. Network slicing is a key feature of 5G networks and will support innovative new deployments and business models. This will provide network capacity with guaranteed quality of service for particular uses in shared networks, which may include a combination of private and MNO networks.

In the UK, regulator OFCOM will dedicate the 3.8-4.2GHz band for local deployments, and will require national operators to hand over unused licensed spectrum to private enterprises. The lower 26GHz band will also be reserved for private and shared access.

German regulator, BNetzA, has reserved 100MHz of 5G spectrum in the 3.7-3.8GHz band to private companies, with 33 companies interested including Bosch, BMW, BASF, Lufthansa, Siemens and Volkswagen. In France, frequencies in the 2.6GHz band have been offered to metropolitan businesses by regulator ARCEP including Airport operator, ADP Group and its subsidiary Hub One, EDF for the Blayais nuclear power plant, and mobility company TransDev. National railway company SNCF and Airbus have also expressed their interest in private 5G spectrum.

In the Netherlands, 5G spectrum at 3.4-3.45GHz and 3.75-3.8GHz is intended to be made available for local use, and Sweden's 5G auction of the 2.3 and 3.5GHz bands will reserve 80MHz of frequencies between 3.72GHz and 3.8GHz for local and regional licences. Other countries outside Europe including the US, Japan, Australia and Hong Kong are looking to identify and allocate spectrum for private 5G networks using the 3.7, 26 and 28GHz frequency bands.

In Japan, Fujitsu has received Japan's first private 5G provisional licence in the 28.2GHz to 28.3GHz range, and Nokia is looking to provide private LTE and 5G networks to industrial and government customers. In Australia, private networks are not new and have been provided for the mining industry for some time and the Australian Competition and Consumer Commission are looking to encourage new entrants to deploy 5G private networks.

Canadian Waze Safety App

Canada: Operation Lifesaver (OL) Canada has announced a partnership with navigation app Waze to alert Canadian drivers to rail crossings through a new safety feature embedded in the app.

Drivers using versions 4.61 or higher of Waze will now see a banner alerting them to upcoming crossings and encouraging them to approach with caution. The feature was developed using rail crossing location data from the Canadian Rail Atlas, the Railway Association of Canada's interactive map of Canada's 41 000km railway network.

Samsung Mission Critical Communications

South Korea: Samsung Electronics has announced the world's first video call on Amazon Web Services (AWS) cloud platform using Mission Critical Push-to Talk, Data and Video MCPTX (also known as Mission Critical Communications). MCPTX delivers multimedia-based communications specifically designed for first responders and public safety services.

The demonstration, conducted at Samsung's lab in Korea, featured the Samsung Galaxy XCover FieldPro, a rugged, secure first responder smartphone, purpose-built for public safety users. Customers for MCPTX will have the option to deploy it on their on-premise servers or AWS cloud platform.

Samsung say MCPTX delivers data and video communications capabilities to enable emergency services to be simultaneously connected with hundreds of fellow responders with easy exchange of videos, images, files and more during an emergency. This will help improve situational awareness and information accuracy.

The new MCPTX solution is an upgraded version of the Mission Critical Push-to-Talk (MCPTT) with enhanced capabilities. Samsung's MCPTT has been operational in Korea's Public Safety LTE (PS-LTE) network since 2018, supporting voice and text communications. It has been deployed across six different railway lines as part of the nation's LTE-Railway (LTE-R) network, providing communications for station staff and train crews.

ETSI remote PlugtestsTM Programme for mission critical voice services

Europe: To accelerate voice Mission Critical Services (MCS) adoption and interoperability, ETSI is running an MCX PlugtestsTM Programme. The MCX (collectively for MCPTT [Mission Critical Push To Talk], MCVideo and MCData services) Plugtests Programme provides for collaborative testing and validation activities among different organisations. The MCX remote lab is a facility to allow participants to connect with each other for interoperability testing activities.

The testing sessions will also benefit from the latest ETSI specification, ETSI TS 103 564 (irse.info/f57rm), on Plugtests scenarios for MCS, and will take place from 21 September to 2 October 2020. The testing sessions will include initial railways-oriented capabilities in 5G 3GPP Release-15 in support of Railway Mobile Communication System (FRMCS).

Safety, standards, health and wellbeing

Covid tracking & tracing standard

Europe: ETSI is a European Standards Organisation and is the standards body dealing with telecommunications, broadcasting and other electronic communications networks and services. ETSI is embarking on a new Industry Specification Group in response to the Covid 19 pandemic and various European governments' desires to set up a workable, Europe-wide track and trace system. The Europe for Privacy-Preserving Pandemic Protection group is establishing a framework that different projects can work under, with interoperability as a major objective. ETSI says "A primary challenge is collecting, processing and acting on information about citizens' proximity at scale, potentially representing tens or hundreds of millions of people. This must also be achieved without compromising users' anonymity and privacy, and while safeguarding them against exposure to potential cyber-attacks".

Employees to permanently work from home?

World: Twitter has become the first big company to allow its remotely working employees to do so indefinitely, according to the New York Times. Employees can choose to come into the offices or not when they reopen, which is probably not before September. Since the announcement many other companies have revealed similar plans.

Facebook, Google and Spotify have allowed most of their employees to work remotely until the end of this year. Amazon are giving employees the option to work from home until at least October. Barclays has 70,000 staff currently working from home, and say a big city office "may be a thing of the past". Mastercard employees can work from home until they "are ready" to return and is looking to consolidate global offices. Microsoft have extended working from home until October for most employees, with Royal Bank of Scotland until at least end of September and WPP – the world's biggest advertising agency, says returning to the office will be voluntary and flexible.

It is anticipated that after several months experience of home working many employees may want to continue with this way of working and employers may also appreciate the cost saving implications and adopt permanent remote working. It will be interesting to see what this means for the rail industry.

Making decisions under pressure

UK: The Rail Safety and Standards Board (RSSB) is an independent not-for-profit company limited by guarantee whose objective is to lead and facilitate work to achieve continuous improvement in the health and safety performance of the railways in Great Britain. RSSB's human factors expert Charlotte Kaul, has made a video to provide guidance and help rail staff be confident with making decisions under pressure. The video can be seen at irse.info/3km16.

Leading health and safety on Britain's railway (LHSBR)

UK: RSSB (Rail Safety and Standards Board) has published a new version of its strategy "Leading health and safety on Britain's railway". The updated strategy sets out the areas where the rail industry in Britain needs to work together to achieve a step change in health and safety performance, while recognising that there are still significant risks involved in SPADs, trespass and workforce safety. The strategy is available at irse.info/psn3x.

Investigation into safety-critical human performance in signalling operations

UK: The Rail Accident Investigation Branch is a British government agency that investigates rail accidents in the United Kingdom and the Channel Tunnel in order to find a cause. Since its inception in 2005 RAIB has investigated numerous incidents in which signaller decision-making has been pivotal.

RAIB also collected industry data on several similar incidents over a five-year period which highlighted the vulnerable nature of such decision-making. In the light of these incidents, RAIB has undertaken an investigation into what affects those decisions, recognising they may be influenced by a variety of systemic factors. The investigation examined five categories of incident: user worked crossing irregularities, line blockage irregularities, users trapped at CCTV level crossings, irregularities involving level crossings on local control, and other operational irregularities.

The investigation identified five common factors influencing the actions of signallers. The report observes that Network Rail's incident investigations do not always fully exploit the opportunities to learn from these incidents. As a result, RAIB has made six recommendations to Network Rail, addressing each of the five areas as well as the observations from incident investigations The full report can be found at irse.info/f98tm. The RSSB has also published lessons learned in the design and operation of user worked crossings which can be found at irse.info/71943.

BS 9992 Fire safety in the design, management and use of rail infrastructure.

UK: BS 9992:2020 a British Standard code of practice covering fire safety in the design, management and use of railway infrastructure, has been published. The standard covers signalling and control centres, permanent way (tunnels, viaducts and open sections), stations (surface, sub-surface and enclosed), depots and sidings.

It includes detailed guidance on designing means of escape, tunnel fire safety, fire safety during construction and firefighting access. The reaction-to-fire section is the only national guidance on the built environment in the UK that contains recommendations covering the smoke and toxicity of building products as well as their flammability. irse.info/vawnu.

UIC level crossing safety project

Europe: The International Union of Railways (UIC) project to improve level crossing safety has released a tool box of solutions to improve the management and design of level crossings. The Safer Level Crossing by Integrating and Optimising Road-Rail Infrastructure Management and Design project (Safer-LC), received funding in 2016 through the European Union's Horizon 2020 research and innovation programme.

The toolbox has been designed as a web-based platform that will be updated by the UIC. The toolbox can be used as a decision support tool which groups several assessment methodologies as well as a wide range of cost-effective safety measures, accompanied by study results.

The measures can be sorted using various criteria including type or users and level crossing, costs and effect mechanism, which can help end-users find the most appropriate measure for a specific context. Each measure is presented through a short description, the potential benefits, recommendations, study results, main psychological functions involved, documents, related measures, a gallery of examples, and a comments section. Further information can be found on the website at irse.info/6a9h5.

Companies

Cisco to acquire Fluidmesh Networks

USA: Cisco has announced plans to acquire Fluidmesh Networks, a wireless Wi-Fi based backhaul company specialising in high speed and widely distributed applications, including railway, industrial Internet of Things (IoT), ports, mines, and factories. The terms of the acquisition are not available, but Cisco expects the acquisition to be in place before the end of 2020.

The takeover improves Cisco's capabilities to support use cases that involve mobility versus static installations. Wi-Fi based systems are generally better suited for stationary or slow-moving objects traveling under 30km/h, but Fluidmesh claim they can transmit data to vehicles travelling at speeds in excess of 300km/h, said Cisco's Liz Centoni, senior vice president for cloud, compute, and IoT business.

Cyber-attack against Stadler IT network

Switzerland: International rail vehicle construction company, Stadler, based in Bussnang in Eastern Switzerland, reports that its IT network has been attacked with malware. The company immediately initiated the required security measures and involved the responsible authorities.

Stadler internal surveillance services found out that the company's IT network has been attacked by malware which most likely led to a data leak. Stadler assumes the incident was caused by a professional attack from unknown offenders. The offenders tried to extort a large amount of money from Stadler and threaten the company with a potential publication of data to harm Stadler and its employees.

A team of external experts was called in and the responsible authorities were involved. The company's backup data were complete and functioning with all affected systems rebooted. In spite of the pandemic caused by the Coronavirus and the cyber-attack, Stadler say they were able to continue the production of new trains and its services.

New appointments at Linbrooke

UK: Jason Pearce, previously group managing director, has taken on the role of group chief executive officer at Linbrooke. Jason has been in the rail, telecoms and technology sector for 20 years. Lee Hallam will take the role of executive chairman and, since incorporating Linbrooke Services in 2002, has grown the business from its home-grown Sheffield roots into a company delivering global projects within the rail, telecoms and power sectors. Linbrooke delivers solutions for telecoms, power, and signalling – predominantly in rail, utilities and subsea sectors, and is a Principal Contractor (PC) for Network Rail and an Independent Connection Provider (ICP) with National Electricity Registration Scheme (NERS) accreditation.

Education and universities

Network Rail STEM lockdown learning pack for children

UK: Network Rail, the owner and infrastructure manager of most of the railway network in Great Britain has created a pack of Science, Technology, Engineering and Mathematics (STEM) learning resources and activities to help parents juggle work and home schooling. Originally created with employees in mind, the material has been modified for anyone to help keep children educated and occupied, and encourage youngsters to take a greater interest in STEM subjects.

The STEM pack includes tasks and activities aimed at children aged between 5 and 16, and there are links to the railway so that participants can better understand the industry. One of the tasks requires children aged between 5 and 8 to watch an animated clip showing electricity being used and identify any safety-related issues. Another task, suitable for all ages, requires participants to register for a Leaders Award that asks them to identify any problem that could be fixed with an engineering solution, inspiring them to start thinking like an engineer. The materials can be found at irse.info/x6kbi.

News from the IRSE

Blane Judd, Chief Executive

The IRSE rises to Covid-19 challenge

The impact of the Covid-19 pandemic has been felt by everyone. IRSE members across the world may be working as normally as possible, be furloughed, or working from home but the common thread that unites us all is a commitment to keeping railways and metros safe.

At the time of writing , the building we share with other institutions in Birdcage Walk, London, remains closed and we have no influence over its re-opening date. We have all been working from home with three members of staff furloughed (a UK government funding scheme helping employers where their operations have been affected by Covid-19 to retain their employees).

I'd like to pay tribute to my team who have adapted to the operational challenges presented by having to carry out complex tasks without the facilities and support of the office environment and being separated from colleagues during furlough.

In addition to keeping the Institution's membership and licensing duties running we've also been working on new ways to communicate with members. Whilst section events can't take place due to social distancing restrictions, we've produced guidelines to help sections hold virtual events. We're working with our new president, Daniel Woodland to ensure that until public gatherings can once again take place, each presidential paper, originally scheduled to be presented at venues around the world will be recorded remotely and available for viewing online by members.

IRSE Engage

Thanks to the enhanced flexibility and functionality of the new IRSE website, we've been able to create engaging content together during lockdown. From informative 'how-to' pieces by the HQ team to event broadcasts from local sections, there's a growing collection of online resources for you to enjoy at **www.irse.org/engage**.

We encourage all members to contribute to this initiative, so if you would like to submit a video sharing your engineering experience and expertise with other IRSE members please get in touch and we'll be delighted to help. Here are the videos you'll find so far:

- A guide to filling out the IRSE Application Form with Judith Ward.
- Developing our "Beyond 2020 Vision" with Blane Judd.
- The IRSE Strategy Explained – with Blane Judd.
- Super Train Challenge – an interactive session for the very youngest members with Prerna Sharma, Aaron Sawyer and Keith Upton.
- "Minimising Safety Risk" – with David Crawley, a talk from the London and South East Section.
- "Crossrail Signalling" – with Tom Godfrey and Rory Mitchell, a talk from the London & South East Section.
- "Merseyrail's New Train Programme" – with David Powell, a talk from the Midland & North Western Section.

IRSE Examinations

The Education and Professional Development (E & PD) committee has decided that the IRSE professional Examination will take place internationally as planned on 3 October with appropriate social distancing measures, subject to local/national restrictions. The committee will meet again in August to review the decision based on the latest information available.

Some candidates will be sitting the new Module A exam for the first time and sharing their experience online later. Module A is a stand-alone qualification in addition to the mandatory pre-qualifier for all wishing to sit the full IRSE professional exam in the future. It covers all aspects of railway control engineering at a foundation level and those who pass will attain the new "Certificate in Railway Control Engineering Fundamentals".

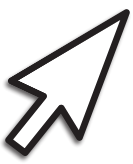
Entries for the Exams are now closed. To help candidates prepare there are several new resources available on the IRSE website including a series of study session videos put together by the IRSE Members at **irse.info/f6klx**. IRSE textbooks are available, with two having been reprinted recently and are available via our online shop **www.irse.org/store**.

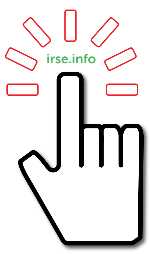
Visit the dedicated IRSE Professional Exam page on **irse.info/irseexam** for full details about the Exam and resources available.

Membership subscriptions

Members who have not set up direct debits are urged to pay their subscriptions online via the website as soon as possible or email **membership@irse.org**. Please take the opportunity to check that all your contact details are correct whilst online.

Keeping it snappy with irse.info





Remember when you see an irse.info link in IRSE News, this is your easy way to visit a webpage. Instead of having to type a long, sometimes very long, address just put the irse.info address (e.g. irse.info/irseexam) into your web-browser, or click on the link if you're reading the magazine online, and you'll be at the right site in no time. *Don't type it into your search engine, Google won't have heard of these links!* So far we have some 400 irse.info links, and they have been clicked more than 16 000 times.

London & South East Section

Open Train Times

Report by Clive Kessell

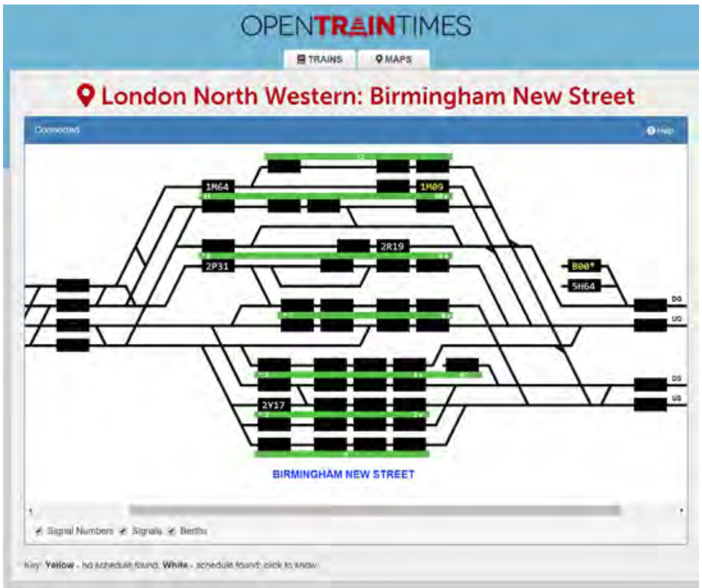
Peter Hicks is the driving force behind Open Train Times, a real time train timetable application for Great Britain. Peter gave a talk to London & SE Section to explain how it all came about, the challenges faced and the work still to do. Peter is a former IP network engineer and now a railway systems consultant and software developer. He is also a rail commuter so has first-hand experience of knowing what is needed.

Producing a robust timetable and systems that can minimise the effects of any disruption is one thing, but conveying real time information about how it is working out in real time to the general public is something else. When disruption occurs, it is a common complaint that 'nobody knows what's going on' or 'staff on the station don't tell us anything'. This can be fair criticism and many will have experienced these situations. Even when things are going well, providing the public with up to date details of train time, platform, train formation and suchlike can be a bit minimal at other than the busiest of stations.

Yet all the information is there even if the associated decision making is not always as sharp as people would like. Can this information be conveyed to the public in a form that is understandable? A trial some years ago at Peterborough involved the provision of a display screen in the concourse showing the train describer movements as being shown to the signaller in Peterborough Power Box. Cynics said that people would not understand what the diagram was conveying nor the head codes or the stepping functions. They were wrong and regular rail users soon learned to interpret the train movements and how these would relate to their intended journey. Maybe the travelling public are not as stupid as some people think! Could the idea be extended further to make train movement data available as a national service that would be accessible from any smart phone or tablet device?

Accessing the data

Since Network Rail compiles the timetable and owns all the signalling systems that deliver train movement information, clearly getting their cooperation was vital. The first step however was knowing what to ask for. Train schedules are created in TPS (Train Planning System) for the current and next timetable period. This is exported in the rail-specific format called CIF, the origins of which date back to a main frame system called TSDB (Train Service Data Base) developed by British Rail. A full timetable is around 600Mbytes of data and contains the timetable for 12 months. Short term changes and variations to existing schedules are loaded incrementally with updates published each night.



An example view from Open Train Times, showing traffic in and around Birmingham New Street during a quiet Saturday lunchtime.

Nonetheless, Network Rail were asked if this CIF data could be made available with real time data feeds for an Open Data project. The answer was firstly 'nobody has ever asked for this before' but a policy decision was eventually made saying 'yes, we can give you access'. So far so good, but the next question was 'can real time data be obtained and can we use this data for distribution purposes so that everyone can take advantage?' This was more difficult and it ended up being discussed at the DfT Transport Transparency Board. Eventually the government decided that it was in the public interest and the data should be made available for general information. The concept of Open Train Times (OTT) was thus borne with the project starting out as 'TSDB Explorer' which was the first iteration of the site

The data needed

In order to provide a credible real time train running information service, a number of data feeds are needed. These consist of:

- TPS (Train Planning System) to give timetable data.
- TRUST (Train Reporting using system TOPS) to give real time running data from designated reporting points.
- TD (Train Describer) which delivers train running information derived from signal and berth data within signalling centres.
- VSTP (Very Short Term Planning) which has in day and next day alterations to the timetable.

From these, live track diagrams can be derived using other material such as the TPS network model and route learning material from TOCs. These diagrams can also be built using scheme plans, block schematics of the track and signalling layouts but remain drawn by hand.

The Train Describer (TD) feed contains plenty of high level information about train movements at signalling berth level and low level information about routes set between signals and signal aspects.

Train describer information is usually aggregated in TRUST for automatic train reporting but there are still many low density or rural lines that retain absolute block working often with semaphore signals and non-continuous track circuiting. Open Train Times cannot generally provide information for these areas, which amount to about 20% of the total but always decreasing as signalling systems are modernised or replaced.

The TD data is delivered as a stream of updates, so not only is this a constant delivery, there is no 'current snapshot' available, which means systems have to build and persist their own berth data locally. The data messages come as two classes. Firstly there are C Class equating to berth messages:

- A step instruction to move a description from berth A to berth B.
- Cancel where a description is removed from the system.
- Interpose to cater for new descriptions being inserted when for example a train splits or joins.

Most C Class messages are triggered by occupation or clearance of track circuit or axle counter sections

Secondly, there are S Class messages which give updates of anything the train describer is set up to provide, such as:

- Routes set and/or signal aspects.
- Point status conditions, normal or reverse.
- Track circuit or axle counter sections.
- TRTS (Train Ready to Start) plungers as used by platform staff
- Level Crossing operational status.

Signalling functions are defined in Group Standard RT/E/C/11205 and any of these may be an output from the train describer. Signal aspect status has only two states – most restrictive (red) and not most restrictive (yellow, double yellow and green) equating to 0 or 1; routes – one bit per route letter and class; track sections – occupied or not occupied. All of these are being constantly fed out. There are also 'latch' messages that relate to an on/off status. TRTS plungers come into this category where they are held 'on' until the route is set by the signaller. They can also be used for emergencies such as to indicate the operation of a 'Signal Group Replacement Control' that instructs all signals in the area to be put back to red.

Open Train Times architecture

One might be forgiven for thinking, why does all this timetable, signalling and train describer information need to be known in such detail? The answer is simple: if a service is to be offered to the general public, then it has to be accurate, timely and understandable. Poor information soon gets an unenviable reputation and will not be trusted.

The development of OTT has evolved. The architecture of the web site has grown to cope with the increasing number of users. The basic flow is as follows:

Feed from NR Open Data Message Queuing Servers (2 off) -> Processors (2 off) that consume the input data and update a database and in-memory data cache -> Multiple Web Clusters spread geographically -> Load Balancers -> Data out to Users

The site is written in the Ruby on Rails framework with some functions being handled by more specialised software suited to the job. The system was initially hosted on Rackspace but migrated to Linode as this offered cost and performance benefits. It has subsequently been migrated to Amazon Web Services, a popular cloud hosting environment used by thousands of companies including National Rail Enquiries.

To give an idea of the scale, the system accepts 750 000 TRUST messages per day, 7 250 000 TD steps per day and 525 300 train schedules per day. All these inputs come free of charge from Network Rail's Open Data platform. There are 126 hand drawn maps on the system with greater than 55 000 map elements and typically around 900 simultaneous concurrent map users. During the period when Flying Scotsman was running on the main line, this figure rose to 1500.

Usage and users

OTT was launched in January 2012. Like many applications, it is easy to access and use once you know how. Start by typing in opentraintimes.com; click on MAPS and type in the geographic location or town that you require. A series of map areas will display e.g. East Midlands, Anglia, London Overground, Sussex, etc and click on the area you want. Click then on the particular line or section of line where you need information. A map will then appear showing the route, signal numbers and train describer berths. You then need a bit of common sense to identify the particular train you are looking for. In the TD berths will appear a four-digit head code e.g. 1A66; this represents a train which will move from berth to berth as its journey progresses. Not everyone will understand the type of train that the head code represents but it is relatively easy to work out the particular train you are looking for. Other letters might appear in the berth which are entered as free text by the signallers. Examples are: "NOT" "IN" "USE" in adjacent berths; "LAND SLIP" "LINE SHUT", "BLOC", anything that gives the status of a particular line or route.

An alternative is to click on the logo and search for trains by location. Clicking on the TRAINS icon will bring up an advanced search engine for anyone who wants to search for trains timed specifically at two points. To achieve this, you may need additional coded information for the specific trains you are looking for.

Usage has since mushroomed; there are now over 1 million visits per month. A number of TOCs use OTT unofficially but this only goes to demonstrate the value of the site and the information it yields. Open Train Times has a presence on Facebook and Twitter where regular updates to the site are published.

Questions were asked about cyber security, which has been considered but it begs the question as to what is open and closed data. Where data is open, the risk is much smaller since it is always available. In any case, the information is advisory and not critical so if something is misinterpreted, no great damage is done. The relationship with Darwin was questioned but Darwin exists to predict future information for Customer Information Screens and will interpret the same data sources to anticipate what information should be displayed.

Peter Hicks has to be applauded for what he has achieved. It is not his full time job and he makes no income from the public website. It is a dedication to providing information for the travelling public.

Younger members section

IRSE
Institution of Railway Signal Engineers
YOUNGER MEMBERS SECTION

YOUNG RAIL TOURS

Young Rail Tour to Japan 2020

Report by Keith Upton

Young Rail Tours (YRT) is a newly-founded organisation that has been collaboratively set up by the IRSE Younger Members section, the Institution of Mechanical Engineers (IMechE), the Institution of Engineering and Technology (IET) and Young Rail Professionals (YRP). Its purpose is to deliver a programme of domestic, European and international railway study tours made affordable, accessible and inspirational for young professionals working in the UK rail industry.

Our inaugural tour was to Scotland in September 2019 with a group of 22 delegates (reported in IRSE News January 2020 issue). Our second and first truly inter-continental tour took place in March 2020 when a group of 21 young rail professionals from across the UK travelled to Japan for 11 days (12 nights). A country famed for its technical innovation and high levels of passenger service.

Due to the suspected demand and to give potential delegates an equal opportunity to take part, places were offered on a lottery basis. We received over 150 expressions of interest. This was fantastic and demonstrated that young railway professionals are keen on accessible, affordable and relevant tours.

It was looking like a great trip with a great itinerary planned across various cities in Japan and some fantastic professional tours with JR-Central, the Railway Technical Research Institute, Hitachi and JR East. However, due to the beginnings of COVID-19 we had to make multiple changes to the itinerary including altering flights and tours to ensure the safety of delegates and Japanese counterparts. We ended up with a different tour than was initially envisaged, however thanks to the YRT organisers, who remained prepared with multiple alternative activities, it didn't result in the tour being any less interesting for delegates and it was still a fantastic chance to experience the Japanese railway network and culture.

The group met early on Friday 13 March 2020 to head towards London Heathrow Airport for an early flight to Tokyo (via Paris). This was a good chance to meet everyone and start to get to know each other as we were together from 0900 UK time to 0910 Japan Time on the 14th, a calm 16 hours.

Arriving into a very cold and snowy Tokyo on Saturday morning we headed to our hostel together and spent the day recovering from jet lag in whatever way we each deemed best. On Sunday we all explored Tokyo. We visited Tsukiji Fish Market, Hamarikyu Gardens, took a water bus up to Asakusa, explored the Senso-ji temple and headed to Shinjuku where some of the group visited the Samurai Museum. This was a good day to network with the delegates as well as exploring some of the sites of Tokyo. Later in the evening we met together for our first group dinner at a train themed café called "Little TGV".

The YRT group after dining at the "Little TGV" railway-themed izakaya in Akihabara.
All photos Keith Upton.

Left, Komachi (red) and Hayabusa (green) shinkansen services travel in coupled formation past Oji station, where the group began their tour.
Above, Takanawa Gateway station has received significant media coverage in Japan as a major development ahead of the Tokyo 2020 Olympic games.

Monday morning was our first professional tour. We met with Japanese tour guides from Otomo Travel in Oji for a "tour for train lovers and photographers of all ages". We explored Asukayama Park, a great viewpoint of the local and Shinkansen railway lines, took a trip on the tram and viewed a local JR depot. The tour guides were very knowledgeable of the Japanese rail network and it was a chance for the delegates to learn about its history. Trams were the main transport in Tokyo until the two rapid transit systems took over in the 1960s. The national railway network was state-owned until privatisation in 1987, when it was split into seven regional companies all under the Japan Railways (JR) Group (though a large number of private, independent railways have long operated across Japan). The Shinkansen was introduced in 1964 just before the last Tokyo Olympics and there are now nine Shinkansen lines each with its own train set.

The afternoon was free for the delegates to continue exploring Tokyo before meeting in the evening for a typical Japanese experience, group karaoke!

Tuesday morning, we attended our second professional tour. It had been recommended by our JR East contacts to visit a brand-new station that had only opened on 14 March, Takanawa Gateway. This station was bright, open and a nice place to be. We weren't the only visitors; there were lots of locals also exploring the station. This station had the latest high-tech features including an automated convenience store and multiple AI (artificial intelligence) posts where you could ask any question and the system would provide an answer. The station was also an eco-site with multiple eco features including a membrane roof, the use of sustainable wood materials and solar/wind power. The group enjoyed exploring this new station and understanding how the Japanese rail network works.

The afternoon was again free for further exploration of Tokyo in smaller groups. Some explored the many transport systems in Tokyo including the Yurikamome Line, an automated driverless metro named after the black-headed gull native to Tokyo, and the Tokyo Monorail. The group gained an appreciation of one of the busiest metro networks in the world alongside all the other transport systems in Tokyo. Impressive on-board passenger information systems display the platform layout at each station including your carriage's location relative to exit/transfer points, and throughout the trip we noticed that the majority of platforms in cities and across the Shinkansen network have half-height platform screen doors with markings for where to queue for each specific coach.

On Wednesday, we left Tokyo and boarded the Shinkansen for Hiroshima using our JR rail passes, kindly donated by Trainline – a guide to all the pass types can be found on their site at irse.info/s1tmz. The JR Pass allowed travel anywhere on the JR network for seven days and was incredibly useful, enabling us great flexibility. Our first Shinkansen trip as a group was on board the Tokaido Shinkansen, which was the first high-speed line in Japan. Tokyo is a large station and different Shinkansen leave at the same time in opposite directions, therefore this was a successful trip as only one person managed to miss the train with the group, and I can neither confirm nor deny that the person who managed to get it wrong was your author.

Everyone was impressed with the efficiency of this network, including the turnaround times at Tokyo where the trains are

The Passenger Information System on a Tokyo Metro 08 series EMU operating the Hanzomon Line.

The famous view of Mount Fuji travelling west out of Tokyo.

often emptied, cleaned and boarded ready to go within 10 minutes. This is partly due to the fact that the cleaning staff line up at each platform screen door before the train enters the platform, so as soon as the train arrives, the passengers leave and the cleaning staff are straight on the train. During the cleaning period the new passengers will line up in the designated queuing spaces on the platforms. Once the cleaning is finished the passengers will board and the train will leave on time.

The trains are very comfortable, with plenty of leg room, wide seats and either 8 or 16 carriages. There is a respect for these trains as all staff will bow every time they enter and leave each carriage. The timings are also perfect. There are multiple trains which use the same route, however some (Nozomi) are faster as they have fewer stops. Therefore, the Shinkansen that we boarded (Hikari) are timed to stop at specific stations for 4-5min, and during this time two faster Nozomi trains will overtake. All Shinkansen lines use a dedicated network and can run up to 13 trains per hour.

After 4.5 hours zooming through Japanese countryside and cityscapes at speeds up to 175mph (285km/h), including some photos of Mount Fuji, the group arrived in Hiroshima.

Arriving in Hiroshima the group went to Miyajima to explore the famous Itsukushima Shrine and the beautiful island. This island can be accessed by either tram or train and is a recommended island for any visits to Hiroshima.

Delegates were also able to visit the harrowing and moving Genbaku Dome, a building that was almost directly underneath the explosion from the world's first atomic bomb. The building was completely gutted by fire but avoided complete destruction, unlike the surrounding area and Hiroshima Peace Park; both are a symbol of Hiroshima and a focus of prayers for world peace.

On Thursday the group boarded the Sanyo Shinkansen for Himeji. Himeji is famous for its magnificent beautiful surviving feudal castle. The delegates explored the castle grounds and the surrounding Mount Shosha before boarding the Shinkansen later in the day for Kyoto.

The evening was free to explore Kyoto before heading to bed for another busy day on Friday.

Friday, we attended professional tour number three where we boarded the Sagano Scenic Railway for a 50 min return trip alongside the beautiful Katsura River. The traditional train wound its way along the valley complete with wooden seats and beautiful views living up to its name as a scenic railway. This was a chance for the delegates to relax and appreciate the beautiful Japanese countryside.

Attendees gather aboard a "torokko" on the Sagano Scenic Railway. The name derives from the English "truck" and refers to an open-air rail coach.

An E6 series train operating the Tohoku Shinkansen (near) and an E7 series train operating the Hokuriku Shinkansen (far) at Tokyo station.

After this scenic train journey, the group split into two. Half headed back into Kyoto while the other half took a 2.5-hour train journey to an onsen town called 'Kinosaki Onsen'. Onsen are Japanese hot baths, with naturally heated water from geothermal springs. This is a traditional Japanese experience, with the group staying in a ryokan (traditional inn) and able to explore the seven onsen in this beautiful town wearing a yukata. This was a new experience for the majority of the group with specific rules and procedures to follow, however it was a chance to relax after a busy first week. The group enjoyed their time in the onsen town and came back feeling more relaxed.

On Saturday, the two groups met together in Osaka. The weekend was free for delegates to explore Osaka (considered the food and drink capital of Japan), with its highlights being Osaka Castle and the Dotonbori district, or Kyoto (considered the cultural capital of Japan). The 30 min distance between the two cities gave the delegates the freedom to explore either city and soak in Japanese culture. On Sunday night the group made their way back to Tokyo on the Tokaido Shinkansen.

On Monday the group made their way to the Usui Pass for the fourth and final professional tour of the trip. This pass was around 90-min outside of Tokyo (using the Hokuriku Shinkansen) and was an experience of more rural Japan. We visited the Usuitoge Railway Heritage Park, a park to look, touch and experience the history of the Japanese rail network. Unfortunately, the museum descriptions were all in Japanese, however we enjoyed looking at some of the older Japanese trains and technology on show (including some older signalling control systems).

Monday afternoon was free time in Tokyo before meeting for the final dinner together in the evening. This was a chance to share memories of the trip and to continue networking. By this point the delegates had become well acquainted and so there was a good atmosphere.

Tuesday was the last day of the trip and so was a free day to explore Tokyo, buy souvenirs and generally get ready to head back to the UK. Our return to the UK on Wednesday was surprisingly smooth and we returned just at the right time before any complications started.

The trip to Japan was thoroughly enjoyed by all delegates and all have come away with an appreciation of the Japanese culture and railway network (even during a global pandemic); many have also learned new skills from the conversations with other disciplines. Furthermore, the friendships and networks that each delegate made during this trip will last a lifetime!

In total we did around 1770 railway miles and walked over 100 miles (over 206 000 steps!) over the 11 days. YRT is currently thinking about its next international trip once the COVID-19 crisis is over and welcomes any young rail professional to consider joining us. So, watch this space. If you have any questions regarding YRT or its future tours, please get in touch with the YRT team on **youngrailtours@gmail.com** or visit the website **youngrailtours.com**

Meet the new Younger Members Section committee for 2020

Chair – Aaron Sawyer

Vice chair – Elliott Jordan

Treasurer – John Chaddock

Secretary – Robin Lee

Publicity secretary – Prerna Sharma

Ex-officio Member – Daniel Woodland

Voting members: Alessandra Sternberg, Shuxia Lu, Michael Herries, Chris Jones, Chris Oxford, Alexander Patton, Tom Corkley and Keith Upton (past chair)

We wish everyone luck in their new roles.

Module A study day

On Saturday 25 April the Younger Members section held a signalling study day to prepare candidates for the IRSE professional examination. Over 60 people participated from around the world (some who stayed up into the small hours to take part) and one of the benefits of moving such events online is to enable attendance by people who wouldn't have been able to travel to the physical event. A 'virtual pub' after the session enabled informal discussion of the day's material by the attendees.

Many thanks to Reuben Dakin, who presented on headway and scheme design, Peter Woodbridge, who presented on the trackside aspects of signalling and led an innovative interactive multiple-choice test for candidates preparing for Module A of the exam, and Andrew Love who presented on automation, both on the train and in the control centre. Thanks also go to John Chaddock and Robin Lee for the superb organisation and logistics for the event. A recording of the event is available on the Insitution website, **irse.info/f6klx**.

Younger Members unlock STEM programme

Report by Aaron Sawyer

In May 2020, armed with pioneering zeal, IRSE Younger Members Section embarked on their first event in the IRSE Science, Technology, Engineering and Mathematics (STEM) programme. This initiative seeks to captivate and inspire quizzical children: a greenhouse to nurture our next generation of engineers.

Now more so than ever, with many schools around the world closed due to the global pandemic, providing the support to parents and teaching institutions is essential. The climate we find ourselves in provides an opportunity to create a far-reaching and meaningful impact on the members of our institution and the wider society. As seen in so many industries the value in online webinar platforms is in providing a powerful vehicle for delivering information remotely. As such the IRSE Younger Members have been quick to utilise this valuable tool to reach our communities and deliver the STEM programme.

The first event kicked off with some of the Younger Members introducing themselves. They discussed how they came to be within the rail industry and the diversity of their engineering careers, embellishing with their very own fun facts about railways around the world.

The event went on to invite parents and children on an adventure around the world with the Super Train Challenge, following the IRSE Younger Members' very own protagonist "The Great Inventor Prerna". Participants were challenged with helping Prerna to design a global railway and journey through forests, deserts, cities, under the seas and over mountains.

As well as coming up with creative ways of tackling the variety of terrains, our budding young engineers were also tasked with route setting and stopping off to visit all the IRSE Sections around the globe. With their route laid, they then began to design and build their very own 'Super Trains'. Creative activities such as sketching, planning and modelmaking enabled the children to practise some of the engineering skills required to pursue our fulfilling and rewarding careers later in life.

The webinar closed with a fun facts quiz and a series of impressive questions from the audience on topics ranging from the famous engineers who inspired us, the energy sources of the future, to our all-time favourite trains. The results from the quiz and the quality of the questions alone demonstrated the positive engagement from the audience, but the pictures shared following the event of the children's Super Trains provided the warmest and most rewarding feedback of all.

Some very young IRSE supporters involved in the STEM Programme.

As an institution whose objective is the collection and publication of educational material, the IRSE now has its very own STEM programme to be proud of.

Spearheaded by the Super Train Challenge, the institution is helping to build the skills, content knowledge and fluency in the STEM fields required to meet the demands of our industry's diverse, dynamic and evolving workforce.

The IRSE Younger Members are looking forward to bringing you the next instalment of the STEM Super Train Challenge.

Past lives: Chris White

Chris White was the epitome of the dedicated railwayman. Born in 1942, his parents ran a market gardening business in the Devon village of Budleigh Salterton. He loved trains from an early age and on leaving school, he became a probationer (nowadays a trainee technician) based at Exeter on the Western Region of British Rail (BR). Chris soon got to grips with the rudiments of basic signalling and telecoms but learned more modern technology as part of the Bristol Power Box project.

Chris White, 1942-2020.

On completion of his apprenticeship, Chris chose to specialise in telecoms and moved to Slough as a maintenance technician. He later became a telecoms works engineer and was involved in the provision of the Bristol-Paddington 4MHz transmission system. In 1976 he became the telecoms maintenance engineer for the Southern Region based in Croydon. Chris soon realised that failures of main station indicators or public address equipment could cause chaos in rush hour, so set about creating a regional telecoms fault control based in Croydon. Staffed around the clock, it quickly revolutionised how telecoms was managed with the control room staff being able to prioritise faults and direct the telecoms technicians around the region.

In recognition of his achievements, he was promoted to the top telecom maintenance post at BR HQ, where he set about introducing the same standards for fault controls on a national basis. During the mid-1980s, Mercury Communications became a competitor to BT (the public telecoms operator) with Mercury installing its own fibre cable network located on the railway and maintained by BR. The maintenance regime stipulated strict times for the repair of faults and financial penalties imposed if these times were not met. Chris and his team had to significantly improve the response times, and he was instrumental in the telecom group being BS 5750 (a quality management standard) registered.

With BR being privatised, a new division was created – BRT (British Rail Telecoms). The managing board was populated by people recruited from the wider telecom industry but Chris and I were transferred to keep the railway communication networks functioning. Chris was never comfortable with the new arrangements, where safety and quality within BRT was initially only given lip service, and the continuity of providing telecom services to the new rail companies was never high on the agenda.

He retired from BRT before its sale to Racal Electronics but Chris took the opportunity to use his undoubted skills in other ways. Working for Atkins, one of his first tasks was to assist Railtrack with the Year 2000 millennium data problems. Other projects included provision of a quality management system for Irish Rail, telecom documentation for the Channel Tunnel route from Waterloo, support to Metronet for the design of new telecom systems on LUL, advice to Network Rail in Scotland on migrating the track to train radio system to GSM-R, telecom systems for a major rail upgrade project in Denmark and lastly, assistance and advice to Crossrail on telecom issues.

Alongside all of this, Chris pursued his love of railways and steam engines. Joining the Bluebell Railway (a heritage steam railway) as a volunteer, he became first a fireman and then a driver, enjoying a regular shift at weekends and a whole week of footplate work during the summer. The Bluebell soon realised he had other talents and Chris became the safety director, where introducing a safety management system was a challenge for a largely volunteer work force.

The Bluebell needed an infrastructure director to complete the extension northwards from Kingscote to East Grinstead and Chris rose to the challenge. The main obstacle was the excavation of rubbish from a filled in cutting. Whilst the logistics of removing the waste material was hard enough, the planning, environmental and financial elements were equally difficult. Removing the rubbish by train was a nice touch and the extension duly opened on 23 March 2013. An interview with Chris about the extension work can be found at **irse.info/iqe31**. Thereafter, Chris continued in his dual role of infrastructure and safety director overseeing all major track and civil engineering projects until in 2017, Chris stepped back from infrastructure and reverted to safety director only. He was persuaded to take up infrastructure again in 2019. During this time, he still worked for Atkins, supporting the main railway telecoms function.

From humble beginnings, Chris achieved much during his career and was an inspirational leader to those who worked for him. His 'can do' ethos will leave a legacy of successful projects and a fitting tribute to his memory. Chris died recently after a short illness and will be sorely missed.

Clive Kessell

Your letters

Existential threats?

I greatly enjoyed reading our new President's Address. And I was encouraged to see that the final paper in the series will combine Ian Mitchell's long experience of control centre automation with an external human factors expert. As we are finding out with our first integrated Traffic Management system, culture is as much an issue as technology.

However, I would take exception to the claim that 'the railway industry is also facing potentially existential threats from increasingly innovative competing transportation modes', with self driving cars instanced as a challenge. I have been surprised to hear this 'threat' quoted by senior railway figures at conferences when I find it hard to think of a credible application.

Commuting? When my autonomous car is stuck in the Swiss Cottage gyratory, my commuter train from Welwyn Garden City will already be in Kings Cross. Intercity? Do I really want to slog up the A1 to York, with no buffet or catering trolley, let alone a cooked breakfast and no toilet?

As far as I can see, the only serious threat is to rural lines where autonomous vehicles could offer mobility as a service. If and when they ever arrive

Meanwhile, the real challenge for the signalling profession is to help provide more capacity on the network to accommodate the modal shift of passengers and freight from road to rail as electrification proves to be the dominant solution to surface transport decarbonisation.

Roger Ford

Working from home: safety impact

I was looking through the 'working from home' section of the IRSE news and it raised a question in my mind.

Has anyone looked into the safety impact of people working from Home? The design offices of engineering companies are now home office based and this may have an impact on the safety of a system. While we can still follow the processes, there is a softer level of assurance that comes from debate and discussion within a design office. This may reduce the overarching safety level of the design process.

I would be interesting in seeing if any companies have picked up a decrease in quality, or introduced additional layers of protection. I am thinking plenary sessions for design at key points in the design phase to try and recreate this assurance level?

Neil Dance

Where is the train?

The early railway pioneers faced a multitude of problems. The actual construction of the chosen line, the design of locomotive and rolling stock, presented an immediate priority. Braking systems did not feature large on the list and dependence on a single brake at each end of a train was common until the late-1800s – rear-end collisions might be regarded as a routine hazard of railway travel. Indeed, continuous braking on freight trains was not common until the 1980s.

Similarly, the separation of trains was not given any priority, by even the simplest signalling system. The question, "Where is the train?" was a permanent preoccupation and this problem emerged at an early stage in railway development. Nobody could be certain, exactly where a train was situated on a track, least of all just which direction it was travelling or expected to travel. It would take half a century before this problem could be resolved.

A crude measurement of a train's position was based on comparison with its timetable. Later, the use of a train staff/token issued to each train gave drivers some confidence that they, and they alone, had authority to occupy a single line. Such systems are commonplace today, in some areas. The days of continuous track circuit block, axle-counters, ETCS, PTC, CBTC, however, were a distant dream. After all, safety measures cost money and were difficult to justify in business terms. Curiously, even today, a business case for expenditure on safety alone can be still problematic. Readers of "Red for Danger" by LTC Rolt would find some details of railway accidents which today seem ludicrous notwithstanding some tragic results.

The invention of the track circuit in the 1870s was a major step forward, although its simple concept could not suit every situation. DC Gall`s book, "The Track Circuit" has a preface which itself was a warning –"The reader is expected to have reached graduate level in his understanding of electrical engineering". The basic idea of insulating a section of track, applying a voltage at one end of the section, operating a relay at the opposite end, and using the axles of a vehicle to 'short circuit', the relay, proved to be overly simplistic. Careful adjustment must be maintained to ensure reliable operation in all conditions of weather and state of ballast, yet always be certain of detecting the presence of a vehicle. However, the track circuit, in all its forms, has served the railway well in some countries, for many years.

Of course, there were implications as the sophistication of train detection accelerated. It is to the enormous credit of the maintenance technicians who absorbed the increasing levels of technology over the years.

The introduction of axle-counters was a long-drawn-out process. Experimental installations in the 1950s were unsuccessful for various reasons, not easily overcome. An early introduction of such an installation near Bristol, took place in 1974 but was only used when regular flooding of the track occurred in winter, rendering track circuit operation uncertain; it was not regarded as a representative as an example for more general application. Advances in design and functionality over the years have now established the axle-counter as the technology of choice for most modern schemes.

However, developments in the field of train detection brought their own problems. One technique depended on the measurement of the distance travelled by the train from a known point and this approach is often the basis of train detection in train borne digital signalling systems. The problem here is that in a `virtual` signalling system, the detection of a train also becomes 'virtual' – there is no positive relationship with the train physically occupying a section of track. That said, if one accepted the position of the train was valid, actually confirming this presented a maintenance technician with a significant problem. For example, he needed to know, and be trained in, the type of train borne system in use on any particular vehicle.

Thus, fault-tracing required knowledge, skills and perhaps tools/ spares, appropriate to the system overall, from the outset. Where this individual should be based and how he would reach the site of work became further problems.

A serious problem can occur in the event of a major power failure. A track circuit failure in such circumstances is self-rectifying once the power is restored. This is not the case with other forms of train detection, such as axle-counter or ETCS/CBTC based systems. Special arrangements are necessary in such cases, to avoid a subsequent wrong-side failure during the passage of a train.

Michael Page

Re Back to Basics: Interlocking part 2

In 'Back to Basics' Part 2 the author states that there is no possibility of reverting mechanical signals when the electrical controls revert. This is not entirely true.

While working in Pakistan in 1971, on immunising the existing signalling, I came across a 'reverser'. This connected the signal operating wire at the signal to the signal arm, when a voltage was applied to it. When a train passed the signal and occupied the next track circuit the feed to the reverser was cut off and the signal immediately reverted. The signal operating lever would not be put back in the frame until the whole of the train had past by, to retain the locking, but the signal was now safely at danger behind the train. No doubt this feature was common throughout India and Pakistan.

The intention at the time was to immunise the reverser by placing an immune relay in the line to it. This relay had to be up for the ongoing feed to the reverser. I had a feeling that this wasn't necessary so arranged a test of a reverser. Even with 440V 50Hz applied it still wouldn't operate, thus demonstrating that they were indeed inherently immune, as I suspected. Hence the modification was avoided. See irse.info/9jt1y.

David Thornber

Recent Industry News

The February edition, Industry News section informed us that a contract for the resignalling of Swinderby had been awarded by Network Rail. This was of interest to me because it was a project I had wished to have seen completed before retirement. Swinderby had been excluded from the Lincoln resignalling project because of possible funding for a road scheme by the department for transport which would have resulted in a reduction of status of various Swinderby area level crossings or even possible crossing closures at some point in the future. The resignalling of Lincoln therefore went ahead without Swinderby included and replaced the semaphore signalling at Lincoln with colour-light signals, also introducing the then new Lincoln Control Centre which was built to control a large part if not all of Lincolnshire. Along the route to Newark from the new Lincoln resignalling, Swinderby then became a sort of "buffer zone" with an isolated section of semaphore signals (SY2 and 3 on the down and SY14 and 15 on the up) which remained between Lincoln Control Centre and the fringe of Doncaster PSB. It's nice to see this logical step being taken to complete this work and hopefully as step towards more renewals work around Lincolnshire in the future.

Following on from this your March edition Industry News included the news that ETCS for the East Coast Main Line was also making progress with the appointment of contractors for the southern section of the route. This was again a slight regret for me at the time of retirement, in that we had spent 18 months up to that point with initial meetings to consider train fitment, driver training, ETCS arrangements, and issues such as the conversion for drivers along the route to and from traditional colour-light signalling areas. A lot of effort had been expended even up to then in consideration of how best to introduce ETCS and so it is good news that this too is progressing.

May I thank the IRSE News for the, articles, papers, and Industry News. All are interesting and keep us informed.

Stephen Gall

Preserved St Albans South Signal Box – an update

IRSE News was kind enough to print in your February 2011 issue an item about the above box having won the Invensys signalling award in the 2010 National Railway Heritage Awards.

Looking at our website to update various of our news pages (irse.info/nub4y) I was reminded of this article and thought your readers might appreciate some further news of this box. The most significant is that up to March's open afternoon this year– the last before the Corona Virus shut-down– we had had some 25 500 visitors since October 2008.

Developments at the box since 2010 include improvements to the computer simulator which runs our demonstrations on the operating floor of the box, installation of a narrow-gauge point (courtesy of the Talyllyn Railway) connected to a ground frame that visitors can work, a second working Midland Railway signal, commissioning in 2011 of a four-aspect signalling demonstration using 1970s signals donated by Network Rail, and in 2016 a similar arrangement of LED signals donated by an East Midlands railway supplier company.

Also of signalling interest is a miniature lever-frame with tappet locking with which visitors can operate model signals to understand better why there is interlocking and how it functions.

A wide range of signalling equipment, railway-related signs and other railway ephemera is exhibited around the site and in our museum in the ground floor of the box.

We are always happy to see professional signal engineers and other railway professionals at the box– once we are allowed to reopen, of course!

John Webb
Trustee and publicity officer

Tell us what you think

Remember that our Institution thrives by the mantra of inform, discuss, develop. If you have information, discussion points or your experience about topics raised in articles you've read in IRSE News, or indeed any relevant issue in the field of railway command, control, signalling and telecommunications let us know so that we can share those views with other IRSE members.

Email editor@irsenews.co.uk.

IRSE Publications

We are pleased to announce the reprinting of two IRSE text books:

Railway Signalling was the first of what has become a sequence of IRSE textbooks dealing with railway signalling and telecommunications developments. The book was first published in 1980 and covers the period of development of the then standard British Railways system of Multiple Aspect Signalling (MAS) through the 1960s and 1970s. The book is largely focussed on British Main Line signalling practices but will also be of use to those elsewhere in which signalling concepts are different who may like to make comparisons with British practices. The book is popularly known as the 'Green Textbook'.

Introduction of Railway Signalling. The first two chapters introduce the subject of signalling and assume no knowledge is held by the reader. They describe in general terms the various items which when connected together make up a signalling system. Subsequent chapters deal with the separate items in more detail – points, lineside signals, relay logic, train detection, interlockings etc. The subject of Automatic Train Protection has a chapter to itself as does the topic of electronic interlockings. Whilst the technology used to control trains continues to evolve with cab signalling systems now becoming common on main-line railways, the basic techniques and topics described in this book will remain relevant for years to come.

Apart from the change to the current IRSE logo there are no changes to any of the content of the books. The books are available at **irse.org/store**.

Quick links

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Advertising

For advertising rates and deadlines call the IRSE London Office +44 (0)20 7808 1180, or e-mail hq@irse.org.
Advertisements are accepted on the basis that the advertiser and agency (if any) warrant that the contents are true and correct in all respects.

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

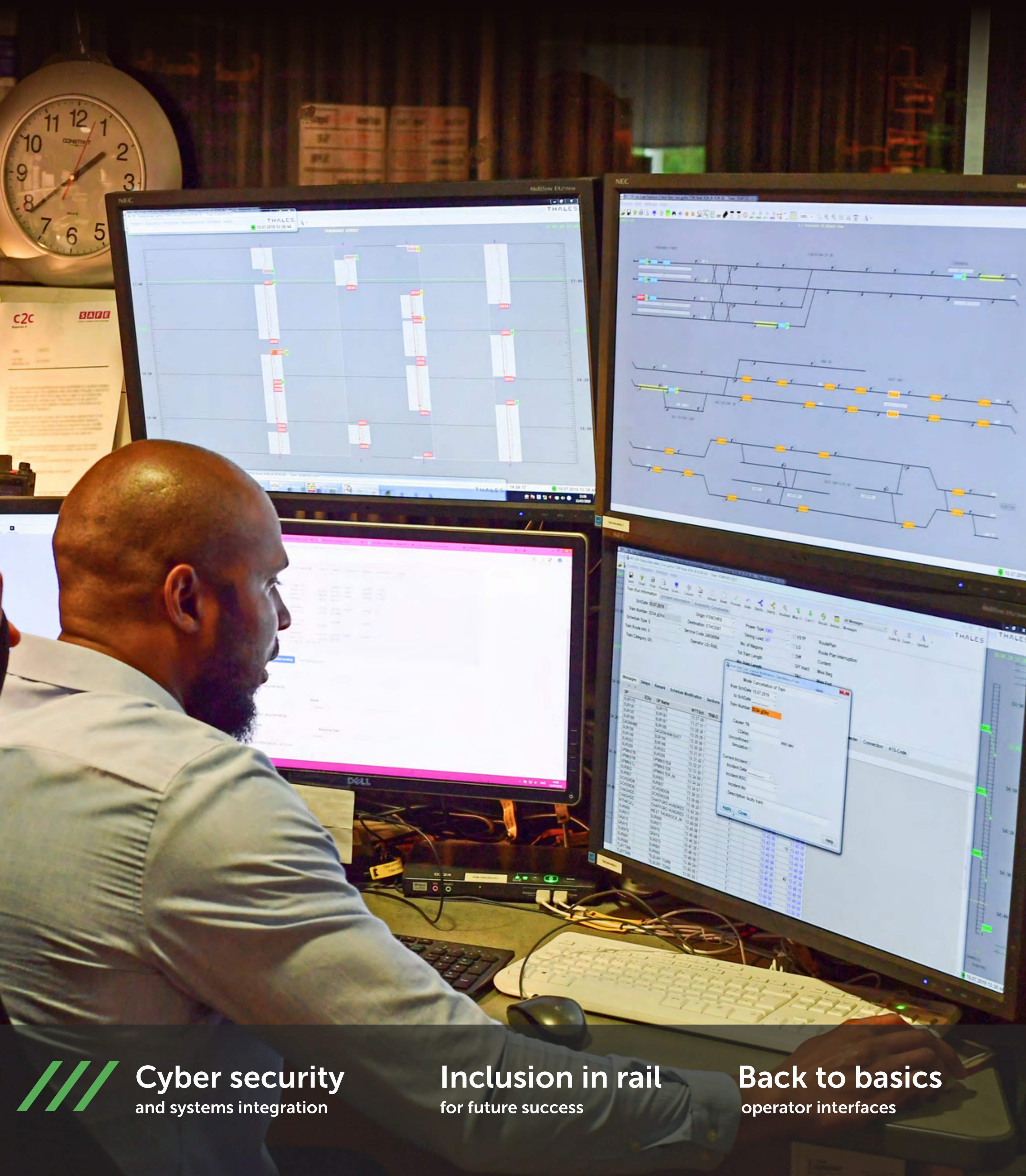
Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

IRSE News

Institution of Railway Signal Engineers

September 2020



Cyber security and systems integration

Inclusion in rail for future success

Back to basics operator interfaces

MAINTAINING THE NEW NORMAL

Signet Solutions continue to follow government guidelines, keeping our staff and clients safe. We are offering courses online as well as operating from our training school. We'll be altering class sizes to comply with social distancing measures, we can also use bigger classrooms if required. We're adapting, maintaining safety and delivering learning in the 'New Normal'. Please look out for courses coming up online and at our training school. From all of us thank you for your support and stay safe!

+44 (0)1332 343 585

enquiries@signet-solutions.com

www.**signet-solutions**.com

Signet Solutions

Raising the Standard in Development

IRSE
Institution of Railway Signal Engineers

Issue 269
September 2020

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

Filling the gap

A global pandemic will inevitably lead to job losses as businesses try to balance the financial impact with demand and the resources needed to meet that demand. Previous recessions created a major skills gap and we must ensure that history does not repeat itself this time.

Inevitably some companies will need to reduce their workforce while others emerging from recession, or who weren't impacted by it, will be looking to acquire new skills and talent. In previous recessions many of these skilled workers with transferable engineering skills were lost to other sectors. Many refused to return for fear it could happen again. The resulting cost to the engineering community in lost capability and the investment made in development of those skills has been enormous.

As part of a UK Government advisory group I have been working on behalf of the IRSE to develop strategies which although they relate to the UK could equally apply internationally. The Talent Retention Service is an innovative web-based tool for both employers and skilled workers which gives employers the facility to redeploy or 'loan' skilled workers to allied engineering businesses. It also gives access to recruit new talent and a route for engineers facing job loss to advertise their skillset to help find alternative employment.

Senior business leaders must now step up and adopt a common-sense approach. Talent is easily lost and hard to regain.

Our members know the letters after their name represent the shortest CV they will ever need to show others in the sector they are competent and ethical. Registration with the Engineering Council at EngTech, IEng or CEng is a global engineering community recognition that many will use to demonstrate their transferable knowledge, skills and competence. Similarly, the Licensing scheme is a categorical statement of signalling and telecommunications excellence, endorsed by the sector itself.

My gratitude goes to the staff team of IRSE HQ and the dedicated volunteers through this difficult time. Using new technologies, working from home, they have maintained routes to membership, registration, licensing and examinations, and the production of IRSE News, while bringing you online thought leadership and informative talks to equip members to meet the demands of post pandemic transport long into the future.

Blane Judd, chief executive, IRSE

Cover story

The technology for the interface between the signalling system and a human operator varies from mechanical levers and control panels with switches or buttons to computer workstations. They all provide indications and information on the status of the signalling equipment and position of trains, and controls to enable the operator to manage train movements. This month's 'Back to basics' covers the subject of the operator interface.

Photo by kind permission of Thales.

IRSE///
Institution of Railway Signal Engineers

Oh cyber security doesn't affect me … right? Systems integration and cyber security

Colin Hamilton-Williams

This article is based on a paper presented at the IRSE ASPECT 2019 conference in Delft, Netherlands.

Cyber security represents a growth area in the design of new and complex transport systems. As we move into the age of the digital railway, retro-fixing digital systems to protect them against cyber-attack is no longer enough. We need to put cyber security and cyber resilience into both new and existing projects in order to deliver systems that are safe, secure and efficient enough for today's and tomorrow's transport needs.

We're already living in an increasingly digital world, where advances over just the past five years have been staggering. Autonomous vehicles are being tested on our roads. Driverless trains are on the increase. Computer systems on aircraft are so advanced that planes virtually fly themselves. The broad perception is that the railways are finally catching up.

The rail industry cannot afford to stand still and is not. The digital revolution is enabling better connectivity, more data and functions than ever before but this connectivity comes at a price and that price is threats. The linking together of systems to create complex systems of systems combines many singular vulnerabilities or threat vectors into larger vulnerabilities to the functioning of the whole system. This also means that railway companies are being increasingly pushed to open-up their on-board networks to provide passengers with better, more reliable Wi-Fi and overall, a better passenger experience. This new extra connectivity between trains, apps, Wi-Fi, websites and email, to name but a few functions, also means the whole network, as an organism, is vulnerable in a way it never has been before.

However, the change is happening, the requirements and the need are there, whether it be through reducing operating costs or user demands to create these linked data rich systems and as such we need to find a way to embrace them whilst also maintaining strong cyber security and cyber resilience. While digital technologies within our railways' operations aren't new, we are designing for them in ways that we haven't in the past and this is where the connection to systems integration comes in.

As an industry it's our duty to protect that entire end-to-end digital ecosystem, the networks, the apps, the Wi-Fi, the control systems and much, much more. The whole system will only be as strong as its weakest link and, sometimes, that weak link could have been avoided if we were using the right processes and mind set.

Background

In the early days of railways, an effective means to signal rail vehicles simply did not exist. Not surprisingly, there were many disastrous collisions and loss of life. Similarly, there was a period in the history of the automotive industry when car manufacturers denied the importance of installing seatbelts. At the same time, the number of vehicles on the road grew rapidly. Again, there were many accidents and significant loss of life. Thankfully, things have moved on in both industry examples, but not without great sacrifice, and only achieved through a series of outcries, investigations, legislative initiatives, regulatory oversight and the passing of laws.

Then we had rudimentary electrical and electronic systems. They, by their design and definition, were both air-gapped because they didn't have the ability to be connected to anything else anyway, and un-hackable because they either required changes in physical hardware or base logic that weren't possible unless you were there in person. At this stage cyber security was very much physical security; prevent the attacker from getting to the system and you prevent any potential malicious activity.

Unfortunately, that was then and this is now, systems are no longer so rigid and separate. This has led to a confusing and potentially dangerous situation where cyber security is not taken seriously during design, or upgrades are made to a system that were once secure, placing them into potentially dangerous and open configurations.

The scale of the vulnerabilities left open is truly startling and is best summed up by the mere existence of the search engine called Shodan. This search engine is dedicated to finding internet connected devices. With a little knowledge you can find devices from CCTV cameras and printers, accessing their feeds using basic default settings [1]. However, this quickly scales up to the major leagues, finding safety critical assets such as traffic lights and even the control system for a hydroelectric dam. This is an unacceptable level of vulnerability for critical industries and we must get stronger at finding, designing for and plugging our cyber security gaps.

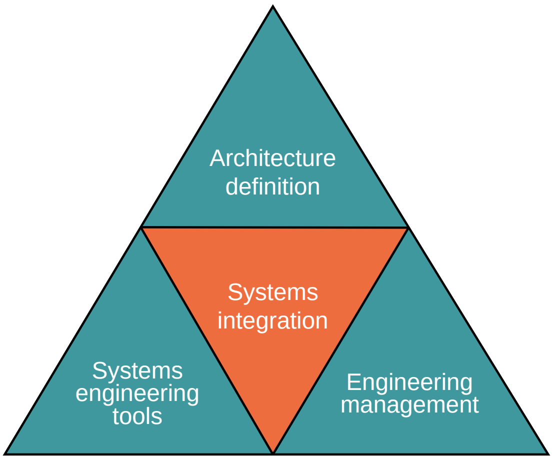


Figure 1 – Main constituent parts of systems integration.

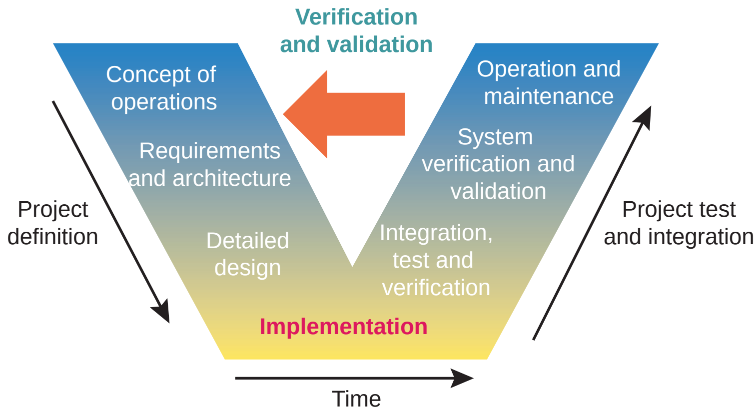


Figure 2 – Lifecycle influence on cyber security.

In 2018, Cybersecurity Ventures (a US based researcher for the global cyber economy, and a source for cyber security facts, figures, and statistics) said:

- Sonicwall reported a 300% year-on-year growth in ransomware, according to KnowBe4.
- Global damage costs in connection with ransomware attacks were predicted at $11.5 billion annually for 2019.
- A previous report estimated ransomware damages cost the world $5 billion in 2017, up from $325 million in 2015 – a 15-times increase in just two years.
- It is predicted there will be a ransomware attack on businesses every 14 seconds, up from every 40 seconds in 2016. This does not include attacks on individuals, which occurs even more frequently than businesses.
- Ransomware attacks on healthcare organisations are predicted to quadruple.
- 91% of cyberattacks begin with a spear phishing email, commonly used to infect organisations with ransomware.

But when so much is at stake, if our rail networks aren't fully protected, and train companies face potential malicious attack like never before, how can we afford not to be resilient? The joined-up approach to managing cyber security and cyber resilience through systems integration needs to consider and address the challenges of concept, maintainability, whole lifecycle costing and future threats.

Cyber security

What is cyber security? In simple terms it is the defence or defensive strategies employed by a system to resist against both remote and local malicious or accidental actions. If we did not have cyber security then it would potentially be possible to hijack and control a system or systems potentially putting them into dangerous configurations.

How does cyber security differ from cyber resilience? If we go back to our example of the seatbelt; cyber security is not crashing in the first place whilst cyber resilience is the seatbelt and airbag prevent loss of life and injuries in the event of a crash. Thus, cyber security is the prevention of access to a system where cyber resilience focuses on recoverability and maintaining functionality, safety and integrity.

Cyber resilience in transportation has unique challenges. Unlike in many commercial enterprises, where data protection and privacy are king, the values at the core of our transportation infrastructure are different. The focus instead centres around three key principles: safety, integrity and operational resilience.

Our current big challenge as an industry is the exponential growth and deployment of digital technologies. That is, both delivering these and doing do so in a secure way. Solutions are designed with good intentions in mind, but by their nature are vulnerable to exploitation and compromise. Previously, industrial systems were protected through a physical separation between the operational environment and the public domain. This air gap is closing, driven by a desire to harvest data and increase automation through greater distributed control across a network.

Systems integration

Systems integration for the infrastructure industry (according to the International Council on Systems Engineering – INCOSE) is the integration of systems within a project, not just the electrical, mechanical, architectural and civil systems, but also all technical and human elements. Often used interchangeably, but incorrectly, with systems engineering; system integration aims to deliver project outcomes through the visualising and managing of the concept system of systems delivering higher level functions and project outcomes. Careful consideration is required to be given to the makeup of systems and sub systems in order to manage the interfaces where complexity and difficulty often lie between disciplines. The main constituent parts of systems integration through a multidisciplinary approach are shown in Figure 1.

Systems engineering on the other hand is a toolset and methodology which can be used to deliver systems integration outcomes. The toolset focusses on the management of requirements and testable outcomes to ensure a system achieves its stated function.

A key tool in the system integration toolset is the management of the systems lifecycle. The systems lifecycle, Figure 2 defines the expected phases of a project and the tools and actions to be used at each key stage. In systems integration, early intervention is key to reducing the cost of change and variation.

Like many industry sectors across the globe, transportation is undergoing its latest evolution: boundless growth in the use of digital technology and widespread connectivity through the Industrial Internet of Things.

Given the many advantages brought about by digital transformation and the advent of Industry 4.0, organisations are understandably eager to reap the benefits and become early adopters. However, this digital evolution must be undertaken in a risk-averse and cyber-secure manner; otherwise, there is a high likelihood of creating more harm than good. Such pivotal change raises some key questions. Is the transportation industry on track to achieve an adequate level of cyber resilience? Are the right technologies, skillsets and frameworks in place to safeguard our nation's Critical National Infrastructure (CNI)?

Combining the lifecycle approach and systems integration thinking with cyber security can not only reduce upfront design costs but also potential issues across the entire life of the system.

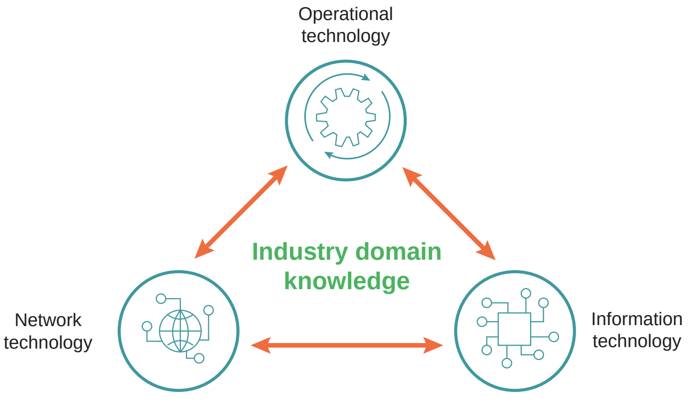
Concept

Business environments typically comprise converging technologies that include information technology (IT), which communicates to enhance business processes via network technology (NT). What sets the transportation and industrial sectors apart is the addition of a third element namely operational technology (OT) see Figure 3. Convergence of these three engineering disciplines creates a "technology trifecta" within which the industry domain knowledge resides. It is the translation of electronic signals in the virtual plane into physical outputs in the real-world plane that amplifies the cyber resilience challenge. In our now cyber-physical world, undesired events can directly affect public safety or the environment.

Rail systems comprise a complex array of network integrated systems and technologies, each with its own specific function and level of criticality. Rail-based transport systems are a melting pot for a multidisciplinary engineering base, where old and new technologies overlap and influence one another. Legacy and modern protocols, in every sense, must now coexist affecting interoperability and accountability. For this reason, addressing cyber resilience for transport infrastructure in greenfield or brownfield scenarios requires a unique approach.

Rail systems and assets are now dispersed, interconnected and remotely controlled in such a way that our infrastructure represents a complex nervous system with many moving parts and entry points. Modern-day rail solutions must be delivered with cyber security woven into the fabric of their design. As a result of this new digital facet, the execution of systems engineering and integration requires a fundamental re-think.

Figure 3 – Converging technologies.



Design

A cornerstone of the cyber security workstream is the Threat and Vulnerability Assessment (TVA). Gaining a system-level understanding of all the assets included within a digital ecosystem, their criticality, function and architecture is required to identify and analyse the threat vectors present in an industrial environment.

A TVA is a key milestone when delivering greenfield infrastructure and is a fundamental element of cyber security engineering work in major projects. Periodic TVAs should be performed throughout the lifecycle of a system to ensure that the cyber security and resilience is maintained.

The goal of the TVA is to highlight the system's weaknesses and translate this analysis into a focused investment of time, effort and resources. Figure 4 shows the different stages of cyber security assessment and how they relate to the systems integration lifecycle.

Safety assets and systems, such as rail control systems or tunnel ventilation systems, are essential to the safe running of metros and railways. Critical systems must be segregated and safeguarded from malicious attack and accidental compromise. Operational resilience is concerned with maintaining availability of passenger services and business continuity of freight movements even in the event of a fault or failure in the underlying network or sub-system components.

These prioritised goals are achieved through pre-emptive secure-by-design and post-inception threat and vulnerability assessments. Cyber engineering must be undertaken by competent authorities who understand the industry domain, the way it operates and the embedded technologies, and can therefore emphasize where risk mitigation or enhancements are required most. Safety, availability, integrity and maintainability are the measures we use to gauge security posture in CNI. Critical systems must be segregated and safeguarded from malicious attack and accidental compromise.

Construction

When considering industrial control system (ICS) digital architectures, there is more than first meets the eye. The Purdue Enterprise Reference Architecture (developed by Theodore J Williams and members of the Industry-Purdue University Consortium for Computer Integrated Manufacturing) was defined to capture Human-Machine-Interfaces (HMI) at the application level, through to the end-point assets, and 'everything' in between. Originally conceived to depict the connectivity between the enterprise zone and the industrial environment, this model is now a powerful tool when depicting cyber security concepts. Below is an introduction to the typical equipment which resides at each level, and a variety of technologies are discussed to explore how our ICS architectures can be secured and depicted in a holistic diagram, comprising the Purdue model (a 1990s reference model for enterprise architecture) levels 5-0. A simplified version of this model is shown in Figure 5.

Enterprise zone (Level 5)

Information Technology (IT) infrastructure systems and applications are confined to levels 4 and 5. Web, accounting and e-mail servers reside in level 5. In terms of security, this level is least trusted and must remain strongly segregated from the operational and/or production environments.

Site business planning and logistics (Level 4)

Level 4 is an extension of level 5 and it incorporates IT systems responsible for reporting, scheduling, operations and maintenance management, e-mail and printing services. Access

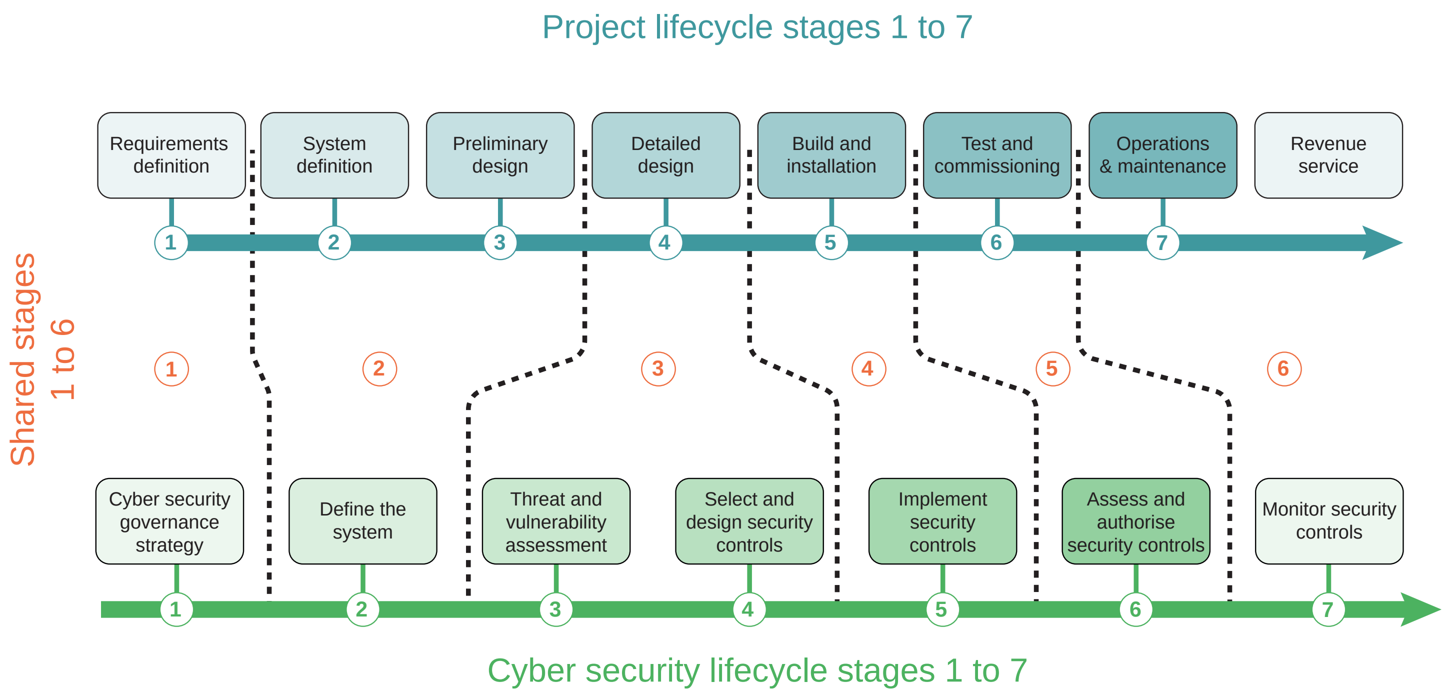


Figure 4 – How the different stages of cyber security assessment relate to the systems integration lifecycle.

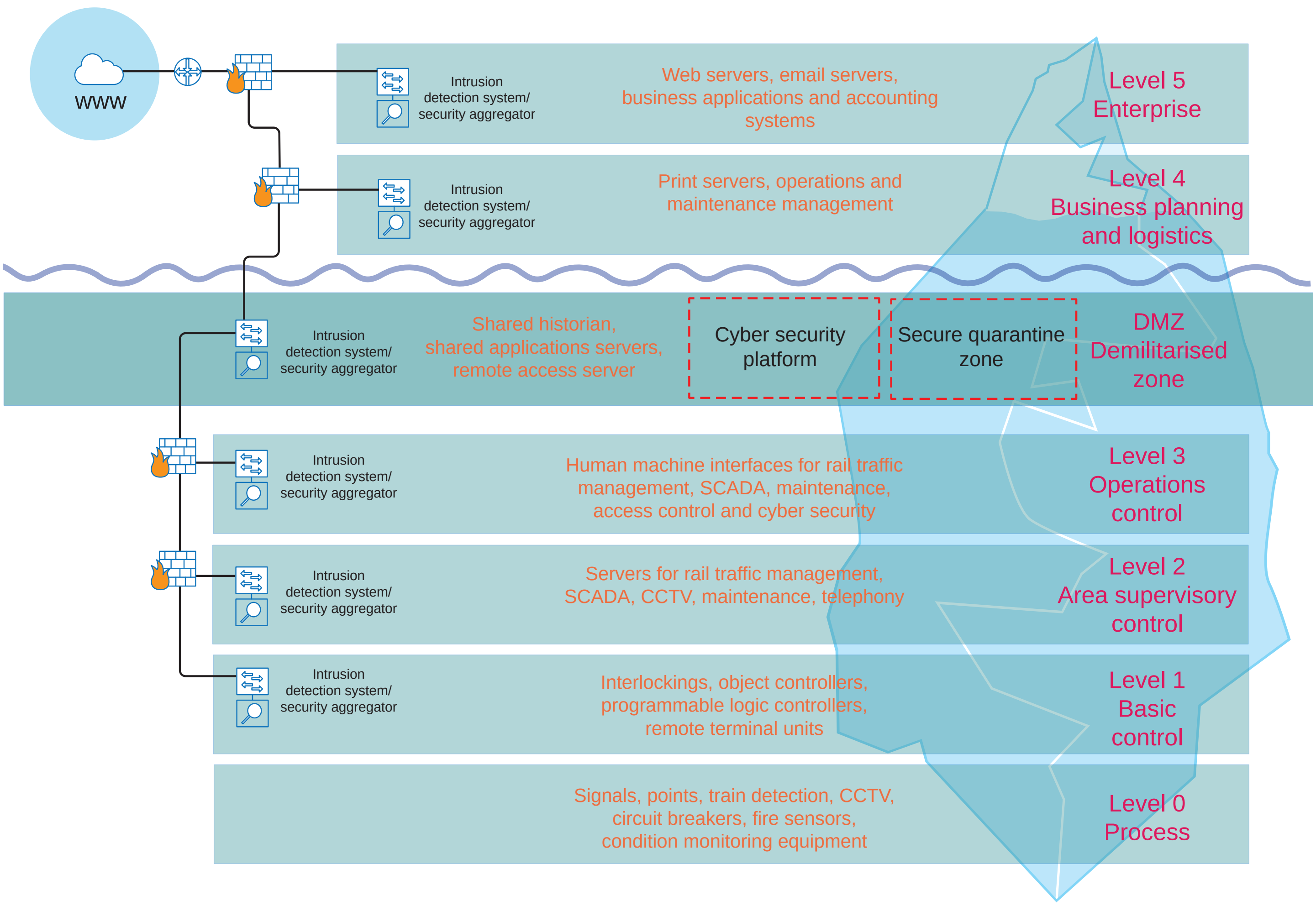


Figure 5 – A simplified version of the Purdue model, showing quite how much of the 'iceberg' sits under the surface.

to the ICS environment is managed through a Demilitarised Zone (DMZ). There is an increasing appetite for transferral of valuable data from the lower levels of the hierarchy into level 4 to enable business and optimisation decisions. This must be carefully enabled to protect critical systems.

Demilitarised zone

The DMZ operates as a buffer where services and data can be shared between the ICS environment and the enterprise zone. The DMZ enables the effective segmentation and security control. High visibility of network traffic exchanged can be gained at this level of the Purdue model, which enables deep packet inspection, anomaly detection, prevention and many other security functions.

A Cyber Security Platform (CSP), comprising security tools and technologies may also reside in the DMZ. The functions are centralised and cascade down to serve the lower levels. The security tools, systems and servers depicted in the Purdue model represent only a sample subset of the potential options that could be implemented within the CSP. A quarantine area is defined in the DMZ where external removable media used for updates and upgrades can be manipulated securely.

Operations and supervisory control (Level 3)

The components in level 3 are typically the front-end interface of the end-point devices. Equipment at this level enables replication, supervision and operation of ICS assets, for example: SCADA, rail traffic management, access control, telephony, CCTV, and the CSP. The HMIs and applications in level 3 communicate with level 4 systems through the DMZ. Direct communication between these levels is highly discouraged.

Area supervisory control (Level 2)

Level 2 is where the core systems, servers and hardware reside. Maintenance terminals here are operated by trained ICS domain engineers and enable configuration, interrogation and manipulation of systems. The Network Management System (NMS) monitors network behaviour, builds a topology and provides a portal for implementation of NMS security policies. The system backup and image servers are also depicted in level 2.

Local control (Level 1)

The DCS represents the control entity, which could be a rail control systems in rail applications, an energy management system in power grids, or a parking management controller in smart cities. Process control equipment is included in level 1 and comprises non-Safety Integrity Level (SIL) and SIL Programmable Logic Controllers (PLC), interlockings and object controllers responsible for continuous, sequence, batch and discrete control. These level 1 devices directly manipulate the behaviour of the physical assets at level 0.

Process (Level 0)

Level 0 includes the instrumentation elements which directly connect to and control the process. For instance, assets at level 0 may include traffic signals, level crossing barriers, CCTV cameras, circuit breakers, sensors, smart meters, ventilation systems and fire detectors. In rail, many of these systems are safety critical.

Testing

Despite a similarity in the technologies used, there is a vast difference between typical data centres and industrial networks. Conventional ways of working in a traditional IT environment are often not possible due to the limitations and requirements of the industrial world as the requirements are different. This changes the way the systems must be designed, procured, built, tested, operated and maintained. Industrial devices and their functions are often proprietary in nature and may be sensitive to patching, updates or overlaid virus protection.

Thorough testing is a must, before deploying updates in a sensitive production or operational environment. Table 1 provides a summarised comparison.

Category	Conventional IT	Industrial control systems
Virus protection	Widely spread	Complicated, often impossible
Lifecycle	3-5 years	5-20 Years
O&M outsourcing, support	Widely spread	Uncommon
Patch management	Regular, daily	Seldom, need approval by Systems Authority
Modifications	Frequent	Seldom
Time dependency	Delays accepted	Critical
Availability	8x5/260 – 24x7/365	24x7/365
Cyber security awareness	Good	Limited
Security testing	Secured, by personnel	Seldom, problematic

Table 1 – A comparison of various characteristics of conventional IT and industrial control systems.

Defences

Relying on firewalling is no longer sufficient to ensure cyber resilience based on the following:

1. Hackers have the resources and capabilities to circumvent a network perimeter to infiltrate critical infrastructure.
2. Insider threat actors may have access to equipment on the protected side of the firewall.
3. The most common cause of cyber incident is human error – a firewall in fact performs a very narrow security function and does not protect against the many sources of compromise.

Firewalls and endpoint protection remain the first line of defence and should be properly implemented and configured. A defence-in-depth approach consists of employing different levels of security and implementing different tools and technologies to achieve cyber resilience. The technologies below offer protection and enhancement beyond that of a firewall.

Software Defined Perimeter (SDP) – SDP is a security solution which combines different security features to ensure that all endpoints attempting to connect to a network infrastructure are grouped, authenticated and authorised prior to being granted access. The SDP technology enables network engineers to define user groups efficiently, through a software driven tool and graphical user interface. This removes the overhead resulting from network reconfiguration and redesign, inherent to conventional mechanisms, e.g. Virtual Local Area Networks (VLANs), subnets and access control lists. The result is a series of manageable and dynamic logical segments, as an overlay to the network fabric.

Asset management – Employing tools that can perform automated asset discovery, classification, register and management is a surprisingly simple security measure which provides full visibility into the ICS network. This also supports planning of maintenance projects, prioritising upgrades, deploying patches, developing incident response plans and proposing mitigation strategies.

Data diodes – Where data exfiltration by the ICS operator or maintainer is sought, this must be achieved in a secure way to safeguard the operational assets generating the data. Unidirectional gateways, or data diodes, can provide a one-way flow of network traffic via a physical network component. Fibre optic technology is used to guarantee that the in-flow of traffic from the Purdue zone with a lower trust level is impossible via this conduit.

Security Information and Event Monitoring (SIEM) – ICSs are heterogeneous environments with a broad mix of operating systems, devices and systems. A SIEM tool should be selected to enable real-time event log monitoring and support of the various environments. The event monitoring plan employed should not only monitor the security event logs but also other logs which could be indicative of matters such as application, hardware issues or malicious software.

The selected technology should enable tracing all monitored events back to their origin.

- Patching – From adding new features to repairing security holes and fixing or removing bugs, regular updates and patches of ICS digital assets should be conducted. A systematic process is required to ensure robust testing and roll-back procedure are in place before implementing a new patch in the live production environment.
- Security logging – Every system within a network generates some type of log file which contains a wealth of important information that could be used to reduce the ICS's exposure to damage, loss, legal liability, intruders and malwares. Proper log management strategy and tools should be employed to automatically manage log information coming from different sources, in different formats and in massive volumes.
- Anomaly detection – Anomaly detection tools enable identification of all the changes to critical assets, whether performed over the network or directly on the physical devices. They generate real-time alerts based on early detection of malicious activity and unauthorised changes, facilitating the troubleshooting of operational problems and the quick discovery of their sources.

Operation and maintenance

During the operation and maintenance period, you may be forgiven for thinking that if it was all done well during design then there is nothing left to do; however, this couldn't be further from the truth. The paradigm now shifts to patching, updating and remedial works. In reality with an ICS there should be no large-scale works required unless a new vulnerability is detected. However with every change of function, additional system added new vulnerabilities and vectors can expose themselves. Doubly difficult, because of the shelf life of such a system is that the original knowledge used to create it is no longer available.

Any in service patching will require taking out of service of the asset which could lead to costly and expensive downtime thus it is necessary to consider and plan for this eventuality both during the design and concept phases of the project.

Through lifecycle management the following can be achieved:

- The cyber landscape can be daunting. Establishing a starting point to assess your current cyber security risk level and exposure to compromise is essential.
- Developing a bespoke roadmap for the proper governance of cyber security, which fits your organisation.
- Adopting cyber security principles throughout all echelons of your business.
- No stone left unturned in the following key areas of human factors, tools & technologies and organisational preparedness.
- Ensuring your organisation's cyber-readiness enhancement is through focused investment and in the areas which need it most, to maximise your benefit.
- Applying the basics to ensure your organisation is employing the fundamental measures to protect itself.

Conclusions

Cyber security and cyber resilience are often afterthoughts in complex multidisciplinary projects. Systems integration, whilst often focussing on how a system should work, can be used to understand how a system may not work. It is therefore in the best interests of all major projects to actively engage these specialisms and combine their relative strengths to reduce costs, the risk of later rework and schedule delays and the overall risk to the system.

In order to deliver the most cost-effective cyber security and resilience, the earlier the engagement from the project, the more likely actions are to be taken and problems are either avoided entirely or mitigated. Engaging later in the project lifecycle leads to increase cost for remedies, the potential for a less secure system or even baked in problems that require additional resource to manage. In some cases, the cost required to rectify or deal with a cyber incident are significantly higher than they would have been if design considerations were incorporated at earlier project stages.

The above represents conventional wisdom for addressing problems early rather than in the eleventh hour. However, a further consideration is to employ both systems integration knowledge and systems thinking to help shape the outcome. Through a multidisciplinary appreciation of the system construction, the communications channels required and potential threat vectors, systems integration tools can help to visualise the system early in the lifecycle, highlighting potential avenues of threat and enabling corrective action to be taken as early as possible in the system lifecycle. This can lead to fundamental changes to architectures to remedy issues with the potential to entirely change designs to increase resilience and reduce costs.

The railway industry needs to consider cyber resilience not just cyber security. In the joined up digital ecosystem, with data driving our daily lives, new interdependencies will cause threats, opportunities, and the need for action. We're already in that world now, and it's no surprise that issues are occurring with more frequency and cyber security is becoming a hot topic.

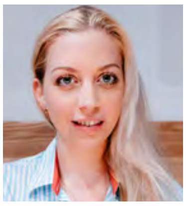
Reference

1. Defcon 20 – Dan Tentler – Drinking from the caffeine firehose we know as shodan [Online video]. irse.info/a2gsv [04/2019].

About the author ...

Colin is head of control systems integration at SNC-Lavalin Atkins. He leads the control systems integration team in the Rail Control Systems Practice, focused on delivering complex transport integration projects throughout the project life cycle.

For rail, an inclusive future is a successful future



Daisy Chapman-Chamberlain

Inclusion within rail has long been a key issue; how do we make the industry more inclusive for all our passengers, a great career option for a wider range of people, and the best possible travel option for journeys of all types?

Now it is more relevant than ever, as we face changes none of us could have foreseen. It is vital that we keep inclusion on the agenda to support rail staff, as well as stakeholders and passengers – with health and safety a key priority.

When considering the long-term impact of Covid-19, it's important to look at rail authorities' and companies' risk registers, such as the UK's National Risk Register. Rail now invests in cyber security measures, which carry a similar probability and impact in risk terms – so why not invest in other risks of similar level – such as pandemics?

Long term resilience is the key; which benefits and safeguards the rail industry, staff roles and passengers needs alike, as well as boosting economic recovery. When considering resilience, especially in the context of Covid-19, inclusion cannot be overlooked; many social distancing measures within rail have disproportionate impacts on people protected under the Equality Act in the UK (e.g. disabled, older and pregnant passengers), for example. Longer times spent standing in queuing systems, communicating essential messages through posters rather than a range of communication methods and blocking out seating can all impact passengers in the safe and easy use of rail.

The current perspective of rail as unsafe, especially for the vulnerable, also disproportionally affects these groups, and can cause social isolation, limited access to employment and life opportunities, and more. Rail needs to both visually appear to be, and be, inclusive and open for all, now more than ever – and there are many changes to be made to achieve this.

However, inclusion goes beyond this; into social inclusion, equality and equal access within that, ensuring rail meets the needs of all our passengers and communities. By improving the rail

Rush hour at Shinjuku railway station.
Photo Shutterstock/Benny Marty.

Madrid's Atocha station with the greenery offers an attractive environment to relieve stress and to boost health.
Photo Shutterstock/dejan83.

environment (and rail processes) we generate long-term benefits for all passengers – socially, and in terms of mental and physical health and wellbeing.

We care more about our communities and wellbeing at this time than we do about economic priorities (source irse.info/x1n9o) and for rail to thrive (as well as all other industries) we must take this into account and look at how our behaviour, as well as passenger behaviour, must and will adapt.

With this in mind, what can we do to make transport systems healthier? How will this global situation change our travel habits? Increasing flexitime use was already giving rise to the potential for reduced 'rush hour crush', which can only lead to healthier, less confined travel practices. With the rise in home working, could this expedite the flexitime effect and give us healthier and more inclusive travel and living patterns?

Alongside this, accessibility in a health and mobility sense comes to the fore; making our systems physically easier to use, as well as reducing stress and anxiety through the built environment, staff, information, use of green spaces, connections to active travel, community stations work and more, which all have ongoing effects in boosting overall community health, physically and mentally.

Looking to the future, it's vital we consider health and wellbeing as an intersectional need intrinsically linked to accessibility and sustainability, especially with an ageing population and growing numbers of rail users; which Covid-19 is unlikely to impact in the long term. In particular, the Health team at Knowledge Transfer Network is well-placed to address innovation around these longer-term needs.

When we consider sanitisation and cleanliness in rail environments, better cleaning processes as well as antiviral surfaces help the most vulnerable but benefit us all. Similarly, more automatic and accessible doors and entrances would reduce transmission of viruses and bacteria but would also make spaces more accessible to passengers with reduced mobility, as well as passengers with pushchairs and luggage.

With IRSE telecoms engineers in mind; customer information being provided in several forms (written, visual, auditory, both in the environment and digitally) and being clearer and more accessible makes rail easier to use for those with communication needs, anxiety, hearing loss and more, and benefits all customers with ease of use and making rail a more attractive option for transport. Less crowding and more coordinated (potentially digital) queuing will help those for whom crowded spaces are alarming, or who have sensory processing needs; but find me the passenger for whom a less crushed commute isn't an incentive! These alterations, which must be made, make rail better and safer for all.

We must also consider rail staff at the beginning of this inclusion journey; ensuring that not only is rail accessible for those working within it, but considering how changes (including more flexible working and working from home) can make some rail roles an employment option for a wider range of talented people, for whom office working and a commute is difficult. Existing rail staff are vital in making this a success; rail is only as successful as its people, and the cultural journey must be led by them.

One of the greatest cultural changes we now face is the need to shift to a more environmentally focussed and green way of thinking and operating; which is intrinsically tied to our Covid-19 recovery and future. In the built environment, green, open spaces, with wide walking routes and concourses enable social distancing, but also enrich public health in terms of emissions and air quality. Green spaces improve health and wellbeing for society as a whole as well as benefiting some of the most vulnerable, including those with respiratory conditions. Creative new designs and innovations around the green agenda, as well as many of the inclusion innovation opportunities above in related technology, would also provide a much-needed economic boost, aiding in our national and global pandemic recovery.

Making stations better environments benefits us all, but especially marginalised groups; around 73% of workers in the poorest fifth of earners in the UK

Wide, open spaces at Liege-Guillemins station in Belgium.
Photo Shutterstock/SBWorldPhotography.

would struggle to work from home and often have no choice but to use public transport (source irse.info/0jz7s), and it's the same in many countries throughout the world. When considering inclusion of homeless people, and many vulnerable groups, toilets and water fountains in railway stations are key facilities; we must ensure these spaces are not only safe but consider how rail can do more to support all groups in our communities; that our spaces are welcoming, inclusive and well-designed. The built environment requirement for cross-industry collaboration to enable the most effective possible collaborations is well-addressed by the infrastructure team at Knowledge Transfer Network.

Inclusion is not optional; it is essential in keeping passengers and staff alike safe and in rebuilding rail, therefore must be included in the 'new normal' from the beginning. We must ensure a diverse range of people are creating and scrutinising policy (including across technology and infrastructure), to avoid data gaps and biases and ensure true inclusion. Collaboration is key in a crisis, and so this unified approach will ensure a stronger future rail industry, faster economic recovery and growth and environmental benefits. The IRSE must rise to this challenge and is ideally placed to share best practice.

Through all these steps, and this best practice, we can restore confidence in rail – with the actions and changes to back it up – not just through marketing, creating a more resilient industry now and into the future. Now is the time of change to invest in these principles, making our networks safer, easier to use and better spaces to be in.

The world has changed forever, and our rail networks can become a shining example of what can be achieved for everyone in our society when inclusion is considered first; a more resilient, dynamic and inclusive railway with greater levels of wellbeing, of health, of economic recovery and of opportunity for all.

What do you think?

How can we make railways more inclusive places? How can we make people feel confident and comfortable about travelling? How much of this is down to the built environment and how can technology help? How can the IRSE contribute to making rail more inclusive? Do you have experience related to accessibility to transport systems, perhaps using app-based technology, smart station ideas, information systems or even alternative approaches to controlling railways?

We'd love to hear from you, email editor@irsenews.co.uk.

About the author ...

Daisy is rail knowledge transfer manager at Knowledge Transfer Network, and has a passion for transport transformation, accessibility and sustainability. She also focuses strongly on Accessible & Inclusive Mobility (AIM), supporting & driving business innovation in AIM across transport modes, and working to enable full inclusion across transport. Knowledge Transfer Network is a UK-wide organisation grant funded by Innovate UK that brings together businesses, academics, government agencies and research organisations to facilitate knowledge transfer and to build better links between science, creativity and business. Her previous role was equality, diversity and inclusion lead for Community Rail Lancashire, where she developed and led several award-winning projects focused on women and girls in rail, inclusion of LGBT+ communities and those with additional needs and disabilities. She is also a board member for the Association of Community Rail Partnerships and a Northern Power Woman; Future List. For more information about collaboration opportunities, innovation and funding potential, please contact daisy.chamberlain@ktn-uk.org.

Back to basics: Operator interfaces

BACK TO BASICS

Ian Mitchell

This article in the 'Back to basics' series covers the subject of the interface between the signalling system and a human operator in a signalbox or control centre. The technology of these systems varies from mechanical levers and control panels with switches or buttons to computer workstations, but they all provide controls, which enable the operator to manage train movements and indications, which provide the operator with information about the status of the signalling equipment and position of trains.

As with other 'back to basics' articles, the intention is to provide an overview for IRSE members new to the industry who do not have experience of working in this specific area. The aim is to describe the systems in a generic manner, but using examples based mainly on UK main line railway practice. The scope is limited to the core signalling functions and excludes voice communications, which is of course also a key element of any operator interface.

Evolution of the interface

In the mechanical signalling era, the operator interface and the interlocking were combined, the controls were levers above the floor of the signalbox that directly interacted with the mechanical interlocking in the locking room below, and via rods and wires to the points and signals on the railway outside.

Example of a mechanical lever frame. Note the indicators on the front of the shelf over the levers, showing the status of points and signals.

Examples of NX panels at Carlisle (left) and Tweedmouth (right). *Photos Westinghouse Archive.*

In the early days there were no indications provided – the position of the levers provided feedback of the state of the points and signals and big windows gave good visibility of passing trains. A signalbox diagram showing the track layout and location of signals was provided, but this simply provided static information such as lever numbers for each point and signal.

The first indications were electro-magnetic devices where the position of a needle repeated the position of the semaphore arm of a signal that was out of sight from the signalbox. These devices are typically mounted on the 'block shelf' above the levers for the signals to which they apply. In later years the electro-magnetic indicators were superseded by modules with coloured lamps. These came to be applied more widely when lever frames were used to electrically control colour light signals and power operated points and the direct connection between lever position and the outside equipment was lost.

"Some early relay interlockings retained the traditional lever interface"

When track circuits were introduced on an intermittent basis, similar indicators were provided on the block shelf to show the track sections occupied by trains, but when track circuiting became more widespread, a better visualisation of train location came to be provided by lamps on the signalbox diagram.

The final elements of the operator interface in a mechanical signalbox are the block instruments that communicate with neighbouring signalboxes. In the early days they were purely a communication system, by which the operators offered and accepted trains over the block section between the signalboxes, and the indications provided the operator with a reminder of whether the section was clear or occupied by a train. In later years they became true controls as an electrical interlocking prevented the starting signal lever being operated until the block instrument indicated 'line clear'.

An inherent feature of a mechanical interface is that when routing a train through the control area, the operator has to first individually move and lock all the points along the route, then operate the signals to give the correct proceed aspects to the train, and finally replace each signal to its most restrictive aspect after the train has passed. In a complex area, this will require several lever operations for every train, with a significant amount of physical effort where the points and signals are mechanically operated.

Control panels

Some early relay interlockings retained the traditional lever interface, with rows of miniature signalling levers on a desk, but the same result can be achieved equally well using standard industrial switches mounted on a control panel. These can be arranged in rows as in a lever frame, or on a schematic track diagram so that each switch is adjacent to the representation of the point or signal it controls. This is known as an individual function switch (IFS) panel, as each switch controls one point or signal, with the operator making the required sequence of switch operations to set the route for a train.

A further evolution of the control interface came with the introduction of 'route setting' interlockings, as described in an earlier 'back to basics' article. The first examples of this were one control switch (OCS) panels on which an individual switch or button was provided to set and cancel each route within the interlocking. This was further refined into the entrance exit (NX) panel, where setting a route is achieved by operating switches or buttons at both entrance and exit of a route on the schematic track diagram. This provided a very intuitive and easy to operate interface and became the standard method of operation from the 1950s onwards. Points on these panels are provided with three-position switches – the centre position allowing the points to move as required for route setting, and the left and right positions locking the points in the normal or reverse positions.

The indications provided to the operator also evolved to provide information on the status of the route locking logic within the interlocking. This is typically a row of white lights on the schematic track diagram to show the path over each train detection section for which a route has been

Example of a first generation computer workstation with screens and a trackerball. This is the workstation controlling Liverpool Street terminus in London at the first Integrated Electronic Control Centre (IECC) commissioned by British Rail in 1989 – still in service in 2020 but due to be upgraded in the near future.

locked. The progress of a train then appears as the white route lights changing to red in sequence along the route.

The NX controls and indications can either be combined on a single panel, or split with controls on a desk immediately in front of the operator and indications on a separate panel (often wall mounted) behind the desk – the latter arrangement is more common for large control centres with multiple operators.

Computer workstations

The operator interface in a modern control centre is now usually a computer workstation, with multiple screens to display a schematic track diagram of the railway under control. The indications of signalling equipment status, route setting and track occupation are provided by colour coding of the symbols on the schematic track diagram, following the conventions that were originally established for lights on panels.

"The operator interface in a modern control centre is now usually a computer workstation with multiple screens"

The operator interacts with the system via a computer keyboard and a mouse or trackerball, with a mode of operation mimicking an OCS or NX panel, e.g. click on route entrance symbol and select a route from a drop down list, or click on entrance symbol and then exit symbol in sequence.

One significant difference between computer workstations and the older technologies is in the method by which an operator applies a 'reminder' to prevent themselves from operating a control; for instance to prevent points being moved when maintenance is being undertaken. With levers or a panel, the reminder is simply a physical device that the operator attaches to the control that prevents it being operated – a collar on a lever, or a cap over a button or switch. On a computer workstation, the reminder is a software function that needs to be designed into the signalling system. A reminder is displayed on the workstation screen as highlighting of the symbol for the signalling object to which it applies, and the interlocking must reject any attempt to operate a control with a reminder applied (this check may be within the computer workstation interface where an older interlocking without this facility is recontrolled).

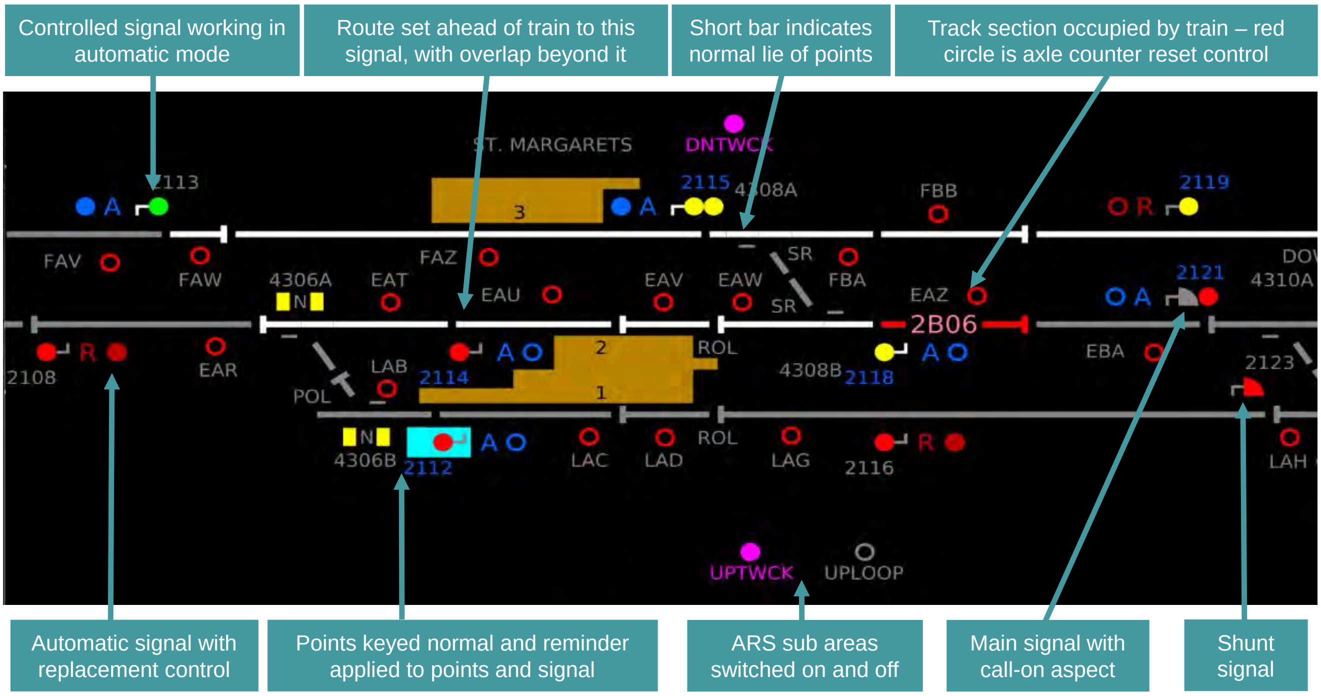
The number of screens is determined by the size and complexity of the area under control. It is usually a requirement that an overview of the whole of the controlled area must be visible at any time, and this is sometimes achieved on an upper row of screens displaying fixed areas, while the operator interacts with a lower row of screens on the desk where a selected area can be displayed in more detail, and to view the status of alarms and other information from the system.

The overview displays may be shared between multiple workstations – sometimes this is a very large wall mounted display covering the whole control centre area. This may be provided mainly for the benefit of managers or other staff in the room; an alternative to this is a 'supervisors workstation' where any of the signalling screens can be selected to be displayed on a 'view only' basis. Some control centres now cover very large areas, with tens of workstations controlling several hundred route kilometres of railway.

Computer workstations often provide additional functionality beyond the standard controls and indications, such as automatic route setting (ARS) or overrun management. Some of these are described later in the article.

Technology and safety

In the mechanical and early relay interlocking era, the technology for the operator interface was simply a direct mechanical or electrical interface between levers, switches, lamps and relays. The concept of the signalling control system as a separate entity from the interlocking appeared



Screenshot showing typical symbols used to provide signalling indications on a computer workstation.

> "With some types of relay interlockings there is a split between the 'vital' logic in the interlocking itself and 'non vital' logic at the operator interface"

when remote control systems were introduced to allow a large control centre to interface with multiple interlockings over telecommunications links. A remote control system comprises an 'office end' that connects to the controls and indications on the panel at the control centre, and a 'field end' that connects to relay coils and contacts in the interlocking. The office and field ends communicate with one another via a telecommunications link, so that every operation of a control on the panel energises the corresponding relay in the interlocking, and a relay contact closure in the interlocking illuminates a lamp on the panel. The most common form of remote control is 'time division multiplex' (TDM) where the signalling states are coded into a digital message, which can be sent through a standard serial interface via a modem. TDM hardware typically comprises a rack of electronics, with a master processor card and a variable number of input and output cards to match the number of controls and indications required.

With some types of relay interlockings, there is a split between the 'vital' logic in the interlocking itself, and 'non-vital' logic at the operator interface. Examples of non-vital logic are translating push button sequences into a route request, or the logic to extinguish a white route lamp when the corresponding red track circuit lamp is lit. These are considered non vital because the impact of a failure of the remote control system that generates an incorrect control to the interlocking is the same as a human error in operating this control, and should be protected by the interlocking logic. Similarly, an incorrect indication can only result in a hazard if it misleads the operator to undertake an unsafe action. The non vital logic was implemented in smaller and cheaper 'post office' relays or in an electronic 'panel processor'. Modern microprocessor based TDMs can now incorporate this sort of logic in either the office or field end equipment.

With the move to electronic interlockings and computer workstations, the same considerations apply, but the safety analysis has become more sophisticated with the arrival of CENELEC standards and the concept of safety integrity levels (SIL). It is now recognised that an operator interface failure in combination with human error could lead to an accident in abnormal working situations and so some of the functions of an operator interface are categorised as SIL 2 (interlockings are in the highest integrity level SIL 4, and non-safety functions are SIL 0).

Where an operator interface function needs to achieve a particularly high safety integrity level, one approach is to require a sequence of controls to be sent to the interlocking, which will only accept them if they are consistent and received within a limited time window. An example of this is an axle counter restoration control, which requires the operator to undertake two different actions (e.g. clicking on a symbol and entering a track section name), which generate separate messages from the interface to the interlocking. This process provides protection against human error by the operator and spurious messages generated as a result of a fault in the interface.

The hardware and software architecture for a computer workstation is generally based on commercial off the shelf (COTS) computing components, engineered into a system that will achieve the necessary SIL and availability targets. Except for the smallest installations, this will imply duplication of all the critical components and data links to avoid single points of failure. The architecture varies between suppliers, but in recent years there has been a trend towards a 'client/server' approach that decouples the interfaces to the interlockings and the area-wide functions such as automatic route setting and train describer (see below) from the operator interfaces. This allows the areas controlled by the workstations to be dynamically reconfigured, for instance to reduce the number of workstations that need to be staffed in quiet periods. A further extension of this concept is to allow dynamic reconfiguration between control centres – for instance to provide a backup disaster recovery facility to maintain train operations when the primary control centre building has to be evacuated as a result of a terrorist attack or a natural disaster.

"The operator also needs to know the identity of each train"

Train describer

The track occupation indications on a panel or workstation show where there are trains in the controlled area, but the operator (or ARS) also needs to know the identity of each train so that it can be routed correctly. Each train will be allocated a number or alphanumeric code (sometimes called a 'headcode') and these are displayed to the operator by a system known as a 'train describer'. Train describers were one of the earliest applications of computer technology in signalling, and with a control panel the train describer is a dedicated processor interfaced to small alphanumeric displays set into the indications panel, or a separate computer screen. On a computer workstation the train describer is simply a software function within the system, with the train numbers displayed at the appropriate locations on the main screens. In either case a user interface to the train describer is required to allow an operator to enter (sometimes referred to as 'interposing'), delete and amend train numbers or enter other codes such as line blocked.

As conventional lineside signalling does not provide a data path for a train to report its identity to the control centre, the train describer requires the train number to be entered manually by an operator or automatically from the timetable at the start of the train's journey, and it then tracks the train through the controlled area by monitoring the sequence of route setting and track section occupation. The train describer logic is based on the concept that trains move between 'berths' – when a train is in the berth associated with a signal, it means this is the next signal it will encounter in its journey. Additional berths are provided at locations where trains may reverse, or where permissive working allows more than one train in a section.

"Modern control centres with computer workstations often include an automatic route setting facility"

When a train passes from one control area to another, the train number is transmitted as a data message between the train describers for the two areas. Similar data messages reporting every train step are also sent from each train describer to a national train running information system, which provides the data source for real time customer and staff information displays, automated public address announcements, and recording systems for performance monitoring.

Alarms and overrun management

Whatever the technology, the interface will provide a number of alerts and alarms. Some of these relate to equipment failures, and others to events that the operator needs to be aware of. A typical example will be a train describer alarm when a track section becomes unexpectedly occupied.

A specific alarm for signal passed at danger (SPAD) was introduced in the UK as a result of the public inquiry recommendations following the Ladbroke Grove accident in 1999. When a track section occupation sequence occurs at a red signal which may be as a result of a SPAD, a distinctive (and loud) alarm sounds and the area of overrun at the signal is highlighted on the workstation screens.

On some recent installations with computer workstations this facility has been further enhanced with an automated response to the SPAD event to stop other trains in the area. The processor in the interface system sends requests to the interlocking to replace other signals on the approach to the SPAD area. This is known as a 'predefined operational protection' (POP) control. Providing this capability in the SIL 2 interface system can allow simplification of logic in the SIL 4 interlocking.

Automatic Route Setting

Modern control centres with computer workstations often include an automatic route setting (ARS) facility. This reduces the operator workload linked to routine train movements, allowing them to focus on problem areas and tasks that require voice communications with staff and the public.

ARS is usually a separate processor within the operator interface system that monitors the movement of trains as reported by the train describer, and uses an electronic version of the timetable for the day to identify which routes should be set to allow each train to run through the controlled area on its planned path and timings. Where possible the objective is to set routes sufficiently far ahead of the train so the driver always sees green signals, although there are exceptions to this, e.g. where departure from a station needs to wait for a 'train ready to start' message from platform staff.

An important principle is that ARS should not 'challenge' the interlocking by requesting a route that is not available to be set. This requires the ARS to be programmed with a copy of the interlocking route availability logic and to monitor the signalling states such as track occupancy, route locking and reminders.

When trains are running late, it is very likely that conflicts will arise where two trains require to run over the same section of track at the same time. This can arise when routes converge or cross, and at crossing points on single lines (see the article by John Francis in the June 2020 IRSE News for some examples). ARS requires an

"Traditionally the timetable used by ARS was updated on a daily basis from the national train planning systems"

"For most metros the key parameter being managed is not the adherence to the timetable but the regularity of trains"

algorithm to decide which train to give priority in these circumstances – this might be to keep the trains in timetable order, 'first come first served' or a comparison of the predicted train delays for the alternative options. At the design stage for a new installation, workshops with operators who are experienced with the train service in the area are a valuable source of information to tailor the algorithms for each potential area of conflict.

The operator retains the capability to set routes manually at any time, and where this is necessary the operator can switch off ARS for an individual train, or for an 'ARS sub-area', typically a single junction or running line between stations. ARS sub-areas will also be automatically switched off if an operator cancels a route that has been set by ARS, a SPAD is detected, or a signal group replacement control is operated.

Traffic management

Traditionally the timetable used by ARS was updated on a daily basis from the national train planning systems. Since ARS can only set routes for trains according to the timetable, additional trains and those required to deviate from the timetable have to be routed manually by the operator. This can be avoided if ARS can be provided with a dynamic timetable, updated throughout the day with changes to the plan. This is the concept behind 'traffic management' which aims to move away from operators making train routing decisions in real time, to a process where issues are identified well in advance, and solutions are identified and incorporated into the dynamic timetable so that all trains can be routed by ARS.

Traffic management systems are another layer of functionality that sit above the primary operator interfaces described in this article. The interface with the signalling is via timetable updates to ARS, so there is minimal safety impact (i.e. SIL 0). They may also be used by operators who have strategic responsibility for a whole route, a 'controller' or 'despatcher' rather than a 'signaller'. The user interface is usually in the form of a train graph or a platform occupation chart, which shows the planned, actual and predicted movement of each train and highlights trains that are deviating from the plan and the consequential conflicts with other trains and with planned line blockages. Edit facilities allow trains to be rescheduled, rerouted or cancelled, and additional trains to be inserted into the timetable. There may also be a 'what if' facility to allow an operator to try out alternative options for rescheduling, evaluate the impact on train delays and other key performance indicators for the train service, and then deploy the chosen option into the dynamic timetable.

Train protection and ERTMS/ETCS

Train protection systems overlaid onto conventional lineside signalling using track mounted equipment to communicate with the train (e.g. TPWS in the UK) have little impact on the operator interface, other than perhaps an indication to warn of equipment failure.

ETCS level 2 introduces a communication link between the train and a radio block centre (RBC), and this may require an operator interface, to provide information on the ETCS mode of operation of each train, and to allow updating of temporary speed restrictions. In early applications these functions have not been integrated into the primary operator interface system (which is only linked to the interlocking), and a separate stand alone terminal from the ETCS supplier provides an operator interface to the RBC. As ETCS becomes more widespread, more integrated solutions are likely to evolve.

Metros

On modern metros with CBTC signalling, the system architecture generally includes a component known as 'automatic train supervision' (ATS), and this incorporates the operator interface, including automatic route setting and traffic management functions. ATS interfaces with automatic train operation (ATO) so that decisions made in the control centre can directly influence movement of trains without involvement of a human driver.

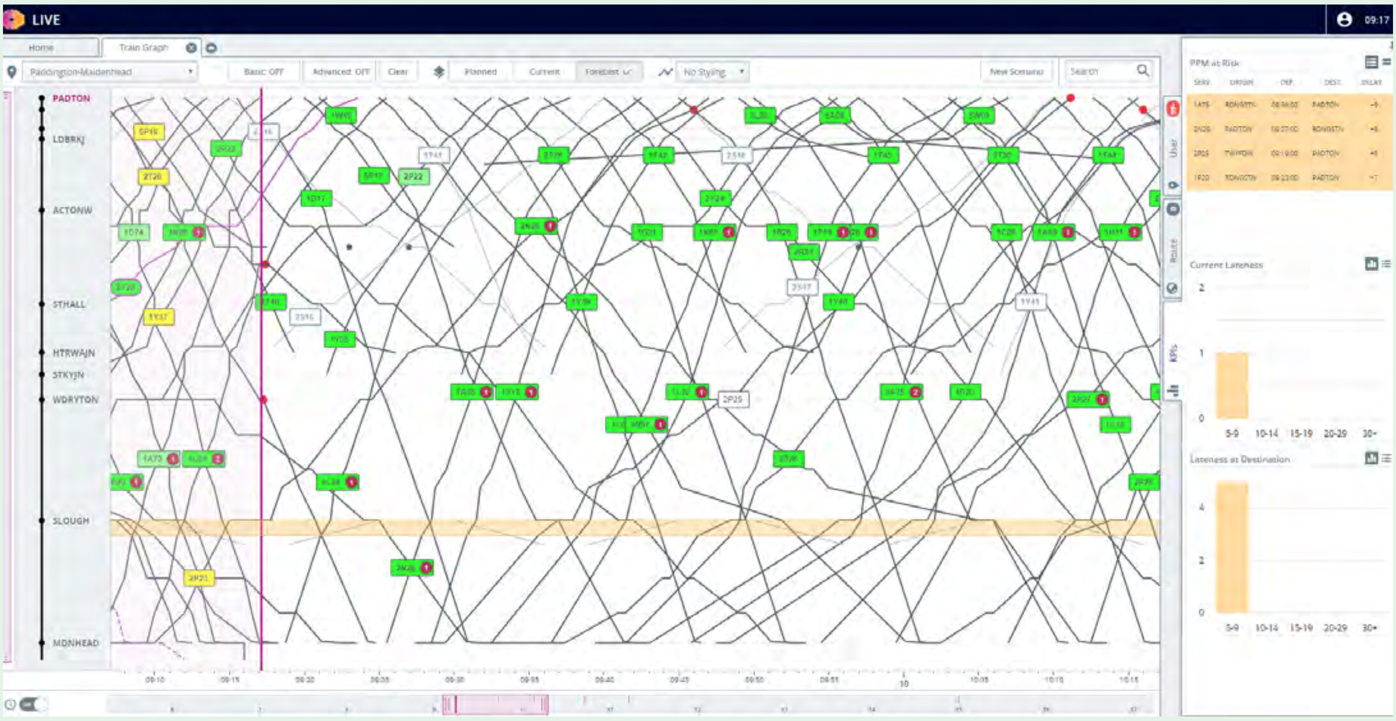
For most metros the key parameter being managed is not the adherence to the timetable, but the regularity of trains, and the operator interface allows this to be monitored and managed. If two trains are running close together, ATS can delay the departure of the second train from a station to even out the gaps in the service, or instruct the ATO to run at reduced speeds between stations to save energy.

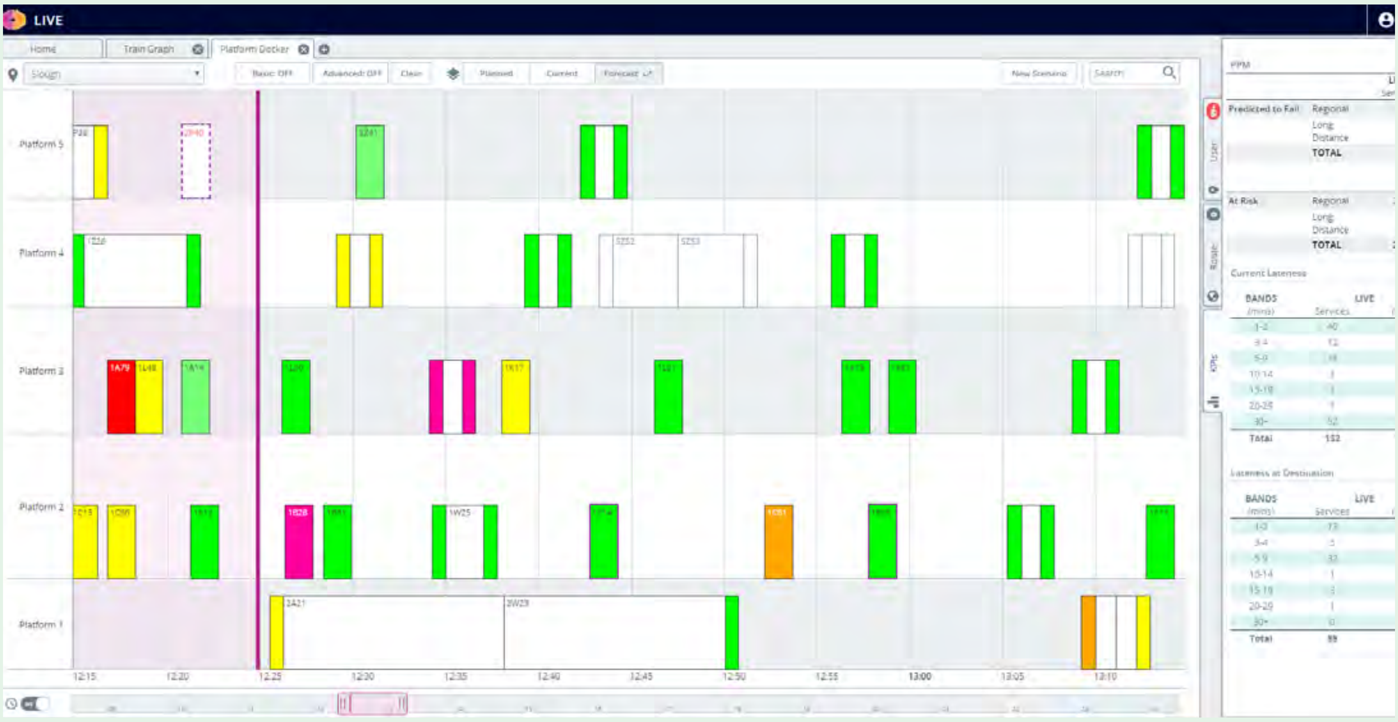
Integration of systems

This article has described the operator interface for the core signalling functions, but in a modern control centre the person at a control panel or computer workstation will also have to interact with a number of other systems. Examples of this can include voice communications with train drivers and track workers, closed circuit television (CCTV) monitoring of level crossings and stations, monitoring systems for vehicle or infrastructure faults, passenger and staff information systems, supervisory control and data acquisition (SCADA) systems for electric traction power supply, and even corporate information technology (IT) applications such as emails and timesheets.

Traditionally there has been little integration of the operator interfaces for these systems – a typical computer workstation will have a separate terminal on the desk for voice communications, an office type personal computer for the corporate IT network, and dedicated screens for CCTV monitoring. The technology exists to integrate all of these into a single interface, but there are practical, commercial and safety assurance obstacles to integrating systems from different suppliers when there are no standard interface specifications, and differing system architectures, SIL requirements and system lifecycles. An integrated solution is most likely to be seen on a turnkey project to build a new metro or high speed line.

Traffic management in action





The figures above are examples of a traffic management user interface – these are from the Luminate system supplied by Resonate for Network Rail's Western route. The train graph (above) represents each train as a line on the graph, the X axis is time and Y axis is distance along the route (Paddington to Reading). The violet vertical bar is the current time with actual train movements to the left and predicted movement to the right. The 'platform docker' (below) shows platform occupancy at a passenger station (Slough). The X axis is again time, and each platform is represented by a horizontal row with rectangles representing each train and the time it occupies the platform. In this case the trains are colour coded to highlight whether they are running on time or late. The panel to the right on each screen gives statistics relevant to key performance indicators for the train service performance and identifies trains that may incur penalties for late running.

Screenshots from Resonate Group Limited.

Human factors

It goes without saying that an effective operator interface to the signalling system must be designed with the operator in mind, and human factors specialists have played an increasingly important role in design of modern control centres. This starts with workload analysis to determine how large an area of railway can be effectively managed by an individual operator, as this will determine the number of workstations and hence the size of the control room. The constraining factor will be determined by the level of automation in the system; for instance where ARS is provided, the workload during busy periods of train operations may be less than at night when the operator has to manage line blockages for work on the track.

At a more detailed level, the size of text and symbols on the screens, the number of screens and their location on the desk, the height of the desk and even the type of chair all need consideration to ensure the operator remains alert and comfortable.

Conclusion

As with other areas of signalling technology, the evolution from levers to computer mouse has been dramatic, but the fundamental principles of controls and indications remain. What has changed the most is the level of automation; modern systems now require little human intervention when the railway is running to plan, but an experienced operator and a well designed human interface are still crucial in dealing with failures and unexpected scenarios.

One of the lectures later in this year's Presidential Programme will specifically explore the issue of automation in control centres – what are the strengths and weakness of existing systems, what further tasks could be automated, and how do we ensure the human and computer work together most effectively?

About the author …

Ian Mitchell has 45 years' experience in the rail industry, in British Rail Research and its post-privatisation successor companies – AEA Technology Rail, DeltaRail and Resonate. He retired as professional head of signalling in 2011, but still does some consultancy for his previous employers as well as acting as one of editors of IRSE News and as a member of the International Technical Committee. He presented a Presidential Paper on the topic "Signalling Control Centres Today and Tomorrow" in 2003, and is due to deliver another in 2021 jointly with Nora Balfe, who is a human factors specialist with Irish Rail.

"Back to basics" and the IRSE Exam

We hope that our "Back to basics" articles are particularly interesting to those of you who are new to the industry and are working to build up your knowledge. For those considering taking the IRSE exam, these articles should be particularly relevant for your studies.

As an example, why not think about how you would answer this question from the 2015 Module 5 of the exam, based on what you've learnt from the article?

Describe, with the aid of a drawing, the layout of either a mimic panel or a signaller's VDU display control system. You should include details of how each of the following are dealt with:

i) Route Setting and cancellation [4 marks].

ii) Manual movement of points [3 marks].

iii) Train detection status during normal and failure conditions [4 marks].

iv) Protection of different types of engineering work [3 marks].

v) How a major failure of the display would be managed [4 marks].

vi) Signals Passed at Danger [2 marks].

vii) Train identification [3 marks].

viii) Adjacent signal box alarms [2 marks].

Vancouver's Canada Line was equipped from opening with an integrated control centre, bringing a range of signalling, station and communication functions together at one workstation. *Photo Siemens Mobility.*

Redefining rail's role in an integrated transport system post-Covid-19

Blane Judd
CEO, IRSE

The second in our series of think tanks was held on May 29, and took the form of a virtual webinar and discussion. Guests from across industry joined the Future Integrated Railway Think Tank (FIRTT) team to discuss rail's role as part of an integrated transport system in a post-Covid-19 world. Chaired by Ben Foulser, associate director of KPMG's Transport Advisory Practice, the assembled experts took on this wide-ranging topic by tackling three core themes:

- Renewing/instilling public confidence in mass public transport.
- Communications-led intelligence to support better informed, more flexible and joined up journeys.
- Industry structure, governance, resourcing and funding.

Underlining these key themes Steve Denniss, technical director of WSP and strategic leader of the Think Tank, expressed an ambition for the industry to collaborate to not just adapt to the current situation and keep everyone safe – as vital as this is – but to emerge stronger from the crisis, to reinvent ourselves. With a long-term drop in passenger demand set to continue, the challenge for rail is to combine the intrinsic benefits it has over other modes with innovative thinking from inside and outside the sector, to become a key part of a truly integrated transport system.

Introduction from KPMG: A route to recovery?

Ben Foulser introduced the webinar. He discussed both the immediate and prolonged effect that Covid-19 is having on public transport, based on KPMG's work with government, economists and transport companies. Sharing TfL research, Ben demonstrated that while social distancing constraints make meeting capacity on London's buses very challenging, the challenge is compounded further for the underground and train. The imperative for us to find safe ways to maximise capacity and mobility is clear.

Economists predict that the most likely scenario we face is a deferred recovery, with mini-lockdowns as the 'R rate' rises causing peaks and troughs in demand. This deferred return to normal demand presents us with an opportunity to reform our system. So what can we do differently? How can we mitigate the 'headwinds' of increased use of home- and tele-working; social distancing restrictions; pre-Covid increases in mobility options affecting market share; the allure of motoring due to less congested roads and cheaper fuel etc. How can we harness the 'tailwinds', among them increased awareness and appreciation of the public health and environmental benefits of rail over other modes, especially improvements in air quality? What about the safety standards that operators have established in the public transport system – does this not represent an advantage? Can rail respond to a popular shift towards active mobility, which promotes mental and physical health? How can we influence the regulatory change needed to realise a vision of the future that benefits operators and customers alike?

Using a three-phased response plan, Ben described how we can grasp the opportunity to reform, not just rebuild, and take actions to create a new normal that serves industry, passengers, freight users and broader society. This requires a top down and bottom up approach, details of which can be found in Ben's slides.

Keynote presentation by Siemens Mobility: Redefining rail's role in an integrated transport system post-Covid-19

The keynote presentation was delivered by technology experts Andy Woods (digitalisation & innovation strategy lead, Siemens Mobility) and Alex Stewart (general manager, Siemens Mobility Inter Modal Solutions). Their view was that rail was doing pretty well before the pandemic: usage was up 3%; punctuality and safety were improving; customer satisfaction was greater than with other public transport modes; and demand for rail freight was also on the up. Through our 'habitual and unthinking' relationship with transport we have come to depend on the familiar to dictate how we move around.

To plan his journeys, Andy said that he relies on 'silos' of information from a multitude of apps all competing to offer transport options, but none of them fully understanding his end-to-end journey requirements. This equates to a lot of options and partial solutions – and a lot of tickets! Where rail is concerned, the common perception of a 'labyrinthine' and even 'conspiratorial' system is only strengthened by the far-from-perfect system of split ticketing. Alex argued that by looking at how data is shared in parts of Europe to offer something closer to Mobility-as-a-Service (MaaS), we can see a mechanism by which supplier data can be given back to the traveller for our collective good.

Looking at what has changed since Covid-19, we can see rail usage is down by 90-95%, crippling operators' ability to run services cost-effectively. With the massive increase in, and success of, remote working it may be that people will never return to commuting at pre-pandemic levels. For rail freight the picture is more encouraging, stepping up to provide a more resilient (and greener) alternative to the road network during the pandemic.

What the future might look like:

- City centres become more leisure focused, and less business-oriented.
- Growth in door-to-door supply chains, instead of door-to-hub/supermarkets.
- Renaissance of 'local'; high streets offering niche and specialist goods and services.
- Move away from global supply chains, driven by people's growing awareness of their adverse impacts.
- Greater use of automated systems that do not rely on people to operate them.
- Population shift away from larger conurbations towards rural areas.

What future transport trends might be:

- Reduction in peak time commuting.
- Less business traffic.
- More rail freight.
- More demand for rural transport services.
- Reduction in personal car ownership as alternatives become increasingly viable.

How public transport needs to respond:

Future transport will need to be dynamic and responsive to events as they happen. Transport solutions need to be based on people's actual travel intentions and requirements. We need to use large scale models to pull data together to provide integrated end-to-end journey options for passengers. We need to shift from an output focus to an outcome focus, rather than concentrating our efforts on moving vehicles. Transport needs to be more efficient and better informed. By exchanging data about people's travel needs we can avoid wasting energy and resources. We need to automate more menial tasks so that staff can focus on the higher-cognitive ability tasks that add value for passengers. Such tasks are more challenging and, by extension, more enjoyable for those undertaking them.

Equipping passengers with the information they need to make the best choice

Future rail users will place more value on the hygiene and cleanliness of trains, not just the timing and reliability of their train. Apps will help to restore confidence and trust in transport by communicating these factors to passengers, for instance informing passengers when carriages were last cleaned. It is about giving passengers all the information they want in order to make their journey.

If trains can only support approximately 10 per cent of their normal capacity for the foreseeable future, we will need a smarter approach to managing crowding at stations. Perhaps this starts with how people book their tickets; maybe passengers will in future have to book access to the station as well.

The future rail user will be able to mix and match transport options that work for them and meet their needs, and they will want to be able to do so with confidence. While technology will get us part of the way there, for change to occur that really meets customers' needs and expectations we need a two-way discussion between operators and passengers.

Most people use the railway because they have to, but by embracing active mobility we can change this in favour of people wanting to use railways. For example, complementary systems and

better designed carriages can make trains a greater part of cycling holidays. A key element in making a success of such initiatives will be finding ways to bring our costs down near to the level of other public and private transport options.

Finally, given the low carbon benefits of train travel compared with aviation, there is a strong case for rail to become part of a larger and wider integrated transport system in a post-Covid-19 world.

Key discussion points

Digital solutions

Managing crowding in stations and loading/unloading of trains is a critical issue for social distancing. If we design for current social distancing rules, how do we future proof for changes in restrictions without needing to completely redesign? 'Digital' provides capability for planning and simulation. Digital Twins can help us predict how people will use a station and identify pinch points to help us find contingencies that go beyond just emergency scenarios. Digital options are more flexible, and the Digital Twin approach allows modelling of layout options as part of design selection. For example, the University of Cambridge's Centre for Digital Built Britain is delivering an Information Management Framework to align industry, academia and government to enable the National Digital Twin Programme.

By modelling passengers' historic travel intentions and activities, we can optimise flow around stations. This can help us make big improvements with simple measures, such as changing the direction of escalators to account for more frequent and unpredictable fluctuations in traffic. With digital signage and apps that are based on those same intentions, we can help people move safely around the station; this is especially pertinent now with the layouts of some stations having completely changed (e.g. exit- or entrance-only), thereby becoming unfamiliar environments for users.

A MaaS platform can provide customers with the information they need to plan and book journeys that suit their precise needs and budgets. And a digital ticketing system that covers all transport modes would make it easier to implement an end-to-end journey planning solution for customers that truly puts their needs first.

Radical thinking v realistic goals

Reduced demand for services, coupled with the need for social distancing, has up-ended the capacity challenge that was facing the railway before Covid-19. We may even move away from 12-car trains towards shorter train sets and more frequent services. In the long-term we may even see the use of small travel pods on railways, rather than large trains, enabling rapid and timetable-free passenger movement.

In the meantime, the move from fixed block lineside signalling to ETCS level 2 (and eventually level 3) and intelligent traffic management will enable us to deliver a range of benefits. For instance, we will be able to provide relatively inexpensive bi-directional signalling and significantly reduce delay minutes. With level 3 we could allow trains to run closer together and dramatically reduce costs on lightly used parts of the rail network. There is no 'one size fits all' solution however, and we need to be open minded about the technology we choose, but we should be optimistic. Lighter vehicles, reduced costs of running the network and automated maintenance are all in development today. They need to be implemented!

Environmental advantage

To go from London to Brussels by plane accounts for 106g/km CO_2 per passenger; the same journey by rail is just 6g/km per passenger. Clearly, there are some big opportunities for industry to promote the intrinsic environmental benefits of rail and their part in meeting the broader decarbonisation goals. With the beleaguered aviation sector facing up to ten years of turmoil, the case for rail on environmental grounds will only strengthen. The carbon efficiency of rail over road is just as compelling.

Before and after. Who could foresee the revolutionary change that hit all of the world in early 2020? For most of the population busy stations like that in the picture on the left were normal and we thought nothing of being in large crowds of people or travelling on very busy trains. The post-COVID world on the right sees far fewer people travelling, most wearing protective face coverings, and many using smartphone apps to plan their journey. We as a profession have a real role to play in giving people the confidence to travel again. *Photos Shutterstock/Bikeworldtravel and Onjira Leibe.*

Mitigating decreased passenger demand

With a precipitous drop in passenger demand and the highly likely scenario of a deferred and very gradual recovery, how do we preserve yield and make running the railway affordable? Parcel deliveries offer a window of opportunity for rail; organisations are already removing lorries from the road with such services. Innovative organisations are already proposing dual-purpose carriage designs, which can carry both passengers and light freight/parcels. More efficient use of information and the deployment of automation will help increase rail's yield. Smarter integration with other modes and affordable ticketing will help rail tap into the domestic holiday and leisure market.

Collaborate to cut costs

Cost reduction is more critical than ever. But as an industry do we really know where our 'big cost buckets' are and where opportunities exist to reduce these? We need to work collaboratively to reduce the high fixed costs that characterise the railway. There are encouraging signs of industry working together to reduce costs. For example, Project 190, led by Network Rail and supported by Department for Transport and the Department for Business Energy and Industrial Strategy, aims to triple the volume of Signal Equivalent Units installed (a unit cost measure of providing signalling) while halving the unit price. In a similar vein, the Coventry Very Light Rail project aims to develop a low cost trackform for the low cost light rail carriages that are already in development.

Daring to leave our comfort zone

Rail is arguably and understandably obsessed with how the railway operates. But this can detract attention away from understanding what the end user wants. We know that, for most customers, frequency is more important than speed, and reliability is more important than shorter journey time. But while these are 'knowns', we don't allow them to drive our objectives, and this has to change. Rather than putting our effort into how we "move metal boxes between stations", we need to understand and design our services to prioritise customer demand and needs. The customer journey does not begin and end at the station, and rail is just one link in the chain. We need to think in terms of end-to-end and 'door-to-door'. Railway operations, while fundamental to the running of a railway, are simply an enabler for us to give the passenger this holistic journey solution. Until we can accurately gauge how individual travellers want to use the railway, these 'metal boxes' will remain a proxy for people. We need to be able to count numbers of passengers on trains automatically, and our control systems need to know where people are and where they are going (what their start and end points are and what their connections are). Just knowing where the trains are timetabled to go is not sufficient. Accurate behavioural data used in concert with intuition, imagination and empathy (putting ourselves in the shoes of the passengers) will help us achieve a truly passenger-focussed railway.

Driving a cultural shift

Rail will need to be agile in responding to post-Covid-19 commuter working patterns, including how ticketing works. We will need to align with an inevitable rejection of the rigid five-day working week in order to remain a cost-effective transport mode for commuters. Flexible season tickets and seat reservations on long-distance travel may help us do this and retain and attract passengers. But it is not just the demand side that needs our attention. To deliver what passengers want we need to remove those deeply embedded but unhelpful 'drivers' which influence our railway culture. Can we remove the KPIs that our Train Operating Companies are driven by, for example? If we want to foster genuine collaboration, can we remove the need for operators to compete for the same journeys? Such changes require bold decisions and strong leadership. As we await the outcomes of the Williams Review, we need to push for a National Transport Strategy to encourage collaboration, and not competition, between parties. Perhaps greater collaboration between operators and authorities should be the first step to enacting cultural change.

Improving our image

While we are good at promoting ourselves within the rail industry, most mainstream media coverage of our railways is negative – whether it is poor service, late delivery of costly infrastructure projects, or industrial disputes. We must work together to present the industry in a more positive light. We need to showcase our cutting-edge use of technology, our progress in making the industry a more diverse and gender balanced work force, and explain why rail could be the 'hero' of our national transport network over all other modes.

Attracting the next generation

Attracting new talent into rail is key for its future health; be they operational, supply chain or construction roles, UK rail should be a strong contender for the most aspirant and capable of our young people and promise to provide careers that deliver transferable skills and digital capability. Sadly, its poor image and the misconception from some that we are an industry slow to embrace change has limited its allure as a viable career path for many. We cannot simply rely on the implementation of digital technology to excite the interests of the next generation, although it is important we promote this exciting aspect of our industry. We must also engage with the values of young people; they care about the environment and decarbonisation; they want to make a positive contribution to the world. We know a career in rail can fulfil these needs. Our challenge is in communicating this message to show potential new talent that what drives them can be found within our industry.

How do we secure a bright future?

Our think tank discussion demonstrates that rail can indeed play a major role in the integrated transport system of the future. The profound disruption and uncertainty caused by Covid-19 provides us with an opportunity to reform, not just rebuild, and become a more attractive transport mode than ever before – for both passengers and freight. But this requires big and bold decisions to be made, strong leadership, a rejection of the silo mentality and competitive culture that holds back progress, and wholesale support from all corners of our industry. To secure a bright future, we need to work as one towards:

- The development of digital solutions to the problems, challenges and opportunities – including the alignment of Digital Twins with the Digital Built Britain initiative.
- A national transport strategy that supports collaboration over competition.
- Less regulation to free up industry players to ensure their contribution to the railway is both what customers want and cost effective.
- Promoting and improving further rail's environmental advantages, as part of the Government's Decarbonisation plan.
- The development of whole-journey, modally integrated solutions – both for journey planning and for ticketing.
- Innovative train design that supports flexible usage.
- A pipeline of new talent attracted to an industry by its dynamism, use of transferable skills and its commitment to meet the transport needs of our society.

IRSE
Institution of Railway Signal Engineers

Principles for project success

Paul Darlington

The Infrastructure and Projects Authority (IPA) is the United Kingdom government's centre of expertise for infrastructure and major projects. It has been talking to project professionals across government, and beyond, about the things that are the core principles underpinning successful project delivery. They have now brought these together as eight key principles for any project's success, and a quick guide on things to get right for any project to succeed.

The eight principles are designed as short, memorable headlines with supporting bullets and further resources. They are deliberately short and action-focused: the aim is for them to be easy to understand, no matter what kind of project is involved.

The principles draw on the experience of project professionals and on a broad range of review findings and guidance, both in government and across professional bodies. The principles are aimed to align with accepted good practice, both nationally and internationally.

The principles sit alongside the UK government functional standard for project delivery (irse.info/w7346) and other IPA tools and guidance, designed to support the wider aim to create a consistent culture of world class project performance.

The principles are summarised below and can be found at irse.info/fl8g7.

Focus on outcomes

Be clear about the outcomes to be achieved before starting the project. Translate outcomes into tangible deliverables and realistic measurable benefits and use these to steer decisions on project scope, time, cost, risk and design priorities.

Plan realistically

Invest time in thorough up-front planning to ensure the project is deliverable and affordable before commitments are given. Use expert, evidence-based cost estimation, using benchmarking and reference class forecasting to identify the range of possible scenarios, and increasing accuracy between each stage gate.

Prioritise people and behaviour

Plan ahead for the diversity of people, skills and experience needed to deliver the project and build a strong, properly resourced and competent team, throughout the project lifecycle. Agree clear expectations on behaviours and make the project a great place to work, where everyone in the team can thrive, grow and feel valued.

Tell it like it is

Foster an open project culture, where people feel safe to challenge and raise risks and issues, and where assurance is valued as a key element of successful delivery. Encourage honest conversations and if something isn't right, isn't ready or isn't working, say so, and take action accordingly.

Control scope

Agree project scope from the start and stick to it at each stage. Agree clear scope for each stage. Exercise strict change control, and test unavoidable changes in scope or design before decisions are taken. Work in manageable project stages, with gated decision points. Track progress to plan, always assessing impact on benefits and outcomes.

Manage complexity and scope

Reduce complexity and risk or plan and manage them. Take a system-wide view and plan for it, with a detailed project execution plan in place. Minimise internal and external dependencies and manage those remaining through the life of the project. Pay attention to integration. Plan how to bring elements together, testing that they work together at each stage.

Be an intelligent client

Build a clear understanding of user needs and design the project accordingly. Consider the whole supply chain, and whether it can deliver what is needed. Involve the supply chain early. Establish channels for dialogue with users and stakeholders so their voice is heard throughout the project. Build trust-based relationships and contract collaboratively to ensure viable contract and incentivise successful delivery for all.

Learn from experience

Seek out and value relevant experience and learning from other projects and use them. Build a culture of continuing professional development. Maintain an 'outside view' of the project: bring in independent perspectives and integrated assurance, and learn from them. Capture lessons throughout, and share them as feedback to improve project delivery for wider public benefit.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

Positive Train Control 98% implemented

USA: A quarterly status update, based on self-reported progress as of 31 March 2020, from the US Department of Transportation Federal Railroad Administration (FRA) says that Positive Train Control (PTC) systems are in operation on 98% of all PTC-mandated route miles. Full implementation of PTC systems is mandated by 31 December 2020.

The report says PTC systems were in revenue service demonstration (RSD) or in operation on 56 541 route miles (91 000km) – 98% of the required 58 000 (93 000) route miles. Specifically, the systems were operating on all PTC-mandated main lines owned or controlled by Class I freight and other freight host routes subject to the mandate. With 33 weeks until the final implementation deadline set forth by Congress, FRA continues to direct additional staff resources to railways at risk of not fully implementing PTC systems by 31 December 2020.

The presidents of MTA Long Island Rail Road (LIRR) and MTA Metro-North Railroad also announced that PTC has been activated on the majority of their tracks, and both are on schedule to complete system-wide activation of PTC by the end of 2020. Work had to be rescheduled and made more efficient with supply chains disrupted by the COVID-19 pandemic, while ensuring adequate social distancing of staff.

Metro-North reported that 202 miles (325km), or 82%, of its routes are now operating in PTC: The complete Harlem Line, the complete Hudson Line, the New Haven Line from Grand Central Terminal to Greenwich, Connecticut, and the New Haven Line's Danbury and New Canaan Branches. LIRR reported that 223 miles (359km), or 73%, of its routes are now operating in PTC, including the Babylon, Central, Far Rockaway, Hempstead, Long Beach, Montauk, Oyster Bay, Port Jefferson, Port Washington and West Hemstead Branches, and the section of the Ronkonkoma Branch from Ronkonkoma to Greenport. All of the routes activated with PTC have it enabled with full interoperability with all other railways who share the infrastructure tracks, including Amtrak and freight railroads. The USA is to be congratulated on the PTC roll-out programme.

East Coast Main Line (EMCL) to become Britain's first main line digital rail link

UK: The ECML is to receive £350m (€385m, $432m) of new investment to install ETCS signalling designed to cut journey times and reduce delays. The investment is on top of £1.2bn (€1.3bn, $1.5bn) already identified to improve passenger journeys on the route, creating capacity for up to 10,000 extra seats a day on long-distance services, speeding up journeys and improving reliability on one of the country's most important rail arteries. A third of the United Kingdom's population lives within 20 minutes of an East Coast Main Line station and together they produce 41% of the gross domestic product.

More than 80 million journeys are made each year on the ECML, linking London with Edinburgh, with congestion on the route compounded by signalling nearing the end of its useful life. The upgrade will be between London King's Cross and Stoke Tunnel in Lincolnshire. Development work is already underway with Network Rail to provide ETCS signalling on further routes including sections of the West Coast Main Line, Midland Main Line and Anglia from 2026. The government also announced £12m (€13m, $15m) is being invested in fitting ETCS equipment to 33 new trains for the Midland Main Line.

ETCS testing Zamora to Galicia

Spain: On May 15-19 high speed test runs using ETCS Level 2 were carried over the 111km section of high-speed line between Zamora and Galicia, completing testing of ETCS between Olmedo, Medina del Campo and Zamora. A Class 112 train made a series of tests under simulated operational conditions along with two Talgo Class 730. Normal and degraded operating conditions were also replicated. The opening of the line from Zamora to Ourense is expected before the end of the year and will complete the long-planned high-speed corridor linking Madrid with Santiago de Compostela.

ATO testing on regional trains

Germany: The Federal Ministry of Economics has awarded Alstom the 'Innovation Prize for Regulatory Sandboxes' to test automatic train operation (ATO) on regional trains. This is planned to commence in 2021 in partnership with Regional Association of the greater area of Braunschweig, the German Aerospace Center (DLR) and the Technical University of Berlin (TU Berlin), using two Coradia Continental regional trains.

Freight fleet fitment of ETCS

UK: DB ESG has announced it has received additional work from Siemens Mobility Limited to provide the vehicle installation design for a European Train Control System (ETCS) to go onto an additional four classes of freight locomotive, class 60, 59, 57 and 47. This order follows on from one announced in June 2018 to provide the mechanical and electrical installation design for the Class 66 freight locomotives.

Estonian railway modernisation

Estonia: The European Investment Bank (EIB) has signed a €95m (£85m, $108m) 25-year loan with Estonian national railway company Eesti Raudtee to modernise tracks and the control-command and signalling systems on the majority of the Estonian network.

The scope includes the refurbishment of parts of the Tallinn to Tartu line, including the construction of a new bridge on the Emajõgi River. Improved safety measures (including barriers) for level crossings and track refurbishment to allow a speed increase up to 135km/h. On the Tapa to Narva line, two bridges will be renovated and 54km of tracks renewed, with level crossings made safer. New signalling devices will be installed on most of the network and train management systems will be digitalised to improve service and safety.

Indra, based in Madrid Spain has been awarded a €18.4m (£16.6m, $22m) contract for the rail traffic management system for the 1214km network. The contract scope includes: centralised traffic control, regulation, and planning systems; together with system maintenance for two years, effective from the start-up of the last line which is expected to take place in 2025.

Guardia onboard ETCS approval

Poland: A joint venture of Stadler and MerMec, called AngelStar, has obtained type approval for its Guardia onboard ETCS baseline 3.4.0 equipment. Stadler Flirt electric multiple-units for Koleje Mazowieckie have been fitted with the equipment which supports dynamic switching between the Polish national train control system and ETCS without trains stopping.

Indian Railways cancels signalling contract

India: Dedicated Freight Corridor Corporation of India (DFCCIL) has said it is to terminate a Rs4.7bn (£50m, €55m, $62m) signalling contract with the Beijing National Railway Research and Design Institute of Signal and Communication (RRDISC). The contract was awarded in August 2016 to design and install signalling and telecoms equipment on a 417km segment of the Eastern Dedicated Freight Corridor (DFC). DFCCIL say in the four years since the contract was awarded, only around 20% of the total work has been completed, despite the contract being planned for completion within three years.

Irish Rail new train control centre.

Ireland: Indra has secured contract from Iarnród Éireann (Irish Rail) to develop a train control centre in Dublin, Ireland for the 2400km network which carried around 50.3 million passengers last year. A video explaining the new control centre can be found at **irse.info/i7p68**.

The company will be responsible for the design, supply, installation and commissioning of the rail traffic management system (TMS) and control equipment, along with maintenance of the system for 15 years with an option to extend to 20 years. The new rail control centre will be equipped with an integrated and automated control system, based on Indra's Mova Traffic line of solutions. Training facilities and a backup control centre at a secondary location will also be provided.

City railways and light rail

Bangkok people mover

Thailand: Bombardier is to supply Innovia 300 people mover cars and Cityflo 650 control systems for the. Gold Line automated "people mover" in Bangkok. Teltronic have also been contracted by System integrator AMR Asia to supply TETRA mission-critical radio communications. The scope includes a high capacity switching control node, base stations, SC20 handheld terminals and desktop units.

The 2.7km first phase of the Gold Line will connect the existing BTS Green (Silom) Line Skytrain station at Krung Thon Buri with residential and commercial property developments. Opening is planned for 2021, with a second phase extending the route to the Phra Pok Klao and Memorial bridges.

GoA4 driverless trains for China

China: Taiyuan is the capital and largest city of Shanxi province in China. The Taiyuan Metro Line 2 is planned for completion in 2020 and the 23.6km line will cross the city from north to south with 23 stations. CRRC Dalian Locomotive & Rolling Stock Ltd has delivered the first of 24 six-car Type A trains equipped for GoA4 unattended automatic operation on the route. The trains will carry 2 520 passengers at a maximum speed of 80km/h with a design life of 30 years.

CBTC for Istanbul, Nanchang and Incheon

Turkey: Çelikler Taahhut have awarded a contract to Gülermak-YSE and Thales to install CBTC on the new 7.5km Line M10, which is being built in Istanbul Turkey, connecting the Kaynarca district with Sabiha Gokcen International Airport. Line M10 will run from Pendik via Kaynarca Central and Hastane to the airport. It will connect with Line M4, which is already equipped with Thales SelTrac, via a link from Hastane to Tavsantepe. This will allow through operation from the airport to Kadikoy with a journey time of 46 minutes.

China: Thales SEC Transportation System (TST), in a joint venture with Shanghai Electric, will install CBTC on the first phase of the new metro Line 4 in Nanchang, China. The first phase of Line 4 will run from Baimashan via the city centre to Yuweizhou. It will be 39.6km long, of which 34.1km will be underground and 5.5km elevated, with 29 stations.

South Korea: Thales and DaeaTi will install CBTC in the Line 2 depot of the Incheon metro, which is being expanded to accommodate six new driverless trains supplied by Woojin, Korea. The new trains are required to cope with the increase in traffic from 90 000 to 180 000 passengers per day since Line 2 opened in July 2016. The new trains will be delivered in 2021 and will be fitted with the Thales Vehicle On Board Controller (VOBC).

Dallas SCADA

USA: Alstom Signalling Operations has received a contract from the Dallas Area Rapid Transit Board to upgrade its supervisory control & data acquisition (SCADA) system, which was installed in 1996.

The scope includes software, servers, workstations, tunnel ventilation control systems, an overview display wall and a cyber security system, and provide data backup with remote-site archiving. The contact also includes multi-site functionality, optical transmission network backbone compatibility, and provision for future multimodal integration, including the Downtown Dallas D2 light rail line and interfaces with the Silver Line commuter rail project.

Communication and radio

Siemens Mobility and Ondas Networks for North American rail market

USA: Siemens Mobility has entered into a partnership with Ondas Networks, a developer of private licensed wireless data networks for mission-critical industrial markets, to bring a Siemens-branded portfolio of wireless radio communication systems to the North American railway industry.

The portfolio will include new radios that are interoperable with Siemens Mobility's Advanced Train Control System (ATCS) radios. The new radios will be Mission Critical IoT (MC-IoT) capable, ready for future advanced train control, signalling, crossing and monitoring applications. The new ATCS radios for both base station and lineside are expected to be available within the next year.

Siemens Mobility and Ondas say they will work closely with international standards organisations and North American rail representatives to promote a public open standard that will benefit railways, suppliers and application providers.

World-record 5G speeds

USA: Nokia says that it has achieved 5G data speeds of 4.7Gbps, which it says is the fastest over-the air speed yet transmitted. The testing, which was conducted in Dallas, used 800MHz of commercial millimetre wave spectrum and enhanced dual connectivity (EN-DC) functionality. The 4.7Gbps speed used base station equipment that is used in major carrier networks in the US.

The method used to achieve the speed was the combination of eight 100MHz channels of millimetre wave spectrum on the 28GHz and 39GHz bands and 40MHz of LTE spectrum using EN-DC functionality in Nokia's AirScale platform. EN-DC enables devices to simultaneously transmit and receive data across 5G and LTE networks. This means devices can achieve a higher throughput than when connecting to 5G or LTE alone.

5G Week – Driving the Business Case London, 7-11 September 2020

UK: The Department for Digital, Culture, Media & Sport (DCMS) and UK5G, the national innovation network dedicated to the promotion of research, collaboration and the industrial application of 5G in the UK, are running "5G Week" 7-11 September 2020. The week of activities are for all organisations involved in the industrialisation of 5G. irse.info/zv0ng.

As an introduction to the week a discussion "How can 5G and other complementary technologies help to drive the 4th industrial revolution?" can be seen at irse.info/y2utj.

HS2 telecoms

UK: New-build high speed line HS2 has begun to appoint a specialist contractor to deliver telecoms systems which will connect the new high-speed rail link between London, Birmingham and the north of England.

The contract, worth approximately £300m (€330m, $370m), will cover the design, manufacture, supply, installation, safety authorisation, testing, commissioning and initial maintenance of the operational telecommunication systems, as well as the route-wide security systems, on Phase One and 2a, between London and Crewe. The scope includes 2760km of fibre optic cabling, 140 trackside cabinets, dozens of equipment cabins and radio coverage across 230km. The winning bidder will also deliver a separate contract for the provision of technical support services.

Separate contract opportunities, expected in 2021, will cover third party communications, including mobile phone coverage for passengers on trains and in stations, Wi-Fi and an emergency services network. The operational telecoms contractor will be expected to take a leading role in the managing of interfaces between the telecoms and other contracts.

CBTC over a public mobile network

Norway: Oslo transport operator Sporveien will use a public mobile operator (PTO) to support its new CBTC metro signalling and train control system. Telia will provide the wireless communications backbone.

The CBTC will replace the existing signalling on Sporveien's six-line metro network, to increase capacity, reduce headways and provide better traffic management. The NOK5.4bn (£450m, €500m, $560m) project is due to be completed by the end of 2027. Unlike other CBTC systems which use dedicated Wi-Fi or radio communications to transmit data to and from the trains, Sporveien believes that using an existing mobile network will be "more future-oriented, more reliable and (with a) lower cost". The agreement with Telia is valued at approximately NOK100m (£8m, €9m, $10m) over the life of the signalling system and the use of a public mobile network, rather than a dedicated private network, is expected to generate savings of between NOK100m and NOK200m (£16m, €18m, $20m).

The contract includes strict availability and service level requirements to ensure there is always full mobile coverage across the entire metro, and that signalling data transfers are prioritised over all other data traffic.

Vodafone says UK's 5G leadership will be 'lost' with Huawei ban

UK: Vodafone has warned that the UK's planned 5G networks will be compromised by the government outlawing all technology made by Chinese firm Huawei.

"The UK's leadership in 5G will be lost if mobile operators are forced to spend time and money replacing existing equipment," said Scott Petty, Vodafone UK's chief technology officer. He believes the government should be focused on expanding the existing infrastructure, rather than removing elements made by Huawei. Vodafone is working with Ericsson and testing equipment from new suppliers, but says it is important to understand the extent of what is at stake now they cannot use Huawei equipment. BT has already said it will have to spend around £500m (€558m ,$630m) just to comply with the previous required 35 % cap on Huawei involvement in their network.

LTE MCX and FRMCS

World: Railway operators have started to deploy new radio networks based on the Long Term Evolution (LTE) mobile network standard. Some have followed the Mission-Critical Services (MCX) standards defined by 3GPP LTE Releases 13 and 14 and these are currently supporting railway operational voice services and automatic train control applications. At the same time, the International Railway Union (UIC) has been defining Future Railway Mobile Communications System (FRMCS), as part of 3GPP Release 16 and 17, to succeed GSM-R. A paper exploring the relationship between MCX and FRMCS and the impact of 5G has been published by Rail Systems Australia and can be found at irse.info/0auln.

UK fibre roll out

UK: Utility firms may be able to lay cables for broadband infrastructure inside water and sewer networks in order to speed up the rollout of fibre broadband. The government is also considering strengthening broadband companies' access to run cables along new and existing infrastructure lining the road and rail networks across the UK. Currently, civil works, in particular installing new ducts and poles, can make up as much as 80 per cent of the costs to industry of building new broadband networks. Research from the National Infrastructure Commission suggests infrastructure re-use could lead to an £8bn (€8.8bn, $10bn) cost saving for companies deploying 'gigabit-capable' broadband.

The UK plans a full fibre rollout to be completed by 2025 and CityFibre has announced plans to hire 10 000 people for the project (irse.info/86dsp). Salisbury has become the first entire UK city to gain access to Openreach's ultrafast broadband network with full fibre broadband now available to more than 20 000 premises in just under a year.

Liquid cooled equipment

Finland: Nokia is making 5G base stations more environmentally friendly by implementing liquid cooling. They say their first deployment of a 5G liquid-cooling base station in Helsinki is a success and the base station was able to cut energy cost by up to 30%, and lower its CO_2 emissions by up to 80%. Approximately 90% of energy consumed by radio base stations is converted into waste heat, and Nokia says the liquid-cooled equipment sites are silent, require less maintenance and can be smaller and lighter than standard active air conditioning units. Could liquid cooled equipment be used in other signalling and telecoms equipment to make them more environmentally friendly?

Safety, standards, health and wellbeing

Level Crossing misuse rises

UK: Network Rail and British Transport Police are concerned that as people emerge from Covid 19 lockdown there is a dramatic increase in the number of people risking their lives at level crossings. For example, at Little Marlow, Buckinghamshire, CCTV captured a small child left on the tracks while the adult with them could take a picture. Another image from the same level crossing shows someone kneeling on the track while holding a dog, again so a picture could be taken. A few miles away at Mill Lane level crossing CCTV footage shows two people almost walk out in front of a moving train before rushing back to safety.

The Little Marlow route has seen 16 people risk their lives on its level crossings since 23 March, which Network Rail said was an increase of 433 per cent compared with the same period in 2019. The use of good resolution CCTV enables such behaviours to be captured to support media briefings and other actions to be instigated. The warning issued by Network Rail coincided with the International Level Crossings Awareness Day.

RSSB SPAD podcast

UK: The Rail Safety and Standards Board (RSSB) has released a podcast looking a Signals Passed At Danger (SPAD) management. It explains what the UK rail industry is doing to help reduce the number of SPADs and how various tools and techniques can assist. See irse.info/oince.

Big data and Artificial Intelligence

Artificial Intelligence white paper

Europe: ETSI has published a white paper exploring the key issues of Artificial Intelligence (AI) that present both huge opportunities and new challenges. The paper details current initiatives and recommends future directions for the ETSI community and industry in general. ETSI technical bodies are already addressing numerous aspects of using AI. These include 5G systems, network planning and optimisation, service provisioning and assurance, operator experience, security, IoT, data management and testing. It also discusses some activities of advisory groups, government-sponsored research projects, open-source AI projects, industry alliances and some other Standards Development Organisation (SDO), which are creating specifications. The paper can be found at irse.info/bqhjf.

RSSB Data Sandbox+ programme

UK: The Rail Safety and Standards Board (RSSB) has announced the three winners of its second round Data Sandbox+ programme, to develop data-driven ways of improving operational performance.

- Utilising deep analytics to predict reactionary delays and dwell time variation in the new accessible railway, led by Transreport in collaboration with the Rail Delivery Group and Govia Thameslink Railway.
- A real-time functional digital twin for the Thameslink route, led by OpenSpace in collaboration with the University of Birmingham, Network Rail, RDG and Govia Thameslink Railway.
- Rapid evaluation & planning analysis infrastructure for railways, led by Frazer-Nash Consulting in collaboration with the University of Hull.

It has also announced two projects to be funded under its Dynamic Train Planning competition.

- Dynamic Freight Capacity Management, led by 3Squared with operators Rail Operations Group and Freightliner, will analyse working timetable path utilisation to identify unused paths for operators needing to use the manual Very Short-Term Planning (VSTP) system. It is planned that the resulting tool would host a real-time capacity exchange, where operators can relinquish schedules for particular days.
- Pathfinder, led by Worldline, aims to use detailed knowledge of current operational requirements and machine learning from relevant historical events to generate and validate new and amended VSTP train paths.

Maintenance and surveying

Drone beyond line of sight

UK: AmeyVTOL has demonstrated the first drone inspection of UK infrastructure to go beyond visual line of sight (BVLoS). The VTOL drone surveyed a 2km area autonomously and out of the sight of the operator. Previously drone inspections were limited to flight within visual line of sight and could not operate further than 500 metres from the operator. The AmeyVTOL's drone can operate up to 100km on a single charge.

This now opens up possible BVLoS inspections of long linear infrastructure such as railways and overhead power lines and roads. This will save time and survey costs, along with the quality, volume, and repeatability of data to enable better asset management and maintenance decisions, and most importantly avoiding people needing to work alongside a live railway, reducing safety risk.

The demonstration was part of a government-sponsored rail First of a Kind (FOAK) programme promoted by Innovate UK through the Small Business Research Initiative (SBRI). SBRI is designed to bring together government challenges and ideas from businesses to create innovative solutions.

Education and universities

The E in STEM

UK: The UK government has produced a video to explain "what is engineering" to young students. The objective is a short, sharp guide to what engineering actually is and in just over two minutes it explains: What engineering is – and a snapshot of the sectors, people and positive impact engineering offers society. Why schools are a key component to the future of engineering and the variety of routes into engineering. See irse.info/yrvja.

Companies and products

432-fibre closure approval

UK: Passcomm Ltd has gained Network Rail approval for its single-ended, O-ring sealed dome closure for splicing fibre feeder and distribution cables (CommScope FIST-GCO2-BE8) for the 432-fibre cable now used on the Fixed Telecoms Network (FTN). The original FTN fibre was 24-fibre. The larger enclosure and ribbon trays provide additional capacity and flexibility for the 432 high capacity fibre count cables, which have been trialled and tested on the Trans Pennine Initiative (TPI) deployment.

Cloud-based cable monitoring and fault diagnosis

UK: Viper Innovations CableGuardian cable monitoring system has successfully received product approval from Network Rail. The product is a cloud-hosted cable monitoring and fault diagnosis system designed to help prevent service affecting failures before they occur.

The system continuously works on live power networks providing cable and conductor condition information in real time, with the insulation resistance and insulation capacitance condition trends graphically highlighted. It monitors and detects the location of both insulation and conductor faults on live signalling power systems as specified in Network Rail specification NR/L2/SIGELP/27725.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE

2020 IRSE Professional Exam

We are optimistic that the 2020 IRSE Professional Exam will take place on Saturday 3 October 2020 at examination centres across the world adhering strictly to the social distancing requirements for each country. The opportunity to book exam modules for this year is now closed (closing date was 30 June). If Covid-19 forces us to close any or all centres we will notify candidates immediately and offer the opportunity to re-sit the examination next year.

Considering the uncertainty created by the pandemic, we have been pleased with the number of candidates registered for the exam which includes over 190 signed up for the brand-new Certificate in Fundamentals of Railway Control engineering. (Module A). This is a qualification in its own right and also a pre-qualification for sitting the more advanced modules.

From October 2021 onwards, only the new Module A plus three new compulsory advanced modules will be available. These new modules will cover the current full exam syllabus with a wide range of questions to enable candidates to answer questions relevant to their own specialisation. Passing all four new modules will lead to the qualification of the "IRSE Professional Examination" just like today. Those who have/ will have passes in the current exam will not lose out, they will not have to start the exam again, and there is no time restriction for them to continue their studies. The IRSE Professional Exam remains a high standard of professional knowledge and is acceptable as a 'top up' to suitable qualifications for registration as Incorporated Engineer and Chartered Engineer status.

Automated Railways Live Seminar

We are delighted to be collaborating with three other leading professional engineering institutions, the Permanent Way Institution, Institution of Mechanical Engineers and the Institution of Engineering & Technology, to deliver a two-day live seminar on Automated Railways. Recorded content will be available to watch on demand in advance of the live 90-minute seminars which will take place on 17 September and 8 October.

As automation, artificial intelligence and robotics technologies continue to develop, they open up many opportunities to increase railway capacity, performance and reliability, while reducing costs and improving customer experience and safety. Much is also to be learnt about how automation can be introduced effectively and safely.

The speakers involved in this seminar will explore the opportunities and issues involved when introducing automation on existing railways. They will also address the less constrained possibilities in new build railway systems. The contributors will evaluate currently available technologies and their implications for railway capacity, operations and asset management, and discuss options for the future. They will consider the human factors, ethical and stakeholder management issues surrounding automation, and will draw out lessons learnt from projects that have introduced increased automation.

As well as gaining a full systems understanding of railway automation, delegates with an interest in railway infrastructure engineering will learn how automated train operation can affect the physical condition and management of the infrastructure, and how automation of inspection, maintenance and track access can contribute to safer and more effective infrastructure management.

Part 1: View three and a half hours of pre-recorded online content from 28 August ready for the live session on 17 September 2020 09.00-10.30 (UK time).

Part 2: View a further three and a half hours of pre-recorded online content from 18 September ready for the live seminar on 8 October 2020 09.00-10.30 (UK time).

The cost to watch all the pre-recorded content and the two live seminar sessions is £80 for Institution members and £120 for guests. Bursary places are available for those new to the industry. For more details and to book visit **www.automatedrailwayseminar.online**.

Blane helps shape UK Government Talent Retention Scheme

Our chief executive Blane Judd is a member of the Construction Leadership Council and its only representative from a professional engineering institution. This group worked with the UK government to help develop the Construction Talent Retention Scheme designed to retain skilled workers following the Covid-19 pandemic.

The scheme, launched in July by the UK chancellor of the exchequer Rishi Sunak, is an online portal that supports redeployment of staff at risk of redundancy across the sector, while also enabling temporary employee loans between businesses. The scheme gives displaced workers from other sectors a route to find new employment in construction.

IRSE Licensing

The IRSE Licensing Scheme provides assurance about the competence of individuals to carry out technical safety-critical or safety-related work on signalling and railway telecommunications equipment and systems.

PM Training & Assessment Ltd has produced a video to describes the process in obtaining and maintaining IRSE Licence. This can be found at **irse.info/i7w9r** and includes guidance and advice on the personal statement, logbook, evidence gathering, the workplace assessment, and the role of an assessing agency.

If any other assessing agencies or IRSE licence holders have advice on obtaining and maintaining an IRSE Licence, please let us know at **editor@irsenews.co.uk** and we would be pleased to share your experiences in IRSE News.

Professional development

IRSE Exam – Signalling the layout without signals

Andy Stringer

As ETCS becomes more and more common, so it is that an increasing number of students have considered answering the main line version of Module 2 with an ETCS solution. This raises the question: can you really get away with just a GSM-R mast in the middle of the layout?

In 2019, for the first time, some students took the plunge and provided an ETCS solution for the main line layout. And of course, the anticipated result proved to be the case; it is possible to either pass or fail the examination module with such a solution. First, it is worth remembering that the module questions ask for a lot more than just the placement of signals; there are usually a number of questions that require an answer before starting on the layout itself. These questions are specific and require an exact answer. If the question asks for a three-aspect headway to be calculated, then a three-aspect headway will be required to score full marks. You cannot negotiate the question by re-wording it to suit an alternative solution.

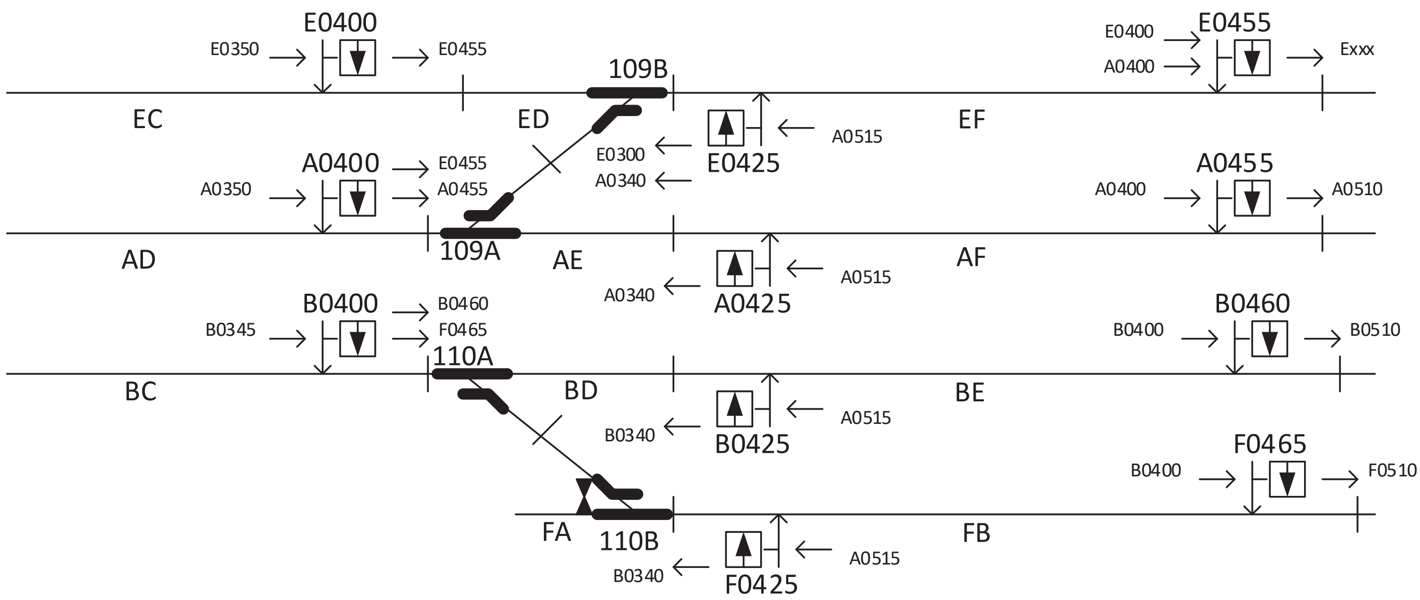
Then we come to the layout itself, and as with conventional signalling, you must demonstrate to the examiners that you have the required knowledge to achieve a pass or better. The question requires a number of elements to be fulfilled and these must all be addressed; the normal lay of points and the boundaries of train detection remain the same regardless of the technology for providing movement authorities. You must clearly describe how your solution will work, showing this on the layout or in a written explanation. A list of standard assumptions is useful (for all solutions), which for ETCS includes details such as:

- Means of train detection.
- Balises and their uses.
- Safe overrun distances.
- Release speeds and junction signalling.
- Reference country or project.
- Shunt modes and Staff Responsible.

An example is shown below of one solution submitted by a student which the examiners agreed gave a very acceptable answer.

It is worth noting that with ETCS many more routes are potentially available, as less physical hardware is required on the ground, but it is not necessary to provide every possible option to answer the examination. Only the routes required to operate the defined service need to be provided.

So, can you answer Module 2 using ETCS? Yes, and you can do so very successfully. Can you get away with just a GSM-R mast? No, unfortunately ETCS is a lot more complicated than that.



Midland & North Western Section

Merseyrail Class 777 trains

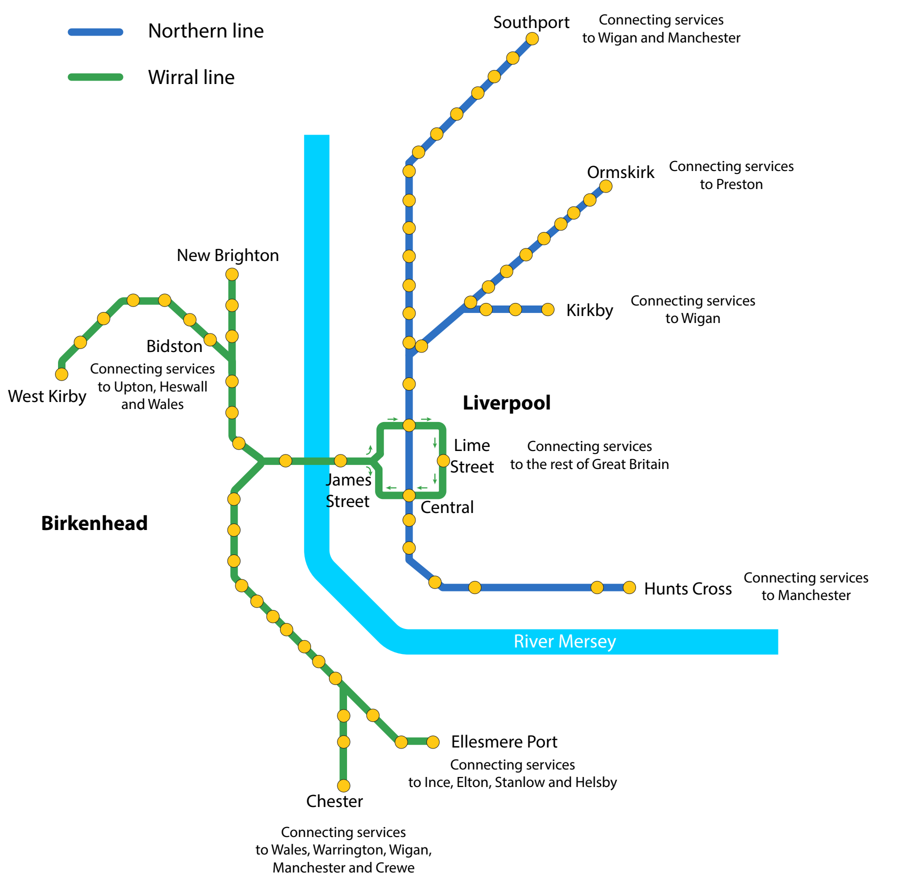
Report by Paul Darlington

In late May the section held its first 'on line' talk when David Powell, rolling stock director Merseytravel delivered an excellent talk on the introduction of new rolling stock to Merseyrail with over 70 attendees taking part. Normal face-to-face meetings held over the last year by the section had an average attendance of 30.

Merseyrail is the commuter rail network serving Liverpool and is the most heavily used urban railway network in the UK outside London. It is formed of two dedicated DC third rail electrified lines known as the Northern Line and Wirral Line, and is an intensive metro-style network of local passenger rail services within Merseyside and the adjacent areas of Cheshire and Lancashire, along with a number of underground stations in the city centre.

Merseytravel is the Passenger Transport Executive and Strategic Transport Advisor for the Liverpool City Region, responsible for the coordination of all public transport in the Merseyside area and will become the UK's only public sector main line rolling stock owner. The trains are being provided by a self-financing, sustainable business model with no rolling stock or leasing company involved. This is a natural extension of devolution and will deliver savings in energy, maintenance and operations plus additional revenue flow to Merseytravel, and with Merseytravel in full control of their new train's specification.

The network normally carries 110 000 passengers on weekdays and a total of 34 million passengers per year along its 75 miles of route with 68 stations. Six stations and 6.5 miles of route are underground. It can be a surprise to some visitors arriving at Liverpool Lime Street main station to find 'full size' trains entering the underground platform every few minutes. The network is currently operated by a joint venture between Serco and Abellio.



A simplified map of the Merseyrail network showing the two lines and connections of the most heavily used urban railway network in the UK outside London.

The Northern Line links underground stations at Liverpool Central and Moorfields with Southport, Ormskirk, Kirkby, and Hunts Cross; and the Wirral Line 'loop' linking underground stations at James Street, Moorfields, Lime Street and Liverpool Central with Hamilton Square the other side of the Mersey River and onto Chester, Ellesmere Port, New Brighton and West Kirby. The network currently operates a fleet of 59 Class 507 and Class 508 three car electric multiple unit trains. These are in the process of being replaced by a fleet of 52 (with an option for 60 more) new Class 777 custom-built train sets made specifically for the Merseyrail network by Stadler Rail. David explained two trains were on site in late May and testing was ongoing with full fleet introduction in 2021.

New trains and Wi-Fi

The new trains are 'state of the art' articulated four-car units, with 50% higher capacity than the current

Artist's impression of the Class 777 stock specifically designed to meet the unique needs of the Merseyrail network.

fleet and with faster acceleration and deceleration to reduce journey times by up to 10%. The new trains are also 5.5 tonnes lighter, with more efficient electrical systems so use 20% less energy. They will feature free Wi-Fi, including coverage in tunnels and underground stations, along with high-quality CCTV and voice links between the trains and Merseyrail's control centre in Sandhills Integrated Electronic Control Centre (IECC). The system will also provide data on the exact number of passengers on each train to enable better management of the network. In the post presentation discussion, the possibility of providing real-time forward-facing CCTV images to aid signal sighting was identified. This illustrates the benefit of IRSE talks.

The Class 777 is specifically designed for the Merseyrail network. The two longer driving cars at each end will only have one set of twin doors on each side, with the two middle trailer cars having two sets of doors. The trains will also have sliding steps to get onto the platform, which will mean passengers using a wheelchair will not have to use a ramp when boarding the train, improving accessibility for all users. Each train will also be provided with power and USB sockets, and bike racks. Instead of having partition doors between each carriage, the units will be articulated and form one large open space.

As well as providing improved passenger facilities the new trains are future-proofed to operate beyond the 3rd rail DC electrification infrastructure; possibly to destinations such as Helsby, Preston, Skelmersdale, Warrington and Wrexham. This is because the trains have been designed to allow retrofitment of 25kV pantographs and transformers, or batteries, as any future extension of the third rail traction system in unlikely to be approved due to the risk to people on the track. David explained that an option could also include a short DC overhead mid-section traction supply with battery charging infrastructure at the far end. The important point is that the new trains provide options to extend the network that are not available with the current trains.

All the new trains will be fitted from the start with small battery sets, for easy movement in workshop and depots. The contract for the new trains with Stadler includes modernisation of the train maintenance depots at Kirkdale and Birkenhead North, along with the provision of a new driving cab simulator.

Infrastructure works

Extensive platform adjustments and track realignment have been required to accommodate the new trains which feature a sliding step and to improve passenger accessibility and all work is now complete. The Class 777 trains will require a more reliable traction power infrastructure to address voltage drop and increase current from 4kA to 5.4kA. So three new bulk supply points are being provided by Scottish Power along with eight new substations and extensive cable upgrades.

New high capacity Wi-Fi

Panasonic is providing an extensive new trackside network wide Wi-Fi system, to provide 100Mbps data connectivity to all trains, which will enable high-quality, real time CCTV, voice and data links between the trains and the Sandhills control centre. This impressive initiative will also provide free Internet access for passengers and is known as the Merseytravel Train Connectivity and Information System (TCIS).

The enthusiasm and knowledge of the presenter really came through in the talk which was followed by 30 minutes of good thoughtful questions, which were all expertly answered by David. The on line talk was a success and Peter Halliwell delivered the traditional MNW Section vote of thanks with the audience showing their appreciation with a round of remote applause. A recording of the talk can be found at irse.info/spg06.

Swiss Section

IRSE Institution of Railway Signal Engineers SWISS SECTION

Getting shipments to change trains like passengers do

Report by George Raymond

To reduce road congestion and emissions, public policy in Europe seeks to shift freight from lorries to trains. Today, the railway offers three main production concepts: block trains, intermodal/combined transport (CT) and wagonload (WL) service. Each has its place. But none of these concepts address the lorry's main market: shipments of lorry size or less travelling 100 to 300km.

Stefan Karch presented this problem – and a new solution – on 21 June 2019 to a gathering of 16 members and two guests of the IRSE Swiss Section. This report is based on Stefan's talk that day and his May 2018 article in the Schweizer Eisenbahn-Revue. Member Ernst Hedinger organised the event in Olten, the presenter's home city. An independent consultant, Stefan also teaches at Dortmund Technical University in Germany. Midway between Basel, Bern and Zurich, since 2014 Olten has also been the home of SBB Cargo, a separately managed subsidiary of Swiss Federal Railways.

The presentation pointed out rail's current limitations. A block train can profitably carry a 200km shipment only if it fills 10 to 15 wagons. CT and WL are generally unprofitable for shipments of less than 400 to 500km. And neither CT nor WL directly handle single-pallet shipments. This task typically falls to freight forwarders who consolidate their customers' small shipments for transport by a CT or – more rarely nowadays – a WL operator.

To address the heart of the freight market, Stefan stressed, rail must enhance its current concepts – block trains, CT and WL – with a fourth production concept (4PC). Under 4PC, trains will run hourly on fixed routes that criss-cross one or more countries. Trains on each route will make multiple stops at high-performance terminals. At each terminal, automatic cranes and robots will quickly unload and load both swap bodies and individual pallets. Some shipments will then pursue their journeys on connecting trains – much as passengers do today. This will enable 4PC to offer even small shipments a competitive transit time between any two points in its network.

Three production concepts today

Stefan described the three main current production concepts for rail freight:

- **Block trains.** Block trains typically carry bulk goods, auto parts or new automobiles and must comprise at least 10 to 15 wagons to be profitable.
- **Wagonload service.** A railway wagon holds roughly twice as much as a lorry. En-route shunting slows WL compared to point-to-point lorry service. And it can usually offer only one departure per day. (In Switzerland, SBB Cargo now offers three pickups a day for high-volume customers.) But WL can connect any origin-to-destination pair on the rail network.
- **Combined transport.** Intermodal CT trains usually shuttle between two terminals. (More rarely, CT involves swaps of wagon blocks or transloading of loading units between trains at intermediate terminals, but this hurts terminal productivity.) Most CT terminals are stub stations for the start or end of a CT train run, not through stations that simplify intermediate stops. This limits the number of origin-to-destination pairs CT can serve. And only hauls exceeding 500km are generally profitable.

CT is the growth segment for rail freight. It has been replacing WL as rail's core offering. A consensus in Germany is that all the freight that could migrate from WL onto CT already has. WL has been increasingly seen as a niche for dangerous, heavy or oversize goods that cannot use CT because it collects and delivers shipments by road.

Rail decline and stabilisation, and current modal split

After 1950, the spread of motorways in Europe helped progressively shift freight from rail to road. The end of the Cold War and the liberalisation of transport furthered this process. Rail reforms in the 1990s brought taxes on lorries and new train operating companies in the 2000s.

Since 2008, rail freight's market share in Germany has stagnated at about 19%. The table below shows rail freight's 2018 share of tonne-km in all modes (source: Eurostat).

Austria	France	Germany	Switzerland
32%	10%	20%	35%

Differences among countries are even starker in the Alps. Here is the rail and road traffic in millions of net tonnes on trans-Alpine corridors in 2017 (source: Litra).

	Austria	France	Switzerland
Rail	24.1	3.4	27.2
Road	53.1	40.7	11.7
Trans-Alpine rail freight market share	31%	8%	70%

Railway path prices have tended to exceed lorry taxes and tolls. This has been a drag on rail's market share. But the presenter saw another problem. Rail's three current production concepts have abandoned the freight market's biggest segment to lorries:

- Most shipments travel less than 500km, and the lorry has a firm grip on them. This leaves little room for increasing rail's share in this segment.
- Current rail production concepts fail to address the large number of small shipments (from roughly 100kg to 10 tonnes) that ride lorries.
- The infrequent departures of both CT and WL lengthen transit times compared to lorries, as do WL's multiple en-route shunting steps.

Two key results:

- The average lorry shipment is 10 tonnes travelling 150km, whereas the average rail shipment, excluding block trains, is 60 tonnes travelling over 300km.
- Whereas hauls of 1000km or more are often already on the train, hauls of 500km or less are what fill the highways.

To address the main market served by lorries, therefore, rail freight needs to better emulate lorry service by offering lorry-like transit times for small, short-distance shipments. In other words, rail freight needs a way to profitably handle shipments that fill a swap body – or less – and travel 150 to 400km.

Swiss rail services for small, short-haul shipments

Some such rail services already run today in Switzerland. As part of its ongoing efforts to protect its population and the environment, Switzerland has long banned lorries from driving at night. This ban has spawned overnight domestic rail services. They operate in the 100-to-200-km range generally considered unprofitable for CT and WL. On the Swiss Post's network, for example, swap bodies sometimes ride three different wagons in one night. Another such service is RailCare, a unit of the Swiss supermarket chain Coop. Its shortest run is the 60km between Aclens and Carouge terminal in Geneva. To speed handling, RailCare developed technology that slides a swap body directly between its wagon and its local truck.

With some exceptions, railways abandoned less-than-wagonload (LWL) services in the 1980s and 1990s because of the high cost of manual sorting. Faced with the night-driving ban, however, some Swiss operators transport LWL shipments in roofed wagons between terminals overnight. Wagons may undergo intermediate shunting. Trucks collect and deliver these shipments, which can be as small as a pallet.

The custom-designed trucks, swap bodies and wagons of the RailCare unit of Swiss supermarket chain Coop enable horizontal loading. Geneva-Carouge, 26 October 2018.
Photo George Raymond.

Axle generator for en-route cooling of the groceries in a RailCare swap body. Aclens, Switzerland, 25 October 2018.
Photo George Raymond.

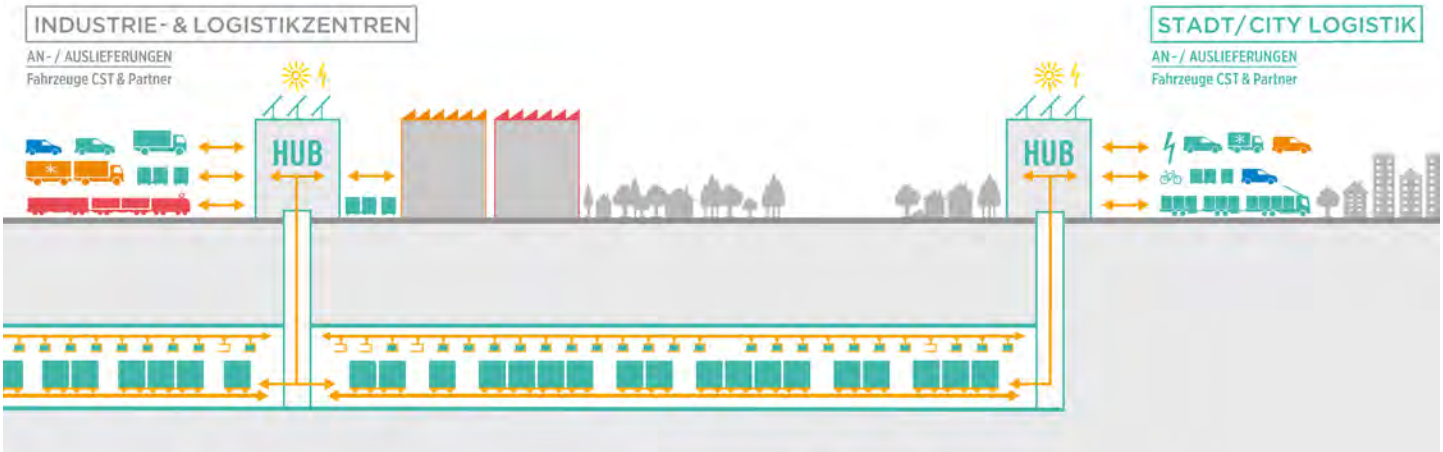
RailCare's current Swiss network.
RailCare.

Less-than-wagonload freight in Würzburg, Germany, on 26 May 1978.
Photo Adolf Wagner.

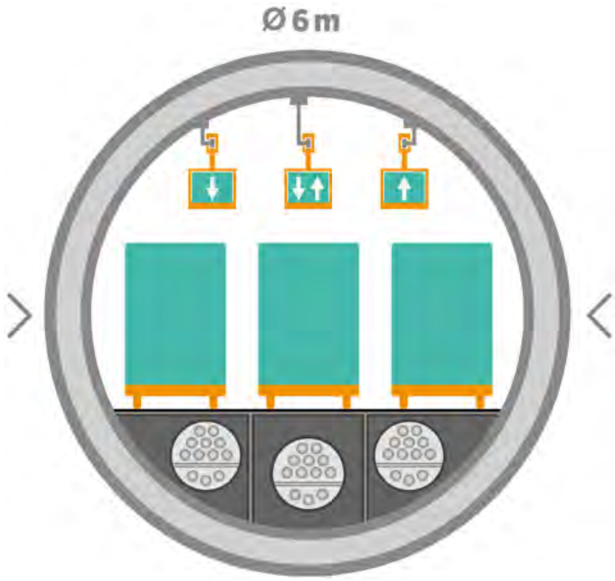
Above, A train of Swiss operator Cargo Domizil readies in Bern for its night run shortly before 18:00 on 1 March 2018.

Left, Outside, the local trucks that brought the small shipments.

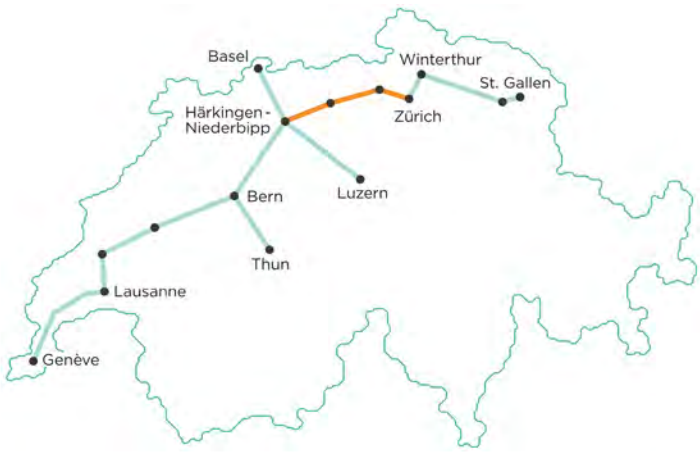
Photos Stefan Karch.



Concept of Cargo Sous Terrain for continuous movement of pallets and mini-containers between major Swiss urban areas. *CST.*



Cross section of Cargo Sous Terrain tunnel for pallet-sized shipments and mini-containers. *CST.*



Initial (by the early 2030s) and ultimate Cargo Sous Terrain network. *CST.*

Fast movement of small shipments is also the raison d'être of Switzerland's Cargo Sous Terrain (CST) project, which is advancing towards realisation. It foresees a network of intercity tunnels whose conveyors will continuously forward mini-containers and pallets between logistics centres in and near Swiss cities. However, that the division of labour between CST and the railway and their integration are still unclear.

Passenger-train service as a model

The current production concepts for rail freight – block trains, CT and WL – generally leave a shipment on the same wagon throughout its rail journey. In contrast, much of the European rail passenger service is based on trains shuttling on fixed routes and stopping at intermediate stations where passengers can change trains. These trains often run on (more or less) fixed-interval timetables every 30 or 60 minutes. By allowing mid-trip transfers between trains, such networks get passengers to their destination faster than could less frequent but direct trains connecting a greater number of stations.

4PC: Trains with fixed routes and consists

Organising rail freight like passenger service would improve both its profitability and market attractiveness for small, short-haul shipments. This is the objective of Stefan's fourth production concept. Under 4PC, shipments take and change between trains running with fixed routes and consists.

In recent decades, improvements in locomotives, wagons and infrastructure have been boosting train length, axle loads, total weight and speeds. But adoption of innovations like automatic couplers, remote brake checks and electro-pneumatic braking is slow. In the meantime, robotics, digitalisation and automation have forged ahead in other sectors.

In 4PC, fixed train consists eliminate any need for automatic couplers or for brake checks after adding or dropping wagons. Here, too, 4PC emulates rail passenger service, which has nearly eliminated mid-journey coach shunting. Like passenger trains, fixed-consist 4PC trains could cost-effectively be equipped with electro-pneumatic brakes. This would allow for a top speed of 120km/h and a start-to-stop average speed between terminals of 80-90km/h.

4PC trains will offer both flat wagons for swap bodies – and possibly other intermodal loading units – and roofed wagons for Euro-pallets.

In Germany, 4PC trains would be up to 700 metres long without the locomotive, run hourly and carry 51 twenty-foot equivalent units (TEUs) of containers and 900 Euro-pallets. In Switzerland, 4PC trains could be 500 metres long but run every 30 minutes. They would carry 600 Euro-pallets and 39 TEUs. On the busy Swiss network, paths for 4PC could come from consolidating existing short-haul domestic services for swap bodies and pallets.

4PC terminal network

In Germany, 4PC would be based on the ICE passenger network, but would need only 37 to 40 high-performance terminals spaced 50 to 100km apart. Switzerland would need 11-12 such terminals spaced about 60km apart. Served by trains running on fixed routes, these terminals would also enable shipments – both swap bodes and Euro-pallets – to change trains and thus minimise the shipments' origin-to-destination (O-D) transit time.

The 4PC's network of fixed-route trains and high-performance terminals will enable a limited number of lines to move shipments from any origin to any destination station on the network, just as passenger networks do.

Train speeds vs shipment transit times

Mean transit time in 4PC depends on both origin-to-destination transit time and service frequency. Lorries can average 50km/h. To be competitive, the goal for 4PC's minimum system speed – the average speed between origin and destination terminals – should be 60km/h. Averaging 80km/h between terminals 75km apart means about 55 minutes between terminals. Transferring shipments between trains within 15 to 20 minutes will allow 4PC to attain the 60km/h system speed that the market demands.

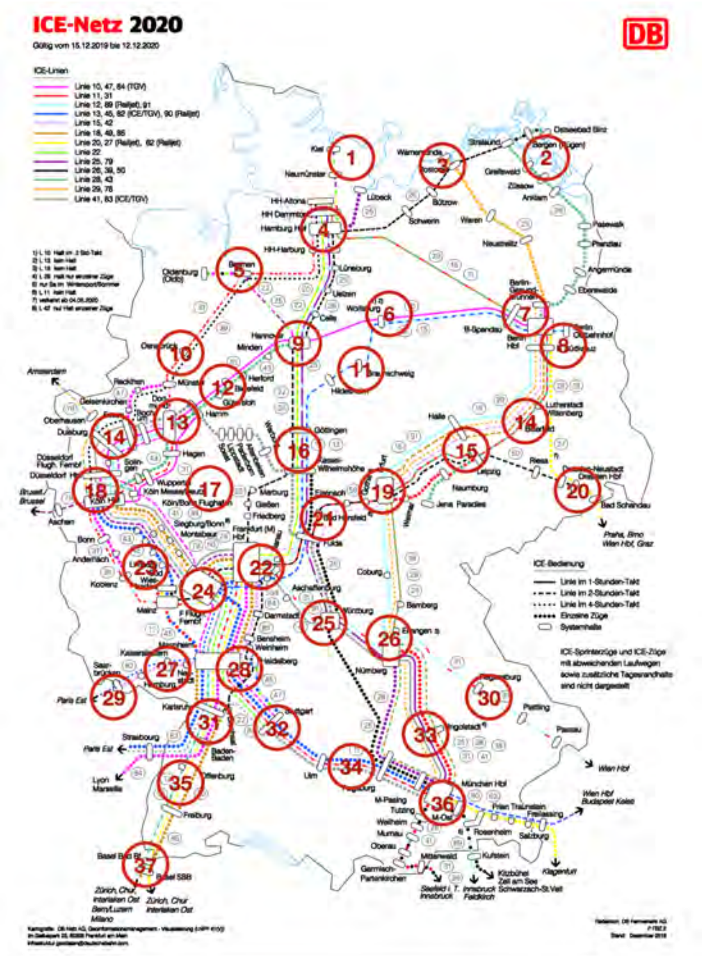
In Germany, a system with these characteristics could move a swap body or Euro-pallet over the 870km between Lübeck and Basel in 14 hours, with hourly departures, 24 hours a day. In Switzerland, where hauls tend to be shorter and lorry speeds lower, a 4PC system speed of 50km/h may suffice.

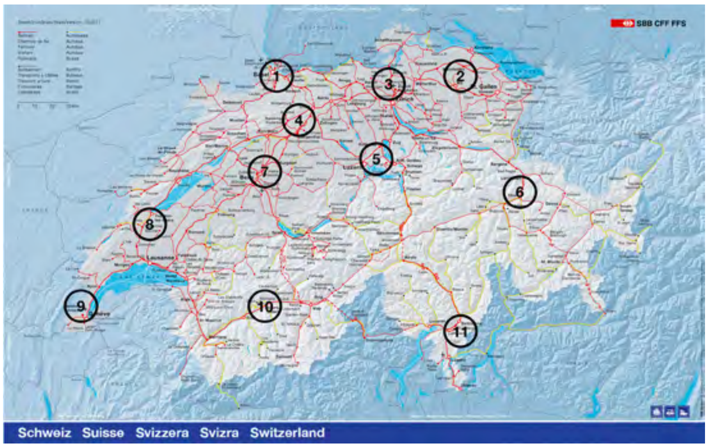
4PC's high service frequency – like that of passenger trains – will enable it to compete with road transport's flexibility. High frequency also ensures the high utilisation that will enable the 4PC terminals to pay for themselves. In parts of the day or week when demand is lower, the 4PC trains can run on a thinned timetable that still maintains fast transfers between trains.

High-performance terminals

Over recent decades while innovation in rail freight has been slow, industrial robotics and automation have forged ahead. 4PC will therefore rely on gradual innovation in its trains while leveraging dynamic and ongoing innovation in automated handling at its terminals.

At 4PC terminals, robots and automatic cranes will be able to exchange 30% of a train's shipments within 15-20 minutes. Each terminal will have at least two loading tracks, each accessible from both sides. Before a train arrives, systems will automatically and precisely position shipments on the platform.

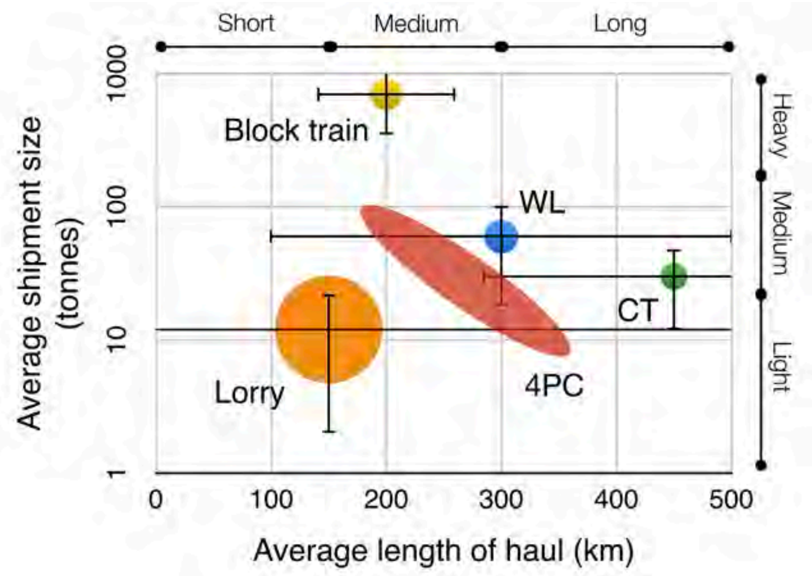




High-performance terminals for the fourth production concept (4PL) in Germany (left) and Switzerland (above).
Stefan Karch.

		Rail freight production concepts			
	Road transport	Block train	Wagonload service	Combined transport (intermodal)	Fourth production concept (4PC)
Smallest profitable shipment weight (tonnes)	0.1	300	20	10	0.1
Smallest profitable shipment (pallets)	1	400	30	15	1
Available origin-destination pairs	Any	Any rail-served	Any rail-served	Between CT terminals	Between 4PC terminals
Mean distance between terminal and customer loading point (km)	0	0	0	50	30
System speed (km/h)	50	70	15-25	70	60
Service frequency (hours between trains)	Customer decides	Customer decides	8-24	12-24	1-4

Table 1 – Comparison of road transport and the four rail freight production concepts.



Zones of relevance in terms of shipment size and length of haul of the lorry, the block train, wagonload, combined transport and the fourth production concept (4PC). *Stefan Karch.*

A track will receive and process up to three trains an hour. Trains will traverse loading tracks without reversing.

True to 4PC's credo, shipments will not spend much longer in stations than passengers do. With hourly train service and fast handling, shipments will wait an average of 45 minutes between trains. Terminals will need only limited space for shipments waiting for connections.

Loading of swap bodies will be either vertical or – following further development of technology like RailCare's – horizontal. Horizontal loading would allow catenary to remain over the terminal track. If loading is vertical, terminal tracks will be devoid of catenary and trains will coast into the terminal. For fast horizontal loading of pallets, wagons will be able to open their doors wide. A roof will cover the terminal for all-weather operation.

4PC will also benefit from automated loading of the trucks that will transport shipments up to 30km to their final destinations by road. These vehicles can be electric and recharge during their frequent stops.

The production concepts compared

Table 1 and the above diagram compare road transport and the four production concepts.

Implementation

Train and terminal operators would organise the 4PC system; a 4PC operator might coordinate. The next steps are: a feasibility study, market analysis, risk analysis, the organisation of actors and their interfaces, a business plan and an implementation and migration plan.

Outlook

Stefan concluded that rail freight can rival lorry performance if, in the context of 4PC, the rail freight sector:

- Adopts passenger service as a model.
- Runs fixed-interval trains averaging 80-90km/h between high-performance terminals where shipments can quickly transfer between trains.
- Handles both swap bodies and single pallets.
- Offers a system speed of 50-60km/h between a shipment's origin and destination terminals.

The freight market is dominated by shipments as small as a pallet travelling as little as 200km. By offering such shipments service comparable to the lorry's, 4PC can improve rail freight's modal share, cut road congestion and make freight transport greener.

Your letters

Re System safety

The article "System safety and their application to railway signalling" IRSE News July/August 2020 by Yuji Hirao is an excellent one, providing insight into application of the latest technology to railway signalling.

When I, as a conventional signal engineer look at the possibility of application of these new technologies, like multicore processors and Artificial Intelligence (AI) into core signalling systems, the following thoughts come to my mind.

So far, we are used to signalling systems whose response to a given situation as well as the internal processes that lead to the response is repeatable. This is true for all types of signalling systems – mechanical, electromechanical and electronic systems. For instance, if in the case of interlocking system, if a given route is set, its signal is cleared and we drop a track relay within the route, the signal will always fly back to "on" if the interlocking is designed correctly. If we test this phenomenon once, we can be sure, the same will happen irrespective of the prior history, i.e. irrespective of the events that took place before setting of the route or dropping of the track relay. We can also trace the steps of events that took place between dropping of the track relay and flying back of the signal to the on position. In case of electromechanical relays, this will be the sequence of relays that changed their positions, or in case of electronic interlocking, the software instructions that were executed to put back the signal. These events will always be the same irrespective of the history of events that took place before setting of the route or before dropping of the track relay. Therefore, these systems are testable to large extent. Of course, it can be argued that in case of electronic interlocking, it is not 100% testable for all possible conditions, but repeatability of the response gives enough confidence to accept the system with limited, but judiciously chosen test cases combined with the software verification. The systematic fault within the processor in the Electronic Interlocking, or incorrect wiring in the electromechanical interlocking, or erroneous interlocking in the locking tray of a mechanical interlocking will always give a repeatable response.

In the case of systems based on modern processors, which are optimised for high speeds, there is a possibility of out of sequence execution of instructions due to a systematic fault in the processor, and this deviation is not always repeatable; it will depend on various factors present at the time of execution as well as prior to it. In case of AI based system, its response will mature over the time, and again, it may not be always repeatable. I agree that these are extreme circumstances and not expected to occur as a routine, but as signal engineers, we are here to ensure safety even in extreme circumstances.

Agreed, these are being contemplated to be used in avionics domain, where the safety standards are more stringent than railway signalling. However, there is a basic difference between the control systems of avionics and railways. In avionics, most of the safety related systems are required to be fail-operational rather than fail-safe. Most of the safety related functions do not have the luxury of a safe state, where they can revert back in case of failures, as we in the railways do. The idea in case of avionics control systems is "do not give up till the last straw"; even in case of extreme circumstances, it will be preferred to go with the last resource available rather than total shutdown. In railway signalling, we have a safe state available for most of the safety related functions, therefore, we don't mind a shutdown of the functions rather than going on with enhanced risk.

Moreover, there is a huge difference between the amount of information to be processed and requirement of speed of execution between the avionics and railway signalling domains. The speed of execution and ability of handling huge data may be a necessity for avionics but perhaps a luxury for us. Recall that fly-by-wire technology, which is based on processors, was adopted by avionics a decade earlier than we accepted SSI. It was their compulsion to reduce the weight of copper by using fly-by-wire. Look at the application of processors in steer-by-wire or brake-by-wire in road vehicles. It is being contemplated and tried for road vehicles, but has not got its place in the regular passenger vehicles even after more than 40 years of its use in avionics. Proposal for application of new technology should be examined based on the benefits in the cost, performance and safety it brings to the system.

Thinking further ahead, why cannot we limit these new technologies in the top layer of the signalling systems where decisions are made depending on various parameters; yes, I am referring to ATS subsystem of the train control system, which requires a relatively lower level of safety, and leave the core interlocking functions to the proven technology, at least for now? Our interlocking functions are much slower than the avionics control systems, and we can afford to postpone the use of these technologies in the core interlocking functions till they are proven in other safety critical applications.

Mukul Verma

Re "It's only a relock"

Stephen Dapre's article on ""It's only a relock" – June IRSE News is a joy to read! Brilliant. He should be writing for "Private Eye" and I have sent him a note. The Back to Basic articles are also excellent. Well done and keep up the good work, despite the other society "diversions".

Colin Porter,
past president and
former IRSE chief executive

Re Traffic Management (1)

Fantastic article by John Francis in your June edition titled 'Traffic management – the bigger picture'. A real practical approach and analysis of a rail operators constant dilemma. We at Queensland Rail are currently facing some of these significant questions in relation to our next big infrastructure project in Brisbane, Australia called "Cross River Rail" and it seems like John has written this article especially for us.

I happily shared some of his insight with my colleagues on a "happy" vs "unhappy" train, as well as finding that "happy" balance between adding another single point of failure and that of having some resilience in the Network.

Thanks to you and John for a great read.

Greg Rooney

Re Traffic management (2)

Traffic management is inherent to efficient railway operation. The article by John Francis (IRSE News, Jun 2020) comprehensively captures this for main line rail operation. Traffic management is equally important for metro rail operation and I would like to present some perspectives regarding this based on my experience.

Metro railway lines are typically 20 to 30km long and trains service the lines continuously. Flexibility in operation is facilitated through track layout having: (a) efficient insertion and withdrawal facility from depot, (b) siding and intermediate turn back facility every 4-5km, (c) efficient turn back facility with redundancy at the end of track, (d) night stabling facility at suitable locations.

The factors requiring the need for regulation for metro rail are similar to the main line railway. The prominent factors are varying headway requirements during the day, infrastructure failures, weather and rail adhesion (elevated sections), driver variabilities (non-ATO zones) and passenger behaviours. The timetable has to utilise the flexibility provided by the track to run different number of trains (catering to varying demand) during the course of the day. The trains would be normally timetabled to be inserted/withdrawn from depot. Night stabling of trains wherever provided helps quick built-up of headway in the morning and also in saving the dry-run to and from the depot. The stabling lines can quickly insert/ withdraw trains and manage asymmetric headway arising out of peak in one direction in the morning and in the other direction in the evening. The timetable has to cater for all these requirements to boost operational efficiency.

Large video screen generally provided at the operation control centre depicts the movement of trains on the entire line and helps operators make decisions considering the overall effect on the network. The timetable has the facility to insert /withdraw trip in case of unusual demand on a particular day as well as exigencies arising out of infrastructure failures. The intermediate sidings are used for managing traffic disruption arising out of disabled trains as trips could be truncated and trains sent to the siding. Failure in any section of the network or weather conditions, such as excessive rain or fog, can slow train movements or stop them all together for some time. In that case an alternative timetable will be implemented to 'short loop' the services using intermediate turn back facilities, thus restricting disturbance in the affected section. Driver variabilities can disturb train spacing on the network and cause undue crowding in some trains (leading to delay due to requirement of higher dwell time at the stations). The timetable can manage this using the train hold and speed regulation features.

DK Sinha

Re Traffic Management (3)

The article by John Francis on traffic management systems in the June 2020 IRSE news on page 8 says "the Automatic Route Setting (ARS) tool used at many control centres in the UK does not recognise pathing time, hence making decisions that are not always optimal."

I should like to clarify that, in the case of IECC ARS systems, the pathing allowances are provided as part of the train schedules in the CIF timetable files and are used in various ways in the ARS prediction calculations. For example, if a train has a 2-minute pathing allowance approaching a junction but is already 5 minutes late as it approaches, then the prediction calculation will assume that the pathing allowance is no longer required and so the train will be able to make up 2 minutes on passing the junction.

The need to include consideration of the effect of pathing allowances on prediction calculations was recognised during the initial IECC ARS design. It has been an effective feature of all IECC ARS installations from the initial implementations in 1989 at Liverpool Street and York to the current generation of ARS systems now supplied by Resonate. This means that around half of the currently operational ARS installations in the UK do indeed recognise pathing allowances and take these allowances into account appropriately when making regulation decisions.

John Hurley

Non-European conventions

The Tim Howard obituary in June IRSE News said his successful IRSE Convention in May 1988 to Hong Kong, was the first time in the Institution's history the Convention had been held outside Europe. However, when I was president in 1981 the Convention was held in Toronto, Canada, where hopefully it will return in 2021. I recall receiving a phone call from the head of engineering at British Rail, who was concerned most of his key signal engineers might be travelling on the same aeroplane!

Leslie Lawrence

Re Techniques at the forefront of system safety

It was interesting to listen to the first presidential programme lecture on "Techniques at the forefront of system safety and their application to railway signalling" by Dr Yuji Hirao. One of the techniques mentioned is the application of artificial Intelligence for safety-related systems, taken from current research in the area of 'autonomous vehicles' and self-driving cars. As correctly mentioned in the lecture, the railway signalling industry need to take a 'wait and watch' approach before applying Artificial Intelligence, Machine Learning and Deep Learning (AI/ML/DL) technologies to 'safety critical' aspects of railway signalling and driverless trains. The ongoing research in the area of 'Explainable AI (XAI)' can play a crucial role in application of AI to railway signalling domain where there is an important need for demonstration (as stated in lecture) that all the errors in ML algorithms are identified and shown to be protected against, behaviour of the algorithm is explainable and the algorithm supports post-incident analysis. After listening to this lecture, I observed that there is already a research project ongoing in EU/UK on this subject exploring potential use of AI/ML in the railway domain. I think the current generation of railway signalling/ systems engineers have a wonderful opportunity to learn and contribute to the development of applications of disruptive technologies like AI/ML/DL in the field of railway signalling. This is akin to what we saw evolution of railway signalling technologies from mechanical signalling to relay-based Interlocking to electronic interlocking to CBTC/ERTMS technologies during the last 25 years. This clearly demonstrates the need for CPD for all IRSE members.

Nagaraju Duggirala
Originally from India,
currently working in Saudi Arabia

Re IRSE Exam

Just been reading your article in IRSE News about the Younger Members telecoms IRSE exam study day. I got out my magnifying glass out to attempt the questions on the paper. I got no marks, and in all modules and for all questions. So, I'd better stick with gardening! Keep up the good work.

Brian Flynn
Ex telecoms supervisor
Carlisle and area engineer Liverpool

Working from home

Working from home cyber risk change

Paul Darlington

In the May edition of IRSE News we talked about 'working from home', considering some of the opportunities and pitfalls of doing so. Some months later many of us are getting used to the 'new normal', and working from home is far more widespread than it was before the lockdowns. However this way of working brings risks as well as benefits.

Throughout the Covid 19 pandemic many members of the IRSE will have been designated key workers and been busy maintaining, installing or commissioning railway signalling and telecommunications assets to keep the railways around the world operational. Other members will have been supporting maintenance, asset management, design and asset renewals, which for many will have included working from home.

A survey of 1500 adult UK residents undertaken by SYSTRA Ltd has identified 29% of office workers never want to return to the office and of those that commute by rail or bus this increases to 32%. 37% of five-day-a-week office workers want to return to the same pattern. 55% would like to work more flexibly. 59% think it is likely their employer will let them make the changes they want. 40% think it is likely they will change jobs if their employer does not allow them to make the changes.

Some companies have embraced remote working before 2020, but due to the Coronavirus pandemic, many organisations and companies have had to accelerate plans with some transforming significantly in a very short space of time, and the risk profile has changed.

Now is the time to explore which roles in an organisation have changed substantially. For example, some may have been used to have all their work locked away in the office at the end of every day, and now, these papers are scattered across their kitchen table. There will be many who've always been office-based, but now they're juggling their responsibilities in their home. Cybercriminals are looking for these changes and to exploit them.

Some roles in a business are valuable due to the assets they have access to. Some are valuable due to the span of control and influence that they have; and some roles are valuable because of what they do or what they know. Everyone may be a target, simply because they have wealth, access or assets outside their normal working environment, and targeting of people personally via scams or phishing can often result in damaging attacks.

Most organisations and companies normally deploy a variety of controls and mitigations to prevent, detect, limit, and restrict the impact of cyber-attacks, but as people move outside their business environments the controls often become less focused and the risks of attack increase. There have been reports of an increase in scams and fraud.

Many organisations and companies have relaxed security polices to make remote working more effective, improve capacity for their remote access infrastructure and allow data to be processed in locations that would been previously been unacceptable. When considering home or remote working, the security controls on user's devices, their connectivity and visibility of their security need to be considered. Education and awareness as to the risks are important, especially when asking users to undertake activity that previously would never have been considered to work remotely.

When assessing which users carry the most risk when working at home, clearly this is a subjective question which depends upon the business and the roles employed. Some threats like scams and phishing may have increased, and some company controls are perhaps no longer applied in the home. Any employee who has access or authority to transfer funds or assets; authorise payments; has access to valuable asset information or research is at increased risk when working at home. This includes senior managers and may also include the commercial and legal teams or those working in finance and procurement. Supporting roles, such as team organisers or executive assistants often have delegated access and authority and as such can also present an equal or even high risk when working remotely.

Roles which are traditionally office-based, such as contact centre, R&D and design also represent an increased risk, especially when some of the process or regulatory controls have been relaxed to enable remote working. Even roles such as system or IT admin which may normally be restricted to rigid access procedures can be very useful to an attacker. Extra care should be taken to protect these roles with more visibility and control than some more general roles.

Although there are some obvious examples, clearly any valuable role working remotely has the potential to expose an organisation to a greater level of threats than perhaps they would if working in the office. With the future likely to involve many working differently, this is an excellent time to review cyber risks and threats to everyone.

What do you think?

Do the benefits, both personal and for your organisation, of working from home outweigh the potential risks? Is the world really changing permanently? Has the pandemic resulted in positive change or are we walking into unimaginable problems? Let us know what you think, email **editor@irsenews.co.uk**.

New book

Jörn Pachl, professor of railway systems engineering at Technische Universität Braunschweig – TU Braunschweig – in Germany, has published a free E book – Railway Signalling Principles.

The E-book is published in English and is based on his long-standing experience of teaching railway operations and signalling at TU Braunschweig and other universities and higher vocational training institutions in different parts of the world. It explains the fundamental principles all railway signalling systems have in common. This is done in a generic way and does not focus on specific national solutions. It covers basic elements and terms, principles for safe train separation, interlocking principles, automatic train protection, and level crossing protection. The E-book can be downloaded from irse.info/mlkie.

Can you help?

With all my time at home I have taken the opportunity to commission my Sykes Mechanical Banner Repeater. Unfortunately, I appear to have two defective coils. I have tried various places (e.g. The Signal Box website) for details of the construction (wire size/turns etc.) with no luck. So, do any IRSE members have two coils I could purchase, or have the details (wire size/number of turns for main and hold coils) and/or suggest a coil winding company?

Peter Sheppard peter@puffernutter.co.uk

Quick links

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Advertising

For advertising rates and deadlines call the IRSE London Office +44 (0)20 7808 1180, or e-mail hq@irse.org.
Advertisements are accepted on the basis that the advertiser and agency (if any) warrant that the contents are true and correct in all respects.

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon · Planting trees to catch carbon ·
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

Membership changes

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Fellow

Kevin Robertshaw, Volker Rail Signalling, UK
Phillip Swift, GCR Consortium, Philippines

Member

Neville Breach, SNC-Lavalin Atkins, UK
Jason Day, Network Rail, UK
Paul Edwards, Network Rail, UK
Mark Gibbs, Westermo, UK
Martha Gordillo Bustos, Transport for New South Wales, Australia
Borislav Karachorov, Arup, UK
Mohammad Tanweer Nasar, Saudi Arabian Parsons, Saudi Arabia
Mohd Syamim Mohd Nor Azmi, MMC-Gamuda JV, Malaysia
Giuseppe Russo, WSP, UK
Tim Shah, Egis Rail, UK

Associate Member

Alfredo Alveraz-Sanz, Siemens Mobility, Australia
Tim Beard, Queensland Rail, Australia
Malay Bhadra, Ircon International, India
Jamie Carroll, Network Rail, UK
Amos Chimombe, On Time Telecommunications, South Africa
Katherine Clarke, Network Rail, UK
Oliver Collins, Network Rail, UK
Christopher Courtenay, Colas Rail, UK
Daniel Gleave, Network Rail, UK
Ben Griffiths, Colas Rail, UK
Mzwekhaya Abel Ngandi, Passenger Rail Agency of South Africa
Gilbert Rapirap, Alstom, Saudi Arabia
Bharath Bhustran Reddy Reddyreddy, Keolis Hyderabad MRT, India
Mohammed Ridouane, Ricardo, Qatar
Robert Watson, SNC-Lavalin Atkins, UK

Accredited Technician

Paul Gardiner, Network Rail, UK
David Hick, Network Rail, UK
Ashley White, Thales, UK

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Nicholas Cantwell, Siemens Mobility, UK

CEng

Jonas Fiori, Network Rail, UK
Robert Kerry, Omada Rail Systems, Australia
Dehzi Li, Alstom, Hong Kong
Robert Paterson, WSP, UK
Rahiman Shaik, Transport for New South Wales, Australia
Rajath Shenoy, Thales, UK
Philip Kai Lap Wong, MTR Corporation, Hong Kong

Past lives

It is with great regret that we have to report that the following members have passed away: Vivian Brown, Stephen Harris, Michael Hynd and Yoshio Ishihara

Promotions

Member to Fellow

Keith Attwood, Alstom, UK
Paul Martin, PM Training & Assessment, UK
Steven Perks, self-employed, Australia

Associate Member to Fellow

Guy Whaley, Network Rail, UK

Associate Member to Member

Kelvin Chau, MTR Corporation, Hong Kong
Liam Cole, Rail Control Solutions, UK
Michael France, Babcock Rail, UK
Paul Hobden, Transport for London, UK
Masud Karim, Arcadis, UK
Wai Shing Lau, MTR Corporation, Hong Kong
Peter Paradza, Network Rail , UK
Simon Read, Network Rail, UK
Rahiman Shaik, Transport for New South Wales, Australia
Jayee Sreetharan, PMCC International, Malaysia
Rob Taylor-Rose, Network Rail, UK

Affiliate to Member

Ping Man Clara To, MTR Corporation, Hong Kong

Affiliate to Associate Member

VP Kameswara Sai Praneeth Challa, JMD Railtech, Australia
Aaron Sawyer, SNC-Lavalin Atkins, UK
Jamil Ahmed Solangi, WSP, Saudi Arabia
Andrew Ward, Transport for London, UK

Affiliate to Accredited Technician

Kate Wallace, Transport for London, UK

New Affiliate Members

Mohammed Sherpudeen Abbas, Alstom, India
Amir Shabbir Ali, Hitachi, India
Raheel Ansari, Bombardier, India
Andrew Bingle, Australia
Conor Burns, Ireland
Belayet Choudhury, Network Rail, UK
Alex Day, Hitachi, Australia
Chun Wai Fan, MTR Corporation, Hong Kong
Artem Glybovskii, Siemens Mobility, Germany
Rosie Hatton, Bombardier, UK
Rajalakshmi Ivaraju, Australia
Peter Johnson, Vivacity Rail Consulting, UK
Nikilesh Kumar, Rio Tinto, Australia
Eddie Kwomo, UK
Paul Neve, Network Rail, UK
Abhimanyu Pandey, Rail Projects Victoria, Australia
Antonio Perez Marquez, UK
Robert Plant, Rail Projects Victoria, Australia
Jesus Prieto, Consulasia, Macao
Andrew Riggs, SNC-Lavalin Atkins, UK
Thomas Rueben, China Communication Construction Company, China
Punti Sarswat, Kalindee Rail Nirman, India
Rakesh Kumar Singh, Thales, India
Rohit Singh, Indian Railways, India
Nicole Symons, Public Transport Authority, Australia
Dave Wilson, UK
Daniel Young, Network Rail, UK
Syed Motasim Zafar Zaidi, Fiber Stream, Australia

Resignations: Adam Allen, Joseph Bates, Marcel Boots, Roelof Bult, John Chun Man Chau, Malcolm Davis, Stuart Doyle, Graham Foster, Robert Halse, Alan Irving, David Kerr, Conrad Maddison, Derrick Marais, Ian Morrice, Berend Ostendorf, Alan Stead, Barend Steyn, Robert Townley, John Varney and Tom Welsby.

IRSE

Institution of Railway Signal Engineers

News

October 2020

Crossrail
integration facility

System integration
begins at the end

Back to basics
telecoms

IRSE ///
Institution of Railway Signal Engineers

Issue 270
October 2020

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

Safe, reliable and cheap

An ideal railway must be safe, on-time and cheap. I recall being told that you can have two, but not all three of these requirements. Meaning that if costs are cut too much, then either safety or punctuality will be compromised. It can also be said that a good engineer can create a safe and on-time railway, but it takes an excellent engineer to make one that is safe, on-time and cost effective.

My view is that when considering the needs of safety, performance and affordability, it all comes down to safety. If railways are unreliable or too expensive then customers will leave rail and use other forms of transport, which are not as safe as rail. Rail is one of the safest and environmentally-friendly modes of transport, but it must be affordable. Railway signalling and telecoms engineers are very good at providing safe control systems, but we must never be complacent and the errors found in control systems in various parts of the world earlier in the year are examples of where we need to quickly learn and improve.

To make systems reliable and affordable, in addition to being safe, requires innovation and creative engineering. We need to learn from other industries who provide products which are far more reliable and relatively cheaper than their legacy products. Research and development with extensive testing are key, but we must resist the temptation to develop 'rail only' products. We must design in interoperability, so we can renew parts of systems and not throw everything away. Artificial intelligence, software defined networks, automated design, installation and testing are starting to make a difference, but we need to encourage more new techniques into mainstream signalling and telecoms deployments.

Infrastructure managers need to specify systems with 'intelligent requirements' and not be too prescriptive, in order to encourage innovation and creativity. Early discussions with operators are essential to get the remit right, with everyone aware of the costs and risks. Designers and the supply chain need to be involved early, so they get the opportunity to be creative with the detailed design and supply chain logistics.

Paul Darlington, managing editor, IRSE News

Cover story

This month's cover photo was taken from North Melbourne station in Australia and shows a train approaching a proceed aspect against a foreboding sky over the Melbourne Central Business District (CBD).

The photographer is on the concourse bridge at the top of the new end of the station. Metro Trains Melbourne, often just known as 'Metro', is the franchise operator of electrified suburban passenger trains on the Melbourne rail network. The organisation runs a fleet of 220 six-car trains operating over a 965km network.

North Melbourne station has six platforms to support Metro Trains' Craigieburn, Sunbury, Upfield, Werribee and Williamstown services, and V/Line Seymour and Shepparton services.

Photo by kind permission of Metro Trains Melbourne.

Crossrail Integration Facility and Test Automation – improving resilience with automated testing

Alessandra Scholl-Sternberg

This paper was originally presented at the ASPECT conference in Delft, Netherlands in 2019.

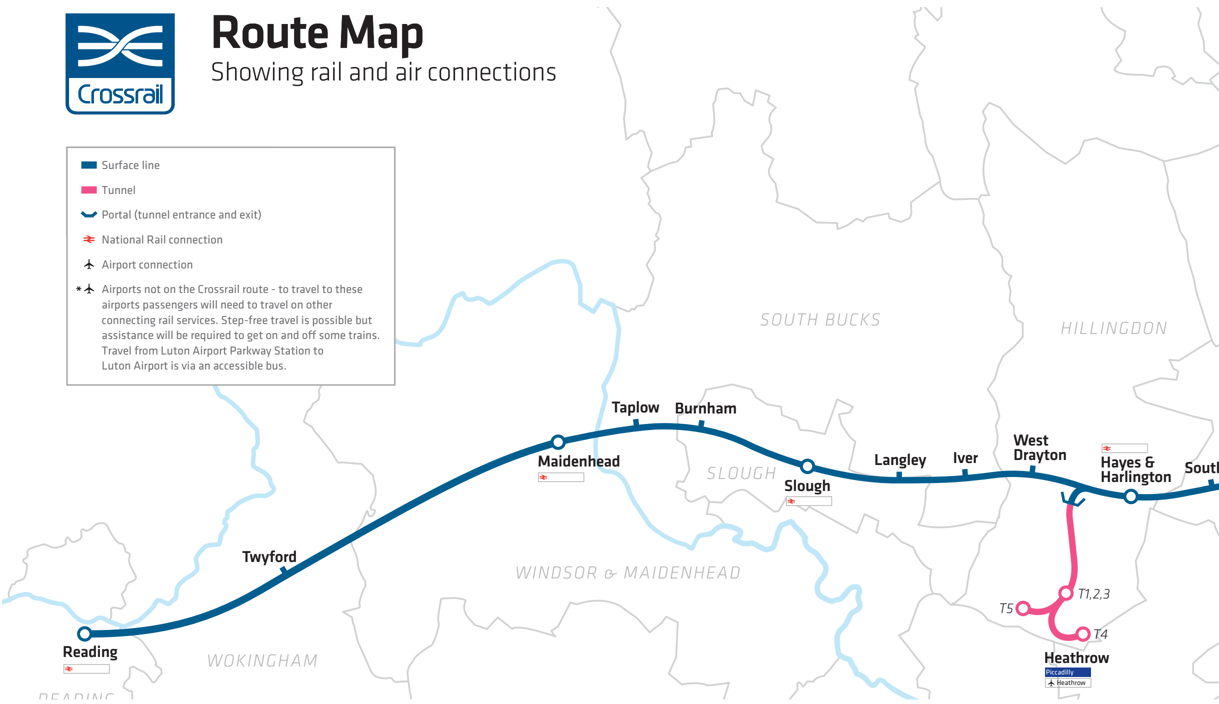
Systems integration has gained a higher level of importance as complex railway projects operate under tighter schedules than ever before and with limited access to tracks to run tests. This paper demonstrates how a fully automated off-site testing facility is extremely valuable to increase efficiency, cost-effectiveness and resilience of systems throughout a railway project life-cycle. The Crossrail Integration Facility (CIF) is a great example of this practice.

Systems integration facilities, such as Crossrail's, provide a means to perform thorough off-site interface, integration, timetable and transition testing, as well as simulation of faults to understand the system's behaviour under degraded and emergency situations. It is a cost and time-effective approach to de-risk the later stages of the project, which brings real benefits to the delivery of railway signalling systems.

Introduction

The railway is a very complex system, involving – in the UK – numerous stakeholders such as: end customer, government, service operators, rolling stock owner, rolling stock supplier, infrastructure owner, infrastructure supplier, infrastructure maintainer – each with individual corporate objectives. Within each category there are potentially several different organisations that consider each other as market competitors. There is also a complexity in technology, with various intricate signalling systems worldwide. A single line might operate under distinct systems in different areas, requiring complex transitions for safe operation of trains. Contemplating these facts makes it clear how systems integration is key for a railway line to work reliably, and how complex the system integration process can be, as it depends on stakeholders with distinct objectives working together. Successful systems integration also relies heavily on system-level tests; however, urban areas are getting bigger and denser, and service hours are getting longer – some railways run 24 hours a day. The real railway is not as available for system testing as would be desirable, which leaves a lack of infrastructure supporting system integration.

Figure 1 – Crossrail, the future Elizabeth Line, showing rail and air connections.
TfL/Mayor of London.



The signalling system's main purpose is to optimise train movements whilst keeping them safe at all times and under all circumstances. Therefore, the system must be proved to be resilient, meaning that it must behave safely and reliably even under unintended operation or under the influence of external faults. It is very challenging to test the system's response to unintended scenarios in the field, even if longer access to it were granted, because to be able to put the system under certain complex situations, a lot of negotiations between stakeholders and risk assessments would have to be undertaken. The difficulties mentioned can be lessened with the use of system integration facilities. A great example of this practice is the CIF.

Crossrail (the future Elizabeth Line in London – Figure 1) is a major railway project that connects one of the largest urban areas in the world. It is currently Europe's largest infrastructure project and it is estimated that 200 million passengers will use it each year. It operates under three distinct train control systems – ETCS, CBTC, TPWS (UK train protection system), with high capacity throughput. To be able to deliver a robust operational railway with limited access to test tracks and the physical railway, the CIF has been implemented to provide early off-site interface testing and integration of critical systems.

The CIF

As already highlighted, the need of a system integration facility for the Crossrail project was identified early in the Crossrail programme due to the restricted access to the railway, the ongoing complex civil works and fact that the Elizabeth Line service will run across existing Network Rail infrastructure. An intricate signalling system, encompassing three distinct train control and protection systems, and the pressure for minimum disruption to the existing operational services add to the complexity. Thus, the CIF was designed and implemented in phases, planned according to the development of the products used within the system.

The objective of building the integration facility is to test and prove the functioning of system interfaces prior to their installation and deployment. It is not intended to replace any steps of the test and commissioning phase of the project, but to support it by identifying and mitigating defects early.

The CIF is a testing facility with 112 interfaces between a mix of real products – the same as the ones used in the railway – and simulators. The products therefore can be categorised under "constituent domain items", which are the subsystems under test, and "test execution domain items", which allow for the integration and operation of the whole system under the integration facility environment. As far as the subsystems under integration testing are concerned, they are part of a system controlling a real railway.

A number of products are integrated in the overall system, including constituent domain and test execution items supplied by Siemens Mobility, Bombardier Transportation and Knorr Bremse.

Key constituent domain items

The list that follows covers the key sub-systems within the CIF that are identical to the ones used on the real railway. They comprise the sub-systems that are under test.

Automatic Train Supervision (ATS) – Controlguide Vicos – is the Central Operating Section (COS) control system, responsible for monitoring and controlling train movements. It is equipped with Automatic Route Setting (ARS) and Automatic Train Regulation (ATR), and is capable of adjusting individual train times to optimise traffic.

Interlocking – Trackguard Westrace Mk2 – provides point, route, Platform Screen Door (PSD) interlocking functions and secondary train detection functions from axle counters. The primary train detection function in the COS is train position reporting.

Platform Screen Door (PSD) Control Unit – Knorr Bremse Platform Door Controller (PDU) – which connects to 27 individual simulated Door Control Units (DCUs) of the platform screen doors as in Bond Street station.

Trackside Automatic Train Control (ATC) System – TrainGuard Mass Transit (TGMT) Communication Based Train Control (CBTC) Wayside Control Unit (WCU) – is the main trackside element of the ATC system used in the COS of the Elizabeth Line.

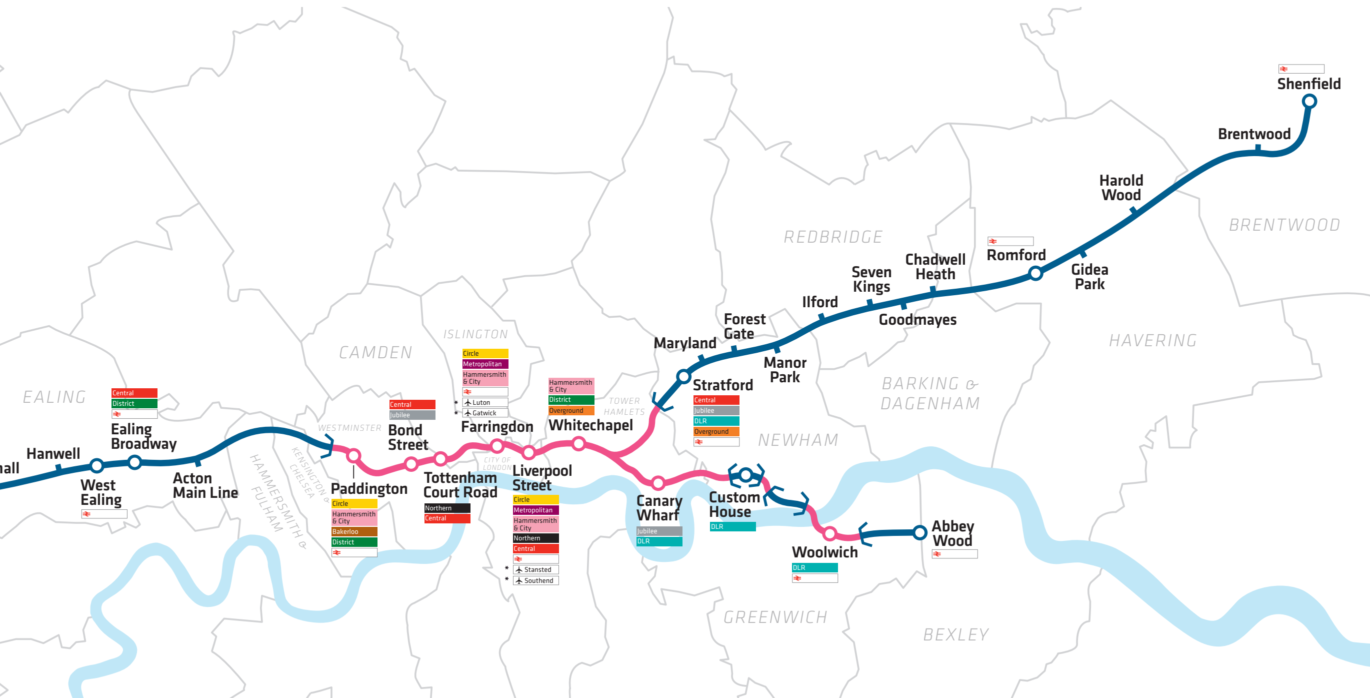


Figure 2 – The class 345 train driving desk and visual software in the integration facility – with Covid-19 precautions in place. *All photos Siemens Mobility.*

Train-borne Automatic Train Control (ATC), which is composed of:

- European Train Control System (ETCS), Bombardier Transportation (BT) European Vital Controller (EVC);
- Communication Based Train Control (CBTC) Trainguard Mass Transit (TGMT) On-board Control Unit (OBCU), which is equipped with Automatic Train Operation (ATO) and Automatic Train Regulation (ATR) within the CBTC area;
- Automatic Warning System (AWS) and Train Protection & Warning System (TPWS) Train Module – Mors Smitt UK Ltd AWS & TPWS Specific Transmission Module (STM).

Key test domain items

It is not possible to test the constituent domain items without a real railway unless test domain items that simulate a railway system with trains running are provided. For this reason, the key test domain items listed here are included in the CIF. With the test domain items working correctly, the constituent domain items can be tested, as if they are operating a real railway.

The Railway Environment and Trains Simulation (RETS), at the very centre of the system is a PC-based software application that provides the trackside equipment simulation for signals, points and axle counters; and provides the interlocking I/O for those objects. It also provides fully simulated trains, which are capable of communicating with real CBTC and ETCS wayside equipment, and one simulated train that hosts the real train-borne automatic train control equipment, including representative train interfaces.

The interlocking of the Great Western Main Line area is a Trackguard Westlock, being used to emulate the Alstom Smartlock for the purposes of the CIF only.

The interlocking for the Great Eastern Main Line area is simulated.

The driving desk (Figure 2) is designed to represent the Class-345 Bombardier train cab. There are two of these to simulate the actual train twin cabs. These interface with the real on-board train control systems. The controls and screens in the driving desks interface with the visual display software, which provides a driver's eye viewpoint when driving on the Elizabeth Line. Providing the functionality of a twin cab added another level of complexity both in the hardware and software, which involved the duplication of hardware and their associated interfaces while developing the software to enable control of the changeover between the two cabs for the system simulations in the various scenarios that were required. All of this was done to a tight delivery schedule by the team based in Chippenham.

The train hardware simulation software simulates the train wiring and train relay logic using the inputs from the driving desks and their associated on-board ATC equipment, and provides the necessary outputs in response. It also performs the train dynamics calculations for determining the speed and acceleration of the train, the output of which is used to provide simulated Doppler radar and tachometer inputs to the on-board ATC equipment. Furthermore, it simulates balises and energises the AWS magnet and TPWS antenna in the Mors Smitt AWS & TPWS trackside module.

Testing

To be able to prove that the system performance aligns to the expected behaviour and that the system integration process is successful, system-level tests need to be undertaken. The integration facility provides the means for thorough off-line testing of a diverse nature, such as:

- Interface testing: test the interfaces between all systems and applications.
- Integration testing: test that products work together to provide the desired emergent properties of the system.
- Timetable testing: Introduction of as many trains as a real railway timetable will run, plus testing the movement of trains in and out of the sidings.
- Transition testing: Run trains between Great Western Main Line (GWML), COS and Great Eastern Main Line (GEML) to test the transitions between CBTC, TPWS and ETCS.

- Stress testing: test the performance of the system and interfaces under overloaded conditions.
- Faults testing: Introduction of faults to understand the system's behaviour under degraded and emergency situations.

Stress testing and fault testing are related to system resilience – these two types of test put the system into abnormal situations due to external factors. An example of a stress test would be to create a timetable with more throughput of trains than the system was initially designed for. A real example of this test is detailed later in this article. One can easily understand the advantages of having a controlled factory environment to perform such a test, as the conditions required can be readily orchestrated in an inexpensive way without the need to negotiate access to the client and other shareholders of the system. It would be very difficult to test the system under this scenario in the real railway – there would be several safety implications and necessary agreements. This highlights the benefit of the CIF to test and consequently improve the resilience of the system.

Test automation

To increase the utilisation of the rig without the need for continuous human interaction, and to facilitate the execution of repetitive tests – while also making the system integration tests more consistent and reproducible – the CIF is equipped with an extensive system automation library. The test automation is designed to interact with the key software components to enable complete testing, with most tests being completely autonomous.

A possible consequence of running automated tests is that the behaviour of the system might be different than when being operated by a human or by a script command, depending on how the automation is designed. Some functionality might not be available for the end user, but it is available for the system integrator writing the test automation. As an illustration, the signaller's workstation is designed so that if a user wants to set a route for an approaching train, they would click the entry signal, followed by a click at the exit signal of the route, and then click request route button. If the same operation is requested by the automation through a "backdoor" command, even though the route appears to be set the same way, the signaller's workstation was not designed to be used in that manner, and the operation might have skipped a crucial check step in its execution. Therefore, it is important to make sure the automation does not affect the result of the test. For this reason, in the CIF, the freeware software AutoIT was chosen for most of the automation functionality. It provides the ability to manipulate mouse moves and key stroke inputs in Windows environments, so that the system sees no difference in the input provided by the automated tests and the input provided by a human user operating the system.

The test automation permits 24/7 utilisation of the rig, enabling robustness tests to be executed without human interaction for long periods of time. Therefore, full utilisation of the facility's time can be achieved without the need for staff working on a shift basis. Logging is also provided by the automation for debugging purposes, in combination with product specific logging.

An extensive system automation library has been written, which enables complex set-ups to be achieved, health checks to be accurately performed, endurance testing to occur over extended periods and the implementation of tests of repetitive nature.

Test automation structure

The test automation is composed of a scenario controller application and test clients. The scenario controller runs in a dedicated automation computer in the CIF. The test clients run in the computers that hold software applications of the CIF

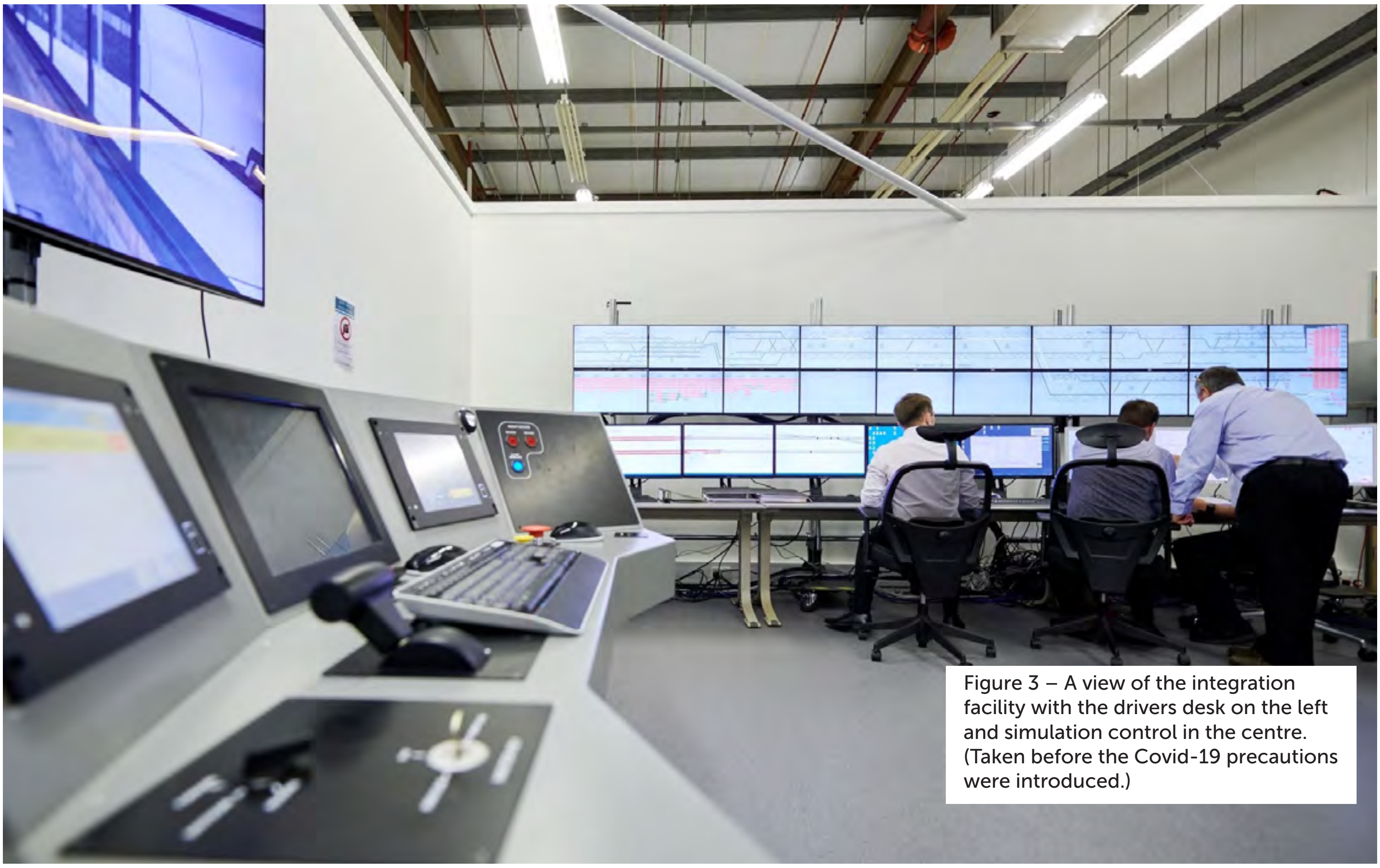


Figure 3 – A view of the integration facility with the drivers desk on the left and simulation control in the centre. (Taken before the Covid-19 precautions were introduced.)

that require automation. The connection between the scenario controller and the test clients is via a TCP interface.

Figure 4 illustrates the automation network (for simplicity purposes, not all client nodes are represented in this diagram). As one can see, the scenario controller can send and receive messages from all applications holding test clients; however, the clients are not able to communicate between themselves through the automation. The clients only send messages to the controller of the nature of health checks or function execution results.

The scenario controller application was developed in-house at the CIF based in Chippenham. It is composed of a Graphical User Interface (GUI) as shown in Figure 5. On the left, the GUI displays a list of test scripts. Tests can be run repeatedly, or different tests run sequentially. The result of the execution of the test is populated as the tests finishes. The middle of the GUI holds the list of sent/received messages. On the right, the GUI displays a list of test clients to which the scenario controller PC is connected. Through this connection, the scenario controller is able to request the execution of the specific automation functions in each product of the system.

The request to execute an automation function can be sent from the scenario controller to a test client either using the debug functionality or test scripts. The debug functionality sends a request to execute a single automation function to a single test client. The test scripts are simple text files with a sequential list of automated functions, which are assigned to different clients.

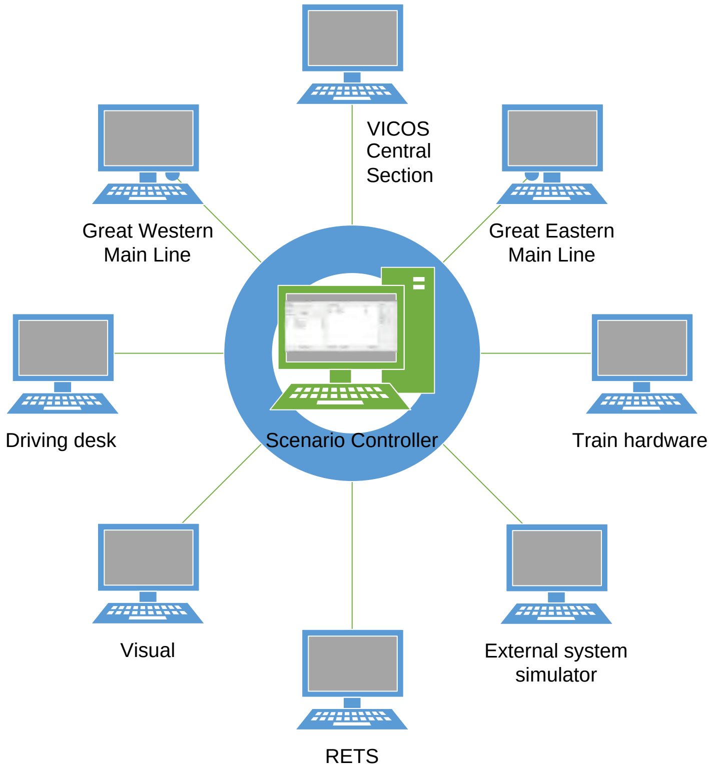


Figure 4 – The automation network structure.

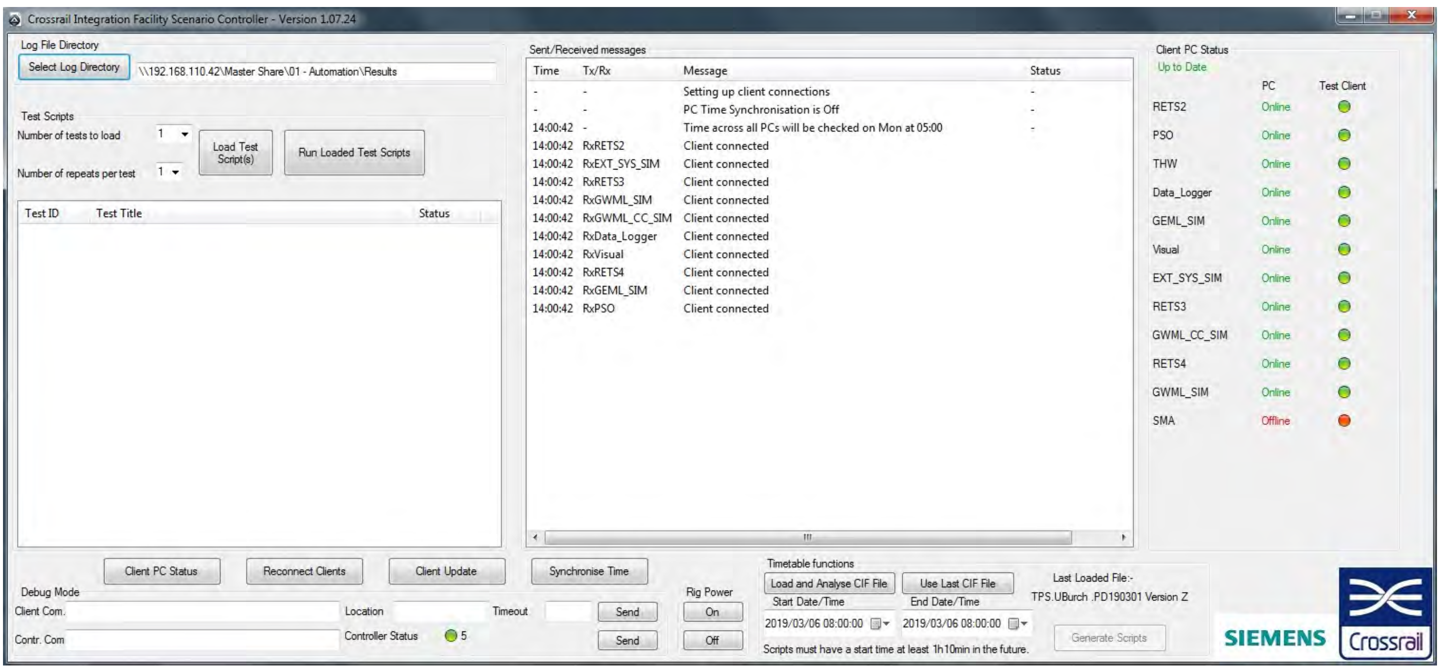
Test clients

The test clients hold the specific automation functions for each software application that is automated. They stay on standby until receiving a message from the scenario controller. Then, they execute the requested function and return a value depending on the outcome of the execution – in most cases it is either a "pass" or a "fail".

All functions are developed by the supplier of the CIF and are bespoke to each product within the rig.

All functions include checks to ensure that its execution was successful. If a failed, or an unknown or unrecoverable scenario is found, the test client returns a "fail" message in response to the scenario manager message that requested the execution of that function. A "fail" message then interrupts the test and makes the scenario manager proceed to a clean-up process, which includes saving logs and taking screenshots of all test clients, so the facility user understands the state of every product at the time of the failure.

Figure 5 – Scenario controller application.



Automation logging and debugging

The CIF is equipped with comprehensive logging. Most software applications have specific built-in logging functionality. The automation provides extra logging.

Each test client logs its activities locally into an activity file. This file registers both commands received individually – sent through the debug mode functionality in the scenario controller – and the specific commands received through a test script. All messages received (automation functions) and sent (outcome of the executed functions) are logged with a time stamp.

There is also central automation logging, which is only used when executing a test script. Its location is determined by the user. In the case of a test failure, debug screenshots would be taken of all clients and added to the log folder for the specific test. The latest messages exchanged with each client, including the test client debug failure message, and a copy of the step result displayed in the controller would also be stored in the same location.

Resilience of the test environment and the test automation system

It is important to consider the resilience of the test environment itself when performing tests in the integration facility. The purpose of the CIF is not to test the test domain items' behaviour. Those components are there merely to enable the testing of the system composed of the constituent items. Hence, a lack of resilience within a test domain item does not reflect the resilience of the system under test, even though it affects the result of the tests that are run within the CIF.

Furthermore, the test automation system's resilience can affect the result of automated tests. Since it is a pre-programmed system, it can only deal with known scenarios. If the system finds itself in a state that was not anticipated, the automation will not have been programmed to cope with that, and will, consequently, fail the test, even though the system itself might have exhibited correct behaviour for that specific scenario. It is up to the user to determine if a "fail" result in the automation test is an automation failure or a system failure.

In addition, not all automation functions are resilient to user interaction. For example, if a user changes the view in the signaller's workstation, the automation will simply change back the necessary screens if requested to set a train's head code – in this case, the automation is resilient. However, if the user simply closes a software application mid-test, the automation will fail the test. Therefore, some measures have been introduced into some test clients to avoid a user induced failure, such as blocking all user inputs in some computers while a test is being executed. That way, only the test automation system can interact with the software application during the execution of the automated tests.

Observed benefits of the Test Automation

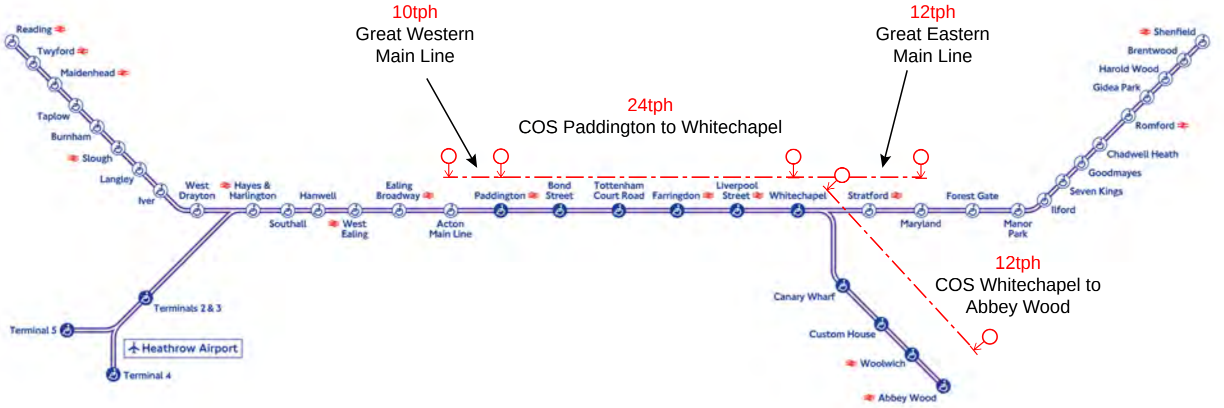
Besides increasing the utilisation of the rig and facilitating the execution of repetitive tests, the test automation has brought other benefits. Firstly, it is very useful to have a tool that provides top-level logging of a test. Usually each product will provide its specific logging, and when a fault occurs, the system integrator must analyse and link logging from the different applications to understand the sequence of events and find the root source of the fault. This becomes more challenging if the time and dates between applications are not synchronised. Having top-level logging provides the system integrator with a reliable record of the sequence of events. Moreover, since the automation's logging is also performed locally, it gives the user a reference, in case of faulty time synchronisation between the applications. This information can then be combined with the specific software logging performed locally, to more easily and readily identify faults of the system.

As the CIF has been built in parallel with the development of the key constituent items, the automation has also proved to be very helpful in allowing advanced system functionality testing whilst the product software itself was still undergoing product testing. The reason for this is that the automation can provide workarounds for known issues quicker than waiting for the next release of the products – therefore, further development can continue to be made with the system, decreasing project execution time. An example of this scenario was found during timetable tests. When a train is entering the COS from either Great Western Main Line (GWML) or Great Eastern Main Line (GEML), the Vicos-ARS is responsible for setting a slot request into the COS area, as soon as the head code (UK's main line network train description) of the incoming train is recognised as having a route through the COS. However, it was known that, at that stage of the Vicos development, this functionality was not working correctly. To work around this issue, automation specific functions were written to set both GWML and GEML slot requests when it identified that a train was meant to be routed into the COS. These functions were incorporated into the automated test scripts, so that the timetable tests could already run reliably.

Example of an automated test

As an example of an automated test, consider the following timetable test. The requirements for the peak frequency of trains in the real railway is represented in Figure 6 for the area covered by the CIF.

Figure 6 – Peak frequency of train service pattern on the Elizabeth line.
Modified diagram from TfL/Mayor of London Crossrail website.



The objective of the timetable resilience test in the CIF is to stress the system by timetabling more trains than the real system would run in reality. To be able to test this scenario, the system integration team has developed its own timetable, with frequencies – trains per hour (tph) – that exceed the peak frequencies showed in the diagram. The frequency of trains in each area in the resilience timetable test is shown in the following table.

Railway Region (as defined in Figure 4)	Frequency (tph)
Great Western Main LIne	10
COS – Paddington to Whitechapel	30
COS – Whitechapel to Abbey Wood	15
Great Eastern Main Line	15

A Common Interface File (CIF file) – the industry standard file format for Network Rail's (the owner and infrastructure manager of most of the railway network in Great Britain) timetables – has been generated for this test by the system integration team, so that it can be loaded into the system.

In contrast to other automation tests, which require the user to write their own automation scripts, timetable tests have a specific functionality in the scenario controller. The timetable automation test script can be generated automatically, once a CIF file is loaded into the automation system. The user only needs to specify a date and a time to run the test.

Even though all trains are simulated, the system only accepts trains being injected into the scenario from a limited number of locations. For this reason, once a date and time is specified, the automation system analyses which trains will be part of the test by working back when they would have to be injected at an allowed inject location.

After the timetable script is generated, the scenario controller will synchronise the time between the different applications in the CIF and the test is ready to be started.

The example of the automation test script in Figure 7 demonstrates how, in a timetable test, the automation does not need to set any routes for the trains, since the signaller's workstation is equipped with Automatic Route Setting (ARS). Therefore, the main focus of the automation is to set up all applications correctly and make sure that all injected trains have the correct headcode assigned to them. At the start of the script (box #1), one can see the necessary commands to set up the system, such as starting the RETS application; loading the appropriate test script in RETS for this test; restarting the interlockings, so that all routes in the layout are cleared out; taking control of all control areas in the signaller's workstation; clearing all headcodes left behind in the layout, and switching ARS on. After that, the system is ready to start the test. The commands after the message "Now starting specific commands for journeys" are executed while trains are running in the scenario. This part of the script mainly consists of assigning the correct headcode to each train, after its injection either in GWML area – using "SendHeadCodeToTDTool" function, which assigns a headcode to a train injected in Acton Main Line platform 3 – or in the COS area – using "SetHeadCode" function with "PDXPLA" parameter, as trains that are injected in the COS get their headcode in Paddington Platform A. The previously mentioned slot request workaround is visible here (highlighted in its first appearance in box #2) – the automation sets the slot request for all trains driving from GWML into the COS appropriately.

Figure 7 – Example of a timetable test.

```
;Automated generation of Automation script based on Timetable
SendMessage('FileCopy("\\192.168.110.42\Master Share\01 -
Automation\Test Scripts\Timetable\CIF File Interpreter\TPS.UBurch
.PD190314 Version A\*", "C:\RETS\Scripts\Timetable\TPS.UBurch
.PD190314 Version A\", 9)', "RETS2", 60)
SendMessage('StartupRETS("TrafficSim")', "RETS2", 120)
PowerControl("TGMT OBCU", "Off")
SendMessage("StopCIPHost()", "GEML_SIM", 300)
SendMessage("StartupCIPHost()", "GEML_SIM", 300)
PowerControl("Interlocking Rack", "Reset")
SendMessage('StartupRETS("TrafficSim")', "RETS2", 120)
SendMessage("WorkstationLogin()", "PSO", 30)
SendMessage("AwaitTracksideOperational()", "PSO", 180)
SendMessage("StartTDTool()", "GWML_CC_SIM", 300)
SendMessage('LoadRETSScript("C:\RETS\Scripts\Timetable\TPS.UBurch
.PD190314 Version A\Tuesday 1000 to Tuesday 1030.rss")', "RETS2",
30)
SendMessage("VicosTakeControl()", "PSO", 180)
SendMessage("SetARSOn()", "PSO", 180)
SendMessage("ClearHeadCodes()", "PSO", 540)
SendMessage('SelectWorkstationView("1")', "PSO", 180)
SendMessage("TDARSOn()", "GWML_CC_SIM", 300)
WaitUntilTime("2019/03/19 09:34:07")
SendMessage('BlockUserInput("True")', "PSO", 120)
SendMessage("StartRETSScript()", "RETS2", 100)
SendMessage("SelectRETSView(2)", "RETS2", 100)
SendMessage("OpenTrainListWindow()", "RETS2", 100)
;******* Now starting specific commands for journeys ******
WaitUntilTime("2019/03/19 09:35:27")
SendMessage('SendHeadCodeToTDTool("9C69")', "GWML_CC_SIM", 60)
SendMessage("SetGWMLSlotRequest()", "PSO", 180)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 09:37:17")
SendMessage('SetHeadCode("9C71#09", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 09:45:17")
SendMessage('SetHeadCode("9C79#09", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 09:47:27")
SendMessage('SendHeadCodeToTDTool("9C83")', "GWML_CC_SIM", 60)
SendMessage("SetGWMLSlotRequest()", "PSO", 180)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 09:49:17")
SendMessage('SetHeadCode("9C85#09", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 09:51:17")
SendMessage('SetHeadCode("9C87#09", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 09:53:27")
SendMessage('SendHeadCodeToTDTool("9C89")', "GWML_CC_SIM", 60)
SendMessage("SetGWMLSlotRequest()", "PSO", 180)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 09:55:17")
SendMessage('SetHeadCode("9C91#09", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
```

1

2

```
WaitUntilTime("2019/03/19 09:57:17")
SendMessage('SetHeadCode("9C93#09", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 09:59:27")
SendMessage('SendHeadCodeToTDTool("9C95")', "GWML_CC_SIM", 60)
SendMessage("SetGWMLSlotRequest()", "PSO", 180)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:01:17")
SendMessage('SetHeadCode("9C97#10", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:03:17")
SendMessage('SetHeadCode("9C99#10", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:05:27")
SendMessage('SendHeadCodeToTDTool("9D02")', "GWML_CC_SIM", 60)
SendMessage("SetGWMLSlotRequest()", "PSO", 180)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:07:17")
SendMessage('SetHeadCode("9D04#10", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:09:17")
SendMessage('SetHeadCode("9D06#10", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:11:27")
SendMessage('SendHeadCodeToTDTool("9D10")', "GWML_CC_SIM", 60)
SendMessage("SetGWMLSlotRequest()", "PSO", 180)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:13:17")
SendMessage('SetHeadCode("9D12#10", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:15:17")
SendMessage('SetHeadCode("9D14#10", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:17:27")
SendMessage('SendHeadCodeToTDTool("9D16")', "GWML_CC_SIM", 60)
SendMessage("SetGWMLSlotRequest()", "PSO", 180)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:19:17")
SendMessage('SetHeadCode("9D18#10", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:21:17")
SendMessage('SetHeadCode("9D20#10", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:23:27")
SendMessage('SendHeadCodeToTDTool("9D22")', "GWML_CC_SIM", 60)
SendMessage("SetGWMLSlotRequest()", "PSO", 180)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:25:17")
SendMessage('SetHeadCode("9D24#10", "PDXPLA")', "PSO", 100)
SendMessage("CheckRETSScriptRunning()", "RETS2", 180)
WaitUntilTime("2019/03/19 10:27:17")
SendMessage('SetHeadCode("9D26#10", "PDXPLA")', "PSO", 100)
```

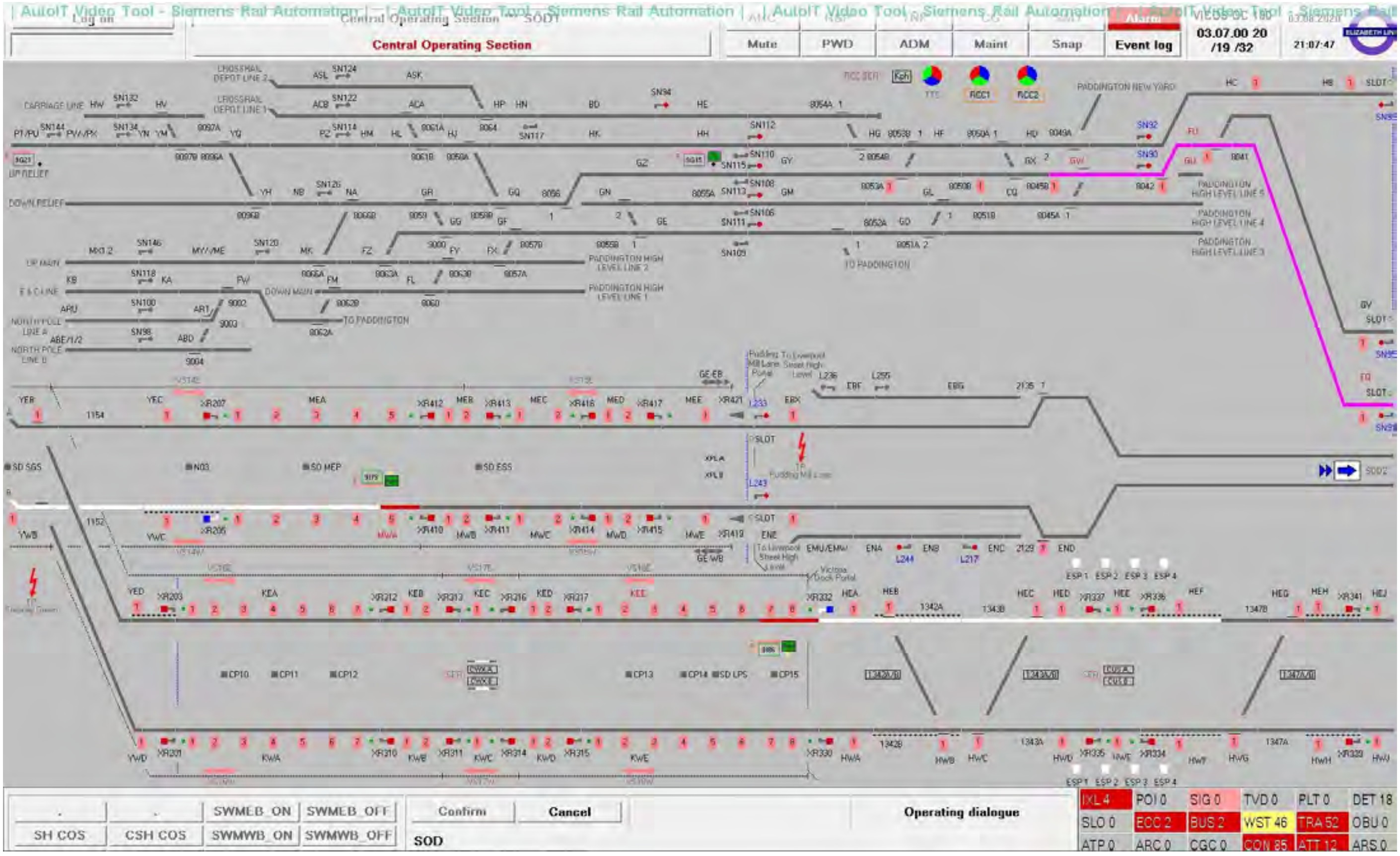


Figure 8 – Signaller's workstation display during an automated timetable test.

The CIF user can observe the movement of all trains through the signaller's workstation, in the same way as the operator of the real railway would. Figure 8 illustrates the signaller's workstation during a timetable test. The details of the layout are not visible; however, one can observe the occupied track (red) sections, which correspond to the location of trains within the layout. With meticulous observation, one can see that each red section is accompanied by a small box with green outline – this box contains the headcode of the train within that occupied track section. The white tracks represent sections of routes that are set and locked for the moving trains, which were set automatically through the automatic route setting functionality. Dark grey sections represent unoccupied tracks.

Observed impact of having an integration facility in the project

Since it replicates the core parts of the real Crossrail signalling and control system, the CIF is itself a very complex system. A team with a deep understanding of the system was needed to build this facility. The investment in building the facility is, however, essential in a complex project like Crossrail to facilitate early system integration. The cost and time necessary to run all tests that the CIF enables would be enormous in the real system.

It is possible to identify several benefits from having a system integration facility in the Crossrail project:

- Fault-finding and debugging in a controlled off-site environment are a lot easier than it would be with the actual live system.
- The detection of defects early minimises the cost and time necessary for their rectification.
- Working in a controlled environment allows the use of some workarounds for specific product faults until a new product release is received. This allows system tests to continue even with known product faults, accelerating further fault finding and correction within the system and the products. Many of these workarounds would probably not be possible in the real system, as thorough risk assessments would have to be performed before their implementation.
- It is an efficient way of de-risking the project, as an off-site facility provides the capability of executing tests that otherwise would be very impractical to perform in the live railway, such as stress tests, tests of how the system operates under degraded or emergency mode.
- Once in the operation phase of the project, the facility will provide the means to test planned updates off- site before being implemented on the real railway, so that general reliability is maintained during updates.
- It provides a means for the maintenance and operation teams to familiarise themselves early with the system, so they can provide inputs to the project early on.
- It can be equipped with extensive test automation, obtaining all the benefits listed above.
- Ultimately, in the long run, one of the best benefits that integration facilities can provide to the railway is the cooperation between the diverse stakeholders involved in running a safe and resilient railway. It is only through cooperation that we can work with complex systems in an increasingly globalised and intertwined world.

Figure 9 – The integration rig brings together a large array of target equipment and simulation systems which, together with extensive test automation, brings a wide range of benefits.

Conclusion

Complex railway signalling projects lack the time and infrastructure access to perform extended testing and integration procedures because of tight project schedules. A solution to this problem is to provide a system integration facility. The Crossrail project is no exception, hence the decision to build the CIF.

In this article I have explained how establishing a fully automated off-site testing facility is extremely valuable to the Crossrail project. The CIF is used to run interface, integration, timetable and transition testing, as well as to test the system's behaviour under the introduction of faults or stress. The benefits of being able to run autonomous test scenarios include increased utilisation of the system and ease of execution of repetitive tests, in combination with ease of implementation of workarounds and fault finding with the extra logging provided. In addition, the scenarios related to testing the resilience of the system are much less complicated to set up in a controlled environment. Generally, it is evident that the CIF has brought several benefits to the Crossrail project itself and has given a lot more in return than the financial and time investment necessary to build it.

I believe that all future major railway signalling and control projects should use a system integration facility to test their products and the emergent properties of their system prior to on-site testing. This additional step within their system engineering process will also be very useful when updating a system – all updates can be tested in a controlled environment prior to their implementation. Updates can go through thorough resilience tests that would probably not be available otherwise. Clearly though, to make the most out of the investment in a system integration facility, it is important to make sure that the facility is completely integrated within the system engineering process, which means that the time for tests within the facility and time for fault rectification need to be incorporated into project schedules.

What do you think?

Railway control command and communications are networks of very complex interconnected systems. System integration testing is therefore becoming increasingly important to deliver thorough off-site interface testing, as well as simulation of faults to understand all behaviour, including degraded and emergency situations, and to provide interoperability. Other industries do similar, with for example the ETSI Plugtest Programme provides an environment for collaborative testing and validation activities for products, and not just projects, among different telecoms organisations. The ETSI Hub for Interoperability and Validation (HIVE) interconnects participants' labs and allows for multi-party remote interoperability testing, proof of concepts and validation testing. Plugtests events allow the plugtest community (who may be commercial competitors) to meet and run face to face intensive testing sessions, with non disclosure arrangements in place. Could railway signalling systems benefit from similar arrangements? What is your experience of system integration testing? Who should lead and manage remote off-site integration testing? We would love to hear from you at editor@irsenews.co.uk.

About the author ...

Alessandra (known as Ale) is a systems engineer at Siemens Mobility, currently working on ETCS projects in Zoetermeer, Netherlands. Ale graduated with a Physics Engineering degree from the Universidade Federal do Rio Grande do Sul, Brazil, in 2016 having spent a year of her studies at the University of Sheffield. She joined Siemens Mobility in the UK as a graduate engineer in 2016, and was soon appointed as a systems engineer working on the Crossrail Integration Facility. She changed roles during 2020, moving to her current position in the Netherlands. Ale is committed to the promotion of science, technology, engineering and mathematics to younger people and has a long track record of developing and running activities in school and work environments associated with this.

IRSE///
Institution of Railway Signal Engineers

Public Warning System for public mobile networks

Paul Darlington

In 2018 the Council of the European Union adopted a new Directive for Public Warning System (PWS). Under the new Directive, from June 2022 all EU member states will have to set up a PWS. This will provide the ability to send alerts to all citizens and visitors' mobile phones in a specific area in the event of a natural disaster, terrorist attack or other major emergency in their area. The alerts will also provide a way to request the public's help, such as searching for missing children.

A PWS must:

- Target the affected population by specific geography so as not to cause widespread panic.
- Reach a high percentage of people in the targeted area, not just residents but roaming visitors using their native language.
- Send messages in real-time, within seconds and with a high degree of reliability.
- Send message without the need for the public to have to opt-in.
- Be free of charge for end-users and not just residents, but also roaming visitors.

The 3GPP standards body for mobile communication has set the criteria for alert delivery, message content and features for PWS over mobile networks. Governments in the Netherlands, US, Canada, Chile, Japan, South Korea and Israel are among those that have already deployed PWS services and the EU directive will bring the benefits of the system to more than 445 million people across the continent.

Options for PWS services

There are two main technology options for PWS: Cell Broadcast Service (CBS) and Location-Based Short Message Service (LB-SMS). According to 3GPP and ETSI, CBS is the most effective way to reach large areas and populations. It offers several key advantages over point-to-point SMS and smartphone message applications. With CBS, authorities and Mobile Network Operators (MNOs) can:

- Broadcast alert messages to millions of people within a few minutes over any public mobile network (from 2G to 5G).
- Target alerts to specific geographic areas with a consistent message.
- Comply with global emergency alert service standards.
- Support standards-based evolution to multimedia-based alerts.

LB-SMS is built on technology that identifies the geographic location of mobile subscribers. It supports the delivery of alerts to all mobile subscribers that reside in identified risk areas. With LB-SMS, governments and MNOs can:

- Improve situational awareness by counting the number of message recipients in a given area.
- Help emergency services by identifying the location of people.
- Support two-way communication with people.
- Provide individual message delivery reports.
- Send alerts and updates to people who enter and leave affected areas.

Some suppliers, such as Nokia, offer PWS solutions that combine CBS and LB-SMS. These enable authorities and MNOs to deploy all the PWS capabilities they need for any emergency scenario. So they could alert a large number of people and/or locate and interact with individuals. This maximises the efficiency of the PWS. The objective is to support message delivery over all generations of mobile networks, which ensures that alerts can reach the highest possible percentage of at-risk citizens. Nokia's PWS is currently in service with several MNOs in the US, Canada, Europe and Central and Latin America. See **irse.info/26xbu**.

There are challenges for countries, such as the UK, with multiple mobile telecoms operators which will need to be overcome.

Reaching populations in their native language by automatically detecting the nationality of a person's SIM card, could improve the effectiveness of communication to visitors and international travellers.

The total number of SIM cards in an area can be seen and the movement of those SIM cards tracked over time without any personally identifiable information being revealed.

This will enable emergency services to confirm if an area has been successfully evacuated and to watch the movement flow of people over time to manage resources required.

IRSE
Institution of Railway Signal Engineers

System integration begins at the end


James Spink and Genevieve Edwards

This article explores the development of system-level requirements to bring about desired rail program outcomes. The defining characteristic of the Systems Integration (SI) approach is to begin with the end in mind.

This core feature means understanding what the operational outcome of a project should be and what benefits the users and stakeholders of the system desire. It is often easy to articulate the top-level goals of a project, whether it is a railway, a building or a product. However, in most cases it is impossible to deliver a solution based only on stakeholder expectations and user needs. So, the expectations and needs must be broken down into pieces that form deliverable packages of work. Applying a systems methodology to the breakdown, structure and management of these expectations and needs, in the form of requirements, can provide the difference between delivering on time and on budget, or not delivering at all.

Issues encountered

A common approach to breaking down a program into deliverable work packages is to create a concept design followed by a plan for delivery (by describing the packages of work and when they need to be delivered), and then move straight to defining the contract requirements. This process often leads to encountering one or more of the following five issues:

1. **Over specifying or underspecifying what the subsystem or contract needs to deliver.**

   Little traceability from the contracted requirements up to the user needs means it is often hard to find out how a contract-level requirement contributes to the operational outcome.

2. **Subsystems or contracts that do not integrate to meet the overall operational outcomes.**

   This means diminished benefits for the end user or additional time needed to align the delivered products to make them work together.

3. **Sections of work are missed or have overlapping boundaries.**

   The concept design may not be complete, or the way the subsystems or contracts have been defined means there are gaps in the overall system. Conversely, two separate subsystems may assume responsibility for the same aspect of delivery.

4. **Missed opportunities for innovation.**

   When defining requirements at the contract level, the main deliverables of the system have already been established; this means lost opportunities for the contractor to meet user needs in an innovative or a new way.

5. **Contradictions and confusion in requirements for the work package.**

   If all the system requirements are defined at the contract level, this can lead to specifying needs that are not clear or too generic so that the contractor cannot fully meet them

Starting right with system-level requirements

Within the systems engineering and systems integration discipline, requirements engineering (also known as requirements management) aims to avoid these pitfalls by developing upfront a set of clear, complete and correct system-level requirements and providing them to those contracted to deliver the work packages (or subsystems). The intention is to ensure that when delivered those packages come together to deliver the desired operational outcomes.

Developing the requirements is done by understanding the capabilities (functions and performance) that represent stakeholder expectations and user needs and determining how the whole system will meet those expectations and needs. Then, an assessment is made to specify the work packages (or subsystems), what those work packages are required to achieve and how those packages must integrate to deliver the capabilities using SI. This holistic process culminates in defining the requirements at the contract level. Each level may have multiple sublevels. A simple example is shown in Figure 1.

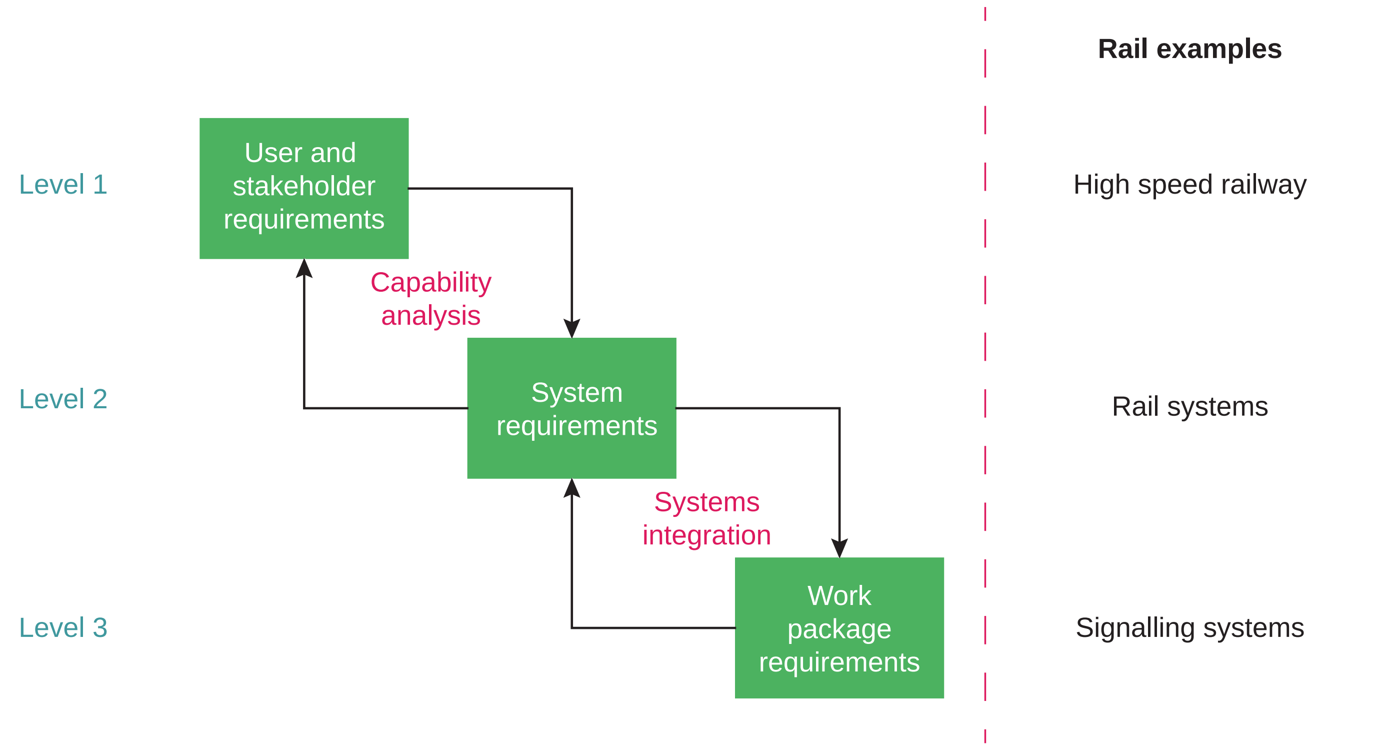


Figure 1 – Requirements structure.

At the top level, the user and stakeholder requirements are captured. These are written to reflect the desired operational outcomes, user benefits and, where appropriate, constraints. The intention of these requirements is to set the scope of what is to be delivered. It is key to avoid too much detail at this level, as at this point the system should be considered holistically.

After capturing and analysing the user and stakeholder requirements, a set of system requirements is established at the system level. One way of doing this is to create operational concepts outlining, at a high level, how the system is expected to behave to meet the user and stakeholder requirements. These concepts describe the functions the system must perform and how the system must perform them collectively, referred to as the capability of the system. The system-level requirements are linked to the user requirements, showing how each of the system functions will deliver the desired operational outcomes. As the definition of the system becomes clear, the user requirements may be updated based on the system-level requirements. Updating can happen for a variety of reasons and is an expected iterative step as the system definition explores the realities of achieving what the user wants within the program constraints.

Once the system-level requirements are understood, the subsystems/work packages can be defined. Defining subsystems can involve the creation of a concept design and the use of a work breakdown structure to govern how to divide the work. The work packages will still likely be distributed primarily by technical areas (such as signalling and telecoms engineering), geography or phases of delivery; however, the division is driven from the system requirements by considering what work packages are required to meet which capabilities and, crucially, how those work packages will interact to deliver the operational outcomes. While the work is being apportioned, how the work packages are going to integrate is captured in the form of interface definitions (e.g. interface control documents). This is key because by definition a system provides more capability than the sum of its parts, and understanding how the work packages will come together before defining them in detail will save significant integration cost in the long run.

Once the work packages or subsystems have been determined, the contract requirements are derived and decomposed from the system-level requirements that are assigned to each contract, in line with the agreed interfaces. This process ensures that each work package will meet the needs of the system (and, through traceability, the needs of the users and the expectations of the stakeholders) and integrate with other work packages. The requirements created this way are then traced back to the system requirements, which might bring change at the system level. Such changes are expected, as the detailed understanding of the work package will inform the system-level design.

In a perfect world, every work package requirement would be derived from the system level. In reality, there will be some gaps and outstanding requirements for the work packages/subsystems that should be developed by domain experts. At this level, the flowed-down requirements may be complemented by the development of additional requirements to reflect the specific functions of the subsystem. This is done by utilising expertise, modelling and design.

Delivering desired outcomes

By adopting the systems integration process and dedicating time to develop each level of requirements, a clear path from user needs and operational outcomes to the work package requirements is created. This approach helps ensure a clear, complete and correct set of requirements describing what is truly needed and confirms that the separate work packages will integrate correctly. Crucially, it puts in place from the start a structure to ensure that the contracts deliver what stakeholders want and users need.

About the authors ...

James Spink is principal engineer, systems engineering & integration, WSP United Kingdom and Genevieve Edwards associate, systems engineering & integration, WSP Australia.

Back to basics: Telecoms part 1

BACK TO BASICS


Paul Darlington and Trevor Foulkes

"Without communications trains cannot move"

This 'Back to basics' article covers the subject of railway telecommunications. As with other such articles, our intention is to provide an overview for IRSE members new to the industry or who may not have experience of working in this specific area. The content may also be useful for people studying for the IRSE Exam. The objective is to describe the subject in a generic manner and we have used examples based mainly on UK main line railways. Part 1 covers telecoms networks and part 2 in another issue of IRSE News will look at telecoms for passenger use.

Communication is essential to all businesses including railways and without telecoms services trains would not run effectively. It is possible for trains to move without signalling, but communications are necessary for efficient operation. Railway telecoms covers voice, data and radio for rail operations, rail business, and passenger use. It can also cover commercial telecoms services for some railways.

Role of operational telecoms

Operational telecoms systems have four roles for a railway:

- To facilitate normal day-to-day voice and data communications. This includes links to support the operation of signalling and electrification systems.
- To facilitate quick communications in the event of a problem or hazard.
- To facilitate communications of those attending an accident.
- To provide bearer services for other systems to enable communications where and when required.

Normal day-to-day operational verbal communication includes the use by signallers to give instructions to drivers to move their trains in the event of a signalling system failure and to persons wishing to use level crossings. They are also used to take and give back line possessions and grant electric traction isolations for emergencies and to facilitate engineering works.


It also includes day-to-day conversations to plan train movements and manage the railway. In all these cases it is very important that the receiver of the instruction correctly interprets the instruction in order to carry it out. Most railways do this by the use of a voice protocol which requires messages to be repeated back. However, for the telecoms service it is important that the voice channel is clear and of sufficient volume to enable messages to be understood. Also, if the display system shows the location or role of the users then this must be proven correct, as far as is practical, since credible but incorrect information could mislead a user into making an incorrect decision or miss-understanding the context of the message being passed. A misinterpretation of an operational message can result in an incorrect action and potentially lead to a hazardous situation.

When there is a hazardous situation it needs to be rectified, often with trains being stopped, before an accident occurs. Railway telecoms radio systems have a key role in managing such situations where trains need to be stopped. Trains may need to quickly alert the signaller of a hazard and request assistance. The person becoming aware of the hazard needs to be able to contact all trains in the immediate area quickly and easily, and instruct the drivers to bring their trains to a stop. Time is of the essence in passing this type of message. Even if the train cannot be brought to a stand before the collision, a reduction in speed can significantly reduce the impact of the accident.

“If there is an accident it is important that the emergency services can be contacted quickly”

If there is an accident it is important that the emergency services can be contacted quickly to help with recovery and reach any injured people. In many cases the emergency services provide their own communications systems but when access distances are extended, for example in sub-surface stations, tunnels, or remote locations, the equipment to allow the emergency services to extend their normal radio systems may need to be provided by the railway.

Voice communications by telephone

Some railways provide lineside telephones for the public at level crossings so they can contact the signaller in an emergency or to obtain permission to cross the track. Other lineside phones may also be provided to facilitate engineering or operational activities, although these are often undertaken using a public or railway specific radio system. Lineside telephones are normally analogue 300-3400Hz in operation and connected via a twisted copper pair in a cable to the nearest signal box or transmission node. No power supply is required at the telephone location, as it is powered over the copper circuit, at normally 50V DC. This is known as Central Battery (CB) working. When a user wishes to establish a call, they lift the handset, which places a 600Ω loop on the pair. This allows a current to flow which is detected at the far end. The actual loop current will be dependent on the resistance of the copper circuit and will decrease with distance. Depending on the use of the telephone, the far end may route the call directly to the signaller and return ringing tone to the user. This is a point-to-point telephone circuit and is commonly used for level crossings. Alternatively, the far end may return dial tone which tells the user to enter the number for the extension or service they require. The number is normally sent as a sequence of multi-frequency tones which are decoded at the far end and used to route the call to the required destination. Once the far end answers the call, a duplex speech path is established back to the initiator and conversations can take place. When the user wishes to terminate the call, he replaces the handset which removes the loop. If a phone needs to be rung, an AC ringing current typically 75V at 25Hz is applied to the line. The current is interrupted to give the distinctive ringing cadence. The telephone will be rung by this current until the handset is lifted and the loop applied. At this point the ringing current is removed and the speech circuit established.

Copper cable

Telephones will normally be connected via a two pair ‘tail cable’ to a lineside location or connection box where the circuit is connected to the main line side cable. Copper cables come in many varieties as the number of pairs can vary from single pairs to hundreds of pairs and the conductor size can vary from typically 0.63mm or 0.9mm gauge (diameter) to much bigger sizes on older copper cables. Each pair is twisted together

Telecommunications are essential for the safe and smooth operation of railways worldwide. The people upon which the network depends work in different roles, and have different needs of their equipment.
Photos Shutterstock/ APChanel, Paveils Dunalcevs, 1000Words and Chuyuss.

to reduce crosstalk from other circuits in the cable and from external sources. In cables with many pairs, these are arranged in layers. A system of colour coding is used so that each pair and the conductors forming each pair (known as legs) can be individually identified. The copper pairs are normally protected by a moisture barrier and petroleum jelly to prevent water ingress, and an insulating sheath, which can be zero halogen and low smoke if required for underground locations. Some older copper cables were provided with a steel armoured layer for electrification traction immunisation purposes, but this is now normally provided by a separate screening conductor. The sheath is normally marked with information so that cables can be identified.

"Telecoms copper cables can be used to carry DC signalling circuits, but not vice versa as conventional signalling cables are not constructed with twisted pairs"

Telecoms copper cables can be used to carry DC signalling circuits, but not vice versa as conventional signalling cables are not constructed with twisted pairs since they are designed for only DC circuits. If a telecoms cable is used to carry both telecoms and signalling circuits it is normally recommended to fully terminate all the cable pairs in every trackside location case, using a method which facilitates easy identification of pairs, testing and isolation. For good quality speech and data services, a telecoms cable will require a cable insulation resistance of several megohms, which is far higher than needed for a DC signalling circuit.

Fibre cables

The introduction of fibre optics revolutionised telecoms cable networks for railways. Fibre optic cables are small and light (compared to copper multipair cables) and can be used to transmit very high data rates (several 100Gbit/s) and are immune from electrical interference. The distance between transmission nodes can be increased significantly compared to copper cabling.

Fibres carry short wavelength light pulses and are used in conjunction with digital transmission systems. Early fibre cables were multimode graded-index but were quickly superseded by single mode fibre using 1310 nanometre (nm) wavelength with improved attenuation and bandwidth. Multimode cable remains cheaper and can still be used on short haul applications, typically in buildings. Early cables typically contained 8 or 10 fibres positioned within a loose tube construction with a Kevlar® central strength member with no metallic elements. Fibre count within cables has increased and cables containing hundreds of fibres in several tubes are now available. Fibre cables, being much smaller than copper equivalents, can be rolled on to a drum in much greater lengths, requiring less joints when installed trackside. Care has to be taken however during design and installation not to bend the fibre cable too tightly around corners.

"UHF radios are generally used for station management, shunting and to facilitate engineering work"

The essential tools for working on fibre are a fusion splicer and an Optical Time Domain Reflectometer (OTDR). A splicer effectively heats and welds the fibre together. Early models required the jointer to align the two ends mechanically using a built-in microscope but now the process is automated. The OTDR is used to send pulses of light down a fibre and measure any reflection that occurs, to identify any problems that might be present in the cable. A clean cut is easy to locate but a poor joint or deteriorating fibre connection will result in a higher reflection reading, with the OTDR indicating the distance to the problem.

Spare network bandwidth can also be leased to others for commercial telecoms purposes, if permitted by the national legislation covering commercial telecoms. This could include individual fibres or capacity in railway telecoms cable routes leased to third parties. Any lease agreements will need to take into account the priority of telecoms services for railway operational purposes and the maintenance arrangements.

Concentrators

At the signal box there will be an operator interface, sometimes called a "concentrator", to which all the lineside phones and other phones are connected e.g. phone connections to adjacent signal boxes, electrical control rooms and operational control rooms. When a phone is ringing in, an appropriate light flashes or the display is changed to show which phone it is. The signaller can choose which line to answer by lifting his handset and selecting the particular line. He can also ring a phone by lifting the handset and pressing the appropriate button. In some railways, phone lines for some level crossings give a distinctive different ringing sound so the signaller can take quicker action. Sometimes the signaller's handset is equipped with a press-to-talk button so that the driver can only hear what is said by the signaller to the handset and not hear conversations on other lines. There are many versions of concentrators based on the technology available when they were brought into service. Some have a key and lamp for each line, others are based on touch screens telephone systems similar to those used in money markets and known as 'dealer boards'. Some combine the radio and fixed lines on the same display as the signalling controls. Modern concentrators are based on computers that communicate using the Internet Protocol (IP) see later.

If the signal box and phone are separated by an appreciable distance, say over 15km (10 miles), then a transmission system will be needed to extend the circuit. This is covered later.

Voice communication by radio

UHF (Ultra High Frequency) radios are generally used for station management, shunting and to facilitate engineering work. Some are used as 'back-to-back' radios and some have base stations which allow the connection of a landline from, say the signal box. UHF radios are normally simplex so each user has to press a button when they wish to talk and release to listen. Individual radios are distinguished by callsigns and strict voice protocol is required as a licence condition. When used by a shunter to give instructions to a driver, some radios have a facility to transmit a confidence tone so the driver knows the shunter still wishes them to continue or else the shunter has to keep

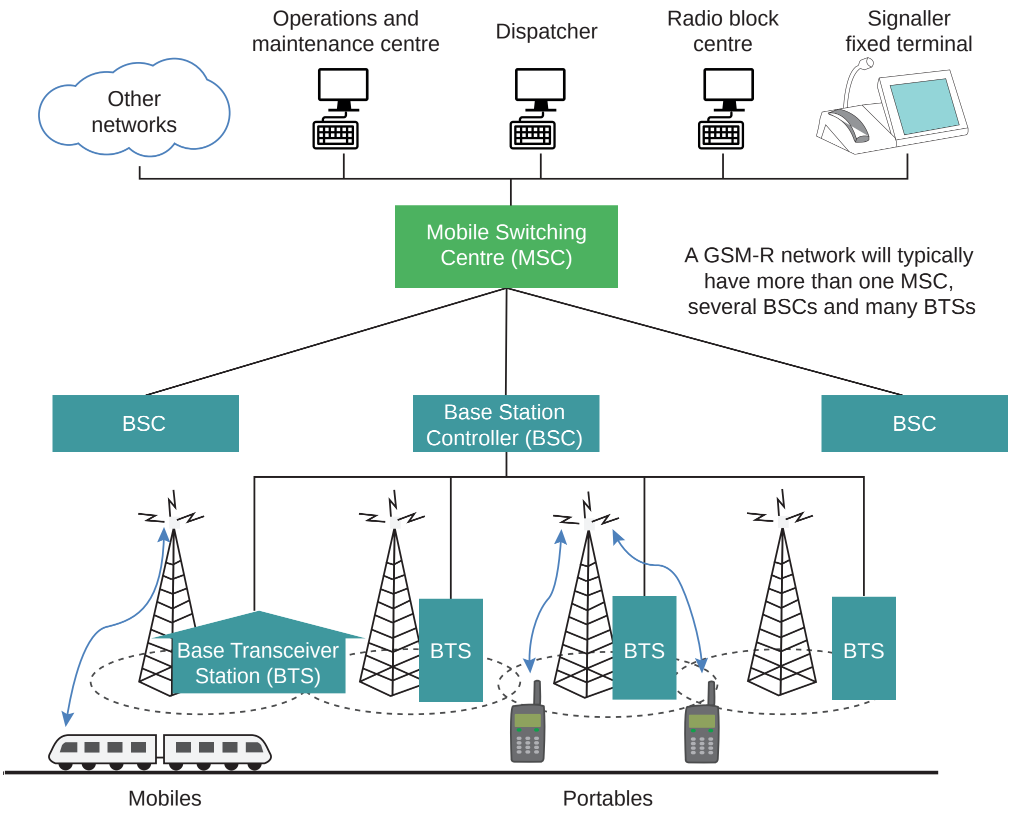


Figure 1 – Schematic of typical GSM-R network.

repeating the instruction. For engineering work public radio networks are often used if there is coverage at the location.

Many railways have or are installing their own national radio networks to the GSM-R standard. This system is based on the 2G version of public networks with some extra enhanced facilities:

- Railway Emergency Call (REC).
- Prioritisation for important calls.
- Location dependent addressing e.g. contact the signaller who controls the section of line for the train making the call.
- Functional dependent addressing e.g. contact the driver of train number 50629.
- Voice group calls e.g. a shunting group.
- Data services e.g. European Train Control System (ETCS) data.

Figure 1 shows a schematic of typical GSM-R system. GSM-R systems have dedicated spectrum which is harmonised across Europe as: Uplink 876–880MHz for mobile transmission and Downlink 921–925MHz for mobile reception.

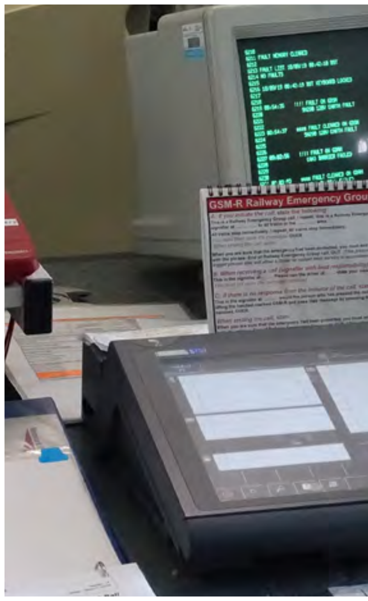
“Radio coverage is critical to the success of a GSM-R system”

Radio coverage is critical to the success of a GSM-R system. Many issues affect radio coverage, including cuttings, trees, hills, mast height and the frequency used. A public mobile system radio coverage will be optimised for revenue and it may be acceptable for small areas to have no coverage. For a railway radio network, complete coverage along a line of route will be required, including all cuttings, bridges and tunnels.

It makes a significant difference to radio coverage design if a network is being designed for vehicle mounted mobile radios or hand held portable radios, as the former can have the antennas mounted on the train or vehicle roof and have higher power levels. As a train passes along a section of route it reselects the next base station to monitor based on the “neighbour list” transmitted from each base station and the relative received signal strengths of each neighbour and the currently selected base station.

In a public network it does not matter which base station is used for a call, but for a railway emergency call it is important as it is established around the GSM-R cell which the train mobile had selected before the call set up, to make sure a call is routed to the controlling signaller. Thus, the control of the reselection is important and needs careful design of frequency allocation and neighbour lists, especially when there is a parallel railway close by. Frequency allocations also have to take account of any noise which may be introduced by the receivers picking up signals on the same or adjacent frequencies from other masts in the area. In addition, to reduce the size and hence impact of a railway emergency call, operators normally want to be able to distinguish between trains on the various lines approaching busy junctions with often the base station mast covering three or more sections of line approaching a junction. This has to be achieved using only a small number of frequencies compared to a public GSM system. In Europe only 19 are currently available for GSM-R.

It is also important for the handover of calls to occur robustly so as to not interrupt speech or data communications. This handover takes time and therefore the handover zone has to increase as the maximum line speed increases. Care has to be taken when trains enter a tunnel, for example, to ensure there is sufficient time for a handover. Additional base station or repeaters



Tunnels require significant consideration when providing radio communications. *Photo Shutterstock/ Dirtymouse.*

may be required in large stations, cuttings, under bridges and tunnels.

A common problem to almost all railways is providing radio communications in tunnels. Communication using a tunnel mounted aerial in a single bore tunnel at 450MHz is possible up to around 500m, whilst it can reach 1.5km in a double track tunnel. At the higher band frequency of 900MHz the distance increases to around 2km or more for double track tunnels. The tunnel dimensions become significant as greater propagation distances have been found in the tunnels on the high-speed lines in Germany, which are built to a more generous loading gauge than other railways, such as the UK.

"Tunnel dimensions become significant"

The effect of introducing a train into the tunnel is to increase the attenuation rate due to the blocking presence of the train. In a single bore tunnel this can be a significant problem, depending on the tunnel dimensions. In a double track tunnel the effect may become significant when trains are passing. At certain frequencies some tunnels can act as waveguides, which can lessen the rate of field strength attenuation through the tunnel. Factors that can increase the rate of attenuation include the presence of bends in the tunnel and the construction of the tunnel (concrete, brick or rock-lined).

The space occupied by trains in the tunnel is also important. In tunnels with no overhead line electrification and a restricted clearance, for example, the distance radio waves propagate is lower than comparable tunnels with a larger gap between the roof of the train and the tunnel ceiling.

The alternative approach to the use of free-space antenna propagation is to use leaky feeders or radiating cables. These have the advantage of having a consistent and generally predictable level of attenuation, which is not affected by passing trains. The cable is 'leaky' in that it has gaps or slots in its outer conductor which unbalances the radio signal in the cable and causes it to propagate radio frequencies along its entire length.

Work is underway on the replacement for GSM-R, called FRMCS (Future Railway Mobile Communication System) but it is expected that the current GSM-R functionality will be carried forward to the new system.

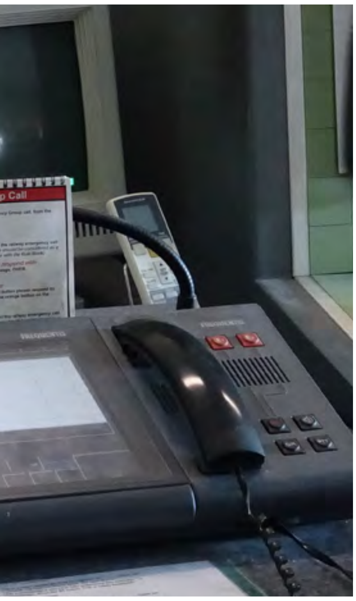
Data

Railway telecoms does not just use voice as data circuits are required to allow remote control and monitoring of equipment. Data circuits are provided to support signalling systems, e.g. SSI, Westlock, Smartlock when long distance terminals are required. Data circuits can be supported over copper cables using modems or plug directly into transmission equipment.

The near continuous data connection between trains and control centre to support the European Train Control System (ETCS) is normally provided via a GSM-R network in Europe and beyond. Railways, particularly metros, that use other cab based signalling systems (e.g. Communications Based Train Control CBTC) may adopt an alternative radio system such as TErrestrial Trunked Radio (TETRA) or even Wi-Fi if the line is in tunnel where external interference can be controlled. Early versions of ETCS used circuit switched data and hence required a constant data connection circuit to be available for the whole journey. This causes problems in dense areas where many trains are trying to access the network. To address this, some GSM-R networks are being enhanced to support GPRS (General Packet Radio Service) which allows better use of the radio bandwidth. Packet and circuit switching are explained later in the IP section.

SCADA Systems

Supervisory Control and Data Acquisition (SCADA) systems can be used to monitor and control many different processes and systems for railways. However, the primary railway application is the control of electric traction systems over wide areas. Telecoms data links with high availability will be required for electric traction SCADA system control, together with robust voice services for routine and emergency isolation purposes.



Above from left, a signallers fixed GSM-R terminal.

Cab GSM-R mobile unit.

Small 'key and lamp' signallers concentrator.

"Transmission equipment is now normally connected using lineside fibre cables"

Eliminating common failures which could isolate more than one successive electrical supply site is important, so an emergency isolation can still be implemented. SCADA systems may also be used for the monitoring and control of ancillary systems such as lifts and escalators, ventilation and air-conditioning and drainage systems and will also require telecoms links.

Traditionally signalling telemetry systems are generally not regarded as SCADA systems but they perform a very similar function, transmitting commands and receiving indications on the status of signals, points, track circuits. However in some railways SCADA capable equipment is used for signalling remote control systems.

Transmission systems

Transmission systems are used to transmit and receive more information than a single cable pair or fibre and over longer distances. They have evolved over time, mainly driven by developments for public telephone networks. Nowadays transmission systems are normally designed in layers to reflect the capacity and points of presence for the different services. The core network layer has relatively few nodes connected by high speed links and configured in a diverse manner. The access layer, on the other hand, would have frequent nodes situated where services are required, e.g. at base stations or signal boxes.

Transmission equipment is normally connected using lineside fibre cables, but older systems may still be connected by copper cable. To provide diversity transmission equipment can also be connected by a service provided from a public telephone operator.

Primary layers and primary multiplexers

Older telecoms and data transmission systems, such as Plesiochronous Digital Hierarchy (PDH) and Synchronous Digital Hierarchy (SDH) are known as "circuit switched" transmission, with a permanent connection established between two applications. The primary layer is where channels are converted from analogue to digital form so they can be combined with other circuits and sent around the network. When the primary layer is connected to line side cables, this is normally done using a primary multiplexer (PMux). PMuxs can support, speech circuits and data circuits up to 2Mbit/s. PMuxs are connected using an E1 data stream at 2Mbit/s. PMuxs can be configured as point to point or in rings. Each E1 data stream has 32 timeslots. Timeslot (TS) 0 is for synchronisation and alarms and normally TS16 is used for channel associated signalling. The other 30 timeslots each of 64kbit/s can be used to support speech or data circuits. The main interface cards used on a railway network may be:

- Subscriber – to connect to a phone via the lineside cable.
- Exchange – to connect to the exchange or concentrator.
- 4-wire E&M – to provide transmit and receive paths and up to 4 status circuits which can be used to operate relays.
- G703 data interface for SSI.
- V24 or X21 for lower speed data.
- ISDN (Integrated Services Digital Network) for some terminal equipment.

A normal telephone circuit has a frequency range of 300-3400Hz. A PMux converts analogue speech into a digital form by sampling the sound every 125μS (i.e. 8kHz) and then converting the sample value to a digital number between -128 and 128 i.e. 8bits. This conversion is called quantising and is done to limit the noise due to the process to a small proportion of the amplitude of the signal. So, the overall bit rate by channel is 8bits/sample x 8000samples/second = 64kbits/s. The interface card then allocates this data stream into a timeslot of the E1 circuit. In addition, it detects items such as the loop condition or ring current and sends codes in timeslot 16 to enable the interface card at the far end to reproduce the condition.

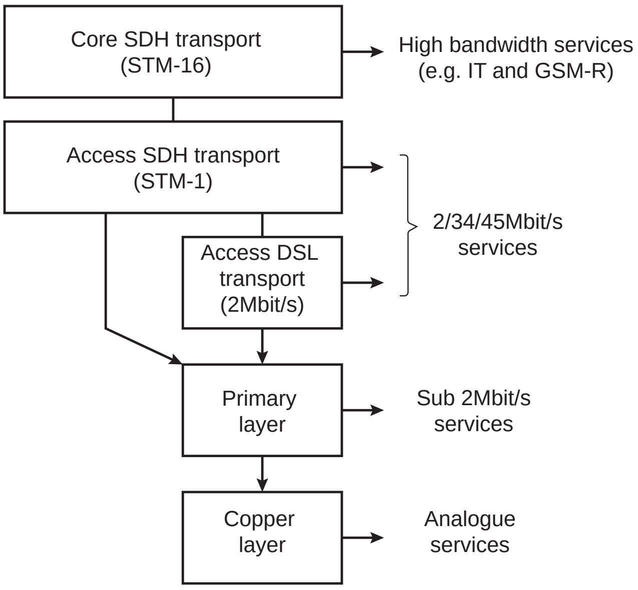


Figure 2 – Typical network configuration based on SDH equipment.

PMuxs are normally connected via bearer services through the higher order transmission layers but can also be supported using Digital Subscriber Line (DSL) modems over lineside copper networks. A typical network configuration based on SDH equipment is shown in Figure 2.

To connect a circuit switched network to an Internet Protocol (IP) network, gateways are required to convert the circuits or E1 data streams into a set of packets to send round the network. Data circuits for some signalling applications (example SSI) have specific time delay requirements which need to be addressed in the design of the core network and require allocation rules for such circuits, or for the E1 data streams supporting the circuits.

Figure 3 shows a typical example of how lineside phones may be connected to a signal box, using older circuit switched transmission.

Internet Protocol (IP) networks

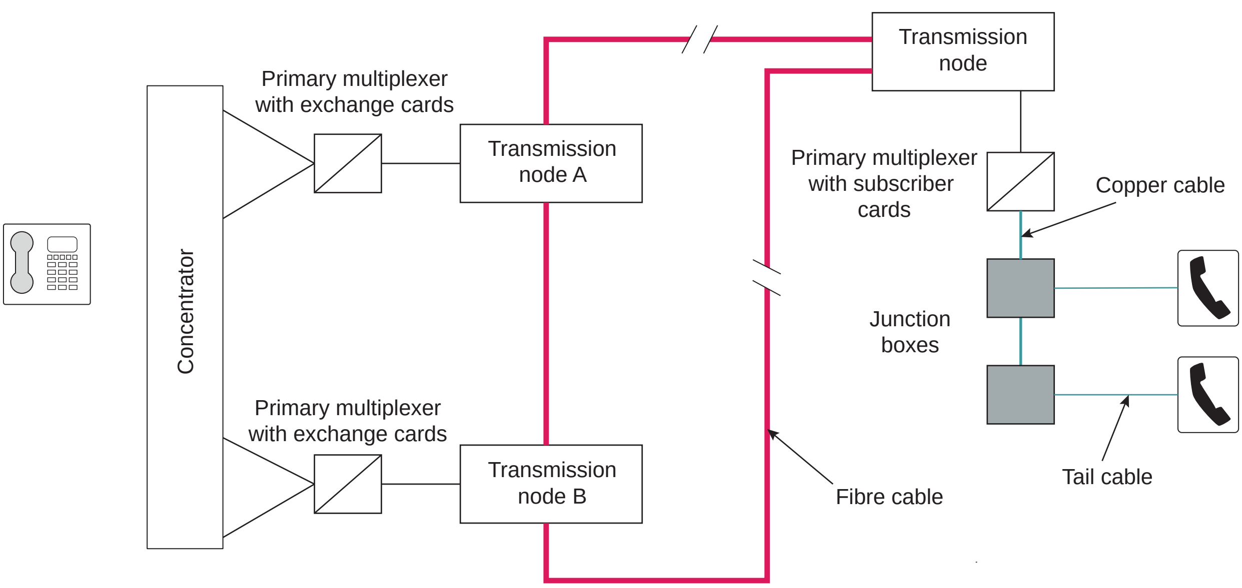
IP (Internet Protocol) as its name suggests is the basic protocol used on the internet, but has been the heart of all new telecoms networks and data communications systems provided for a number of years.

The PDH and SDH "circuit switched" transmission, with a permanent connection established between two applications, 'locks up' the communication resource and is inefficient, as the transmission path is used even when no data is being transmitted. IP however is a "packet switched" network, with the data message split into small packets to share capacity and transmission paths which are only used when data needs to be sent. This requires 'routing' to be established for each data exchange, however resilience is built in and the communications resources are shared, making IP far more efficient than circuit switching.

Each packet needs to be given information about the destination, its origin, and other information, to allow the data to be routed around a meshed network of routers. An IP packet is shown in Figure 4. The payload is a variable amount of data to be transmitted and is typically a few kilobytes, but can be up to 64 kilobytes. The IP header is fixed at 20 bytes and contains a 32-bit source and destination address as well as an indication of the length of the overall packet. Other fields provide a checksum, the version of IP being used, and a simple type of service indicator. The "time to live" field is used to set the maximum number of hops between router nodes to prevent unsuccessful delivered packets circulating and clogging up the network. After the packet has transferred its specified number of hops it is simply discarded and 'dies'.

The IP network as described in its raw state is simply a "best effort network", and there is no guarantee of the packets arriving, or in which order they arrive, and the network is what is known as connectionless, so the transport layer manages the flow of IP packets. Transmission

Figure 3 – Lineside telephone connected using circuit switched transmission.



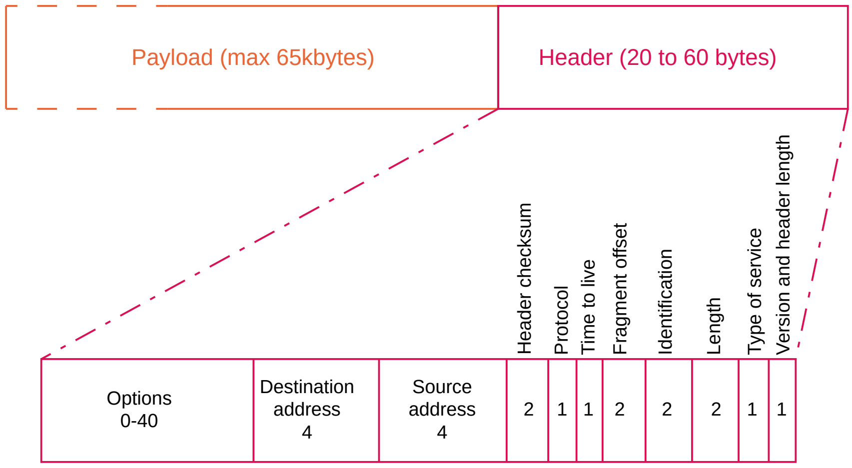


Figure 4 – An IP packet.

Control Protocol (TCP) sits within the IP payload and envelopes the source data by a 20-bit header and is carried by the IP packet as the payload. TCP acts as a connection-ordinated protocol within the connectionless network, it assumes the IP network is unreliable and numbers the IP packets or "datagrams" at the transmitting end of the link. It examines the numbers at the receiving end and requests the retransmission of any packets not arriving within a specified period. The numbering sequence is used to arrange the packets into the correct order, and finally TCP monitors the flow of packets getting through the network and adjusts the launch rate accordingly.

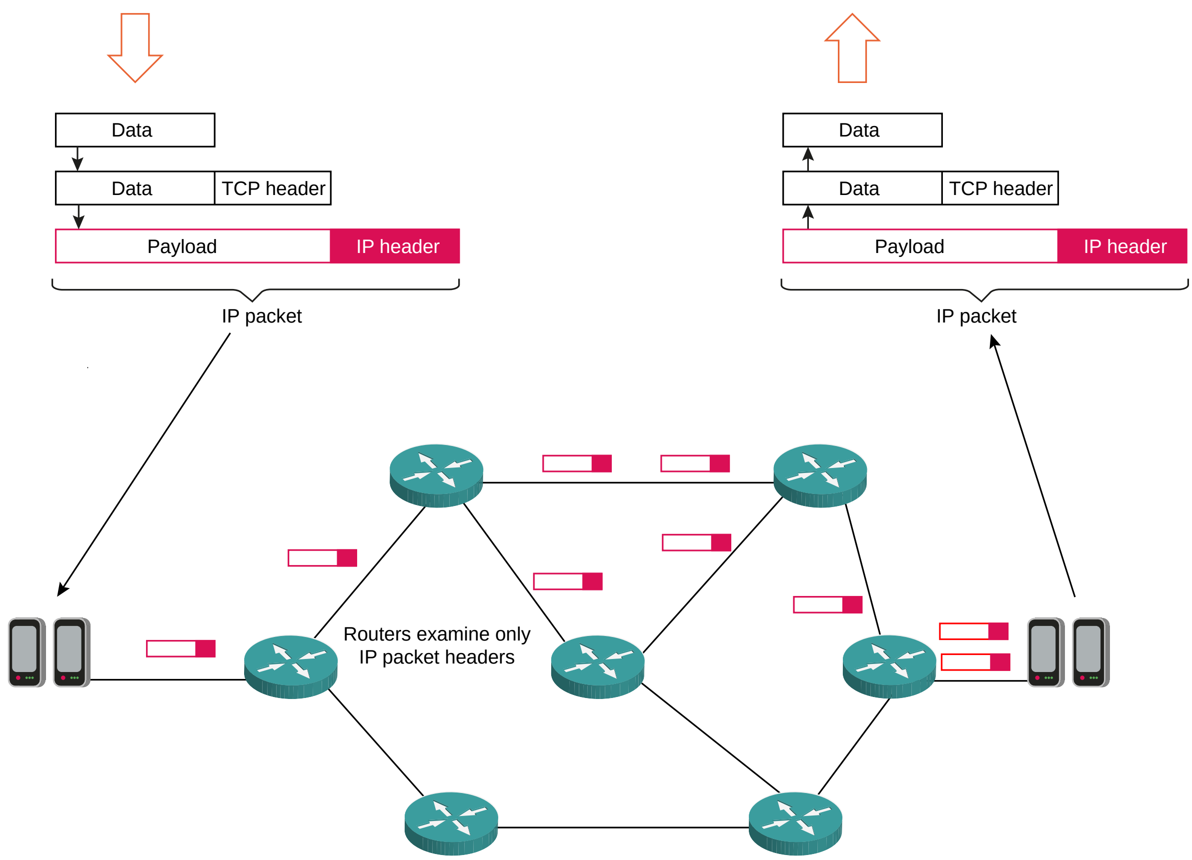
A network of routers is shown in Figure 5 together with the role of the TCP and IP headers. The routers only examine the IP packet header, and simply pass the datagram packet onto the next router in the network, according to a table held within the router. Multiple paths for the packets are available so the transmission network is more reliable and it is possible for consecutive packets to be routed over different paths between router nodes. Once the packets are delivered to their end-point, the TCP assembles packets in the correct sequence and requests the retransmission of delayed or errored packets if required.

Not every application has the same requirements for the delivery of IP packets. For example, when transmitting a document or email it is critical the entire data message is transmitted with no corruption. It does not matter if it takes a few milliseconds to receive the data message, so TCP is used, which will request the re-transmission of any missing or corrupt data packets. However, a voice or video image signal is time critical but very small gaps in the image or voice can be tolerated, and may not even be noticed. For these applications User Datagram Protocol (UDP) is used. This assembles the data packets in the correct order, but does not arrange for the retransmission of corrupt or missing packets; they are simply discarded.

Multi-Protocol Label Switching (MPLS)

MPLS is a method of providing a guaranteed Quality of Service (QoS) and Virtual Private Network (VPN) capability within an IP network, and is a method of making the connectionless IP network connection orientated. MPLS uses

Figure 5 – A network of routers showing the role of TCP and IP headers.



'labels' to specify a virtual path for the IP packets to follow using a 20-bit label attached to the front of each packet. MPLS provides better latency for time critical applications, such as voice and video, and with VPN capability for security. The faster routing is because the label switching is done in hardware, whereas normal IP routing involves the slower processing of software to deconstruct and decode the IP address. MPLS also incorporates Class of Service (CoS) network performance to differentiate between time critical, high priority traffic and delay tolerant, low priority traffic. To use this service, MPLS capable routers are required.

Voice Over IP (VoIP)

VoIP systems offer many advantages compared to a traditional circuit switched telephone exchange network, as voice simply becomes another application running on an IP network, this offers many advantages and the capability of exceptional good quality sound. This is because high speed codecs convert the voice to IP packets without needing the normal 4kHz frequency filtering. This higher quality is subject to loading on the IP network, which can lead to loss of packets and hence degradation of sound quality; which is why a high Quality of Service (QoS) IP network is required for VoIP. A power supply for the VoIP telephone will also be required.

"Security is a concern with IP networks, so real time cyber security is critical"

Security is a concern with IP networks, so real time cyber security using encryption and firewalls along with "defence in depth" techniques with multiple layers of defences is critical.

Protocol layers

One way of explaining the various IP protocols and layers is to map TCP/IP and its supporting protocols against the Open Systems Interconnection (OSI) model as shown in Figure 6. At physical Layer 0 and 1 there are the various transmission systems and cables in the access and core network. At Layer 2 there are various data link systems that may be used in the telecoms IP network, including Ethernet and possibly the Public Switched Network for dial up connections. IP resides at Layer 3, the Network layer. At Layer 4, the Transport Layer, there is either TCP for the latency tolerable, or UDP for the latency intolerant applications. There is a vast array of protocols covering many possible applications that may run over an IP network, either internet or intranet or an IP based secure signalling system; and it is at this level where full end to end data security needs to be addressed. The design and standards for IP and the internet are administered by a consortium of users, academics, and manufacturers known as the Internet Engineering Task Force (IETF), unlike traditional telecoms networks which were designed to international standards governed by the International Telecommunications Union (ITU). The IETF have set recommendations for OSI layers 2 to 7, however the IETF considers layers 5 to 7 a single entity.

Management of a telecoms network

Software-Defined Networks (SDN) are now common. SDN enables remove dynamic, efficient network configuration and alarm management in order to improve network performance and monitoring, making it more like cloud computing than traditional network management.

In many cases modern business systems are based on an IP network and the methods of connecting computers, printers and servers are well defined. VoIP telephones are increasingly used in offices and if a railway telecoms IP network is provided for operational use it is also possible to extend it for business purposes. Interfaces may be required to any older circuit switched digital telephone exchanges which could still be used in a railway network.

Increasing capacity

Coarse Wavelength Division Multiplexing (CWDM) or Dense Wavelength Divisional Multiplexing (DWDM) technology can be used to make better use of installed fibre. These systems use Frequency Division Multiplex (FDM) with between 18 and 160 wavelengths of light over single mode fibre. In this way many transmission links can be overlaid onto the same fibre, to significantly increase capacity.

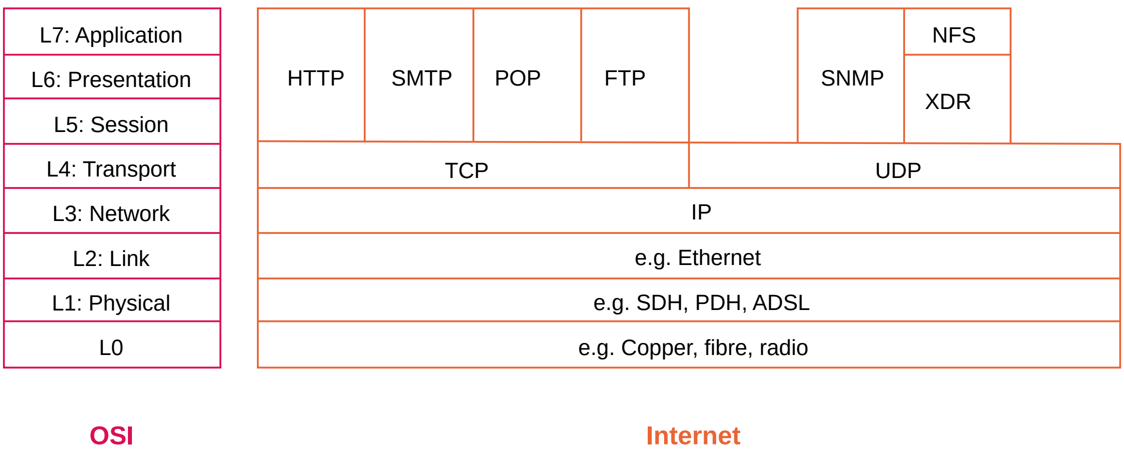


Figure 6 – The Open Systems interconnection (OSI) model. HTTP is Hypertext Transfer Protocol, SMTP is Simple Mail Transfer Protocol, POP is Post Office Protocol, FTP is File Transfer Protocol, SNMP is Simple Network Mail Protocol, NFS is Network File System, XDR is External Data Representation, PDH is Plesiochronous Digital Hierarchy and ADSL is Asynchronous Digital Subscriber Line.

Electrification, interference and immunisation

Electric traction systems can cause problems for telecommunications with electromagnetic induction of high voltages and noise into speech circuits. This can arise from harmonics resulting from the electric field generated by the current drawn by electric trains in 25kV overhead line systems, or by the AC feeder cables and the crude rectification of the AC supply to provide a DC traction system either using third rail or overhead catenaries. S&T engineers have to ensure interference will not cause malfunction of safety related circuits, particularly that short circuit currents do not generate high voltages that would damage equipment or cause a dangerous health hazard to staff. Also, higher frequency harmonics from traction systems should not cause speech circuits to become noisy and interfere with data circuits.

"S&T engineers have to ensure interference will not cause malfunction of safety related circuits"

Various traction systems are in use around the world with 25kV 50Hz one of the main systems in use today. The ITU (International Telecommunications Union) requires induced voltages in telecoms copper cables under normal conditions to be no more than 60V RMS, and under system fault conditions 430V RMS. The noise limit for telephone circuits is a psophometric electromotive force of 1mV. Psophometric noise is 'weighted' the same as human-perceived levels of noise. This is more important for telephony than the raw noise voltage.

A range of solutions are required to mitigate the effects of traction power supplies on line side services:

- Limiting the lengths of copper cable section.
- Having a robust balance to earth interface for powered equipment.
- Position of the cable route (and hence cables) with respect to the traction cables.
- Providing an earthed screening cable in the cable route.
- Replace longer distance copper cabling with a fibre optic based system.

Some railways provide traction current at 25kV, 50Hz to the train with currents of around 300A flowing through the train from the catenary wire to the rails. To minimise interference, a booster transformer is used whereby the overhead line equipment (OHLE) is separated into in sections of about 3km and at the end of the section a Booster Transformer (BT) is used to 'suck' the return current out the rails and into a separate return conductor mounted on the outside of the overhead stanchions roughly at the same height as the catenaries. This creates an opposite phase and opposing electric field that helps to cancel out the effect of the current in the catenaries but the effects of the currents within the occupied overhead line section still need to be addressed.

"The advent of fibre optic cables with no metallic components has significantly reduced the problem of electrical inteference"

More recent electrification projects use a 50kV auto-transformer system whereby, a 'second catenary' is mounted on the outside of the stanchion to permit a 25kV-0-25kV arrangement giving a more balanced system. Trains continue to take power at the 25kV voltage with the current being returned in the 'other' catenary wire. In this way, for sections which do not have a train taking power, the currents in the OHLE conductors are the same magnitude but in opposite phase. This means that at any point which is an equal distance from both the conductors the induced magnetic field will be effectively zero. This is the ideal place for the cable route. It is not possible to directly align with this ideal positioning as the catenary wires move from side to side and go up and down for obstacles such as bridges and level crossings. However the nullifying effect still significantly reduces the electric field. As has been mentioned previously, the advent of fibre optic cables with no metallic components has significantly reduced the problem of electrical interference and associated immunisation for new systems and in some cases may allow the use of simple feed catenary systems.

In part 2 of this article we will look at telecoms systems for passenger use and the differences between public and railway telecoms networks.

"Back to basics" and the IRSE Exam

We hope our "Back to basics" articles are particularly interesting and useful to those of you who are maybe new to the industry and are working to build up your knowledge, or who have moved to a new role involving telecommunications. For those considering taking the IRSE exam, these articles should be particularly relevant to assist your studies.

As an example, why not think about how you would answer these questions from the 2019 Module 6 of the exam, based on what you have learnt from the article?

You are required to produce a radio communication system that provides coverage for trains within tunnels and for station staff throughout an underground system. The train traction system is an overhead 25kV catenary system.

a) With the aid of diagrams describe your chosen system and explain the factors you would consider as part of your design. [12 marks]

b) Produce an outline test plan including the tests you would undertake to prove the functionality of the system. [13 marks]

You are the telecommunications designer for a project which is to renew a telephone concentrator and associated lineside telephones.

Using a risk assessment methodology of your choice outline the hazards, and proposed mitigations, throughout the asset lifecycle. [25 marks]

Safety management simplified

Somnath Pal

During my tenure at Indian Railways Institute of Signal Engineering and Telecommunications (IRISET), I observed that some trainees found it difficult to absorb the terms used in safety management. In India we have one of the best manuals for teaching called Panchatantra. It was written in ancient times but still serves the purpose even against the best management guidelines. In this storybook for children, the teacher tells a story and explains all complex topics. I have followed Panchatantra and written a skit to explain the terms of safety management and hope even the serious readers will like it.

Sitting in a relaxed mood in a hall, Chris is reading a newspaper. His friend Alex enters with a plastic laminate photograph of Alex in one hand and a hammer with a few nails in the other. Alex looks towards the rear wall and tries to choose a suitable spot for hanging the photograph. Chris observes this for some time and asks –

"Alex what are you looking for? You are simply hanging the photograph."

Alex: "No, Chris, it is not so simple. First of all, it is to be placed such that the décor of the room is not affected. For any kind of installation, an Initial Site Survey is essential."

Chris: "Oh! Is it? So, I learned a new thing today."

They then choose a place on the wall. Alex brings a three-legged stool.

Chris: "Now give me the hammer and a nail and I shall fix it."

Alex: "Take two nails. If the photograph is fixed using only one, it will fall if the nail is broken. If two nails are used, even if one of the nails breaks, the photograph will not fall. This is the Redundancy Principle."

Chris: "But if one of the nails breaks, though the frame will not fall, it will hang awkwardly. It's better to use three nails. Then two good nails will keep the frame in the correct position."

Alex: "Correct! This is 2 out of 3 Redundancy principle. It would satisfy both the Reliability and Availability requirement."

Chris: "Now let's start the job."

Alex: "Don't be in such a hurry. First check whether the hammer-head is fitted tight to the handle; and whether the nail is straight and the legs of the stool are firm."

Chris: "Why are all these needed?"

Alex: "If the hammer-head is loose, it may fly while you try to hit the nail. If the nail is not straight, fixing it to the wall is difficult. If the legs of the stool are loose, you may fall down! Thus, two of the faulty situations can be hazardous as they can cause injuries. This process is known as Failure Mode Effect and Criticality Analysis. You need to anticipate the effect of faults."

Chris checks all of those and proceeds to start the job of fixing, but Alex interrupts again.

Alex: "Oh Chris, you are in too much of a hurry. Have you thought of keeping antiseptic, bandages and ice nearby?"

Chris: "Now that's quite funny. Why do we need those items here?"

Alex: "This is Disaster Management. You should be prepared to tackle the potential disaster, instead of arranging for the necessary items after any mishap occurs."

Chris fetches all the items. By this time, he looks a bit fed up with his friend.

Chris: "Can we start now at least or do we need some more things?"

Alex: "Do you know how to hold the hammer and the fingers you should use to grip the nail with? How much force should you use to hit the nail?"

Chris: "Everyone knows all these. Does even that need some standard or training?"

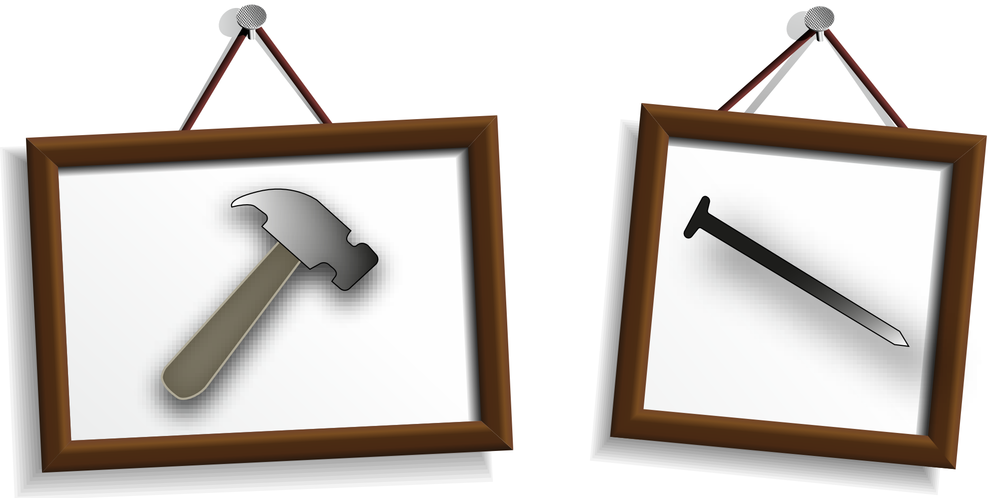
Alex: "Haven't you heard about the ISO 9001 standard? Even for sweeping a floor you should have a documented guideline. A lot of discussions and meetings are to be held before satisfying that the process is understood."

Chris shows Alex the positions of the hammer and how to grip the nail. Suddenly Alex has a new point.

Alex: "Who should climb the stool, you or me?"

Chris: "Does it make any difference?"

Reliability, availability and maintainability



Alex: “Yes. If you fall down, it might not affect you much as you are young and a sportsperson. But if I fall, I might have to go to the hospital. This is called Consequence Analysis. The fall may be due to the stool or a lack of balance. We can know this by Cause Analysis.”

At last Alex agrees that all points are covered. Chris climbs the stool and Alex supports it.

Chris: “Come on. There is no need to hold the stool!”

Alex: “This is a Risk Mitigation process”.

Chris: “OK, OK, got it.”

After fixing the frame, the friends sit and rest.

Chris: “I am puzzled. How did you learn all these sophisticated terms and make a simple job such a complicated one with so much analysis?”

Alex: “Oh, it’s nothing so complicated at all. It’s just safety management. You’ve probably forgotten, that recently my father underwent a training course for signal engineers at IRISET.”

Chris: “Do they teach about the hero of Indian epics, RAM? I’ve noticed that his notebook has several mentions of RAM.”

Alex: “This RAM is not the epic hero. No, it’s the acronym for Reliability, Availability and Maintainability.”

Chris: “Tell me more.”

Alex: “Consider a ceiling fan. You know that it starts rotating if the switch is ON. If you repeat this, say, hundred times there might be a chance that the fan rotates ninety-nine times and fails once. The probability that the system performs in the specified way over a period of time in a given environment is called Reliability. Now suppose, if the fan and the switch are both all right, the absence of power supply will fail the system. Thus, the Availability of the system will be absent. Finally, if the system fails, its chance of getting repaired or replaced to sustain the service is known as Maintainability.”

Chris: “Is that all?”

Alex: “Not yet.”

Chris: “OK, carry on, sounds interesting.”

Alex: “While fixing the fan, you are also to check for the chance of its falling on your head and causing injury. This is Safety Analysis. So, that’s all for today.”

Chris: “Thank you for updating me on such complex concepts by simple examples. I admit, it did sound boring while I was fixing the nail, but as I started getting the concepts, I realised that it was just ‘child’s play’. Hats off to IRISET, it has not only taught your father but has also brought out a great lecturer in you. So, when are you joining an institution?”

About the author …

Somnath Pal MIRSE, MIEEE was a system assurance manager at Radharani Rail engineering Systems Pvt Ltd and faculty member of Institute of Metro & Rail Technology, Hyderabad. Somnath was assistant professor at IRISET Secunderabad for 10 years delivering lectures in railway signalling, telecommunications and IT subjects to officers and supervisors of Indian Railways.

IRSE

Institution of Railway Signal Engineers

Chiltern ATP obsolescence

Paul Darlington

Following the investigation into the 1988 Clapham Junction Railway Accident in England, recommendation 46 of the report required that after a specific type of ATP system had been selected, British Rail (BR) were to fully implement ATP nationally within five years throughout the network. BR instigated two ATP pilot systems; one on the Great Western route and one on the Chiltern route (between London Marylebone station and Aynho Junction) to help identify an ATP system which should be installed nationally.

The Chiltern route was selected for a system based on the LZB system used in Germany, developed by Standard Elektrik Lorenz (SEL) and called SELCAB. SELCAB used inductive loops to communicate between the track and train with loops sometimes several hundred metres long and terminating at the foot of the signal. SELCAB had some adaptions to fit the BR market, which made it a bespoke system and one not used elsewhere.

TPWS not ATP

In 1994 a study was carried out into the cost-benefit of providing ATP across the whole national network. This concluded that the cost per fatality prevented of £14 million could not be justified and ATP deployment would not proceed beyond the two trial systems. A project was then launched jointly by Railtrack, the new infrastructure manager, and the British Railways Board (who at the time were the exclusive train operator) to pursue a Signal Passed At Danger (SPAD) Reduction And Mitigation (SPADRAM) project. An outcome of SPADRAM was the Train Protection and Warning System (TPWS).

TPWS was and is a simple system that reduced ATP preventable risk by circa 70 per-cent but at a fraction of the cost as it was an enhancement of the Automatic Warning System (AWS). AWS uses an electromagnetic arrangement to provide a driver with an indication to show if they are approaching a green signal or not. If a driver reacts to the first warning given by AWS, they will normally have time to stop at a red signal. The risk is that the warning is not enforced and can be over-ridden by the driver. In more complex situations (such as running on cautionary signals) it relies on drivers' vigilance to initiate the brake application.

TPWS added radio frequency (RF) loops to provide an automatic train stop and an overspeed sensor on the approach to the signal. TPWS does not entirely prevent SPADs from occurring, but in the majority of cases it reduces or avoids the consequences of drivers failing to react to signals. TPWS was mandated by the Railway Safety Regulations 1999 (RSR1999), which came into in force from January 2000.

RSR1999, and therefore the law, requires infrastructure managers and train operators to only permit the operation of trains with train protection equipment fitted. Train protection equipment is defined as a system which can: stop a train if it passes a red signal, if it approaches a red signal at too high a speed, or is driven too fast. RSR also says where it is reasonably practicable to fit ATP then it must be used. This meant that both the Chiltern and Great Western ATP systems were to remain in service alongside TPWS.

The timescales for TPWS fitment were challenging and required it to be fitted on all trains and at all 'selected signals' (such as converging junctions and complex track layouts) by 1 January 2004. TPWS has been a huge success and SPADs are no longer the risk they once were in Britain. The RSSB annual safety report for 2019/20 highlighted that the 10-year rolling average for fatalities caused by train accidents had fallen significantly since 1994, partly due to the reduction in signal over-run risk.

Once fitted however, the benefits derived from TPWS undermined the economic case for providing full ATP, but TPWS trackside equipment is only fitted to signals beyond which conflicts or other serious situations are likely to arise. This meant there are many hundreds of signals, such as most automatic signals, with no TPWS protection. ATP is fitted to every lineside signal and permanent speed restriction, and provides continuous speed supervision, but TPWS is normally only fitted to signals protecting conflicts and has limited capabilities to protect over-speeding. With ATP, the braking calculation is carried out on-board, and is therefore relevant to the characteristics of a particular train. The design of trackside TPWS is a based on a general model of train braking ability and this may not be effective for all trains that operate on a particular route.

Gary Faulkner and John Bartoszek maintaining the SELCAB ATP.
Photo by Steve Fulcher.

The Chiltern ATP equipment was supported by Alcatel and then Thales, but with the system a bespoke 'one off' and no other systems ever deployed, keeping a complex technical system such as this one operational for longer than ten years was a major achievement. So in 2011, 21-years after its instigation, Thales formally advised of the Chiltern ATP system impending obsolescence. 'Last buys' of equipment were initiated to create a spares holding to sustain the fixed infrastructure and fleet fitment, and a life extension programme for the on-track part of the system instigated. This consolidated documentation and training materials, and created a replacement solution for programming and verifying the EPROMs that hold the TSR and ESR data. The obsolescence problems became critical for the on-board equipment with no modern equivalent available and no spares stock.

Providing a European Train Control System (ETCS) would have seemed the obvious solution, as ETCS Level 2 delivers ATP and is the long-term signalling solution for the country. However, the rest of the signalling assets on the Chiltern route are not life expired and there are other routes in the country with a greater need for the resource and capital required for ETCS. Current deployment date for ETCS on the Chiltern route is around 2035. Providing ETCS was therefore not seen as deliverable within required timescales for the ATP obsolescence, or at an affordable capital cost.

Enhanced TPWS

TPWS is an expandable system so additional loops can be provided at automatic signals; buffer stops or speed restrictions. Therefore, it was anticipated that TPWS enhancements could make TPWS closely match the functionality provided by the obsolete SELCAB ATP. Enhanced TPWS would provide Train Stop System (TSS) loops at signals not fitted with TPWS and Overspeed Sensor System (OSS) loops designed to stop a train short of a conflict. Enhanced TPWS would also provide optimum protection for ALL trains operating over the Chiltern route, as currently not all trains using the Chiltern route use ATP.

All on-train TPWS equipment would be upgraded to the most recent design standard, known as Mark 4 TPWS. The newer Mark 4 equipment benefits from design changes to improve the effectiveness of TPWS. Compared to earlier TPWS control panels, Mark 4 features three separate indicators to show the cause of a brake demand, SPAD, Overspeed and AWS. It also adds a covered 'Brake Release' button to involve the driver in the brake release process.

Providing enhanced TPWS instead of ATP would however require an exemption from RSR1999 and to demonstrate a TPWS based system would represent the only reasonably practicable solution. RSR1999 says that the ORR may grant an exemption to the law but were required to conduct a public consultation to assist the decision.

To provide expert independent guidance Network Rail commissioned Mott MacDonald to complete a study into the potential solutions for an interim train protection system and Sotera Risk Solutions Limited to provide a comprehensive independent risk assessment to analyse a wide range of potential future risk control strategies for the route. The risk assessment considered East West Rail Phase 2, HS2 construction traffic and future passenger growth. The assessment concluded that enhanced TPWS would provide a broadly similar, and even marginally lower, level of risk than the existing ATP fitment. It was calculated that the Fatalities and Weighted Injuries (FWI) would be 1.9 per cent better using enhanced TPWS as all trains would benefit from it.

Public consultation

The public consultation for "Exemption from train protection duties: Chiltern Railway routes", commenced 17 June 2020 and concluded 15 July 2020. The consultation invited the public or any party to express a view on the application and in making their final decision the ORR committed to consider all views. The consultation included all the detailed proposals, risk assessments, options and safety arguments. This attracted constructive feedback from industry stakeholders and all the comments were addressed to the satisfaction of the ORR and to enable the production of an exemption certificate which came into force on 13 August 2020.

With the exemption now in place, mobilisation and design work for both trains and infrastructure is underway, with infrastructure and train upgrades to be implemented from early 2021 through to mid-2023. This will allow ATP to be turned off, sometime in 2023.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

Data fusion in Norway

Norway: Alstom has announced that it has received full certification of the latest interoperability standard for rail, European Train Control System (ETCS) Baseline 3 Release 2 and has been certified by Belgorail (an inspection and certification body) to implement its data fusion algorithms, using both satellite navigation and inertial movement, to accurately and safely measure the location and speed of trains. The new odometry system based on data fusion is applicable to all types of trains and all environments, including the harshest weather conditions. By 2026, 450 trains will be equipped with the new standard and in commercial service across Norway.

Data fusion obviates the need for the external radar components for localisation and speed measurement. It is a process for aggregating multiple data sources to produce more consistent, accurate and useful information, than provided by any individual data source.

Arriva to refit trains with Stadler GUARDIA ETCS

Netherlands: Arriva Nederland and Stadler have signed a contract to refit 36 trains with ETCS GUARDIA. The project will include the homologation of GUARDIA for the Netherlands, Belgium and Germany and includes eight trains that have already been used on the international train line RE18 in Limburg.

Arriva is the first regional carrier in the Netherlands to order the system and it is the first time for Stadler to win a contract to refit trains with its own ETCS system. The installation will be carried out at Stadler's service centre in the Netherlands between 2020 and 2024. The first refitted trains will enter operation on the cross-border track in 2022.

ProRail to test automatic shunting operations

Netherlands: Lineas, the largest private rail freight operator in Europe, is supporting ProRail and Alstom to test ATO in shunting activities. ATO has been identified as part of a solution that will enable rail freight companies to double rail volumes in Europe and help deliver the EU Green Deal's target for smart and sustainable mobility.

The tests will see a Lineas diesel-hydraulic shunting locomotive being equipped with Alstom's automatic control technology, intelligent obstacle detection and recognition. The project will first focus on the development of the software for automating tasks such as starting and stopping, coupling of wagons, controlling of traction and brakes, and the handling of emergencies (obstacle detection). Tests will start in 2021 under the supervision of authorised train staff.

NJ TRANSIT PTC milestone achievement

USA: NJ TRANSIT in Newark NJ has advanced its Positive Train Control (PTC) program into the Extended Revenue Service Demonstration (ERSD) phase. This follows completion of the Federal Railroad Administration's (FRA) requirement to perform 384 error-free test runs in the demonstration area between Denville and Summit. NJ TRANSIT will now expand its Revenue Service Demonstration to the entire Morristown Line from Hackettstown to Newark Broad Street as well as the Gladstone Branch.

By entering ERSD, NJ TRANSIT has increased its testing territory from the 17-mile demonstration area between Denville and Summit to approximately 100 miles or 33% of the total system mileage required for full certification. NJ TRANSIT is the USA third largest transit system with 166 rail stations, 62 light rail stations and more than 19 000 bus stops linking major points in New Jersey, New York and Philadelphia.

US railway Q2 Positive Train Control (PTC) implementation progress

USA: The Department of Transportation's (USDOT) Federal Railroad Administration (FRA) has released a quarterly status update on self-reported progress, as of 30 June 2020, toward fully implementing PTC systems by 31 December 2020, as required by the US Congress.

Nearly all railways subject to the statutory mandate are either operating their systems in revenue service or in advanced field testing, known as revenue service demonstration (RSD). As of 30 June 2020, PTC technology remains to be activated on approximately 700 required route-miles (1130km), with PTC systems in RSD or in operation on approximately 56 846 route-miles, 98.8% of the 57 537 route-miles (93 000km) that are subject to the mandate. This represents a 0.7% increase since the first quarter of 2020 and indicates that PTC technology was activated on an additional 305miles (500km) during the second quarter.

In addition, the USA railway industry continues to make notable strides toward completing interoperability testing and meeting the interoperability requirements under the statute and FRA's regulations. As of 30 June 2020, they reported that interoperability has been achieved by 65.5% of the 220 applicable, host-tenant railroad relationships, a 17%increase since the first quarter of 2020. Based on the criteria FRA uses to evaluate the risk of noncompliance, FRA currently considers two railways at risk of not fully implementing PTC on all required main lines by 31 December 2020: New Jersey Transit (NJT) and New Mexico Rail Runner Express (NMRX/Rio Metro).

Two were removed from the at-risk list: The Northeast Illinois Regional Commuter Railroad (Metra) and TEXRail. Both entered RSD on 100% of their required main lines, submitted their PTC Safety Plans and are now focusing on completing interoperability by the December deadline.

USDOT has provided approximately \$3.4bn (£2.6bn, €2.9bn) in grants and loans to support the industry's mandated implementation of PTC technology. FRA continues to help railroads fully implement PTC systems by providing direct technical assistance, on-site technical support, and hosting industry-wide collaboration sessions.

Italy to pilot Hitachi satellite-based ERTMS system

Italy: Infrastructure manager Italian Rail Network (RFI) and Hitachi have signed an agreement for a pilot ERSAT EAV (ERTMS on Satellite-Enabling Application Validation) signalling system for the Mediterranean corridor between Novara and Rho.

The ERSAT EAV system will integrate ERTMS with GPS and the Galileo satellite navigation/geolocation systems and public telecommunications networks. By using satellite location and public networks the system is intended to bring the benefits of ERTMS to lower traffic regional lines with lower installation and operating costs than using conventional ERTMS. The pilot system will initially use GPS to determine train position, with subsequent replacement with the Galileo system when available.

ERSAT aims to reduce the installation and maintenance costs of ERTMS by using a satellite link to create 'virtual balises' every 50m to track the position of trains. Some lineside infrastructure will still be required, but base stations would only be needed every 7km, rather than balises every 1.3km or less using conventional ERTMS. RFI completed the initial testing of the ERSAT system on the Cagliari-Decimomannu line in Sardinia in February 2017.

New signalling at Hither Green

UK: Siemens Mobility Limited has delivered the final commissioning of the Hither Green Area Resignalling Project, serving Hither Green into Lewisham, Central London and into Kent. The work is part of Network Rail's £250m (€280m, $330m) programme to improve signalling and track reliability through the Lewisham area of South East London, and was the UK first major commissioning to be delivered during the COVID-19 pandemic. Following a nine-day blockade, the new signalling system was signed into operation on 2 August 2020, covering the route from Hither Green to Grove Park, Sidcup and Bromley North. Control of the route has been transferred from the London Bridge Signal Box to Network Rail's Three Bridges Rail Operating Centre (TBROC).

The scheme enables 12-car trains to now stop at platform three at Grove Park and for turnback opportunities to be created at Hither Green, Grove Park and Lee, enabling trains to turnback in the event of delays or during engineering works. The Trackguard Westlock Computer Based Interlocking and Westrace Trackside System have replaced the interfaced solid-state interlocking at Hither Green and remote relay interlocking at Bromley North. With 21 stages across two years 58 signals were provided and existing track circuits replaced by 254 axle counter heads.

The Siemens Mobility equipment was manufactured in the company's UK factory at Chippenham.

All voice and data telecoms circuits have also been migrated from the old legacy infrastructure in the area to new IP transmission and copper and fibre cables along the route, with a new keyboard being added at the TBROC to enable the signaller to use the new lineside telephones.

City railways and light rail

Siemens Mobility to re-signal Buenos Aires Line D

Argentina: Buenos Aires metro authority SBASE has selected Siemens Mobility to install Communications-Based Train Control CBTC and a new passenger information system on the capital's Line D.

SBASE began work in 2016 on the modernisation of the 11km line, which runs from Catedral station in the central Plaza de Mayo to Congreso de Tucumán in the north of the city, serving 16 stations. Siemens, Alstom and Benito Roggio had originally bid for the Line D resignalling, but SBASE re-called tenders last year, dropping its plan to install platform screen doors.

The contract now announced is for Siemens Mobility to install interlockings and other lineside equipment for the radio-based CTBC, as well as retrofitting onboard units to 24 existing trainsets. The modernised line will be managed from the metro's newly-established operations control centre.

Siemens will supply its Trainguard MT technology, which has been in use on Line H since mid-2016 and was commissioned on Line C in February. This will replace an Alstom automatic train protection system that has been in use on Line D since 2008. The CBTC will support attended ATO to Grade of Automation 2 and enable trains to operate at 135 seconds headways, increasing capacity on the line by an estimated 30%, or 67 000 passengers/day. Installation is expected to start before the end of this year for completion by the beginning of 2023.

"This important project further underscores our leading position in delivering automated signalling systems, and expands our growing footprint in South America", said Siemens Mobility CEO Michael Peter. "The state-of-the-art technology will augment operations on this line and allow for an enhanced passenger experience."

Edinburgh tram extension

Scotland, UK: Siemens Mobility has received a contract for the Edinburgh Tram 4.69km-long extension from York Place to Newhaven. The scope includes electrification, supervisory control and data acquisition (SCADA), telecoms, and tram and road traffic signalling. The extension is expected to complete in 2023 and will increase the accessibility between Newhaven, the city centre and the airport. The new double-track line will feature eight stops and two substations to provide the traction power for the entire extension.

Zhengzhou Metro Line 6

China: Thales SEC Transport (TST), Thales' joint venture in China, will provide its TSTCBTC® 2.0 signalling system for the Zhengzhou Metro Line 6 phase 1 project. The system has already been deployed on the Shanghai Metro Line 5 and Line 14 projects.

The Zhengzhou Line 6 phase 1 project is one of the key projects in the city's urban rail transit construction, which will significantly enhance the urban mobility. The line runs from Jiayu Town station to Xiaoying station, with a total operational length of 39.2km (2.8km elevated, 36.4km underground), serving 26 stations (one elevated and 25 underground), and includes nine interchange stations.

The TSTCBTC® 2.0, is a signalling system developed by TST. With a dual CBTC (Communication Based Train Control) architecture, the system aims to achieve a high level of redundancy and availability, significantly simplify wayside equipment and reduce life cycle costs. TST was established in 2011 via a joint investment by Thales and Shanghai Electric Group.

Communication and radio

National Infrastructure Commission support for rail and data communications

UK: The National Infrastructure Commission (NIC) – chaired by former Network Rail chief executive John Armitt – provide advice to the UK government to shape and develop the national infrastructure. Research from the NIC has suggested using existing infrastructure alongside rail and road networks could lead to an £8bn (€8.9bn, $10.5bn) cost saving for companies deploying gigabit-capable data networks. The government is now considering strengthening telecoms companies' access to run cables along existing infrastructure, such as rail links. Minister for digital infrastructure Matt Warman said: "It makes both economic and common sense for firms rolling out gigabit broadband to make use of the infrastructure that already exists across the country". Civil works, such as installing new ducts and pole routes, currently make up as much as 80% of the costs of building new networks. The government aims to "significantly" reduce the time and cost it takes to roll out gigabit-capable broadband to every home and business in the UK, after pledging full fibre rollout to be completed by 2025. CityFibre, one of the firms building the infrastructure, has announced plans to hire 10 000 people for the project. See irse.info/hbk4a.

The NIC has also said decisions on future rail investment in the North and Midlands should consider factors that capture the wide range of benefits that rail transport into dense cities and towns can bring. They have published an interim report which sets out the methodology it proposes to use to undertake its review to inform the government's integrated rail plan for the North and Midlands. This plan will set out the sequencing and integration of HS2, Northern Powerhouse Rail, Midlands Rail Hub and other major rail schemes. The interim report sets out the Commission's plans to apply research findings on the particular value of improved rail services in its analysis of various packages of proposed schemes.

Six-year cab radio framework

Norway: Rolling stock owner Norske tog AS has awarded a six-year framework contract to Siemens Mobility Limited for the supply of 570 GSM-R train cab radios. The programme will resolve obsolescence issues and reduce the risk and performance impact caused by radio interference from 4G public mobile network operators.

The contract includes an option to upgrade the existing radios to operate the Future Railway Mobile Communication System (FRMCS), the first such upgrade contract to be awarded in the industry. The contract also includes a 12-month trial of Siemens Mobility's Trainborne Condition Monitoring (TBCM) smart application, which will provide the facility to remotely monitor the condition of its track assets. TBCM will wirelessly create a digital representation of the condition of the track assets, enabling better preventive and predictive maintenance.

Secure communication principles

UK: The National Cyber Security Centre (NCSS) supports the most critical organisations in the UK, the wider public sector, industry, as well as the general public with cyber security. When incidents do occur, they provide effective incident response to minimise harm to the country, help with recovery, and learn lessons for the future. The NCSS has issued guidance and a set of principles to help all organisations make sound security decisions when selecting products and services for secure communications. It is aimed at risk owners and security professionals who wish to assess communication technologies for their organisations, to help them achieve the right balance of functionality, security and privacy. The principles can be found at irse.info/q6nb7.

Improved connectivity using overhead line equipment

UK: The transport secretary Grant Shapps has announced a £200K (€222K ,$262K) government investment for research into developing an innovative prototype that will improve mobile connectivity for rail passengers.

With over a third of the 11 000 miles of Great Britain's railways electrified using overhead line equipment (OLE), it is proposed to attach communications antennas to them, improving connectivity for rail as well as reducing the need to build additional track-side masts.The report has found there is significant potential to utilise existing structures to mount equipment, such as is already being used in countries such as Austria to improve railway mobile connectivity.

Telecom operators are now being urged to come forward and develop suitable equipment for the next phase of the trial which will test how antennas can be safely fixed onto OLE in a live railway environment with findings expected to be published by March 2021.

Private 5G mobile solutions

Nokia has launched two private wireless solutions for 5G. Digital Automation Cloud and the Modular Private Wireless solution. Nokia describes the Digital Automation Cloud as a "pre-integrated, plug and play, as-a-service solution" that will be commercially available late this year. With this solution, some applications run at the edge and some in a cloud. The Modular Private Wireless networks are fully customisable end-to-end solutions with trials this autumn, with full commercialisation expected by next spring. Both solutions use Nokia's AirScale radio portfolio, which now includes mmWave for private wireless, and build on their existing private wireless solution, known as 4.9G, which uses cloud-Radio Access Network (RAN) and large antenna arrays to boost LTE speeds to 1 gigabit per second or more, and can reduce latency to less than 2ms.

Private LTE networks have already been deployed for several companies, including Deutsche Bahn, Lufthansa Technik, Sandvik, and Toyota. Deutsche Bahn is using its network to validate future applications for use on trains, Lufthansa Technik uses its network to enable cameras and sensors for remote inspection of airplanes that are being repaired, Sandvik is deploying 5G at a test mine in order to trial robotics, remote and autonomous operations, full-fleet automation, analytics and enhanced safety technology, and Toyota is using a private network to help develop the next generation of manufacturing application machine tools. Deutsche Bahn is using the Modular Private Wireless solution, while the rest are using Digital Automation Cloud.

5G industrial-grade private wireless networking

Finland: Nokia has announced new 5G industrial-grade private wireless networking solutions, for industrial and manufacturing use cases; such as mission-critical reliable low latency and high data rate applications.

This follows 3GPP's recent completion of Release 16 Phase 2 and is of particular interest for mission critical communications users. The announcement includes support for Band 87 (410-430MHz) which will allow full, timely migration/replacement of existing TETRA and #DMR networks by providing comparable coverage; improved uplink to allow real-time, latency-constrained applications and guaranteed network slicing with robust service level agreements and key performance indicators.

5G private networks will enable future industry-related features, such as Ultra-Reliable Low-Latency Communication (URLLC), Time-Sensitive Networking (TSN), and other industrial capabilities that will feature in future 5G 3GPP specification releases (R16-18). Nokia believes the solution will address the needs of markets such as Germany, Japan and the UK which, due to local 5G spectrum availability, are fundamental to early adoption of private 5G technology and benefits.

Ofcom spectrum access for Wi-Fi and rail in the UK

UK: Ofcom (the UK spectrum regulator) has decided to permit licence-exempt Radio Local Area Network (RLAN) use, including Wi-Fi, in the lower 6GHz band (5925- 6425MHz). Indoor use up to 250mW and outdoor use up to 25mW will also be permitted, and will remove DFS (Dynamic Frequency Selection) from the 5.8GHz band (5725-5850MHz). DFS is a system that makes Wi-Fi routers change frequency when a radar using the same frequency is nearby and has been widely criticised as unnecessary. Most of the 5GHz band in the UK has been constrained by the DFS requirement.

The full decision can be found at irse.info/y903p.

The bands will be made available on a licence-exempt (non-protected and non-interference) basis with measures to protect other users. The UK becomes only the second country in the world to release 6GHz band to Wi-Fi, following the USA FCC's decision in April. The 500MHz of new Wi-Fi spectrum for the UK is less than the US 1.2GHz-wide spectrum release, but is still a welcome large increase in the total Wi-Fi spectrum in the UK. Ofcom has gone further than the US with also releasing the band for VLP (Very Low Power) outdoor use. VLP outdoor operation means the 6GHz band in the UK now can be used, for example, to create shorter-range 'personal wireless network' portable, interconnected wearables.

Ofcom have also published their advice to government on improving rail passenger access to data services, see irse.info/fphq6. They believe the 39-40GHz and 66-71GHz bands may be best for providing rail connections and to deliver a more reliable data connection to passengers. The report looks at the current and future demand for data services from passengers on the UK's main line railways; the spectrum bands that have the potential to meet these data requirements and that could, in principle, be used for track-to-train connectivity; and how, in principle, Ofcom might authorise the use of spectrum for rail connectivity. However, Ofcom also say they have not yet considered whether spectrum should be made available for these purposes.

Cyber security

Cyber-crime losses increase by 50%

USA and Europe: According to the Hiscox Cyber Readiness Report, cyber losses per firm have risen nearly six-fold, from an average of $10 000 (£8000, €8500) a firm to $57 000 (£45 000, €48 000). The report, published annually, says one in six of companies attacked had surrendered by paying a ransom following a ransomware-attack, with the highest loss for a single firm targeted with ransomware $50m (£40m, €42m). It also revealed that total cyber losses increased 50% to nearly $1.8bn (£1.4bn, €1.5bn) last year.

The biggest reported cyber loss among firms in the eight countries surveyed (US, UK, Belgium, France, Germany, Spain, the Netherlands and Ireland) was suffered by a UK financial services firm, at $87.9m (£71m, €75m). The highest loss from any one cyber event was $15.8m (£13m, €13.4m), involving a UK professional services firm, after a series of cyber-attacks on British firms.

The one very positive thing in this year's report was clear evidence of a step-change in cyber preparedness, with enhanced levels of activity and spending, although the report also says firms are many times more likely to have a cyber incident than either a fire or a theft, which are normally covered by insurance; unlike cyber losses.

While cyber-attack losses rose in 2019, the report also showed that firms are increasing their defences, with spending on cyber security rising 39 per cent. For example, the study found average spending in the UK rose from just under $900k (£724k, €764k) last year to $1.5m (£1.2m, €1.3m). Hiscox also said there were new cyber threats emerging from the coronavirus crisis, with an increase in so-called phishing scams due to less-secure home-working.

Safety, standards, health and wellbeing

Rail remains one of safest forms of transport

UK: The Rail Safety and Standards Board (RSSB) Annual Health and Safety Report 2019/20 says that rail remains one of safest forms of transport, with Britain's railway the safest of the top 10 biggest railway systems in Europe with 1.4 fatalities per billion-train-kilometres. France has 7.2, Germany 11.4, the European average is 24.2 and Spain the highest at 89.2 fatalities per billion-train-kilometres. Before a Scotrail passenger train derailed in August, near Stonehaven station in Scotland, there had not been a train accident in Britain involving a fatality to passengers or the workforce on-board a train for over 13 years. However, there are still areas of risk that need focus from industry to effect further improvements.

RSSB's Precursor Indicator Model (PIM) tracks the underlying risk from train accidents. It shows real long-term reduction, but that it has risen over the last two years. Investigations into high-risk events continue to highlight issues that might have led to worse consequences. Track worker safety is also a concern. Prior to the Stoats Nest Junction fatality of November 2018, there had been no fatal accidents for a number of years. Yet Stoats Nest was followed by Margam and Roade within 24 months. The near miss trend also suggests that underlying risk has remained relatively static.

The Covid-19 pandemic has brought about profound change, with reduced services and trains carrying far fewer passengers, but RSSB say what hasn't changed is their commitment to keeping everyone who uses the railway and everyone who works on it healthy and safe. The full report and a video can be found at irse.info/dvbyl.

Big data and Artifical Intelligence

Level crossing inspection trial

USA: Railway Internet-of-Things developer Wi-Tronix has been awarded a grant to test the use of an Artificial Intelligence (AI)-aided machine called Violet Edge IoT platform, for the automated inspection of level crossing equipment.

The trial will evaluate the ability of train-mounted forward-facing cameras to detect and analyse level crossing equipment such as lights and barrier/gates. The funding was awarded following a submission to the USA Department of Transportation's Small Business Innovation Research programme.

Companies and products

Signalling power cable approval

UK: Tratos UK Ltd has been awarded a Network Rail certificate of acceptance (PA05/07165) for its enhanced unarmoured signalling power cable supplied to NR/L2/SIGELP/27408 Product Specification for Signalling Power Distribution Cables. The cable range comprises aluminium and copper conductors with PVC or LSOH (Low Smoke free Of Halogen) sheathing and with glass fibre weave and water blocking tapes. The cables will at manufactured at the Tratos factory in Knowsley, Liverpool.

New LTE and wireless routers

Sweden: Westermo Network Technologies has added two new products to their Ibex range of wireless solutions for data communications within rail applications. The Ibex-RT-330 and Ibex-RT-630 are compact LTE and wireless routers developed for wireless connections onboard trains, and to support applications such as data offloading between stations, monitoring and remote maintenance. The product range is for applications such as wireless communication for train to ground systems, wireless inter-carriage links, for onboard Wi-Fi, remote access and vehicle positioning.

News from the IRSE

Blane Judd, Chief Executive

We still find ourselves in unprecedented times. As the Covid pandemic continues to alter the way in which we all lead our lives, IRSE members across the world are finding new, innovative ways to overcome the challenges presented by the virus. I have been extremely impressed by the resilience and professionalism being demonstrated every day by those involved with our Institution.

Here in the UK, the IRSE headquarters office at Birdcage Walk in London remains closed. The building is managed by the IMechE and we, together with several other professional engineering institutions rent space within it. Until adequate social distancing measures have been implemented at Birdcage Walk, the head office team will continue to work from home – and once again I have to thank everyone for their dedication and hard work under such difficult circumstances.

Membership subscriptions

We have been unable to access our postal mail since the start of lockdown. Please accept my personal apologies for the fact that as a result, membership payment cheques have not been cashed, nor have we been able to acknowledge their receipt. We are looking at ways to safely enter the building to retrieve mail but in the meantime I can assure you that we will be taking no action regarding late payments until we have completed all of the postal sorting.

IRSE Professional Examination 2020

Thanks to the efforts of the Education & Professional Development committee, Exam committee, head office staff and volunteers the 2020 IRSE Exam is still taking place on Saturday 3 October. After exploring every possible scenario to hold the exam at regional centres, the committee has agreed that a remote online software solution was the only way this year's exam could be delivered to all candidates regardless of their location.

I would like to thank all those candidates who have not only been preparing for the exam but also have made huge efforts to assist us in finding venues, facilitators and invigilators to run the exam. You have shown that there is a great future within our railway control and communications engineering industry, being interested in not only your own but others' professional development. I wish all candidates every success.

Railway Automation Seminar

The pandemic has led to a series of 'firsts' for the IRSE including leading the way in a major collaboration with the IET, IMechE and PWI to hold an international seminar on railway automation completely online. The paid-for event gives delegates online access to over 20 presentations delivered by industry experts and the opportunity to participate in two live Q & A sessions with some of the presenters. The first took place last month and the second is on 8 October. To book and for full details visit the dedicated event website (**www.automatedrailwayseminar.online**).

IRSE

Institution of Railway Signal Engineers

Presidential Programme

Dr Daniel Woodland, IRSE president for 2020/2021 has had to adapt to 'presidency in the time of Covid'. He has enthusiastically embraced delivering his programme 'virtually' and looking to honour his international section commitments online wherever possible. He has already 'visited' South Africa, where he presented his presidential speech and 'met' members afterwards in an online Go To meeting session.

Here are details of the presidential programme events for you to cut out and keep.

30 October webcast/Switzerland: **The crossover between rail and autonomous road vehicles**. Tom Jansen, global domain leader Connected & Automated Vehicles, Ricardo Nederland.

19 November webcast/York: **Cross acceptance of systems and equipment developed under different standards frameworks**. Professor Rod Muttram, independent consultant Forth Insight Ltd and IRSE ITC.

2 December webcast/University of Birmingham: **Testing modern electronic/software systems**. Nicholas Wrobel Railway Systems, managing director, Aerobel Defence Technology Ltd and Robin Hirsch managing partner, Kingdom Technology, director, CARIS Research Ltd & teaching fellow, University of Birmingham.

January 2021 webcast /Glasgow date to be confirmed: **Cyber security**. Alžbeta Helienek Co-Founder at C4SAM and principal consultant at Ricardo Rail.

4 February 2021 webcast /Dublin: **Traffic management systems and automation in control centres**. Ian Mitchell, IRSE ITC committee and Nora Balfe, human factors specialist at Iarnród Éireann Irish Rail.

Professional Development

Volunteering for the IRSE

Judith Ward

Similar to many professional engineering institutes, charities and social organisations, the IRSE is very appreciative and grateful for all its volunteers who carry out numerous support roles for the organisation. These include Council members, sections around the world, all the supporting committees, invigilators for the IRSE exam, professional registration reviewers and interviewers, IRSE News production, speakers and presenters, organisation of IRSE dinner, lunches, conventions and ASPECT. To all volunteers we extend a very big thank you.

There are also many benefits of volunteering. Aside from feel-good factor from giving time to help colleagues and a worthy cause, volunteering can help peoples career. It can be a great way to gain practical experience, and can help individuals to 'stand out from the crowd' and enable them to learn new skills, which can make them more desirable to prospective employers. Sometimes an employer may have candidates with similar qualifications and experience, but having a candidate who can demonstrate their contribution to an organisation like the IRSE can make them far more interesting to interview and potentially employ. Once at the interview, they will have the opportunity to impress recruiters with their experiences and passion for the industry. Employers are well aware of the benefits of volunteering and recognise the initiative and commitment that is required for volunteering.

Volunteering can help to widen your network of people in the industry. IRSE volunteers may be commercial competitors, or in a contracting/employer relationship, but while volunteering for the IRSE they are working as colleagues for the benefit of the institution and the industry. As well as helping to equip volunteers with the skills that many companies look for in staff, volunteering for IRSE sections and committees can expose you to a range of core workplace activities, including communication, line management, teamwork and using initiative.

The IRSE sections around the world exist by authority of the IRSE Council, and operate in accordance with a set of Articles of Association (or Byelaws) that have been approved by Council. There are sections in various parts of the world (Australasia, China, France, Hong Kong, India, Indonesia, Ireland, Japan, Malaysia, Netherlands, North America, Southern Africa, Thailand) and six of which are UK-based; London & South East, Midland & North Western, Plymouth; Scottish, Western and York & North East.

The North America Section includes the USA, Canada and Mexico. The Ireland Section includes both Northern Ireland and the Republic of Ireland. London and the South East is the most recently formed UK section, established in March 2018, and are therefore ideally placed to advise on the formation of any new section.

Two other non-geographical sections also exist – the Younger Members Section and the Minor Railways' Section, although their activities are predominantly within the UK. Some geographical sections also have Younger Members groups. Each section has an organising committee, with elected officers for key roles, such as chair, secretary and treasurer. They are always open to new committee members, no matter what time volunteers may have available, to organise presentations, technical visits or social events. Another unofficial volunteering opportunity is simply welcoming people, in particular new attendees, to meetings and presentations.

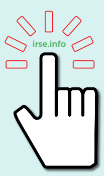
The Institution has a number of committees, accountable to Council, through which various activities are managed. They are Licensing; Membership; Recruitment, Marketing & Publicity; International Technical; Education & Professional Development; Younger Members'; Audit; Finance; Management; and Examination. In addition ad-hoc working groups are formed from time to time which focus on specific tasks.

The IRSE's Audit committee undertakes independent internal audits to complement the external audits, in order to ensure the Institution is running efficiently and effectively. The audits focus primarily on the role and remit of each of the principal committees of the Institution.

Volunteering for the IRSE can help to you get the experience you may need to develop your career, or if you are retired it provides the opportunity to share your experience and put something back to the industry you have benefited from. Volunteering can be a CPD activity if it fits in with your development plan – developing your knowledge and skills through activities like leading and managing, acquiring and sharing technical knowledge and working with new people – so don't forget to include this in your CPD records. The benefits don't end there, as you will meet new people, try new things and almost definitely have some fun at the same time!

If you're interested in volunteering for the IRSE, then contact your local section or get in touch with **blane.judd@irse.org** or **judith.ward@irse.org**.

Keeping it snappy with irse.info



Remember when you see an irse.info link in IRSE News, this is your easy way to visit a webpage. Instead of having to type a long, sometimes very long, address just put the irse.info address (e.g. **irse.info/irseexam**) into your web-browser, or click on the link if you're reading the magazine online, and you'll be at the right site in no time.

Midland & North Western Section

Human factors in signalling operations

Report by Ian Mitchell

IRSE ///
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

On 4 August the Midland and North Western Section held its second on-line event of the Covid-19 era, a webinar comprising the 2020 Annual General Meeting and a presentation by Mark Young who leads the UK Rail Accident Investigation Branch (RAIB) work on human factors. Before joining the RAIB in 2012, Mark worked in academia, researching and teaching in human factors, with a focus on transport safety. The presentation was based on a recent RAIB 'class investigation' report (irse.info/qzhck), that is a review of multiple incidents over several years, rather than an investigation of an individual accident.

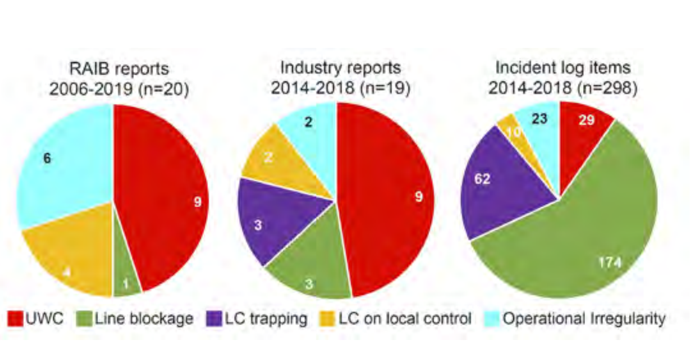
This study arose from an initial review looking at reports of incidents that did not meet the threshold to trigger an RAIB investigation, but were instead the subject of an industry investigation by Network Rail or a train operator, and where decisions of front line workers were pivotal to the outcome. Many of these incidents involved signallers, and fell into five categories:

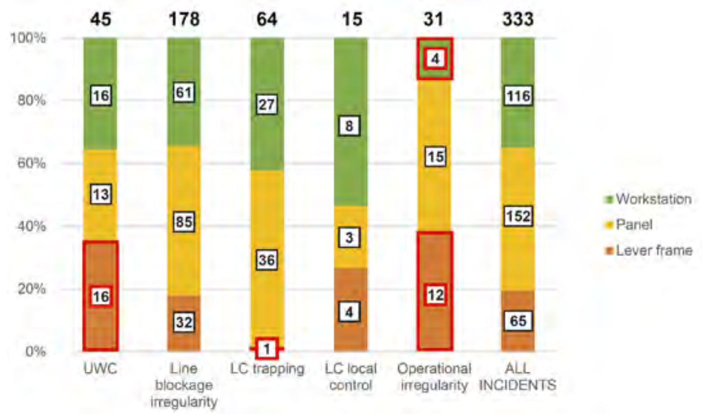
- User worked crossings.
- Line blockages.
- Users trapped in CCTV level crossings.
- Level crossings on local control.
- Operational irregularities (e.g. train movements without protection of the signalling system).

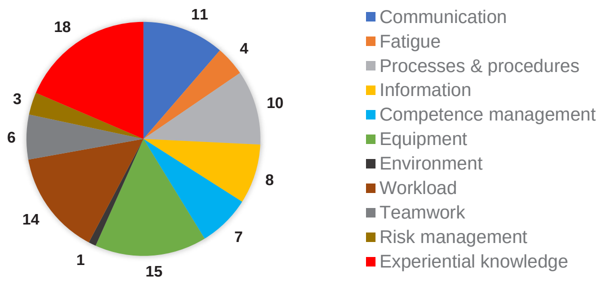
Mark described examples of each of the categories, all of which had resulted in 'near misses' that could have led to an accident, and then explained the methodology that had been adopted to gather information, analyse the data, and identify common causal factors. The data gathering was supplemented by visits to four control centres with different types of operator interface – at each location signallers were observed at work, and then participated in a group interview.

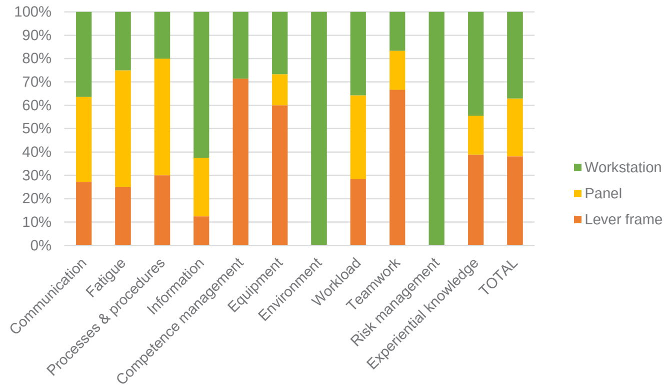
Signallers' work involves balancing safe operations, punctual service and providing access and protection for level crossing users and trackworkers. This implies they have to make implicit trade-offs between performance and safety within the constraints and resources available, and based on experience as much as rules, and information from a wide range of sources, not all of which are reliable, exhaustive and timely. This implies that the incidents considered were not solely the result of individual decisions or actions, but part of an overall pattern of events and performance, influenced by contextual factors and system constraints. To understand this better, RAIB reviewed how the 10 'incident factors' in the Great Britain (GB) main line Rail Industry Standard for Accident and Incident Investigation (RIS-3119-TOM) contributed to each type of incident, and added an additional factor 'experiential knowledge' that they identified to be particularly important in the signaller role.

RAIB analysed incidents and categorised them by the type of interface at which the signaller was working.

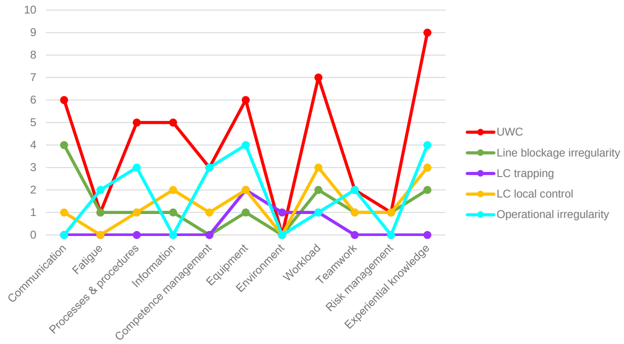








Generic rail industry Incident factors were assigned and mapped to the five types of incident and three types of signaller interface in the study



One technique used by RAIB in the investigation was the AcciMap approach (**irse.info/gfqrl**) which involves the construction of a multi-layered causal diagram in which the various causes of an incident are arranged according to their causal remoteness from the outcome. The most immediate causes are shown in the lower sections of the diagram, with more remote causes shown at progressively higher levels, so that the full range of factors that contributed to the event are modelled, with the highest levels typically representing company and organisational-level factors.

The conclusion of the study was to identify five areas where RAIB recommend that Network Rail should improve its processes to reduce the risk of these types of incidents in future. These were:

Signaller workload – existing methods of workload assessment do not reflect cognitive aspects of the workload, such as when monitoring an automatic route setting system (ARS).

User-centred design – signallers reported occasions in which changes to control centre systems resulted in problems that could have been avoided with better consultation at the design stage.

Competence management – improvements to support for the staff who are responsible for training and assessment of signallers, and more systematic use of training simulators.

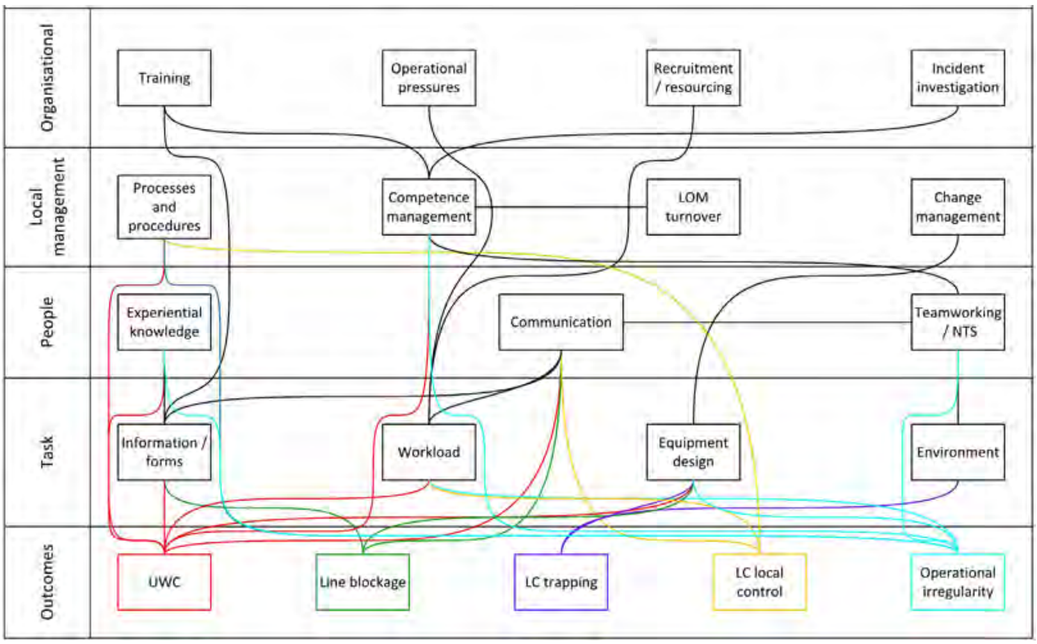
Experiential knowledge – research to better understand how this is used by experienced signallers so that it can be incorporated into training and development.

Organisation structure – the Local Operations Manager (LOM) role responsible for supervising and managing signallers is widely perceived as unattractive, with a high rate of staff turnover.

At the end of the talk there was a good flow of questions submitted via the GoToMeeting chat facility which were relayed to Mark by Ian Mitchell who was chairing the meeting. The topics included the relationship between the signaller and ARS, types of level crossing barrier controls and comparisons with overseas railways and other transport modes.

The online audience of 75 people was roughly double what we expect at a typical well-attended face to face meeting of the section and included people well outside our usual catchment area. A video recording of the talk is available on the IRSE web site at **irse.info/mnws**.

RAIB used the AcciMap approach to analyse common causal factors for the five types of incident.



Your letters

M&NW technical talk from the other side of the world

It was good to be able to sit in on the Midland and North Western Section technical talk "Human factors in signalling operations" by Mark Young on Tue, Aug 4, from the other side of the world (Sydney, Australia) via the IRSE internet connection – even if I had to get out of bed at 2am in winter for it.

I'm on my way this morning with a human factors specialist to meet signallers about proposed changes to controls for a level crossing.

Adam Greaves

Please don't keep us in the dark!!

Do we hold the correct email address for you? If you have just joined the digital community or recently changed your email address you will not be receiving important membership information or IRSE e-communications.

Don't miss out. Please email your new contact details to **membership@irse.org** to enable us to update our database.

Quick links

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Advertising

For advertising rates and deadlines call the IRSE London Office +44 (0)20 7808 1180, or e-mail hq@irse.org.
Advertisements are accepted on the basis that the advertiser and agency (if any) warrant that the contents are true and correct in all respects.

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon • Planting trees to catch carbon
9444263
Printed on Carbon Captured paper

IRSE ///
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

IRSE News

Institution of Railway Signal Engineers

November 2020

Innovation learning from automotive

System design in the digital age

Back to basics telecoms part 2

IRSE///

Institution of Railway Signal Engineers

Issue 271
November 2020

In this issue

Feature articles

News and opinion

From the IRSE

Is 5G delayed?

Work began on the 5G mobile radio standard in 2015 with Release 15 and now in 2020 the content of 3GPP Release 17 is agreed, which will include the requirements for Future Railway Mobile Communications System (FRMCS) . Following the news from 3GPP of the potential delay to the Release 17 date by three months, it is a good opportunity to explain some of the features of 5G and the potential benefits and challenges for rail.

1) New Radio (NR) has been developed to provide low latency high data rate services. In Release 17, further work on Ultra-Reliable Low-Latency Communication (URLLC) is expected to meet the critical machine-to-machine reliability and latency requirements for automation applications.
2) 3GPP has continued to work on advancing practically implementable Multi-User Multiple-Input Multiple-Output (MU-MIMO) techniques. MU-MIMO enables the transmitting and receiving of more than one signal simultaneously over the same radio channel where the wireless terminal has access to multiple antennas.
3) The NR Cellular-Vehicle-to-Everything (C-V2X) solution enables direct communications to allow vehicle-to-vehicle communication, vehicle-to-mobile and vehicle-to-infrastructure. Enhancements to the NR C-V2X for broadcast, groupcast, and unicast unlocks the potential for multiple train-to-train communication links.

When I studied for the IRSE exam I remember occasions of disheartenment; thinking of counterparts in fast-moving tech industries – busy developing the latest and greatest in telecoms – whilst I learnt systems of the 80s. Despite my disheartenment at the start of my studies, I grew to understand and enjoy attaining knowledge of legacy systems, while also learning about the latest 5G exciting performance improvements.

Despite the potential delay to the 5G Release 17 date, I cannot help wondering whether the rail industry can keep up with the telecoms industry. Generations of telecom equipment are delivered roughly just eight years apart, so can we continue to source experts for telecoms systems separated by up to 30 years of technology change?

Aaron Sawyer, chair, IRSE Younger Members Section

Cover story

This month's cover photo shows the Hither Green depot in London and the Hither Green Area Resignalling Project, serving Lewisham, Central London and into Kent. The work is part of Network Rail's programme to improve signalling and track reliability through the Lewisham area of South East London. It was the UK's first major commissioning to be delivered during the COVID-19 pandemic.

During a nine-day blockade, control of the route was transferred from the London Bridge Signal Box to Network Rail's Three Bridges Rail Operating Centre (TBROC).

12-car trains can now stop at platform three at Grove Park and new facilities have been created to enable trains to turn back in the event of delays or during engineering works. New computer based interlocking and trackside systems have replaced interfaced solid-state interlocking at Hither Green and remote relay interlocking at Bromley North. 58 signals and 254 axle counter heads have been provided.

Photo by kind permission of Network Rail.

Automating our railways – lessons learned from bold automotive innovators


Tom Jansen and Rick Driessen

This, the second paper in the 2020-2021 Presidential programme, was presented in Switzerland and online on 30 October.

The global demand for passenger transportation is growing (disregarding the current short-term effects of the Coronavirus pandemic). In large parts of western Europe demand is outgrowing supply, with almost 3000km of track declared as congested [1], and with only conventional technologies the sector is struggling to keep up. Currently available technical solutions such as ERTMS have some potential to optimise the utilisation of the railway system, creating some breathing space, but on its own it is doubtful whether ERTMS will provide sufficient capacity increase in the long term.

"The railway industry is facing potentially existential threats from innovative competing transportation modes"

Besides this challenge in capacity, the railway industry is facing potentially existential threats from innovative competing transportation modes. The Advanced Driver Assistance Systems (ADAS) for cars in the short term, and self-driving cars and even Urban Air Mobility in the long term, are welcome additions to the transportation ecosystem. Since innovation in the railways has been very slow in recent history, the question that comes to mind is: How can the railway industry still be competitive and attractive enough in the mobility landscape of the future?

Luckily, the railway industry has become aware of its challenges and has seemingly entered a period of rediscovery. Soon major choices will have to be made regarding the strategies required to tackle these challenges. One of the major areas of interest has recently been focused on the topic of automation. The great promises of automation, such as the automotive industry has envisaged, include benefits such as safer public roads, more leisure time and higher capacity for our infrastructure. Even if these promises could be achieved, when applied to the railway system they challenge us with complex questions. What benefits do we get by replacing the driver by computers and how do we demonstrate the safety and integrity of a self-driving train and its software? How safe do these innovations need to be before we adapt them and what will be the role of the legislator? How can we improve our business case making use of automation knowledge and products from other industries?

This paper will highlight and discuss the key challenges for further automation of the railway industry, in order to stay competitive and to optimise the market share for rail transportation, while comparing these challenges with recent innovations in the automotive industry. The main question is therefore: How can recent developments in the (autonomous) automotive industry benefit the railways to ensure safe, sustainable, comfortable, affordable, and timely means of transportation, to meet the predicted growth in passenger transport demand in 2030 - 2050?

Goals of automation

To be able to understand the benefits of automation, we will first look at the goals the automotive and the railway industry are striving for. There is a significant difference between what both are trying to achieve and why each industry has taken up automation as one of the leading drivers for innovation.

Automotive goals

The automotive industry has been innovating towards automated driving for decades, with the first automated vehicle concepts being showcased in the early 1920s and 1930s, then

Figure 1 – A futuristic advertisement of leisure time in a self-driving car, from America's Independent Power Companies, 1956.

more commonly known as the "phantom auto" [2]. While these cars were not driven by computers as is the concept in current times, the idea behind the telegraph-operated remote-controlled system was that the occupants of the vehicle would be able to use their voyage in a more leisurely way. At the time, cars were quite dangerous to operate, and traffic rules were less developed and less well enforced than they are now. Scholars and justices were even debating whether the automobile was, perhaps, inherently evil [3]. Automating the driver's tasks would make travelling by car safer, which would improve the public opinion of the automotive industry. It was then that the big dream of self-driving cars was born, promising to free up time for the occupants of the vehicle to spend any way they like, while travelling in the comfort and safety of their private vehicle.

"The driverless car will significantly increase overall road use and may thereby lead to additional congestion"

Nowadays, the European Commission foresees that autonomous cars will focus around three primary themes [4]. The first mentioned theme is safety. With the introduction of ADAS, the driver is already greatly assisted with automatic braking, lane keeping, collision protection, and emergency assistance. The evolution towards further automation aims to further improve safety by preventing even more potential accidents. Secondly, autonomous cars will be equipped with connectivity features. Vehicle-to-vehicle (V2V) communication will allow the vehicles to anticipate nearby vehicles, even when there is no visual information available. On the other hand, vehicle-to-infrastructure (V2I) communication will allow the vehicles to anticipate, for example, traffic signs and traffic congestion. Additionally, telematics and infotainment services will further improve the car's operation while increasing comfort by letting the passengers, for example, stream their favourite movies to the car's displays. Third is the functionality of autonomous driving itself. As the technology develops towards full automation, commonly referred to as SAE level 5 (the Society of Automotive Engineers (SAE) defines six levels of driving automation ranging from 0 (fully manual) to 5 (fully autonomous) [5]), the driver's tasks will diminish to no more than setting the destination. Thus, the now already historic promise to free up time with comfortable and safe autonomous transportation is still very much alive and seems closer than ever.

Another dominant idea that the public and lawmakers seem to share is that the introduction of self-driving cars will optimise the use of the available road capacity, which is a major goal for urban environments. When all road users maintain a uniform speed and when automation prevents incidents from happening, the number of traffic congestions should significantly reduce. However, the driverless car can also create new target audiences that will significantly increase the overall road use and may thereby lead to additional congestion. For example, the average acceptable commuting distance and time may increase since commuting is no longer seen as wasteful time. Driverless cars can also be beneficial for the elderly and for people with physical disabilities or for parking cars on the outskirts of the city. Driverless taxis are expected to become more affordable and may gain terrain over public transportation. Unfortunately, impact studies for the Netherlands [6, 7] show that these effects may well negatively impact urban environments, if policies do not actively address autonomous vehicles in the near future. It is therefore of great importance that we decide in what way these vehicles should be implemented to benefit society as a whole, and that we implement effective mechanisms and legislation that guide our urban transportation in the socially desirable direction.

Railway goals

In the railway industry however, completely different goals are driving the automation of trains. Since passengers on our railway network already have their hands free to do (almost) whatever they please, the automotive driving factor of freeing up time is not relevant. Considering safety and accident statistics, rail is also one of the safest modes of transportation (as we will show later in this paper). Even though there is always room for improvement, improving passenger safety should therefore not be a main driving factor either.

Instead, automation is mainly seen to optimise the capacity of our railway network. This could provide considerable savings for the railway industry, by saving the infrastructure managers from costly expansions to their infrastructure to cope with the expected growth. The promise of automation here is that a computer would be able to drive a train more predictably and accurately according to the planned path compared to a human driver. Indeed, in a recent pilot project this has been demonstrated to be plausible, although there are still some technical challenges that need to be overcome to truly obtain the benefits in this area [8]. Such challenges include the automated operation of existing train series, automation for legacy signalling systems (as ETCS is not yet widely deployed), the reliability of telecommunications and positioning, dealing with objects and level crossings, etc. Further on in this paper we will discuss such challenges of automation in more depth. However, as several current (IRSE) papers already focus on the challenges of railway automation, we will instead focus on what we can learn from the emerging automotive approach.

"People can be encouraged to change their mode of transportation"

Now that we understand the difference in goals the automotive and railway industry are striving for, we can better analyse how both industries can learn from each other's progress, and how we can use the available technology and solutions for the benefit of railways. In the next section we will elaborate on safety as a potential driver for automation, and why for the railway sector this should not be a main driving factor.

Safety in transportation

Before any changes to the railway system are made, a certain level of safety must be guaranteed. But how high does this level have to be? Is it an absolute number or is it arbitrary, based on the passengers' or other road users' perception?

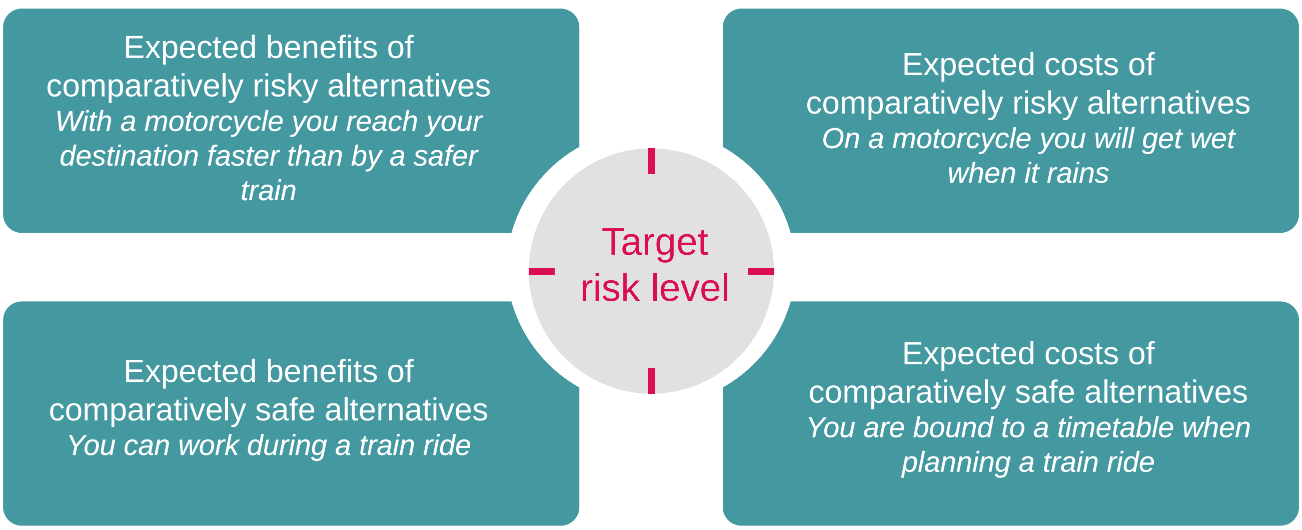
The risk homeostasis theory argues that people adjust their behaviour based on their perceived levels of risk [9]. People have an ideal, or target, level of risk and act on it by engaging in aggressive behaviour when feeling safer than their target level and engaging in risk avoidance behaviour when feeling less safe than their target level. There are four factors that influence the target risk level, these are shown in Figure 2.

An interesting practical example favouring the risk homeostasis theory, is the effect around Dagen H. In 1967, Sweden switched from driving on the left side of the road to the right side (on the so-called Dagen H). While many expected an increase of accidents during the time drivers needed to get familiarised with this radical change, the number of accidents actually went down [10]. The risk homeostasis theory would have expected this decrease, because drivers perceived a higher level of risk and subsequently adjusted their behaviour by driving less aggressively.

Thus, the person will decide on an action when the perceived risk level is lower than the target risk level, while the target risk level is influenced by the benefits and costs of alternatives. All in all, this theory states that people can be encouraged to change their mode of transportation by lowering their perceived risk level, by increasing the benefits of the alternative mode of transportation, and by increasing the costs of the current mode of transportation.

Since perceived risk affects the choice in mode of transportation, or at least theoretically, it would be interesting to understand the relationship between different modes of transport. A Norwegian study investigated the differences in risk perception in transport among Norwegians in 2004 and 2008 [11]. Its objective was to examine differences in perceived transport risk, worry, priorities, and demand for transport risk mitigation. Perceived transport risk was expressed in the combination of the probabilities and severity of consequences regarding transport accidents and it was measured among ten modes of transportation. As shown in Table 1, the airplane has the lowest perceived probability of an accident, but its consequences are perceived the worst. The train is perceived second lowest on account of probability, but its perceived consequences are significantly lower than that of the airplane. The private car has both a significantly higher perceived probability as well as more severe consequences than that of the train.

Figure 2 – The four factors influencing the target risk level.



Mode of transport	Perceived probability of accidents		Perceived consequences of accidents	
	Mean	Standard deviation	Mean	Standard deviation
Plane	1.64	1.14	6.04	1.83
Train	1.88	1.20	5.03	1.73
Ferry	2.08	1.22	4.66	1.74
Coaster	2.44	1.41	4.90	1.79
Bus	2.75	1.40	4.71	1.52
Walking	3.81	1.70	5.04	1.74
Bicycle	4.38	1.53	5.02	1.68
Private Car	4.53	1.61	5.44	1.47
Motorcycle	5.38	1.45	5.81	1.87
Moped/scooter	5.18	1.47	5.58	1.88

Ratings given on a 7-point scale from (1) very unlikely/certainly non-fatal to (7) very likely/certainly fatal.

Table 1 – Differences in perceived probabilities and consequences of accidents by different means of transport in 2008 [11].

Thus, on the notion of safety, the train is perceived to be superior to the plane or car. However, the choice of a certain mode of transportation also depends on other characteristics. The researchers examined the public's priorities when choosing a mode of transport. They found out that availability, passability (i.e. the ease of use), and travel time are more important than safety. However, economy and comfort are less important. The study also shows that gender, age, education, and having a driving license have significant individual impacts on the relevant variables.

"The choice of a certain mode of transportation also depends on other characteristics"

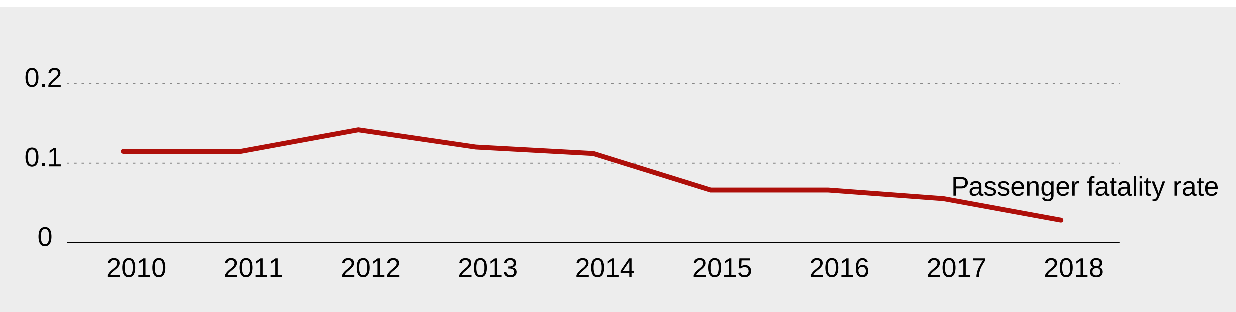
After these conclusions, we can focus on the actual risk of travelling, since it is conceivable that the actual risk is an influencing factor on the perceived level of risk. The most suitable indicator of safety in this research is the number of fatalities per travelled distance per passenger. The notion of a fatality is more clearly defined and its occurrence often better registered than an injury. The distance a passenger travelled makes it possible to objectively compare different modes of transport. Still, statistics around this topic are not always exhaustive and measuring methods and the interpretation of definitions differ per research. This also applies to fatalities outside of the accident vehicles (e.g. suicides or collisions with pedestrians). To refine the scope of this study, the choice has been made to leave out any fatalities outside the vehicle and focus on passenger fatalities.

When comparing several common modes of transport, airplanes are generally considered to be relatively safe. In 2018, airlines worldwide carried around 4.3 billion passengers, logging 8.3 trillion revenue passenger-kilometres [12]. In the same year, a total of 11 scheduled commercial air transport accidents resulted in 514 fatalities, thus a ratio of 0.0062 deaths per 100 million-passenger-kilometres [13]. To place this in perspective; on average, one fatality occurs every flown distance equivalent of 402,941 laps around the Earth. Additionally, for decades the number of fatal accidents has been decreasing while the number of kilometres flown has kept increasing. A total of 54 accidents occurred in 1989, 43 in 1999, and 23 in 2009. In 2019 there were 14 passenger flights involved in a fatal accident, resulting in 268 fatalities [14].

Rail traffic is also considered relatively safe. In contrast with aviation, where international bodies like the International Civil Aviation Organisation (ICAO) are able to keep track of each fatality on a global scale, in rail it is more difficult to register each fatality, especially those on regional lines in less developed countries. Organisations like the International Union of Railways (UIC) are dependent on data received from its members. That being said, the UIC's members reported 45 fatalities amongst rail passengers in 2018 [15] and a total of 2.8 trillion passenger kilometres [16]. This gives a ratio of 0.0016 fatalities per 100 million-passenger-kilometres globally.

In contrast, the European Union (in combination with Norway and Switzerland) reported a rate of 0.004 passenger fatalities per 100 million-passenger-kilometres in 2018. In other words, one fatality occurs each 25 billion passenger kilometres. For several years, this number seems to steadily decline, as shown in Figure 3 [17].

Figure 3 – Train passenger fatalities per 100-million-passenger-kilometres in the EU over 2010-2018 [17].



The passenger fatality ratio reported by the EU is significantly higher than the ratio reported by the UIC based on its global members. This is remarkable because the EU also reports that its rail passengers enjoy a relatively lower risk than in South Korea, Australia, USA, and Canada. A possible explanation is that a different method is used to calculate the total number of passenger kilometres or a different interpretation of the term passenger fatality is used.

The number of road traffic deaths is estimated to be significantly higher. However, accurate and comprehensive numbers are lacking. It is estimated that a total of 1.35 million people lost their lives in 2016 while driving a vehicle, motorcycle, bicycle, or while walking [18]. The United States reported a fatality rate of 0.29 deaths per 100 million-passenger-kilometres among light duty vehicles (passenger cars, light trucks, vans, and sports utility vehicles, SUVs) in 2018 [19].

"Driverless vehicles might well introduce a whole new category of accidents that would have been easily prevented by human drivers"

The share of autonomous cars (SAE level 3 and up) on public roads is relatively small and often involves experiments. At the time of writing this paper, there have been five fatal accidents with a car driving in SAE level 2 and none in level 3 or up [20]. With so little available data, we cannot estimate the number of fatalities per travelled distance per passenger in autonomous cars. However, a study estimated a vehicle crash rate of 2 crashes per million kilometres driven by the Google Self-Driving Car project (the study only included crashes that involved personal injury and significant property damage). This number was compared with the United States' crash rate estimated that control for unreported crashes, with a value of 2.6 crashes per million kilometres [21]. This would give the premature indication that autonomous cars are only somewhat safer than human driven cars.

The absence of uniform data makes it complex to compare the safety of different modes of transport on a global scale. The EU created an overview [22], as shown in Table 2, however as it is dated, the table is supplemented with data discussed in this paper, which shows significant progress in safety.

At this point it is fair to say that rail transport is extremely safe when compared to other modes of transportation, based on the fatalities per passenger kilometre. Yet, innovation in the automotive industry seems to move faster than in the aviation and rail industry. Is it possible that innovation in rail transport is slowed down by the high level of safety that we, the rail-engineers, uphold? And do we encounter the same challenges?

Challenges in safe automation

As transportation is moving towards higher degrees of automation, developments in the past few years have shown that there are still many challenges that need to be overcome before the mass deployment of autonomous vehicles becomes a reality.

One of the main challenges in vehicle automation, besides the business case and lagging legislation, remains demonstrating vehicle safety. While the functionality of these vehicles has been claimed to have been solved by many stock-listed tech-enterprises, the sad reality remains that their safety has not. More recent forecasts by automotive manufacturers highlight that the challenges of autonomous vehicles have proven to be significantly more difficult to solve than expected, both for big tech and for automotive manufacturers [23]. Thus, exhausted by the race to put the first fully automated SAE level 5 consumer vehicle on the road, we now see a move towards partnering [24]. The task at hand appears to be too large for even the biggest, smartest, and wealthiest organisations out there to tackle alone.

Proving the safety of these vehicles is indeed challenging, especially because driving a vehicle is such a dynamic task. While it is claimed that autonomous vehicles can prevent up to 90 percent of all crashes which are caused by human error [25], what is often left out is that these vehicles might well introduce a whole new category of accidents that would have been very easily prevented by human drivers (as illustrated in Figure 4). Such accidents are already seen today, often caused by issues in properly detecting or interpreting the environment, illustrated by lethal crashes failing to detect a truck semitrailer [26] and failing to interpret faded highway lines [27]. Thus, autonomous vehicles may not improve safety as much as we would like or may perhaps even deteriorate the current status quo.

The main challenge that we now see in the autonomous vehicle sector, is that there are nearly endless scenarios and conditions that the car would need to handle, which have become quite natural to human drivers. There are vast

Table 2: Deaths per 100-million-person-kilometres [22, p. 12] supplemented with additional data.

Mode of transport	EU (ETSC, 2003)	Calculated data (2018)
Road (total)	0.95	
Motorcycle/moped	13.8	
Foot	6.4	
Cycle	5.4	
Car	0.7	0.29 (US)
Bus and coach	0.07	
Ferry	0.25	
Air (civil aviation)	0.035	0.0062 (global)
Rail	0.035	0.0016 (global) / 0.0040 (EU)

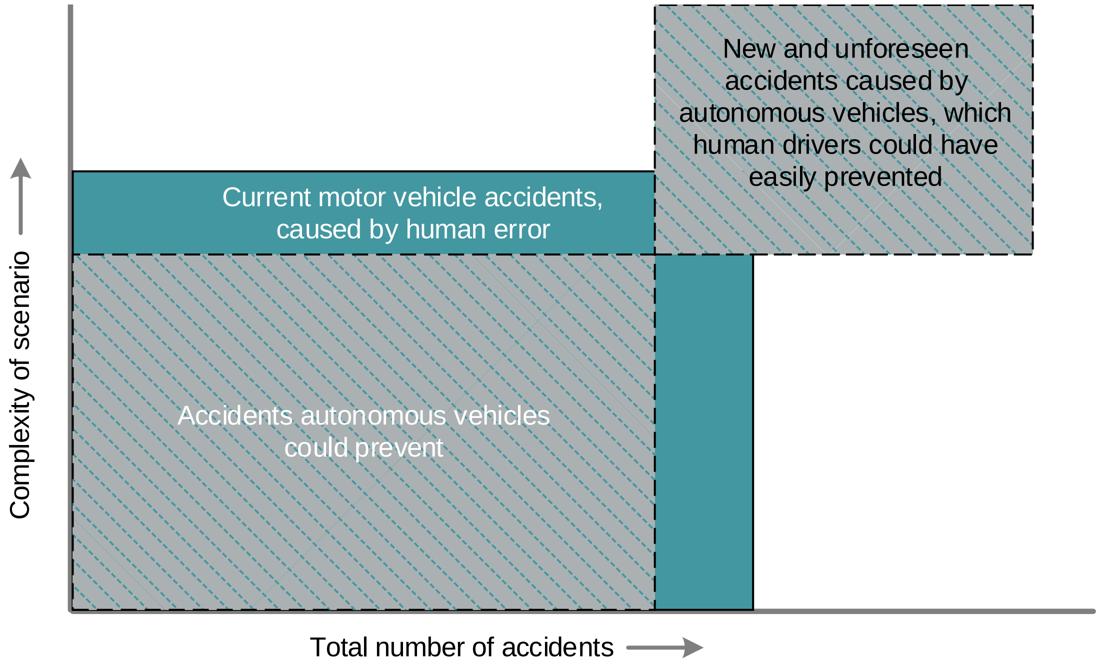


Figure 4 – Autonomous vehicles could introduce a whole new category of accidents.

databases of scenarios being built by big tech and automotive companies, collecting data on all encountered scenarios in shadow mode. One example is Tesla, collecting all real-world data from their ever-growing clientele of paying test drivers [28]. The idea behind this approach is to ultimately collect every single possible scenario coupled with the appropriate driver response into one big database. Thereby solving the automated driving challenge by replicating this desired response.

However, will these cars really have seen every corner of the world? Encountered every single possible variable in every possible combination? Every single weather condition on every single intersection of every single street in the world, at every possible time of day? Best guesses on the distance that test-vehicles have to drive in the real world, to meaningfully demonstrate the failure rate of autonomous vehicles, are in the range of 14 billion kilometres [29]. This is something which even a fleet of 100 test vehicles, driving 24 hours a day, would take over 400 years to achieve. We might at some point think we have captured all scenarios, having all the unknowns at least made familiar, but, this task is simply too large to fathom. There are too many unknown unknowns (Figure 5).

"We simply cannot predict every single event that might ever occur"

Thus, the problem in the current approach to demonstrating safety is exposed. We simply cannot predict every single event that might ever occur, not even if the brightest and biggest corporations have a go at it. Nor do we currently have a suitable approach to test and validate our designs for all these events (although most of the industry agrees that the solution is in simulated environments). Further challenges apply as well, such as for validating the rapidly changing software versions and in artificial intelligence that may be present in the vehicle control systems.

What if we could change the approach to demonstrate safety, to better align with the inherent uncertainty of current emerging technologies? What if we would be able to monitor all relevant data from all operational autonomous vehicles (perhaps even obligate the publication of this data by law), and would leverage techniques such as big data analysis and artificial intelligence to recognise and predict dangerous situations? If we can define what a safe and healthy vehicle is, in terms of data points, we could then identify the outliers in our data set (perhaps even before they pose any real threats), take immediate corrective actions and investigate why the fault has occurred. This would enable us to achieve a closed loop feedback on design, testing and implementation, which in turn can be used to ensure the safety of our vehicle fleet while potentially reducing the burden of our current up-front safety approach. Additionally, this would enable us to better cope with the ever-increasing rate of change in hardware and software designs in a much more efficient and nimble way. Of course, challenges such as around data privacy and commercial concerns apply [30] and we would still need to reduce risks up front as

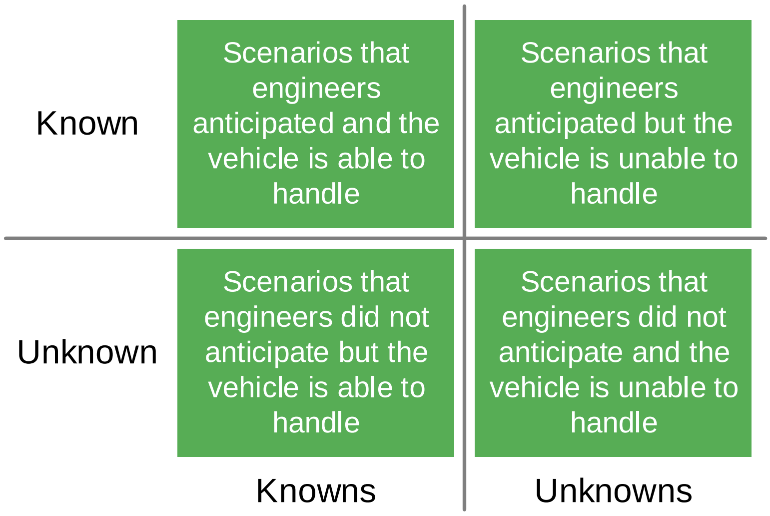


Figure 5 – A major challenge of automation are the 'unknown unknowns' (Rumsfeld Matrix).

much as reasonably practicable, but after a very controlled and gradual introduction, continuous monitoring could become an essential part of our safety regime. This enables us to embrace new technologies, automated driving in particular, with much more confidence, without trying to identify all our unknown unknowns beforehand.

Solutions in automation

Looking at the previous identified goals for railway automation, there have been recent advances in automotive innovation that are available on the market today, that can help us achieve the rail industry's ambition. In this section we will provide a brief overview of selected key enablers.

"There have been recent advances in automotive innovation … that can help us achieve the rail industry's ambition"

Technology for obstacle detection

Obvious examples of relevant technology in the automotive domain are increasingly cost-effective sensors such as GPS/Galileo, radar, lidar and (3D)-cameras, that could help us automate our trains in certain conditions. Example applications for these sensor sets are fully driverless operation (for infrastructure that is not completely closed off), shunting operations and city trams. So far, we have seen advancement in ADAS implementations for light rail [31] and pilots that utilise computer vision obstacle detection systems [32]. However, enabling heavy rail driverless operation with level crossings remains a major challenge, with research on this topic being scarce. To improve the usability of this technology, further work is needed on demonstrating the suitable sensor set for heavy rail operations, either on-board, in the infrastructure, or a combination, and in demonstrating the reliability of the sensors in all (weather) conditions.

Processes that facilitate experimentation

One interesting application of automation in the automotive domain, can be found in autonomous shuttle buses. One such example is the Rivium ParkShuttle (as shown in Figure 6), which has been operational since 1999 (but is currently being upgraded) and has been transporting approximately 2,500 passengers per day from a nearby metro station to a business park which would otherwise have been cut off from public transport. The technology can help us make public transport more attractive to a wider audience, by improving the first and last mile experience, which has traditionally been hard to provide quality service in, especially in rural areas. While the technology is currently still stretched when operating in full mixed traffic conditions, governments around the world have found ways to pilot this technology within their cities in 'living labs'.

Essential for these pilot implementations is the collaboration between the authorities and the sector, in which the Netherlands has paved the way with specifically tailored 'Experimenteerwet' legislation and its predecessors. This legislation opens a clear path for applicants to apply for individual implementations of autonomous technology on public roads in a dialogue between applicant and authority, while more generic legislation is still under development. This enables all involved parties to learn on a small scale and 'fail fast', then implement these lessons in developments for the long term. Something that seems to be less common in the railway sector, where legislation needs to be fully developed beforehand.

Vehicle-to-vehicle communication enabling capacity increase

Ultimately, the goal of achieving optimum capacity will lead us towards what we call virtual coupling in rail, or platooning on roads (as visualised in Figure 7). While virtual coupling is still quite a novel concept for rail, with many associated discussions, it has been assessed to offer significant benefits over moving block signalling [33], potentially

Figure 6 – Rivium ParkShuttle 2.0 in commercial operation. *Photo 2getthere.*

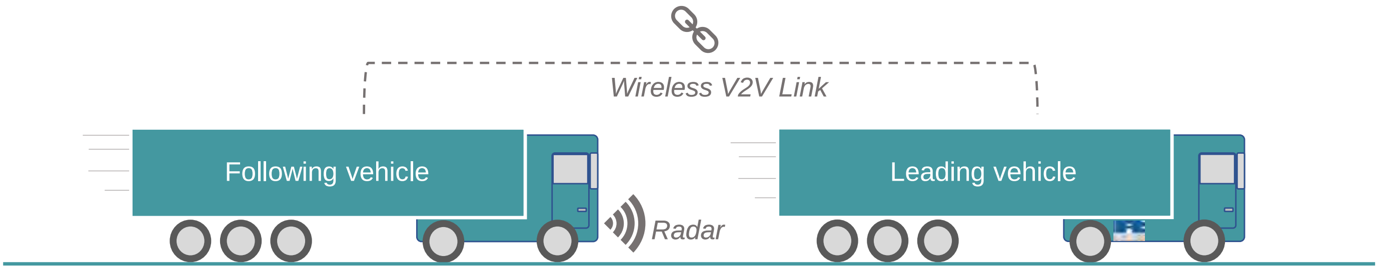


Figure 7 – High level overview of the EcoTwin truck platoon.

further reducing headways for high-speed segments from 74 seconds to 11 seconds. However, actual tests in operational conditions still remain scarce. Meanwhile, platooning has already been demonstrated successfully for both passenger cars and heavy-duty trucks multiple times on public roads [34, 35]. In fact, these pilots have been so successful, and their business case so appealing for logistics operators, that there are ongoing developments in this regard, aiming to solve challenges such as interoperability, safety and standardisation, enabling further commercial implementation of the technology [36].

Of course, many would argue that the difference in braking performance between platooning on roads and virtual coupling trains is significant. Perhaps somewhat unexpectedly though, this is not of immediate interest for the inter-vehicle distance we can run at, as long as the vehicle with the best braking performance is in the rear. What the platooning system effectively does, is directly communicate any acceleration/braking information from the leading vehicle to the trailing vehicle, enabling it to react to any changes almost instantly and initiate similar acceleration or braking promptly. In this case, that would mean that the distance between both vehicles needs to be sufficiently large to allow for the delay in braking to be absorbed in the gap, taking into account possible differences in braking performance between the vehicles and foreseen variations due to external conditions. With inter-truck distances as low as 0.3 seconds at highway speeds, during the EcoTwin III demonstrator it was illustrated that the communication could be made reliable and fast enough to platoon with sufficient safety mitigations built in for real-world operation on public roads.

“Innovation and safety do not always easily go hand in hand”

Having such ultra-reliable and low-latency communication is essential when driving vehicles at relative braking distances, as would be the case when virtual coupling trains. While progress is being made on ultra-reliable and low-latency 5G technology, current 4G network architectures dictate latencies around 20-50 ms in best case scenarios [37]. Alternatively, the 802.11p based wireless communication used for truck platooning, also known as ‘Wi-Fi-P’, already can achieve the required low latencies through a direct vehicle-to-vehicle link (2-3 ms has been achieved in test track trials [38]). Practical range and performance of Wi-Fi-P applications vary depending on conditions, but real-world studies in railway environments have already shown the viability of a stable link up to 2000 metres, with little negative effects reported for speeds of over 200km/h [39, 40].

Technology, then, no longer seems to be the limiting factor for virtual coupling. However, difficult decisions need to be made. Especially in signalling, the status quo is hard to debate. One of the most prominent discussions around Virtual Coupling for example, is what to do with our switches? And what about the risk of derailment? Moving forward from this status quo requires bravery. What if we could engineer a switch that has a uniquely high reliability? Again, technology does not have to be the limiting factor, since such a concept has already been demonstrated by Loughborough University with their Repoint switch [41], but it appears there is hardly any uptake from railway infrastructure managers. But what if we would realise the true benefits of such a reliable switch? What if it would enable us to think differently within our signalling principles, and throw a switch right before an approaching train?

Coming back to the concept of virtual coupling, a simple thought experiment comes to mind. Say we have two trains operating on the same line with 100 passengers each, while the leading train is heading to a faulty stretch of infrastructure. The trailing train will keep the minimum distance needed to be able to stop, at any time, without colliding with the leading train. By keeping this braking distance, up to 100 passengers are exposed to the risks of derailment or collisions. On the other hand, it is common practice to physically couple trains. By doing so, we then have 200 passengers at risk, which is completely acceptable in today’s operations. Yet, the concept of virtual coupling, letting go of that sacred absolute braking distance and letting the computer dynamically determine the safe minimum distance between the trains, may have the same effect on risk as a physical coupling, but is much harder to discuss. Why is that? Because of our belief that innovation should always lead to a safer system?

Ultimately, innovations such as these can bring us the much-needed capacity and efficiency, which would otherwise lead us to costly expansions of our railway infrastructure. If only we would dare to embrace them.

"Would the railways maybe not be just a little bit too safe?"

Discussion and conclusions

As we have demonstrated in this paper, safety is an important factor in the push for automation. However, innovation and safety do not always easily go hand in hand. The question that we might ask ourselves is: how safe does any innovation in the railways really need to be before we adopt it?

When asking anyone involved in the railway at point blank, many would answer something similar to – "absolutely safe of course" or – "we are striving for zero casualties!". These are of course very socially desirable answers. But what if we had to trade off this safety in the railways, versus safety on our roads?

We have shown in this paper, which should not be news to most readers, that the railways are, in terms of fatalities per passenger kilometre, still a much safer means of transportation than cars and even airplanes. Travelling by train is also perceived by the public as very safe. Though, interestingly, the perceived safety of travelling by car is not nearly the same factor lower as the difference in accident rates would lead us to believe. Apparently travel by car is generally still perceived as safe enough by the public.

This leads us to pose a difficult question for anyone in the railway industry – would the railways maybe not be just a little bit too safe? The very high safety standards we have imposed on ourselves stifle innovation and raise costs. Thus, for every passenger that boards a train, more passengers are pushed away onto other, less safe modes of transport. The total risk across all modes of transport is thereby increased. This scenario was illustrated, unfortunately effectively, in the aftermath of the October 2000 Hatfield derailment. Here the severe imposed reductions in operation led to an estimated 5 additional casualties due to the induced modal shift towards road travel [42].

"Society would be better off, with fewer casualties overall, if more people find their way to public transport"

This, essentially, is what we might see happening in the future if we, people of the railways, do not strategically plot our route ahead. Working in both the automotive and the railway sector, the authors of this paper see dangerous precedents being set. While the automotive sector is innovating with near unlimited budgets and with relatively less emphasis on safety, the railway sector has long been struggling to innovate, perhaps paralysed by our praised safety culture. This calls for an integrated level of risk management for our transportation systems; a notion that has been addressed before [42] though seemingly has never found its way into the management of our railways and roads. Meanwhile, impact studies for autonomous vehicles show us that indeed a significant number of respondents would trade in public transport for future self-driving car alternatives [6, 7].

With a new era of technological innovations closing in on us, we must therefore ask ourselves: what exactly will happen if we fail to innovate? Will society be better off, because we have allowed ourselves to become hostages of our own safety culture? Could we instead perhaps allow ourselves a little slack, and go on this innovative adventure one step at a time, all the while closely monitoring and feeding back the results of each pilot, making sure that ultimately we indeed will remain one of the safest modes of transport, but also become more competitive as a sector?

Overall, the authors believe society would be better off, with fewer casualties overall, if more people find their way to public transport. Even if we need to temporarily loosen the reigns on our safety mechanisms ever so slightly, in favour of innovating towards more capacity, efficiency, and less costs. Is that higher level of awareness not something we must ultimately keep in mind when providing transport for the public?

So, let us learn from what is out there. Let us strive to move forward and use what is available in other sectors. Committing ourselves to take steps towards meaningful innovations one small step at a time, learning from each other and from other industries. Let us make the railways more competitive, efficient, and affordable, so that in the distant future, our preferred mode of transportation will still matter!

References

The reference list for this article can be found at irse.info/pp1020refs.

About the authors ...

Tom works for Ricardo plc leading the companies' global connected and automated vehicles activities. He has over ten years' experience in engineering, commissioning and verification of complex, electronic safety systems and is experienced in the functional safety domain related to transport systems, having a degree in embedded electronics and a professional background as railway signalling engineer and as certified independent safety assessor. His recent experience includes multiple truck platooning projects (in the Netherlands, Belgium and UK), autonomous shuttles on Brussels Airport (BE), WEpods, ParkShuttle Rivium, Bluewaters autonomous shuttle, multiple heavy rail ATO pilots and several speaking tasks at leading conferences and universities.

After earning a degree in Electrical Engineering and in Management of Technology, Rick started his professional career at Ricardo plc in 2017 as a consultant in ERTMS. In this field of work he was involved in several train track integration campaigns and in ERTMS data analysis. Rick has gained valuable experience working on safety analyses for automated people movers such as for Bluewaters Island and Rivium Parkshuttle 3.0. Currently he is supporting the Dutch Railways as a requirements engineer for the ERTMS retrofit of the VIRM trains, where, in the coming years, a fleet of 176 passenger electrical multiple units will be provided with ERTMS onboard equipment.

Back to basics: Telecoms part 2

BACK TO BASICS


Paul Darlington and Trevor Foulkes

Part 2 of 'back to basics' for railway telecommunications covers telecoms for passenger or customer assistance. As with other similar articles, the intention is to provide an overview for IRSE members new to the industry or who may not have experience of working in this specific area. The content may also be useful for people studying for the IRSE Exam. The objective is to describe the subject in a generic manner and we have used examples based mainly on UK main line railways.

Public Address (PA)

PA systems have always been important for communicating with customers and staff, and are also used for emergency purposes when linked to fire detection systems. A badly designed sound system will quickly annoy customers and may result in negative comments and poor publicity. So, all sound systems should be designed by competent sound communications engineers.

A good PA system will depend on four key requirements:

1. Loudness or sound pressure level. This should be at a volume or level to please those intending to hear the communications message, but not too loud to annoy neighbours and residents close to a railway station, or train passengers who may not need to hear the announcement.
2. Intelligibility. This is one of the most important requirements of a PA system and where many systems fall short.

The concourse at Birmingham New Street station in the UK is typical of the challenging environment for PA designers.

From left, a row of speakers at Birmingham New Street station.

Speakers at Crewe station.

Inductive loop for hearing aid users.

Combing PA with CIS is effective for good communications.

3. Naturalness. A natural sounding PA system is one where pre-recorded announcements will sound the same or similar to real time voice announcements.
4. Reliability. All PA systems need to have good reliability and availability, with appropriate redundancy in their design, this is especially important with voice alarm systems which may have performance requirements mandated by national legislation.

The first three requirements are dependent on the acoustic environment, which can be particularly challenging at railway stations with variable building design and noisy trains. Sound may be reflected, refracted, diffracted, absorbed or transmitted through obstructions, dependent upon the material and size of the obstruction.

"A typical railway station will need careful design of its speaker system to make the best of what can be a very challenging acoustic environment"

A typical railway station will need careful design of its speaker system to make the best of what can be a very challenging acoustic environment. The sound design engineer will need to consider: the operating environment of the equipment in terms of temperature, humidity and dust; security of equipment; listed building consent as many stations in some countries are protected buildings; any noise abatement notices that may have been served; density of nearby housing and residents; platform possessions and isolations needed for installation and maintenance; feedback from users on the existing system, such as areas of poor coverage along with any customer complaints; glass shelters, as these can attenuate sound by approximately 25dB.

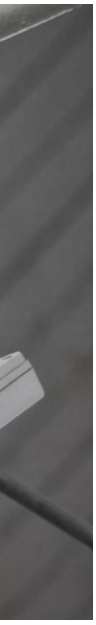
Coverage in general should be provided in all areas where most customers stand when waiting for information on train services or disruption, and in all weather conditions. In Europe the regulations for Persons with Reduced Mobility (PRM) require PA coverage in all public areas of the station and the UK Equality Act 2010 requires all station operators to take reasonable steps to ensure they do not discriminate against people with reduced mobility.

Loudness and intelligibility

Station PA systems must be carefully designed to avoid conflict between wanted and unwanted noise, and simply specifying a sound pressure level and intelligibility requirement may provide a system acceptable for rail users, but one which annoys nearby residents. There have been cases where PA systems have been renewed with an overall lower volume, but with better intelligibility resulting in more complaints from neighbours. An extreme case resulted in a noise prohibition notice and for the station PA system to be switched off until the problem was resolved. A detailed investigation found a number of issues. The station at times was busy with announcements as frequent as every 30 seconds. A second issue was that some announcers took 34 seconds to communicate the same information as other announcers did in 6 seconds. The solution consisted of a number of changes which included zoning of the system and establishing common scripts for all announcements.

Ambient noise sensing continuously monitors the changing ambient noise levels and adjusts the audio level of the PA system. This is particularly relevant for railway stations with wildly varying background sound levels usually caused by trains. The maximum volume of the PA will need to be limited as some trains can be very loud and it may not be possible to announce over the top of the train noise for health and safety reasons. Storing and transmitting an announcement when the background noise is lower is something that can be considered.

Dividing a station public address system into defined zones can be helpful, particularly where limiting the noise to neighbours is required with only those zones selected being addressed. The output from the amplifier can be automatically routed to the chosen zone or zones either by using zone selection keys on a controller, or by a stored speech system announcing the timetable to only areas requiring the message. Simultaneous but different announcements can be made to



different parts of the station and using male and female voices can help to distinguish between the messages but care must be taken to minimise the over hearing between zones.

A PA system can be used to feed directly to hearing aid users using a specially designed induction loop amplifier and associated cable system. The engineering and design of induction loops is complex and is environment dependent – steel-constructed buildings can make it particularly difficult.

Background music can be used to fill the 'silence' between announcements and is sometimes used at less busy stations. If provided this should not be loud enough to be obtrusive, but should be adjusted so that it adds to the ambiance of the environment. Music should never be so loud that customers cannot communicate, or that advice given by station staff cannot be heard.

"Public Address Voice Alarm (PAVA) sound systems designed to warn of danger normally require special fire-safe wiring"

Voice alarm systems

Train operators have a duty to ensure the safety of customers at all times. When an emergency such as a fire or a security threat arises or whenever there is the need to evacuate a station this can be best achieved by a speech announcement, rather than bells or sounders. The spoken word can be 'live' from a microphone, or pre-recorded. Stored announcements can be initiated by the station's or an adjacent building's fire alarm installation. When the alarm is activated the sound system automatically broadcasts the stored emergency message.

Public Address Voice Alarm (PAVA) sound systems designed to warn of danger normally require special fire-safe wiring and complete building coverage with approved loudspeakers sited to cover all public and staff areas. The provision of auxiliary power sources, so that in the event of an AC mains supply failure, the sound system can continue to operate, will be required. In addition equipment redundancy, self-checking alarms, sound level and intelligibility requirements should be considered.

Passenger (or Customer) Information Displays

Visual PIS/CIS are now common in many railways. They generally originated with hand painted boards but migrated to using revolving printed 'flap' displays installed at larger stations to increase the display content, either operated manually or using card reading machines. In the 1980s processor systems controlling monochrome Cathode Ray Tube (CRT) displays started to be installed at smaller stations with 'next train' platform displays and departure/arrival summary displays. Flap displays were inflexible and required extensive 're-flapping' when timetable changes were carried out. LCD displays originally using a 7x5 dot matrix often replaced flap displays to increase flexibility although often with a poorer display readability. LED displays then replaced LCD at larger 'main board' displays and CRT platform displays to improve both readability and reliability. It is easier to read upper- and lower-case than all upper- case, which is why road signs in most countries use upper- and lower- case. Displays should therefore be able to display information ideally in the train company font with both upper- and lower-case text with proper descenders, e.g. for "y" and "g".

PIS/CIS systems consist of either a central or local processor and controller for the displays, together with power supplies and communication links to and from the displays. These links have migrated from RS422/RS232 to Ethernet and Wi-Fi, with systems now controlled from real time signalling control systems (usually the train describer) and linked to comprehensive train timetable systems. Systems can also provide real time train information to third party mobile applications for public use. Unfortunately, when train disruption is severe and with no trains moving it can be difficult to display train information at just the time it is really required. It is hoped that traffic management systems may be able to provide accurate predictive information for displays in the future.

York station with CCTV coverage of all train movements. This camera is broadcasting live, see irse.info/zibhw. *Photo Network Rail.*

Most cameras are now fixed.

"Involving human factors specialists and local operators will help to identify the location of displays to maximise their effectiveness"

"It is important that CCTV systems provide quality video images in an easily re-playable form"

When designing and siting displays on stations the structure gauge for the railway should be complied with and take into account signal sighting along with installation and maintenance access, cable containment and power supply requirements. Listed building consent may be required, and if replacing an existing system feedback from users of the system should be obtained and analysed together with any customer complaints. The footfall where most people stand when waiting for a service in all weather conditions should be taken into account when designing the system, together with requirements for persons with reduced mobility. Future train service changes should also be considered.

Involving human factors specialists and local operators will help to identify the location of displays to maximise their effectiveness. Double sided displays should be used where ever possible to maximise the network capability of the system. Some operators use scrolling displays, but these can be difficult for persons with sight and comprehension issues to read and understand. Displays which change but hold messages fixed for a short time are better.

Closed-circuit television

Closed-circuit television (CCTV) systems provide surveillance capabilities to improve safety, assist railway and station operation, and to combat crime and terrorism. A CCTV system links a camera to a video monitor or receiving system using a direct transmission system. This differs from broadcast television where the signal is transmitted over the air and viewed on screen. It is important that CCTV systems provide quality video images in an easily re-playable form to third parties, such as law enforcement agencies. This can be critical should there be a need to use the images as evidence of a crime. This article does not cover driver only operation or level crossing CCTV systems.

CCTV technology is improving all the time with better performance in areas such as digital equipment options, data storage, component miniaturisation, wireless communications, and video image analysis. A CCTV system for a railway may be part of a multi-layered security system. Undertaking a comprehensive needs assessment at the start of any project helps to ensure all required functionality is identified. Clear requirements, a comprehensive site survey, compliance with legislation and proper equipment selection will all contribute to the design of a good CCTV system.

In order to properly implement a CCTV system and to highlight any engineering, operational, management and monitoring issues, the site-specific characteristics need to be assessed by a knowledgeable multidisciplinary team with the right level of expertise. This could include operators, security personnel, power and structural engineers to identify key functional and operational needs and restrictions. Functional requirements will include determining the area of surveillance, locations or assets that will benefit from CCTV surveillance. Operational requirements will define what information and detail the system will be expected to provide. Factors to consider may include the viewing scope of the area, the ability to recognise someone walking through a barrier or door, and to read vehicle registration numbers.

There are four key requirements that need to be covered in the initial design.

- Functional – to define the precise area of camera coverage such as surveillance of perimeters, storage areas, key assets and entrances and exits.
- Operational – to define the capabilities of the CCTV system components that will provide the expected information under all operating conditions. These will include security, day and night operation, lighting, weather conditions, vibration and temperature changes.
- Infrastructure – to include installation constraints for installing or accessing fibre

and /or, copper data cables, wireless networks access, power, listed building constraints, and people with reduced mobility. Authorisation for works on listed buildings may be required before any works commence.

- Video retention – to define the video retention and storage needs. These should take into account security and data protection, which may be subject to legislation.

"Nowadays video transmission for CCTV is normally via unshielded twisted pair (UTP) or fibre cable"

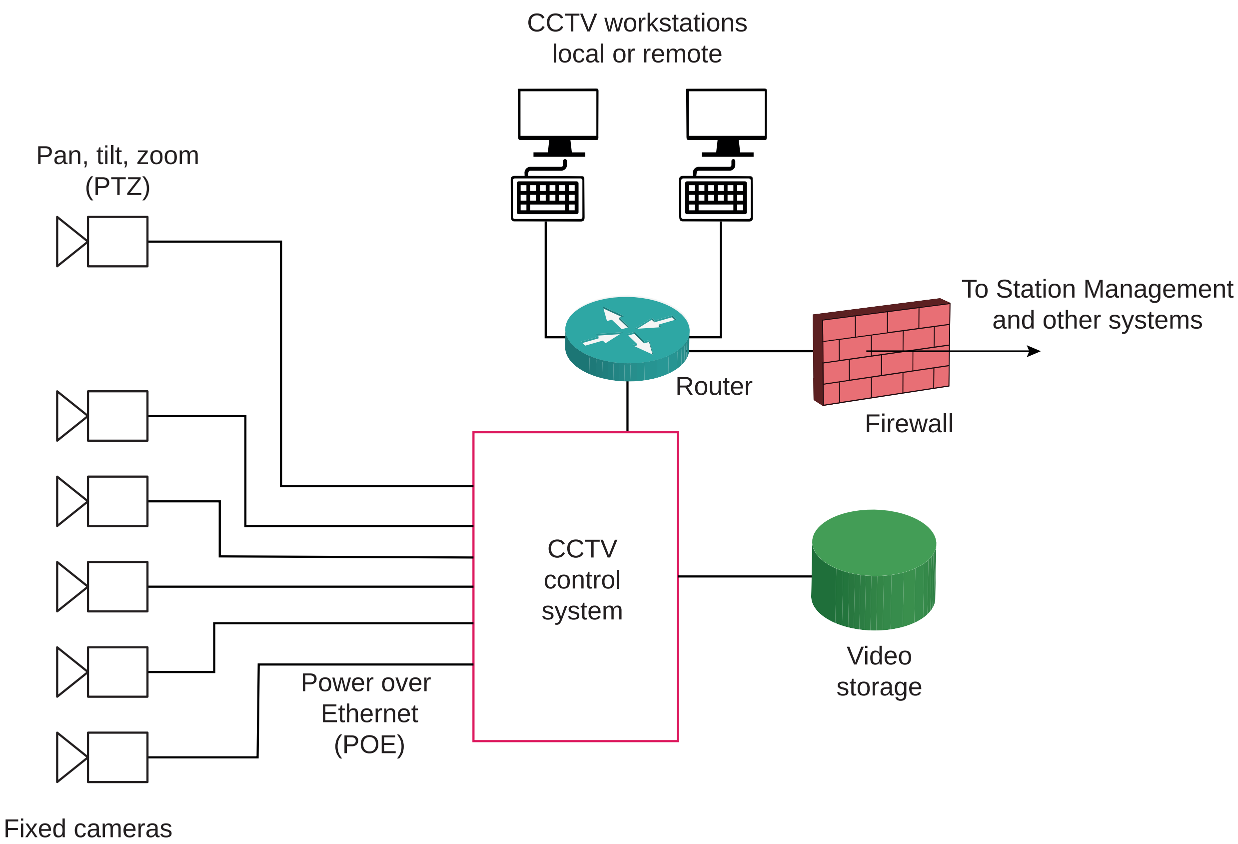
Whenever possible, CCTV systems should be included in the planning and design stage of any new facility, building or asset to ensure all necessary infrastructure requirements for the CCTV are adequately incorporated into the overall design. Factors to consider in the detailed design of any CCTV system include: the number and locations of cameras including lens selection, cabling and cable containment together with fixing arrangements; lighting levels for all proposed camera coverage areas; unhindered but secure camera access for both installation and maintenance; no interference or blocking of signal sighting; power requirements, including appropriate separation of power and data cables to comply with standards and reduction of interference.

Inadequate power can be a problem with CCTV equipment and can often cause interference. Proper system performance requires a clean and reliable power source. Therefore, the design may need to specify power conditioning or backups, to ensure the quality of the video across the entire system is unaffected by primary power source disruption. Placing low-voltage power components near high-voltage lines can induce currents in the low-voltage system, presenting hazards. A power source located too far away can cause power fluctuations and may require larger conductor sizes to reduce voltage drop. Therefore, it is advisable to locate the power source close to the CCTV control equipment and to include an Uninterruptible Power Supply (UPS) to protect equipment and ensure the power supply is stable.

Older CCTV systems generally used co-axial cable to connect cameras to the control hub, but nowadays video transmission for CCTV is normally via unshielded twisted pair (UTP) or fibre cable. Many problems with video image quality can be avoided by selecting the appropriate transmission media and following manufacturer's recommended installation techniques and procedures. As CCTV technology has evolved, video transmission has progressed from analogue to digital equipment, often with an Internet Protocol (IP) capability to transmit compressed video as digital data. Some railways now mandate all new CCTV systems will use IP, but analogue systems using digital recording are still used by some railways as IP CCTV systems can be complex to configure.

IP CCTV solutions, while complicated, do offer more facilities and can be integrated seamlessly with other control systems to deliver integrated centralised control and monitoring. Data from other security devices and from business systems can be linked with IP CCTV images and recordings while cameras can be easily controlled and monitored from web browsers.

CCTV systems regularly need to be checked to meet changing operational requirements and equipment obsolescence so the ability to easily incorporate hardware and software updates should be considered. Using existing



Overview diagram of a typical station CCTV system.

Clockwise from left:

A CCTV camera and loudspeaker sharing a lamppost.
Photo A N Hurst.

Fixed camera installation in a concourse area.

A similar camera to that in the first photo, but mounted on a passenger display sign.

"Most systems nowadays use fixed cameras to view and record complete areas as PTZ cameras require full time operators"

CCTV infrastructure such as cameras, housings and cable runs may reduce costs, but CCTV equipment is improving all the time, as the capabilities of CCTV components advances. Replacing old equipment and infrastructure may therefore improve system performance and be a more cost-effective solution.

Station Management Systems (SMS) are typically deployed at large stations or in a group of stations along a route managed from a central location. The SMS is the focal point for station operations and provides the operator with a user-friendly, functional environment from which to monitor and control all station systems. The SMS should gather information from many sources and provide control of the various individual station systems, such as CCTV, public address, customer information and alarm systems. Integrating the control and operation of the CCTV system in a clear, consistent and integrated format will help to provide efficient and cost effective management of the station. The SMS will usually be interfaced with a fire alarm system so that in the event of an alarm activation, cameras covering the area will automatically be displayed to the operator.

A CCTV system is built up from a number of different components.

Cameras

CCTV cameras are either fixed or pan-tilt-zoom (PTZ). Fixed cameras are intended to constantly view a single scene, while PTZ cameras are motor driven and can pan left or right, tilt up or down, and zoom in or out to instantly customise the view as needed. Most systems nowadays use fixed cameras to view and record complete areas as PTZ cameras require full time operators.

An Ingress Protection (also known as IP and not to be confused with Internet Protocol) rating is to protect equipment from attack from solid foreign objects e.g. stone throwing, and from harmful effects due to the ingress of water. Ingress Protection IP always has a number. So cameras should typically have an IP rating of IP34 when used internally and IP65 for external cameras. The "IK" rating or code is an international standard to define the level of resistance of enclosures to mechanical impacts. Cameras are recommended to have an IK vandalism rating of IK10, along with a typical operating temperature range of -15C to 45C external to the housing. This may need to be revised depending on local conditions. The minimum resolution of cameras in a railway system is typically 720 pixels, and systems with 1080p resolution or higher are often provided.

"Power over Ethernet (PoE) IP cameras will not generally require a local power supply"

Despite increasing use of IP network cameras, analogue cameras still exist in many older systems since there may be a high cost involved in upgrading and converting to a new transmission network. Analogue cameras can also transmit high definition pictures, making them appropriate for various surveillance needs. These cameras also have cyber security advantages because the cable connections require a physical access for them to be breached or damaged. They are easier to configure, but will not provide as many features as IP systems.

Power over Ethernet (PoE) IP cameras will not generally require a local power supply but must be able to operate in the railway environment. PoE extenders will need to provide sufficient power to meet the camera's operational requirements. Connections to individual cameras can be via wireless such as Wi-Fi, but a local power supply will be required and the wireless connections should be encrypted for security. Possible interference with other Wi-Fi channels in the area should be assessed.

"Notices may be required at locations in areas of CCTV coverage to inform members of the public that an area is being monitored and recorded"

Day/night cameras and low-light or night vision cameras can be used to capture images in dark environments. Low-light cameras are designed to perform in some level of ambient lighting, such as indoor conditions, station lighting, or a full moon but are not intended for use in complete darkness. Night vision cameras used in CCTV systems typically consist of near-infrared (NIR) and infrared (IR) cameras with built-in IR illuminators and are designed to allow the viewing of night scenes. The IR light emitted can be at wavelengths that are invisible to the human eye. Some operational environments may require a thermal imaging camera to detect situations even if conditions such as fog or smoke are encountered. These detect infrared or heat radiation that is invisible to the human eye.

The most complex CCTV systems may incorporate hundreds of cameras and sensors integrated into one overall security network. With larger quantities of data being collected, it is essential that the system be capable of retaining data in accordance with a company's policies and procedures, together with data protection and CCTV legislation. EMC requirements will need to be considered, such as defined in standard EN 50121-4.

Camera lenses

A lens has components and characteristics that determine its capabilities. These include the focal length, type of aperture and focus control. The focal length and size of the image sensor determine the angle from which the lens accepts light to focus on the image sensor. Any lens with a focal length greater than the standard lens is a telephoto lens, while a lens with a focal length less than the standard lens is a wide-angle lens.

Camera lenses shall normally be fitted with either an auto-iris fixed lens, vari-focal lens or zoom lens. Remote vari-focus, zoom, controlled back focus and remote camera alignment will all contribute to efficient operation and maintenance of the system, and will eliminate the need for working at height to adjust the camera.

Cameras mounted on extendable or hinged posts will facilitate easy maintenance and minimise working at height during both installation and maintenance, but no hinged or extendable post should come close to any electric traction system or other hazards. Fixed camera mounts with adjustable horizontal and vertical planes will maximise operational effectiveness. Camera positions should be selected to enable routine access (for cleaning and replacement) without the need for blocking train movements or isolating overhead power. Individual and isolated columns supporting lighting or cameras should be positioned to avoid creating obstructions to the movement of station users. The camera assembly, housing and sunshield should take account of the effects of sunlight during the course of the day and also the seasons of the year in order to maintain the viewing requirements of the system.


From left. Traditional camera housing and a dome camera housing.

"Recorded images should be strictly controlled to prevent tampering or unauthorised viewing"

Notices may be required at locations in areas of CCTV coverage to inform members of the public that an area is being monitored and recorded. These will need to be provided in accordance with national and local legislation, such as the General Data Protection Regulation (GDPR) and the UK Data Protection Act 1998.

CCTV workstation and monitors

To provide good picture quality, the minimum monitor resolution should be at least that of the cameras. Multiple camera images at original resolution may be required for viewing onto a high-resolution screen, so for example, a 30" 4K resolution monitor could display 4 x 15" 1080p resolution cameras. The camera identification should be easily available so the operator knows where they are looking.

A bank of monitors to create a 'video wall' is commonplace in larger control centres. These can be programmed to periodically change the picture displayed on the monitors to help relieve the boredom from seeing the same scene all the time and to concentrate the multitude of camera images on to a sensible number of screens. A typical railway CCTV control room could have 500 cameras covering a route with about 50 monitors in the video wall.

"External remote access will also need security via firewalls and compliance with individual company's security policies"

An ergonomic assessment of the operator's workstation location should be undertaken to determine the most appropriate size and position. Providing the control systems for camera selection and PTZ operation with industry standard telemetry protocols with an open architecture, will help with the whole life support of the CCTV system and interoperability with other systems.

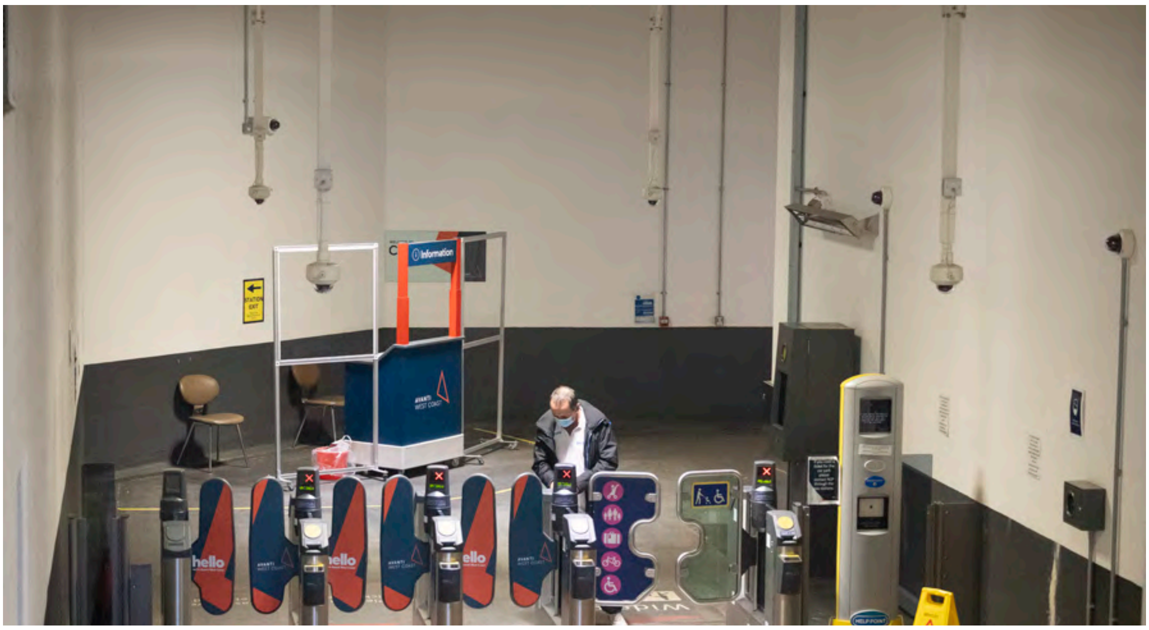
An agreed format for event reporting and alarms will be required and telemetry data from all camera input channels with time/date and camera description will provide a consistent format to identify station, camera location and camera number. This will assist the operation and management of the system, especially if the information is consistent with details in the asset register.

Monitors may be required for public behaviour and surveillance monitoring, for example at ticket gate lines, so higher performance specifications should be considered to enhance visibility of the display. Public surveillance monitors may require additional vandalism and ingress protection suitable for the location in which the monitor is being installed, such as a minimum IP65 for all external monitors and IP32 for all internal monitors.

Control system

ONVIF (Open Network Video Interface Forum) is an open industry forum for the interface of physical IP-based security products. The ONVIF specification covers how IP products within video surveillance and other physical security areas can communicate with each other. Therefore, procuring CCTV systems in compliance with the ONVIF specification will assist interoperability between network video products from different suppliers. ONVIF aims to provide standardisation of communication between IP-based physical security products to give interoperability regardless of the brand, and is open to all companies and organisations. Using ONVIF equipment will help with not becoming locked in to any particular proprietary technical solution devised by individual manufacturers.

System security is important so access to the system and any recorded images should be strictly controlled to prevent tampering or unauthorised viewing. This could be via electronic access controls, including but not limited to passwords or encryption, to prevent unauthorised access to the building, system and recordings, with an audit trail and record of who accessed the system and when. Different levels of user privileges, such as Administrator, User and Maintainer, may be appropriate. Further information can be found in BSI document 'Code of Practice



A number of dome cameras providing comprehensive monitoring of a ticket barrier.

An historic clock at London Victoria station, mounted next to several very modern speaker arrays.
Photo Institute of Sound, Communication and Vision Engineers (ISCVE).

"Accurate clocks are important for a smooth-running railway"

"The positioning of clocks needs to take into account similar criteria to PA, CIS and CCTV systems with regards to height, maintenance and not obstructing signal sighting"

for Legal Admissibility of Information Stored Electronically' (BIP0008) or from local Police Crime Reduction Officers.

External remote access will also need security via firewalls and compliance with individual company's security policies. The system should prevent transmitted images from being corrupted or modified in transit. Where the proposed system does not provide the specified security functions, the network or transmission medium used could be employed to provide equivalent security.

Video analytics such as the detection of unusual movement in a normally static picture may be specified in the design, as these can further improve the overall effectiveness of the CCTV security solution. Video analytics monitor the video streams in near real-time and automatically create security alerts when recognising specific types of events and activities. Video analytics can also be used for analysing historical data to identify specific incidents and patterns (forensic analysis).

Using a video analytics system to automatically monitor camera video feeds and providing alerts for events of interest enables efficiency and cost reductions by reducing the need for human concentration and helps operators to notice and respond to threats sooner. Typical uses are for perimeter protection intrusion management, crowd management and situation awareness. They can also be used for 'footfall' counting to assist the commercialisation of retail space on stations and passenger loading on trains.

On initial installation, consideration should be given to fit spare switching, optical and Cat 5E/6 copper cable (where appropriate) for at least an additional 10 per cent spare capacity in agreement with stakeholders' policy. This will allow expansion for future requirements.

Video storage

The system will need to store recordings for all connected cameras for a time period of typically 31 days so as to assist with any post incident investigations. All video data once past the stated time period should be automatically deleted unless marked for retention. A facility for local or remote users to mark specific pictures or sequences identified as relevant to an investigation for retention should be considered. To optimise storage capacity, agreement from stakeholders should be obtained as to the circumstances in which images will be recorded for review and at what resolution, together with date and time stamping requirements. Care may need to be taken that any video compression does not compromise video quality.

Clocks

Accurate clocks are important for a smooth-running railway, and telecoms engineers in many railway companies have provided clock systems for many years. Originally they were provided using centrally located 'master clocks' communicating with slave clocks via telecoms cables. More recently clocks are Global Navigation Satellite System (GNSS) controlled, so just need a power supply and possibly an external antenna to receive the satellite signal. The positioning of clocks needs to take into account similar criteria to PA, CIS and CCTV systems with regards to height, maintenance and not obstructing signal sighting.

Internet connection for trains

Most train passengers now have an expectation that a connection to the internet will be available on trains. With an on-board internet connection, real time ticket sales via debit/credit card are possible, along with seat occupancy reporting and real time seat reservations. Communications

"Antennas are one of the most critical items to deliver good connectivity on and off the train"

and preventative maintenance are also key to enhancing operational efficiency. This could include data to monitor and manage the train, and if adequate bandwidth is available real time forward and rear facing CCTV cameras for track and signalling maintenance. While GSM-R will provide the wireless connection for ERTMS / CBTC movement authority, it does not have sufficient capacity for train Wi-Fi applications and use of public 4G or 5G LTE networks is more usual for provision of the internet connection. The replacement for GSM-R, known as FRMCS (Future Radio Mobile Communication System), is planned to provide for all train connectivity requirements, including business and passenger communications.

To improve or provide an internet connection on trains it is likely to require equipment both on the infrastructure and train. Like many applications, such as operational voice and ETCS/CBTC, this will require close working between rolling stock and S&T engineers, and for each to have an appreciation of the engineering principles for both infrastructure and trains.

By their construction, train vehicles create attenuation which degrades the usable signal in the train. The degree of attenuation varies between 5 to 35dB depending on the rail vehicle profile and a loss of 3dB results in halving the available power. The on-train user experience can vary as a result of the differing levels of signal attenuation due to a significant mix of different devices, with an increasing trend towards the use of multiband smartphones and tablets. Multiband devices incorporate wider band receivers which weaken the performance for any one single band, and coupled with multiband antennas becoming integrated into the handsets themselves makes reception on-board trains even more challenging. There is a significant cost involved in the design and implementation of additional public operator radio sites along rail routes and careful consideration is required for any additional public radio coverage to avoid signal interference with GSM-R and FRMCS.

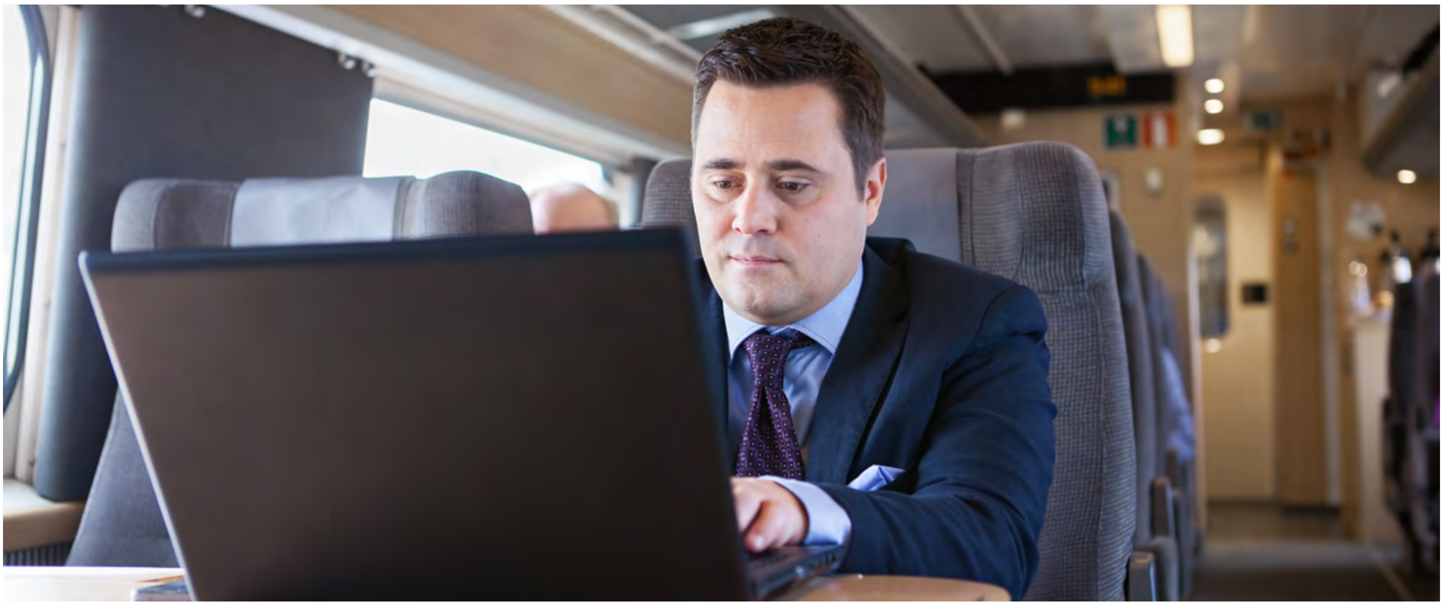
Internet connectivity can be improved by providing digital on-board repeaters (D-OBR). A D-OBR is an active multi-band, multi-operator repeater which is designed to provide coverage within train vehicles by amplifying and re-radiating (repeating) the external 2G, 3G and 4G/LTE mobile operator signals through dedicated ceiling-mounted antennas. A D-OBR will provide Internet access to mobile phones without a Wi-Fi facility; however, most passengers now expect Wi-Fi to be available, although some train operators have 'quiet coaches' to restrict nuisance use by some travellers who can adversely impact the journey experience.

One or more external mounted wideband antennas can be provided on trains and connected to a communications device known as a Mobile Communications Gateway (MCG). A wideband antenna capable of receiving a wide range of Mobile Network Operator (MNO) services and 2.5GHz or 5GHz point to point Wi-Fi connections at stations can be provided, with 6GHz Wi-Fi systems also being introduced. Care will be needed on the location of the wideband train antennae so they do not interfere with the train GSM-R antenna.

Antennae are one of the most critical items to deliver good connectivity on and off the train, and creating an efficient antenna solution will do much to improve system efficiency. Many of the radio frequency problems associated with antennae also stem from poor fitment of feeder cables, which should be installed in accordance with the manufacturer's instructions.

The MCG (or number of MCGs) provides 'a cloud' of connectivity to the train via a number of MNO services and external Wi-Fi connections aggregated together. Fixed Wi-Fi at stations or trackside is a good way of enhancing the connectivity as this is within the control of the rail industry. At terminal stations it can provide a good link to a train and this is where many people open their device and 'log on'. Wi-Fi systems are 'licence free' so care may need to be taken to prevent interference from other Wi-Fi systems, which could be located away from the railway.

Most train passengers now have an expectation that a connection to the internet will be available on trains. *Photo Icomera.*



The connectivity to the MCG may also include satellite connections, although some systems can be troubled by higher latency times to and from a moving train. A train compares unfavourably with a more stable platform like an aircraft, which is how an internet connection is provided in the air industry. Satellite communications will not work in tunnels or deep cuttings.

An acceptable customer service in order to support email and social media browsing can be provided with a data bandwidth as low as a few hundred kbits/s, but obviously the more bandwidth the better. Limiting each customer to a maximum will help to provide an acceptable service to all customers on the train. In order to provide a reliable non-discriminatory service, certain high bandwidth applications, such as video and audio streaming services or peer-to-peer file sharing, may need filtering and restricting. On train bandwidth requirements will vary depending on the number of active Wi-Fi customers and may increase as passengers become aware of Wi-Fi availability, therefore additional bandwidth should always be planned for.

Final thoughts

So, given all that has been covered in both parts of the back to basics of railway telecoms, what makes railway telecoms different from providing a public telecoms network?

Many pieces of equipment can be used for railway and public telecommunications e.g. cables, transmission and exchange equipment. There are pieces of equipment which are specific to the railway such as signalling centre concentrators and GSM-R cab radios. These items are normally developed to provide a feature which is unique to the railway – e.g. using the GSM-R frequency bands or needing to be designed to prevent an activity which may cause risk, such as two drivers speaking to a signaller at the same time. The equipment also has to operate correctly in the railway environment which is normally harsher than an office environment. Factors to take into account include Electromagnetic Compatibility (EMC), vibration, temperature, and humidity.

Railway telecoms is managed in a different way to a public telephone network. An example would be that railway operators expect any engineering or station works that will disrupt the train service, to be pre-planned, agreed with them and to be told when a facility is restored. Similarly, if a significant fault occurs it has to be investigated to ascertain the root cause so that, if necessary, steps can be taken to prevent recurrence. Such situations demand telecommunication requirements that may be difficult to obtain from the service provided by a public telecom operator.

A railway telecom engineer is expected to understand the rules and procedures employed on the railway so that when they are designing systems to support the operation, they can define what functionality is required and also understand the safety and performance implications of any failures. So if an off the shelf piece of equipment is used, the engineer needs to be sure that it is fit for the purpose intended, for example, it provides sufficient protection to be used in places of high induced voltages or vibration.

If it is decided to use a public telephone system (fixed or mobile) to support a railway application, then the possible shortcomings of using the standard facilities should be considered. For instance, the radio coverage may change over time and not cover areas of the track. A public operator may not be able to provide diversity between two circuits for the last few miles at a reasonable cost. The public service may be turned off for maintenance overnight and at short notice. If these shortcomings are acceptable then the use of public services can provide a cost-effective solution for some railways.

There may be a temptation for some governments and railway authorities to 'sell off' the railway telecoms assets and resource to raise finance or for commercial purposes. This has occurred several times across the world. However, in nearly every example, the railway authority has had to buy back or re-install its own telecoms infrastructure, plus rebuilding a telecoms workforce. Telecoms is a vital part of railways operations and with the increasing use of digital signalling systems and the internet of things, it is becoming ever more important.

About the authors ...

Paul Darlington CEng, FIET, FIRSE, joined the S&T department of the London Midland Region of British Rail in 1975 as a trainee telecoms technician. After maintaining telephone exchanges, he became an instructor at the regional S&T training centre. In the 1980s he moved to the telecoms project office in Birmingham and was involved in designing and implementing CIS, CCTV, SPT and radio systems.

Moving to Railtrack in 1994 Paul led the asset management of telecoms for the north west of England and became engineering manager for all disciplines. In 2008 he moved to London as head of telecoms engineering for Network Rail and finished his full-time career as route asset manager signalling in Manchester. Paul also led the work to enhance the Network Rail network with IP, which led to the creation of Network Rail Telecoms (NRT) and the Network Rail FTNx IP network. He also chaired the safety approval panel for the GSM-R Network.

Retiring in 2012, today Paul is an engineering writer, managing editor for IRSE News and also interviews applicants for professional registration with the IET and IRSE.

Trevor Foulkes MA, CEng, FIRSE joined British Rail in 1979 as a sponsored management trainee engineer. After graduating from Fitzwilliam College, Cambridge his training was based in the S&T department of the Western Region, followed by a series of roles in the design of systems and the management of technicians and engineers.

In 1994 Trevor joined Railtrack and specified telecoms works for the south and west of the country after which he joined HQ and set national standards for equipment. He then joined the West Coast Main Line (WCML) resignalling team in 1996.

In 2000, he led the business case development for the telecoms network, now known as the Fixed Telecom Network (FTN), before becoming the design authority for the FTN and GSM-R systems. In 2012, he was seconded to the High Speed 2 project to develop the control, command & signal engineering design. He also led the Spectrum Group of the UIC project developing the next generation of operational radio to replace GSM-R.

Trevor retired in 2015 and is chair of the London & South-East Section of the IRSE and has assisted with the telecoms aspects of the new Certificate in Railway Control Engineering Fundamentals (module A).

Command, control and signalling design in the digital age

Dominic Taylor, Alexei Iliasov, Karl King, Oliver Jarratt
Silas Benson and William Dearman

IRSE News is currently running a series of 'back to basics' articles covering topics including interlocking, principles of safety engineering and train protection. Although this is not another in the series, in this collaborative article by SYSTRA Scott Lister, Frazer-Nash Consultancy and The Formal Route, we are going 'back to basics' in a sense, to look at signalling design processes and consider how they can better meet the needs of modern 'digital' Command, Control and Signalling (CCS) systems.

As well as using different technologies, modern CCS systems tend to be much more complex and data hungry than colour-light and semaphore signalling systems they replace. A consequence is that design processes developed for these earlier systems may be inappropriate or inefficient. So, it is appropriate to consider what is required of a design process for a modern CCS system, and how to optimise it to reduce delivery costs and timescales whilst improving the quality of the end result.

A key principle for designing complex systems is that investment in early development work pays dividends later in the project lifecycle through the avoidance of expensive and time-consuming re-work and an outcome that better meets client needs. In this article we consider three areas where we believe such early development is vital to the successful delivery of modern CCS systems:

- Managing data.
- Modelling and systems development.
- Automation of design.

Managing CCS data

The data challenge

Modern 'digital' CCS technologies depend far more on accurate and up-to-date data models of the infrastructure they supervise or control than their colour light and semaphore predecessors. European Train Control System (ETCS) and Communications Based Train Control (CBTC) systems depend on such models to control train movements via electronic movement authorities, in accordance with physical stopping locations, speed restrictions and other features. Traffic Management (TM) systems need infrastructure models to accurately predict the movements of multiple trains for dynamic re-planning. Driver Advisory Systems (DAS) and Automatic Train Operation (ATO) similarly need accurate and up-to-date models to provide meaningful regulation of trains travelling over physical infrastructure.

Experience has shown that traditional CCS engineering approaches to collating and managing data representations of railway infrastructure often struggle to meet the needs of modern 'digital' technologies. This can incur significant additional cost and delay in delivering such technologies and leave a legacy that is exceedingly difficult to maintain. There are various reasons for this:

- The traditional signalling scheme plan approach of specifying asset locations as distances from a datum point can lead to cumulative measurement uncertainties that increase with distance from the datum, hindering the alignment of survey data from diverse sources.
- The 'distance from datum' measurement approach also makes it harder both to identify where installed asset locations deviate from plans and to re-evaluate the locations of individual asset locations in isolation (e.g. using a handheld device).
- Survey and installation tolerances may not be specified, meaning that positional accuracy, even relative to the datum, can be difficult to determine.
- Data representations may only be deemed reliable at the time of surveying, because they are not updated when changes are made to the infrastructure.
- The same information may be repeated in multiple places (such as scheme plans, location area plans, sighting forms) making updates hard to manage even when they are known about.
- Updates are further complicated by the 'distance from datum' measurement approach as a small change in infrastructure, e.g. remodelling a section of track, can have knock on effects on the recorded locations of all assets beyond that section.

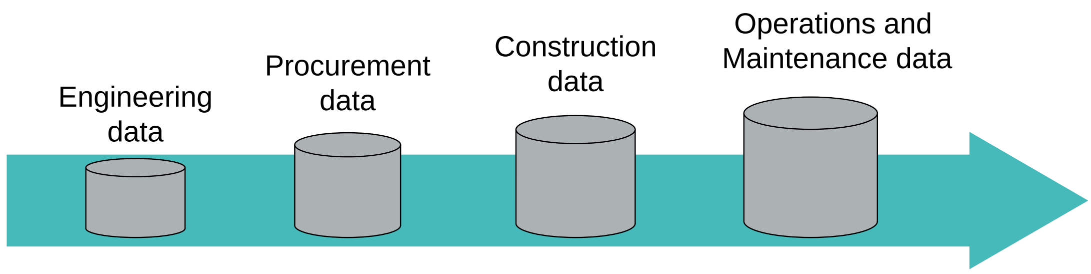


Figure 1 – Asset data lifecycle.

Information management

Many of these challenges are not unique to CCS and there are many lessons to be learnt from how they have been tackled in other industries. The asset lifecycle of multiphase infrastructure engineering projects in the oil and gas industry involves many separate parties exchanging data and information in near real-time and at longer term handover. Coordinating and controlling this information exchange can be challenging as the quantity, variety and rate of change of data increases over the asset lifecycle (Figure 1).

Information Management within the oil and gas industry is an established capability that aims to manage this data over the asset life-cycle by controlling, distributing and receiving data and information between relevant parties. For large geographic assets such as pipelines (long linear assets) this is often achieved by managing data based on its location in the real world and/or distance along the asset. The use of location and mapping technology for information management and decision support continues to grow and develop alongside the wider digital revolution, and central to this growth are geospatial technologies such as Geographic Information Systems (GIS).

Geographic Information Systems

GIS provides a spatial information management framework to enable stakeholders to understand and have full visibility of the assets over their lifecycle, thus improving collaboration, engagement, delivery, services, safety and reliability. GIS provides a data management framework that overlays data into the context of its real location and position on the infrastructure, allowing stakeholders and machines to manage information using asset locations. GIS and BIM (Building Information Modelling, also known as Better Information Management) together provide the framework, platform, roadmap and processes for geo-enabled data collaboration. Combining the spatial context of GIS and the detailed modelling of BIM within an overarching information management framework, creates a progressive solution that enables information to be captured, organised, retrieved and analysed to support successful project delivery.

Technology, and tools such as linear referencing, relational databases and persistent storage accessed via web-based interfaces, come together with cloud technology to provide an efficient platform for data management and exchange, based on a single source of truth. Once a central asset data hub has been established (Figure 2), additional data such as location-specific signalling information can be added, and managed accordingly. Data can be uploaded or retrieved from the field or design office to help progress business activities efficiently. In addition, all relevant parties can use the same central source of asset location to access, manage and submit asset data. One powerful benefit of this approach is the ability to discover where deviations from the plans or designs cause clashes in the system, providing stakeholders with a framework for collaborative working and common understanding. Supporting this technology are also the appropriate procedures, documentation and organisational structure.

Figure 2 – Central data environment.

Opportunities for applying some of these lessons, particularly those of BIM, were presented several years ago in the IRSE Aspect 2017 paper 'Building Information Modelling, opportunities for the control and signalling industry' (Francks, 2017). The paper showed how the application of robust requirements and standards for collating, owning and maintaining data for signalling models, in accordance with the BIM philosophy, could address many of the challenges currently faced. Similarly, following the BIM philosophy, the paper explained how 3D and 4D representations of location data could resolve ambiguities inherent in the conventional signalling survey methodologies. It also showed that moving from a traditional 'drawing-centric' approach to a 'data-centric' one, where asset data is stored once in a common database and accessed as needed, could deliver data management efficiency and reduce the scope for error.

Modelling & systems development

How modelling can positively support decision making

Modelling has huge potential to improve the decision-making capabilities of stakeholders in signalling design. The range of applications of modelling is extremely broad (although it can certainly be overused) as it allows decision makers to inform themselves about the issues that actually matter to them. Employed correctly, modelling can quantify key risks and uncertainty, underpin financial planning and crystallise use cases (written descriptions of how users will perform tasks using the system) and systems requirements. If misused, modelling can become a sprawling mess which fails to inform, has no clear guidance and is extremely costly. To avoid the latter, it is of utmost importance to remember that the primary purpose of any modelling exercise is to answer a question to a sufficient level of fidelity, rather than try to represent a system to ever-increasing levels of accuracy.

Let us consider the early pre-contract phases of a large signalling infrastructure project. At this point, the headline goals of the project (and the budget) are probably known, but the minutiae of the eventual solution are far from defined. Project sponsors can use high-level modelling techniques to compare and contrast different approaches, perhaps in no greater detail than to assess time/cost/quality trade-offs. Often these are the most important choices that impact a project's successful completion, yet they are not always evaluated in a rigorous way. The important early decisions may have been made based only on past experience, and where modelling is used, it may have been applied downstream in the programme to guide macroscopic decisions. We ask the question: Would it not be better to use more accurate modelling up-front, to support the important initial decisions that really matter?

Very often a project would benefit from greater insight into the key risks to successful delivery. Signalling projects are frequently brown-field engineering projects, where an infrastructure system must be moved through a series of operational states. Each state must be safe and meet performance requirements, and each transition is restricted by time and resource availability. This greatly influences the final programme design. Creating an end goal without cognisance of the intermediate transitions is likely to result in a poor cost-to-benefit trade-off, where small alterations to the final design may substantially alleviate costly state transitions. This may not be obvious from reviewing the final design in isolation.

We propose modelling the states and transitions as an optimisation problem, as illustrated in Figure 3. Certain constraints are enforced at both the state and transition level and forming an optimisation function to represent cost, risk, total project time, or other pertinent factors. This form of model would not seek to assess safety, time or other constraints to a level of complete certainty (attempting this would almost certainly fail or be cost-inefficient at an early project stage). Instead, it would use approximations and estimates with uncertainties and distributions. The model could then be driven within a Monte-Carlo style statistical analysis package to strategically explore the uncertainty space. This would result in expected ranges and distributions of answers, meaning that decision makers can make choices both on the most likely outcome and the severity of the worst-case outcome.

The challenge of Railway Systems Engineering

In order to successfully utilise modelling at these key stages, it is essential that a systematic approach is taken to the specification, development and deployment of complex multi-discipline systems of systems such as CCS. This has not always been the case, or even possible with the way that CCS systems have been traditionally developed and procured – certainly in Britain. Historically Network Rail has used their Governance for Railway Investment Projects (GRIP) process to develop and procure CCS systems, which consists of eight stages:

1. Output definition.
2. Feasibility.
3. Option selection.
4. Single option development.
5. Detailed design.
6. Construction test and commission.
7. Scheme hand back.
8. Project close out.

Although newer (and larger) projects are not using GRIP, Network Rail is still generally carrying out all CCS programmes (including ETCS and TMS) over two distinct phases:

1. Feasibility (GRIP 0-3)
2. Delivery (GRIP 4-8)

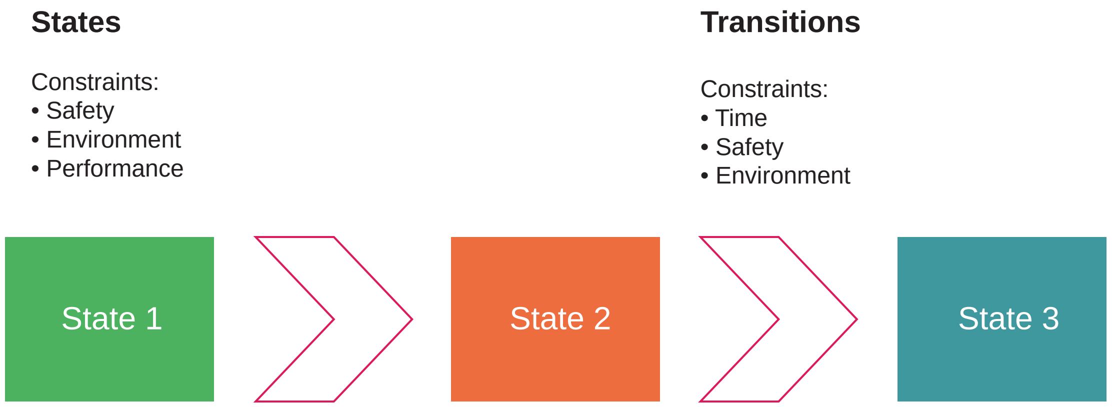
The Feasibility phase is often led by the client (Network Rail) in-house and consists of:

1. Identifying the scheme.
2. Developing initial scheme design.
3. Investigating options.
4. Choosing the single option.

The Delivery phase starts when Network Rail appoints a primary contractor who carries out:

1. Develop detailed scheme design.
2. Deliver technical solution (technology).

Figure 3 – Modelling states and transitions.



3. Install, test and commission system (including migration stages).
4. Gain system assurance (product acceptance, safety case, etc.).
5. Hand back to Network Rail.

The INCOSE Systems Engineering Handbook (INCOSE, 2015) defines at least two levels of design:

1. Preliminary design (sometimes called high level or system design).
2. Detailed design.

A problem with the approach outlined above is that the client sometimes starts developing the detailed design during the feasibility phase. That detailed design work is then passed on to the contractor for the delivery phase as the main source of the requirements for the eventual solution. On major programmes the client's design work often needs to be extensively re-designed to accommodate the supplier's technology, which can be expensive (and not budgeted for). There is also often a lack of adherence to key system engineering principles such as requirements management, engaging end-users and developing a concept of operations, all of which should happen during the feasibility phase.

The W-lifecycle

Further complications arise from a lack of understanding within the railway industry of the difference between generic systems and specific applications (King, 2016). Suppliers of CCS technology tend to develop generic systems based on global market requirements. This enables them to develop adaptable systems that can be sold to different local markets throughout the world (Bourne & Clark, 2007). To develop these systems, they tend to follow a V-lifecycle model very similar to the adapted waterfall model utilised for product development.

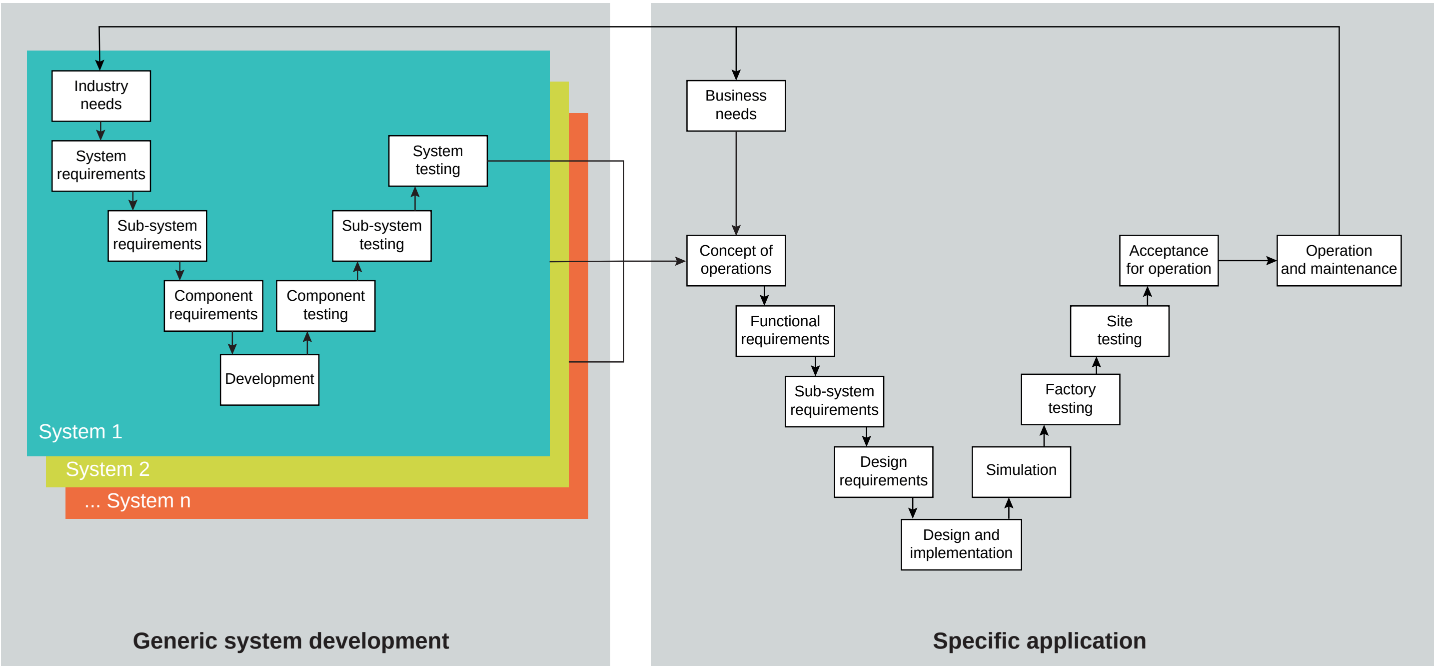
Typically, the system supplier takes the common needs of railways throughout the world, and uses these to develop a system platform that will be comprised of various sub-systems, each of which will in turn use various hardware and software components. They will then develop the system to take to market .

Railway operators should identify business needs for a CCS system, and develop a concept of operations before going to market to identify and procure a system that will meet their needs (Bourne & Clark, 2007). They should then follow a V-lifecycle model more akin to the INCOSE version of the V-lifecycle developed for complex systems

The operator then contracts the chosen supplier to deliver the system to the concept of operations it has developed. The supplier will determine the specific functional requirements that will have to be provided by their generic system in order to meet the operator's requirements. These will inevitably necessitate modifications to their sub-systems, to create the generic application for the client. They will then need to design the specific implementation of the system for the route and track layout to be re-signalled (the specific application), which will in turn be simulated and factory tested, before being installed and tested on site and subsequently accepted by the operator.

The development of the generic system, generic application and the specific application each comprise part of the story of the CCS system development. What is really needed is a 'W-model' showing all the stages and which entity is responsible for each of them. However, even this can be somewhat simplistic, as it assumes that a single-source supplier is utilised for the complete system (i.e. the same supplier provides all sub-systems and integrates them into a complete system). This is becoming increasingly unlikely on many mainline networks where separate programmes are developed for traffic management and train control technology in order to maximise competition within the supplier market. An operator will then need to integrate them into a complete system on their railway, for which they may contract with a separate system integrator. Thus, there will be multiple generic system V-lifecycles that must be integrated in the specific application V-lifecycle as shown in Figure 4.

Figure 4 – W-cycle for complete CCS development and implementation (multiple supplier sub-systems).



Formal specification of a CCS system

Having identified the needs that a CCS system should meet and embarked on a system design, the next step is to specify the detailed requirements the system and its constituent sub-systems must satisfy. Traditionally such requirements have been specified as plain text through various signalling standards and project specifications.

Plain text is vulnerable to ambiguities. Some of these can be resolved by using modelling languages such as the Unified Modelling Language (UML) and Systems Modelling Language (SysML). However, to remove ambiguities completely, a formal mathematical language is needed. The SafeCap project, in the UK, has been doing just that for signalling principles, as outlined below. SafeCap is a collaboration between SYSTRA Scott Lister and The Formal Route, a company founded to apply academic formal verification expertise to industry.

Starting with a very basic example, that of points deadlocking, we may express the requirement in plain text form along the lines of 'Whenever points are commanded into a new line, all track circuits over those points are clear.' We can attempt to remove some degree of ambiguity by insisting on a certain structure of an informal formulation using the controlled natural language approach. A statement is split into two parts – the conditioning or filtering part and the checking parts. Hence, the point deadlocking could be phrased as:

> '**for every** command to move the points
>
> **it holds that** all the point track sections are checked free'

Expressing this in a machine-readable, first-order logic that can be automatically verified, it becomes that shown in Figure 5.

However, even this relatively simple expression is not quite as straight forward as it might seem. Is the commanded position of the points the internal state within the interlocking memory, or the output sent to the points? Which train detection sections should we check for 'A' and 'B' point ends that are commanded together? Do we consider cases where points are not commanded in either direction, as might occur at interlocking start-up? To avoid ambiguity, each term used in such formal expression must itself be rigorously defined.

Expressing signalling principles in a formal language must also take account of how those principles are implemented. Implementation practices that economise on interlocking computing power can require more complex formal expressions. Take the example of opposing route locking, which could be expressed as a plain text requirement: 'opposing route locking must be free before a route can be set.' In the UK at least, to meet this requirement, interlockings generally do not **directly** check that all opposing route locking is free before setting a route. Instead, they check that the last part of the opposing route locking (that coincides with the route being set) is free and rely on the principle of sequential release of route locking to infer that the rest must also be free. This is illustrated in Figure 6.

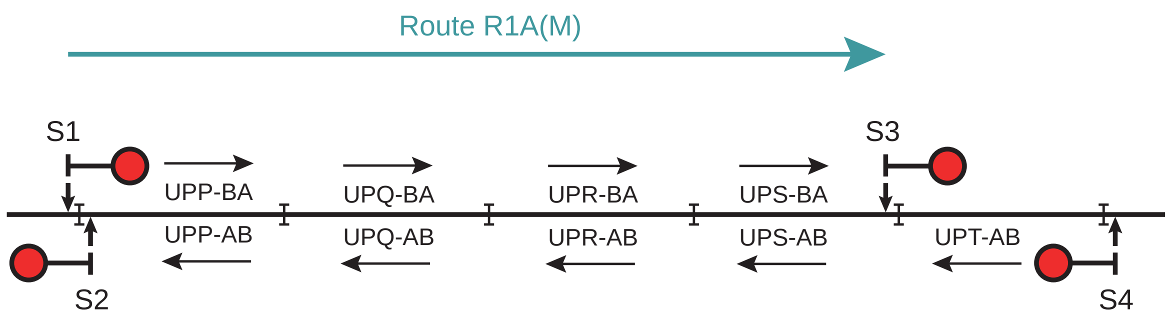
Setting route S1(M) requires four opposing sub-routes to be free (UPP-AB, UPQ-AB, UPR-AB and UPS-AB), however only one sub-route is actually tested to be free: UPP-AB. That UPQ-AB is also free is inferred, because UPP-AB can never be free without UPQ-AB also being free – which must be verified as a separate property (sequential release of locking). Similarly, with UPR-AB and UPS-AB. An apparently simple principle, implemented in an economical way, thus needs to be expressed as multiple formal properties: one concerning the opposing locking that is actually tested; the other concerning the sequential release of that locking.

The situation becomes even more complicated when the state of opposing route locking is inferred by the state of opposing overlap locking. It then also becomes necessary to prove that the opposing overlap locking cannot release (for example by timing out or swinging) before the corresponding opposing route locking.

Figure 5 – The example expressed in a machine-readable, first-order logic that can be automatically verified.

```
forall p:Node                        \ for each node in a layout (referred to here as 'p')
  point_c(p) != point_c'p(p)         \ the previous commanded position of any points
                                     \ associated with that node being different from the
                                     \ current commanded position
  =>                                 \ implies that
PointTracks[{p}]/\track_o == {}      \ none of the train detection sections over those
                                     \ points are occupied
                                     \ ( or more literally that the intersection between
                                     \  the set of train detection sections over the points
                                     \  and the set of occupied train detection sections
                                     \  is empty)
```

Figure 6 – Opposing route locking.



Automation of Design

Automated design tools

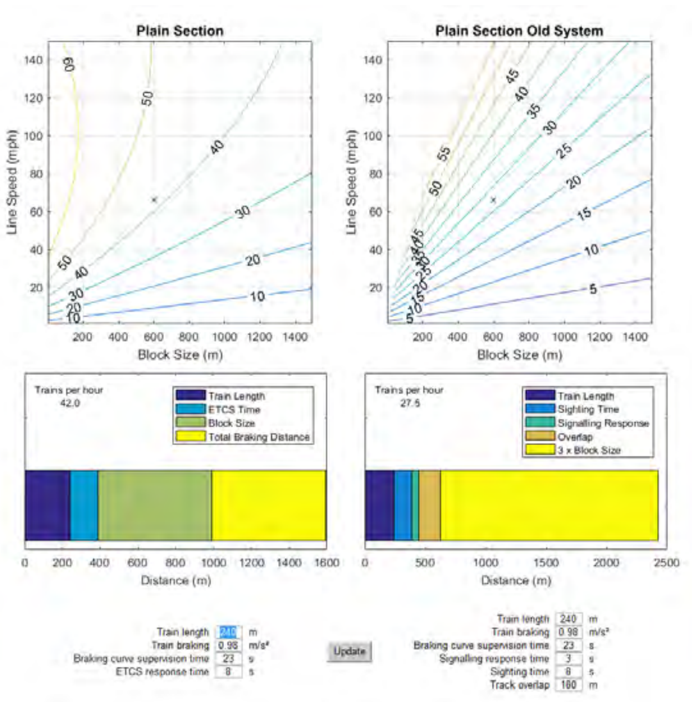
Once the system behaviour has been represented in a computer-based model, one of the exploitations of that modelling is to build automated design tools. These tools can take many different forms and their value can be realised in different ways.

An automated design tool can be considered as a re-usable algorithm that reduces the required manual work of designing a system. This can be as simple as automating repetitive tasks. As the understanding of the system develops, more intelligence can be built into these tools. For example, building a tool to reduce the design space of a system based on known input parameters. This can be extremely beneficial as it reduces the number of options for the system designer to explore, pointing them in the right direction. Models can also be folded into the design process as a validation step, testing for unintended consequences and ruling out poor designs before they are submitted for a costly review. The ultimate design tool in terms of automation is one that fully optimises a system design based on all input criteria. These tools can provide immense value. However, as their complexity increases, so does the obsolescence risk and the configuration time.

In most cases, a middle ground is most appropriate. Using the computer-based model to visualise the performance of a system design and rule out options that do not meet pre-defined criteria. At Frazer-Nash, we created a tool for a major signalling control system supplier that visualised the throughput of trains for a plain section of track under conventional line-side signalling and ETCS L2 paradigms (pictured in Figure 7). This tool allows the designer to easily understand the combination of line speed and block length that gives the desired number of trains per hour, enabling them to focus on more complex areas of the design.

Tools such as this enable a more efficient design process, by allowing options to be identified quickly and design trade-offs to be seen immediately.

Figure 7 – Train throughput model.



Digital signalling plans

The next stage is to provide a more dynamic method of representing the design, as distinct from the traditional 'static' signalling scheme design approach. The conceptual machine-readable representation of a signalling plan is absolutely essential for the automation of various signalling design activities. A signalling plan produced in a vector drawing tool is not conceptual in the sense that it does not preserve high-level information about train detection sections, points etc, but instead distils these into low-level graphical primitives such as lines, curves and arcs.

A conceptual model of a track plan is naturally a graph. Graph nodes could be joints, sections or, for high-level models, sub-routes and even routes. Recovering the conceptual track plan graph from a drawing is typically achieved by manually reconstructing the whole of a track plan in a tool that supports conceptual representation. This is a tedious and time-consuming task.

Machine vision can be used to automate this process, although it is not a simple task. Rasterised track plan drawings are very large images that cannot be processed at once. Furthermore, there is a significant semantic gap between the low-level machine vision toolkit of detection and the classification and the overall goal of constructing a track plan graph. Naive detection of track elements would lead to a very 'noisy' output requiring laborious manual changes.

To bridge this gap, we use a form of recurrent neural network that navigates the track plan drawing along track lines and decodes annotations such as circuit boundaries, signal placements, AWS magnets and so on. In this way, for each linear piece of track it constructs a sentence where "letters" are joints, signals, labels etc., spaces are track segments and every sentence starts and stops at a point branch or edge node. A network learns not only how to recognise boundaries between individual symbols and decoding symbol images but also the structure of a well-formed collection of sentences.

Automation of testing

Once a signalling plan is in machine readable format, as illustrated in Figure 8, it can be used as an input to other automated design tools. Taking machine readable signalling plans, signalling interlocking data and signalling principles expressed in formal notation (as described earlier), the SafeCap project has successfully automated the verification of these principles. Automated tools convert the signalling plans into logical models embodying the relationships between the different elements (train detection sections, points, signals etc.) and interlocking data (in its native format) into a sequence of state transitions conditionally applied to that model. Automated proving tools then verify whether the signalling principles, expressed in formal notation, are upheld for each possible transition state.

A key advantage of this 'symbolic theorem proving' approach to formal verification is that it is highly scalable. Early 'model checking' approaches to formal verification of railway layouts suffered from a problem known as 'state explosion'. As the number of elements in the model grew, so the number of possible combinations of states grew exponentially, limiting the complexity of layouts that could be verified formally. By contrast, symbolic theorem proving analyses state transitions rather than combinations of states. Complexity thus increases in proportion with the number of state transitions so that even complex railway layouts can be, and have been, analysed in a few minutes on a moderately powerful laptop.

Figure 8 – Machine readable signalling layout in SafeCap.

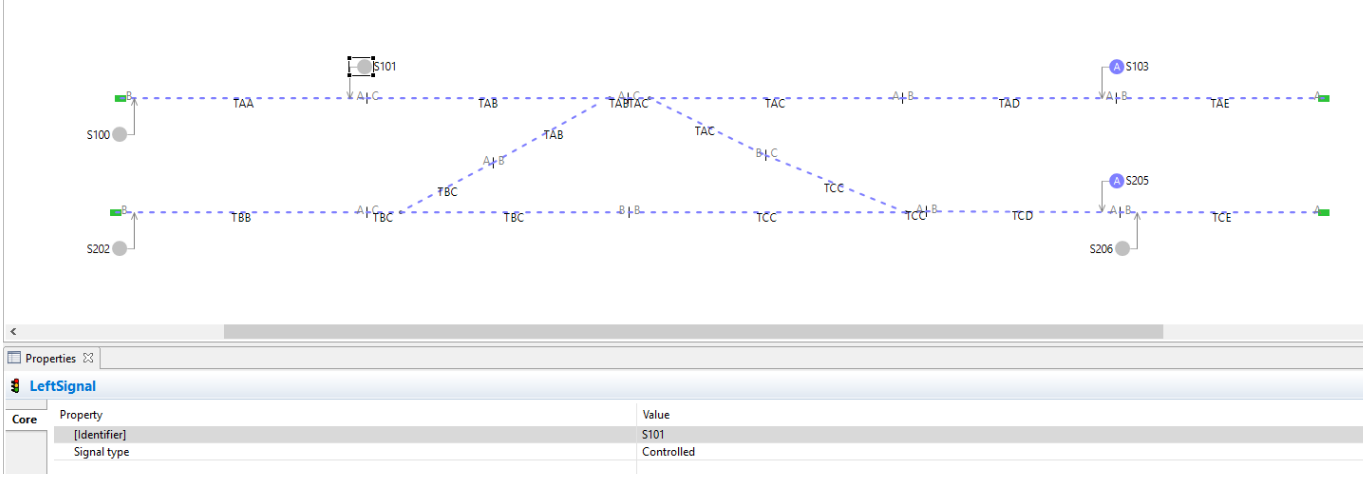
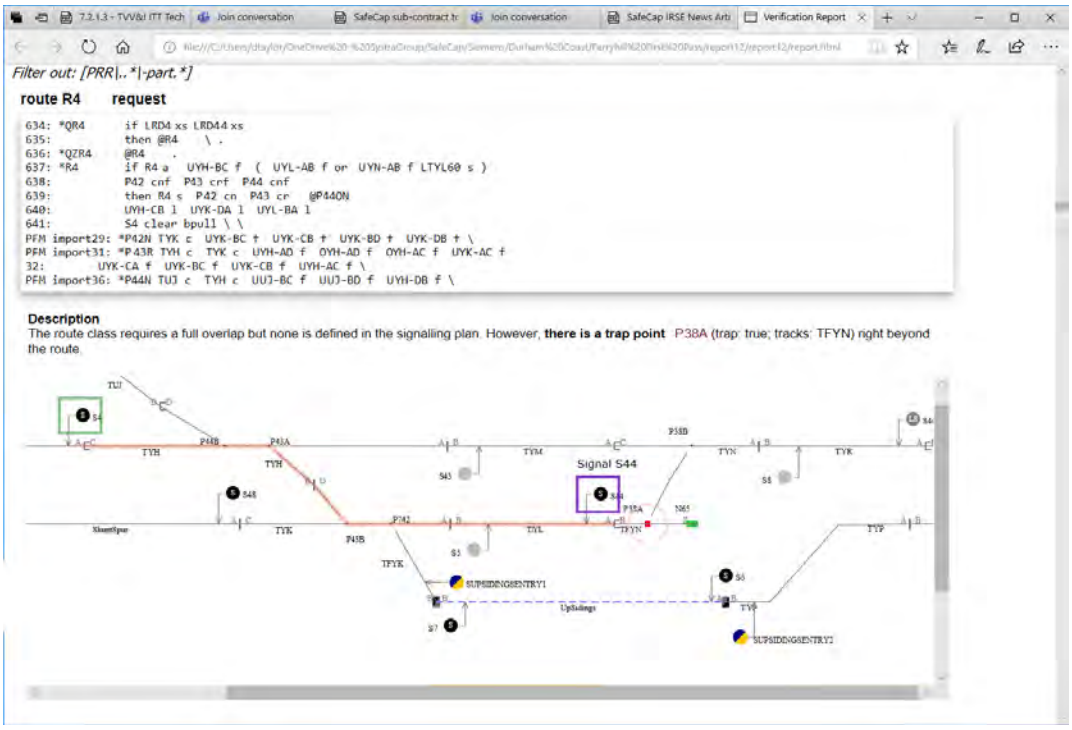


Figure 9 – SafeCap report extract.



The symbolic theorem proving also facilitates identification of the specific point in the state transition system (interlocking data) where the violation of a formal safety property (signalling principle) occurred. SafeCap exploits this using sophisticated algorithms to produce machine readable reports showing where-exactly in the interlocking data violations have been found and which part of the layout this corresponds to. An example of this diagnostic output is given in Figure 9. The example illustrates the case where the SafeCap property that each non-permissive shunt route must have an overlap has been violated. Along with details of where the violation occurred, the SafeCap automated report also proposes a possible explanation – the presence of a trap point beyond the exit signal.

SafeCap is currently being used as a 'set-to-work' automated verification tool to provide an additional level of verification over and above that of traditional manual testing. However, the ability to verify data rapidly and objectively has the potential to deliver much greater benefits. An automated tool used during the data preparation process could ensure errors are identified and removed before data even reaches independent checkers and testers, saving time and money through fewer rework cycles. In the longer term, subject to the development of a supporting safety case, the approach could be used as an alternative to manual checking and testing, thereby greatly reducing data preparation time, testing time and costs.

Summary

In this article we have shown the different nature of modern 'digital' CCS systems compared with their colour light and semaphore predecessors necessitates a 'back to basics' re-evaluation of how they are designed.

Modern CCS systems are dependent on accurate and up-to-date data models of the infrastructure with which they interface. Traditional signalling design has not needed to provide and maintain such models, but BIM, GIS and techniques developed in the oil and gas industry (amongst others) can help us rise to this challenge.

Modern CCS systems are highly complex systems-of-systems, and hence the need to apply rigorous systems engineering approaches is more important than ever. Key to this is identifying at the outset the business needs that a project involving CCS aims to address. Early investment up-front in requirements capture and option development can save significant time and money later, and lead to a much better-quality output.

Use of modelling in the early stages of a project can also help optimise design, reduce risk and enable better evidence-based decision making. Modelling is generally much less expensive than building prototypes or conducting real-world testing, and is easier to verify independently than relying on expert opinion. Key to its successful application is ensuring that models are representative of the real world and that they can be validated. A simple, approximate model with known uncertainties is preferable to an un-validated complex model that inspires false confidence.

As CCS systems become ever more complex and railways become more and more reliant on them for efficient and dependable operations, the use of automated design and testing tools becomes vital for ensuring system delivery in an affordable manner whilst maintaining high standards of safety and performance.

References

Blanchard, BS & Fabrycky, WJ, 2011. Systems Engineering and Analysis. Pearson.

Bourne, A & Clark, G, 2007. Jubilee and Northern Upgrade Project The Challenges of Applying Proven Product to an Existing Railway.

Bruegge, B & Dutoiyt, AH, 2010. Object-Oriented Software Engineering. Prentice Hall.

Faulconbridge, I & Ryan, M, 2014. Systems Engineering Practice. ArgosPress.

Francks, J, Kitchen, D & Taylor, D, 2017 Building Information Modelling, opportunities for the control and signalling industry. IRSE ASPECT Conference 2017.

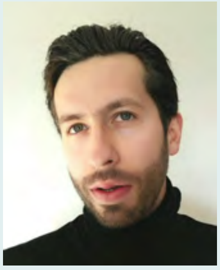
King, KM, 2016. Systems Engineering Framework for Railway Control & Safety Systems. IEEE International Conference on Intelligent Rail Transportation (ICIRT).

INCOSE, 2015. Systems Engineering Handbook A Guide For System Lifecycle Processes And Activities, Fourth Edition. Wiley.

Sharpe, J, Ramdas, V, Fawkner, L & Roberts, C, 2015. Vision Case for Capacity Improvements Woking to Waterloo, A Whole System Approach to the Identification of Key Technologies.

About the authors ...

Dominic Taylor is the technical head of Systems and Signalling at SYSTRA Scott Lister. He has fifteen years' railway signalling experience with a focus on the introduction of new technologies into the sector including formal verification, ETCS, traffic management, video surveying and novel data management techniques.



Alexei Iliasov is a director and founder of The Formal Route and a visiting fellow at Newcastle University. He is interest is in applying formal methods to modelling and verification of signalling and railways in general.

Karl King is Frazer-Nash's CCS systems engineering lead responsible for the development and integration of systems including ERTMS & CBTC, leading the integration for programmes including Cambrian ERTMS Early Deployment Scheme and the Victoria Line Upgrade. He has also carried out academic research earning a Master of Research degree into developing a Systems Engineering Framework for CCS Systems.

Oliver Jarratt is a senior consultant within Frazer-Nash's Data Science and Systems group, specialising in geographic information systems and information management. Oliver has a background in the transport, geospatial, energy and civil engineering sectors, specialising in geospatial solution architecture for enterprise-scale solutions.

Silas Benson is a senior member of Frazer-Nash's AI & Analytics group and is responsible for leading delivery of bespoke software tools to clients in the Transport, Energy and Defence sectors. Silas' has expertise in developing rapid prototype models using Python and is an advocate for incorporating software engineering best practice from the DevOps and Agile movements into traditional engineering environments.

William Dearman is a consultant in the Mathematical Modelling group at Frazer-Nash. William specialises in simulation and developing computer-based models of real-world systems. William has worked on projects across multiple business sectors including Nuclear de-fuelling, army fleet logistics planning, railway signalling and infrastructure cost modelling.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

New signalling system for Saint Martin Line Viaduct

Argentina: Working for Autopistas Urbanas (AUSA), Alstom has provided a new signalling system in the renovated Saint Martin Line Viaduct area in Buenos Aires, for 6km of new track between the Palermo and Villa del Parque stations. Testing, validation and commissioning was successfully carried out while the Covid-19 related restrictions were in place. The new system is compatible with the future electrification of the San Martin Line.

UK's most operationally challenging railway junction

UK: Network Rail most challenging flat railway junction, located to the north of East Croydon station, regularly cause delays to the 1700 trains each weekday as trains often need to stop to allow others to pass in front of them. This creates a bottleneck that amplifies delays on the Brighton Main Line, its branches and the wider network.

Network Rail is proposing to replace the flat junctions with new viaducts, bridges and dive-unders to separate the tracks, creating clear routes for trains, which would result in a significant boost in service reliability. The proposals also include plans for an expanded and enhanced East Croydon station including two new platforms to ensure incoming trains would no longer queue outside the station for a platform to become available. The upgraded station would also include new escalators and lifts to improve accessibility.

The expansion of the railway to allow the new platforms at East Croydon station also means that Windmill Bridge (north of the station) would need to be rebuilt to increase its span to provide space for three additional tracks underneath. A video to explain the project can be seen at **irse.info/9scwt** and the work could begin in 2023.

Croydon, the UK's most operationally challenging flat junction.

Western Australia's top Engineering Excellence Award winner

Australia: The AutoHaul® autonomous railway system has been announced as Western Australia's top Engineering Excellence Award winner and Sir William Hudson Award finalist. Described by Rio Tinto as the world's largest robot, AutoHaul® is the first fully autonomous heavy haul railway system in the world. Trains up to 2.5km long travel driverless across the world's largest privately-owned rail network.

The Australian Engineering Excellence Awards (AEEA) recognise Australia's top engineering projects and the engineering teams behind them. Projects from each of Engineers Australia's nine divisions are selected to win an AEEA. One winner from each division is also selected as a finalist for the Sir William Hudson Award – the highest honour for a project awarded by Engineers Australia.

The AutoHaul® project started automation studies in 2006, with driverless operation commencing over two years ago, and which now runs almost 90% of all services. Developed by Rio Tinto and Hitachi Rail STS, the solution is based on the digital radio-based signal and train protection system ATO over ETCS Level 2 (GoA4) which provides fully automated train operation.

Each locomotive is installed with an onboard driver module which generates automatic reports on the exact position, speed and direction of travel via IP communication to a central control centre in Perth, more than 1500km away.

Core Valley Lines Transformation programme

Wales, UK: Siemens Mobility Limited has secured a three-year contract from Transport for Wales as part of the Core Valley Lines Transformation programme. The project will cover the renewal and replacement of lineside signalling infrastructure, as well as the creation of a new integrated control centre.

On completion the project will improve the railway for the 1.5 million people who live and work in the Cardiff Capital Region with improved journey times and increased train frequency (from two trains per hour to four) on each of the Core Valley Line routes. From a depot at Treforest, Siemens will be working with Transport for Wales, KeolisAmey Wales, Balfour Beatty plc and Alun Griffiths (Contractors) Ltd to deliver the project, which will include 50 new signals, over 300 axle counter sections and 98 signalling location cases.

Stuttgart digitalised rail hub

Germany: The federal Ministry for Transport and Digital Infrastructure (BMVI) and Deutsche Bahn have announced a €462m (£422m, $543m) plan for a 'digitalised rail hub' in Stuttgart. Scheduled to open in 2025, the hub will provide all stations and approximately 100km of track with ETCS control and high specification ATO systems.

The Stuttgart project is one of three pilot projects in the Starter Package Digital Rail Germany scheme. The other projects involve the Cologne – Frankfurt Rhine-Main high-speed line and the TEN-T Scandinavia-Mediterranean corridor.

JR East's capital investment

Japan: East Japan Railway (JR East) has announced Yen 711bn (£5.3bn, €5.7bn, $6.8bn) infrastructure investment in 2020, although this is down by Yen 30bn (£220m, €240m, $290m) from 2019, as a result of the Covid-19 pandemic dropping revenue.

The investment will include installing obstacle detection equipment at level crossings, expanding the installation of operating safety devices and countermeasures to deal with large earthquakes. Platform screen doors will be installed at Tokyo station and additional CCTV cameras will be installed alongside upgrades to fences and other security measures around stations, on trains and along tracks. Stations will be improved with better passenger information displays, to make stations easier to navigate.

JR East also plans to implement innovations to change the way staff work and improve productivity, including more one-person operation. The amount of information available through the existing JR East app will be increased and the company is also developing a "Ringo Pass" Mobility as a Service (MaaS) app.

"Ringo Pass" is a smartphone app designed for implementing MaaS services in a city. It will include an authentication function and technical verification in the MaaS field using Near-Field-Communication (NFC) reader/writer mode and NFC tags.

New joint venture for ETCS onboard equipment

Belgium: A joint venture involving ERTMS Solutions and freight operator Lineas called TSC is developing ETCS onboard equipment for the operator's fleet of Class 77 diesel locomotives. It also hopes to market it to other fleet owners. TCS is now working with the Try & Cert collaboration of Laboratoire ERTMS France and notified bodies Certifer and Belgorail, for the first accredited laboratory to support 'software in the loop' testing using ERTMS interoperability test sequences specified in Subset 076.

The use of a cloud-based testing approach is said to avoid the need to send ETCS onboard hardware to a dedicated laboratory. TSC anticipates that continuous integration with 24/7 testing 365 days a year will enable the identification of interoperability issues earlier and speed up the baseline upgrade process, to save time and not involve a large team of engineers. The continuous integration testing of the TSC "ETCS Onboard" is expected to run until 2022 and will be followed by certification tests in 2022-23. TSC plans to offer a fixed price for future baseline changes, so that railway operators will know how much it will cost to keep their systems up to date.

New on-board signalling equipment for Infrabel locomotives

Belgium: Alstom has been awarded a contract by Belgian National Railways (SNCB) to supply and commission TBL1+ and ETCS level 1 & 2 signalling equipment on 23 type HLD77 locomotives, with an option to equip five further locomotives.

Alstom's centre in Charleroi, Belgium will deliver and maintain the equipment for five years after the warranty period. Installation will be carried out by SNCB in five of their workshops.

Completion of Weaver to Wavertree re signalling

UK: Over the late summer bank holiday weekend Ditton Re-control, the final stage of the Weaver to Wavertree re-signalling project near Liverpool, was signed into service at 23:45 on 31 August. This involved moving control of the railway from Ditton to a Siemens Controlguide Westcad workstation at the Manchester Rail Operating Centre (MROC).

Over 76 hours the team decommissioned the control panel at Ditton Power Signal Box and connected the Ditton and Halewood SSI interlockings to MROC via a remote interface. The work involved updating the interlockings to provide new functionality, altering the train describer, along with several signalling changes. For a report on the previous stages of the Weaver to Wavertree resignalling project see **irse.info/ylzhw**.

City railways and light rail

Automated train operation tested in Moscow

Russia: Following further successful tests with an Lastochka electric multiple-unit in August, Russian Railways (RZD) say Automatic Train Operation (ATO) could be introduced on the 54km Moscow Central Ring line in 2021. Trains would run under Grade of Automation (GoA) 2, with a driver in the cab to monitor operations. The trials have been carried out at Cherkizovo station and tested the train's response to emergency situations including obstacles on the track.

RZD launched its ATO project in 2017, with three shunting locomotives being equipped with sensors, cameras, radars and Lidar. The first self-driving train with a Sinara/Siemens ES2G Lastochka trainset fitted with a machine vision system was tested at RZD's Shcherbinka test site in August 2019.

Sydney Metro appoints Ricardo as shadow operator

Australia: Sydney Metro has appointed Ricardo supported by Seoul Metro as the shadow operator for the Sydney Metro West and Western Sydney Airport link expansion projects. Sydney Metro West is a planned 25km underground line from an interchange in the city's Central Business District (CBD) to Westmead. The Western Sydney Airport link is a north-south 23km line which will connect St Mary's suburban line station, via Orchard Hills, Luddenham, the airport terminal and airport business park, and the Western Sydney Aerotropolis.

Both lines will be fully automated, in line with the existing Sydney Metro network which operates to a GoA4 standard with CBTC. Ricardo will be responsible for providing advice and technical input from the viewpoint of prospective operations and maintenance contractors for the projects, and will support the handover once an operator is formally chosen. Seoul Metro will support Ricardo by providing insight into the day-to-day operation of a fully automated railway.

Early engagement with an operator is an essential element of working towards a successful high-performance railway. The objective is to create diversity for the network after the first metro line in Sydney was heavily influenced by Hong Kong's metro operator MTR.

Sydney traffic management

Australia: The government of New South Wales has awarded Siemens Mobility a A$80m (£44m, €49m, $58m) contract to supply a Traffic Management System (TMS) covering Sydney Trains operations with completion planned for 2023. The TMS forms part of Transport for NSW's More Trains, More Services programme of investment in the Sydney Trains network.

The Digital Systems programme also includes replacing trackside signalling equipment with ETCS Level 2 and implementing automatic train operation to provide faster and more consistent journey times. In 2018 the state government awarded Network Rail Consulting a A$16m (£9m, €10m, $12m) System Integrator contract for the programme. Digital Systems will initially be deployed to two sections of Line T4 from Sutherland to Cronulla and from Bondi Junction to Redfern. Future deployments on other parts of the Sydney rail network are in the planning stage.

Zhengzhou Metro Line 6

China: Thales SEC Transport (TST), Thales' joint venture in China, will provide its TSTCBTC ®2.0 signalling system for the Zhengzhou Metro Line 6 phase 1 project. The system has already been deployed on the Shanghai Metro Line 5 and Line 14 projects.

The Zhengzhou Line 6 phase 1 project is one of the key projects in the city's urban rail transit construction, which will significantly enhance the urban mobility. The line runs from Jiayu Town station to Xiaoying station, with a total operational length of 39.2km (2.8km elevated, 36.4km underground), serving 26 stations (one elevated and 25 underground), and includes nine interchange stations.

The TSTCBTC ®2.0 is a signalling system developed by TST. With a dual CBTC (Communication Based Train Control) architecture, the system aims to achieve a high level of redundancy and availability, to significantly simplify wayside equipment and reduce life cycle costs. TST was established in 2011 by Thales and Shanghai Electric Group.

New chief executive of UK Light Rail Safety and Standards Board

UK: Carl Williams has been appointed as the new chief executive of the Light Rail Safety and Standards Board; the organisation responsible for safety standards across the UK's light rail sector.

Carl is currently director of operations at West Midlands Metro and previously held senior positions at Keolis UK, Manchester Metrolink and Sheffield Supertram. He was a project manager on the NET Phase II extension project in Nottingham and was also managing director of operations and maintenance company Transdev Edinburgh.

New communication systems for Movia metro

Singapore: Land Transport Authority (LTA) has awarded a contract to Bombardier Transportation to upgrade the communication systems on the Downtown (DTL) metro line's 92 three-car units, delivered between 2013 and 2017.

Bombardier will deliver and install their Train Control Monitoring System (TCMS) and an Automatic Track Inspection (ATI) system software update to improve the performance of the system. The contract also includes upgrading the Dynamic Route Map Display (DRMD), along with other communication systems.

Communication and radio

5G conspiracy health implications

UK: The government has published a guide for 5G masts, intended to stem the conspiracy theories surrounding possible health implications. While the spectrum used by 5G networks is considered to be well within safe limits the last few months have seen 5G conspiracies on social media platforms, including theories that the coronavirus epidemic could be linked to the new networks in some way. This led to people vandalising 5G masts.

The information pamphlet, '5G Mobile Technology: A Guide', see irse.info/y0p1b, explains how 5G works and states that regulator Ofcom found the RF emission readings taken from the masts are "a small fraction" of the amount permitted by the International Commission for Non-Ionising Radiation Protection (ICNIRP).

Passenger Information Improvement Plan (PIIP)

UK: The Office of Rail and Road (ORR) has called for passengers to have effective advice and reassurance during disruption, with clear and reliable information, which is consistent across the network. In response the rail industry has created a strategy and plan, the Passenger Information Improvement Plan (PIIP) to improve passenger information particularly during disruption.

The PIIP comprises 13 work packages designed to provide passengers and staff with timely, accurate and more complete information. Funding of £7m (€7.7m, $9m) has also been agreed to redevelop the National Rail Enquiries website to improve the quality of information provided, and the enhancement of a personalised information tool to provide proactive alerts regarding crowding and information on social distancing.

The ORR is also working with the industry to develop a new way to drive continuous improvement in delivering customer information. A Customer Information Measure (CIM) will allow management of passenger information by individual train companies to be assessed; identify areas for improvement and provide a benchmark for comparison. Two train operators, Cross Country and LNER, working with Network Rail are undertaking pilot assessments using the CIM.

Record 178Tbps telecoms fibre speed

UK: The Optical Networks division of University College London (UCL) have achieved a record single core, single mode fibre throughput (net) speed of 178.08 Terabits per second over a distance of 40km, using experimental "hybrid discrete Raman and rare-earth doped fibre amplifiers" and a continuous, ultra-wideband (16.83THz) transmission window.

It is unlikely that this sort of speed will be delivered, or required, for railways any time soon, but the ability to carry more data down existing fibre cables tends to result in cheaper capacity from suppliers, which ultimately benefits everybody in business and society.

Rail connectivity outlook 2020

UK: Early in 2020, BAI Communications surveyed more than 2400 rail users in five global cities: Hong Kong, London, New York City, Sydney and Toronto. Respondents were asked how they saw transport and connectivity, and its role in the future of their city.

The key findings discussed in the report include that demand for wireless services will continue to grow. Commuters will benefit from faster and more reliable connectivity, while transit authorities and operators will be able to host more concurrent connections, deploy more sensors, and improve data analytics. Personalised services for transport users can provide an enhanced experience. Four out of five rail users are comfortable with their anonymised data being used to improve transport systems. Opportunities include streamlined inter-modal transfers, access information provided to passengers with special needs and advice on optimal seating locations based on occupancy levels.

BAI conclude that rail users are ready for technology to play a more significant role in their lives. Connectivity infrastructure should not only extend to provide seamless connectivity, it should also redefine how citizens interact with their city. The report can be found at irse.info/c9i2q.

Safety, standards, health and wellbeing

Rail still safer than road during Covid-19

UK: Analysis by RSSB, the rail safety body for Great Britain, has shown the risk of contracting Covid-19 while travelling by train is about 1 in 11000 journeys. This is equivalent to a chance of less than 0.01%, based on an hour-long train journey in a carriage with no social distancing or face coverings. On safety alone, for an individual traveller per kilometre travelled, the car is 25 times less safe than rail. Cycling is 403 times, walking is 456 times, and travelling by motorcycle is 1620 times less safe.

When the effect of the virus is considered and compared against the average road safety risk, the risks are almost the same (road is 1.14 times the risk of rail). The infection risk findings have now been published by RSSB and verified by the chief scientific adviser at Department for Transport in collaboration with the Defence Science and Technology Laboratory. See irse.info/k3qv5.

Stonehaven derailment interim report

UK: Following the derailment of a passenger train near Carmont in Scotland on 12 August 2020 an interim report has been published. This suggests that a significant contributing factor to the derailment was heavy rainfall washing material onto the track. See irse.info/r0yk5.

The report does not pre-empt the outcome of formal independent investigations, but examines the immediate facts from the Carmont derailment, current asset and operational controls, short term improvements, longer term strategic sustainability, financial facts, and sets out some next steps. Among the items mentioned is technology to monitor similar events and improve warnings to trains.

Revised standards for professional engineering competence and commitment

UK: The Engineering Council (EC) the UK regulatory body for the engineering profession, holds the national Register of Engineering Technicians (EngTech), Incorporated Engineers (IEng), Chartered Engineers (CEng) and Information and Communication Technology Technicians (ICTTech). It also sets and maintains the internationally recognised standards of competence and ethics that govern the award and retention of these titles.

The EC has published new editions of the standards for professional engineering competence and commitment. This follows completion of the five-yearly standards review process, a wide-ranging consultation with stakeholders, including registrants, professional engineering institutions (PEIs) – such as the IRSE, employers, education providers and the general public.

The overall approach in redrafting the Standard for Professional Engineering Competence and Commitment (UK-SPEC) was to aim for greater clarity, making the requirements more obvious, while providing better examples of how applicants might provide evidence of having met the standard. An emphasis has been placed on accessible language, clarity of structure and internal consistency with other standards documents. No competences have been added or removed to the fourth edition of UK-SPEC.

The standards will be implemented by 31 December 2021 and all current and revised EC standards are available on the website at irse.info/xl0ra.

Surveying and civil engineering

New high-quality imagery survey

UK: Network Rail has teamed up with Fugro, a Geo-data specialist Network to introduce what they claim is a new innovative way of inspecting a railway using high-quality imagery across west London, the Thames Valley, the west and south west, as part of plans to reduce delays for passengers and improve safety for staff. The system was used successfully on the Wales route in 2019 and captures high quality images of thousands of track miles to millimetre accuracy for analysis.

The trial is being funded with a £394K (€440K, $520K) grant from the Department for Transport through the First of a Kind 2020 (FOAK2020) programme, managed by Innovate UK.

The imagery measures absolute track position, track geometry and the wider rail corridor and they say will enable any faults on the railway to be detected sooner. The imagery survey, known as a Rail Infrastructure Alignment Acquisition (RILA), will capture 97% of Network Rail's Western route, which runs from Paddington to Penzance and to the Welsh border, providing an almost complete view of the network to levels of accuracy that have never been experienced before.

Research & Development and Universities

Partnership for Rail Research and Innovation

Europe: The European Commission (EC) has invited comments to support a proposal for the creation of a European Partnership for Rail Research and Innovation to build on the work done by Shift2Rail. The new partnership will look at accelerating research, development and demonstrations of technologies and solutions to make rail a more attractive mode of transport, enabled by digitalisation and automation. The Commission hopes that the partnership will achieve up to 75% market uptake by 2030 to improve competitiveness and European leadership for rail technology.

The EC says the new partnership will have a long-term commitment from the European Union and its members "to deliver system-focused solutions ready to enter industrialisation, deployment and operation." And will "focus on accelerating research, development and demonstrations of innovative technologies and operational solutions to make rail more attractive, enabled by digitalisation and automation".

The core membership will comprise around 20 organisations representing infrastructure managers, passenger and freight operators, train builders, signalling and infrastructure equipment manufacturers, ICT solutions providers for ticketing and data, and rail research centres. Members will be expected to contribute about €30m (£27m, $36m) each, of which 5% will go towards running costs. The partnership will also be able to access various European programmes such as the Connecting Europe Facility, Digital Europe Plan, European Regional Development Fund and the Cohesion Fund to fund programmes and projects.

Companies and products

VisioStack receives SBIR Grants

USA: The US Department of Transportation has awarded Greenville, South Carolina based VisioStack, Inc phase I and II SBIR (Small Business Innovation Research) grants for two projects to improve traffic and pedestrian safety at level crossings. Both projects will help identify crossings that pose a risk to traffic and prioritise planned improvements.

The phase I project involves creating an autonomous system that can assess key assets at crossings using VisioStack's RailLinks® FFV (forward-facing video). This will include determining whether crossing gates are functional and if key signage, such as warning signs and stop signs, are present.

The phase II project involves VisioStack's AXIS (Aerial Crossing Inspection System), described as "an innovative highway-rail grade crossing inspection system" that uses UAVs (Unmanned Aerial Vehicles) and machine learning to undertake crossing inspections.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE

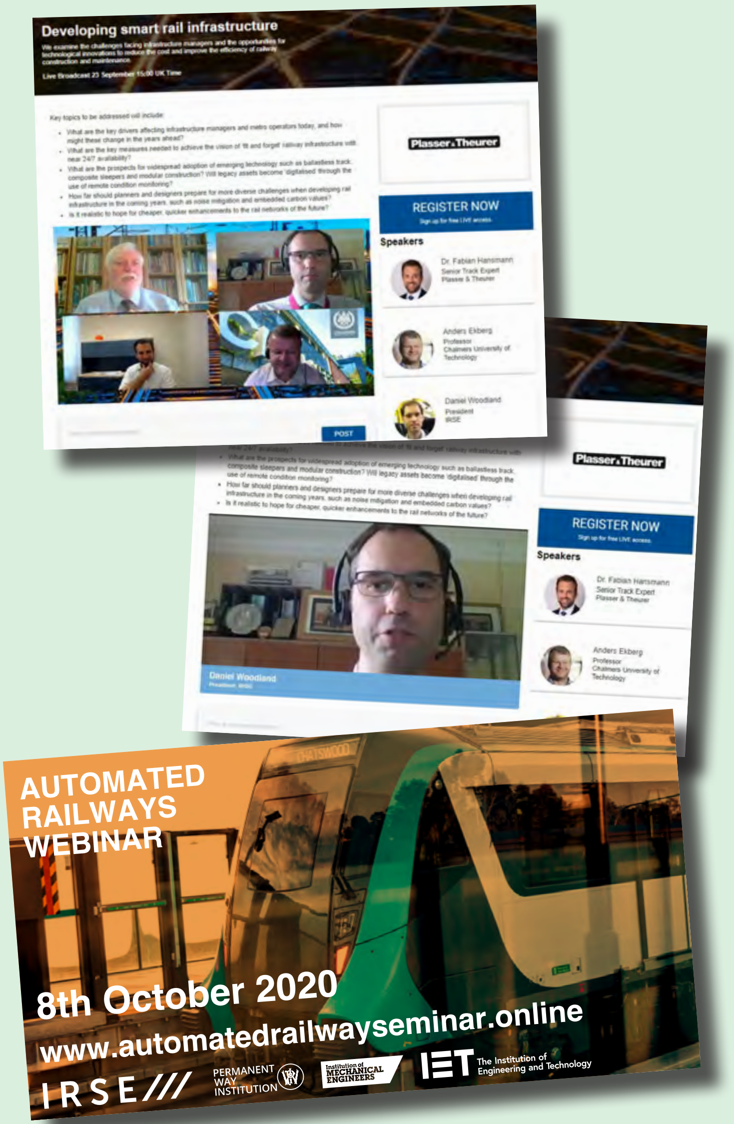
IRSE Online

As the world continues to face challenges presented by the Covid-19 pandemic, the IRSE has been busy ensuring its voice is heard, with an enhanced on-line presence within the industry.

Our president Dr Daniel Woodland was the driving force behind the recent highly successful collaboration with three other professional engineering institutions: the IET, PWI and IMechE to deliver the first ever paid-for interactive webinar on automated railways. Screenshots from the event are shown to the right.

The event gave subscribers exclusive online access to 17 pre-recorded technical presentations and case studies and the opportunity to join in two live Q&A discussions with the key presenters held on 17 September and 8 October. We're delighted to report that over 200 people signed up for the seminar generating income for the IRSE and demonstrating that online events are a viable way forward for us.

Paid access to the entire content from the Rail Automation Seminar and the two Q & A sessions is available via **www.automatedrailwayseminar.online**.



Rail Broadcast Week

The Railway Gazette Group, one of the industry's leading media organisations, held its first online conference in September and once again our president Daniel Woodland stepped up to represent the signal and telecommunications side of our industry. He was a panellist for the session held on "Developing smart rail infrastructure". He was joined by Dr Fabian Hansmann, senior track expert from Plasser & Theurer, Professor Anders Ekberg from Chalmers University of Technology and Chris Jackson, editor in chief of Railway Gazette International, to examine the challenges facing infrastructure managers and the opportunities for technological innovations to reduce the cost and improve the efficiency of railway construction and maintenance.

IRSE Professional Examination

In another 'first' since being introduced in 1946, the 2020 Professional Exams took place online last month. Determined not to disappoint the candidates who had been studying hard, in just three short months, we did what few other examination boards have done – transformed the delivery of this year's exam from a traditional pen and paper, physical exam to be fully online.

As time went on it had become clear to the Educational and Professional Development (E & PD) committee that it would not be possible for delegates and invigilators in ten different countries cross the world, each at different stages of the virus and with their own social distancing rules, to physically attend one of the original 29 examination centres.

It took a phenomenal effort by our small head office team and loyal volunteer members serving on the committee to produce a digital version of the exam and identify robust software capable of delivering the examination without compromising its academic integrity. We'd like to thank everyone involved and of course wish the candidates every success.

Council nominations

A reminder that the deadline for nominating a member to be elected to Council is the end of this month. Following the resounding success of last year's elections when we received the highest number of nominations in the Institution's history, we have once again engaged the specialist services of CIVICA Election Services to assist us with this process. If you are a corporate member of the IRSE, you will have received an email from CIVICA attaching the nomination form. If you would like to submit a nomination please do so as soon as possible. For a copy of the form, please email **hilary.cohen@irse.org** or visit the IRSE website at **irse.info/membership**.

Professional development

Engineering Council registration

Paul Darlington

Professional registration provides a benchmark through which the public, employers and their clients can have confidence and trust that registered engineers and technicians have met globally recognised professional standards. To achieve registration an applicant's competence and commitment is independently and thoroughly assessed by their peers. Professional registration therefore underpins the systems and processes that ensure the current and future safeguarding of society.

Professionally registered status shows employers that you are committed to maintaining and enhancing the knowledge, skills and competence required to meet the engineering and technological needs of today. The prestige of your title will improve your CV and may lead to wider employment options, career progression and promotion.

Average salaries amongst professionally registered respondents are higher in every industry sector and at every level of seniority. The Engineering Council's survey of professionally registered engineers and technicians regularly indicates that those holding the titles EngTech, IEng, CEng continue to benefit from pay increases above the national average. Employing professional registered engineers brings benefits to employers, such as increased customer confidence. This can help them to win more contracts, in turn improving profits.

Professional registration demonstrates your commitment to professional standards, and to developing and enhancing your competence. Your title proves that you have a positive attitude and the drive to succeed within the engineering profession. These are attributes that are highly valued by employers and customers. It shows that you will work safely in a way that contributes to sustainable development and that you have committed to complying with codes of conduct.

The UK Standard for Professional Engineering Competence (UK-SPEC), against which individuals are assessed for EngTech, IEng or CEng registration, is well respected across the world. The Engineering Council also works with many international engineering organisations to promote recognition of the standard and titles overseas. This helps to facilitate the international mobility of professionally registered engineers and technicians.

The UK Passport list of occupations for a counter signatory includes 'engineer – with professional qualifications'. This is the document referenced by the Joint Money Laundering Steering Group (JMSLG) when defining an 'appropriate person' to certify copy documents used as proof of identity where business is not carried out face-to-face. Therefore, professionally registered engineers are accepted as certifiers of documentary evidence of customer identity, as may be required to open a bank account for example.

Becoming registered by the IRSE

There are two stages to registration: Interim, relating to academic qualification/underpinning knowledge; and Final, which relates to the ability to perform specific competences and the commitment to maintain them.

Engineering Council registration is open to all IRSE members, but before deciding to apply, you should first consider the definitions of each of the three grades of registration and the exemplifying qualifications.

Engineering Technician (EngTech)

Engineering Technicians apply proven techniques and procedures to the solution of practical engineering problems. They are required to apply safe systems of work and to demonstrate:

- Evidence of their contribution to either the design, development, manufacture, commissioning, decommissioning, operation or maintenance of products, equipment, processes or services.
- Supervisory or technical responsibility.
- Effective interpersonal skills in communicating technical matters.
- Commitment to professional engineering values.

Standard Route qualifications for EngTech are an Advanced/ Modern Apprenticeship or other work-based learning programme approved by a licensed professional engineering institution, or a qualification, approved by a licensed professional engineering institution, in engineering or construction set at level 3 (or above) in the Qualifications and Credit Framework/National Qualifications Framework† for England and Northern Ireland; or at 04.19 2 level 6 (or above) in the Scottish Credit and Qualifications Framework or at level 3 (or above) in the Credit and Qualifications Framework for Wales or equivalent qualifications approved by a licensed professional engineering institution. For examples of some of the IRSE 'EngTech ready' licences, see **irse.info/licensing**.

Many potential Engineering Technicians have not had the advantage of formal training but are able to demonstrate that they have acquired the necessary competence through substantial working experience. Thus, individuals without the types of qualifications described above may apply for an Individual Route assessment. This process includes assessment of prior learning and of current performance. Evidence of employer recognition of competences and relevant skills may be helpful.

Incorporated Engineer (IEng)

Incorporated Engineers maintain and manage applications of current and developing technology, and may undertake engineering design, development, manufacture, construction and operation. They are required to demonstrate:

- The theoretical knowledge to solve problems in developed technologies using well proven analytical techniques.
- Successful application of their knowledge to deliver engineering projects or services using established technologies and methods.
- Responsibility for project and financial planning and management together with some responsibility for leading and developing other professional staff.
- Effective interpersonal skills in communicating technical matters.
- Commitment to professional engineering values.

Standard Route qualifications for IEng are an accredited Bachelor's or honours degree in engineering or technology, or a Higher National Diploma or a Foundation Degree in engineering or technology, plus appropriate further learning to degree level, or an NVQ4 or SVQ4 which has been approved for the purpose by a licensed professional engineering institution, plus appropriate further learning to degree level.

Appropriate learning includes passing the full IRSE professional examination. Further details of qualification levels and higher education reference points can be found at **irse.info/sa5q8**.

Chartered Engineer (CEng)

Chartered Engineers develop solutions to engineering problems using new or existing technologies, through innovation, creativity and change and/or have technical accountability for complex systems with significant levels of risk. Chartered Engineers are required to demonstrate:

- The theoretical knowledge to solve problems in new technologies and develop new analytical techniques.
- Successful application of the knowledge to deliver innovative products and services and/or take technical responsibility for complex engineering systems.
- Accountability for project, finance and personnel management and managing trade-offs between technical and socio-economic factors.
- Skill sets necessary to develop other technical staff.
- Effective interpersonal skills in communicating technical matters.

Standard Route qualifications for CEng are an accredited Bachelor's degree with honours in engineering or technology, plus either an appropriate Master's degree or Engineering Doctorate (EngD) accredited by a professional engineering institution, or appropriate further learning to Master's level; or an accredited integrated MEng degree.

Appropriate learning includes passing the full IRSE professional examination. Further details of qualification levels and higher education reference points can be found at **irse.info/sa5q8**. If you have other qualifications which do not fulfil the Standard Route criteria, or none at all, but can demonstrate competence and commitment to the appropriate depth and level through your work experience, then you can be assessed by the Individual Route.

The Final stage competences which form the standard for each of the three registration grades are defined in the Engineering Council document UK-SPEC V3, accessed via **irse.info/7i0op**.

To apply for Professional Registration, we ask you to complete and return the 'Initial application for Engineering Council registration form' **irse.info/fowjs**. This will enable us to determine whether you already meet the Interim stage (i.e. underpinning knowledge) requirements for registration. If you do, we will then send you a Summary of Evidence Report form to complete. This form lists all the competences required for Final stage registration. If you do not hold the exemplifying qualifications for Interim stage registration, we will assess your career history and education and training record and then advise you of the alternative routes.

Part of the process of CEng and IEng Final registration involves a Professional Review Interview (PRI) with trained members of the IRSE who will also hold CEng/IEng. An Engineering Council representative may also attend the interview as an observer.

Once you have submitted your completed Summary of Evidence Report form, it will be assessed and if it appears to contain all the appropriate information, a PRI will be arranged. During the interview you will be able to discuss your Summary of Evidence Report and any relevant aspects of your work. After the interview, a report is submitted to IRSE's Membership Committee after which you will be notified of the outcome. We then notify the Engineering Council of those applicants who were successful, and they will then provide a certificate confirming registration. Those applying for EngTech registration do not normally undertake a PRI. As a Final stage registrant, you would be able to use the appropriate designatory letters after your name (EngTech, IEng or CEng).

In straightforward cases, the process could be completed in around twelve weeks, but this usually depends on how quickly you are able to complete and return your Summary of Evidence Report form. Once we notify the Engineering Council, we would expect them to confirm your registration within a reasonable timeframe. To see details of the Engineering Council's annual fees, please follow this link **irse.info/icz36**.

A new, fourth version, of UK-SPEC was published on 29 August 2020 and will be implemented by 31 December 2021. The new V4 version does not change the registration requirements, but provides greater clarity, making the requirements more obvious, while providing better examples of how applicants might provide evidence of having met the standard. Other changes include 'Recognised Qualifications' and 'Individual Assessment' replacing 'Standard Route' and 'Individual Route', to convey that both routes are equal in status.

Once you have studied the requirements for professional registration, just complete the "Initial application for Engineering Council registration" and email to **caterina.indolenti@irse.org** with the relevant accompanying information. We will then get back to you as soon as we can to advise you of the next step.

What do you think?

What is your experience of professional registration via the IRSE? We would love to hear from engineers who have been through the process. Let us know at **editor@irsenews.co.uk**.

Past lives: Raymond Leonard Weedon

Known as Ray to thousands of IRSE members throughout the world during and after his time as honorary general secretary of the Institution, Raymond Leonard Weedon, aged 90, died on 10 September 2020 in hospital in Torbay, Devon, UK after a serious fall earlier this year.

He was born in Reading on 18 October 1929, one of a large family, the son of Ray, a car mechanic at Cowley and Violet Weedon (née Manning), although he was brought up with his step-father, Bill Thatcher, when his mother remarried. His introduction to the IRSE came in 1958 when at that time he was employed as a junior clerk in the office of the British Railway Board's chief S&T engineer. He was approached by J F H (Jack) Tyler, the Institution's president that year, who suggested it would be in his interests to take over the 'part time' role as the IRSE's honorary general secretary. He faithfully served in that role for 41 years, until on 30 June 1999 he retired, being succeeded by Ken Burrage. Even then, he continued to organise the Institution's International Conventions for a further four years.

Generations of Institution members will remember what Ray did for them during that period. He was perhaps the key member of the Council and Management Committee acting as the secretary of those activities throughout his period of office. Countless IRSE presidents also have reason to thank him for the able and tactful way he not only dealt with their own annual programme of technical events and visits, but the very efficient way he, almost single handed, dealt with the administration of all the Institution activities within the UK. He also acted as the main liaison with all the IRSE sections, both UK and non-UK, each of which had their own secretary. For most of this time, the Institution had no employees and the key roles were rewarded with annual, modest, honoraria, something that only started to change in 1994 with the first full-time employee being the licensing registrar, although in practice this employment was initially handled via another engineering institution, the IEEIE.

Ray Weedon at IRSE Committee meeting, 8 October 1996.
Photos Colin Porter.

Ray and Jeannette.

During his period of office, he was supported by his wife, Jeannette, whom he married in 1959, and their two daughters, Alison and Elizabeth (Liz) all of whom were regularly roped in to help with the monthly mailing of information to members at a time when the main method of distribution was the postal system. As the Institution membership grew, and his own full-time job in the personnel/administration function at the headquarters of the British Railways Board developed, additional committees were formed to deal with some of the workload, particularly membership applications. Even for those activities where he did not take the lead, for example in

Ray, right, with Francis How, Ken Burrage, Clive Kessell and Cliff Hale.

organising technical conventions, he still dealt with much of the administration of those activities acting as the interface with members. At the time of his retirement on 30 June 1999, membership totalled 2918. 21 Avalon Road, Earley, Reading, Berkshire will be an address etched in many members memories, since that is where Ray and Jeanette lived for so long and it was the registered office of the Institution. They moved to Dawlish in Devon in 1988 when Ray retired from British Rail, and the Institution's registered office and administration activities moved with him.

Ray was elected an Honorary Fellow of the Institution in 1984 and upon his retirement in 1999 he was presented with the first ever President's Award in recognition of his outstanding and exceptional services to the Institution.

In his personal life, when younger, he was a very keen football referee. Perhaps the pinnacle of that particular part of his life being when he officiated at an international match between Manchester United and Lazio in Rome in 1973. His family has a photo of him kissing the hand of the Pope, with Matt Busby and Bobby Charlton in the background. When he moved to Dawlish, his interest in balls was rekindled, albeit this time with the bowling club there.

On a more personal note, I can well remember Ray organising my Thorrowgood Scholarship study tour of Germany in 1976, and the help he gave to someone who was just a young student member at the time. I really got to know him well though when I was asked to computerise the Institution's membership records in 1983, initially somewhat "over his dead body" but he adapted well to it, and when implemented in 1984, it saved him much time and effort over the years. One of his regular and more difficult tasks was arranging the seating plan for the members and partners at the 'informal dinner' held at the end of each convention, and at Clive Kessell's convention held in Budapest in 1999, he sat me, as a newly divorced Council member, next to Claire Henley, also a Council member. As a direct result of that 'date', two years later we were pleased to invite Ray and Jeanette to our wedding. I marvelled at the subtle way he helped steer the Council on so many occasions over the years particularly when it was faced with difficult decisions. He was always, though, clear that the responsibility for the Institution rested with the Council, and I can remember him saying so many times that the Council could do whatever it chose to do, providing it remained within the provision of the Institution's Articles of Association.

From left to right Jim Waller, Cy Porter, Ray and Ken Burrage.

Ray's period of office in the Institution, totalling over 45 years is unlikely to be equalled, and we all owe him, and his family, a debt of gratitude for his service to the Institution and us all.

His funeral was held at Exeter Crematorium, in the UK, on 28 September 2020.

Colin Porter
past-president (2003-4) and former chief executive (2006-15)

Book reviews

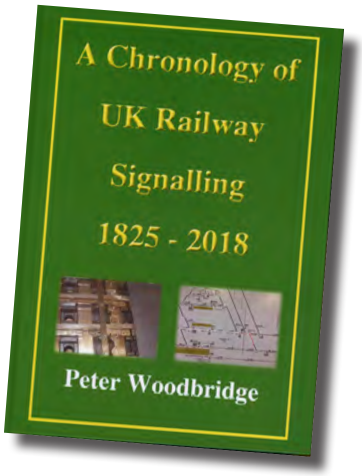
"A Chronology of UK Railway Signalling 1825-2018", by Peter Woodbridge

I met Peter at the IRSE Annual Convention 2016, held in Beijing China-during which the IRSE China Section was inaugurated. The impression I got of Peter was formulated by a lengthy yet technically fascinating conversation we had at the foyer of the Grand Hyatt Beijing Hotel. He had wide knowledge of the railway discipline, yet he never lacked depth. This impression was fortified when I bought and read his 444-page book: A Chronology of UK Railway Signalling 1825-2018.

The book does not only capture the historic events that contributed to the evolution of UK railway signalling as we know it today, but intelligently, whether intentional or not, leaves the reader asking pertinent questions: As railway professionals, how have we constructively evolved the railway system to respond to the many railway accidents/ incidents in our environment? How have we innovated and implemented solutions that contribute to the avoidance of safety-related incidents? Are we mere onlookers, participating only in moderated discussions that perpetuate idle 'skindering'? What will railway professionals living in the year 2211 write of the railway history we have created, today? How are legislative railway authorities doing in entrenching safety and standardisation within the railway industry-are they doing well?

The book gives an account of 193 years of a chronology of significant railway events that shaped legislation, principles and rules of UK railway signalling from 1825 to 2018. This review is befitting, as a good portion of the South African railway was founded on British railway principles, during the early years of the colonial era, during the 1800's. The book therefore serves as a relevant reference for my country.

Methodically, Peter dissects the 949 entries of the most significant events by topic categories ranging from Accidents and Incidents, Block working-enforcing of following train separation on uni-directional double lines, brake, companies, electrical/electronic discoveries and inventions, Interlocking (controls, computer/solid state, mechanical lever-frames, relay-based), IRSE history, legislation-railway specific, miscellaneous milestones, operations control, points, power distribution, power signalling (lever frames, panels), remote control, signals, signal box, single line-enforcing occupation only by a single train on a line used in both directions, telegraph/telephone/ communications, transmission based signalling-including automatic train operations, train detection, train describer-including passenger information and automatic route setting, train warning & protection systems, VDU Train Control.

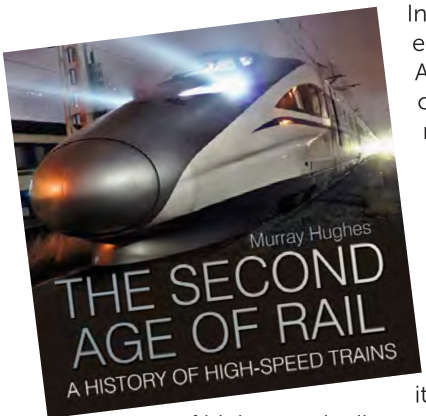


Though Peter does not make it clear in any form of conclusion if his primary objective for writing this book was met, the historic evidence presented in the book has brought to light that there are numerous railway events and incidents that have shaped railways to be what we know today. The introduction and evolution of railway signalling technologies and railway legislation has, throughout the years, been influenced by these events and incidents. The account thereof does demonstrate that, to a large degree, railway signalling technologies indeed evolved by accident.

Through the study of history and having the ability to learn from it, combined with the willingness to absorb and apply knowledge, any railway system has the capability of functioning at its optimum. This book, when studied for the purpose of application, offers an opportunity to learn from past events in order to effectively manage the railway system and would also offer an opportunity of not having to engage in activities that see us repeatedly report on injuries, fatalities and loss of assets without a clear legislative direction. It would potentially see the railway networks being effectively managed and maintained from both the legislative and operations perspective. The history narration in the book highlights the critical role of railway regulatory bodies in enforcing standardisation and safety of the railways-these were and still are practically authority-entrenching bodies rather than partaking at a ceremonial level.

Philile (Portia) Nkuna

"The Second Age of Rail", by Murray Hughes



In this new and updated edition of The Second Age of Rail, the full story of high-speed trains is retold in a journey across countries and continents. Japan set the precedent with its "bullet trains" in 1964; since then more than a dozen countries have built high-speed routes. China is now leading the world with its nationwide network of high-speed railways, but countries such as Morocco and Saudi Arabia have also built high-speed routes, with trains that can travel at 300km/h or more. Murray explains how the USA lags behind and is already outpaced by new lines in Turkey, Morocco, Saudi Arabia, Asia and Western Europe, where Eurostar links London to the international high-speed network via HS1, with construction of HS2 to northern England now finally under way.

The book contains some excellent photos and maps of the high-speed routes throughout the world.

Murray Hughes is the editor of Railway Gazette International, in which capacity he has witnessed many key events in the development of high-speed trains in different countries. Previously he was foreign/news editor for Modern Railways, and has spent time working with Swiss Railways and the International Union of Railways in Paris.

Paul Darlington

Membership changes

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Member

Musawer Ali, Parsons, Saudi Arabia
Jagdish Prasad Meena, RITES, India
Andrew Woods, HDR, USA

Associate Member

Shahbaaz Ahmed, Alstom Transport, Saudi Arabia
Stephen Martin, Eurotunnel, UK
Thomas McClymont, Siemens Mobility, UK
Jonathan Start, Alstom Transport, Australia

Accredited Technician

Joshua Dallas, Omada Rail Systems, Australia

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Paul Gardiner, Network Rail, UK
David Hick, Network Rail, UK
Uday Singh, Siemens Mobility, Australia

CEng

Alexander Laver, Network Rail, UK
Lee Ross, Network Rail, UK
Malcolm Smith, Network Rail, UK

Past lives

It is with great regret that we have to report that the following members have passed away: Walter Cooper, Paul Coulson, John Franklin, Michael Horne, Richard Stokes and Ray Weedon.

Promotions

Member to Fellow

Andrew Gardner, AECOM, Australia
William Whitmore, WSP, Saudi Arabia

Associate Member to Member

Richard Ashley, Siemens Mobility, UK
Daniel Ferguson, Linbrooke Services, UK
Stuart Maddock, Network Rail Consulting, USA
Suhas Tiwatane, WPS, Australia
Srinivasulu Veguru, Mott MacDonald, Australia

Accredited Technician to Member

Phil Dakin, Command Control Solutions, UK

Affiliate to Member

Michael Bastow, SNC Lavalin-Atkins, UK
Andrew Belson, Alstom Transport, UK
Wing Yan Heather Lam, MTR, Hong Kong

Affiliate to Associate Member

Sai Pradeep Penugonda, Serco, UAE

New Affiliate Members

Sonia Adin, India
Daniel Heywood, John Holland, Australia
Caroline Horton, Linbrooke, UK
Gavin McDowell, Omada Rail Systems, Australia
Shree Kumar Mishra, ETOE Transportation Infrastructure, India
Loganaden Nagalingum, Metro Trains Melbourne, Australia
Robert Romjin, Pilz, Netherlands
Jacob Saiju, UK
Nitin Kumar Srivastava, General Electric, India
Anugya Tiwari, UGL, Australia
William Treloar, Colas Rail/South Rail Systems Alliance, UK
Waqid Ullah, Alstom Transport, Saudi Arabia
Scott Valentine, Self-employed, UK
Abdullah Zia, Rail Projects Victoria, Australia

Resignations: Alan Bean, Neil Bulgin, Ross Gordon, Klaas Hoekstein, Alan Jevon, Siri Kamalasuriya, Adrian Knowles, Stephen Mercer and Chuang Yu.

How much of your work counts towards your CPD?

Continuing professional development is an essential part of being a professional engineer and a member of the IRSE.

Had you ever thought about how many ways there are to carry out this CPD though? Here are just some examples of how you can do this – just remember to record your activities!

Additional responsibilities: Increasing or refreshing your skill set and demonstrating your personal responsibilities by volunteering to take on additional duties such as supervising others.

Buddying, coaching or mentoring: Sharing your knowledge of your company, discipline or industry by acting as a buddy, coach or mentor.

Shadowing: Increasing your understanding of your company or industry or widening your domain knowledge through work shadowing.

IRSE events and conferences: Increasing your technical knowledge and widening your network.

Management skills: Increasing and practicing leadership skills by organising sharing knowledge sessions such as 'lunch and learn'.

Developing your career: Increasing your profile by transferring to another grade in IRSE.

Technical knowledge: Increasing or refreshing your knowledge by reading up in technical papers, journals (like IRSE News) and specifications on projects, techniques or equipment being used.

Your letters

Re: Cyber security

Excellent edition of IRSE News (September 2020), especially Colin Hamilton-Williams Cyber Security article, although I couldn't help noticing his Figure 5, the simplified version of the Purdue model for Industrial control systems, was spookily like the Open System Interconnection (OSI) 7 layer model discussed for signalling by the IRSE in Tim Howard's reign as president in 1988! I also noted that in Industry News, the article about UK fibre roll out said that broadband may be speeded up in the UK by running cables inside water and sewer networks, along roads and railways. Indeed, as it was also discussed by the IRSE in 1988 with Thames Water proposing cables in sewers, British Waterways Board along canals, Department of Transport along the roads and British Rail had already shown they could be laid by the track! Add in the convention to Hong Kong and particularly mainland China; so perhaps Tim Howard's presidency should be remembered as one of foresight?

Martyn Hart

Career changing moment

Not wishing to trigger a new section titled the above subject but ... The letter from Brian Flynn in October "Your letters" brought back such an incident in the early 1980's. I was at the time a senior telecoms technician at Liverpool Lime Street, frustrated at the lack of promotion prospects to technician officer in the locality. Brian was our area engineer at the time and was moving on to pastures new. At his leaving celebration I had a coherent discussion with Brian near the end of the evening about the issue. His advice was to go south young man, and next day I put in for the job of technician officer at Norton Folgate exchange at Liverpool Street. And I never looked back, thanks Brian.

Ian Fazakerley

Quick links

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the Editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Advertising

For advertising rates and deadlines call the IRSE London Office +44 (0)20 7808 1180, or e-mail hq@irse.org.
Advertisements are accepted on the basis that the advertiser and agency (if any) warrant that the contents are true and correct in all respects.

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon · Planting trees to catch carbon ·
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

REMOSdl by Park Signalling

REMITdetect by Park Signalling

PARK SIGNALLING
a Unipart Rail Company

Resolve your SSI Data Link Problems

REMOSdl

Diagnostic Smart tool for SSI Datalink Problems and Datalink Restoration

REMITdetect

Record the occurrence of missing reply telegrams and glitches

All Park Signalling technical solutions are:

- designed as whole-life cycle solutions from design to delivery
- proven with in-service success
- uniquely customisable to specific SSI
- designed to support the life extension of SSI systems

SCAN ME
REMIT

SCAN ME
REMOS

Scan the QR Codes or visit our website for more information:
www.park-signalling.co.uk/remosdi.html
www.park-signalling.co.uk/remitdetect.html

PARK SIGNALLING
a Unipart Rail Company

Design • Develop • Integrate • Investigate

IRSE News

Institution of Railway Signal Engineers

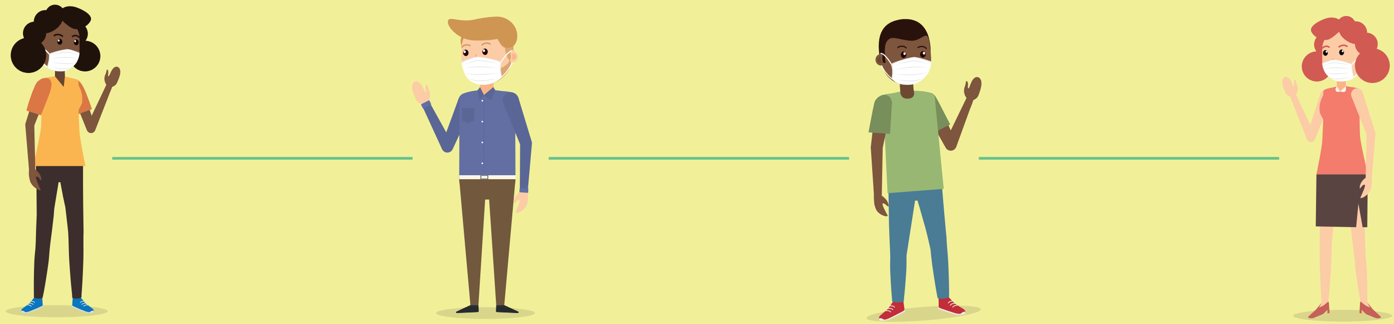
December 2020

Cross acceptance
dealing with different standards

Safety is no accident
lessons learnt

Zero disruption
project delivery

SAFE TRAIN SEPARATION



SAFE PEOPLE SEPARATION

High-quality signalling technical training, safely conducted by online delivery or with safeguards in our training centre.

Get in touch today to book a course or discuss any enquiries!

From all of us at Signet Solutions we wish you a Merry and safe Christmas and look forward to seeing you in the New Year!

+44 (0)1332 343 585

enquiries@signet-solutions.com

www.**signet-solutions**.com

Signet Solutions

Raising the Standard in Development

IRSE ///
Institution of Railway Signal Engineers

Issue 272
December 2020

In this issue

A year like no other

What a year this has turned out to be so far! Very little of my presidential programme, or indeed any of the IRSE's plans for the year, have survived intact. This has created a lot of extra work for everyone. The staff and volunteers have been amazing in keeping things going despite the disruptions – the only insurmountable problem was, for quite some time, being refused access to our offices even to collect the post. Otherwise everyone rallied around to keep addressing the membership's needs despite the difficulties.

Presidential programme lectures and most local section events have found a new online format, opening up a more accessible institution where anyone in the world can attend (not just those lucky enough to live near the chosen venue). The joint institution seminar on "Practical Integration of Automated Operation in Railways: A System of Systems Perspective" was pulled together after commencement of lockdown and delivered a fantastic set of presentations and Q&A through September and October (more about that can be found inside this IRSE News). I must then also mention the IRSE Exams. How do you facilitate an examination during COVID-19 restrictions where some centres require over 100 people to attend an invigilated exam? You take it online too, of course.

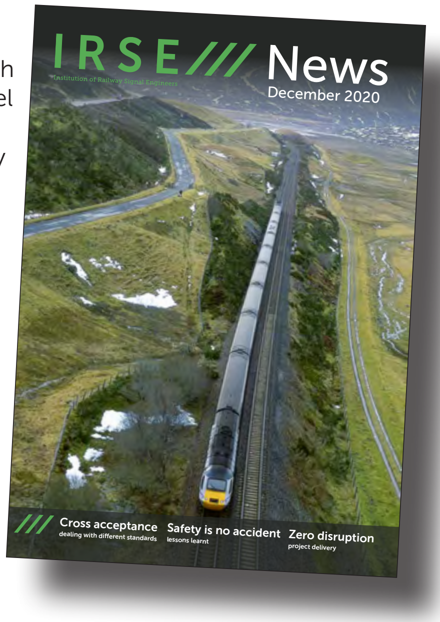
For an institution representing a traditionally conservative industry, the rate of change in our activities during this year has been staggering. What a jump into the future! I think that we, as members of this institution, can be very proud of our response. Attendance figures have increased, and lessons are being learnt every time we put on an event. Our online presence will continue to grow and in so doing to better serve the global membership.

My main regret is that I have been unable to visit local sections as I had intended. I have joined their online meetings, raised questions, given presentations, but as in all aspects of life currently, that is not the same as interacting in person!

Thank you to our staff. Thank you to all our volunteers. Your hard work has made a huge difference in these difficult times.

Daniel Woodland, president, IRSE

Cover story



Our cover this month shows a Class 43 High Speed Train (HST), officially the fastest diesel train in the world, with a record speed of 148mph (238km/h). The trains were built by British Rail Engineering Limited from 1975 to 1982 and introduced in 1976.

Until the HST's introduction, the maximum speed of British trains was limited to 100mph (160km/h). The rapid acceleration and deceleration of the HST reduced the need for major signalling alterations and made it ideal for passenger use, and it slashed journey times around the country.

After being in service for nearly 45 years the HST is now coming to the end of its life in fleet use. Older trains such as this must accommodate new control and communications systems throughout their life, and in the case of the Class 43 this has included ATP, TPWS, GSM-R and Wi-Fi.

Photo by kind permission of Icomera.

Cross-acceptance of systems and equipment developed under different standards frameworks

Rod Muttram

This, the third paper in the 2020-2021 presidential programme, was presented online on 19 November.

Many readers of this paper may know me through my previous IRSE articles on behalf of the IRSE International Technical Committee (ITC). As a member of the committee for five years now I have had the privilege to lead or be a contributor on seven topic papers published before this one and there are four more 'in progress'. But some members have served the committee for much longer.

The subject of cross-acceptance is one that the ITC has visited before. Indeed, it was the subject of the first ever ITC Paper (Paper 1, what we would now call Topic 1) "Safety System Validation with regard to cross acceptance of signalling systems by the railways" in January 1992. As you might expect after over 28 years, none of those on the committee at that time are still involved, indeed many of the names from that time are unknown to myself who joined the industry in 1994 from a prior career in defence; but the chair in 1992 was the late, great Eddie Goddard who became a firm friend and is greatly missed. Eddie was a much better 'www' than the one we all use as a reference today. He was warm, welcoming and wise and gave me a huge amount of help, particularly during my years with Railtrack – then the infrastructure manager in Britain. Eddie was also a major contributor to the "Yellow Book on Engineering Safety Management" that some who are reading this may have used. So it was doubly interesting to look back on what the ITC said about cross-acceptance under his chairmanship.

The ITC wrote again about cross-acceptance as Topic 6 "Proposed Cross Acceptance processes for railway signalling systems and equipment" in April 2003 and three still active members of the ITC were involved, Wim Coenraad, Yuji Hirao and Lassi Matikainen. Two of the then members also remain corresponding members, Clive Kessell and Jacques Poré. This was followed up by an article by Wim Coenraad on behalf of the ITC in the IRSE Hong Kong Section Newsletter issue 22, September 2006 entitled "Cross-Acceptance of

Railway systems in every country, for example (left to right), the USA, Switzerland and Japan share many basic requirements. It is, however, not always straightforward to use technologies in different countries. Cross-acceptance is an important route to allow this.

Signalling Systems – The Myths and the Reality". Those with access should also read Wim's article on "Proposed cross-acceptance process for railway signalling systems and equipment" in SIGNAL+DRAHT (97) 9/200

So after 14 years it is time for the ITC to issue an update on this subject and whilst it is with some trepidation that I follow in the footsteps of such illustrious predecessors, the fact that five contributors to the previous paper are still ITC members and have given support to this paper and presentation shows one of the strengths of our Institution is in terms of the continuity of its volunteers.

"If a technology/system operates safely and reliably in one country, then it should be able to do so in another country without the need for back to basics approvals"

What is cross-acceptance?

The 1992 ITC paper does indeed make interesting reading. It paints a fascinating historical picture of the assurance and acceptance arrangements at that time and details many on-going or proposed activities that would make cross acceptance easier. But nowhere does it define what cross acceptance is or means! Many of the measures it discusses have come to fruition and evolved, particularly in a European context, albeit the timescales have been much longer than envisaged. It made me think hard about what was meant by "... developed under different Standards frameworks." Back then it was certainly more about different national frameworks whereas now we would think more about things from inside and outside the 'CENELEC world'. It was also a little surprising to see extensive use of the terms 'Vital' and 'Non-vital' which are now more familiar in what we shall call, for shorthand purposes, the 'US framework' (of which more later) than in the more 'quantified' approach which has emerged in European and IEC Standards.

The 2003 paper defines cross-acceptance in its "Glossary of Terms" using the definition from EN50129, EEIG General Glossary – Version 2.

Whilst recognising this has its origins in the EN50129 of the time I do not view the glossary definition as very satisfactory (and it is clear the ITC of the time did not either). Firstly, because it is too 'Euro centric' and secondly because 'without the necessity for further assessment' is an unrealistic goal. The aim should be to minimise the work needed, but in the vast majority of cases at least some checking of the equivalence of the application and the operational environment is unavoidable.

Wim Coenraad summed it up very well in his 2006 article for the Hong Kong Section Newsletter (based on Section 6 of the 2003 ITC paper):

The concept of Cross-Acceptance is that "if a technology/system operates safely and reliably in one country, then it should be able to do so in another country without the need for back to basic approvals".

Cross-acceptance is defined in EN 50129 as "The status achieved by a product that has been accepted by one authority to the relevant European Standards and is acceptable to other authorities without the necessity for further assessment".

Cross-acceptance should also be applicable if recognised accepted standards other than European standards are used. Cross-acceptance can be applied to subsystems or parts of products as well. Cross-acceptance is not only technical, but also a matter of political and commercial will, trust and engagement, strongly conditioned by the national regulatory framework.

I wholly agree with this and the ITC always tries to avoid a purely European mindset.

The latest version of EN50129 (2018) now reads: "status achieved by a product that has been accepted by one authority to the relevant standards that is acceptable to other authorities without the necessity for further acceptance". At first sight that is an improvement, but further examination reveals that this latest version of EN50129 is Euro centric throughout, for example containing the statement "When using a previously accepted Generic Product or a Generic Application in the context of a Specific Application, safety acceptance should be based on existing related independent safety assessment (i.e. cross-acceptance). No cross-acceptance shall be possible for Specific Applications."


Paul Darlington.


Rod Muttram.

Whilst that is surely correct, the underlying assumption of the existence of Generic Product, Generic Application and Specific Application along with an Independent Safety Assessment (ISA) report reflects the European framework and is not common or widely understood within countries/companies that do not use that framework.

The previous version of EN50129 had an accompanying application guide for cross-acceptance, TR50506 parts 1 and 2. This was withdrawn when EN50129 2018 was issued on the basis that it was no longer necessary as such matters were either covered within the revised standard or by use of the Common Safety Method (CSM). I believe that was an error which again reflects a narrow European mindset and I have lobbied for its re-instatement. More on this later.

"Cross acceptance is about the re-use of prior acceptance by other authorities, recognising the need to validate the new operational environment and rules"

TR50506 pt1 contains the following in section 4.2: "Cross-acceptance is an aspect of the technical and legal process principally aimed at establishing the fastest route to the deployment of Product, System or Process in a target (new) context or environment. The Product, System or Process considered for cross-acceptance is generally assumed to satisfy the qualifications for reliability, tolerable safety and environmental performance in their native (original) context or environment. The target application is also assumed to possess significant synergies with the native environment, thus making the deployment technically feasible viable/advantageous without significant alterations. However, the essence of cross-acceptance currently relates to the assurance of safety and potentially environmental performance of product, system or process which are subject to a regulatory regime."

Those are good words and reflect the point above about the need to check the equivalence of (and any differences in) the application environment. The sentence "The target application is also assumed to possess significant synergies with the native environment, thus making the deployment technically feasible viable/advantageous without significant alterations" is also an interesting one. Many of the failures of cross-acceptance I have witnessed came about because the target application was too different from the native one, albeit that may not have been recognised at the start. Indeed, in some cases the target environment was not understood to anything like the detail necessary before the project started.

So, cross acceptance is about the re-use of prior acceptance by other authorities, recognising the need to validate the new operational environment and rules; it is not just about the re-use of evidence although sadly that is where it often ends up, sometimes because the differences in the operating environments are just too great.

Background frameworks

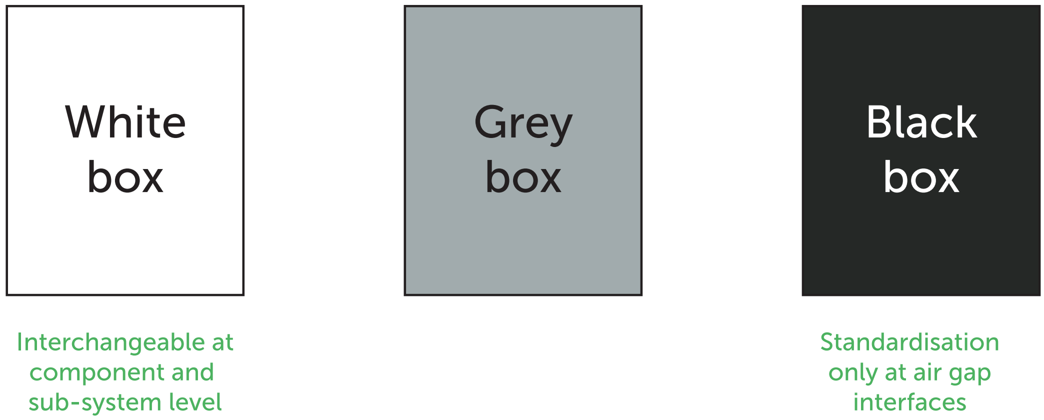
Sitting behind all these standards there are two dominant approaches to securing safety/safety approval in the rail domain.

In Europe and associated countries, the 'safety case' approach has gained prominence with technical approval and acceptance of products in safety functional chains evaluated as much as possible in quantified terms, looking to demonstrate that failure rates will be commensurate with defined safety targets. CENELEC Standards in the EN5012X series (based on IEC61508) classify products by their assessed failure rates as being capable of supporting safety functions in 4 'bands' from SIL 1 to SIL 4. SIL 4 represents the highest level of safety with a failure probability in the range of 10^{-8} to 10^{-9} for continuous safety functions. The ITC has reported many times that SIL can be mis-understood and wrongly used leading to excessive approval costs. (It was a paper on that topic that led to me joining the ITC). The principle remains absolutely sound (leaving aside SIL 0 which I view as a flawed concept leading to muddle between safety and reliability) and if used correctly leads to products which should be safe in their intended application. That said, many of us probably have examples of where failures have still occurred at a point in the project lifecycle where they should not

The concept of safety integrity level is well understood. Or is it?

Safety Integrity Level

SIL	Probability of dangerous failure
1	10^{-5} to 10^{-6} h^{-1}
2	10^{-6} to 10^{-7} h^{-1}
3	10^{-7} to 10^{-8} h^{-1}
4	10^{-8} to 10^{-9} h^{-1}



Interchangeable, interoperable or neither? The concept of white box, grey box and black box brings the different preferences of stakeholders into stark relief.

have done if the process had been effective. That particularly affects software driven systems and will be returned to later in this paper. I also recommend reading Roger Short's paper "Does SIL live up to expectations?" from ASPECT 2019 which can be found on the IRSE website. The CENELEC approach often involves gaining a 'one-time' approval for a Generic Product (GP) and then approvals for a Generic Application (GA) in each user environment followed by assessment of each Specific Application (SA) site/project within that environment. This is intended to facilitate efficient re-use of approvals and evidence. Thus, for items designed within the CENELEC framework cross-acceptance should be relatively easy. So far so good.

Within Europe the TSIs (Technical Specifications for Interoperability) made under the Interoperability Directives call up these CENELEC standards and for interoperability constituents set common GA requirements for the areas within their scope. The Interoperability Directives evolved from a desire to facilitate cross-border high speed trains and then international freight traffic to improve competitiveness against air and roads respectively. The need to carry multiple different types of on-board signalling equipment and/or change locomotives and drivers at borders was seen as a major barrier to efficient flows and to be supporting state railway monopolies. Individual railway safety acceptance processes were also seen as anti-competitive. Hence ETCS and GSM-R (two parts of ERTMS) were born as common signalling and communication systems and cross-acceptance is inherent within the concept. The Safety Directive also introduced the CSM with the objective of harmonising safety processes as well as equipment. Hence also the changes to EN50129 regarding cross acceptance which simplify the standards in a European context but, in my view, make them less useful for the rest of the world. The 2003 ITC paper anticipated much of that but raises a smile when it says "The whole process of co-operation to develop ERTMS has taken a long time, in fact over 10 years". In the case of GSM-R that might be right but for ETCS the first 'really usable' specification was System Release 3, Maintenance Release 2 in 2017, 27 years after ERRI created the A200 group to write the specifications, a very long time indeed.

I must also look back to having lost the 'white box, grey box, black box' argument in the late 1990s. The railways wanted the ETCS specifications to be 'white box' with interchangeability at the component and sub-system level, whereas the suppliers favoured black box with standardisation only at the air gap interfaces (grey box would have been somewhere in between). The suppliers won so competition can really only take place at the procurement of (for instance) complete on-board systems and spare parts can then only come from the original supplier. So even ETCS cross-acceptance has its limits – something the railways still regret and have continued to try to change.

"So even ETCS cross-acceptance has limits – something the railways still regret and have continued to try to change"

Additionally, to get equipment approved in the UK, TSI compliance is not all that is needed. In addition to the TSIs there are the Notified National Technical Rules (NNTRs) which are those rules (standards) which the Interoperability Directive require each Member State to notify in the absence of a TSI covering that area. In areas not within TSI scope in the UK there are still Railway Group Standards, Rail Industry Standards and Network Rail's own company standards too. It would not be unfair to say the barriers to entry are still quite high. But within Europe, since that original ITC paper in 1992, there is no doubt that cross-acceptance between different member state railways has been eased in some areas by harmonising the standards rather than accepting those of others.

In the USA and associated countries similar approvals are carried out against a suite of standards from AREMA (American Railway Engineering and Maintenance-of-Way Association), the IEEE, MIL-STDs and the railroads themselves. Equipment safety requirements are generally only split to two levels, vital and non-vital i.e. supporting safety function delivery or not involved in safety. Whilst a 'safety report' is required, the safety evidences of a generic product are rarely mandatory standalone deliverables within that and individual pieces of equipment tend to be more assessed against standalone standards based on long established custom and practice.

In my experience it is (or certainly historically was) rare to find the GP/GA/SA structure being used in the US. It was more common for each new project to take the last version from the previous

ETCS continues to bring many advantages based on interoperability, but the road has not been straightforward.

one and build upon it; an evolutionary approach. Software validation tended to be focussed on extensive product or system level testing with the use of lower level techniques such as those listed in EN50128 being more ad hoc and company by company than systematic.

The approach followed in the US does not strictly constrain the organisation for safety and/or verification & validation that the supplier has to use in order to develop a vital product; and the development process is less constrained in comparison with the one defined in CENELEC. That said the approach has generally also delivered high levels of functional safety and the product level standards are quite robust.

"It has been suggested by some that the CENELEC approach is better because it is quantitative rather than qualitative"

It has been suggested by some that the CENELEC approach is better because it is quantitative rather than qualitative, but it is very hard to find evidence to support that view in terms of outcomes, which is what really should be important in terms of cross-acceptance.

It is also worth remembering the differences in background practice and legal framework between Europe and the US which very much condition behaviours and what we might call 'the art of the possible'.

In Europe railway signalling supply has developed into a 'systems market' where major companies like Siemens, Alstom and Atkins deliver a total project as the lead contractor. However, the legal framework very much focuses on the 'duty holder' which for signalling issues is mostly the Infrastructure Manager (IM) – Network Rail in the UK. As we move more towards ETCS and cab signalling the Train Operator (Railway Undertaking – RU) may become more involved but because (certainly in the UK) they tend to lease their assets, so the technical performance and maintenance of the on-board equipment tend to lie with the leasing company/maintainer. In the early days of privatisation in the UK, I remember more than one train operating company arguing that, as AWS was a signalling asset, maintenance of the on-board equipment should be Railtrack's (the IM) responsibility. Regardless, under this framework of responsibilities it is hardly surprising that the safety case approach has gained prominence as a method for the IM/RU or asset owner both to satisfy themselves that what the system supplier delivers is safe and to provide evidence of appropriate diligence in the event of a problem.

In the US, the structure is much more similar to the way it was in Europe prior to the reforms of the 1990s. Generally, the Class 1 railroads themselves act as the responsible system integrator buying components and sub-systems from various suppliers. If a bought in sub-system such as an interlocking or grade (level) crossing suffers a failure which leads to an incident or accident it is the supplier that is likely to find themselves on the receiving end of legal action. It is thus unsurprising that there is more reliance on prescriptive standards with which the suppliers can demonstrate compliance as a means of evidencing appropriate diligence.

Following on from that, it has also been said by some that it is easier to get CENELEC products approved in the US than vice versa. My view is that that would be a dangerous assumption. Some of the AREMA requirements are very demanding especially in areas like vibration and shock, reflecting the US environment being predominantly a heavy haul freight railway and the legal framework issues outlined above.

Current situation within Europe

"There is no doubt that the TSI framework has made many aspects of cross-acceptance within Europe much easier"

There is no doubt that the TSI framework has made many aspects of cross-acceptance within Europe much easier. Rolling stock acceptance is no longer the drama it once was with most manufacturers using common 'platforms' with many known characteristics as the core of offerings to several customers. In terms of ATP, ETCS is now really the 'only show in town'.

For ETCS this has been achieved at a very high up-front cost. The 2003 ITC report said "The need to try and achieve common operating rules was not appreciated in the beginning, it is now seen as essential to unify the rules, especially where operational irregularities exist, before the start of any future system development." How true, and the impact of not managing to do so is one of the reasons why ETCS has taken so long and

Shutterstock/Tobias Arhelger.

"The IMs have still spent a huge amount of time and effort agonising over transitional strategy"

cost the industry so much. All safe systems are built on three pillars: good processes, competent people and high integrity equipment. A common ATP system really needed common operating rules. But, despite some commonality of high-level operating principles, the European railways had many detail differences in operating rules. Changing them would be by no means simple, with a huge retraining cost and significant transitional risk during the period within which both rule sets would need to operate. So ETCS became a 'tool kit' capable of supporting all of the heritage rules. For transition it was also decided to give the capability for ETCS fitted trains to run on heritage infrastructure; for the on-board European Vital Computer (EVC) this meant lots of additional software and for the on-board system as a whole additional hardware in the shape of Specific Transmission Modules (STMs) and antennas for the heritage system or systems on the route or routes concerned. All of that safety critical functionality means tens of thousands of lines of safety critical code, all of which needs to be validated and then re-validated after any significant change. For the developing manufacturers that has involved a lot of sunk cost to amortise into projects; little wonder the equipment is expensive. New participants are now entering the market, but they are developing equipment to the 'open' specifications (without much of that sunk cost burden) not cross-accepting existing equipment. The complex functionality and the multiple interfaces are far too unique for that. So, a huge barrier to the import and cross-acceptance of any on-board system from another framework has been created.

"So, even after a huge investment in harmonising standards the idea of a 'plug and play' railway is still not really there, and in some respects the barriers to entry have got higher"

Despite all that cost and delay to accommodate heritage systems within the ETCS on-board sub-system the IMs have still spent a huge amount of time and effort agonising over transitional strategy. To really get economic benefit from ETCS requires it to be implemented at one of its higher levels; Level 2 without lineside signals or Level 3, to minimise lineside hardware. "No lineside signals" means that trains need to be fitted with a compliant ETCS on-board to enter the fitted infrastructure creating a real problem for a mixed traffic railway like the UK in upgrading 'route by route' as many freight locos can go almost anywhere on the system. This has led to innovative 'compound' solutions like 'Hybrid ETCS Level 3' (see IRSE News, Issue 260, November 2019) to allow the capacity and service recovery benefits of level 3 to be realised whilst still allowing unfitted trains to run on the fitted route during a transitional period. Of course, that involves additional infrastructure cost; not ideal, but it can be better than the up-front cost and disruption of fitting every train that runs on the route concerned in a very short time period.

The situation for interlockings is running some years behind ATP. Projects like 'Eurointerlocking' have attempted to produce a harmonised specification, but without harmonised rules it is really very difficult, given that the function of an interlocking is to enforce a large proportion of those rules. It should become easier as ETCS is rolled out at its higher levels but whilst lineside signals remain, the number of aspects, configuration, sequence and meaning are all largely national.

So, even after a huge investment in harmonising standards the idea of a 'plug and play' railway is still not really there, and in some respects the barriers to entry have got higher.

As mentioned above, another facet of that is the recent changes to EN50129 and its supporting documents. Prior to the issue of EN50129:2018 there was a supporting application guide for EN50129 called TR50506, Part 1 of which was concerned with cross-acceptance. When EN50129:2018 was issued this was withdrawn. The guide is still within the two year 'grace period' following withdrawal but only until the end of 2020. I consider this a significant error which is rendering a lot of very useful and clear material less accessible and less recognised. For instance, TR50506-1 sets out a well-structured seven step process for cross acceptance:

a) Establish a credible case for the native (baseline) application.

b) Specify the target environment and application.

c) Identify the key differences between the target and native cases.

d) Specify the technical, operational and procedural adaptations required to cater for the differences.

e) Assess the risks arising from the differences.

f) Produce a credible case for the adaptations adequately controlling the risks arising from the differences.

g) Develop a generic or specific cross-acceptance case.

TR50506-1 also defines a 'cross acceptance life cycle' which is particularly useful in showing the roles that lie with the customer and supplier.

Whilst TR50506-1 is somewhat European process focused it is sufficiently general to be more broadly useful. In particular, whilst risk based there is no mention of quantified targets so it is equally applicable to a qualitative process. The only thing that comes close to requiring a quantified approach is the detail text on the specification phase which asks for a Tolerable Hazard Rate (THR) to be set by the customer based on risk assessment. The approach to achieving the target is not dictated.

"Whilst TR50506-1 is somewhat European process focused it is sufficiently general to be more broadly useful"

The clear elucidation of customer roles in TR50506-1, including appointing the ISA, is particularly welcome. Another factor that can make cross-acceptance unduly difficult is failure by the end client to properly fulfil their roles. This can be due to the client simply not having the information required regarding interfacing heritage systems or in my experience it can be more down to an attitude that if the supplier wants to offer an existing piece of kit it is their job to prove it suitable and safe without requiring any work from the client. That is not possible and dooms the acceptance to failure at worst, or lots of additional cost at best.

Evolution of the US framework

The US government decided in the 1990s to move towards "consensus-based standards and regulations" whereby all parties affected by the standards and regulations were involved in the process of their creation. However, this has not led to the level of 'unification' that the TSI and CEN/CENELEC Standards framework has in Europe.

The Federal Railroad Administration (FRA) created the Rail Safety Advisory Committee (RSAC) to assist in the creation of a number of regulations in many areas including those for computer-based safety critical equipment and then for Positive Train Control (PTC) – the train protection system mandated by the US Rail Safety Improvement Act following a number of high profile accidents. The railroads and the rail unions pushed for performance based rather than prescriptive standards and for regulations allowing them a more flexible approach. As a result, whilst the safety processes have been shown to be robust, they are less consistent than one would find in Europe.

"In my experience the issues tend to be different moving from the US framework to CENELEC than moving in the other direction reflecting some of the issues discussed"

Under the US approach, each railroad (or for PTC sometimes a group of railroads) develops its safety plans within certain FRA guidelines, tailored to its risks and needs. The FRA assesses and approves those plans then carries out ongoing monitoring and regulation against them. This approach led to several different and non-interoperable forms of PTC emerging but regulatory action and the need for interoperability has now led to Wabtec i-ETMS being adopted for most freight and Alstom/Bombardier/Siemens ACSES II on Amtrak/Metro North and Long Island Railroad passenger services.

The standards that support the US systems are also diverse, created and managed by several organisations. As well as the FRA and the FTA (Federal Transit Administration) regulations many aspects of system and component design are covered by AREMA standards. These can be very detailed, covering things down to the level of items like circuit board track spacings for safety applications. For vital signalling products/projects AREMA compliance is usually mandatory. Whilst these standards are in many cases quite prescriptive, they do not dictate the form that the safety report/safety case should take. For software and computer systems a suite of IEEE Standards is also used, many of the techniques within which are the same/similar to those in EN50128. At the system level Department of Defense MIL-STD-882 is also still used covering system safety methods. Whilst this is currently at Rev E the older Rev C seems to be the one used on most projects I have encountered.

Probably the most significant difference from CENELEC and the US approach is that approval and certification of generic products and generic applications separate from the project application is rarely done. Little evidence has been seen of that changing, whilst the globalisation of the signalling industry has led to some industry movement towards the CENELEC approach the US railroads and the FRA see no reason to change something with which they are familiar and which has had good outcomes.

Experience/problems

In my experience the issues tend to be different moving from the US framework to CENELEC than moving in the other direction reflecting some of the issues discussed.

Going from CENELEC to the US the problems tend to be mostly about the different and often more extreme environmental requirements for the US as embodied in the AREMA standards. These include vibration (reflecting the predominance of heavy freight), as well as temperature extremes, solar radiation and the differences in the EMC frequencies and power levels. The fact that the contract sets the framework also means that it is not unheard of for more stringent requirements to be imposed (e.g. 'vibration tolerance will be 2x AREMA'). That means that even very mature products developed in Europe can require significant modifications to pass. If those modifications impact other features then the benefit of prior approvals and use can soon be lost.

Roma Termini uses Ansaldo's ACC interlocking for a complex station layout. The same system was imported into Manchester South, but with some challenging changes to comply with UK requirements.
Photo Shutterstock/ Alexandr Medvedkov.

Going in the other direction bringing products and systems from the US to Europe can be even more problematic.

Even step a) in the in the TR50506 process of establishing a credible baseline can be challenging regardless of how mature and successful the product has been. With no generic product, prior projects can often be seen as different variants and thus any evidence chain is viewed as broken. Worse, the lack of a quantified and numerate assessment makes it hard for European assessors to say a contract has been complied with if the client's criteria are quantified safety targets and/ or tolerable hazard rates. For software operated systems this is particularly difficult due to the commonly held misconception that EN50128 compliance delivers a quantified SIL rather than just greater confidence that the software error rate will be in the right range.

"For software operated systems this is particularly difficult due to the commonly held misconception that EN50128 delivers a quantified SIL"

Much has been written regarding the termination of Bombardier's contract to re-signal London Underground's (LU) sub-surface lines, a lot of it ill-informed. In my view the type of contract used was certainly unsuitable for the early stages of the project, where the detail requirements were so uncertain, but another significant factor was the attempt to 'fit' the US developed CBTC software to the CENELEC GP/GA/SA structure which it had not followed before. That is not to be critical, the UK legal framework requiring ALARP (As Low As Reasonably Practicable) makes it really difficult not to require 'best practice' in terms of process, but the restructuring of the software destroyed the very maturity that LU had wanted to buy, as well as adding very significant delays. So a product that is in use all over the world, including on heavy Metros like Madrid Lines 1 and 6 suddenly became 'unsuitable'. The track record from any one of the previous (considered different) variants was insufficient to get anywhere close to a 'proven in use' argument for SIL 4 (and this definitely was a SIL 4 application unlike some of the overspecification seen) so testing down to module level on the restructured software was needed, effectively starting afresh.

In both directions point d) of Tr50506 "Specify the technical, operational and procedural adaptations required to cater for the differences" can also result in significant work. As discussed above in the context of ERTMS/ETCS railways have operating rules and procedures that vary greatly from country to country and in the US from railroad to railroad. Some of these differences are accidents of history, some were deliberate (railways were significant assets in time of war so it was undesirable to make them easy for enemies to use) but they do impact the technical equipment used. An excellent and significant example relates to interlockings. In the mid-nineties when I was a director at Railtrack in the UK we initiated the process to improve competition by bringing proven non-SSI electronic interlockings into the UK. Several projects resulted which were completed after I moved on but I would have to admit that their success was 'patchy' despite all the products being excellent and well proven in other markets. The Ansaldo STS (now Hitachi) 'ACC' interlocking on the West Coast Main Line in South Manchester was commissioned in 2003. To quote Ansaldo at the time, "We are really proud that the major challenge of tailoring our ACC system for use in the UK has been successful." One of those challenges, on what was a mature interlocking already in service in Rome, was that the Italian convention in the case of interlocking failure was 'all signals to black' whereas in the UK there is a firm requirement that 'all signals go red'. That sounds like a simple change but to the required integrity it certainly is not.

Atkins was involved in the work to certify Manchester South and that experience fed into their programme to deploy the US ElectrologIXS

Examples of technology introduced via cross-acceptance. Clockwise from top left an Ansaldo SDO signal used on the Manchester South scheme. Banner signal controlled by ElectroLogIXS, and control centre for one of the Atkins projects.

Interlocking (originally by Harmon, GE and now Alstom) into the UK. I'm most grateful to Atkins for providing this interesting and relevant recent example.

Atkins's intention was to enable the safe, efficient and assured delivery of "Digital Railway" ready signalling projects for the UK market. As part of this development they identified the benefits that technology, already proven in other markets, could bring to the UK mainline railway to form "next-generation" interlocking, object controller and level crossing controller solutions. Working collaboratively with Network Rail (NR), Atkins identified Alstom's flexible and powerful vital 'logic processing' platform known as ElectroLogIXS, which was already in established use in North America, to meet the aspiration for a PLC-like interlocking, using ladder logic (widely used in industry) for application data, with a software development process compliant with EN50128 and capable of enabling NR's Digital Rail programme.

The ElectroLogIXS hardware was the successor to the Vital Harmon Logic Controller (VHLC) product which had been successfully applied in the UK on a number of schemes (Bedford to Bletchley, Cromer Branch, Sittingbourne to Sheerness); Atkins had provided design and test support to these schemes, so were already familiar with the technology. There was a an obvious opportunity to build upon the maturity of the product demonstrated in the US market, approvals for these previous VHLC schemes in the UK, as well as a single existing European application of the ElectroLogIXS hardware (on the Rotterdam Metro) to support the proposed UK deployment.

To suit the UK application efficiently (i.e. eliminating the need for interfacing relays), new input/output cards needed to be developed to suit typical UK interfaces. These included:

- A vital AC I/O card to drive standard UK loads including signals, indicators and AWS.
- A 24V DC I/O card to interface with existing UK level crossing equipment.

- A 50V DC I/O card to interface with typical BR930 series relay circuits.

These new cards were developed from existing ElectroLogIXS /VHLC cards.

To ensure that the installations were delivered efficiently and without error, and were consistent with best practice, and compliant with EN50126/8/9, a new application delivery process framework called "Atkins Signalling Method" (ASM) was developed. This covers all aspects of procurement, application development, data preparation (using standardised data modules, assessed to the appropriate 'T' level from EN50128), integration, automated testing and commissioning. The intention was that as well as reducing cost and ensuring quality, this process would reduce the quantity of scarce design and test resources required to deliver a scheme, and hence increase the delivery capability of the UK signalling industry. ASM won "Innovation of the Year" at the 2020 National Rail Awards.

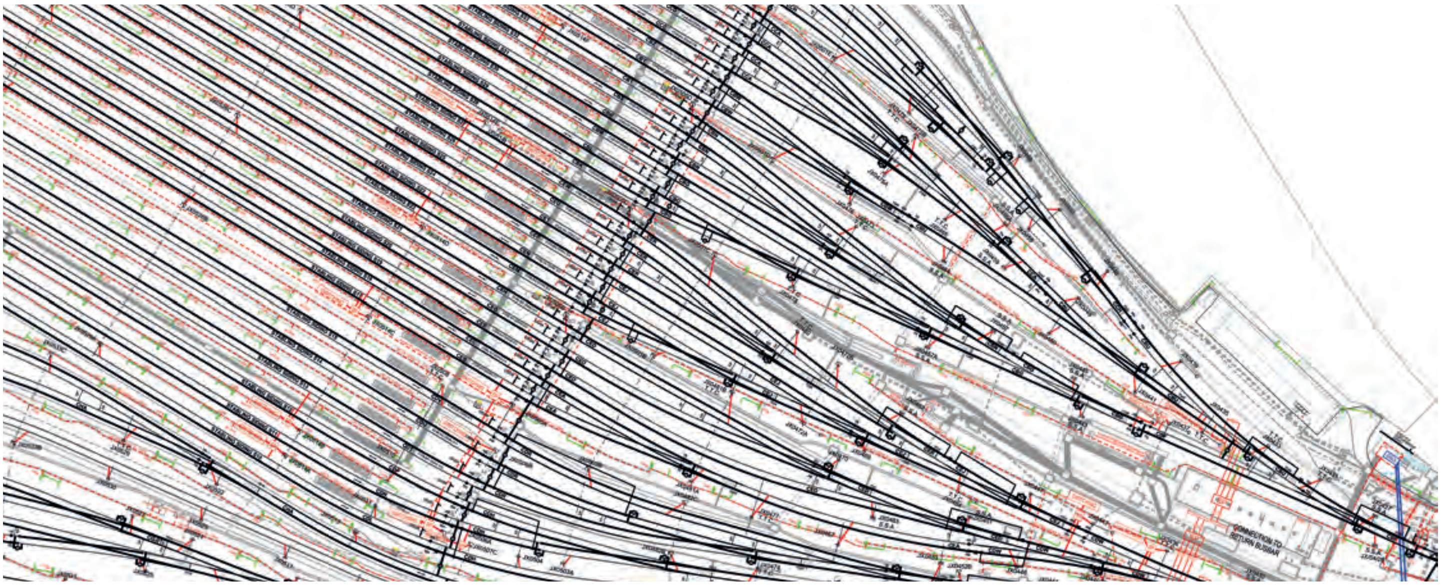
The first applications of ElectroLogIXS within the UK rail market were:

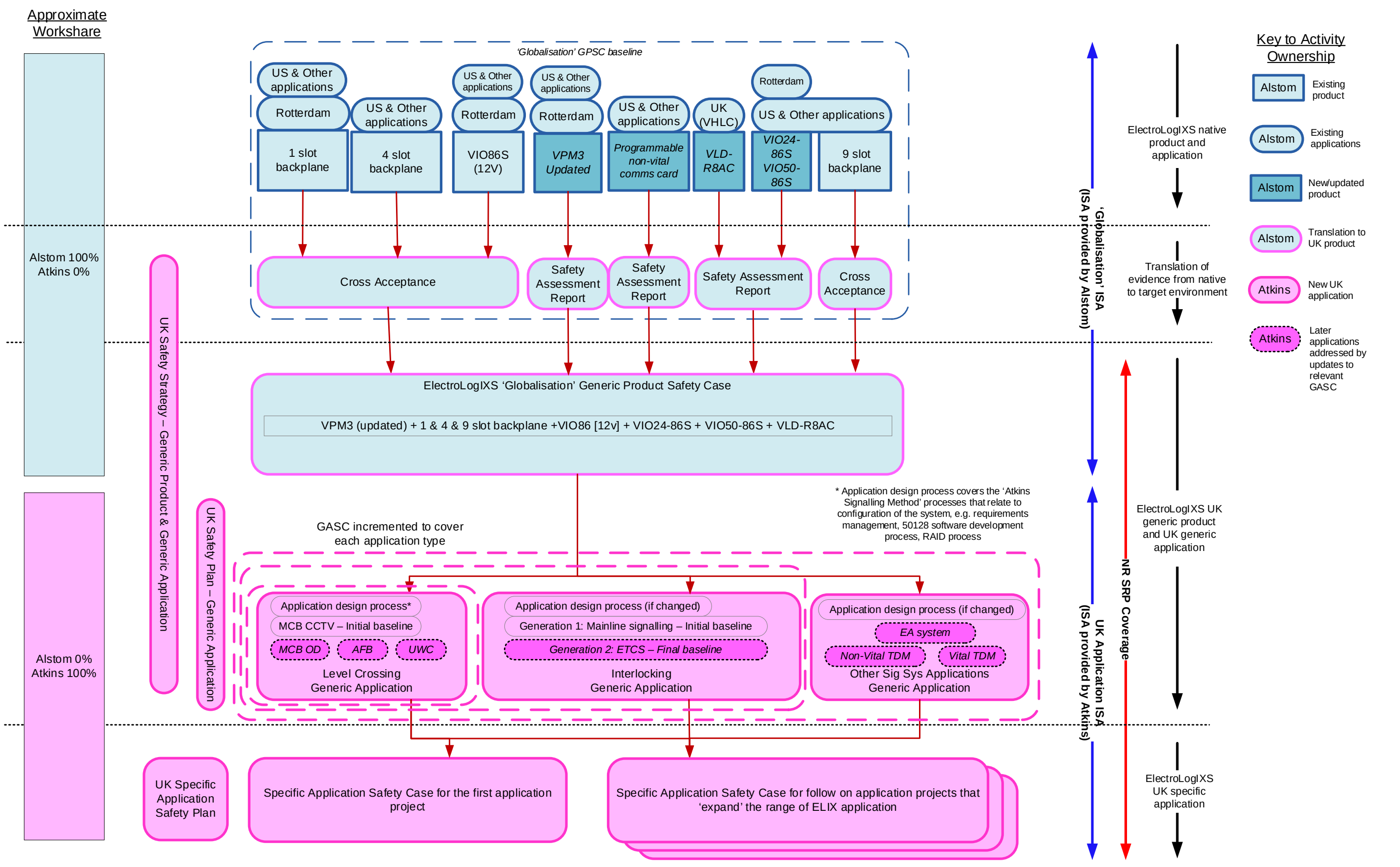
1. The signalling system for the new Crossrail depot at Old Oak Common – Bombardier depot infrastructure that fringes to Network Rail.
2. A technology demonstrator and training system deployed at Network Rail's Basingstoke Regional Operations Centre.
3. The signalling system on the Shepperton branch line, including an integrated MCB-CCTV renewal at Hampton.
4. The signalling system for Norwich-Yarmouth-Lowestoft (NYL), including six integrated MCB-CCTV renewals and four integrated Miniature Stop Light (MSL) level crossings.
5. The signalling system at Feltham for resignalling the Feltham power signal box area and re-control to the Basingstoke rail operating centre, including a number of MCB-CCTV level crossings (in progress).

Each of these schemes builds upon the subset of functions approved for the previous schemes, giving a progressive assurance path towards an unrestricted approval for the ASM Process on NR Infrastructure.

With regard to cross-acceptance, the formal request for product acceptance of ElectroLogIXS was submitted to the Network Rail Acceptance Panel (NRAP) in accordance with their Process NR/L2/RSE/100.

ElectroLogIXS was used for the complex Old Oak Common depot for the Bombardier rolling stock for Crossrail.





Specific activities for the overall system assurance process for ElectroLogIXS in the UK.

> "The ElectroLogIXS product approval process identified and recorded all residual system constraints on the certification provided by TUV"

With the potential to introduce new, or alter existing, risks that could significantly increase risk (for example, enhancements and complex renewals), schemes utilising ASM and ElectroLogIXS were categorised as 'C' under NR/L2/RSE/100/02, which requires safety verification by a Competent Independent Person (CIP).

The product approval and cross acceptance of the ElectroLogIXS system was subsequently tailored for the specific application projects with the expectation that coverage of ASM product approval would expand over time.

As part of the native assurance process for the ElectroLogIXS products followed by Alstom, in the development of their products and for the application of ElectroLogIXS to Rotterdam, TUV (formerly Railcert) were employed as the product and the application Independent Safety Assessor (ISA). In addition, TUV were employed as the ISA for Alstom's 'Globalisation' Generic Product Safety Case which forms the basis of approval for the UK ElectroLogIXS product approval application. This continuity and history proved useful in simplifying the cross-acceptance requirements.

For the Generic Application of ElectroLogIXS within the ASM process, Atkins appointed Ricardo as the UK based ISA organisation. The diagram above shows the specific activities completed by the various organisations as part of the overall system assurance process. As can be seen, despite the use of cross-acceptance it is still very complex.

The ElectroLogIXS product approval process identified and recorded all residual system constraints on the certification provided by TUV. The UK generic application development accepted these constraints as part of the ASM system requirements and developed the signalling system in accordance with the constraints identified.

The lessons learned were:

- The maturity of the ElectroLogIXs product and the previous work completed by TUV ensured the UK product approval process for the system hardware was well supported with extensive in-service data. The previous CENELEC approval from the Rotterdam scheme was accepted by Network Rail as the basis of the product safety case.
- Further UK equipment trials to confirm specific elements of system performance such as EMC and environmental behaviour were then tailored and completed more efficiently to cover the specific items where further detail was required for UK deployment.
- The collaborative approach between Atkins, Alstom and Network Rail for the development of the UK specific system variants enabled a simple route for the assessment and assurance of the modifications to the ElectroLogIXS system.
- The integration of the ElectroLogIXS system verification and validation requirements into the overall ASM framework was completed during the system development works,

however, these activities did result in some misalignment of the overall EN50126 compliant process with the legacy Network Rail standard signalling delivery handbooks which required careful management through the system review process.

- The comprehensive identification of application requirements such as maintenance information and operational instructions and the representation of these items in the complex acceptance process in the form of a comprehensible Assurance Process Map was well received by all stakeholders. This has been extended post commissioning to cover the system support and continuous improvement activities.

"Hopefully this paper has shed some light on why it is not quite so simple"

Atkins's conclusion is that the overall experience of the cross-acceptance activities was positive and has worked well for the assurance of the ElectroLogIXS product and its application within ASM. This remains a testament to the collaborative way in which these activities were completed by Alstom, Network Rail, Ricardo and Atkins.

Conclusion

What does all this lead me to conclude about cross-acceptance? Throughout my railway career, managers and politicians have asked, "if it works and is approved on one railway why can't it just be used on another?". Hopefully this paper has shed some light on why it is not quite so simple.

Since those 1992 and 2005 papers some things have got easier and some have got harder, but for sure the objective of reducing industry costs has not really been delivered.

"Cross acceptance can get equipment into service with less work than starting afresh – just usually not a lot less work"

For components like, for instance, a point machine it is largely about the application conditions and environment, often as set out in standards. A component designed and proven on a passenger railway may have problems on a heavy haul line. A component designed and proven in the relatively stable temperatures of a maritime climate may have problems in the extreme temperature highs of the desert or the lows of Alaska or Siberia. Going in the other direction a maritime environment may well cause corrosion problems. Radio spectrum usage is different from country to country meaning EMC performance cannot be assumed to be the same. A component designed for a more demanding environment may have other performance issues such as operating time and of course meeting additional performance requirements adds cost, so simply 'gold plating' to enhance acceptability may render the product unattractive in that regard. It is usually unavoidable to do additional qualification testing.

As we move to more complex systems which include more functionality then they are highly likely to reflect the operating practice and rules for the application environment they were designed for. Approval will depend not only on technical interfaces but on the degree of change needed to match a new operating environment and the impact of that change on the original design. That can mean a great deal of work; quite small differences in operating practice may require significant changes to the equipment, and don't forget all of the supporting systems – data generation tools for a system generated outside the CENELEC framework are unlikely to have EN50128 'T' ratings and the validation evidence that does exist may not easily convert. If you can't assure the data, you can't assure the resultant system performance.

Great strides have been made in securing interoperability within Europe by harmonising the standards and that inherently includes cross-acceptance within their scope. But it has been achieved at great cost in terms of complexity and time by making a system that can be configured for all the different European railway operating rules. That will not help in applying systems where the operating rules are different again and, if anything, it has increased the barriers to bringing anything developed outside Europe into Europe.

For software driven systems the problems can be the greatest, particularly coming into Europe or other areas/contracts that have adopted the CENELEC processes. I have written and spoken extensively about the folly of the arbitrary and un-analysed allocation of SIL levels and the mistaken belief that use of one of the combinations of measures in Annex A of EN50128 guarantees that the appropriate failure rate for that SIL will be achieved. But still we see excessive and unnecessarily widely applied safety targets under EN50128 and EN50129 specified. Particularly in any domain where the ALARP principle is used along with CENELEC that conditions behaviours. The CENELEC process must be that which delivers ALARP otherwise why specify it? Assessors and clients thus have little choice but to try to fit any available evidence into the CENELEC structure. That usually leaves many gaps for a product coming from any other framework, and even for those from the same framework but a different operating regime. The only way to fill the gaps is to do more work to produce evidence that does fit – often even to get to the stage of a credible baseline before any changes are implemented. Evidence that does not fit the CENELEC framework carries little or no weight.

All that said, cross acceptance can get equipment into service with less work than starting afresh – just usually not a lot less work. Despite its withdrawal, keep a copy of TR50506 pt1 in your library, it is not perfect but does provide a really useful roadmap.

What do you think?

Is cross acceptance a useful process? Do we use it properly, or do we use standards to protect our own regional views and traditional approaches?

What's your experience – positive or negative – of introducing new technologies to a railway or country where they haven't been used before?

Share your experience and insights with our readers, we'd love to hear from you. Please email **editor@irsenews.co.uk**.

Safety is no accident: lessons from a different railway

Karl Davis

In this article Karl, a train manager with GB Railfreight, shares an operator's view on operational safety and considers whether we've learnt all the lessons we should have from past events.

For over a century, the railway network in the UK, like many around the world, has lived and died almost exclusively on the dedication and skill of train drivers, guards, signallers, and other safety critical staff. Today's railway places understandable value on the improved operational standards management, training, and NTS (Non-Technical Skills) that have become an everyday part of modern railway operations.

The railway of old simply did not have these types of issues on its radar. In the UK under British Rail (BR), and indeed into the first few years of privatisation after 1994, railway management essentially relied on experienced staff passing on the wisdom they had earned to the newer recruits. Standardised route learning materials simply did not exist, and although a sizeable percentage of traincrews produced their own maps and memory aides, the accuracy and quality of them was predictably unreliable. The inquiry into the Ladbroke Grove collision highlighted this very issue, and whilst massive strides have been made in terms of improvement and access to resources, the standard of route learning information and educational tools available is still far from perfect in a lot of cases.

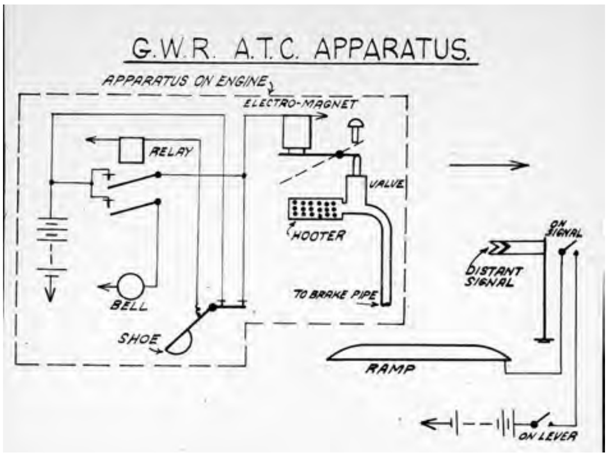
Whilst personally I tend to err more on the side of "Hanlon's Razor" (an expression that states, "never attribute to malice that which is adequately explained by stupidity") when it comes to such matters, a more cynical approach may speculate that leaving the burden of competence on the shoulders of safety critical staff would provide an opportunity to pass the liability for incidents arising from the kind of opaque competency management system prevalent at the time.

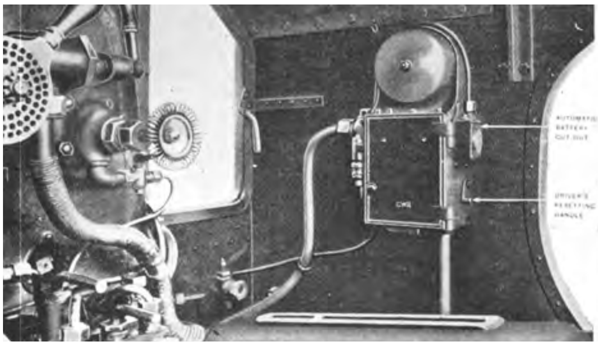
Despite being recommended by several investigating officers reporting on terrible crashes, train protection simply was not a priority of BR or its successor Railtrack. Many locations on the network were simply not protected adequately by the traditional systems, despite being a major risk for decades. The investigation into the 1989 crash at Purley highlighted systemic shortcomings in the signalling system between Stoats Nest Junction and South Croydon Junction on the Brighton Main Line. The only assistance provided to train drivers at the time was the AWS (Automatic Warning System), a descendant of ATC (Automatic Train Control), a system first used in 1906 on the Great Western Railway.

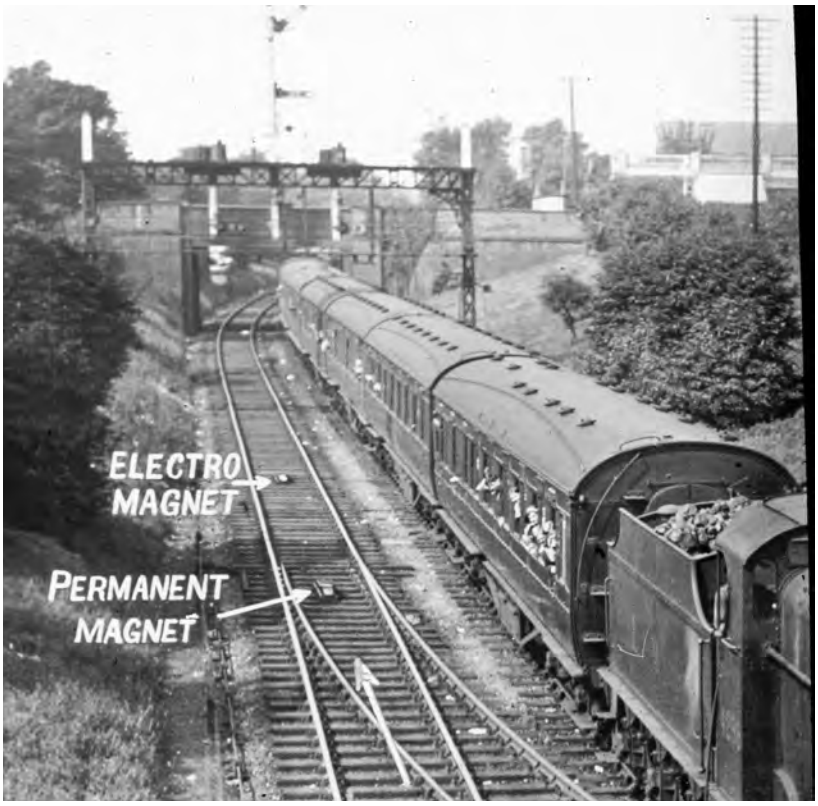
AWS was developed in the 1930s by an engineer called Alfred Earnest Hudd and was widely installed across the network from the 1950s. The system uses a permanent magnet and an electro-magnet installed between the rails that activates a receiver underneath a passing train, and sounds a horn in the cab that must be acknowledged by the driver by pressing a button within what was originally 4-7s, but is now 2-4s otherwise the train's brakes will apply, when the train approaches a cautionary aspect, danger aspect, or warning associated with a speed restriction or open or locally monitored level crossing. A visual display will show a yellow and black disc, often referred to as a 'sunflower'. For this to happen, the electromagnet between the rails must be unpowered, so the train only detects the permanent magnet. When approaching a green 'proceed' aspect, the electromagnet is powered, alongside the traditional magnet. The on-board receiver interacts with the charged electromagnet, resulting in a bell sounding in the cab, and the visual reminder displaying an all-black disc.

The Purley crash occurred when an express train from Littlehampton on the Sussex coast to London Victoria was being signalled to a stand on the approach to Purley, a station at which such services would not routinely have called. It had caught up with a stopping service from Horsham to London Bridge. The driver failed to control his train in accordance with the cautionary aspects he received, and the express collided with the rear of the train ahead, before careering down an embankment and coming to rest in the gardens of a row of terraced houses.

Five people lost their lives in this incident, and 88 were injured, some severely. The train driver, Robert Morgan, was sentenced to prison for being negligent in his duties. The investigation at the time found driver Morgan almost wholly responsible. Years later, driver Morgan's conviction was overturned on the grounds that his defence team were not aware of undisclosed evidence that would have allowed him to plead not guilty.







Precursors to AWS came from early in the 20th Century. Left, general arrangement and cab equipment of the GWR system. Right the Hudd system in use on the London, Tilbury & Southend Railway. Note the separation between the permanent and electromagnets which are directly adjacent in the final BR system.
Photos Westinghouse B&S Archive.

That evidence centred around known risks regarding the sighting of signals in the area, and of the inadequate lengths of signal overlap (the stretch of railway line beyond a signal at danger designed to reduce the risk should a train fail to stop at the signal due to a relatively minor misjudgment of the braking whether caused by human error or technical problem, or that must be unoccupied by a previous train before that signal is able to display a proceed or cautionary aspect) as the lengths of the signal sections (the length of line between each signal) decrease rapidly towards Purley Oaks from Coulsdon.

Following the awful crash at Clapham in 1988, British Rail began trials of a system designed to constantly supervise the speed of the train in relation to caution, danger aspects, and permanent speed restrictions. ATP (Automatic Train Protection) was installed on the routes from Bristol to Paddington and from Aylesbury and Aynho junction to Marylebone as part of a trial of two competing designs. Whilst ATP is undoubtedly a superior system of train protection, and many of the advantages of the system are present in ETCS (European Train Control System), the initial political appetite for the system wide implementation swiftly waned in the face of a bill that today would be several billion pounds!

As successor to BR, Railtrack opted for a much cheaper alternative in TPWS (Train Protection Warning System). The system uses two electrical loops which set the maximum permitted speed for a train to pass over the equipment. The first loop is an ‘arming’ loop which starts a timer in the TPWS on board system. If train then passes the second ‘trigger’ loop before the timer de-activates, the train is exceeding the permitted speed and the onboard system will apply the train’s brakes.

In addition, the system has loops installed at the signal, which are energised whenever the signal displays a danger aspect. These are called “Train stops” and are designed to apply the brakes of the train in the event of a SPAD (Signal Passed at Danger) and stop the train within the signal overlap. The system is designed to be effective at speeds of up to 75mph (120km/h), with supplementary equipment designated as ‘TPWS+’ for speeds of up to 90mph (145km/h).

The train stop element of TPWS is an electrical equivalent to the mechanical system installed on London Underground lines, which uses physical equipment next to the running rail to engage with a ‘trip cock’ which opens the train’s brake pipe, thus inducing a brake application. Following the Moorgate crash in 1975, this technology was also used in a TETS (Train Entering Terminal System) application whereby a series of train stops on the approach to a buffer stop are lowered in sequence at a rate corresponding to the required braking profile.

An often-asked question is whether TPWS would have prevented the collision at Purley from happening. At face value, the answer would be yes. However, the underlying issues surrounding signal sighting and inadequate signal overlap on the route would likely have been remedied as installation of TPWS was completed, an initiative that may well have assisted driver Morgan in stopping his train at the signal protecting the train ahead. So where the case against the driver would initially appear compelling, the operational realities present a much more complicated landscape exposing a multitude of cultural, historical, and systemic deficiencies allowed to manifest unchallenged for generations.

Similarly, the collision at Colwich Junction on the West Coast Main Line (WCML) appears at first look to be the epitome of the ‘open and shut’ case. On 19 September 1986, the 1700 express from Euston to Manchester Piccadilly, 1H20, was approaching Colwich Junction having been routed from the Down Fast to the Down Slow. The route across the junction had been set for the 1720 express from Liverpool Lime Street to Euston, 1A76, which was approaching at approximately 100mph (160km/h) under green signals, with driver Eric Goode at the controls.

The driver of 1H20, driver Shaw, observed flashing yellow signals in advance of Colwich Junction. In UK signalling, flashing yellows generally meant that "the route ahead is set across a diverging junction". When flashing yellow signals were introduced to Britain's railways in 1977, drivers were told that they meant that the route was set all the way across the associated junction. Driver Shaw took the flashing yellow he sighted on approach to Colwich as meaning that he was signalled all the way across Colwich Junction onto the Stoke line. With this in mind, he reduced his speed accordingly for the junction ahead, not realising that at this location, the flashing yellow he encountered had only signalled him from the Down Fast to the Down Slow, where he was still approaching a danger aspect protecting the junction, as a result of the route being set for 1A76.

This signalling arrangement was different to most locations where flashing yellows had been installed. At another nearby location 12 miles north along the WCML, Norton Bridge, the signalling arrangements meant that trains were signalled all the way across the junction, and the driver of 1H20 cited he believed he had authority all the way across the junction and onto the Stoke line.

Also worthy of note is the presence in the cab of 1H20 of a trainee driver, M R Organ, based at Brighton, who was in the cab without authorisation. Much of his evidence corroborated that of driver Shaw, and although trainee driver Organ was quick to emphasise that he had not distracted driver Shaw in the run up to the incident, there was no evidence to corroborate, or challenge the claims he had made.

Tellingly, the circumstances of the incident were exacerbated by four things:

- Driver Shaw had failed to consult Section C of his WON (Weekly Operating Notice). The details of the signalling arrangements were published in the most up to date edition he had signed for as part of his duties.
- Colwich Junction had been remodelled when the flashing yellow signals were commissioned. BR did consider providing flank protection (where the signalling sequences at a location are programmed to prevent any conflicting movements by ensuring that the points are set to divert a train away from any move signalled to cross its path) in the signalling system, but had decided against it on the grounds that it would limit the range of routes available.
- BR had failed to communicate clearly the fact that the signalling sequence briefed to drivers when flashing yellow signals were introduced may not apply at every location where flashing yellows signals were in operation. It was due to this failure of communication, combined with the failure to check Section C of the relevant WON that led to driver Shaw misinterpreting the flashing yellows on approach to Colwich Junction as authorising 1H20 right across the junction and onto the Stoke lines.
- Driver Shaw controlled the speed of his train in the belief that Signal CH23, which protected the junction, was set up to clear to a proceed aspect as 1H20 approached. When it remained at danger, driver Shaw realised 1H20 was travelling too fast to avoid a SPAD and made an emergency brake application. It was too late. 1H20 passed signal CH23 at danger and came to a stand with the locomotive foul of the junction.

One can only imagine the shock and terror that filled driver Goode as his train bore down on the locomotive of 1H20. Driver Shaw, and trainee driver Organ jumped clear of the locomotive seconds before impact. Driver Goode was not so fortunate and died in the crumpled cab of the Class 86 locomotive that had smashed into the leading locomotive of 1H20. In evidence, driver Shaw had maintained that he had approached the signal at approximately 30mph (50km/h), making an emergency brake application approximately 40yds (37m) from CH23, although when pressed he could only say that the speed of 1H20 was "definitely less than 40".

Colwich Junction today looking north with the Manchester line to the right. The memorial garden to driver Goode is to the right of the junction cross over, where 1A76 came to a rest.

When approaching a signal at danger at 40mph (64km/h) or so, most trains would struggle to stop before the associated signal, perhaps except for one or two of the most modern multiple units. It is standard practice nowadays for passenger train operators in the UK to mandate that drivers ensure their train does not exceed 15mph or 20mph (24km/h to 32km/h) when 200yds (183m)from any signal at danger. For train drivers operating freight trains, the mandated speed is 10mph.

So, could TPWS have averted this disaster? Yes, it certainly could, though as in the case of the Purley crash, TPWS would have undoubtedly prevented either the collision itself, or the SPAD by intervening to apply the brakes of the Manchester bound train before any conflicting movement materialised. However, had any one of the factors explored here been avoided or resolved, it is highly likely that the only interaction drivers Goode and Shaw would have had that night was a brief wave as they passed at speed.

The whole concept of "approach release" signals has been either an immediate or underlying cause of countless SPADs over the years. One characteristic of railway work is repetitive routine, and a significant product of repetitive routine is contemptible familiarity. There are all too many locations where drivers approach signals at danger too fast, simply because 'the signal always clears when you get up close'.

I cannot stress loudly and passionately enough that approach release signals are only of relevance to signallers. Drivers should, and thankfully for the most part, do, treat ALL signals at danger with the respect they deserve. Drivers nowadays are trained NEVER to expect a signal at danger to clear before they bring the train to a stand. This kind of policy is the type which sadly would have been sneered at in years gone by, as would the prospect of additional train protection. As in the case of the Purley crash, a cursory glance at the particulars of the incident led to the driver being burdened with the blame. However, even a basic level look below the headlines quickly highlights the deficiencies in training, route assessment, operations standards, and the prevalent culture within the messrooms of the day.

This is precisely why operations training, and operations standards are so pivotal to the safety performance of any railway. It is easy to regard these disciplines as 'luxuries to be hacked at in hard times', but the truth is that, even in the crazy amphitheatre of business during COVID-19, and the deep seated recession that is certain to land upon us soon, training and standards are, and will be, never more vital to the success of an operator, and it is an extremely short-sighted leader who takes the opposing view. After all, not only is it true to say that "safety is no accident", it is also simple good business sense to remember that, whilst safety improvement can be expensive, it is always more cost-effective than disaster.

What do you think?

Thankfully route learning and operations training have improved since 1986, but could signalling engineers still do better? How do you ensure your signallers and drivers are adequately trained and operating standards are properly briefed and understood for the systems you design? We would love to hear your thoughts, so please share your experiences with us, email **editor@irsenews.co.uk**.

About the author ...

Karl is train manager with GB Railfreight in the UK and is a qualified train driver, who works alongside customers and colleagues to improve driving standards, by amending, phrasing and designing operations and policy documents. He also advises on training materials and related content. He has considerable experience as a standards and railways operations technical author, and managing operational competencies and professional driving standards. Karl also works as a freelance voiceover artist, working with enterprises and creators internationally to produce professional voice services for documentary, commercial, training, and educational purposes.

The well-kept memorial garden.

IRSE///
Institution of Railway Signal Engineers

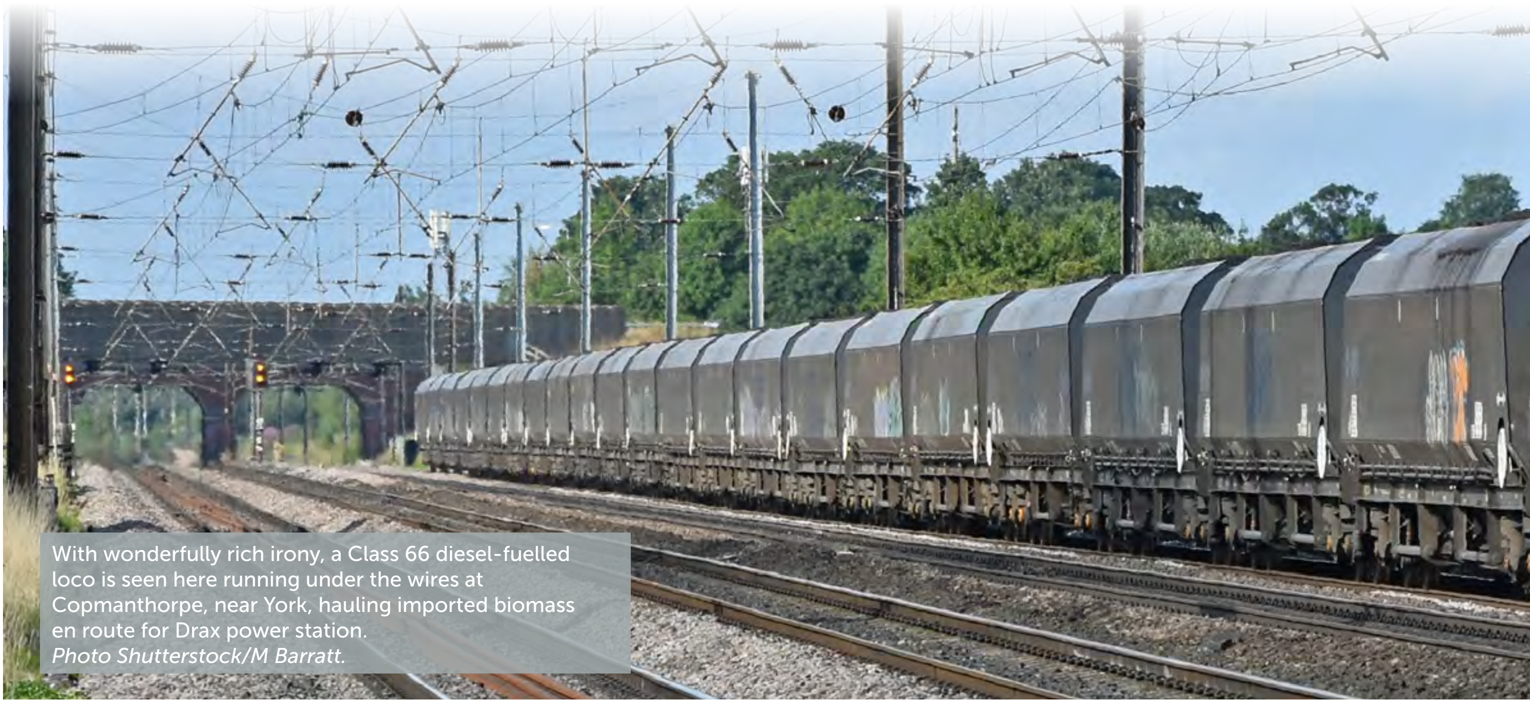
Traction decarbonisation in Great Britain

David Fenner

As part of the UK government aim to achieve net zero carbon emissions by 2050 the Department of Transport requested the rail industry to report on the removal of diesel trains from the British main line rail network. Network Rail recently published a Traction Decarbonisation Network Strategy (irse.info/f9j81) in response to a recommendation from The Rail Industry Decarbonisation Task Force. The report uses some data from the parliamentary Committee on Climate Change (irse.info/jfd7s) and thus quotes figures on a UK basis including Northern Ireland. The objective of the document is to provide recommendations to the governments of England, Scotland and Wales that support future decision making with particular reference to the removal of diesel trains. This is the first stage in a long journey with the aim of eliminating or at least reducing to a very low level the carbon dioxide emitted by trains during operation. Other work streams are looking at limiting the carbon dioxide emitted as a result of other functions such as construction.

The report notes that UK emissions have declined overall by 44 per cent in the last 30 years mainly due to replacing coal with renewables in the electricity generation mix. However, surface transport (excluding air and waterborne transport) has increased emissions by 4 per cent in the same period and is now the biggest contributor of greenhouse gases creating 23 per cent of UK emissions. But, of course only a small percentage of that comes from rail, partly due to market share and because rail is relatively low carbon. The low rolling resistance of steel wheel on steel rail make rail low carbon, and many high-density rail services are already operated using electric trains. However, there is much to do to remove diesel traction.

To deliver significant carbon reductions there needs to be an element of modal shift away from road and air transport toward more environmentally acceptable modes including rail, noting that rail freight produces 76 per cent fewer emissions than road freight. Rail freight needs to have electric traction available over more routes so that diversions for engineering or capacity reasons do not result in more diesel traction.



With wonderfully rich irony, a Class 66 diesel-fuelled loco is seen here running under the wires at Copmanthorpe, near York, hauling imported biomass en route for Drax power station. *Photo Shutterstock/M Barratt.*

The report looks at three alternatives to diesel; electrification, hydrogen and battery powered trains. The principal concern is the energy requirements of different train types and journeys and the significantly lower energy density of both battery and hydrogen storage systems. Essentially the report proposes that hydrogen and battery operated trains are not feasible for high speed (above 160km/h, 100mph) or for long distance or freight traffic. In fact, the report is sceptical about the use of batteries for trains operating at above 120km/h, 75mph, although bi-mode (or multimode) trains would allow these to operate at such speeds on an electrified network.

The consequence is the need for a large-scale electrification programme, much of which is driven by the needs of freight and long-distance passenger trains. Currently there are 15400 Single Track Kilometres (STK) of diesel operated railway. The report suggests that 11700 STK be electrified, with 400 STK of battery operation and 900 STK of hydrogen operation. The remaining 2300 STK is "yet to be decided" but the initial report suggests around half would be electrified. There would be a small rump which may still require diesel operation, particularly around freight yards, but this would be dealt with by offsetting the emissions.

This is planned to be achieved over an extended rolling programme of electrification with different options ranging from 259 STK per annum to 658 STK per annum. The latter is not considered feasible with a maximum achievable rate being around 450 STK per annum in terms of supply chain achievability.

Should such a programme come to fruition what will it mean for signalling and telecoms? In the past electrification schemes have resulted in significant renewal of the signalling assets not least to make them immune to interference from the traction supply. The advent of computerised interlockings, the use of axle counters for train detection and fibre optic communication facilities means many of our modern signalling systems are substantially immune to traction interference by design . That is not to say there will be no adjustments to provide local immunity or protection to the local cables, data circuits and trackside objects but in many cases wholesale resignalling should not be required. The IP enabled FTN (Fixed Telecom Network) provides a national network of data connectivity that could be expanded relatively easily to provide the SCADA system for electrification control as well as linking centralised interlocking to object controllers. An issue with such a comprehensive programme of electrification is that it covers many secondary routes which may not have been resignalled for many years, and in fact some may still be operating mechanical signalling. Given the plan is for a thirty-year programme it should be possible, if necessary, to link signalling asset renewal to the electrification programme.

It would also be nice if ETCS level 2 without lineside signals could be delivered on at least some parts of the network prior to electrification. Achieving this would avoid signal sighting issues caused by the new overhead line equipment, removing a challenge to both the signal and electrification engineer. Whether this can be achieved is perhaps less certain as the existing trains on the route would need to be ETCS equipped prior to electrification and those trains may have a short life once new electric trains come on stream. However, a sensible cascade policy could support such an approach. Another advantage of using ETCS is the ability to reasonably easily increase capacity especially on secondary routes where additional sections can be created by adding more train detection. This could be useful given the desire to deliver an element of modal shift, especially for freight because heavy lorries suffer similar issues in terms of energy consumption and the viability of batteries and hydrogen for longer distance road transport.

It may also be necessary to consider the effect of locations where high-power fast charging will be required for battery operated trains. Whilst it is likely that battery operated trains will also draw power from the overhead line, some places, especially on branch lines, could well provide charging facilities and no doubt to keep turn round or dwell times low will require a fast charge function. Is there a possible source of interference associated with such high-power facilities?

These proposals are ambitions and given past UK government antipathy toward electrification we cannot be sure they will proceed, especially with the post Covid-19 drop in traffic and the current high demands on public expenditure. But assuming the climate crisis becomes a dominant feature as we leave the pandemic behind there is a significant chance that a major programme of electrification and with it signalling enhancement could occur. If it does happen it is perhaps essential the industry comes together and acts with "one directing mind" to execute the work in the most efficient and effective manner.

C-DAS Connected Driver Advisory System

Paul Darlington

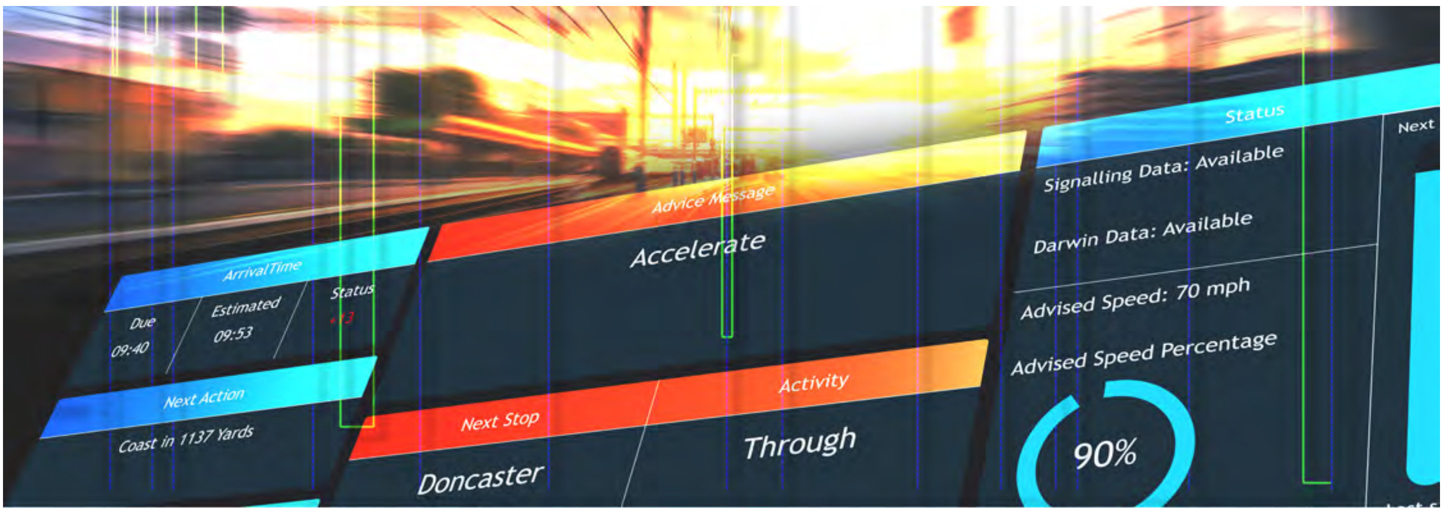
A Driver Advisory System (DAS) is an on-board processor-based system that provides a driver with information to achieve the timetable sustainably, by regulating the speed profile and avoiding unnecessary braking.

Standalone DAS (S-DAS) has data downloaded to the train at the start of its journey, but Connected DAS (C-DAS) is enhanced with a communications link to provide real-time updates of information to the train, including train describer berth (where available) and Darwin information along with other information such as temporary speed restrictions. Darwin is the GB rail industry's official train running information engine, providing real-time arrival and departure predictions, platform numbers, delay estimates, schedule changes and cancellations.

C-DAS is what it 'says on the tin' and it only 'advises' a driver, so the system does not require a high safety integrity in terms of signalling design and asset management. Safety is ensured by the train's on board normal control and braking system together with the line side signalling system. This allows more cost-effective C-DAS solutions to be quickly rolled out compared to other safety critical components in the Digital Rail Programme.

C-DAS calculates and displays to the driver an energy-efficient speed profile to enable the train to meet the timetable, taking into account timing points, line speeds including speed restrictions, and the train's characteristics and capabilities. The advisory information helps the driver to achieve the timetable and monitors the train's progress towards the next timing point to identify any changes required to the speed profile. This is complemented by a suite of reporting facilities. The information is provided to the driver through a Driver Machine Interface (DMI) which in some installations may be part of the driver's existing DMI.

If the train is behind time and if the line and train speed limits are capable of a higher speed, then this will be advised to a driver, or if the train is running early a more efficient speed profile can be advised, both to save energy and wear and tear of the train and track.



C-DAS provides advice to drivers to allow them to optimise fuel use and train running.

Above left, the train display unit.

Above right, the connected nature of C-DAS requires significant functionality to be available in the control centre.

C-DAS also helps to ensure a train arrives at any junction in time to avoid timetable conflicts with other trains, and it can avoid the need to brake at adverse signals, thereby reducing the risk of signals passed at danger.

Implementing C-DAS

Siemens approached KeTech in the UK to provide a C-DAS system for their Class 350 trains. The system has been designed to use an updated version of the existing DMI, but a larger graphical standalone DMI could be used in other classes of train. The communications link is provided by public LTE telecoms networks. This allows a much higher data bandwidth than that currently available via GSM-R. The system intelligently manages the communications connectivity and is able to fallback gracefully to S-DAS mode in the event of comms loss.

Collaborative opportunities

KeTech is also working to introduce C-DAS in Australia, partnering with railway signalling company Omada Rail Systems. Increasing the fuel efficiency of freight trains in Australia is a priority, and C-DAS can help in achieving this objective. Omada is assisting with their local experience in track topology and signalling, along with their design engineering and systems integration capabilities.

Resilient architecture

With the capability to be completely connected to the whole rail network, the C-DAS updates drivers and provides advice to facilitate a smoother journey, greater efficiency and significant energy savings. The class 350 C-DAS product rely not just on Global Navigation Satellite System (GNSS) receivers, but have access to many other sources of positional and real-time information including signalling data and the train management system (TMS) – a train-borne distributed control information system, with data such as wheel rotation counting to ensure an aggregated reliable, accurate location information feed. The C-DAS uses train describer data, where available, to identify when a train has been changed from its planned route and reforecast the revised route that the train will be taking, adjusting the route profile automatically.

One reason for having a diversity of positioning systems, rather than just using GNSS is that for GNSS to work reliably there needs to be clear 'line of sight' from trains to satellites, and trains may be hidden by bridges, tunnels, cuttings and when travelling on sub surface lines. GNSS alone will not have adequate resolution to determine which line a train is on when several lines run parallel, and another issue is that neither the infrastructure manager nor the train operator will have any control over the availability of the GNSS signal.

C-DAS, while delivering route and train status information to the driver with fuel efficiency and cost saving, also facilitates passenger comfort and a smoother journey. Passengers can get frustrated with experiencing a fast and potentially uncomfortable journey with hard braking, followed by waiting outside a station for a platform to be available, even if the train still arrives at the platform on time. C-DAS provides a solution to this problem.

What do you think?

This C-DAS aims to make best use of the information systems available ahead of the deployment of traffic management, but are the benefits systems such as this worth the investment? What is your experience of using or providing connected or standalone DAS for your railway? Have you had good, or bad, experiences? Perhaps you have found a way of using alternative solutions to improve in service operation?

We'd love to hear your experience, and for you to share lessons learnt with our 5000-strong community of railway technology professionals worldwide

Email us at **editor@irsenews.co.uk**.

IRSE
Institution of Railway Signal Engineers

Zero disruption project delivery

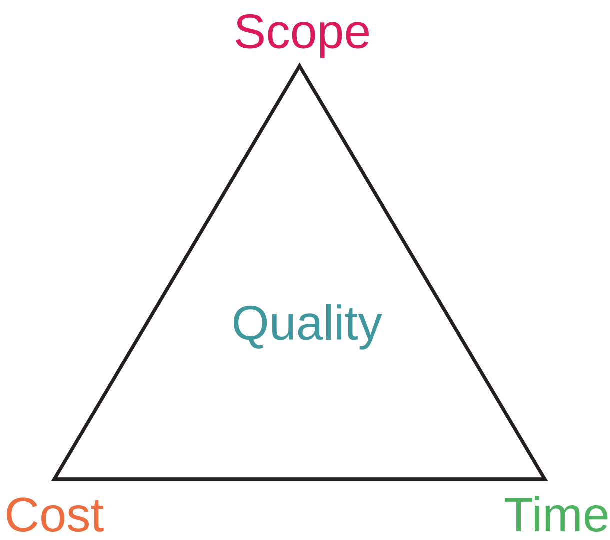
Frank Heibel

This article was first published as a three-part series in the "High Performance Signalling Newsletter", available at docfrank.com.au. This version has been edited to enhance the flow when presented as a single article.

Successful project delivery needs to go increasingly beyond the balancing of the classic cost-time-scope triangle. Causing excessive disruption of train services during delivery can severely damage the reputation and patronage of the railway. Modern advanced signalling technologies with reduced trackside equipment offer ways towards "Zero Disruption Delivery" of projects, which is not just suggested as a fourth criterion for project success but as the new 'superpower' for project delivery. This article discusses why service disruptions by project works are less tolerable than ever and outlines ways for project design, installation and testing which can minimise if not eliminate any need for shutting down the railway.

When asked about criteria for successful delivery of signalling (or other) projects, people with project management background usually come up with the three generic aspects of the project management triangle – cost, time, and scope. Cost – project delivery is successful if it stays within the project budget. Time – a successful project is completed on schedule or slightly earlier. Scope – successful projects delivers the initially promised scope with quality that is fit for purpose.

This concept is sometimes also called the "triple constraint" and it seems to have become gospel over time that it is virtually impossible to deliver on all three, and delivering on two of those constraints will inevitably lead to a disaster in the third one. Yet it ought to be possible for a well-planned project to deliver on all three aspects, cost-time-scope, and get at least close to expectations. This article takes it a step further by defining a fourth criterion for successful project delivery which relates more to the actual delivery process, whereas the above three constraints are more outcome-oriented.



The Project Management Triangle.

A process-oriented success factor

That fourth criterion for project success is Zero Disruption Delivery. That means for a railway signalling project in an operating "brownfield" environment that its delivery must not disrupt ongoing train services. There is a distinguished success indicator for Zero Disruption Delivery: When using the train timetable, not a single one of those timetabled services must get cancelled or reduced due to project delivery activities. Not one, this is what "zero" means.

Mindsets and loopholes

The reaction of project people to this clear-cut requirement indicates the likelihood of Zero Disruption Delivery becoming a reality. A quite common attitude is "this is impossible" and people thinking that will likely be proven right if that is their attitude to this challenge. They will try to do everything just as they have always done it, based on their "wealth of experience", and the outcome will be the same as it always was – service disruption from multiple shutdowns of the railway, which are simply undesirable for passengers even when softened by bus replacement services.

Photo Shutterstock/EtiAmmos.

Another common interpretation of Zero Disruption Delivery is "doing the best we can" by reducing the number of shutdowns caused by their own project. The usual way to tackle that is to piggy-back on planned shutdowns by projects of other disciplines (who are usually unenthusiastic about that). But no, passing the buck of responsibility for shutdowns to others is not the solution here. Avoiding shutdowns altogether, is.

A more mature reaction might be "I can't see (yet) how this will work but let's discuss the potential". Now this is the mindset needed to make it work or have at least a fighting chance. It may well be that Zero Disruption Delivery might have never been achieved for this particular railway, with the processes and regulations that were always followed and the technologies that were applied to date. Getting to different (and clearly better) results requires doing certain things differently. This applies to the concept for the technical solution which needs to lend itself to Zero Disruption Delivery, and to the execution of inevitable parts of the project delivery on site.

Service disruption become less tolerable

Before looking at options for accomplishing Zero Disruption Delivery it is worth recognising why this is more important than ever. This is under the premise of projects introducing high performance signalling to an existing railway.

High performance signalling, be it Communications-Based Train Control (CBTC), advanced varieties of the European Train Control System (ETCS) or any equivalent technology for Automatic Train Control (ATC), is expensive. Railways invest in it not just for fun but because they feel an urgent need for the additional capacity and performance enabled by this new technology. Now, such urgent need only occurs when the existing services are reaching their limits. In Hong Kong for example they coined the term NCO – Near Capacity Operation to describe that state. Railways which operate at or near their capacity limits are particularly sensitive to service reductions. Shutdowns for field works tend to affect far more passengers in a busy railway than in a hardly used one. Zero Disruption Delivery resolves that problem.

The annoyance of shutdowns to passengers in a busy railway is not the only problem. The more serious consequence, especially of extended shutdowns, is that rail passengers are forced to find alternative ways to travel. And once they got used to those alternative ways, they may not come back to use the railway, at least not to the same extent as before the shutdowns. An instructive example happened a few years ago in Perth, Australia where for works at the central station a substantial number of services were shut down entirely for a whole week. Not just once but twice within three months. The resulting nosedive in patronage numbers took forever to recover, and some passengers may have never returned. Once passengers start perceiving they can't rely on the train services things go downhill for the railway very fast. When passengers need to cater for alternative transport anyway they may just as well use it permanently.

Front page or "silent legacy"?

Apart from the above-mentioned problems which call for Zero Disruption Delivery more than ever, there is also the opportunity to leave a "silent legacy". Now what does that mean? Major impacts on public transport services usually find their way into the local media, and often onto the front page. And not in a nice way. In contrast, very rarely will local media report on railway work that went so smoothly that no-one noticed. That is the silent bit of the "silent legacy". But the more exciting thing is the legacy bit. Because railways were not used to Zero Disruption Delivery and often did not even believe in the possibility, the achievement of it will be seen as all but a miracle. The people achieving it will be in high demand once the appetite for more disruption-free projects is whetted. One might even see the ability to deliver projects disruption-free as the new "superpower" in the world of railway projects.

How it might work

When aiming for different (better) outcomes you'd better change your approach too and mitigate obstacles that used to be in your way. It helps that high performance signalling – meaning CBTC, advanced ETCS Level 2 or any other ATC technology with no or only very few lineside signals – offers opportunities for Zero Disruption Delivery which previous conventional signalling technologies simply could not provide. And a more wholesale equipment replacement approach, often considered for high performance signalling introduction, will help greatly too. That is not "cheating", it is exploiting novel possibilities for the greater good of disruption-free continuation of railway services while bringing in the new technology.

Zero Disruption Design – new and old in parallel

It starts with the planning of the system design. When introducing CBTC or ETCS Level 2 it is critical for smooth delivery to replace the associated interlockings, with the whole wayside subsystem to come from a single supplier. That does not only eliminate any devastating problems in developing a complex new interface. It also allows the setup of the new signalling system in parallel to the existing old one which is needed to keep the railway running without disruption. The bundling of CBTC/ETCS and new interlockings with a new control system, Automatic Train Supervision in CBTC terms or Traffic Management System for ETCS, further supports this separation between the old and the new signalling and control system. And if the new system requires track vacancy detection, axle counters are the way to go and they can be overlaid to existing track circuits or axle counters without interfering. Any "softening" of this parallel approach, for example by retaining "only some" of the existing equipment, will make it (much) more difficult to deliver the project disruption-free. By the way, point machines are the exception to this rule – their handling will be explained shortly.

So, if there is a largely independent new signalling and control system on the wayside that can be installed and tested without impact on the existing signalling and control system, that existing system can continue to control train services, disruption-free. For this to work, installation and test of the new technology must not require a shutdown into the regular service hours. Let's see how to do that.

Zero Disruption Installation

High performance signalling with a lean and pure design concept does not require lots of equipment on the track. By and large it comes down to fixed-data transponders or balises, and axle counting heads. Each of those can be installed easily during nightly engineering hours, including any tail cabling for axle counters. All the other equipment sits off the track in cable ducts or equipment rooms. Problem solved for disruption-free installation. If you have lots of other stuff to install on the track, it may be worth revisiting the concept design for less complexity (that means it is probably too complicated).

Zero Disruption Testing

Now, testing. The trick here is to reduce the time required for service-disrupting field tests to, ideally, zero. This requires significant off-site testing, for example in a specific test facility for the new technology. That will be much easier for software-based technologies such as CBTC or ETCS, compared to hardware-heavy conventional signalling with lots of widgets on the track. But not everything can be tested offline. Enter "shadow mode testing". While the old system can keep running the railway, the parallel-built new system can be tested in parallel "in the shadow" of the operating old signalling system, 24/7 without disrupting the old system at all. The exception is again point machines which are assumed to be retained with the turnouts they operate.

Now let's deal with those point machines. For obvious safety reasons, they must not be interfaced by the old system (for running the train services) and the new system (for testing) at the same time. A limitation for shadow mode testing, clearly. What is needed here, and all major signalling suppliers of CBTC and ETCS have that concept on offer today, is a swift cutover mechanism for point machines to switch point control between the old and the new signalling system as needed. Old system: during the day for disruption-free operation. New system: during non-service hours for testing. This can be done as much as needed to convince testers and operators that the new system is fit for commencing service. And then the "big commissioning" is not much more than a final cutover from the old to the new system, only without switching back.

Simple, unless made difficult

Simple, right? But difficult too, mainly because of the need to deal with all those ifs and buts. Convincing the tester in charge that a new signalling system can be signed into service without the traditional 54-hour weekend shutdown "which we always had for my entire career". Convincing the operator that if the new system was perfectly fine during nightly tests it will run just as flawlessly during the day (it's not depending on daylight!). And so on. These changes of "how we have always done things" are the price to pay for disruption-free project delivery. But looking at the upside of it, isn't it a rather small price to pay?

What do you think?

Do you agree with Frank's analysis? Is disruption free project delivery possible – or does it even exist? Perhaps you have experience where longer closures caused less passenger disruption than a series of conventional commissionings. Tell us, and the rest of the IRSE, about it.
Email **editor@irsenews.co.uk**.

About the author ...

'Doc Frank' is a globally recognised strategy advisor and thought leader for high-performance railway signalling such as CBTC and advanced ETCS. He has advised government railways in all four biggest Australian cities and several projects outside Australia on planning and implementing their next-generation signalling technology to boost capacity and improve operational performance.

In his quest to promote modern performance-enhancing signalling in easy-to-understand ways, Frank is highly prolific in spreading his knowledge on social media, in his free newsletter and blog, and in his unique 'Kickstarter' training courses for CBTC, ETCS and (coming soon) Traffic Management.

Photo Shutterstock/MrDoomits.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

ASFA expansion for ADIF

Spain: National infrastructure manager ADIF (Administrator of Railway Infrastructures) has awarded a €50.3m (£46m, $59m) contract to a joint venture of Indra (75 per cent) and Instalaciones y Técnicas Eléctricas Asturianas – Intel (25 per cent) for the installation of ASFA Digital trackside equipment. This is part of its programme to update and expand automatic train protection across its 1668mm gauge conventional network.

The ASFA Digital (ASFAD) or Automatic Braking and Announcement of Signals system processes information from the signals and sends it to the trains using beacons as transmission medium. The onboard system generates corresponding control curves and operates the brakes when it detects the supervised speed limit is exceeded.

Under a separate contract valued at €820k (£742k, $961k), Indra will extend the Da Vinci traffic management and TSAD remote control systems at ADIF's Atocha control centre to cover the Pedralba – Ourense section of the high-speed line serving the north of the country. Developed in collaboration with ADIF, Da Vinci is now in use on more than 3000 km of the Spanish high-speed network.

Under a third contract worth €3.3m, (£3m, $3.9m) Indra is to set up a new landline and Wi-Fi communications network connecting the stations at Madrid Puerta de Atocha, Madrid Chamartín, Pontevedra, Salamanca and Bilbao Abando Indalecio Prieto. This forms part of ADIF's 'hyper-connected' project to improve connectivity and provide public internet access at major stations and retail facilities.

Berlin Declaration supports international rail freight

Germany/Europe: In September 2010, the European Parliament and the Council adopted Regulation (EU) No 913/2010 concerning a European rail network for competitive freight. Followed in 2016 by the Rotterdam Declaration on "Rail Freight Corridors to Boost International Rail Freight", which was adopted by the Sector Statement Group of relevant railway stakeholders.

Now in September 2020 in Berlin, the EU and EFTA's transport ministers signed the ministerial declaration "Rail Freight Corridors: The Future of Rail Freight in Europe", to continue the progress. The declaration notes that "During the COVID-19 pandemic, rail has proven to be reliable and punctual and an essential element of a resilient multi-modal transport system. Rail freight has continued to run largely without interruption. This has highlighted the key success factors of rail freight, namely good quality and high-capacity infrastructure."

Commenting on its priority areas for rail, the declaration endorses digitalisation – automation, interoperable IT systems, the deployment of ETCS and ERTMS both trackside and on-board – and research & innovation. Both areas underpin the European Green Deal as they help drive modal shift and increase climate-friendly transport.

The EU's transport ministers said they wanted "to support international rail freight and further strengthen the Rail Freight Corridors" by making the following commitments:

- Further strengthen and develop the Rail Freight Corridors.
- Support rail freight stakeholders to enable them to better adapt to market needs.
- Enhance rail freight transport as one of the most environmentally friendly ways of moving freight.
- Bring about further technical and operational harmonisation.
- Recognise that a strong rail freight sector requires skilled workers.

The declaration reinforced the need for infrastructure managers to develop virtual European Traffic Management, for 740m trains and for mitigating rail noise to increase rail freight acceptance among the public. Automatic digital coupling was another key area of interest and support.

Approval for Texas high-speed line construction

USA: The Federal Railroad Administration (FRA) has completed the regulatory approval process for the Texas Central high-speed line linking Houston with Dallas, and construction is expected to start soon.

On 21 September the FRA released its final Rule of Particular Applicability and the Record of Decision for the 385km high-speed line. This establishes a comprehensive set of safety requirements covering signalling and train control, track design, rolling stock, operating rules and maintenance.

Texas Central Railroad says the design incorporates "accident avoidance measures that are significantly more stringent" than those required for conventional US railways. According to Texas Central, FRA's rule "establishes regulatory requirements codifying the service-proven technological, operational, and maintenance aspects of the Tokaido Shinkansen Japanese high-speed network".

Long-term plan to improve rail services in south east UK

UK: A new partnership between Transport for the South East and Network Rail aims to encourage people out of their cars as part of a long-term plan to improve rail services, increase capacity and reduce carbon emissions.

The memorandum signed by the two organisations sets out a range of common goals which they will work together on to achieve. These include better cross-regional train services, schemes to increase network capacity and new journey opportunities, shifting freight from road to rail, wider use of multi-mode smart ticketing and an end to diesel trains on the South East's railways.

Transport for the South East is a sub-national transport body, bringing together local authorities, business groups and more to speak with one voice on transport investment priorities. Its thirty-year transport strategy, published this summer, sets out how investment in transport can more than double the South East's economy, increasing employment, improving quality of life and cutting carbon emissions to net-zero by 2050 at the latest.

Working with Network Rail, Highways England and partners from across the public and private sectors, Transport for the South East say they will turn the strategy into a strategic investment plan, setting out a prioritised package of schemes and initiatives to transform travel and support sustainable economic growth.

Priorities covered by the agreement include exploring options for better cross-regional services including new links between Gatwick Airport and destinations in Kent, improved journey times along the south coast between Brighton and Southampton and the extension of high speed services from Ashford to the East Sussex coast. The partners will also work together to support development of major upgrades to the Brighton Main Line at East Croydon, the South West Main Line at Woking and new southern and western rail links to Heathrow Airport.

City railways and light rail

Crossrail extension study

UK: Atkins is to head up a major study into proposals for a £1.5bn (€1.67bn, $1.9n) extension of Crossrail to Ebbsfleet in Kent. The £4.85m (€5.3m, $6.3m) study backed by the Ministry for Housing Communities and Local Government (MHCLG) will advance the business case for the extension. If approved the extended route could have a Crossrail/HS1 interchange and provide a direct access to Heathrow.

The study will investigate transport enhancements between Crossrail's south eastern terminus at Abbey Wood in the London borough of Bexley, and Ebbsfleet. Atkins will undertake the transport and growth analysis, with KPMG to consider the funding and finance options.

The study is being overseen by C2E Partnership, which comprises Kent County Council, the boroughs of Bexley, Dartford & Gravesham, Ebbsfleet Development Corporation, The Thames Gateway Kent Partnership, the Greater London Authority and Network Rail. These organisations have been working since 2015 on proposals to improve transport links within the sub-region to support much needed new homes and jobs and more sustainable travel patterns.

Guadalajara Metro Line 3 inaugurated

Mexico: Line 3 of the Guadalajara light rail network has been opened. It runs over 21km and has 18 stations, with an expected passenger volume of 230 000 a day. The line will be operated by SITEUR.

Alstom was chosen in 2014 by the Mexican Communication and Transportation Ministry (SCT) to provide an integrated system for the new line. The total project investment was €330m (£301m, $388m), with Alstom's share €240m (£219m,$282m).

The contract included 18 Metropolis trains, communication systems, high-voltage and traction substations, and traffic control systems based on Alstom's CBTC system Urbalis 400. The trains are equipped with air-conditioning, video surveillance and passenger information systems.

CBTC for San Francisco and Oakland

USA: Solutions provider Parsons has secured a $45m engineering services contract to implement a CBTC (Communication Based Train Control) system for the Bay Area Rapid Transit District (BART). CBTC is part of BART's $3.5bn (£2.7bn, €4bn) Transbay Corridor Core Capacity Program, which includes five new traction substations and 306 new rail vehicles, and will replace the existing automatic train control system on 125 miles (202km) of track.

BART currently has the capacity to operate up to 23 trains an hour in every direction via the Transbay Tube between San Francisco and Oakland and serving Berkeley, Fremont, Walnut Creek, and Dublin/Pleasanton, are important for commuters, shoppers and visitors across the Bay Area. The Transbay Corridor Core Capacity Program will increase train frequencies between San Francisco and Oakland by over 30 per cent.

Mobilitie will also provide a new digital network to improve modernize connectivity across tunnels, stations and trains to deliver 5G connectivity to support BART's new digital railway initiative.

An underground wireless network will provide 5G connectivity via a distributed antenna system in nearly 11 miles of existing tunnels, 11 underground stations and the new central subway line expected to be completed in summer 2021. Mobilitie will deploy Wi-Fi 6/802.11ax, throughout 48 stations, including BART's Fleet of the Future trains that will be fully Wi-Fi enabled. The fibre network will include dark and lit fibre options to improve communication networks, broadband internet services, together with links for hotels and data centres.

Indian CBTC

India: A prototype version of i-ATS, an automatic train supervision system, has been developed by Delhi Metro Rail Corp. The work is part of a programme to produce 'Made in India' Communication-Based Train Control (CBTC) technology. The programme is intended to reduce Indian metros' dependence on European and Japanese suppliers. Led by DMRC, it is backed by the government's strategic planning think tank Niti Aayog, the Ministry of Housing & Urban Affairs, Bharat Electronics Ltd and the Centre for Development of Advanced Computing.

DMRC is intending to use i-ATS for the upgrade of the Red Line and any future metro expansion. The technology has been designed to work with train control and signalling equipment from different suppliers and is intended to be suitable for use on the Indian Railways national rail network.

A memorandum of understanding has also been signed for the indigenous development of a cab simulator for training metro drivers in train operation and troubleshooting.

Communication and radio

Task force to diversify UK telecoms supply chain

UK: A new task force has been formed to drive forward work to diversify the UK's telecoms supply chain and reduce reliance on high-risk vendors. The UK Government is keen to address a market failure where companies, including railways, are limited to using just three major suppliers in their mobile radio networks. This limitation restricts choice and poses a risk for the security and resilience of the UK's future digital networks.

The Telecoms Diversification Task Force will provide independent expert advice to the government. It will inform the development and implementation of the forthcoming Telecoms Diversification Strategy, which will set out the key areas for boosting competition and innovation in the UK market by building an open, sustainable and diverse telecoms supply chain. This follows the government's commitment, informed by advice from the National Cyber Security Centre, to ban the use of new Huawei 5G equipment from the end of this year, and remove all existing Huawei kit from 5G networks by 2027.

The task force will also look at ways to develop the capability of the UK's telecoms sector. It will explore how to incentivise research and development, including accelerating the development of open and interoperable equipment which can be used by multiple vendors, such as OpenRAN.

The government says it is working closely with its international allies to develop solutions that will result in lasting change in the global telecoms market. Alongside the Diversification Strategy, the Telecoms Security Bill will give new powers to the government to control the presence of high-risk equipment vendors, and to Ofcom to drive up security standards.

WIFI@DB free connected network

Germany: Deutsche Bahn has announced that by the end of 2020 it will have 130 stations with Wi-Fi as part of its WIFI@DB free connected Wi-Fi network. All IC trains, currently being equipped with Wi-Fi will immediately become part of WIFI@DB. Several hundred regional trains and buses will follow onto WIFI@DB in 2021.

With WIFI@DB passengers will only have to log in once. After which they can get online at stations and in trains all day for free and passengers will remain online even when switching trains. Deutsche Bahn has invested more than €200m (£181m, 234$) in Wi-Fi with 3800 access points to date and laying 230km of cables. It is currently investing around €44m (£40m, $52m) in expanding the Wi-Fi network. The ICE fleet has provided Wi-Fi since 2017.

The most important factor for a stable internet connection to trains is an adequate mobile network along the route. The Bundesnetzagentur (federal network agency) has made this the responsibility of mobile network operators and by the end of 2022 the most important railway lines are to have full mobile coverage, with all lines provided by 2024.

Telecoms supply in Europe

Europe: Huawei of China has supplied Europe's largest telecoms operators for several years, but the US is exerting strong diplomatic pressure on Europe to exclude Huawei on security grounds. Huawei has repeatedly denied the concerns.

France has informally excluded Huawei from its 5G network and the German government is reportedly planning stricter oversight of telecom suppliers. This will make it harder for Huawei to supply the German market, whilst stopping short of an outright ban.

In the UK Nokia has been awarded a major technology arrangement by BT, the country's main telecoms network provider, which will see Nokia become BT's largest single supplier of equipment. This is as a result of government instruction to remove Huawei from the network. Currently Nokia's equipment is used at approximately a third of its 4G sites, which will be upgraded to 5G, while Huawei's kit is currently used at the remainder.

Nokia has been a significant supplier of hardware and software systems to BT, along with many railway telecoms networks throughout the world, but the new agreement will make Nokia become the major supplier of 5G Radio Access Network (RAN) systems in the UK and increase its presence in BT's fixed access and core network.

Nokia used to be the leading RAN vendor in the UK, but ten years ago Huawei introduced an excellent product and competitive pricing. Over the last two years however Nokia has made major advances with its new RAN equipment. BT's Nokia-powered network, which currently includes Greater London, the Midlands and rural locations, will be extended to also cover other locations in Scotland, the South and East of England.

BT has chosen Ericsson to replace Huawei's equipment in the core parts of its network and they are the favourite to be BT's second radio access network supplier. If so, they will however be likely to lag Nokia, in terms of the number of 5G masts and base stations it would provide.

Government and economy

UK transport review

UK: Led by Sir Peter Hendy CBE, chair of Network Rail, an independent review will look at how to improve transport infrastructure across Scotland, Wales, Northern Ireland and England. Faster road and rail links to Scotland, upgrades to Welsh railways and new connections between Great Britain and Northern Ireland, are among the range of potential projects to be considered in first of a kind study into improving transport infrastructure across the United Kingdom.

Working closely with the countries devolved administrations and local authorities, and set to cover not just rail, but road, air and sea links, the study will provide independent advice on a wide range of possible options to improve the quality and availability of transport links across the UK, including looking at the potential feasibility and economic case of options for:

- Reviewing air links within the UK.
- Exploring the cost, practicality and demand for a new fixed link between Great Britain and Northern Ireland.
- Boosting road and rail links to Scotland.
- Cutting journey times to North Wales by reviewing the Welsh railway network.
- Improving major road links across the country, such as the A1.

Sir Peter brings extensive experience and knowledge to the role with over 45 years working in the transport sector – including as chair of Network Rail and successfully running London's transport network during the Olympics.

The review will also look to the future, and consider the role of future technologies and assessing environmental impacts of current and future infrastructure. Sir Peter will be expected to publish his final recommendations in Summer 2021, to include advice on how best to improve connections, and if there is a need to invest in additional infrastructure by the UK government.

Environment and sustainability

Road congestion levels higher than before lockdown

UK: At the end of September it was identified that road traffic congestion in outer London (in roads outside the capital's central congestion charging zone) was far higher than it was the previous year, as people have gone back into their cars after the spring/summer lockdown. Congestion climbed above 2019 levels in August and had increased to nearly a fifth on average above last year.

The most congested day was Monday 7 September when congestion stood at 153 per cent of 2019 levels. This coincided with many schools returning to the classroom and followed government messages advising people to return to the office rather than continue to work from home.

Congestion within the central charging zone stood at just over half the levels of 2019, though this is still a substantial increase on spring when the full lockdown was in place. Congestion fell to just 6 per cent of the 2019 average on its lowest day, in early May.

The information comes from the Waze for Cities programme data, which uses GNSS data submitted by users of the navigation app and analysed by Environmental Defence Fund Europe. The data is compiled from about 1 million active monthly users in London and is based on journey times recorded automatically by GNSS.

Environmental campaigners said the new congestion data was worrying, as higher congestion levels are associated with dirtier air and an increase in greenhouse gas emissions. Oliver Lord, head of policy and campaigns at Environmental Defence Fund Europe, said: "Traffic congestion is precisely what we should prevent as our polluted city emerges from lockdown. We need to help people get around without private cars because congestion delays buses, disrupts essential trips and makes it horrible to walk and cycle. This analysis is a rallying call for action, including safer streets for cycling instead of driving and more public transport connectivity, and a concerted effort from business to curb the record number of vans on our streets."

The data reinforces early indicators from other sources that traffic and air pollution are increasing after lockdown, and that many people were returning to office work in their cars rather than using trains and buses.

Training and education

New digital competence centres

Spain: National railway operator RENFE is establishing a series of digital competence centres to decentralise skills development to smaller communities around the country.

Transport Minister José Luis Ábalos announced the launch of the programme, which will be branded as 'Clouds', in September. Teruel has been chosen to host the first hub, partly because it has a station building large enough to support the 50 to 60 posts the scheme will create, and because it is convenient location at the heart of the Zaragoza – Sagunt Cantábrico-Mediterráneo Corridor, which is now being modernised at a cost of €4.8m (£4.4m, $5.6m) to support increasing volumes of freight traffic.

The focus will be digitalisation of infrastructure maintenance and renewal, and it will be available from May 2021.

Research & Development and Universities

HS2 trials AI solution to cut carbon emissions

UK: HS2 is trialling an Artificial Intelligence solution to cut carbon emissions at several HS2 sites managed by the Skanska Costain STRABAG joint venture. The building information model (BIM) processes are automated by AI so that different design options can be simulated using varying types and quantities of construction materials. Carbon emissions and environmental impacts of construction can then be visualised, measured and compared, resulting in a more environmentally friendly solution.

Skanska UK is leading the project, working with software developer Nomitech, design consultant Mott MacDonald, the Manufacturing Technology Centre (MTC Data and AI Research), the Royal Institution of Chartered Surveyors and HS2, and is funded by Innovate UK. It is intended to replace the manually measuring 3D drawings, and to assist the design process in delivering carbon and cost savings.

It is also hoped to lead to shorter pre-construction phases, reduced project management costs, greater visibility of carbon emissions and overall improved cost and carbon control. The project will also develop industry best practice for estimation and cost management.

Companies and products

Safety Alert Message Indicator prototype

UK: Vodafone has built a prototype product recall system that allows manufacturers to notify recalled faulty or potentially dangerous electrical goods and shut them down remotely if required.

The Vodafone Safety Alert Message Indicator (SAMI) prototype system uses a miniature electronic device module – similar in size to a SIM card – installed within the appliance to provide a link over Vodafone's network. This allows a manufacturer to notify consumers of a potential issue with their appliance and, if necessary, disable the appliance. In situations that pose no risk, messages can be sent to an LED on the product to notify the recall of their appliance.

It has received innovation awards from both the Institution of Engineering and Technology (IET) and Electrical Safety First (ESF) – a UK charity dedicated to reducing and preventing damage, injuries and death caused by electricity.

While the solution is aimed at domestic 'white goods' appliances, there may be applications within industrial electrical engineering that may benefit from the system.

Industry 4.0 – Digital Automation Cloud (DAC) functionality

Finland: Nokia has announced new added value features and digital automation enablers for its Nokia Digital Automation Cloud (DAC) private wireless networking platform. The features include Nokia High Accuracy Positioning, Nokia SpaceTime scene analytics, Nokia DAC team comms and VoIP, as well as several industrial connectors; along with Microsoft Azure IoT Edge services enabling deployment of Microsoft Azure IoT Edge Modules such as Modbus.

The Microsoft Azure IoT plug-in follows a joint Microsoft and Nokia announcement to accelerate digital transformation and Industry 4.0. Microsoft Azure IoT services enable customers to address interconnected scenarios across multiple industries that include manufacturing, logistics, utilities, smart cities and transportation.

First 5G NR broadcast service

China: ZTE has launched the industry's first broadcast service based on the 5G NR (New Radio) physical layer technology. Up 700M device users will be able to simultaneously receive 5G radio broadcast signals using one set of radio resources.

ZTE say the end-to-end broadcast service is implemented on 30MHz 700M spectrum and can broadcast/transmit multiple channels of 1080P HD videos/4K HD videos. The broadcast service will use "free to air" mode, so that all devices will receive synchronised 5G NR broadcast videos, without occupying more air interface resources as the number of users increases.

Heritage railways

Historical railway gains axle counting modern diagnostics

UK: The Dean Forest Railway (DFR) heritage steam railway has installed the Frauscher Advanced Counter FAdC axle counter and nine RSR123 wheel sensors for train detection. These are electronically integrated into the mechanical interlocking, with the Frauscher Diagnostic System FDS used to provide remote web access via a VPN.

Frauscher UK assisted the Dean Forest Railway volunteers of the heritage railway to install and commission the FAdC and RSR123 sensors, which took a total of six days, including laying the cable.

Dean Forest Railway meets the national Network Rail infrastructure soon after Lydney Junction, which is its most southern point. As a fully operational heritage railway, high standards in terms of signalling and safety must be met, whilst maintaining a historical theme using traditional steam engines, rolling stock and restored stations

To meet the Office of Rail and Road (ORR) regulatory requirements, Dean Forest Railway also installed two new Schweizer Flex level crossing systems, complete with barriers, in September 2018. These also incorporated Frauscher RSR123 sensors and the ACS2000 axle counting system to initiate the automatic barrier movements.

News from the IRSE

Blane Judd, Chief Executive

As 2020 draws to a close, I can safely say that this is a year we will all be glad to see the end of. The global pandemic has turned the world upside-down and taken the lives of countless thousands. All of us here at IRSE HQ send heartfelt condolences to those who have lost loved ones and our thoughts are with members impacted either professionally or medically by the virus. Hopefully a vaccine will be available in 2021 and normal life may slowly begin to resume. We wish you a peaceful festive season and a safe and hopeful New Year.

But there have been some positives in 2020. As an organisation we've had to step up and look for new, innovative ways to deliver all the services members expect – and more. Our head office team of five full time and four part time staff have all been working from home since the UK was first locked down in April and it is unlikely we will be able to return to our offices together until mid 2021 due to social distancing rules. Despite this we have managed to keep the 'office' running whilst at the same time striving to devise strategies for delivering aspects of our service that have always been face to face.

Not wanting to disappoint those who had been studying hard for the Professional Exam we established a robust way to offer online, making Institution history. We ensured the presidential programme continued online which can be watched via the website **irse.info/webcasts** , and our president Daniel Woodland organised and hosted our first ever International paid-for webinar collaboration with three other professional engineering institutions (PEIs) – IET, IMechE and PWI. This Railway Automation Seminar was a great success, watched by people all over the world, generating information for the membership – more information about the event can be found overleaf. We have also assisted sections to hold virtual meetings and presentations – all of which have seen a far greater 'attendance' than would have been at a traditional attend in person meeting. Take a look at **irse.org/engage** to see new and informative content added to our website during lockdown.

Significant alliances have been forged as we deliver the new IRSE Strategy **irse.info/edi6h**, positioning IRSE at the forefront of our industry through establishing closer links with key stakeholders. 2020 sees the end of the first year of our new strategic plan. Rather than create a static five- year plan, we will be reviewing the progress made this year and adapting the plan to extend for a five-year period. It is hoped that by adopting this rolling programme we will be able to respond swiftly to change and ensure that the strategy and hence the Institution remains current and relevant to you its members.

Tomorrow's Engineers Code

Encouraging more entrants into engineering and supporting diversity are two of our stated aims. The IRSE was one of the first signatories to Tomorrow's Engineers Code, a newly launched UK government backed initiative to encourage organisations working within the engineering industry to work towards common goals or pledges, to increase the diversity and number of young people entering engineering careers.

Signatories of The Code make four pledges about their approach to funding, designing, delivering, and learning from engineering-inspiration activities. For more details see **irse.info/zgrl1**.

Nominations to Council and Governance Review

The nominations have now closed for this year's Council elections, and you will soon be receiving your ballot papers from CIVICA Election Services who we have engaged once again to assist us with this process.

Council members are elected by the corporate members of the Institution, i.e. fellows, members and associate members, for two-year terms, and they can stand for election for subsequent terms if they wish.

Please take the time to vote – this is your opportunity to get involved with the governance of the IRSE.

The role of the Council and its duties are defined in the Institution's Memorandum of Association and Articles written for the incorporation of the IRSE on 3 December 1912.

The IRSE in the twenty-first century has moved on a great deal since then and has a far more international reach with 47 per cent of members outside of the UK. Whilst the core objects of the Institution remain the same, a great deal has changed, and it is felt that the current Memorandum of Association and Articles needs significant updating.

A governance review is currently underway, with a working party led by the junior vice president Andy Knight. This group is taking a close look at how we should update the Memorandum of Association and Articles to ensure that membership of the Council provides the continuity of knowledge and expertise necessary to drive our Institution forward and reflects the truly international nature of today's IRSE. Look out for more on this governance review in future issues of the IRSE News.

New Honorary Fellows

Congratulations to Claire Porter and Mike Moore who have both been made Honorary Fellows of the IRSE. An Honorary Fellow is a person who, in the opinion of the Council, has rendered outstanding or exceptional services to the profession or the Institution.

Congratulations

We also send our congratulations to all those members who have been promoted in their workplaces during 2020, including Anshul Gupta, from the IRSE India section. He is now chief of signalling in India having been appointed as the additional member(signals) of the Indian Railways Board.

Professional development

Railway Automation Seminar

Daniel Woodland

During 2019, whilst planning the programme for my IRSE presidential year, I approached the IMechE Railway Division to propose a joint seminar between institutions on Railway Automation. The topic is one that I have long been interested in, having had the opportunity to engage in feasibility studies, specification, implementation and independent assurance activities related to various forms of automation. The topic followed on from the last paper in my predecessor's presidential programme ('Converting a GoA1 commuter railway to a GoA4 driverless Metro – The Sydney Metro Experience', by Steve Allday), which can be found in the May 2020 issue of IRSE News. It also sits well within the theme for my IRSE presidential year 'The Challenges of Change in Complex CCS Systems', as well as within Professor Schmid's theme for his year as chair of the IMechE's Railway Division, which is based around 'Practical Issues of System Integration'.

The reason for approaching the IMechE was that in many ways the 'Signalling' parts of automation are now standard and there is little difference between functionality for Grade of Automation 2 (ATO) and Grade of Automation 4 (UTO) – a statement that could well result in a flood of letter to IRSE News, but I think this is generally true. However, the wider 'system' differences required are much more significant. Efficiency of implementation, effectiveness of delivery, availability, safety and performance are all multi-disciplinary and require engagement of all of the rail disciplines.

Following initial enthusiasm for a joint event as a paid seminar in London, COVID-19 arose and made such an event, along with much of the other planned activities for the year, impossible. So we began to explore a

'web based' format, and expansion of the event into one of the major global rail events of the year.

Following a positive response from the IMechE, the PWI and IET were also approached and we began to flesh out what the seminar would cover and the guiding theme 'Practical Integration of Automated Operation in Railways: A System of Systems Perspective'.

Being 'web based' we were no longer constrained by either speakers or participants being able to attend in the UK and thus were able to tap into a richer pool of international experience, making for a very exciting event line up.

Seminar objectives

Whilst automation in railway operation has been around for a long time now, railways have tended to adopt automation (and indeed most aspects of control) in a piece-meal fashion as technology has evolved and accidents have highlighted system weaknesses. In the signalling and control field, we can see that in developments from the introduction of train detection, through warning systems, train stop systems

and then automatic train protection to support drivers. This has then developed to see adoption of automatic driving (ATO) to increase capacity and predictability of services. We can also see it in automatic route setting and train supervision to assist signallers.

In recent decades we have also seen implementation of 'driverless' systems across the world, mostly for new build light rail, people movers and metros, but also for a small number of upgrades and some heavy haul mining railways. As the technologies have become more

established it has also become clear that, as the railway is a 'system of systems', decisions relating to automation that are optimal for one subsystem may well have impacts on others.

The Post Office Railway

As I already said, automated railways are not a new or novel concept. Whereas it is now a manually driven tourist attraction, the Post Office Railway in London opened as an automated railway in 1927, moving post and parcels from Paddington to Whitechapel via the main sorting offices along the route.

Control of train movements was managed by control of the traction supply: 440V DC traction between stations enabled speeds of around 40mph, whilst the 150V traction supply in station areas supported around 7mph. No traction supply caused the brakes to apply and the train to stop.

This early example begins to illustrate the point that multiple systems need to work together to deliver automation.

Seminar format

For accessibility to a global audience and management of the material, the event committee elected to use pre-recorded content, released in two batches, with two follow up live webinars for questions and answers with the panel of speakers (one associated with each batch of presentations). The live sessions were timed in the morning in the UK and kept intentionally short, such that the majority of members in all of the institutions involved could readily access them during 'sociable hours'. Unfortunately, that did mean unsociable hours for North America so, to ensure accessibility for all, the live sessions were also recorded and made available to delegates after the event. In order to ensure that as many questions as possible would receive answers, all submitted questions were captured and un-asked ones were passed to the speakers after the close of the event to be answered off-line and also be uploaded to the site.

'Batch 1' of the seminar

The speakers contributing to this conference addressed a wide range of issues that arise when increasing the level of automation in the operation of a railway. The first batch of content released considered: the background to definitions, functional requirements and architectures; an overview of the 'systems' perspective; operational concepts for automated railways; the psychological impact of automation; communication challenges presented by fully automatic operations; the maintenance challenges presented by fully automatic operations... and experiences to date of applying automation to both the Thameslink main line railway and the Singapore metro railways. Between them these presentations discussed the technical, functional and operational requirements and associated solutions for the control systems, on the one hand, and the impact on the stakeholders and surrounding railway subsystems, on the other... but probably more from the control systems perspective than that of the full system. In essence, 'Batch 1' was a very good quality IRSE seminar. Our intent in holding this seminar as a multi-institution event was to move beyond that and consider the broader implications of automation as part of a 'system of systems'.

'Batch 2' of the seminar

Having worked several times on GoA4 system activities, I am not only interested in the subject but also have my own set of views on what is involved! So, as an introduction to Batch 2 I presented my view as to what GoA4 (UTO) means, and how that differs from GoA2 (ATO) in relation to provision of technical systems and functionality. This was followed by presentations on: automation and its impacts on rolling stock and infrastructure assets; rolling stock changes with GoA2, 3 and 4; the implications of introducing ATO for track and infrastructure; automation challenges for inspection, maintenance and track access for work on the infrastructure; obstacle detection requirements; ETCS and the implications for such items as route availability and speed differentials, and finally, ethics in decision taking for automated systems when specifying and developing algorithms and software.

Participation

Over 200 people signed up to the event ahead of the live Q&A sessions and it isn't too late to join them, as all of the recordings (including of the question & answer sessions and post event answers) are still available to view, at a post-event discounted price of £65 for members and £100 for non-members at **automatedrailwayseminar.online**. Hopefully this overview will show you something of what you have missed out on so far and encourage you to sign up to catch up!

I was very keen to ensure that this event would have good attendance by Younger Members – a desire that found resonance with both the organising committee and the IRSE Management Committee. 10 free places were offered to Younger Members from each of the IRSE, IET, PWI, IMechE and IRO by the organising committee and a further 22 places were paid for by the IRSE Bursaries fund – so in all, 32 IRSE 'Younger Members' from 11 countries were able to participate in this event at no cost. That is a fact that I am very proud of on behalf of the institution.

I will now be building on some of the themes of this seminar through the rest of the year's presidential programme. Most notably through:

- "The crossover between rail and autonomous road vehicles" by Tom Jansen of Ricardo Nederland (which should already have been presented by the time this article is published and will be available to view via the IRSE website and to read in November IRSE News).
- "Traffic Management systems and automation in control centres" by Ian Mitchell of the IRSE International Technical Committee and Nora Balfe of Iarnród Éireann (which will be presented in February 2021).

Past lives: David John Norton

David Norton was born in Bath in 1927 and educated at Aldenham School in Hertfordshire and Faraday House Electrical Engineering College, London. He completed a graduate apprenticeship with GEC at Witton and at the end of 1953 he joined the Westinghouse Brake and Signal Company in Chippenham to become involved in the design of signalling relays and marshalling yard systems.

In 1960 he joined the IBM Research Laboratories at Hursley for a period and then returned to the Westinghouse Brake and Signal Company, Signal Division. In 1964 he was appointed chief electrical engineer, then chief research engineer in 1967. He was appointed chief engineer in 1974 then managing director of Westinghouse Signals Ltd in 1980. In 1984 he became the director responsible for Research and Development and Overseas Liaison.

A Chartered Engineer and Fellow of the Institution of Electrical Engineers (now Institution of Engineering and Technology), he joined the IRSE in 1957, was elected a Fellow in 1975 and served on Council from 1975 before becoming the IRSE president for 1984-85. In 2005 he was elected an Honorary Fellow of the IRSE in recognition of his long and distinguished service to the profession and to the IRSE.

David had many facets to his character. He possessed a quiet and genial temperament with an unobtrusive sense of humour; always questioning yet respectful of past practice; seriously committed to safety yet always challenging the costs of safety practices; he trusted others to develop his ideas yet remained interested in progress. He was extremely helpful to his work colleagues and inspired them with his superb technical knowledge and amazing inventive ability. In the 1970s he pioneered the principles and mathematics of achieving fail safety by redundancy and this work is recorded in one of his many patents and in his seminal technical paper to the Institution of Railway Signal Engineers on the 7 March 1979 entitled “Safety by Redundancy”.

His innovation and experience enabled him to make a tangible contribution to our industry at the time of immense technical change. He was years ahead of others in recognising the potential application of digital computers to railway signalling. In his presidential address to the Institution in 1984, when the signalling industry was on the verge of an era where electronics in the form of microprocessors was about to enter into the very heart of safety railway signalling, he foretold the day when microprocessors would replace relays and solid state interlocking would become the norm. He had the engineering aptitude to inspire the best engineering – novel but never impractical, and the business nous to ensure that new ideas were commercially viable. It was his many abilities which make him hard to define, yet he lived whole “total systems engineering” long before that term became recognised.

He had a number of interests outside work and in pursuit of a particular favourite he was persuaded to join three colleagues who had enrolled on a weekly evening course for a Yacht Masters qualification. All four candidates passed but it was David who went on to the next level of highly complex and mathematically demanding astronavigation studies. An interest he retained for many years.

David John Norton, CEng, HonFIRSE, FIEE, 1927-2020.

On retiring David moved to Poole, moored his boat in the marina and was often seen sailing single handed or in the company of ex colleagues and friends around the Solent. He also embarked on some epic voyages when crewing on a friend’s boat across to Europe and Scandinavia.

Often travelling back to Wiltshire and elsewhere for technical meetings or reunions, David kept in touch with industry developments as well as socially with many ex colleagues throughout his retirement. In later years he suffered from macular degeneration and eventually gave up sailing and moved to Cliveden Manor, a care facility in Marlow Berkshire. There, until relatively recently when David had to rely on audio books, he was able to continue his keen interest in all things mathematical, scientific and technical aided by the latest software to help compensate for his failing eye sight.

He passed away in September after a slow decline in his health and our sincere condolences are extended to his family.

Ken Burrage

Additional information provided by Mike Harding, John Corrie, Terry George, and Tony Howker.

Past lives: Richard Stokes

Richard's background was as an S&T engineer who worked on the terrible Hixon level crossing crash enquiry in 1968. He was also an assistant S&T engineer at Liverpool Street and the new works manager on the South West Division, where he was instrumental in resignalling Brockenhurst box whilst keeping a near normal service running. Richard subsequently went to the London Midland Region to work in Management Services before joining Eurostar.

Richard was one of the first senior BR managers recruited in 1988 to help start up what was then called European Passenger Services, a section of British Rail. He worked with Malcolm Southgate (deputy managing director) to help plan and develop the new Eurostar trains and service patterns through the Channel Tunnel to Paris and Brussels. He used his extensive contacts in SNCF, TML and SNCB to build strong relationships with counterparts across in Europe, and helped to bring together the teams required to design the new fleet of trains and create joint technical standards for the exciting new project. He spent much of his time in those early days travelling, working and staying in France and Belgium. As the Eurostar service became established, he went on to become the production manager on the Channel Tunnel Rail Link (CTRL).

After his retirement from CTRL in 2006 Richard worked on several projects including at the Ffestiniog and Welsh Highland railways, and working with the European Cab Design Group to establish a standard cab design for all new trains throughout Europe.

For many years Richard's hobby was developing the signalling system used on the Great Cockcrow Railway in Chertsey. He also owned three miniature steam locomotives that ran on the Great Cockcrow, and he worked as a signalman during open days at the railway as well as training new recruits in the art of railway signalling.

Ricard Stokes (left) at the 1983 French technical convention in Paris. Martin Govas is on the right.

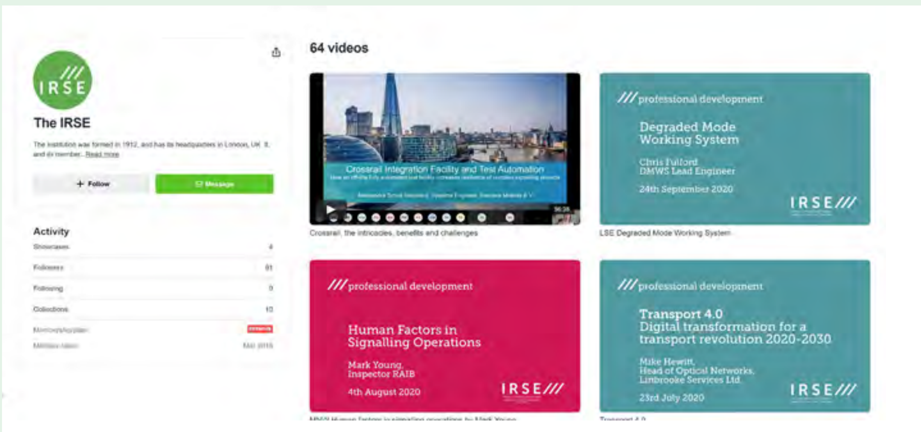
Richard and I were engineering students together on the London Midland Region in the early 1960s, working on the commissioning of the then new Watford Power Signal Box. He had an incredible knowledge of signalling circuitry and a photographic memory. He and I remained friends down the years and he was a regular supporter of IRSE events.

He passed away on 22 September 2020 aged 78 at the Princess Christian care home near Woking after a short but serious illness.

Clive Kessell

Did you know ...

that many of the IRSE presidential papers, section meetings and exam support events are now available to view on the Vimeo video platform?



visit irse.info/vimeo

Past lives: Michael Ian Page

Mike Page was born in Reading in 1931 to an already long-established railway family. His father Jack (John F) Page worked for British Rail in freight and operations, and his grandfather was Frederick HD Page OBE, chief S&T engineer of the Great Western Railway 1937-1946. A career in the railways was perhaps inevitable but his aptitude for engineering made it a natural choice and all things S&T became his great love.

After secondary school at St Illtyds in Cardiff he joined BR in 1948 as an S&T apprentice at Reading, whilst continuing his education at Regent Street Polytechnic in London, and fitting in National Service. Soon after joining BR he was persuaded to notionally change his name to Ian Michael Page for official BR purposes as there was already a senior Michael Ian Page in the organisation and such deference was considered tactful.

After training he made swift progress in the Reading signalling design office and was involved in every major WR resignalling project over the period from 1959 to the mid-1970s. This included the power signal boxes at Plymouth, Reading, Old Oak Common, Newport, Port Talbot, Cardiff, Swindon, Gloucester and Bristol. Only Plymouth, commissioned in 1960, remains of this part of his early career, all the others have now gone. His technical legacy also includes involvement in the development of the Western Region's iconic E10K route relay interlocking, described in his article in IRSE News October 2018.

In 1970 Mike moved to Cardiff to become the divisional S&T Engineer. This was a newly re-instated Cardiff based role, last held by his grandfather. It was a role that he obviously enjoyed and carried out with fairness and strict discipline supported by his skilful and knowledgeable staff. He had a reputation for having high expectations but also for rewarding hard work and carefully mentoring any who showed aptitude, or at least enthusiasm. There are many who still remember with gratitude the positive influence he had on their careers in the railway.

With their youngest son, Charles, off to university and starting his own career in the railway industry with Westinghouse, Mike jumped at the opportunity to take up a role with Transmark, BR's consultancy arm. He was given a four-year assignment to Hong Kong to work in a multi-disciplinary team on the KCR Modernisation and Electrification Project. His role was to help transform the railway signalling system of KCR from old mechanical (semaphore) to modern colour light signalling and relay interlockings.

Mike and his wife Pam loved their time in Hong Kong and made many friends there. He went to classes to learn Cantonese and felt that was a great help in interacting with the local artisan staff. Charles (CP) Lung of the Hong Kong section recalls how influential and generous Mike was in mentoring him and a cohort of young engineers and technicians just starting out in the world of S&T. Many now senior S&T staff from those days in HK can trace their early professional education to Mike's tutelage and encouragement.

After Hong Kong and towards the end of his main railway career with BR, he returned to the directorate of S&T engineering, British Railways Board in London as computing systems manager, a role that was rather more remote from the day-to-day railway affairs that Michael preferred and enjoyed, and in which he excelled. He eventually retired from BR in 1987 after a long and successful career in railway signal engineering but continued to undertake consultancy and training assignments for many years after.

Mike Page FIRSE, 1931-2020.

Four generations in rail. From left, Mike Page, Jack Page, Charles Page and Frederick HD Page (seated).

Mike started his lifelong involvement with the IRSE very early in his career. He joined as a student member in 1950, becoming an Associate Member in 1960, full Member in 1967 and a Fellow in 1979. He was very active in the Western section, including a period as section chair. There cannot be many who have or will reach 70 years in our Institution.

Many IRSE members will know Mike and Pam through the many friendships established through their regular support of the IRSE international conventions. With their son, Charles, living in Australia they made many friends with a connection to the Australasian IRSE section, refreshed through their regular visits. Mike and Pam were also regular attendees of the international conventions for many years with their last to France in 2014 when their frailties eventually slowed them down and international travel became impractical.

Ken Burrage (past president) comments that Mike certainly never lost his interest or enthusiasm for the railway in general and signalling in particular. He was a regular contributor to IRSE News, writing articles and letters. He continued with his regular attendance at IRSE meetings as well the monthly meetings of the Retired Railway Officers Society up until the last year or so. His last message to Ken on a technical topic was as recent as April this year and Ken will miss his thought provoking views on such topics as the Great Western electrification scheme, problems of the Severn Tunnel, and ETCS implementation.

Mike had been troubled with various health issues in later years that affected his mobility but he still remained active and engaged with the world. However, the passing of his beloved Pamela in May 2020 was a great blow from which he never recovered. He passed away suddenly but peacefully after a short spell in a local nursing home in late September.

Charles Page

In remembrance of Mike Page: a friend and teacher

It is with deep sorrow that the railway community in Hong Kong, especially the railway signalling circle, heard about the passing away of Mr Michael (Mike) Page, FIRSE.

Mike had a relatively short, yet significant working connection with Hong Kong, from 1981 to 1983, in helping to transform the railway signalling system of KCR from old mechanical (semaphore) to modern colour light signalling and relay interlocking.

I was then new to the profession and, together with a group of young engineers and technicians, assisted Mike in the design, installation and testing of new signalling system, trying our best to learn from the wealth of knowledge in Mike. He was my most respected teacher in railway signalling, always guiding me well to gain the knowledge and skill of this demanding profession.

In addition to being my teacher, Mike and his wife Pam have also become good friends of me and my wife. They were keen participants of the IRSE conventions. From the time I joined my first convention in 1988 (Hong Kong), I have met them in all the conventions I attended up to 2014 (France). I am sure they have also attended in the years which I have missed. In 2015 Mike suffered from some health problems which prevented him from long-haul flights, thus unable to join the conventions in the following years in Australia, China and the United States.

I have not met Mike and Pam again since 2014. Yet we kept in touch with frequent email exchanges, discussing various topics from railway signalling to Brexit to the recent Covid-19 pandemic. Another way to keep in touch was the annual exchange of Christmas greetings, from paper cards in the past to emails in more recent years, right up to 2019. I was also interested to read the occasional contributions of Mike to the "Your letters" column in the IRSE News, the latest of which appeared in the July/August 2020 issue, indicating that he still had a clear mind and sharp thinking then. Unfortunately, Pam passed away in June 2020, which proved too great a blow for Mike to take. But it is comforting to know now that they have finally joined up in heaven and stay together ever after.

Although I could not see Mike again, I still remember his kind face and cheerful character, and the time we spent together in Hong Kong and in many countries of the world.

I think Mike would feel most satisfied to know that the seeds he sowed in Hong Kong have flourished and grown into a strong and active railway signalling community, serving Hong Kong in the years to come.

Charles CP Lung

Left, Mike in action during the KCRC modernisation project.
Right, Mike and Pamela with Charles Lung at the 2014 Convention.

Your letters

Re Learning from automotive

The paper presented at the end of October "Automating our Railways – lessons learnt from bold automotive innovators" made me think about several issues. Overall, I felt the paper was thought provoking especially when discussing how society thinks about safety and how we as railway engineers think about the subject. The accident rate per million passenger miles provided some interesting comparisons and showed rail in a favourable light. It was also interesting to hear about the challenges of proving safety for autonomous vehicles with the probable consequence that safety will be a process of continuous development. One may argue that is how railways have become safe over almost 200 years but unfortunately in many cases not without serious accidents. I also found it interesting to learn that The Society of Automotive Engineers have a five step ranking for levels of autonomation in vehicles which seems to be remarkably close to our four Grades of Automation (GoA).

I was however somewhat disappointed with one of the early comments suggesting "innovation in the railway has been very slow in recent history". I would contend this is not true. Because railways are a long established system most of the eye catching developments took place some time ago and the more recent innovations have been to underlying elements often applying technology from other fields. For example, new interlockings are now usually computer based, the application of computer technology and reliable communication has enabled axle counters to be the prime means of train detection, obstacle detection systems operate at an increasing number of level crossings and of course much of our communications is now handled by fibre optic cables and digital radio. The next step will be to an in-cab signalling system probably based on ETCS.

My other point of concern is to question "virtual coupling". My initial concern is the extent to which those proposing virtual coupling have considered the critical differences between road vehicle platooning and its application to a railway. The first significant difference is in the brake application delay. A road vehicle will apply braking effort almost immediately, fractions of a second. On a modern passenger train it is likely to take one or two seconds to fully apply the brake. Secondly and probably more importantly the difference in stopping distance between two vehicles on a road or more especially a motorway where platooning is likely is relatively small. It is difficult to conceive of a situation where the front vehicle can stop in significantly less distance than the following vehicles especially when all are being driven autonomously (e.g. a jack knife is unlikely). This is far from true on a railway where, should the leading train derail or hit an obstruction it is likely to stop much more quickly than the following train using conventional brakes. Given these constraints virtual coupling possibly means trains travelling at perhaps 1600m intervals (mainline, significant speed) and indeed the paper hints at this by commenting on communications reliability up to 2000m. This would compare with circa 2500m for current four aspect signalling at up to 125mph (200km/h).

But my other concern is does virtual coupling actually deliver a benefit. Headways on plain line are not the operational constraint. It is the junctions, stations and especially terminals that pose the capacity problem as has been illustrated by articles in IRSE News by others such as John Francis. There is also the challenge of mixed stopping patterns and mixed train performance especially on the national network which is why timetable planners usually use a minimum of around three minutes between trains even though the signalling headway is often 100 seconds or less. Block section length can be a capacity constraint especially if it has to be transited at less than design speed and this is where ETCS and moving block in particular will offer benefit. But will "virtual coupling" give us more? Will it be sufficient to justify the investment? What about the reliability risk created by the additional sensors and continuous low latency communications?

David Fenner, UK

Re Telecoms

Thank you for an interesting October issue and one where telecommunications features strongly.

On the Industry News section, it is noted that the Norwegian rolling stock owner has ordered a significant number of train radios from Siemens Mobility. The version 4 of these radios is currently being rolled out into all trains across the UK. These are being manufactured by the Siemens factory at Poole in Dorset.

It is noted that the National Infrastructure Commission led by John Armitt (a former head of Network Rail) is recommending that telecom companies should use the railway infrastructure to run cables – presumably fibre. Do these people never look at past events? Many of us will remember the advent of Mercury Communications in the early 1980s who negotiated the same kind of agreement with British Rail (BR). It was heralded as a breakthrough and indeed was new ground as nobody knew what the appropriate rental charge would be. It was guessed at £2000 per mile with BR being paid to install and maintain the cables. It did provide a useful income for the BR Board but was never going to solve the railway's financial difficulties. There were stings in the tail; getting access to the railway for the laying and jointing of cables was difficult even then and could be a real headache nowadays with much more stringent safety rules for the granting and taking of possessions. Equally when cable damage occurred and with hard penalties imposed for not restoring service within a given time frame, the technicians of the day struggled to locate the problems, to get access to the site where the damage was located and to rectify the problem in often inclement weather. As a result, considerable sums of money were paid out in compensation.

So whilst I applaud the initiative, please go into this with your eyes open and recognise that giving the right level of service to the potential customer will at times be difficult.

Clive Kessell, UK
IRSE past president and former head of telecoms with BR

Re October IRSE News

A great cover indeed in the October issue of IRSE News. IRSE News being published month after month for many years is like a guiding light to signalling professionals across the world. Thanks to the team.

Nikhil S, India

Re Back to basics, Telecoms part 1

Congratulations to Paul and Trevor on the telecoms BtB article – clear and comprehensive. It will be a rich seam to mine for future IRSE Exam Module A questions. It also expanded my knowledge somewhat on IP networks.

Hedley Calderbank, UK

Re Back to basics Telecoms part 2

I did enjoy the 'Back to basics: Telecoms part 2' article and on reflection I think it is important to explain the various systems in sufficient detail to show that they indeed do require substantive engineering to deliver good quality systems. The November 2020 edition is definitely "in the digital age".

Allan Neilson, New Zealand

Proceedings

My late husband was a member of the IRSE for several years. I have a small collection of Proceedings which may be of interest to a member or two! I can sell individually or as one. They are 1914, 1916, 1917, 1924/5, 1925, 1925/6, 1926/7, 1932/3, 1933, 1950, 1957, 1959, 1961, 1962, 1968/9, 1969/70, 1970/1, 1971/2, Diamond Jubilee edition 1972/3, 1973/4, 1974/5, 1975/6, 2 copies of 1976/7, 1977/8, 1978/9, 1993/4, 1994/5, 1995/6, 2 copies of 1996/7, 1997/8, 1998/9 and ASPECT 91 International Conference edition.

Sue Ruffell
s.ruffell907@gmail.com

Quick links

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

IRSE News
Institution of Railway Signal Engineers
January 2021

Testing software
for critical systems

Technology drivers
for safe and sustainable railways

DMWS
degraded mode working

HAPPY NEW 2021 YEAR

Signet Solutions would like to thank their clients and delegates for a successful 2020, coping with a 'New Normal'. Thank you for your patience and willingness to learn as always. We wish you a healthy, happy and prosperous New Year.
For upcoming courses in 2021 please visit our website or call today for more information.

+44 (0)1332 343 585
enquiries@signet-solutions.com
www.**signet-solutions**.com

Signet Solutions
Raising the Standard in Development

IRSE ///

Institution of Railway Signal Engineers

Issue 273
January 2021

In this issue

Feature articles

News and opinion

From the IRSE

Culture change

Plans are now being made to celebrate the bi-centenary of the opening of the Stockton & Darlington Railway in 1825. During the following two centuries the railway has both developed and imported technical innovation and nowhere more so than in signalling and telecommunications.

When the uninformed talk about the potential for 'digitalisation' of the railway, signal engineers can utter a weary sigh and point out that the railway's digital control centres, for example, are now on their second generation and being enhanced with facilities that offer today, what in wider circles are considered aspirations.

But technology by itself does not create change. Its potential has to be exploited by those who put it to work. How many people really use all the 'features' in their computer software?

Currently one of the most advanced signalling control centres on the UK network is at the Thames Valley Signalling Centre at Didcot, where Network Rail has a second generation IECC, with Enhanced ARS plus Integrated Traffic Management (TM). This is providing controllers and signallers with unprecedented abilities to adjust the working timetable to reflect real time changes in running.

But this ability to intervene represents a cultural step change, even for someone used to a first generation screen-based control centre, let alone transferring from a traditional NX panel. A consultant's study of the introduction of Integrated TM at Didcot concluded that it created an entirely new operating environment, requiring a cultural change on the control and signalling floors.

They also found that a small number of users have been making a 'disproportionally high' number of timetable edits, indicating varying degrees of confidence. From personal observation of another digital interface – the Train Management System (TMS) display in cabs, this is not surprising. On successive journeys, one driver was reluctant to use it – the other whizzed through the screens to correct a problem.

With the availability of Integrated TM extending, and the roll-out of ETCS underway, controllers, signallers and drivers are also due for a 'wet-ware' upgrade. Training to use the latest technology is one thing. But for the benefits to be realised the confidence to exploit the unprecedented facilities must be fostered – and that is down to culture.

Roger Ford, industry & technology editor, Modern Railways

Cover story

A drone view of a freight yard in Nova Scotia Canada. Attracting more freight to rail in a post Covid-19 world will require signalling and telecoms engineers to provide systems to enable efficient and timely freight paths to meet customer requirements, maximise automation, reduce carbon emissions, and to contribute to a sustainable future. As an example: between China and Northern Europe, a typical air freight consignment involves the emission of 139 tonnes of CO_2. The same consignment by sea results in 77 tonnes of CO_2, but by rail freight it is only five tonnes of CO_2 emissions.

Photo iStock/ShaunL

Testing of software-based critical systems in railway applications

Nicholas Wrobel

This, the fourth paper of the 2020-2021 presidential programme, was presented online on 2 December 2020.

The purpose of testing software-based critical systems in railway applications is to find and fix as many faults as possible before releasing the software onto the railway and to demonstrate – within given confidence limits – the fitness-for-purpose of this software prior to its release onto the railway. This paper outlines the importance of system level testing of software-based critical systems before releasing the software onto the railway.

The paper is based on information gained on London Underground's Victoria line upgrade programme (VLUP) in the period 2003 to 2009. The line was the first Automatic Train Operation (ATO) metro railway in the world when it opened in 1968, with the full line opening in 1969.

For those who are not familiar with the Victoria line in London, it is the metro railway coloured light blue on London Underground's network map. It is 22.5km long with 16 stations – all underground in tunnels. The primary aim of the upgrade was to increase the capacity in the peak by 32 per cent without impacting the day-to-day operations and without any line closures. This required 43 new 8-car trains running in the peak with a frequency of 32 trains per hour.

Four reports [1][2][3][4] on system level testing of software-based critical systems in railway applications were produced in early 2011 at the request of David Waboso, director of Capital Programmes at London Underground (LU). Andrew Tunnicliffe was LU's technical sponsor.

This paper focuses on the contents of the first and third of these reports which were produced by the author for LU. The second report contains a literature review of software metrics which showed there was considerable information

Photo Shutterstock/Kiev Victor.

London Underground's Victoria line is one of the city's major arteries. The first automated railway when it opened in 1968, it was running a 36tph timetable pre Covid, the only line in London to do so.

available in the USA at that time on testing in IT, nuclear, aerospace and defence applications but a dearth of published information on testing in safety-critical railway applications.

In particular it was found that, whilst standards such as BS EN 50128 provide limited guidance in this field, there is a considerable volume of material on best practice to improve software reliability that had been developed by the US Department of Defense (DoD)-funded Data Analysis Center for Software (DACS) and Reliability Information and Analysis Center (RIAC). For example, DACS had produced a comprehensive "Software Reliability Source Book" [5].

The most interesting of the findings from this literature review were:

- Approximately 25 per cent of faults in software development are due to incorrect specification of the requirements.
- Approximately 75 per cent of faults in software development are due to either incorrect specification understanding or coding of the requirements.
- A software developer having processes with a Capability Maturity Model (CMM) level 2 would result in a predicted number of 256 faults per 100k lines of source code.
- Fixing faults is typically the single largest cost of software development.
- The maintenance costs, which are typically driven by latent defects, account for as much as 80 per cent of the software lifecycle cost.

"One would imagine that these benefits would be sufficient to persuade signalling contractors to switch to and maximise off-the-railway testing at system level"

The fourth report produced for LU addresses the business case for system level testing. Whilst this aspect is not covered here, LU's request for this report indicates there was still perceived to be an industry-wide reluctance at that time to spend money on testing systems off-the-railway using a test rig. This has now substantially changed in the industry.

The requirements for and benefits of system level testing

Requirements

The primary requirements for system level testing are:

- Validate that the upgraded railway has met the programme requirements on which the business case was based.
- Minimise access to the railway and hence potential disruption to operations.
- Find and correct defects as early as possible in the programme lifecycle.
- Acquire sufficient evidence for the Engineering Safety & Assurance Case (ESAC) – in particular, that the upgraded railway is safe for passenger operation.
- Minimise the software development and maintenance costs.

It is well understood in the industry that access to the railway is extremely limited during a line upgrade and testing on the railway is very costly. Nevertheless, despite this limitation, the "go-to" position at that time was to test a new train with a new signalling system on-the-railway.

Benefits

The benefits of system level testing using an off-the-railway test rig include:

- Reduced access to the railway.
- Reduced delays to the delivery programme and consequential reputational damage, and hence reduced overall cost of the delivery programme.
- Increased operator confidence when passenger operations commence due to an increased test coverage.
- Reduced operational delays after commencing passenger operations due to fewer Service Affecting Faults (SAFs).
- Reduced number of software releases (and hence cost to the signalling contractor) after commencing passenger service.

One would imagine that these benefits – even if not all were actually realised – would be sufficient to persuade signalling contractors to switch to and maximise off-the-railway testing at system level. Surprisingly, the experience on the VLUP was that none of the parties involved – even the independent safety assessors – appreciated at the outset the magnitude of the benefits of using a system level test rig.

Terminology

The reports produced for LU [1-4] provide definitions for the following terms:

- **System boundary.**
- Sub-system and system level testing.
- Critical software.
- **Scenarios.**
- **The operating envelope.**
- Test cases and runs.
- Level of maturity and fitness-for-purpose.
- Software metrics.
- **Test coverage.**
- **Level of confidence.**
- Errors/defects/faults/failures.

As there is insufficient space here to include all these definitions with examples, this paper focuses on those terms in bold type.

System boundary

The reports for LU use both a new signalling system and a new signalling control system as examples. This paper uses the example of a typical new ATO signalling system which is shown in Figure 1 overleaf. It can be seen that the assets within the system boundary comprise numerous lineside and train borne equipment; in particular, the interlocking on the lineside with the ATO and Automatic Train Protection (ATP) sub-systems being train borne.

Scenarios

A scenario is defined as a sequence of operational events within a generic or specific geographical context. Examples in a railway context are situations that occur:

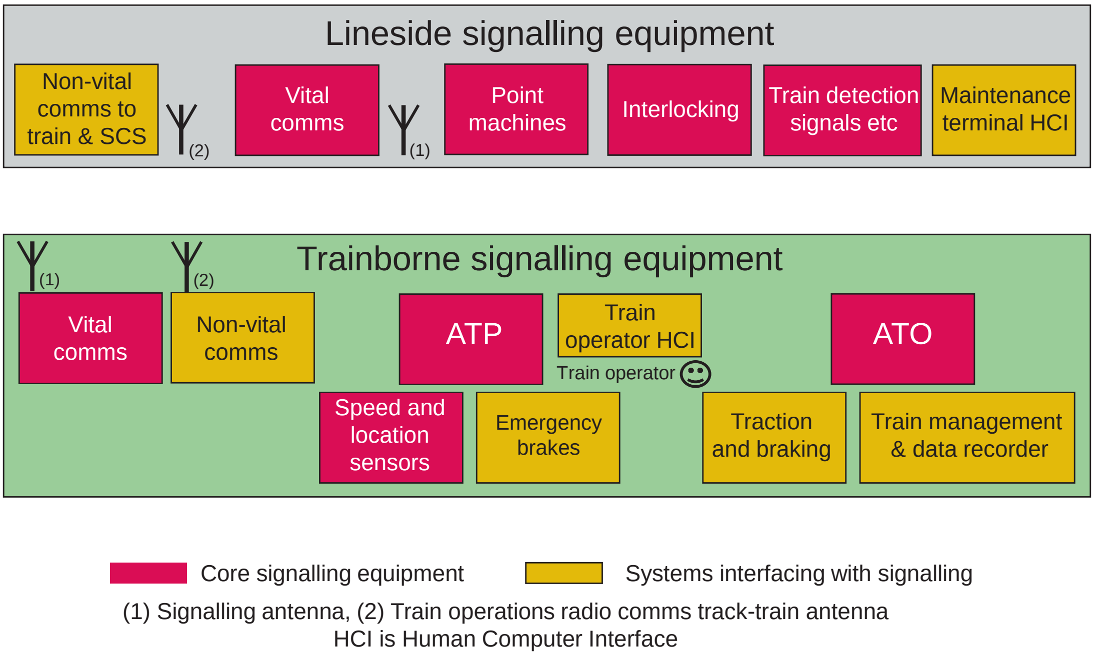


Figure 1 – Schematic of a typical ATO signalling system.

- Frequently during operation of the railway (e.g. a single new train with a new signalling system running in both directions on a specific section of the railway, stopping at all stations and stopping points and moving into and out of specified sidings for the turnarounds).
- Infrequently during operation of the railway (e.g. a single new train with a new signalling system terminates at a station on a specific section of the railway and then turns around).
- Following an incident/in emergencies during operation of the railway (e.g. a single new train with a new signalling system is diverted onto another line and turns around at a station on that different line).

"Regrettably, this simplistic representation is insufficient to describe the operating envelope"

The operating envelope

As some railway engineers may not be familiar with the concept of an 'operating envelope', Figure 2 illustrates a sequence of tests that might be undertaken for a new train with a new signalling system running on a test track. Thus, in this example, a sequence of tests has been used to represent the operating envelope of a new train with a new signalling system running on the test track.

Figure 3 shows a schematic of the whole operating envelope for a new train with a new signalling system using this simplistic representation. It can be seen that the sequence of tests culminates in running multiple new trains in close headway (and potentially new and old trains in a squadron) – a test that is difficult to undertake on the railway and has much greater risks than the previous tests.

Regrettably, this simplistic representation is insufficient to describe the operating envelope since, when tests are undertaken on a test track and/or on the railway, great effort is taken to ensure that all sub-systems are functioning perfectly – a situation that does not occur all of the time during railway operations!

Therefore, we also need to consider the five operating states of the railway to have a more complete representation of the operating envelope:

- Normal operating conditions (e.g. all sub-systems functioning correctly and within their specification).
- Non-degrading failures (i.e. a technical fault that does not lead to the train running in a degraded state; an example is the loss of a single lane in the ATP and its recovery).
- Degrading failures (i.e. a technical fault that leads to the train running in a degraded state; examples are a traction unit loss, two lanes lost in the ATP, one or more balises missed and an odometer fault).
- Degraded operating conditions (i.e. the train is running in a different, lower-performing operating condition; examples are reduced line voltage, reduced friction, the operator changing from (say) Manned Automatic (MA) to Protected Manual (PM) mode and the application of a temporary speed restriction).
- Operational incidents (i.e. an event(s) that leads to the train having a delay of greater than two minutes); examples are a door failing to close and lock due to customer behaviour and a passenger emergency alarm/platform emergency button activation.

Thus, the operating envelope is usually described by:

- A set of scenarios (including the geographic area) representative of the planned operational usage.
- The operational constraints (e.g. maximum safe speed and hence the line speed).
- The modes of operation (e.g. unmanned automatic, MA, PM and Restricted Manual (RM)) and the operating states.
- The range of the entities' attributes (e.g. nominal/tare/crush mass, nominal and maximum acceleration and braking deceleration).

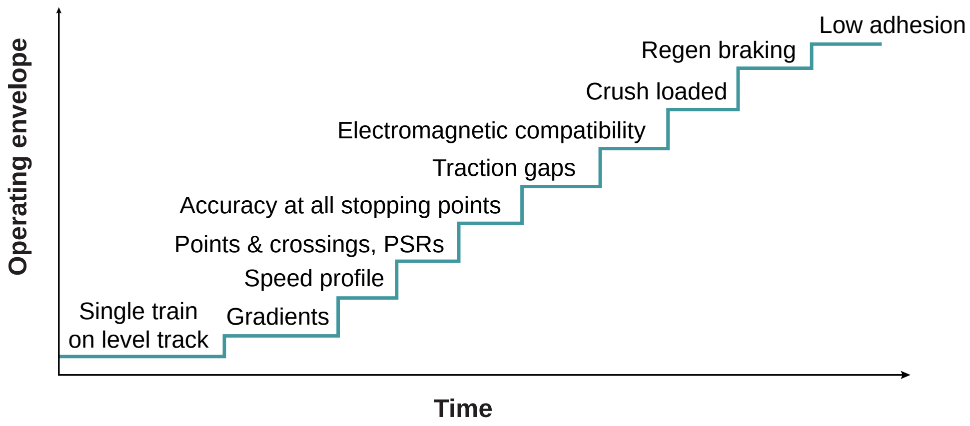


Figure 2 – Schematic of the operating envelope for a new train with a new signalling system running on a test track.

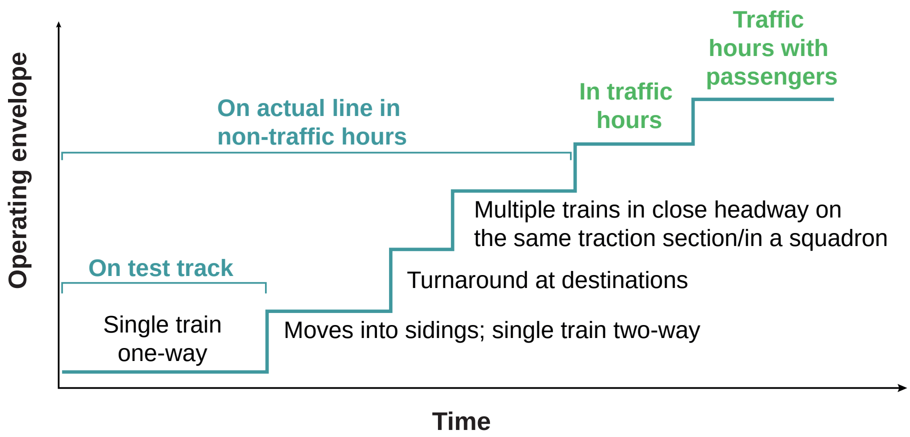


Figure 3 – Schematic of the operating envelope for a new train with a new signalling system.

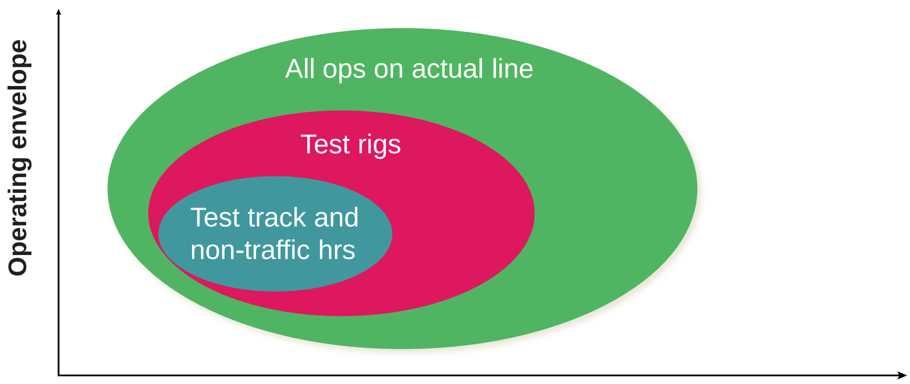


Figure 4 –Schematic of the typical coverage of the operating envelope by testing using a test track, running on the railway in non-traffic hours and test rigs.

Test coverage

The term 'test coverage' refers to the percentage coverage of the full operating envelope during testing.

The DACS "Software Reliability Source Book" [5] advocates a 'satisfactory' threshold for overall success (i.e. per cent of the complete set of requirements validated) of >= 99 per cent. Thus, in order to achieve this threshold, the test coverage needs to be >99 per cent. DACS also proposes an "alarm" level of 95 per cent for the test coverage.

In contrast, the typical coverage of the operating envelope during testing in railway applications is illustrated schematically in Figure 4. It can be seen that testing on a test track and/or on the railway in non-traffic hours is likely to cover only a small part of the operating envelope of a new train with a new signalling system.

"It is unlikely that a test coverage of >99 per cent will be achieved."

Even with rigorous product and system level testing using off-the-railway test rigs, time and delivery pressures on a railway upgrade programme make it very unlikely that a test coverage of >99 per cent will be achieved.

Level of confidence

The 'level of confidence' is defined in a testing context as "the probability that the hypothesis concerning the test result is correct". For example, we may aim to have a 95 per cent level of confidence that the number of faults found in a particular version of the critical software when used within a given operating envelope will remain unchanged to within (say) +/- 2 faults if tested/used more extensively.

A framework for off-the-railway system level testing using a test rig

Comprehensive system level parametric testing is confirmed as good industry practice in BS EN 50128 and the DACS Software Reliability Source Book. In BS EN 50128 it is called "Probabilistic testing" which is "Recommended" for Safety Integrity Level (SIL) 1-2 software applications and "Highly recommended" (the highest classification) for SIL 3-4 software applications.

A generic framework for system level parametric testing of critical software in railway applications – describing the process (i.e. "what to do") – was devised on the VLUP comprising the following:

- Specify the requirements for testing.
- Determine the type of testing required (including criteria for deciding whether any system level testing is required).
- Determine the scope of the system level testing required (including criteria for selecting the scenarios and complexity of the test cases).
- Determine the best balance between testing on a system level test rig and on the railway.
- Determine the requirements for the test rig and hence the capability required.
- Identify the key decision points and establish a methodology to address each of them.
- Develop and validate the test rig.
- Use the test rig to meet the testing requirements above.

A flow diagram showing this process together with the key decision points (KDPs) is illustrated in Figure 5. This enables a user to maximise the fault finding prior to the release of software onto the railway and to acquire in a timely manner evidence for the signalling contractor's safety case in order to achieve Consent to Load (CTL) for the software and eventually its Approval to Operate on the railway.

There are four KDPs and details on addressing each of these are contained in Refs 1 and 3.

The 'model' (i.e. "how to do it") is described later in this paper for a specific railway application; namely, a new train with a new ATO signalling system.

Application of this framework to the system level testing of a new train with a new ATO signalling system

Scope of the system level testing

On the VLUP, in order to determine the scope of the system level testing required (including criteria for selecting the scenarios and complexity of the test cases), the operating envelope was represented by six regions (called I to VI).

These regions are shown in Table 1 together with the selected scenarios and associated constraints and modes of operation (where the key changes are shown in italics). This approach provided a route map for testing in a similar manner to the migration route map (called the "Tube Map to Success") that the author devised for the VLUP.

Requirements for the system level test rig and the capability required

The requirements for the system level test rig flowed from: The V&V strategy which identified the six operating envelope regions required together with the selected scenarios and associated constraints and modes of operation.

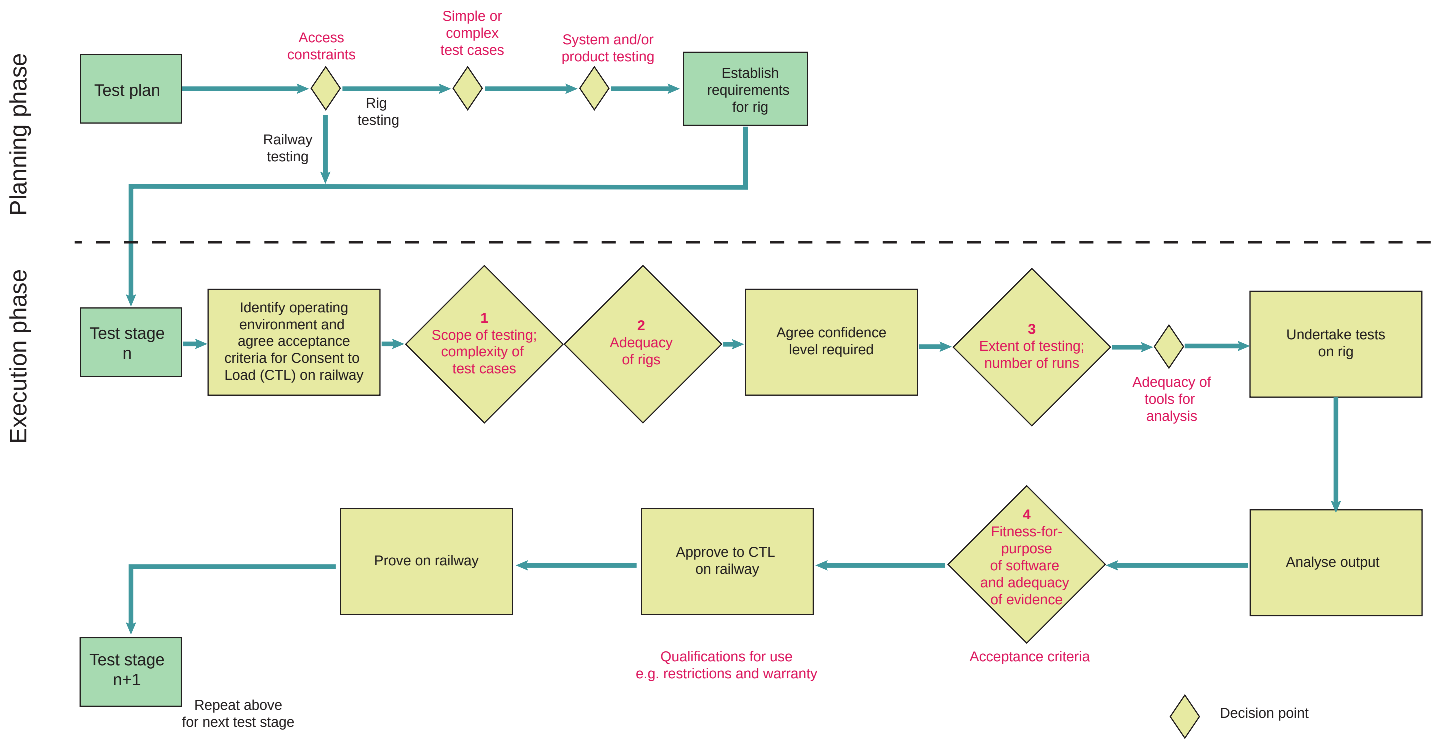


Figure 5 – Process/flow diagram for parametric testing of critical Software in the two selected railway applications.

Operating envelope region	I		II	III	IV	V	VI
Scenario	Single train runs one-way on test track/ part of the line.	Single train runs *two-way* on part of/the whole line *with turnarounds at stations and via siding.*	Single train runs two-way on same traction sections over part of/the whole line.	*Multiple* trains run two-way on same traction sections over part of/the whole line.	Multiple trains run two-way on part of/the whole line with turnarounds at stations and sidings.	Mixed fleet runs two-way on part of/the whole line.	Mixed fleet runs two-way on part of/the whole line.
Constraints	Non traffic hours. Under possession. Max safe speed and permanent speed restrictions.		Non traffic hours. *Under protection of new signalling system.*	Non traffic hours. Under protection of new signalling system. *In close headway.*	Non traffic hours. Under protection of new signalling system. *To current timetable.*	Non traffic hours. Under protection of new signalling system. To current timetable *as a squadron.*	*Traffic hours* (with and without passengers). Under protection of new signalling system. To current timetable.
Mode of operation	MA and PM with all entities operating in nominal condition.		MA and PM with all entities operating in nominal condition.	MA and PM *with variations in entity characteristics and perturbations.*	MA and PM with variations, perturbations and *degraded operating states, non-degrading failures, degrading failures and operational incidents.*	MA and PM with variations, perturbations and degraded operating states, non-degrading failures, degrading failures and operational incidents.	MA and PM with variations, perturbations and degraded operating states, non-degrading failures, degrading failures and operational incidents.

Table 1 – Regions of the operating envelope adopted on the VLUP.

The test plan which established the objectives and the test stages for each region of the operating envelope (e.g. Stage 'm' – prove safe to run a single new train in MA both ways over a specific part of line under own signalling protection) and finally, test cases required for each test stage.

On the VLUP, ten test stages and circa 80 test cases were adopted leading to five levels of rig capability (called 'A' to 'E') being needed to run the associated scenarios – see Figure 6. These levels of rig capability are described in detail in Ref 3.

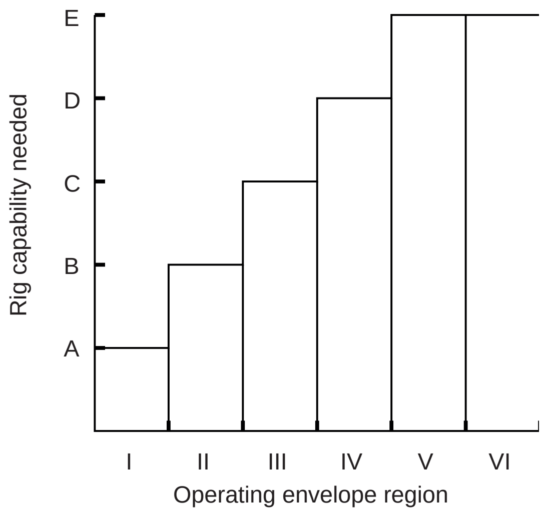


Figure 6 – The capability required in the test rig on the VLUP.

Development and validation of the test rig

It was clear early on that, in order to meet the system level test rig requirements on the VLUP, the three safety-critical sub-systems that had been assigned a SIL of more than 2 (i.e. the ATO, ATP and Fixed Block processor (FBP)) would have to be hardware in-the-loop – see Figure 7 overleaf.

Similarly, the train dynamics and station stops would have to be represented by a stochastic, event-driven computer model. Comprehensive diagnostics would be required to record all key parameters with time-stamps to enable synchronisation. Finally, data analysis software would have to be developed to compare semi-automatically specific outputs at key events and flag up any anomalous behaviour (e.g. between each run when compared with an idealised baseline run with all sub-systems functioning perfectly) in order to reduce the manpower needed to analyse the output data.

A key step was the validation of the test rig using data acquired from running the new train on the test track and testing the new train with the new signalling system on the railway in non-traffic hours. The level of agreement in the output was extremely good giving high confidence in the capability of the test rig.

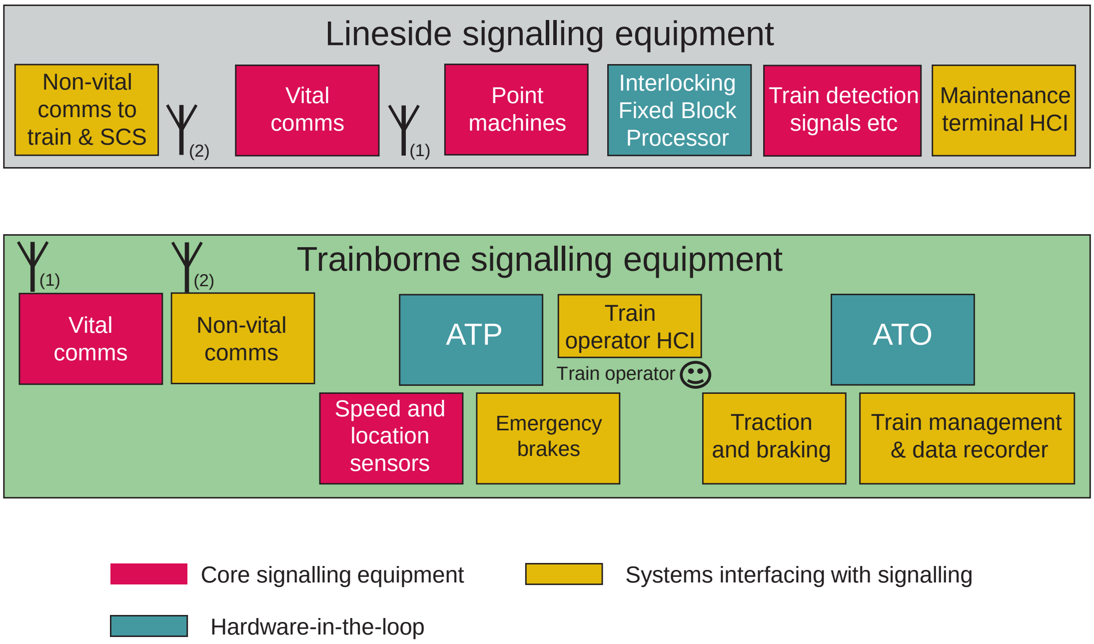


Figure 7 – Schematic of the system level test rig.

Using the test rig

The process for using the test rig adopted both 'orthogonal array' and 'statistical usage' testing in order to reduce the number of test runs required. This is shown in Figure 8. In essence, one fixes the parameters in the red, orange, yellow and green boxes and undertakes 'n' runs in order to achieve the desired level of confidence in the output.

During each run, variables such as the traction voltage, brake rate and platform dwell time are sampled from a pre-defined distribution (based on measurements or specification) on either a run-to-run/occasion-to-occasion, station-to-station or event-to-event basis as appropriate. Then a new test case is selected (with the parameters in the red, orange and yellow boxes remaining fixed) and the required number of runs is undertaken.

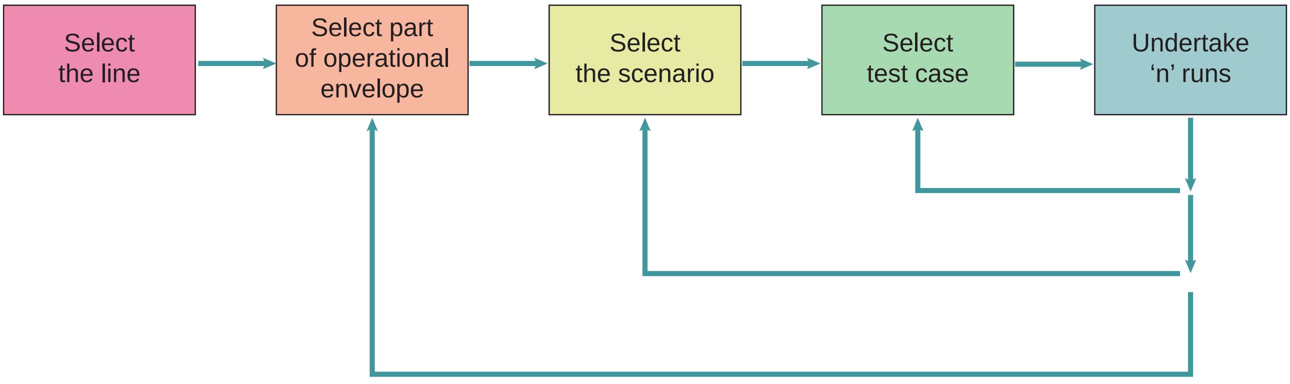
When all of the test cases have been undertaken, a new scenario is selected (with the parameters in the red and orange boxes remaining fixed) and the process to the right (i.e. in the green and blue boxes) is repeated and so on.

Thus, an example might be as follows:

- An initial scenario comprises a single train running one-way along a specific part of the line and stopping at all of the stations and stopping points.
- A reference test case might be the single train running in MA mode with all sub-systems functioning correctly with all attributes having a nominal value well within specification resulting in no unexpected behaviours
- A series of runs will then be undertaken for this scenario and test case but with variations in the characteristics of some sub-systems within their tolerance band (e.g. variations in traction voltage and brake rate and in speed control), and operational perturbations (e.g. variations in platform dwell time).
- A series of runs will then be undertaken with the same scenario but for the next test case with (say) variations in train load or communications load (which affects latency) or a different probability of reliable operation and/or variations in performance of some sub-systems (e.g. acquisition and latency of balise reads or temporary/transient loss of signal between sub-systems) or changes to the mode of operation (e.g. running in MA but with a selected sub-system/product operating in a degraded or failed condition).

However, on the VLUP, due to the late development of the system level test rig, the focus was initially on testing the safety-critical software on the railway. This is despite the latter being the

Figure 8 – Process for undertaking runs.



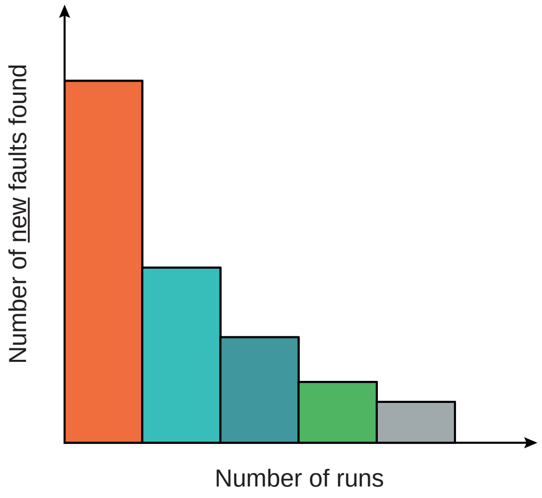


Figure 9 – Schematic of the number of new faults found with an increasing number of runs for a given scenario and test case.

Operating envelope	Min n for varying confidence levels						
	95%	92%	90%	88%	83%	80%	75%
Ia	3,007		1,820			784	507
Ib & II	423		256			110	**72**
III	57		35		20	15	10
IV	57		35	**31**		15	10
V	57	**44**	35			15	10
VI	**57**		35			15	10

Table 2 – Minimum number of runs needed to achieve a given level of confidence for each region of the operating envelope.

first time that the three critical signalling sub-systems (which had been developed by different sub-contractors/groups) were brought together.

The signalling contractor used the system test rig mainly to undertake regression testing to ensure that the faults already fixed had not introduced new faults and to replicate specific tests undertaken on the railway in non-traffic hours.

When the focus shifted later to using the system rig for parametric testing in order to find new faults as early as possible, time and programme delivery pressures meant the nominal, best and worst case values were assigned to all of the key parameters and then sampled during a run rather than sampling from a pre-defined distribution as described above.

Notwithstanding this limitation, most of the faults observed during testing on the railway in non-traffic hours were also seen during rig testing. Indeed some faults were found during rig testing (e.g. train roll-back) but dismissed by the signalling contractor as not realisable on a railway – only for them to be seen subsequently on the railway.

“Eventually, passing tests on the system level test rig became the route for approving the release of the safety-critical software onto the railway”

Key findings

The benefits of system level parametric testing

In the earlier section many of the benefits of system level testing were listed. So this begs the question “Were these benefits realised on the VLUP?” The easy answer is “Yes” but interestingly, in the heat of the delivery programme, other benefits were at the forefront since the number of new faults being found during system level testing (>500) was considerably greater than expected.

Consequently, the focus was on greatly improving the process of finding faults in the signalling software, identifying the root cause(s), fixing and product testing the fixes, enhancing the product level test rigs (which should have picked up many more faults early on) and managing the large number of signalling software versions needed. Typically there was a period of ~one month between updates (costing ~£0.5m each) and ~three months between major upgrades (costing ~£1m each).

Eventually, passing tests on the system level test rig became the route for approving the release of the safety-critical software onto the railway.

Typical results from the test rig

The first key finding using the system level test rig was that the number of new faults found decreased rapidly as the number of runs was increased – see Figure 9. This is despite each run being different on the test rig due to the run-to-run variations in the characteristics of some sub-systems and the operational perturbations (as described earlier).

A similar trend was found when a new test case was run (with the same scenario) and when every update and upgrade of the software was tested on the system level test rig. Initially, there would be a large number of new faults found – almost all of which were genuinely new rather than having been introduced when the previously-identified faults had been fixed – followed by a rapid decrease with each subsequent run.

Whilst this finding may imply that very few runs are needed, this is not the case in safety-critical applications since a single new fault which occurs only very rarely may still result in a catastrophic outcome.

Test coverage and level of confidence

A statistical analysis was undertaken in the third report produced for LU [3] in order to determine the minimum number of runs ‘n’ required to achieve a given level of confidence. The results are summarised in Table 2.

It can be seen that the minimum number of different runs ‘n’ required to achieve an accuracy of (say) +/- 2 faults with a level of confidence of

75 per cent in the new signalling system in regions Ib and II of the operating envelope is typically >70. Similarly, the minimum number of runs required to achieve a level of confidence of 95 per cent in the new signalling system in region VI of the operating envelope is c. 60.

It is worth recalling that the system level test rig on the VLUP runs in realtime since it contains hardware-in-the-loop. This contrasts with software-only driven computer simulations which generally run many times faster than real time. On the VLUP, 60 runs of a single test case using the system level test rig would take typically between 30 and 60 hours elapsed time.

"With three system level test rigs running 24/7 the number of runs that could be undertaken within a 24 hour period was only 15 runs (at best) for each of 10 test cases"

Therefore, if such a statistical analysis had been available during the VLUP, it would have been clear that a level of confidence of (say) 95 per cent with this hypothesis (i.e. that no more than two further faults will be found if more extensive testing is undertaken) was not realisable.

With three system level test rigs running 24/7 (once the signalling contractor belatedly produced two more test rigs), the number of runs that could be undertaken within a 24 hour period was only 15 runs (at best) for each of 10 test cases (cf. the c. 80 test cases planned). Thus, even without this statistical analysis, it was clear that the time and delivery pressures on the VLUP meant that a high level of confidence could only be achieved on the basis that there was still a significant number of faults yet to be found.

The estimated test coverage on the VLUP from running the new train with the new ATO signalling system on the railway in non-traffic hours and using the system level test rigs is shown in Figure 10.

It can be seen that the test coverage on the railway was estimated to be only ~10 per cent in region I of the operating envelope. The test coverage on the railway in region II of the operating envelope – "a single train runs two-way on part of/the whole line with turnarounds at stations and via sidings" – has been re-assessed by the author to be less than 40 per cent (rather than the 10 per cent figure given in the report).

Only ~30 per cent of the c. 80 test cases adopted on the VLUP for approval of the new ATO signalling system could readily be undertaken on the railway.

In contrast, it can be seen from Figure 10 that the test coverage achieved on the VLUP using the system level test rig was estimated to be ~70 per cent for the early regions of the operating envelope and ~80 per cent for the later regions. The remaining ~20 per cent of the operating envelope covered mostly non-degrading and degrading failures, and operational incidents. These regions were not covered adequately using the test rig due to its late development and VLUP time and delivery pressures.

Interestingly, the success of testing is generally measured by the (reducing) number of faults that are found rather than the completion of a particular set of tests without failures.

However, the various delivery managers across the VLUP preferred to use the percentage of tests passed on the railway – running the same test case – as their measure of success. This overlooked:

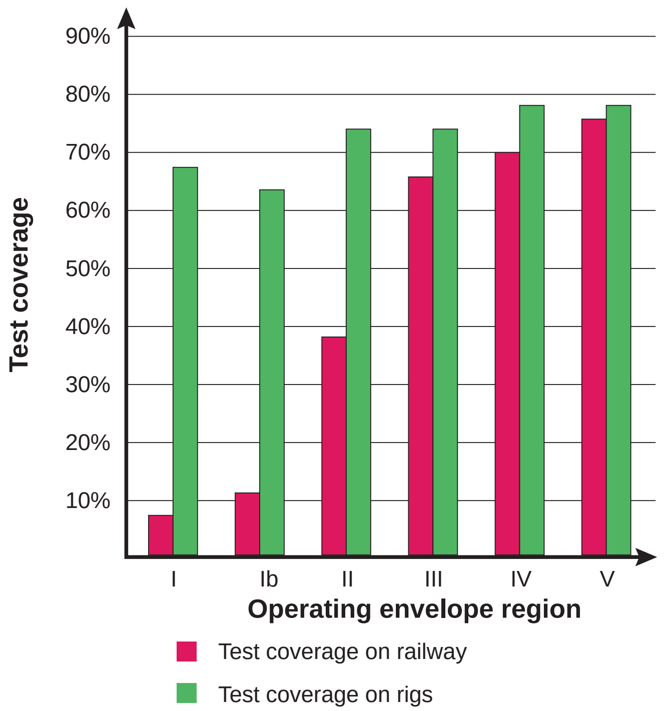
- The first key finding from the test rig.
- The large number of faults found early on during system level testing rather than during product testing.
- The new faults being found on the system level test rig using a range of test cases.
- The time to find faults in the signalling software, identify root cause(s), fix and product test the fixes resulting in the number of outstanding faults becoming so large that only a sub-set of known faults could be fixed in time for each software update/upgrade.

The net result was that the testing on the railway in region II continued for a period of ~9 months with a static ~65 per cent of the tests being passed.

At the end of this period, it was accepted by LU that testing on the railway alone would not find most of the remaining faults in the signalling software. It was also agreed that only the system level test rig was capable of finding many of the remaining faults in the signalling software and thus enable testing on the railway to progress to the next region of the operating envelope. Therefore, it was accepted that the system level test rig would be the mechanism for approval and release of the signalling software prior to testing on the railway which would simply be confirmatory.

The pre-eminence of the test rig was finally accepted by all parties on the VLUP when it became evident that even though the new trains had a modified acceleration profile to match the current trains, there were serious concerns about running a mixed fleet test as a squadron in close headway on the railway in non-traffic hours (see Region V of the operating envelope). Only after

Figure 10 – Estimated test coverage for each operating envelope region on the VLUP.



passing this test case on the test rig was there sufficient confidence to undertake this one-off confirmatory test on the railway. Approximately 90 per cent of the evidence needed in the signalling contractor's safety case – for inclusion in LU's Engineering Safety and Assurance Case (ESAC) – came from the system level test rig test results thereby enabling the commencement of passenger operations on 21 July 2009.

Summary and conclusions

This paper, which is based on four reports on this subject produced for LU in early 2011, has outlined the importance of system level parametric testing of critical systems before releasing the software onto the railway. BS EN 50128 confirms that comprehensive system level parametric testing is good industry practice.

"Only ~30 per cent of the test cases adopted on the VLUP for approval of the new ATO signalling system could readily be undertaken on the railway"

The main conclusions from the VLUP regarding the role of the system level test rig were:

- A common top-down methodology was devised and successfully applied to determine the scenarios and complexity and extensiveness of the test cases required for system level parametric testing of both a new ATO signalling system and a new signalling control system.
- This methodology was used to prove the safety-critical software before its release for testing on the railway and/or for passenger operations.
- The signalling contractor and the independent safety assessors did not recognise that the former's system level test plan failed to adopt best industry practice albeit that the signalling contractor believed that its key product sub-contractors were adopting best industry practice.
- Many of the faults found within operating envelope regions I and II should have been found in the product level test rigs; these were inadequate and needed to be significantly enhanced.
- The system level test rig eventually became the pre-eminent testing facility with testing on the railway being simply confirmatory.

The main conclusions regarding future line upgrade programmes were:

- The system level test rigs provided ~90 per cent of the evidence needed in the signalling contractor's safety case – for inclusion in LU's Engineering Safety & Assurance Case (ESAC) – thereby enabling the commencement of passenger operations on 21 July 2009.
- Earlier acceptance of the importance of the system level test rig would have shortened the overall testing period and enabled a much earlier commencement of passenger operations.
- Only ~30 per cent of the test cases adopted on the VLUP for approval of the new ATO signalling system could readily be undertaken on the railway.
- The test coverage achieved using the system level test rig on the VLUP was ~80 per cent of the full operating envelope and this was well below the >99 per cent figure recommended by the US DoD-funded Data Analysis Center for Software and their "alarm" figure of 95 per cent. This was due to lack of elaboration of the operating envelope in the contract for the new signalling system and in the signalling contractor's test plan, belated development of the system level test rig, the very large number of faults found in the signalling system software, and the resulting programme time and delivery pressures.

Recommendations

Several recommendations were made in the four reports produced for LU; these recommendations included:

- The operating envelope needs to be elaborated in the contract for any new signalling system and new signalling control system.
- Use of system level parametric testing (which is "Highly recommended" for SIL 3-4 software applications in BS EN 50128) should be mandated by the customer in the contract to achieve best industry practice.
- Test rigs should be recognised as hugely beneficial to line upgrade/new signalling programmes as demonstrated by the VLUP such that a business case should be produced up-front to convince the management team of the benefits of developing/enhancing the test rigs early on.
- The signalling contractor should include a test coverage approaching 99 per cent of the operating envelope in its system level test plan.
- The customer should consider at the outset either the procurement of the test rigs or their use by the signalling contractor after passenger operations have commenced to prove subsequent software updates/upgrades.

References

1. A Framework for Parametric Testing of Safety-Critical Software. Nicholas Wrobel; ITLR-T26361-001 dated 21 January 2011.
2. LU Operating Envelope and Parametric Testing: Literature Review of Software Metrics. James Lucas; ITLR-T26361-002 dated 17 November 2010.
3. LU Operating Envelope and Parametric Testing: Determination of the Scenarios required and Quantification of the Number of Runs needed for Parametric Testing. Nicholas Wrobel; ITLR-T26361-003 dated 25 January 2011.
4. Draft Business Case for the use of System level rig testing in support of Line Upgrade programmes. James Lucas; ITLR-T26361-004 dated 25 January 2011.
5. Data Analysis Center for Software (DACS) Software Reliability Source book; September 2001.

The views expressed in this paper are those of the author and do not necessarily represent those of London Underground or the IRSE.

IRSE

Institution of Railway Signal Engineers

Technology drivers for Safe and Sustainable Global Railways

Daniel Woodland

President, IRSE

Our Vision

Back in 2018 we began to work on a ‘beyond 2020’ vision for the IRSE, which you can see laid out in full at **irse.info/strategy**. To summarise, this encapsulated our vision, to ‘Deliver Safe and Sustainable Global Railways’ and five pillars of activity, or goals, on which that is based:

The IRSE vision is to:

Deliver Safe and Sustainable Global Railways

IRSE ENGAGE GROW NETWORK DEVELOP ASSURE

To ENGAGE with and GROW a global NETWORK of railway signal and telecommunications engineers in order to DEVELOP and ASSURE high standards of ethics, knowledge, competence and safety in all aspects of train control.

1. Engage (with the sector and community). Creating a digital platform that is suitable for a global professional body to service its membership and the wider industry. Promoting both early-career support opportunities and senior member leadership of the profession, through the codification of good practice based on expertise and strong ethical /moral leadership.
2. Grow (increase our membership). Enhancing and communicating our value proposition for IRSE members and prospective members globally, recognising that the expertise and experience of IRSE members’ are key to addressing many of the sectors challenges.
3. Network (facilitate interactions globally). Building on the work of our sections and committees to provide a platform for wider collaboration and impact, shared learning, insight and challenge to current thinking. We all have a vital role in encouraging knowledge transfer, collating good practice and facilitating professional networks.
4. Develop (enhanced capability of the railway sector workforce). Our aim is to support engineering, railway engineering and in particular railway signalling, control and communications engineering in attracting, developing and retaining skilled engineers and technicians.
5. Assure (set and uphold standards for people and processes). The IRSE will continue to set and uphold professional standards, offering routes to recognised qualifications for all engineers in railway signalling and telecommunications businesses, promoting adherence to a code of professional conduct alongside professional registration and licensing.

This vision drives what we are doing as an institution in support of our ‘charitable aims’, as defined in the IRSE’s Articles of Association:

- The advancement for the public benefit of the science and practice of signalling by the promotion of research, the collection and publication of educational material and the holding of conferences, seminars and meetings

and

- The maintenance of high standards of practice and professional care amongst those working within the industry and the promotion of improved safety standards for the protection of the general public

We have a lot of mechanisms for achieving these within our ‘normal’ institution ‘learned society’ activities, such as high-quality lectures, seminars, papers, conferences, IRSE News, and our annual professional examinations in railway signalling and telecommunications. We also engage with academia and have provided the syllabus for several academic diploma and MSc courses and we have our International Technical Committee (ITC), focusing on pooling the best of international knowledge and experience to assist our members and wider industry. However, there needs to be some structure and basis for these activities if we are to achieve the aims outlined in our articles. We

need to understand and influence how technology can best be applied and used to respond to emerging needs/drivers and structure our activities to target key learning areas for our members and wider industry.

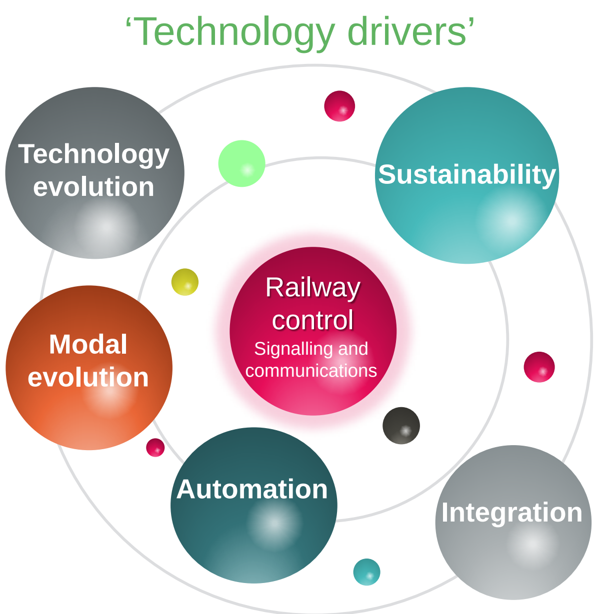
Technology drivers

To that end, a working group was set up on 'Technology drivers', aiming to identify key challenges that our members and industry face and need to prepare for. If we don't, there is potential for a skills gap between where we are and where we will need to be once these drivers have exerted their influence.

It is clear to see that, even pre COVID-19, societal attitudes to transportation were changing, with expectations for all modes becoming ever higher. Rail is no exception to this. There are also general changes in society with potential to affect rail in the long term. Population growth, increasing urbanisation and an increased public awareness of environmental issues and the need for energy efficiency, for example, assist in a demand for increased rail transportation, whilst increases in connectivity, digitalisation and expectations over mobility apply pressure to rail to improve our game.

Looking more specifically at changes in technology, the world of 'big data', the internet of things and Artificial Intelligence (AI) raise possibilities that we couldn't, and certainly wouldn't have considered a few years ago but very much need to consider now.

This is a bit like looking at the interaction between planet gravity fields. We, in the IRSE, are part of a traditionally conservative, and many have said immovable, railway control industry – that has developed good safety performance through a long and hard process of trial and error, lessons learnt and very gradual change. However, the technology drivers exert a huge gravitational pull on our industry that we need to adapt to.



Technology evolution

Evolution in the available technology itself is one significant area. During my career we have moved from predominantly relay based systems (with a fairly large amount of mechanical too) to electronics and software-based systems. We are now seeing enhanced capabilities due to faster processors, availability of abundant cheap memory, high bandwidth communication systems and associated with all of those, increased complexity in software. Along with those changes has come an increased problem of obsolescence – back in mechanical days we designed systems for a 50-year life and with some judicious maintenance here and there, and the odd replacement part that any workshop could produce for us, kept those running for 150 years. When we moved to relay based systems, we designed for 40 years but found that after 30 we had wire degradation problems. Now in the computer age we may design for 30 years but find that the components are obsolete after 5 – well, actually probably obsolete before the system goes into service. All of this means we need to be better prepared for managing complexity and obsolescence, and the general management of innovation.

Automation

Another sphere of influence is automation – which is enabled by the technology evolution but is fundamentally about how we choose to operate our railways. As I noted in my article on the 'Practical Integration of Automated Operation in Railways: A System of Systems Perspective' seminar, in last month's IRSE News, automation in railway operation has been around for a long time now. However, there are a lot of complexities involved in delivering the systems engineering required to integrate automation into the complex railway 'system of systems', including not just signalling and communications but also rolling stock, permanent way, electrification and operations.

I already made mention of AI, and that is also likely to pose significant challenges for our industry and our traditional approaches to safety management – if the system thinks for itself, learns for itself and finds its own ways of deciding what to do, how can we be sure what it will do – or even what or why it did do it?

I won't say more about automation – you can always refer to last month's article or register to view the material from the seminar, which is still available on-line for a small fee at **www.automatedrailwayseminar.online**.

Integration

A third significant sphere is integration. I have already alluded to the need for a 'system of systems' approach. We are also seeing pressures for greater integration of systems – operators don't want to have to use different control interfaces for communicating with each of the signalling, communication system and SCADA. They want with a single mouse to be able to select a train on the signalling overview, initiate a secure call to the driver and implement needed changes to system configuration. However, integration brings difficulties in managing cyber security for safety critical systems, so there is also a pressure to keep systems ring fenced and separate. We as an industry need to find optimal ways around those issues in order to enhance efficiency and safety of operation and grasp the potential offered by 'the internet of things', for example.

We then also need to consider sustainability – there has been a lot of movement towards centralisation – both for operational efficiencies but also for safety and availability (making systems easier and safer to access for maintenance and faulting). There is also a continual drive towards miniaturisation – our equipment tends to be bulky and we somehow need to fit it into ever smaller spaces in order to reduce costs and maximise passenger space. Our traditional 'fail safe' approach is not enough on its own – it isn't actually safe to stop everything and hand over to a human for unusual procedural recovery. So, redundancy and diversity have become important considerations. Train Centric control is also an emerging idea to enhance availability, reduce communication delays and move equipment into a more accessible, train based, location. Regarding system performance there is now an increasing focus on energy saving and traffic optimisation. We are also starting to see the concepts of relative braking (where trains are spaced by less than full braking distance, and through communicating with each other ensure that the following train will stop before a collision if the leading one brakes) and related to that virtual coupling and platooning. These are terms that may be readily recognised from autonomous vehicle developments, but we can expect to see more of in rail too. Then, of course, we also have to consider sustainability in our design and implementation processes – so new tools and methods for design, verification, test and assurance should also be on our agenda.

Modal evolution

That brings me onto the final sphere from our list of top technology drivers – modal evolution. I mentioned autonomous vehicles a few paragraphs ago. Can we really expect the automotive industry to push forward with autonomous vehicles and for it not to affect what we do in rail? The volumes of units being considered for road vehicles make development of new technologies viable that we could never justify for rail – but once they exist, what should we be doing to adopt and adapt those technologies and the automotive concepts for their application? If we fail to learn and adapt with our competing modes there must be a real risk that rail will become outdated and the best rail solution of the future will become removal of the rails, tarmacking the guideway and running automated buses! I actually think that may really be the answer in some cases, but not in all – for societal interest there still will be a place for rail if we are able and willing to adapt to fill it. Potentially we could face similar challenges from hyperloop. And indeed, our experiences should be assisting both hyperloop and autonomous vehicles in resolving the difficulties that we face – we don't need to be parochial to rail. We are, as railway signalling, communications and control engineers fundamentally system safety experts.

One final point for me to mention is the more mundane convergence of metro and main line signalling and control solutions – most manufacturers are now using common components and sub-systems for their CBTC and ETCS solutions, for example. We can expect to see continued convergence, and need to be prepared to support and enable that in the interest of efficiency and performance.

Acting on the outcomes

The outcomes of this study have been shared with the ITC and the presidential team to aid thinking about what to include in our programme of activities. During my year as president of the IRSE, I have arranged a series of presidential programme lectures around the theme of 'Complexity of change in modern CCS systems', looking to address a number of the areas that I have just outlined.

In June Professor Yuji Hirao from Japan presented a paper on 'The forefront of system safety and its application to railway signalling'. In October Tom Jansen and Rick Driessen of Ricardo Nederland presented a paper exploring crossover between rail and autonomous road vehicles. That was followed in November by a paper on 'cross acceptance of systems and equipment developed under different standards frameworks' by Professor Rod Muttram. Then in December Nicholas Wrobel presented on testing modern electronic/software systems. The programme will continue in January, when Alžbeta Helienek will present a paper proposing a digital resilience railway maturity matrix (a method to categorise, recognise and support organisations with their roadmaps to integrating security into daily operations). That will then lead into the final paper in the series on 'Traffic Management systems and automation in control centres' by Ian Mitchell of the IRSE International Technical Committee and Nora Balfe of Iarnród Éireann (which will be presented in February 2021). Details of all of those events can be found at **irse.info/events** (for the ones yet to come) or **irse.info/webcasts** (for the ones that you may have missed).

DMWS – Degraded mode working system

Chris Fulford

In September 2018 IRSE News carried an article about the Network Rail COMPASS programme and the Degraded Mode Working System (DMWS) that emerged from it. This article aims to update the details, explain the principles and put some context around the complexities of developing a new railway control system. This article is derived from an IRSE L&SE section lecture given in September 2020.

Why DMWS?

DMWS aims to improve passengers' experience by enhancing the industry's response to significant signalling failures. It forms a strand of Network Rail's "Putting Passengers First" initiative.

The requirement for DMWS is to provide a means of moving traffic when the primary signalling system has failed and traditionally Temporary Block Working (TBW) would have been instituted. Typically, such failures would arise from:

- Loss of signalling power supply.
- Cable damage and theft.
- Track circuit and axle counter failures.
- Loss of communications to/from interlocking.
- Component failures.
- Panel failure.

TBW was resource hungry, required operations staff to manually secure all point ends and ground frames, and provide hand-signallers at both ends of the section. Mobilisation of the resources often resulted in excessive delay (typically three hours) and consequential heavy disruption. TBW has been replaced by Emergency Special Working (ESW) which has improved the response. ESW can be set up in as little as 20 minutes but still relies on human performance and is a low capacity low performance process, usually with around two to four trains per hour. Even with ESW, staff are required to secure points and ground frames if the signaller has no indications of status on their panel or workstation.

Delays caused by signalling failures are sizeable costing Network Rail over £100m per annum. Whilst some of this can be recovered by reducing the incidence of failure using improved signalling power supplies, reductions in cable theft and "intelligent infrastructure" failures will still cause significant delay. The DMWS business case is based on a 6.7 per cent per cent reduction in signalling delays if the core infrastructure and most trains are equipped with the system.

Project complexities

Chief amongst the complexities which I will explain in this paper are:

- Developing a cross-industry system in today's regulatory framework.
- Managing the desires and demands of multiple stakeholders.
- Ensuring the apportionment of system functionality is equitable between the Infrastructure Managers (IM) and Railway Undertakings (RU).
- Working with multiple suppliers in a public sector procurement framework.
- Making best use of existing systems and equipment.
- Ensuring the system is safe and secure enough without going over the top.
- Ensuring all likely operating scenarios are considered, the requisite functionality is provided and an acceptable set of operational rules can be provided.
- Maintaining a simple yet effective system and avoiding over-engineered solutions.

There are many challenges to overcome, not least the concern that DMWS is trying to be a low-cost signalling system with attendant lower safety integrity levels. This has parallels to the early stages of Train Protection Warning System (TPWS) development in the late 1990s. TPWS was 'not fail safe', did not have a SIL rating, was not ATP! If DMWS becomes as successful as TPWS in delivering significant gains at reasonable expense, then we should all be happy.

Previous project phases

DMWS was part of the COMPASS programme commenced in 2011 under the National Operating Strategy (NOS). The COMPASS programme looked at several operating issues including track worker safety, user worked crossing safety and improving the response to signalling failures. DMWS became a standalone project to focus on the rising trend in signalling failures.

In 2012 a trial on the LNE route between Stoke tunnel and just south of Doncaster was proposed that could relay information about the status of points back to Doncaster signalbox. The trial did not progress.

The DMWS system uses the GSM-R radio fitted fleet-wide. This is a typical cab installation.

In 2015 the DMWS project took a new turn with five suppliers undertaking feasibility studies. This reduced to two suppliers (Thales and Altran) to create laboratory simulations and finally Altran to build a concept demonstrator. Demonstrations were undertaken on the Hertford Loop with control being exercised from the ETCS National Integration Facility (ENIF) test facility at Hitchin and track equipment interfacing to points and TPWS at Walsall training centre.

Since the demonstration in early 2018 as reported in IRSE News in September 2018 the focus has been on defining the safety, security, RAM and human factors requirements and the development of a Generic Application Safety Case (GASC) and its independent review. In addition, a business case has been developed that was sufficiently robust that Network Rail authorised the spend of £15.7m on a trial of DMWS.

Where are we as a project now?

DMWS sits within the Future Communications and Train Control (FCTC) portfolio under the R&D programme in Network Rail, being fully funded from the R&D budget. At this point in the development life-cycle, the project is following the Rail Industry Readiness Level (RIRL) governance process. RIRL is a framework to support product development that not only requires the system to demonstrate a Technical Readiness Level (TRL) but further demonstrate readiness in terms of software, reliability, system integration, manufacture as well as non-functional facets such as market demand and operational application.

So far, the project has completed all stages up to RIRL4 (industry Specification). The current phase provides funding to complete RIRL5 (Prototype) and RIRL6 (Operational Transition), which will culminate in an operational trial of the production DMWS system. At the end of this phase, the project will face 'Gate 3' of the framework after which the system should progress to initial deployment (RIRL7), full roll out (RIRL8) and whole-life management (RIRL9). RIRL does not supersede GRIP which still apply to individual projects planning to implement the system.

The target is to undertake a three-month trial toward the end of 2022 and then complete all the reports for the necessary approvals by March 2023. DMWS for the trial will follow the appropriate processes for the route selected including GRIP and a Specific Application Safety Case (SASC). The subsequent extent of roll out will depend on the outcome of the trial.

Scope of application

The key functionality of DMWS is built around replacing ESW and is thus restricted to deployment on lines signalled in accordance with Track Circuit Block (TCB) regulations and ERTMS routes. This means interfacing with relay, SSI and modern CBI interlockings.

Routes with Absolute Block (AB) signalling and single lines are not in the scope. It is also not intended to use DMWS where the faults are symptomatic of points failures for example.

DMWS has minimal interfaces with the underlying signalling system: it uses the train describer data to announce to the signaller the approach of a train to the failed area; piggy backs on detection circuits to determine state of the points and inhibits certain controls. Areas equipped with ETCS can be operated with DMWS since once in the area the system is agnostic about the nature of the stopping location be it a signal or marker board. ETCS Level 3 will present added challenge but that is true for several other factors in its implementation. Incidentally it is currently anticipated that DMWS will perform less well in ETCS areas because of restrictions imposed when operating in staff responsible mode.

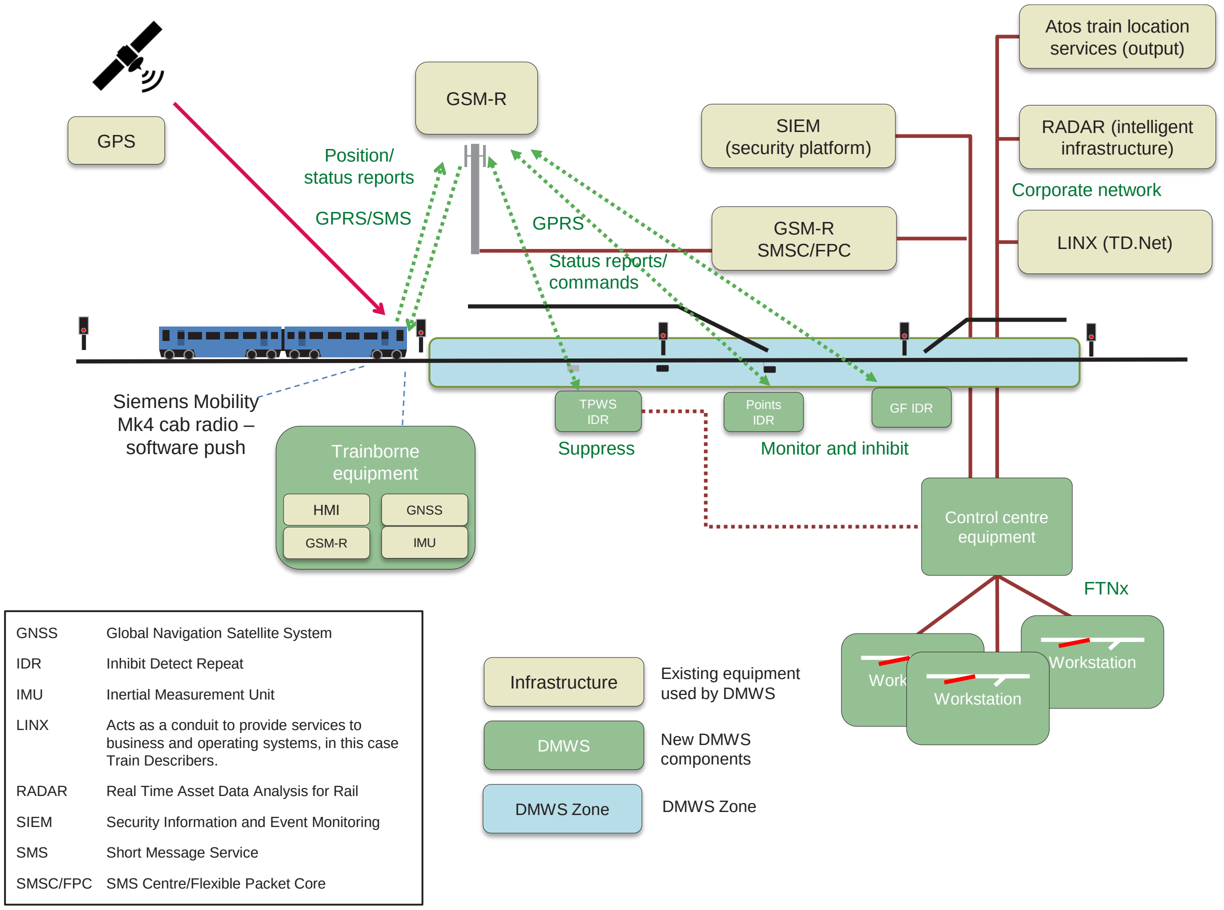
The business case suggests that about 25 per cent of the national network could be justified for DMWS fitment, being the main strategic route sections together with 100 per cent of trains.

DMWS architecture

The expectation is that DMWS will be used perhaps 200 times per year nationally. It is not expected to handle trains at normal throughput or speed. It is intended to provide technical support to both the signaller and driver when operating abnormally and thus to improve performance compared to ESW.

The ethos in developing DMWS has been influenced by TPWS experience, keep it simple to make it affordable, avoid the desire to gold-plate everything, or in fact anything, and use systems and equipment already available where you can. So for example, we have resisted the temptation to interface to the train's braking or control systems, or to supervise the train's speed at speed restrictions, instead relying on the driver. The approach has been to identify existing systems, equipment and information sources that could form the backbone of the DMWS.

The system requires equipment on the train to determine and relay its position, present the movement authority to the driver and accept inputs, and to communicate with the central DMWS subsystem to receive commands. Adding equipment to a train, particularly in the



The DMWS system architecture.

cab, is challenging. Our solution is to use the Siemens Mark 4 GSM-R cab radio, which is currently being rolled out to almost all main line rolling stock. This equipment has the hardware needed, save maybe the GPS antenna, has the connectivity, and has the processing capability. In summary, this means adding DMWS functionality to a train can be as simple as a software upgrade and perhaps adding a GPS antenna.

The concept also uses the existing GSM-R and FTNx communications networks between the central equipment and the trains and trackside equipment. No enhancements to the GSM-R infrastructure are needed, and the current national programme rolling-out General Packet Radio Service (GPRS) over GSM-R presents a win on bandwidth as well as transmission reliability and ability to use TCP/IP addressing. GPRS also enables management functions in the trackside equipment, such as downloading diagnostics and security logs remotely.

But GSM-R is categorised as an open transmission system with out of date 2G security, and so cyber security dictates application of certification and authentication techniques and requires a Key Management System (KMS). Fortunately, Network Rail is implementing a Public Key Infrastructure (PKI) system with Online KMS (OKMS) to support ETCS, and other data centre applications. DMWS will become a service user rather than implementing another KMS.

DMWS will need a new centrally based control system connected to new signaller workstations. The central control equipment will comprise commercially available servers and the workstations, standard PC-type equipment, connected via the existing FTNx IP-enabled telecoms network. The core DMWS software application will be written in SPARK and Ada, running on a Linux Red Hat server operating system. A new role for a DMWS System Administrator will be required to manage configuration, control access, source logs and undertake other general housekeeping activities.

Deciding where to locate the central server platform (and redundancy server) is a challenge: in a ROC equipment room? In one of NRT's data centres? Or off Network Rail property at one of the Crown Data Centres?

Network Rail's Signalling Innovations Group (SIG) have been developing a number of tools and techniques aimed at improving the efficiency of signalling scheme design and the project has been working closely with them to harness these initiatives. A key element is the System Data Exchange Format (SDEF) used to capture infrastructure data from video records taken by service trains. This process captures the position of key infrastructure (e.g. point ends, signal posts,) together with sufficient data for track mapping, and outputs it in XML format for use in other programmes. One of these programmes is intended to create a scheme plan (Sketch Tool). It is intended to develop the DMWS scheme plan using this tool. New functions are required to import the SDEF data in to the central DMWS equipment and then create zone maps. The accuracy of the SDEF data is predicted as around 1 to 2 metres which is more than sufficient for DMWS applications.

DWMS will also import the data currently held on signallers route data cards to assist with external controls to protect a DMWS zone and it will output data from the cab radio and GPS subsystem to the Train Location Services gateway.

A new Inhibit, Detect and Repeat (IDR) product specification has been developed with the aim of providing monitoring and isolation functions for points, ground frames and TPWS transmitter loops and similar equipment.

In principle the IDR is similar to existing data loggers and disconnection devices used for track worker protection. However, these devices do not have a SIL rating and in many cases the latency in message transmission is too great.

How DMWS functions

The following is a brief summary of the functionality. For more detail see IRSE News September 2018.

During design several DMWS Role Areas will be defined typically being a subset of the primary signalling control area since DMWS will be implemented on route sections that justify the investment. Within a Role Area a number of DMWS Zones will be pre-defined to cover various signalling failure scenarios. These Zones may be small areas covering just a few signals or larger areas to cope with an interlocking failure or significant power outage. For TBW and ESW the operating arrangement is "one train at a time". To improve performance DMWS may divide the zone in to more than one section up to a maximum of four but more typically two. In addition, the system will allow for other operating scenarios such as level crossings and permissive moves in to occupied areas. Each zone requires a working signal at the entrance and exit, preferably fitted with TPWS to provide overrun protection. Further protection arrangements may be required according to the route cards. The DMWS scheme designer and operator will determine the degraded level of service to be provided and then make judgements on the size and number of zones to be provided and the number of sections within a zone. The preparation of suitable guidance for this process is part of the project.

Without active train protection between the mid-Zone Block Sections, DMWS needs to manage safety appropriately. Whilst DMWS operation with block sections can be considered the equivalent of plain line signalling where TPWS is not generally provided, safety will be managed with enhanced information for the driver (distance to go), emergency alarms to the driver and signaller if the movement limit is exceeded, and generous 'virtual' overlaps and limited transit speed.

All key locations within the Zone are virtual, being GPS waypoints, with no new physical interface on the ground. Waypoint markers are typically a signal or ETCS marker board for the driver to aim for if it is the movement limit.

The new trackside equipment will monitor the status of all point ends and any ground frame in a Zone. This equipment is called the Inhibit, Detect, Repeat (IDR) and will relay the position of the point ends and ground frames back to the control equipment. If the points are not in a suitable position then either the signaller can move them using the individual point control or staff will manually move them. Once in the necessary lie the IDR will be commanded by the Central Control Equipment (CCE) to isolate the point control circuits or ground frame release effectively providing the equivalent of clipping and scotching. An added advantage of this function is there is no need to return to site to remove the clip or scotch when no longer required.

IDRs will also be connected to TPWS control circuits, arranged to suppress TPWS transmitters on signals inside the Zone, and at the Zone entry signal when a train is authorised to enter the Zone. TPWS on the Zone exit signal will always be controlled by the exit signal aspect controls not DMWS.

On an ERTMS route, the overriding of active train stop functions will be undertaken onboard by the driver using the Override function.

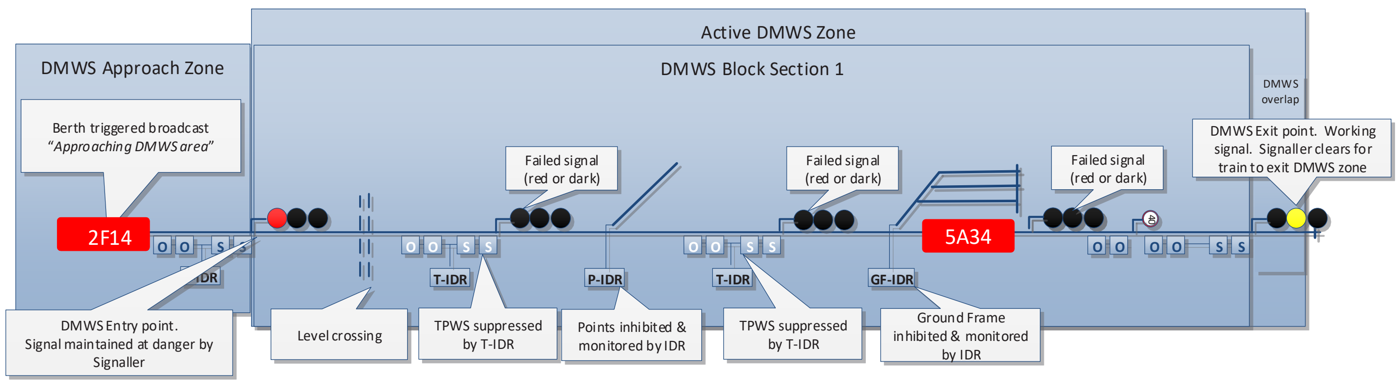
The signaller will have a workstation on which a Role Area and Zone can be selected. Once the Zone is set up, is protected and safe for trains to transit, the signaller can use the Workstation to issue a movement instruction. This is termed an Authority to Move (AtM) to differentiate it from ETCS Movement Authorities. Several types of AtM are available depending on the operational circumstances:

- Standard – the default normal authority.
- First Train – issued to the first train to transit the Zone.
- Drive at Caution – issued if there is a need for the driver to be cautioned through the Zone.
- Permissive – issued for a permissive move into an occupied platform.
- Non DWMS – issued for an unfitted train to transit the Zone.

Before an AtM is issued, the signaller and the driver will use the cab radio to come to an understanding about the extent of movement. There is no need for the driver to write this down unless any exceptional circumstances exist requiring a specific caution to be given, e.g. an AHB under attendant control.

DMWS needs to know the status of any automatic (AHB) or manually controlled (MCB) level crossings before it can issue an AtM. A function will exist to provide a reminder of a UWC (with telephone) that has been authorised for use. The management of level crossings will follow the existing Rule Book requirements, there is no intention to create new or modified rules for this critical activity. The signaller will be responsible for confirming the status of any level crossings at zone set up and when trains are authorised through a zone. If the status can't be ascertained from the signal box indications including CCTV where relevant, this will have to

An example of DMWS in operation.



Renderings of potential AtM messages that would be sent via the DMWS to the driver of a train being talked through a section of track.

be determined locally, preferably by an attendant or by the driver of the first train until an attendant arrives

The process for issuing an AtM starts with the signaller proposing the movement by selecting the train to move and the limit of the required movement (the AtM Proposal). DMWS will validate the proposed AtM to check it is valid, level crossings have been confirmed safe to pass with or without a caution, no other trains exist in the DMWS block section(s) and the route is secure. The type of AtM is also determined by pre-defined constraints depending on the state of the zone and infrastructure in the zone.

If the AtM validation checks pass, it is offered to the driver (the AtM Offer). The driver is required to confirm the offer is the same as the movement discussed with the signaller, and is being provided to the correct train. Once validated by the driver DMWS will recheck the status of the zone security and confirm the AtM back to the train (Confirmed AtM) presenting the driver with an authority to pass the protecting signal, the 'distance to go' to the AtM limit and the identity of the signal or block marker at the end of the limit.

The driver of a train on a conventionally signalled route will operate the TPWS Train Stop Override to enter the zone. The driver of an ATP-fitted train will need to put ATP into temporary isolation to avoid a train trip on passing red aspects, and the driver on an ERTMS route will need to select Staff Responsible mode and operate the ETCS Override to enter the DMWS Zone.

As the train transits the Zone, the driver is presented with relevant information including a countdown of the distance to go, instruction on where to stop (the AtM limit) and confirmation that each intermediate signal/block marker can be ignored. On an ERTMS route it may be necessary for the train to stop at marker boards with a 'Stop if in Staff Responsible' balise group to operate the ETCS Override. The display will inform the driver which need to be overridden and which can be ignored.

The first train through a Zone will act as a sweep train, proceeding at caution prepared to stop in case of an obstruction, and at no more than 15mph over points and crossings. This mirrors the approach for ESW and TBW.

Once the zone is swept and clear of obstruction, subsequent trains will be limited to 50mph (80km/h) maximum. On an ERTMS route the SR ceiling speed may reduce this speed further. The GPS function of on train DMWS equipment will enable an alert to be given to the driver should the 50mph limit be exceeded. Lower speed limits will not be monitored relying on driver vigilance. This is because of the extensive nature of additional information and equipment required to properly implement such a function.

All commands, messages and key actions will be logged in each subsystem, available should there be an incident needing investigation. Key events will be available to be logged on an On-Train Data Recorder if connected.

As the train approaches the zone exit, the signaller will be notified and can set a forward route allowing the train to exit the zone without stopping.

The zone entry signal will be maintained at danger and both the entry and exit signals will normally have active TPWS to control unauthorised entry and exit. Consequently, TPWS will be active on the train unlike ESW and TBW.

If an AtM is to the end of an intermediate block section, should the train exceed the limit, detected by GPS, then an AtM exceedance will be detected and the driver and signaller will receive an alarm. There will not be any active train stop function. GSM-R will also be available to set up a Railway Emergency Call (REC)to stop all trains in the area.

System safety

DMWS is a system to support the operators when the primary train control system is non-functional. As such it does not require ORR authorisation. However, the proposal is considered a significant change and is therefore following the Common Safety Method (CSM). There were no identifiable reference systems.

An Independent Safety Assessor (ISA) has been in place since 2018 with a remit to review the project's safety plan, hazard management, risk assessment and safety case. An assessment Body (AsBo) has similarly been in place since 2018 to ensure compliance with CSM through to the end of the trial. A Generic Application Safety Case (GASC) is being prepared and interim reviews conducted by a special Safety Review Panel (SRP).

The project needs to provide SRP with evidence the safety requirements have been met and delivered by competent parties. A fairly complex set of interacting safety cases are required to build up to the GASC, based on each subsystem meeting its own safety requirements and demonstrating that as a whole a safe system is being created. These will need to be supported by application standards and rules.

Explicit risk estimation is also required to meet CSM as there are no reference systems to use. Risk analysis using data derived from RSSB's safety analysis of TBW and ESW allows the demonstration of risk is on a par with ESW despite DMWS being used more frequently.

At project commencement there was no tolerable hazard rate so first principles were applied to determine an appropriate Safety Integrity level (SIL). Two approaches were used, the risk graph and the layer of protection analysis. Both suggested SIL 2 was appropriate.

A key interface is to the trackside equipment where DMWS will be interfacing to point and ground frame control and indication circuits and to suppress TPWS functions. These will be fundamental areas of focus going forward. The trackside equipment will be subject to Network Rail Product Approval.

The trackside interfacing equipment for DMWS is being treated like other signalling equipment and will be subject to compliance with appropriate standards for design, installation, testing and maintenance. However, there are no specific modules for DMWS so the project will need to develop new modules as necessary.

DMWS will be an industry-wide system, Network Rail acknowledges its approach should not stifle options for train borne deployment, or add unnecessary cost. The DMWS governance structure is well defined with the Vehicle Train Control & Communications System Interface Committee acting as the System Authority.

Whilst Network Rail can look after the interface between the central equipment and the trackside equipment, the interface between the central equipment and the trains needs to be an open interface such that other suppliers can offer competing solutions to the Siemens development funded by the project. To cover this, RSSB will develop a DMWS Rail Industry Standard (RIS) for DMWS.

System security

As mentioned earlier, communicating over an open system means messages need to be secure. When the demonstration system was conceived, security was proposed to use Digital Signature Algorithm (DSA) but this has a significant overhead for each message such that 3 SMS messages would be needed for the security element for each SMS containing a command or message.

Since GPRS has become available this has been eased with greater bandwidth available, but it is still intended to use SMS for some applications. Hence a more streamlined authentication and encryption approach was needed. The security architects have settled on Advanced Encryption Standard (AES) for message authentication which should allow the message and the header to be contained in a single SMS. This approach is functionally similar to the ETCS KMAC.

The project is in dialogue with the Digital Railway Key Management project and proposes to become a user of the ETCS online KMS being procured to support the next ETCS application in 2022.

DMWS will log security events and output these to Network Rail's Security Information and Event Monitoring (SIEM) platform. The Security Operating Centre (SOC) in Manchester will monitor security events and relay these to the DMWS System Administrator.

Maintaining DMWS

As the train borne functions will be delivered by a software update in the Siemens Mark 4 cab radio, maintenance tools and process basically exist and can be applied to the new functions.

Maintenance responsibility for the central equipment servers will depend on where they are located both functionally and physically. The final location and arrangements can be decided in due course.

The regulatory framework

Within the framework of the Train Control TSI written orders are the operational mode if ETCS/ERTMS is non-functional and these are undefined. The DfT confirmed that TSI's would not apply to DMWS thus authorisation under Railway Interoperability Regulations 2011 would not be required. As mentioned earlier the internal Network Rail safety management systems define the implementation of DMWS as a significant change requiring the application of the CSM to demonstrate the system is safe.

System development and operational trial

The project is now at the start of production development and plans to undertake laboratory and dynamic integration testing followed by an operational trial. The development activities follow a traditional systems engineering approach. Network Rail has defined the system requirements which have been apportioned to the subsystems by the system integrator (Altran). These form the input specifications for the subsystem suppliers.

Subsystem suppliers are contracted to provide prototype equipment and Altran is responsible for system integration, verification and validation.

Altran will build a test lab at their Bath offices and Network Rail will make available the Rail Innovation and Development Centre (RIDC) at Melton for the dynamic testing. RIDC offers an opportunity to also test the system in an ERTMS environment.

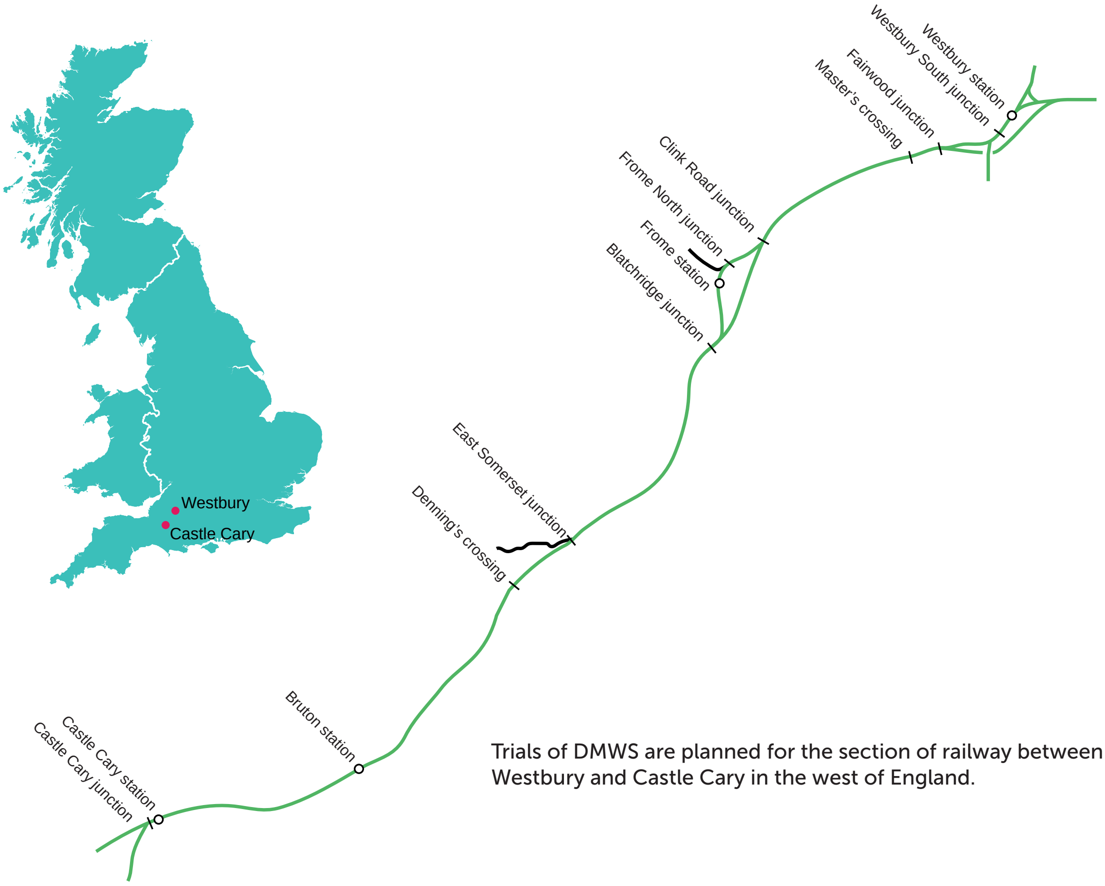
After satisfactory integration testing, the suppliers will develop pre-production equipment to be used in the operational trial.

Western Route has agreed to trial DMWS with the route between Westbury and Castle Cary identified as a candidate area. Both Great Western Railway (GWR) and South Western Railway (SWR) have agreed to cooperate, and Network Rail is keen to engage a freight operator for the trial.

The route between Westbury and Castle Cary has a route relay interlocking, NX panels and colour light signalling. The two-track route has a reasonably busy mix of intercity and regional passenger trains intermixed with stone and infrastructure maintenance trains.

The operational trial will be a little different from the usual period of monitored and supported operation because DMWS is only intended for use when the primary signalling has failed. Because DMWS is independent of the signalling system there is no need to wait for a failure or to emulate a failure. It can just be used as part of a series of trial scenarios.

It is unlikely GWR and SWR will want to cause delays to their service trains during the trial so the expectation is that the DMWS operational trial will be using test trains within white periods or possessions.



Trials of DMWS are planned for the section of railway between Westbury and Castle Cary in the west of England.

Operational challenges

The technical challenges in developing a new system are matched by the operational challenge to ensure the system will be accepted and used by the signallers, drivers and other key operational personnel and are endorsed by the trades union representatives. The importance of engagement with the users and their representatives is paramount to successful implementation.

Just producing a Concept of Operations (CONOPS) is not enough. The development of the system needs to include seasoned operators to make sure the right functionality is provided, is usable and supports the users. That way the system stands a very good chance of being accepted. Achieving this required an Industry Working Group (DIWG), tasked with looking after the CONOPS and its subservient operational description. The DIWG has representation from all parts of the industry affected by the system and their union representatives. DIWG are a key resource able to add practical experience into the mix and ensure the system can be used and is used safely and efficiently.

RSSB, being the custodian of railway standards and the rule book, have been engaged on the DMWS project from its beginning. Work has now started on drafting the framework for the rule book governing DMWS. This is an important step as assumptions made now about the systems use may omit key functionality that is required when the rules do not support the method of operation proposed.

Another key element of the operational design is the approach to human factors. DMWS has human machine interfaces (HMI), and these need to support the users, reducing risk of human error; reducing workload; and be intuitive and supportive. But there is a balance to strike. The system can have a high level of intrusion and spoon-feed the users to follow strict patterns, or can expect highly trained, competent people who can be trusted to exercise judgement and apply their skills, knowledge and expertise following a set of rules. Getting the balance right between supporting or de-skilling the users is key.

Altran is supporting the project with a programme of human factors work, applying a range of tools and processes such as task analysis, workload analysis, error analysis, HMI design, user trials etc. This will be used to support the operational processes and workstation designs.

Conclusion

DMWS aims to provide an independent means of moving trains during a failure of the primary train control system. It must be reasonably easy to use for both the signaller and driver whilst providing a safe and affordable method of control that will only be infrequently used. The service especially to the driver must be simple but at the same time supportive to driving without the normal signalling indication. To meet these challenges requires a complex multidisciplinary project and need to be tackled head on in a diversified industry.

About the author …

Chris joined the Southern Region in 1976 as an apprentice technician in the Regional Mechanical and Electrical Engineer. Following 14 years in fleet engineering Chris joined the Director of Operations to look after the interests of train crew in all new build rolling stock and control system projects. This role morphed into the BR Group Standards (forerunner to RSSB) and finally managing train operational safety at BRB during the privatisation process. In 1997 Chris entered railway consultancy undertaking many and varied assignments at home and abroad. Notably this included the development of TPWS, inputs to ETCS development at home and at European level, and the management of the roll-out of the train borne next generation RETB system.

Configuring safe software driven systems

Rod Muttram
On behalf of the IRSE International Technical Committee

Can multi-lane/multichannel systems be false friends? In many transport applications engineers strive to produce control systems that deliver high and quantified levels of safety along with exceedingly high levels of reliability/availability. At the same time, the desire to deliver complex functionality and, in terms of wayside systems, ever larger areas of control have increasingly moved us towards software driven systems.

Designing a computer based, software configured and operated system which is both safe and highly available can be challenging. They need to be able to safely handle both random failures (such as an electronic component becoming defective) and systematic failures such as errors (bugs) in the software. We cannot afford the historic interpretation of 'fail-safe', which a lot of older mainline railway infrastructure still utilises, based on 'right-side' and 'wrong-side' failures, where a wrong-side failure has immediate safety consequences but a failure that causes loss of function and stops the trains is classified as 'right-side' and thus to some degree acceptable. Not only must no single fault cause an unsafe failure, but no single fault must cause a loss of functionality either, and the probability of multiple or 'cascade' faults must be acceptably low. Furthermore, all faults must be detectable even if they cause no immediate loss of functionality. Undetected dormant faults may compromise safety and/or reliability.

The safety requirements will usually demand a lower failure rate, but availability targets are now often 99.99 per cent or even higher.

To service these potentially conflicting requirements a number of architectural solutions have emerged, each with their own advantages and disadvantages. Most of the approaches use multiple computers in some way cross checking one another and these are sometimes known as 'multi-lane' or 'multi-channel' safe computing platforms.

Why this article?

The motivation for producing this article was a letter to the IRSE News regarding an ITC article on human factors and automation that in part examined the circumstances leading to the two well publicised fatal Boeing 737 MAX crashes. The part played in those disasters by the Manoeuvring Characteristics Augmentation System (MCAS) has become infamous and the letter contended that the crashes would not have happened had the 2oo3 architecture of the Solid State Interlocking (SSI) been used.

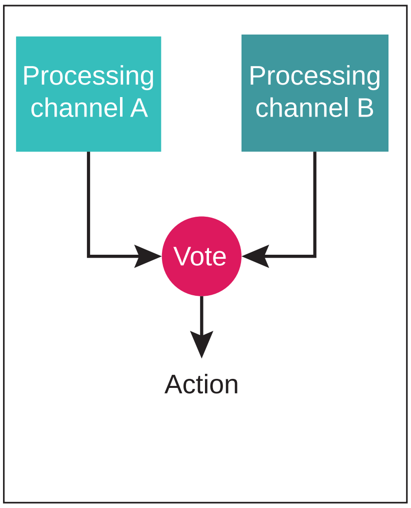
But in common with all modern commercial aircraft the Boeing 737 already uses a sophisticated multi-lane control system. So that was not the issue. The 737 MAX is (in part) an example of the problem of using a single data source or input without the appropriate integrity and/or suitable failure management arrangements.

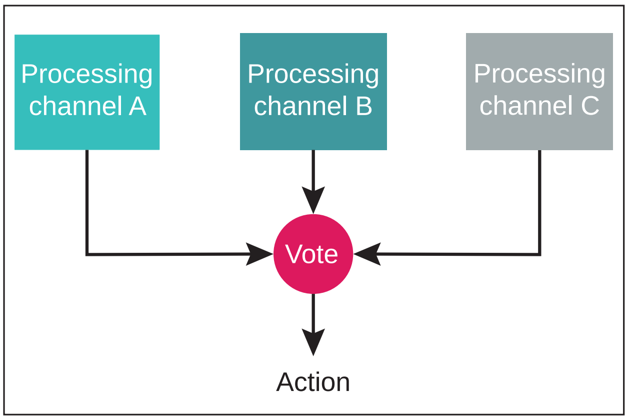
The use of such multi-lane architectures does not guarantee safety or availability without a lot of other things also being correctly put in place. There are a number of 'pitfalls', sometimes quite subtle in nature, that can result in such systems failing to deliver these design objectives. In this article we try to explore some of those, based on real problems experienced by ITC members.

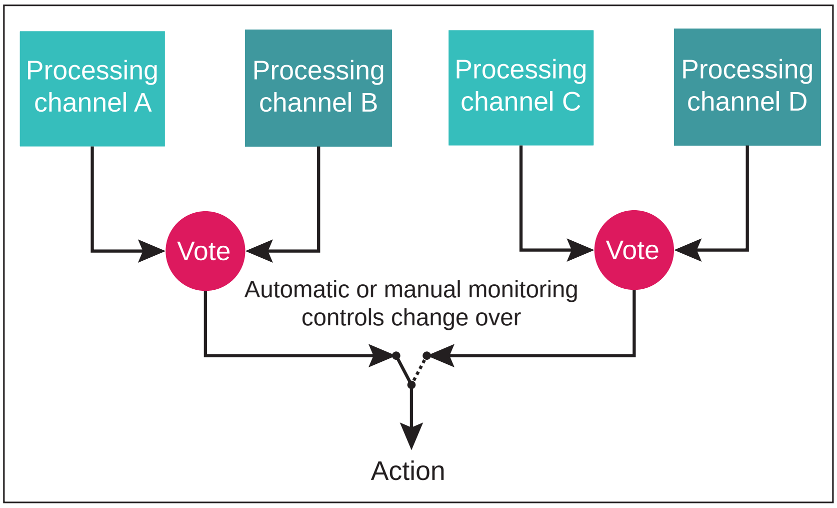
Commonly used architectures:

Two out of two (2oo2)

This is one of the simplest architectures and was one of the first used. Two computers, or more commonly micro-computers, each monitor what the other is doing and execute a safe shut down if they disagree. Clearly if the same software is run on both computers this may not protect against systematic errors unless other measures are taken. Different software can be run, known as diverse coding, but that adds cost and with complex functionality presents an additional reliability hazard if code mismatches occur. With diverse coding it can be particularly difficult to maintain synchronism in terms of timing, particularly if action/decision times need to be maintained to tight margins; timing differences can be interpreted as errors, but too much buffer time may allow unsafe errors to 'slip through'. The use of different operating systems and maybe compilers is possible and is used, although again this is not risk free in terms of timing







The three most commonly used architectures for safe software systems.
Clockwise from top left:
Two out of two (2oo2).
Two out of three (2oo3).
Two times two out of two (2x2oo2).

issues. Nonetheless 2oo2 architectures have been used and may be the best solution under some circumstances.

This architecture was the first used by the author for a defence product application where the duty cycle was up to 10 years of unpowered storage followed by power up, a maximum of 17 seconds immediate safety critical use, then being thrown away. No time for any error correction, recovery or switch over so this was the most appropriate solution for that application.

Two out of three (2oo3)

This has been a popular solution in the rail industry for several years whilst computer hardware was relatively expensive. A third computer is added along with a high integrity system which looks for agreement between the three. If one of the computers disagrees with the others it is shut down in a secure way (sometimes by blowing its fuse) and the other two lanes continue to run the system. A flag is raised that the system needs maintenance and there is normally a safety related application condition that attention is needed within a given time. Again, running the same software in all three lanes requires significant effort to be spent on test, validation, and additional design measures to avoid common mode failures. Diverse coding for three lanes would be very expensive and have a very high risk of code mismatches and I am unaware of it ever having been attempted on a commercial scale. Management of the three lanes can be quite complex, particularly in terms of handling inputs, outputs, and derived data (data combination rules), with examples of some of the issues than can arise being given later.

There are variations on this theme; sometimes one 'lane' is allocated the 'master' role and performs some of the management functions. If the master lane disagrees with its two slaves (which agree) the master role gets handed over to another lane. The 'old' master is shut down or, given that many errors are software related, it may be re-booted and allowed to re-join later if it then agrees. This avoids the need for some external maintenance interventions but carries some other risks. In any three-lane system there must be a finite risk that one channel is correct and the other two wrong leading to the wrong lane being shut down and it needs to be demonstrated that the probability of that happening is in line with the target safety level required.

Two times two out of two (2x2oo2)

In this architecture two separate 2oo2 systems are used with one as a master and the other as a 'hot standby' slave. The hot standby system is not in active control but receives all the same inputs and commands and mirrors the master system. A management system monitors the performance of both systems and in the event of a failure of the master system hands control to the slave. This requires a change-over system of an integrity commensurate with the safety requirements of the main system. The faulty 2oo2 channel may be shut down and maintenance action indicated or, again, it may be re-booted and if it comes up healthy take on the slave role. In the latter case the fact that a shut-down occurred should still be recorded so that software bugs that cause even very rare shutdowns can be addressed in subsequent system revisions. This architecture has always been favoured by some

Boeing's 737 MAX has become one of the best-known examples of the outcome of using a single data source, transducer or sensor. In this case, the angle of attack sensors, seen on the forward fuselage in the right hand photo, were at issue.

manufacturers and is becoming increasingly popular now that hardware has become relatively much less costly because the change-over system is simpler to design and validate than the lane management needed for a 2oo3 system.

Other variations

Even more complex configurations have been used. For the space shuttle NASA used five computers, four in a redundant configuration with outputs voted on at the control actuators and with cross comparison between channels feeding a shut-down system for units that disagreed with the majority. Up to two failures could be tolerated and then the final two computers would revert to a 2oo2 system. The fifth computer contained a back-up flight software package written by a different contractor than the four in the redundant system, a form of diversity but without the mis-match error risk.

It is also not uncommon to find an additional 'no-SIL' computer within the overall configuration to handle some of the fault monitoring, housekeeping, and non-redundant aspects of communication.

On the other hand, when hardware was expensive there was a strong incentive to minimise it and that led to some innovative safety solutions in the rail industry based on a single processor. These have a single logic processor running relatively easy to understand ladder logic supplemented by external timers and diagnostic systems to minimise errors. These have been developed by several suppliers and have proven popular and quite robust, particularly for simpler layouts and lower traffic frequencies like predominantly freight railways, but as the focus of this paper is multi-lane systems they will not be considered further here.

Some common pitfalls with the potential to compromise safety

Using a single data source, transducer, or sensor

The 737 MAX is, at least in part, an example of this. If the data fed into each channel of a multi lane system is the same and wrong, then the wrong conclusion will be drawn/wrong output produced. Nothing in the architecture can prevent this if the single data source is the only input available. The safety analysis needs to cover the complete system and if the integrity of the input data cannot be assured to the required level then measures must be taken to correct that, by using or configuring a higher integrity source or implementing some form of 'data diversity'. Furthermore, the required integrity needs to be kept under constant review if application conditions or interfacing parts of the system change. A good example of this in the rail industry is track circuits, which normally provide a single source data input to interlockings and are designed to be 'fail-safe' and have a high integrity. Historically AC traction railway used simple DC track circuits, and DC railway used simple AC vane relays; but as more complex traction systems, such as chopper control and three phase AC drives with on-board power conversion, were introduced the integrity of these designs was compromised by conducted interference. In response more sophisticated audio frequency, and digitally encoded track circuit systems were introduced. Note also that most interlockings have additional protections, such as track circuit power supply monitoring and sequence proving to ensure the function of 'train vacancy proving' meets the required integrity.

The key thing is that the safety analysis must consider the whole system under all credible normal and failure conditions and all changes must be properly impact assessed; also, some standards contain specific requirements in these areas for particular configurations and those must, of course, also be respected.

In both 737 MAX crashes the initiating technical failure appears to have been a damaged or defective Angle of Attack (AoA) sensor. These sensors, as their name implies, measure the direction of the airflow over the nose of the aircraft. They have been there on every 737 but now they had an additional function, providing data to MCAS. The failed/mis-calibrated sensor provided incorrect data which led MCAS to believe the nose of the aircraft was rising up/too high so it tried to push it down as it had been designed to do; largely to make the 737 MAX feel the same as earlier models of the same aircraft. There is no indication that there was any kind of software failure or error within the control system, nor of any hardware failure other than the AoA sensor itself. The control system responded as designed to the input it was receiving. The failure was much more at the overall system design and integration level. It is inconceivable that a bird strike on, or other failure of, an AoA was not on the list of credible failures. The aircraft was fitted with two (redundant) AoA sensors each of which fed a multi-lane system on either side of the aircraft. But each system had a single sensor input and any change-over between the two systems depended on the pilots. An 'out of correspondence' alarm to warn the pilots that the data from the two sensors was inconsistent was an optional extra. The objective of making the aircraft feel the same as earlier models was in part to minimise the re-training required to fly the new type. MCAS was not considered a critical system so there was no simulator training provided on managing its failure – indeed before the first crash pilots seem to have had little knowledge of MCAS existence and functioning. So, it appears that there were failures in both the safety analysis and in the overall system safety management involving all three of the critical factors of people, processes, and equipment. The people were insufficiently informed about the system (there was a lack of transparency), the failure management processes seem to have been inadequate and poorly trained, and the equipment configuration at the system level introduced unnecessary risk in the form of hard to understand behaviour introduced by MCAS when the AoA sensor failed.

Thus, the multi-lane architecture could not help avoid the failure because of the use of a single source of data with no error checking. However, had the discrepancy between the two sensors fitted been indicated to the pilots, their responses might have been quite different and the accidents might have been avoided.

The real lessons must be about better whole system safety analysis and the need for pilot training not to be underestimated. With hindsight the changes were certainly not a minor evolution of the type.

Could such a failure have happened in the rail industry? Yes, absolutely. Generally, our processes have been robust enough to find such issues in testing rather than them leading to a catastrophic outcome, but they have happened because 'multi-lane' systems still require a great deal of surrounding discipline and rigour to ensure there are no critical failures.

Taking outputs from a single lane

Most multi-lane systems use some form of high integrity data combiner to produce the system outputs (effectively a high integrity 'AND' gate). However, there are ways in which this can be compromised.

One example I have encountered on a mainline rail project involved a 2oo3 system where one lane was used as the 'master'. The master lane alone generated certain output messages via a radio communication system, the argument being that the radio channel is non-failsafe and simplex so using the lane combiner is unnecessary and other safety protections need to be incorporated for the function(s) involved. The three-lane system concerned did not immediately shut down a lane if it disagreed, rather the lane management would hand the 'master' role to another lane and then attempt a 'reset' on the lane which was faulty or in disagreement with the others. This is an effective methodology for avoiding excessive shutdowns due to 'soft' faults caused by timing issues or minor software errors but as was demonstrated, is not without other risks. In the case concerned the conditions were met for the master to initiate an external event via the radio but before it could do so an unrelated error occurred which caused the lane control to shut it down and hand the master role to another lane. As it is fault initiated, even though the process is very quick, this means there is a small 'dead time' in the 'master' function. When the new 'master' took over, the external event conditions had passed, so it did not send the initiating signal (one could say that it assumed it had already happened).

Fortunately, the system level design had other failsafe measures which meant that whilst the external event occurred slightly outside of the required timing window it still occurred. There was an increase in risk, but it had no consequences in the incident where the issue was discovered. The design was subsequently changed to ensure that unless a confirmation signal was received back from the external object the initiate signal would be resent on each processing cycle.

Several lessons come from this.

Firstly, in any safety analysis timing is very important, beware of any 'dead periods' for a particular function, particularly those involving one off events, whilst other processes are being executed.

Secondly, using one processor of a multi lane system to perform any output function outside of the 'AND' lane combiner, even if the function is believed fail-safe in other ways, is unwise.

Thirdly, layered protection works and is always good practice provided it meets specified reliability requirements as well.

Requirements error

Most processes we use for safety validation check back to the requirements. Quite rightly, we want to know that any system does what is required, how else do we measure correct behaviour? That is why the process of validating the requirements is so important and should be conducted using the best experience and domain knowledge available. The best formal methods also use tools that convert requirements into a format where another part of the tools-suite can compare actual performance/outputs with those requirements in an 'across the V' validation process. Very powerful; but none of that will help if there is an error or errors in the requirements. For software that can mean not only the prime functional requirements but the derived requirements for the software which will include things like timings and details of the lane management and data handling (see the output example earlier). If software is being produced by a 'specialist' software contractor without specific domain knowledge and they are also producing those derived software requirements there is a risk of errors in the derived requirements resulting from misinterpretations of the prime functional requirements even if those requirements are validated and correct. So it is very important that derived requirements are verified by a team that includes people with both specific software competencies and domain knowledge.

I encountered this going wrong on a metro project when acting in a safety oversight role for the prime contractor. The signalling contractor had sub-contracted the software for a 2oo3 processing system to a highly competent contractor, but one without rail domain knowledge.

Despite extensive and rigorous laboratory testing, the use of validated tools and compilers and oversight by a competent Independent Safety Assessor (ISA), a safety critical error was discovered late in the on-track testing programme. The root cause was traced to a missing/incorrectly derived software (safety) requirement.

So why did the error get detected so late in the development process?

Firstly, those who wrote the derived requirements did not have specific railway domain knowledge against which to 'sense check' what they had done.

Secondly, the lower level testing was conducted to validate system performance against those derived requirements. Unsurprisingly, the software tested as error free against them.

So the lessons learned are:

Firstly: Requirements generation, validation, derivation, and verification should be a top down process based on the total system requirements and involving people with specific domain knowledge throughout.

Secondly: Whilst modelling and laboratory-based testing is important and valuable, whole system testing in the real environment remains an important part of the process. Testing should not only be conducted against the equipment level functional, non-functional and derived requirements (which as my friend Peter Sheppard says risks being 'success focused' testing) but should also include testing against the system level requirements and what is sometimes called 'break-it' testing i.e. tests with unusual and even what might be considered invalid combinations of conditions to see how the system responds. It is important to know not only that the system does what it should do, but also that it does not do what it should not do.

Thirdly: This was to some degree another instance of using a single data source. The data combination rules in the three-lane system took input data from a single lane and, whilst that looked all right for that single process taken in isolation other processes and issues led to that data being wrong/stale. The data combination rules need to be considered and analysed for reliability and safety assuming all credible faults and issues with the input data however it is generated whether from an external or internal source.

Fourthly: The data concerned was not credible when compared with the previous data point as to have produced it would have required the train to have defied the laws of physics. It is also good practice to include feasibility checks on the data in any software system of this type. If new data does not fall in a credible range, then it is obviously incorrect and should be rejected.

Adding further additional hardware and software to improve availability

On Monday March 18 2019 a well-publicised accident occurred on the Hong Kong MTR when two trains collided during the nighttime testing of a new signalling system.

The new system was a modified version of Thales well proven and mature Seltrac CBTC. The form of Seltrac familiar to most of us uses a 2oo3 central Vehicle Control Centre (VCC) with distributed 2oo2 Station Controllers (STC) commanding and reporting the status of the wayside objects to the VCC. For some projects in Asia, Thales implemented 'Zone Controllers', which for improved availability were originally 2oo3 but then migrated to a 2x2oo2 architecture using a primary and secondary 'hot standby'. Continuous communication between primary and secondary units enables seamless switchover between units in the event of failure. For the signalling system where the incident occurred the track was divided into two control zones with each zone having three 2oo2 zone controller computers: Primary (A); 'Hot' stand-by (B); and 'Warm' stand-by (C). This is not a configuration Thales had used before but was required by the client. The additional warm standby 'C' computer was intended to reduce recovery time during signalling failure incidents. This change over would not be seamless, requiring some operator intervention, but should be quick. The test on March 18 was for Operations staff to familiarise themselves with the operational procedures when computers A and B failed and the switch to computer C to control the signalling system should take place.

The addition of the warm standby computer required software changes during the development process. Software implementation errors were made when performing a change in 2017 that had been intended to avoid common mode failures in Computer C should there be a problem in Computers A and/or B. – i.e. to prevent errors being 'mirrored' in the warm standby (C) machine. This is not without risks (as was demonstrated) and conflict zone protection information was not accurately reflected in Computer C, which led to a collision.

The lessons from this are all about adding complexity and managing change. The addition of a third computer was purely intended to improve availability, or at least reduce downtime, it had nothing to do with safety. In attempting to avoid a common mode failure of the additional computer a safety issue was introduced that the existing mature system did not exhibit. The client has been highly critical of the contractor's software processes but I would question the wisdom of the original decision to use this particular way of improving availability by adding further complexity and complex interfaces rather than using alternative measures to deal with what are very rare failures of the underlying system. Once again it is demonstrated that parallel hardware alone does not guarantee safety (or availability), in fact it can have the opposite effect. Metros in Asia do achieve extremely high levels of availability, it is questionable whether they always do it cost effectively.

Additional issues affecting reliability

We use 2x2oo2 and 2oo3 systems to detect and safely manage random errors whilst still maintaining high levels of reliability/availability. Experience shows that many reliability

The March 2019 incident in Hong Kong offers a salutary reminder of the importance of considering how safety software operates. *Photos MTR Corporation.*

issues derive from supporting systems like power supplies and communications, although requirements issues can also play their part. Thus, the supporting sub-systems also must be carefully configured and analysed or we can end up not meeting the required availability. It is always worth remembering that when the signalling system fails completely, we end up moving people and trains using manual procedures that are generally far less safe than even a somewhat degraded technical system.

Some examples of 'real world' reliability issues

Interlocking power supply (with thanks to Jens Schulz)

An infrastructure manager took delivery of what it believed was a well-designed and specified, brand new interlocking type. An ITC member went to site to take some pictures for training purposes. The interlocking used different modules, built as a multi-channel 2oo3 system, but he noticed at the back of the rack that there were only 2 power inputs. Investigation revealed that one of them was used to feed the whole 2oo3 multi-channel computer system and the 2nd was used to feed the redundant cooling fans!

The interlocking system description and the safety case clearly stated that the power supply was an integral part of the 2oo3 system. The configuration used for the RAMS calculation bore no resemblance the system delivered.

After an 'interesting' discussion with the prime contractor new interlocking module sub racks were delivered, now with three power interfaces.

How did this happen? Company A got the contract and wrote top level requirements and the safety case, company B got a sub-contract to design the hardware for a "2oo3 computer sub-rack with a redundant power supply", company C got a second-tier sub-contract for the backplane and the wiring for a "redundant power supply". The cascaded (derived) requirements at the lower level were too simplistic. Tests were only done on the full system. The safety assessors just followed the paper trail, and the client did not undertake non-safety related tests to save time and money. An example of poor requirements management down the contract chain, reminiscent of the game of 'Chinese Whispers' with the information lost or distorted at each contractual interface. Luckily, it was spotted before what would have been an inevitable system shutdown. A mixture of poor requirements processes and poor contract management.

Another power supply related example: The same end client as above traditionally specifies extremely high RAM requirements. However, it does not make much sense to require a Mean Time Between Failures (MTBF) for a 'total interlocking' shutdown failure of about 50 years when the best available UPS on the market (2 independent power inputs, e.g. 50Hz + 16.7Hz, multiple redundant rectifiers and inverters) only provides an MTBF of 34 years. Asking for more at the system level will lead only to failure, deception or wasted money.

And a third: following an 'upgrade' on an older interlocking platform, based on 2oo2 and 2oo3 system configurations, the 2oo2 modules were replaced by a 2x2oo2 configuration to increase overall interlocking system availability. The change-over between the two 2oo2 systems required a manual initiation. Unfortunately, because part of the former installation was used the change-over system was powered from one channel so in the case of failure of that power system the second channel could not be started.

An ATP example

This is an example of another type of contracts and requirements error like that described earlier but for an on-board system. I was asked to conduct a critical project review on an ATP project which was failing to achieve customer acceptance on the grounds of not meeting the contractual requirement for MTBF. Critical examination of the data over a significant period of in service running, particularly after discounting incidents classified by the client as faults because they had caused operational disruption, despite the ATP having intervened as specified and designed (unfortunately not uncommon), and by any international benchmark the supplied (2x2oo2) ATP was performing exceptionally well, although the complete on-board system was falling short of the contract requirement. It transpired that as part of the in-country content requirements of the contract the single Visual Display Unit (VDU) used for the Driver Machine Interface (DMI) had been sub-contracted to a local supplier. The negotiated sub-contract reliability figure for the DMI (which the delivered item met, but only just) was such a significant percentage of the overall system reliability figure that the rest of the system would have needed to achieve several times better than 'best in class' to deliver it.

Interlocking shut down and system instability

This led to a 'yo-yo' effect of instability/oscillation on the dispatcher/signaller's terminal.

2oo3 computer systems must exchange their inputs, using internal connections, to maintain synchronism and as part of avoiding failures due to single source inputs as described above. That means computer 1 exchanges data with computer 2, 2 with 3 and 1 with 3. Quite often diverse I/O boards are used to execute this. Any inconsistencies lead (directly) to a

Of course rail and aerospace are not unique in facing the challenges of maintaining safety in software based systems. Other transport modes like autonomous vehicles face similar issues, as do nuclear power plants, defence systems and medical electronics have similar issues to face. *Photos Shutterstock/ Metamorworks and Vadym Stock.*

It is unreasonable to expect even the most highly educated and skilful maintainer to diagnose complex faults resulting from multi-lane software failures in every situation, least of all under pressure to restore service to a busy railway line. *Photo Shutterstock/Godzilla Majing.*

voter/decision logic driven safety reaction. The results of the calculations are checked in the same way, often using the same I/O boards. Another, possibly parallel, process manages transmission of the final calculations to the target systems.

There are many different system layouts and transmission protocols. The 2oo3 system referred to uses two independent transmission channels for availability reasons. Each of the transmission channels transmits data from two truly independent computers, selected (after the successful voting) for the transmission. Note, that for safety information, it is good practice to transmit a "normally coded telegram" from one computer, followed by an "anti-valent coded telegram" from the other. In other words, a vital interlocking message consist of two telegrams with anti-valent coding. To save calculation time, both selected computers transmit the same information onto the redundant transmission channel, but in the opposite sequence. E.g. if computer 1 and 3 are selected, computer 1 sends on transmission channel one a "normal coded telegram" (some bytes only), then computer 3 send its "anti-valent coded telegram". At the same time computer 3 sends to the redundant transmission channel its "anti-valent coded telegram", then computer 1 follows with its "normal coded telegram".

Note: If the transmission to one of the two transmission channels fails, the target system just uses the data of the successful transmission. Data from the "faulty channel" will be ignored, but a failure message is created on both sides (and the system internal log is updated). Depending on the type of failure the "faulty transmission channel" may be shut down or forced to restart. In the best case the signaller and maintainer get a prompt, something like "Interface x, transmission channel 1 or 2 is defective". It is then possible that the failure will disappear if an automatic restart of the affected transmission channel is done successfully.

Many people believed that the system concerned worked perfectly – until one day when one of our ITC members was 'on duty' for first line support:

The local maintenance staff, responsible for the interlocking reported a "periodic 'yo-yo' system reaction on the signaller/dispatcher's screen", rail operation was stopped over approx. 100km of line. The interlocking screens were sometimes showing a "red flashing picture" (which means there is no interlocking status available), and sometimes "actual pictures but not vital ones" (which means that the safety indicator was red – the displays concerned are on a SIL4 control desk), then for a short period "actual and vital (correct) pictures", followed again by "non-vital ones", then "red flashing" again on a repeating cycle.

After around two hours on the phone without locating the fault our intrepid member made his way to as close as he could get by train (but by then an operational nightmare was unfolding with many trains at a stand) and was then picked up by maintenance staff and taken to the interlocking room.

The fault was then fixed within a few minutes, using the diagnostic monitors directly connected to the three multi-lane-computers. To find the failure it was only necessary to re-start the failure logging related to diagnostic functions simultaneously on all the computers of the multi-channel computer of the central interlocking module (a two-person operation). All the computers of the 2oo3 system reported transmission failures (e.g. transmission telegram stop-bit errors, which are very common but not "mission critical") but only computer 2 displayed many byte failures, some of them "3 times in a row" which should lead the affected computer to trigger a restart of the affected transmission channel. Computer 2 was then stopped manually (2oo3 -> 2oo2) and the system restored.

So what happened?

The internal computer to computer data exchange was working correctly, therefore no computer was forced to stop. The multi-lane computers of the affected interlocking module switched after a defined amount of time the duties of the transmission channels (for example once a minute). This function was also working correctly. When computer 1 and 3 were "on duty", the operating system got all the necessary data and provided actual and vital pictures (white safety indicators). A minute later computer 1 and 2 took over control of the transmission channels. Because computer 2 was producing too many transmission failures, the affected transmission channel was declared as "disturbed". In that case the interlocking operating system displays actual, but non vital pictures (red safety indicator). The module and the operation system used data from the redundant transmission channel and triggered a restart of the "faulty channel". Then the same thing happened on the second part of the telegram and the 2nd transmission channel was also forced to restart, which takes some time....in the worst case more time than the maximum accepted by the interlocking operating system, which then set all the monitors to "not actual (unavailable)" (red flashing).

In the meantime, the process responsible for the transmission channel allocation shifted that task to computer 3 and 1. Both transmission channels were then successfully restarted within a few seconds. Now another failure source appeared: after both channels of an interface fail simultaneously it is necessary to re-load the whole interlocking element/segment related status data due to basic safety constraints (it is a Safety Related Application Condition – SRAC). In an interlocking of that type (and time) depending on the number of controlled field elements this takes from 30sec up to 2 min. That means there is a rather good chance that computer 2 is "again active" shortly before the general data transmission was accomplished or even a short time later. Hence the long term 'yo-yo' effect observed by the operators. To expect local maintenance staff, however well trained, to diagnose such a complex fault is optimistic to say the least.

This type of failure is not limited to the specific interlocking type involved in the above event. Theoretically all 2oo2 or 2oo3 system configurations, using "full redundant" (that means not only "hot stand by") transmission channels can be affected if the internal timing is not coordinated between all the system functions. A reliability rather than a safety issue and a complex one but another example of the criticality of timings in these multi-computer, interactive systems. The interlocking concerned was quickly corrected and has now worked very reliably for many years .... that is good, but if it happened again would the maintenance teams remember?

Conclusion

Multi-lane computing platforms (2oo2, 2x2oo2 and 2oo3) are a powerful technique for avoiding random failures producing an unsafe condition in safety critical software driven systems. However, as well as using the appropriate software production and validation methods to avoid systematic failures, designers must be very careful to avoid re-introducing random failure modes by using single data sources, data combination rules that effectively produce a single data source, or outputs from a single lane of the system however protected that may appear. As always, it is essential to consider the system in its entirety in conducting requirements validation, safety analysis and safety validation.

As we see Neural Network, Artificial Intelligence and Machine Learning based systems coming into service in any safety role we will face a whole new set of related but different challenges in designing systems that are both safe and highly available.

Mukul Verma's letter in IRSE News (issue 266) very much supports and was almost an accidental 'trailer' for this article. Regarding his last paragraph it is worth repeating yet again that in safety it is always important that the whole system is considered in any assessment. The ITC has written much in these pages regarding Safety Integrity Levels (SILs) and we have repeated many times that these relate to functions NOT pieces of equipment. To quote IEC61508 (part 4, section 3.5.8 'Safety Integrity Level', NOTE 3): 'A safety integrity level (SIL) is not a property of a system, subsystem, element or component. The correct interpretation of the phrase "SIL n safety-related system" (where n is 1, 2, 3 or 4) is that the system is potentially capable of supporting safety functions with a safety integrity level up to n.' Each safety function must be analysed end to end including all input and output elements. There is no such thing as a 'SIL 4 Interlocking' only an Interlocking that supports SIL 4 functions if correctly installed and configured into a system with other components and sub-systems of the appropriate integrity. The CENELEC standards must be interpreted and implemented in that way.

If you have not already done so please also read Ian Mitchell's article in IRSE News issue 264 regarding the Cambrian ERTMS loss of temporary speed restrictions, which details how a single point software failure managed to exist undetected in what should have been a SIL 4 function. The ITC also strongly supports recommendation 3 of the investigation report into that incident, that the industry should capture and share safety learning regarding the failures that occur in these complex software-based systems. Hopefully this article contributes something towards that, but unfortunately commercial sensitivities have meant that some of the examples have had to be anonymised and disguised to avoid identification of the actual incident concerned, but be assured that all of the rail examples relate to real incidents known to ITC members.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

Czech ETCS

Czech Republic: The Ministry of Transport (MDCR) has approved the rollout of full ETCS for all Czech core Trans-European Network for Transport (TEN-T) lines by 2030. Currently, the lines use ETCS in a supervisory role in combination with the legacy LS signalling and control system.

The phasing will be: 2025 – the Děčín-Břeclav and Břeclav-Petrovice u Karviné main lines, as well as the Česká Třebová -Přerov branch line. 2026 – the Prague-České Budějovice -Horní Dvořiště line, and 2027 – the Prague-Plzeň-Cheb line.

Funding has also been approved to improve signalling on local lines, with some to incorporate elements of ETCS. The improvements are expected to be rolled out between 2022 and 2026.

The eventual implementation of ETCS is expected to cost around Koruna 84bn (£2.8bn, €3.1bn, $3.6bn) when the project is completed in 2040. A further Koruna 23bn is expected to be necessary to equip all rolling stock. The programme will be funded primarily through the European Commission's (EC) Connecting Europe Facility (CEF). The EC has also approved an additional €134m (£121m, $156m) of funding in February to support the installation of ETCS on rolling stock.

ATO freight train trial

Switzerland: An automatically operated freight train has successfully run on trial between Sierre and Sion using ATO over ETCS. The trial run was part of a pan-European research project backed by Shift2Rail, using a section of SBB's Rhône valley main line equipped for ETCS Level 2 operation. The train of seven freight wagons was hauled by a DB Cargo locomotive, which had been fitted with onboard ATO by AŽD Praha.

The demonstration is part of two Shift2Rail innovation programmes. Automated Rail Cargo Consortium (ARRC) led by DB Cargo, along with Bombardier and Siemens. They are also part of a Thales-led X2Rail-3 project, which is working to develop advanced signalling, automation, and communications technology.

A joint architecture and interface specification has been agreed between ARCC and X2Rail-3, defining how ATO over ETCS will support attended operation to GoA2. This uses standard interfaces in the central architecture which is intended to permit the use of onboard units from four suppliers: Alstom, AŽD Praha, Hitachi, and Siemens.

EU grant for Baden-Württemberg onboard ETCS installation

Germany: Baden-Württemberg State Rail Vehicle Authority (SFBW) has received a €16.7m (£15m, $20m) grant from the European Commission (EC) Connecting Europe Facility (CEF) for the installation of ETCS on 238 of its regional trains.

The grant will support ETCS installation on a new fleet of between 120 and 130 EMUs planned for delivery by 2025, as well as the retrofitting of the system on a fleet of 118 existing trains at a total cost of approximately €1.95bn (£1.8bn, $2.3bn). The rolling stock upgrades are expected to be completed to coincide with the launch of the €462.5m (£417m, $540m) Stuttgart "digitalised rail hub" project in 2025, which will equip around 100km of track in the Stuttgart metropolitan area with ETCS and ATO systems.

Ferrybridge to Goole resignalling

England: Network Rail has awarded a contract to Alstom for the resignalling of the Ferrybridge to Goole line for Network Rail's Eastern region. Starting in 2021, the project scope will include renewal of six level crossings, including point machine conversions and civil engineering works and will be commissioned in the summer of 2023. As part of the £28m (€31m, $36m) contract, Alstom will carry out two work packages – in Ferrybridge and in Goole – to improve the reliability, safety, and efficiency of the Ferrybridge to Goole line.

Driver training for ETCS for East Coast Digital Programme

UK: 3Squared and Rail Professional Development (RPD) Inspire will deliver a number of training solutions for the East Coast Digital Programme through London North Eastern Railway (LNER) and Govia Thameslink Railway (GTR).

3Squared will provide the digital solutions and RPD Inspire the operational and driver training expertise to support the development of familiarisation and training of drivers.

3Squared has worked in mainland Europe, supporting operators and standards teams as drivers, crew and ground staff are transitioned to ETCS. RPD Inspire have worked on the development of ETCS national driver training strategy with Network Rail's People Capability Team and ETCS implementation with MTR Elizabeth Line, Great Western Railway and GTR.

ETCS onboard testing

Norway: A trial with the first diesel locomotive to be equipped with Alstom's latest ETCS onboard equipment has begun as part of the national ERTMS programme. A Class Di8 diesel locomotive has been fitted with train control systems to the latest Baseline 3 Release 2 specifications.

The trial will prove the compatibility of the onboard systems with earlier generations of the ETCS trackside specifications, which meet the Baseline 2 and Baseline 3 Release 1 standards.

Alstom is providing all the onboard equipment for the national ERTMS programme, under a framework contract negotiated by Bane NOR on behalf of the 14 participating railway vehicle owners. The installation work will be undertaken at a depot adjacent to the Nyland campus, which will cover 467 trains of 55 different types. This is due to begin in 2021, ready for the start of commercial service in 2022, and is expected to be completed by 2026.

LGV Sud Est improvements

France: The 409km LGV Sud Est high-speed line between Paris and Lyon is being upgraded by SNCF Network. The scope includes providing the high-speed line with ETCS to replace the original TVM cab signalling system by 2025 and help to increase line capacity from 13 to 16 trains per hour.

The ETCS work is being delivered by Alstom, Setec, Vinci, Hitachi Rail STS France, Eiffage and Systra at a cost of €700m (£632m, $817m) of which €125m (£113m, $146m) is funded by the European Union.

Presidential support for rail

USA: Amtrak was one of the first organisations to welcome the news that Joe Biden had won the US presidential election. They say Biden has been a strong passenger rail advocate throughout his five decades in politics, earning him the affectionate nickname 'Amtrak Joe'. He has been a near daily commuter for many years between his home in Wilmington, Delaware, and Washington DC using Amtrak's Northeast Corridor inter-city services.

Amtrak has been hard hit by the pandemic, cutting service frequency on many routes, leading to concern among some that its network of long-distance routes across the country may never be fully restored. Amtrak had been a target for large budget cuts under the Trump administration, which had also hindered progress on major infrastructure projects that would benefit the operator, notably the Gateway Programme to build more tunnels between New York City and New Jersey.

Amtrak say "expanded Amtrak service is essential to decarbonising the transportation network, which generates roughly 28 per cent of the US annual carbon emissions. With cars and trucks responsible for nearly 82 per cent of those emissions, we need passenger rail alternatives throughout the nation".

City railways and light rail

Istanbul driverless metro

Turkey: Metro Istanbul has commenced passenger service on the first stage of line M7 and is the first driverless metro line to open on the European side of the city. Running from Mecidiyeköy to Mahmutbey, the first phase of line M7 is 18km long, with 15 stations and an end-to-end journey time of 32 min. Bombardier Transportation has supplied its Cityflo 650 CBTC to operate the system.

With a capacity to handle up to 70 000 passengers an hour it is predicted to carry around 3 million passengers a year. Work is underway on a 6.5km, four-station extension from Mecidiyeköy to the Kabataş ferry terminal on the Bosporus and a western extension is also planned.

Communication and radio

Fifth Generation Fixed Network (F5G)

Europe: ETSI (European Telecommunications Standards Institute) has released a White Paper for the evolution of fixed access, and aggregation telecoms networks called "Fifth Generation Fixed Network (F5G): Bringing Fibre to Everywhere and Everything".

ETSI says fibre networks are the foundation of society and industry, providing sustainable and cost-efficient communication with high bandwidth, stability, reliability and reduced latency, enabling a sustainable economic growth through advanced services and applications. Next generation fixed networks are essential for complementing and supporting the 5G/Wi-Fi 6 wireless networks being deployed across the world, that would be hardly viable without F5G, as well as supporting the growing number of cloud services that require high bandwidth and/or low latency connections. Building on previous generations, F5G is being designed to bring unprecedented benefits to fixed networks and communications.

Key points in the White Paper include:

- A status on the evolution of on-premise, fixed access, and aggregation networks.
- How ETSI F5G allows a closer coordination between these networks that can be regarded as a single extensive optical network.
- A general description of the main characteristics of ISG F5G, enabling use cases such as Cloud VR, Cloud Desktop, Cloud-enterprise, online gaming, online education, online medicine, Smart home, Smart factory, and Smart city, and the support for the evolution of 5G networks.
- The main features of F5G as Enhanced Fixed Broadband (eFBB), Full-Fibre Connection (FFC) and Guaranteed Reliable Experience (GRE).

The White Paper can be found at irse.info/tw7xz.

New DECT standard

Europe: Digital Enhanced Cordless Telecommunications (DECT) is the ETSI standard for short-range cordless communications, used for many license exempt frequency applications around the world. It is suited to voice (including PSTN and VoIP telephony), data and networking applications up to 500m in range.

DECT-2020 is the latest development, providing very reliable radio transmission supporting advanced channel coding, high-rate forward error correction (FEC) and automatic repeat request (ARQ) error-control, for fast re-transmission. The applications include, but are not limited to, cordless telephony, audio streaming, public address, data for consumer and of Internet of Things (IoT) applications such equipment automation and monitoring, and in general solutions for local area deployments of Ultra-Reliable Low Latency (URLLC) and massive Machine Type Communication (mMTC). See irse.info/6mov3.

5.9GHz for real-time road and urban rail transport safety information exchange

Europe: The European Commission (EC) has adopted an implementing decision to improve safety of road and urban rail transport. This harmonises the use of the 5.9GHz band for real-time information exchange on safety conditions for connected transport.

The decision is to enable real-time information exchange about safety conditions in intelligent road and urban rail systems, such as tramways, metros and suburban lines. The new implementing decision doubles the available spectrum for safety-related Intelligent Transport Systems (ITS).

The EC say the 5.9GHz band for ITS is a key step in reinforcing road and urban-rail safety in Europe, and will play a crucial role in meeting the goals set in the EU road safety policy framework 2021-2030, including a 50 per cent reduction target for casualties and for serious injuries.

"Connected and automated transport is among the new, revolutionary services that 5G connectivity will fully enable. The EC recently published a Connectivity Recommendation to encourage and guide Member States in pursuing best practices for a faster rollout of 5G."

Consequences of a ban of Chinese suppliers for 5G deployment

Europe: The European Competitive Telecommunications Association (ECTA), is the pan-European pro-competitive trade association that represents more than 100 telecoms operators and digital solutions providers across Europe. ETCA have denounced any bans of Chinese 5G suppliers for geopolitical reasons and emphasises that such decisions can only be justified based on well-established facts. They say the 5G Toolbox™ provides standard-compliant functions for the modelling, simulation, and verification of 5G New Radio (NR) communications, and will provide a suitable EU framework for responding to any security issues affecting the networks of the future, while respecting European and national sovereignty.

ECTA and its members say a reduction in the number of worldwide suppliers from five to three will increase costs, negatively impact performance, delay the deployment of 5G networks and constrain innovation potential. Their key message is that competition is the best driver of efficient investments and the greatest enabler of innovation, choice and benefits for citizens and businesses, as well as for the European economy overall.

5G first peak speed of 5.06 Gbps

USA: Verizon, Ericsson and Qualcomm Technologies are believed to be the first in the world to demonstrate 5G peak speeds of 5.06Gbps. This has been achieved using 5G mmWave spectrum with carrier aggregation. This combines multiple channels of spectrum to provide greater efficiency for data sessions transmitting over wireless. Eight separate channels of spectrum were used to achieve the 5.06Gbps.

The demonstration was completed in a lab environment and was delivered using 800MHz bandwidth in the 28GHz spectrum, combined with 40MHz 4G LTE spectrum. The demonstrators say 5G has the potential of reaching speeds up to 10Gbps, with latency under 5 milliseconds. It will enable mobile connections to happen at up to 500km/h with the ability to manage over a million devices per km^2 and data volumes of $10Tb/s/km^2$. While the 500km/h is great for rail, 28GHz and 40MHz will require many access points.

Big data and information

Northern Trains to introduce real-time train information for passengers

UK/England: A system known as 'Know Your Train' will allow Northern Trains passengers to find out a wide range of information about the train that they will be travelling on in real-time. Northern has teamed up with web based Realtime Trains to provide its customers live information about its trains.

"Know Your Train" will allow Northern customers to find out, in real time, what model of train they will be catching, how many carriages it has and what facilities will be on board – including whether the train has at-seat power/USB sockets.

Northern say they operate 17 different types of train and have more than 370 trains running across our network. It can, therefore, be quite confusing for customers who may not know which train is going to operate their service. Know Your Trains is available via the Realtime Trains website, while customers can also find information about their trains via the free mobile app.

Research & Development and Universities

5G based autonomous train-to-train communication control system

South Korea: Korea Railroad Research Institute (KRRI) say they have successful tested a 5G-based autonomous train control system at its dedicated test track in Osong.

Working with SK Telecom for a number of years, they describe this as the world's first smart train control system using 5G communications through a public-private partnership. The testing with two vehicles started in April and the nine-year autonomous train development programme is being undertaken as a Big Issue Group project backed by the National Science and Technology Research Council of the Ministry of Science & ICT. The total cost of the project is estimated at 33.1bn won (£22m, €25m, $29m) and will run to 2024.

KRRI is implementing a distributed control method, with each train determining its own performance profile based on direct train-to-train communication and position reporting. It believes this could reduce the amount of lineside signalling equipment by up to 30 per cent. KRRI says the use of 5G communications helps to reduce the transmission delay between trains, with improved data transmission capacity and reliability compared to GSM-R. It estimates that the use of train-to-train communications could reduce headways by up to 30 per cent, to a minimum of around 60 seconds.

Government, industry and economy

Rail to help drive infrastructure-led recovery in Australia

Australia: The Australasian Railway Association (ARA) say rail will be an essential part of Australia's infrastructure-led recovery after the Federal Budget confirmed key rail projects would be funded as part of stimulus measures.

$528m (£268m, €318m, US$371m) for regional rail upgrades in Victoria and $102.3m (£56m, €62m, US$72m) for METRONET high capacity signalling in Western Australia were among the new funding commitments in the 2020-21 budget, along with $15m (£8m, €9m, US$11m) for Sydney to Newcastle faster rail planning and $4m (£2.1m, €2.4m, US$2.8m) for investigation of a Perth to Bunbury faster rail corridor. Planning and business cases include $30m (£16.2m, €18m, US$21m) for Western Rail Plan planning in Victoria, $7.5m (£4m, €4.5m, US$5.3m) for improving connectivity to the Port of Melbourne business case and $5m (£2.7m, €3m, US$3.5m) for Kenwick Intermodal Terminal planning.

The paper sets out five foundations to deliver a net zero recovery. It says the government:

- Must ensure that recovery packages work together as a whole to pivot the UK towards a net zero economy.
- Spending on new infrastructure must avoid the trap of high carbon construction methods and lay the foundations for a future net zero infrastructure system including minimising the need for future retrofitting, by basing spending choices on outcomes and including whole-life carbon evaluation.
- Should drive digital transformation as an essential enabler of net zero and resilience.
- Must increase the UK's technical capability to deliver net zero by creating a national workforce planning strategy and implementing proactive policies on diversity and inclusion in employment and training that will help reverse the impact of COVID-19 on employment opportunities for women and people from Black, Asian and minority ethnic backgrounds.
- Should deploy a cross-sectoral systems approach to policymaking that accounts for the impact that transforming one part of the economy or national infrastructure will have on the others.

UK government investment too low to achieve net zero recovery

UK: A new report from the National Engineering Policy Centre calls for greater investment in net zero capacity and digital transformation, and national workforce planning strategy to increase technical capability. The report says there is a large gap between UK government funding commitments and the true scale of changes required for a net zero economic recovery from COVID-19. The policy centre represents 43 UK engineering organisations with a combined membership of nearly half a million engineers.

It calls on the UK government to step up the level of investment it is prepared to make in clean growth to match that of other nations such as Germany and the Republic of Ireland, to maintain international competitiveness, and build on the UK's strengths and capabilities in clean technologies.

2020 Rail Technical Strategy

UK: An updated version of the Rail Technical Strategy (RTS) originally published in 2012 has been launched to provide a vision for the development and deployment of technology in rail. The strategy has been developed by a cross-industry group including RSSB, Network Rail and the UKRRIN research and innovation community. It includes input from more than 130 organisations and cross-industry groups including the Rail Delivery Group and the Railway Industry Association.

It describes a vision of how the UK railway might look in 2025 and 2040, and a series of 'stepping stones' which will inform the research and development priorities for the next five years. It is built around five 'functional priorities', these being: 1. Easy to use for all. 2. Low emissions. 3. Optimised train operations. 4. Reliable and easy to maintain, and 5. Data driven.

As well as setting priorities for the use of existing research funding, and establishing pathways for development through a series of Rail Industry Readiness Levels, the strategy is looking to harness research beyond the transport sector which might be applicable to rail.

Companies and products

5G for driverless vehicle development

UK: HORIBA MIRA (formally the government funded, Motor Industry Research Association) and one of the world's most advanced set of facilities for developing self-driving vehicles, is installing a Vodafone 5G mobile private network at the company's Nuneaton site.

This will be used in the development of driverless technologies as well as the use of artificial intelligence for unmanned ground vehicles in the defence sector. HORIBA MIRA say the 5G communications will be used by car makers, self-driving disruptors and their suppliers, to develop driverless technologies through new forms of engineering, testing, verification and validation.

Vodafone say the latest 5G technology offers ultrafast data speeds, allowing vehicles to communicate with each other and the surrounding infrastructure – including traffic signals – in near-real time. By communicating with other vehicles, they can react much quicker to fast-evolving emergency situations, form co-operative groups of vehicles for more efficient delivery of goods, and improve air quality through better route planning and more efficient operation.

It will be interesting to see if any of the MIRA developments can be transferred to rail for autonomous train operation and traffic management purposes.

CRRC fully automatic signalling system

China: CRRC Zhuzhou Institute has released a fully automatic signalling system with more than 20 additional functions including train start-up, dynamic and static self-testing, obstacle and derailment protection, and remote reset. CRRC say it is an upgrade to their CBTC system.

The system is compatible with conventional CBTC and provides several benefits including enhanced operational flexibility, improved capacity, reduced labour requirements, and reduced energy requirements and emissions.

CRRC says the automatic operation supports adjustable departure times as well as 24 hour operation, seven days a week, and reduce human errors, stopping times and headways, along with improved energy efficiency by controlling the power supply and to improve the use of regenerative power.

Signal supplier removes 13km of plastic packaging a year

UK: Unipart Dorman, a supplier of LED railway signals, has announced the removal of plastic packaging from their signal heads equating to 13km of plastic a year. They began by designing plastic-free packaging for their North American Wayside Signals, then made a similar change to their UK signal packaging, with an even greater impact.

Unipart Dorman said they already packed their products with shredded used cardboard boxes – which is both re-use and recyclable/biodegradable, and were actively looking at further ways to reduce environmental impact. Working with customers they assessed the packaging of signals and realised plastic could be removed completely without any effect on the product's performance.

They are pleased that so much could be saved with just one small activity and are now looking at other ways single use plastics can be reduced or removed completely from their manufacturing process.

Prototype Assisted Remote Shunting (ARS)

Switzerland: Knorr-Bremse Rail Vehicle Systems is providing a prototype Assisted Remote Shunting (ARS) obstacle detection system, developed by Rail Vision for SBB Cargo. Knorr-Bremse and Israeli based Rail Vision have been partners in obstacle detection technology for rail vehicles since March 2019, when Knorr-Bremse acquired a 21.3 per cent share of Rail Vision.

ARS is designed to enable a single person to control a shunting locomotive from a remote location, rather than requiring a driver and someone outside to watch for obstacles and monitor the distance to wagons. The system uses electro-optic sensors combined with artificial intelligence and deep learning technology to detect and classify obstacles, providing drivers, remote operators, and control centres with real-time alerts. It also monitors turnouts and recognises signals up to 200m ahead.

If testing is successful, Rail Vision could supply up to 30 ARS units worth up to €2.8m (£2.5m, $3.3m), with options for an additional 45. Dr Nicolas Lange, chairman of Knorr-Bremse, said the system could be "a building block in realising the future scenario of automatic train operation".

Power-free IoT devices

UK: Arm Ltd, the British semiconductor, processors and software design company, which is being acquired by NVIDIA of the US, is examining alternative power sources for Internet of Things (IoT) and the possibility of making billions of devices that do not need battery power.

Project Triffid is an ultra-low power microprocessor that requires such a tiny amount of power that it can be activated by an RFID scan, which remains active until the power dissipates. This can be as long as a minute or as short as a few microseconds and enough time to generate a data identification. The device has embedded non-volatile memory, so the last action taken by the device remains intact and is revived the next time the microprocessor is powered-up. Such attributes have obvious uses in IoT for logistics and other reporting applications.

Another innovative is Project Morello. Funded by the UK government, this aims to radically change the design of CPU architecture and the programming of highly robust microprocessors which enable vastly-enhanced built-in security.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, Shift2Rail, Railway-Technology and TelecomTV News.

News from the IRSE

Blane Judd, Chief Executive

Under normal circumstances I would open this January message with the traditional "Happy New Year" but instead I am saying "Here's to a hopeful New Year". Please note our (virtual) office is closed for staff Christmas annual leave until the morning of 5 January.

At the time of writing good news is emerging regarding vaccines, and we are seeing a glimmer of light at the end of the pandemic tunnel, although realistically I don't expect things to return to anywhere near 'normal' for us until much later this year or even into 2022.

Last year presented the world with huge challenges, but also made us seek innovative solutions and new ways of working many of which have enhanced our services provided to the membership. Here at the IRSE our London HQ remains closed with the head office team still working from our homes, although we are now able to access the building to collect post. We hope we may be able to return to Birdcage Walk in a limited way in late spring, but of course that is all dependent on the science and government guidance. I'd like to repeat my praise and gratitude to our small hard-working team and also ask that you continue to bear with us.

New phone system

We now have a new VOIP (voice-over internet protocol) telephone system that enables HQ staff to make and receive phone calls through our Microsoft Teams desktop application wherever they are based. The system will deliver significant savings in call charges for the IRSE and has far more features. Staff direct dial numbers remain unchanged.

Examination update

All candidates who sat modules 1 and 3-7 last October will receive their results by the middle of this month or sooner if possible. For those candidates who had signed up to sit module 2, 'signalling the layout', the Education and Professional Development committee and head office are still working on a solution for you to sit the final module 2 paper in 2021.

Presidential Papers and Local Section lectures

Following on from the enhanced digital service introduced last year, all presidential papers in 2021 will be presented via GoToWebinar for members across the world to watch live and take part in the following Q & A session or watch later on demand. Local sections should be congratulated for the way in which they put their comms skills to good use, quickly adapting to the 'new normal' to hold meetings online increasing attendance as a result! Section lectures that have been recorded are also available to watch on demand via the 'Get Involved' section of IRSE.org giving the wider membership access to these most interesting sessions for the first time.

A helpful guide by Trevor Foulkes and Paul Darlington on "how to run a virtual section meeting" has been produced and will be circulated to all sections soon.

Governance of the Institution

A working party has been set up to review the governance of the IRSE (GRWP). Here Andy Knight, junior vice president and chair of the working party answers some key questions.

What is governance?

There are many definitions of this, but we also must put it into context regarding the IRSE.

I found a good definition via Google.

"Good governance is at the heart of any successful business. It is essential for a company or organisation to achieve its objectives and drive improvement, as well as maintain legal and ethical standing in the eyes of shareholders, regulators and the wider community". (Google)

"Corporate governance is the system by which companies are directed and controlled; boards of directors are responsible for the governance of their companies." and/or

"Corporate governance is therefore about what the board of a company does and how it sets the values of the company. It is to be distinguished from the day to day operational management of the company."

If we refer to this and look at how we need to manage our organisation it helps us to appreciate that we have to be assured we are taking an ethical approach as to how we run the Institution and recognise the needs of our organisation with regard to our members and the wider audience and stakeholders.

We should always remember we are trying to advance the science of railway signalling and communications within a global audience and this involves trying to influence and contribute to many authorities around the globe. They all have different rules and regulations, but the link of command and control systems is universal.

The way in which we operate and provide support to this arena provides many challenges to the Institution's governance. How we manage our organisation is a vital part of how we can be perceived and ultimately will affect our possible influence.

We should be aware of our structure and, in simple terms, we have two elements to the Institution from an organisational point of view. We have the IRSE Enterprises Board and the IRSE Council. The intention (or purpose) of this is that we have a business element (enterprises) and a charity element (IRSE). The latter means we must adhere to charity guidelines, good practice and ultimately have a duty to the UK Charity

Shutterstock/Photon photo.

Commission. Within their guidelines are examples of 'good governance'. Therefore, we need to ensure we are in line and up to date with these guidelines.

Everything we do in the IRSE is affected by 'governance' in its literal meaning. This involves how we inform and communicate with our membership, how we select members of Council within the election process to ensure we have a measured representation across the membership, to specifying how we operate on a daily basis, to reporting our accounts and selecting a president. The remit and scope of 'governance' is wide ranging and perhaps could be described as good judgement and behaviour.

Why does it need to be reviewed?

As in any field, you can only confirm that your business/organisation is in good shape if you put a structure in place that reviews your practices and procedures on a regular basis. If this is done to a reasonable schedule you can ensure you are up to date with current practice and can adapt within a reasonable timescale. It also demonstrates you are carrying out 'good governance' of the IRSE and ensuring we endeavour to meet our objectives and our strategic plan.

The original governance documents were drafted in 1912 and a lot has changed since then. Although there have been some minor changes to them over time, we were finding that things are being done differently and are not reflected in our current governance documents. One of the biggest changes is the growth of our international members. 50 per cent of our members are from outside the UK and it is important that the Institution allows all its members to be involved in how it is run. Simple developments like online meetings and election processes need to reflect today's Institution, which is far more digitally focused than it ever could have been in 1912. It is like comparing today's signalling technology with that of the last century, or perhaps not!

The amount of activity the presidential team (comprising the junior vice president, senior vice president, president and immediate past president) is engaged in has increased as we grow our technical presentation offerings and so we are exploring ways we can share the load and still offer a high quality programme of technical events.

Who is on the working party and how long has the process taken?

When the Council decided to form a working group on the subject of reviewing the Memorandum and Articles (M&As) of both Enterprise Board and the IRSE it was felt this was a good project for the junior vice president (JVP) to chair as part of the presidential development path.

The group was formed and includes members from the senior team within Council (Management Committee) and the CEO. It was also felt early on that another member from the Council would be a good addition, so this was acted upon following our first meeting. The group therefore consists of Andy Knight (chairman and JVP), Ian Bridges (senior vice president (SVP), Steve Boshier, Rob Cooke, Paul McSharry and Blane Judd (secretary and CEO).

We have also asked Colin Porter to act as a reviewer of our completed documents. Colin brings a vast amount of experience and skills from his previous roles (past president and CEO of the IRSE) and he has been involved in the review and amendments of the documents in the past. The group felt this would provide a good final approval of the documents before passing onto to Council and the wider membership for comment.

We were tasked with forming the group following the June 2020 Council meeting and the first meeting of the Governance Review Working Group (GRWG) was held in August. We have been meeting monthly since then and reported progress to Council in October 2020.

This entire process is anticipated to take some time to allow the review of the documents and the necessary editing of the relevant portions and, as with all reviews, will require to be ratified by Council. It is felt that some changes could be ready for consideration at the 2021 AGM.

However, if there are changes required to the election process, for example, that may take a little longer, we would not want to hinder the existing procedure. Therefore, the review and changes may need to be implemented through a two-stage process over the coming 12 months with the complete review taking us into the second half of 2022.

How did you approach the task?

When we discussed this issue at the June 2020 Council meeting it was agreed that the M&As of both Enterprises and the IRSE had not been reviewed for some time and it was felt we should assure ourselves of their suitability. There had been a few comments over the last couple of years about terms of office, workload, and procedures, which gave us a head start on what to look at first.

The initial approach was to ensure we looked at all the documents and any necessary guidelines that are in place to assist our review. We were able to use MS Teams as a platform to have video conferencing meetings and this has not only become our norm as an organisation but it also allows this group to align our meeting times with time-zones involved for the group members (UK, Australasia, Singapore & Canada). Therefore, we have held our meetings at 07.00hrs (UK time) to accommodate this but, as is the case with many other groups, the important issue is the amount of work that takes place in-between meetings. That is important and as chairman I am very grateful for the input of the group, which involves their own time and how they manage to balance this.

Following the review process, we found two clear issues that would benefit from a focused approach and would allow us to spread the workload. Therefore, we split into two sub-groups to focus on the following areas: -

- Review the language used in the documents and ensure we are in-line with modern practice and guidance.
- Examine the election process mandated at present to ensure we can achieve a good cross section of membership on Council.
- Ensure we can maintain a continuity of membership and knowledge within Council.

Some of the above issues were already part of discussions at Council and possibly one of the reasons for the review since, whilst we may wish to look at specific issues, we need to check our processes and make sure we align with our processes and once again this comes back to our approach to governance.

To ensure we could share our reviews and have a clear accessible place to keep documentation and track the review process Blane Judd set up a SharePoint site for the group (Microsoft). This allows all work being carried out to be jointly reviewed and feedback received as we advance the work. It also allows us to collaborate on work efficiently as well as having a clear tracking approach as we change things.

It became clear that we could attain a review of the Enterprise Board documents in a quicker timescale than the IRSE ones, and we have already started work with Tozers (IRSE solicitors) who have a clear skill set with regard to charity regulations. They have already provided an updated set of Articles for the Enterprise Board and these are being reviewed by the group. This has also allowed the group to focus on the IRSE documents that require more understanding of the internal workings of the Institution, which is the strength of the GRWG members. We will still require a final review of the IRSE documents to ensure that these are in line with the charity obligations applicable today and ensure we are consistent with the Enterprise Board documents.

What has been the most interesting aspect of this project for you?

As a member of Council I have had the opportunity to see the 'inner workings' of the Council and how we try to provide the membership with information and how we can best support the overall strategy. This has led to me being asked to be JVP, which is a very exciting activity in its own right but the individual element of this working group allows me to be part of a small group that could influence some positive changes in the organisation for the longer-term.

Also, by its nature, it has allowed me and members of the group to look at issues in more detail and quite rightly question, in some cases, how and why we do things. In any organisation this is a good thing so it will be rewarding and challenging to bring this back to Council and the membership.

What are the key outcomes?

I think the real headline here is we will have reviewed the key documents our organisation uses to 'govern' itself and quite rightly will be able to say we are aligned with modern best practice. It should also result in the Council being suitably stable to allow members to have an influence and input to the on-going development of the organisation as well as ensuring we have a good and fair representation on the Council, which will ultimately encourage people to consider being a member of Council.

Will changes be made to the Council?

I don't think there will be changes to the Council as such but the way in which we operate and select members may change and consequently the election process may be modified to reflect the objective of the wider representation on council. It will also ensure that how we operate and manage the business of the IRSE will be aligned with modern and up to date practices.

How will the review affect me as a member?

As a member the changes will be minimal, but once the review is complete, we will communicate the proposed changes and ensure we keep you up to date as we review the procedures and processes. This interview allows some of this to be achieved but it is envisaged that the IRSE News will be used as a conduit to keep you up to date with progress.

Ultimately, as a member, we need to ensure that you are part of a modern and well run organisation that meets the challenges of the environment we are part of, whilst ensuring that you are able to access the information and support a member requires within a professional body.

Of course, the Institution belongs to its members and we will be giving all corporate members the chance to vote on the changes we propose. We hope you will follow carefully the developments so that when the time comes you will feel you have had adequate chance to comment and challenge the ideas we will be putting forward, before casting your vote.

Looking ahead, how often will governance for both the business and the charity be reviewed?

I think most of the documents we have been able to review to date suggest we should be looking at our processes on a 2/3-year basis. This may seem overly frequent, but I think most organisations will carry out this type of review with some regularity and, once we have carried out our review and future reviews on a regular basis, it will only benefit the organisation.

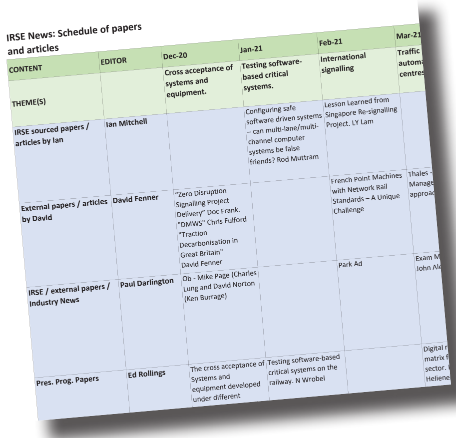
IRSE News

Producing your magazine

IRSE News is produced eleven times a year in full colour with between 36 and 44 pages per issue. However, we are always looking out for interesting and relevant articles, so if you have an idea, please contact any of production team, and we will be pleased to advise and assist you in the production of a quality article.

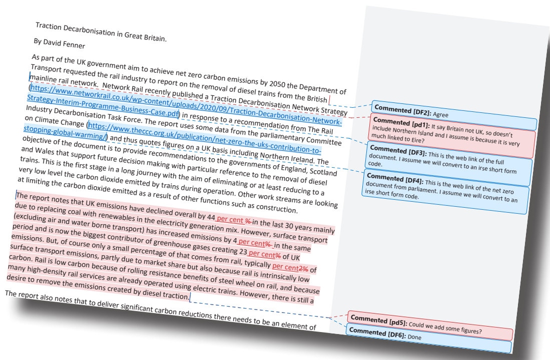
The magazine is produced by a voluntary group of IRSE members and is published with a print resolution of at least 300 dots per inch – the same as or better than the magazines you can buy in the high street. We are a technical institution and articles should not be aimed at primarily selling products or services. To assist any new writers the production process is explained below.

1. **Identifying content.** The team of editors tirelessly looks out for articles, news items and IRSE news of interest to our readers. This never stops during the year. We are incredibly grateful for papers produced by the International Technical Committee and presenters of all the Presidential Papers. The 'back to basics' articles have been popular and we would welcome any new topics to add to the series. Magazines are produced in multiples of four pages; which is why we often need to write one, two, or three page articles at short notice!
2. **Article submission.** Our managing editor chooses which items should go into any particular edition of IRSE News. Text of articles should be submitted in a standard word processing format – normally Word. Photographs and illustrations should be high resolution JPEG, TIFF or RAW files – the larger the better in order to let us print these at our 300dpi target. We also need copyright permission to publish. Crucially, please do not import these into your Word document as doing that destroys the fine detail in the pictures. Diagrams should be in their 'native' format – so PowerPoint, Visio, Illustrator or similar – so that we can get the diagrams as sharp and legible as possible and in the IRSE colours and font. We have a style guide available to assist writers and for example we only use leading upper case for proper nouns, the same as most technical journals, media organisations and newspapers. Double spaces at the end of sentences are not required and please do not refer to other parts of articles as 'above' or 'below' as once laid out in the magazine column format this may not be the case.
3. **Editing.** One of the editors will be allocated to your article, who will edit and check spelling, grammar, sense, compliance to our style guide, and ensure articles are technical and not just disguised adverts. We work hard to try to ensure articles can be understood in all parts of the world, which can be a challenge.


IRSE News: Schedule of papers and articles

CONTENT	EDITOR	Dec-20	Jan-21	Feb-21	Mar-21
THEME(S)		Cross acceptance of systems and equipment.	Testing software-based critical systems.	International signalling	Traffic automa centres
IRSE sourced papers / articles by Ian	Ian Mitchell		Configuring safe software driven systems – can multi-lane/multi-channel computer systems be false friends? Rod Muttram	Lesson Learned from Singapore Re-signalling Project. LY Lam	
External papers / articles by David	David Fenner	"Zero Disruption Signalling Project Delivery" Doc Frank. "DMWS" Chris Fulford "Traction Decarbonisation in Great Britain" David Fenner		French Point Machines with Network Rail Standards – A Unique Challenge	Thales - Manage approac
IRSE / external papers / Industry News	Paul Darlington	Ob - Mike Page (Charles Lung and David Norton (Ken Burrage)		Park Ad	Exam M John Ale
Pres. Prog. Papers	Ed Rollings	The cross acceptance of Systems and equipment developed under different	Testing software-based critical systems on the railway. N Wrobel		Digital r matrix f sector. Helene

We plan well into the future with IRSE News to try to make sure that we have a good range of interesting topics for months to come.


Traction Decarbonisation in Great Britain.

By David Fenner

As part of the UK government aim to achieve net zero carbon emissions by 2050 the Department of Transport requested the rail industry to report on the removal of diesel trains from the British mainline rail network. Network Rail recently published a Traction Decarbonisation Network Strategy (https://www.networkrail.co.uk/wp-content/uploads/2020/09/Traction-Decarbonisation-Network-Strategy-Interim-Programme-Business-Case.pdf) in response to a recommendation from The Rail Industry Decarbonisation Task Force. The report uses some data from the parliamentary Committee on Climate Change (https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/) and thus quotes figures on a UK basis including Northern Ireland. The objective of the document is to provide recommendations to the governments of England, Scotland and Wales that support future decision making with particular reference to the removal of diesel trains. This is the first stage in a long journey with the aim of eliminating or at least reducing to a very low level the carbon dioxide emitted by trains during operation. Other work streams are looking at limiting the carbon dioxide emitted as a result of other functions such as construction.

The report notes that UK emissions have declined overall by 44 per cent ~~%~~ in the last 30 years mainly due to replacing coal with renewables in the electricity generation mix. However, surface transport (excluding air and water borne transport) has increased emissions by 4 per cent~~%~~ in the same period and is now the biggest contributor of greenhouse gases creating 23 per cent~~%~~ of UK emissions. But, of course only a small percentage of that comes from rail, typically per cent~~2%~~ of surface transport emissions, partly due to market share but also because rail is intrinsically low carbon. Rail is low carbon because of rolling resistance benefits of steel wheel on rail, and because many high-density rail services are already operated using electric trains. However, there is still a desire to remove the emissions created by diesel traction.

The report also notes that to deliver significant carbon reductions there needs to be an element of

Commented [DF2]: Agree

Commented [pd1]: It say Britain not UK, so doesn't include Northern Island and I assume is because it is very much linked to Eire?

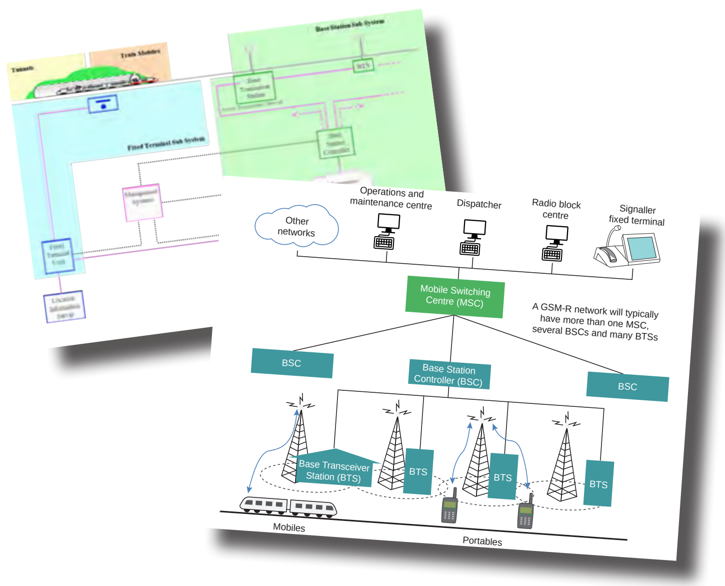
Commented [DF3]: This is the web link of the full document. I assume we will convert to an irse short form code.

Commented [DF4]: This is the web link of the net zero document from parliament. I assume we will convert to an irse short form code.

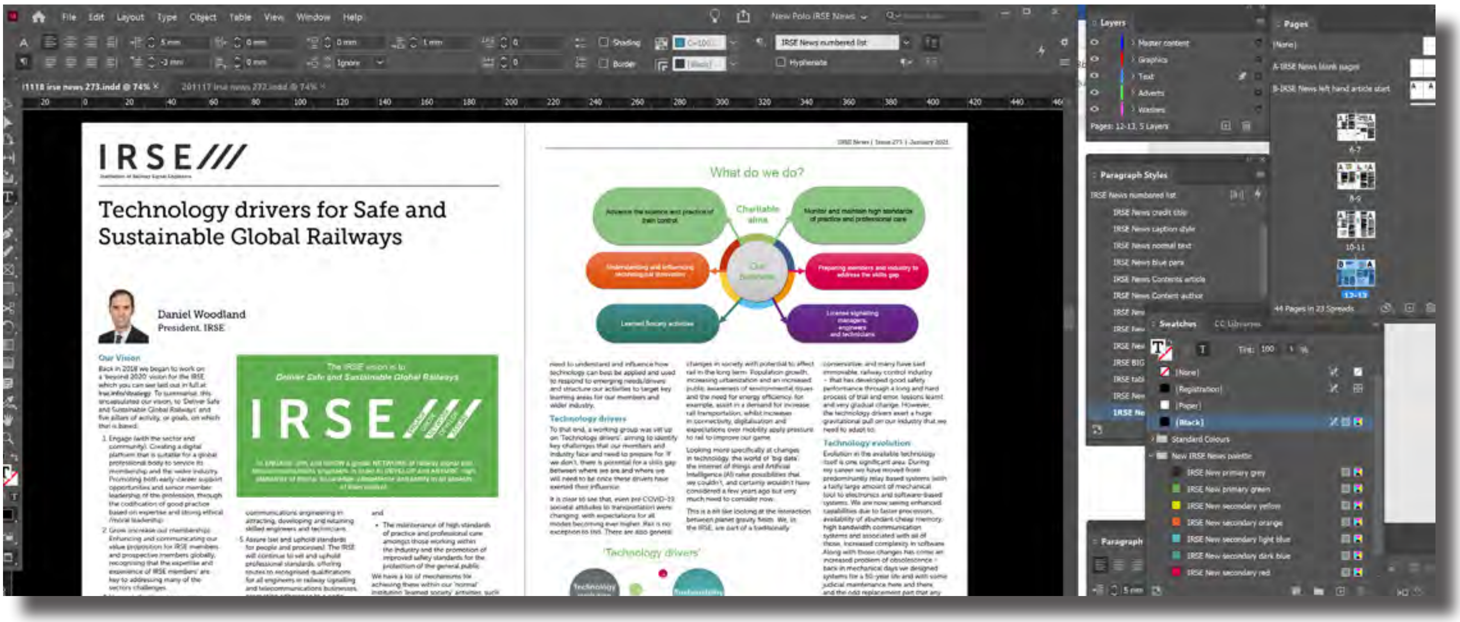
Commented [pd5]: Could we add some figures?

Commented [DF6]: Done

Articles usually arrive as Word documents which are then edited and peer reviewed by our international team.



Where possible we use diagrams in their 'native' format to create vector-based versions that will print at high quality. If necessary, our production manager will create new versions of diagrams – this can be a time-consuming task, but helps his continuing professional development!



Typeset and layout for a magazine will typically start six to eight weeks before 'press day', with Adobe Creative Cloud software used to create the files used by our printers. A typical magazine will take 30-40 hours of production as well as the time invested by the authors and editors.

4. **Other content.** Each IRSE News contains industry news which is collected by our managing editor from various sources on a continuous basis. Each is edited to meet our style, and then added to the magazine. The IRSE communications manager leads the creation the 'News from the IRSE', and we ask a range of people to write the 'News View' editorial section each month. The membership lists also take some time to prepare with the IRSE head of membership and registration working with the production manager to do this.
5. **Typeset and layout.** And over to the production manager where the edited files are now formatted, typeset and laid out. Photographs are adjusted for print, and the diagrams for the articles either optimised or redrawn. This can take a lot of time, which is why we need all content at least eight weeks, ideally ten weeks, before publication. A mixture of Macs and PCs are used with the Adobe Creative Cloud suite of production software – mainly InDesign, Illustrator and Photoshop.
6. **Advertisements**. Our advertisements arrive as print-ready PDF files which are placed into the magazine. These are an important source of revenue for us and we thank Signet Solutions and Park Signalling for their continuing support. We would welcome more advertisers too, so please contact the chief executive of the IRSE if your company would be interested in using IRSE News to share your messages and support our Institution's aims.
7. **Draft review.** A complete draft of the magazine must be ready for review by the full editorial team about five weeks before publication. The international check by the assistant editors is important to make sure content can be understood by members who may not have English as their first language and to accommodate different terms throughout the world.
8. **Final review.** The production manager incorporates all the review comments and adds in any advertisements. The quality of photographs and diagrams are checked one last time and the table of contents is created. This sounds simple, but it can be complex with conflicting comments to address, particularly for technical accuracy.

High quality photography is very important to IRSE News, and can come from unexpected sources. We first saw the stunning photo on the October issue reshared by an IRSE member on LinkedIn. This allowed us to contact Metro Trains Melbourne and get permission for its use in the magazine.

9. **Sign off.** The communications manager and managing editor have one final check of the 'finished' issue, identifying the last few improvements to be made, with 'the editors decision is final' before giving the production manager the sign off to create high resolution PDF files ready to go to the printers, Herald Graphics of Reading.
10. **Production.** IRSE News is printed two to three weeks before publication as it is sent to members in 54 countries. The production manager provides lower resolution versions of the magazine and covers to go on the IRSE website and social media streams— and we start all over again. Although we try to be working two issues ahead of publication at all stages.

Past lives: Graham Brown

Graham was born in Crewe, Cheshire in 1935 to Frank and Doris, and was the youngest of three children. He was educated at Crewe Grammar School and married Carol in 1963, and they lived in and around south Cheshire. They had three children – Louise (1974), Chris (1976), Richard (1978), and four grandchildren – Guy, Drew, Dougie and Benji.

A railway friend who knew Graham at school in his teenage years speaks highly of him and how bright and clever he was and never seeming to revise, simply turning up for exams and passing with flying colours! Even then, he was known to be an exceptionally talented pianist, something that would continue to be a feature throughout his long life.

Graham joined the signal and telecoms department of British Railways as an engineering student around the start of the 1955 Modernisation Plan, which set out to modernise all aspects of the national rail network. At the time and indeed throughout most of his career, the railway was organised into several regions and his career alternated between the London Midland and the Southern.

He began his career in Crewe and, after the end of his training, his aptitude was quickly recognised, and he steadily gained promotion and experience in the many aspects of signalling. By the late 1950s Graham was a section leader of one of the new works design sections at Wimbledon, working on the provision of colour light signalling and several new signalling control centres along the Kent Coast. His musical talents proved unstoppable as throughout this time he was also very active playing in jazz clubs in and around London.

At the conclusion of this scheme, he transferred back to Crewe to work on new signalling installations on the West Coast Main Line, again part of the Modernisation Plan. Some while later, in the late 1960s or early 1970s, he was appointed area engineer at Warrington during the time of the resignalling and electrification of the West Coast Main Line from Warrington to Glasgow.

Towards the end of the 1970s Graham was appointed assistant engineer (construction) based at Crewe, responsible for all installation and testing of the further signalling and telecoms modernisation works which were necessary in the Manchester and Liverpool areas as well as on the lines out of London St Pancras as far as Leicester.

In late 1985, Graham was once more on the move, this time to Croydon, and was appointed as the signal engineer (works) in charge of all new work schemes on the Southern Region. He was there at the time of the serious train collision at Clapham in 1988. In 1990 he transferred back to Birmingham as signal engineer (works) for the London Midland Region from where he subsequently retired.

Graham Brown, 1935 - 2020.

He played the organ in many churches in south Cheshire from a tender age. He started to play the organ at St Bertoline's Church in the village of Barthomley, Cheshire shortly after the installation of a new organ in 2006 until 2011, after which he shared the duties with two colleagues until the autumn of 2020. He played a major part in the choral tradition of the parish as well as holding regular organ recitals at summer lunchtimes.

Graham had a wide range of musical tastes, not least as an accomplished jazz pianist and accompanist. He will also be fondly remembered by the church for his membership of the their walking group every week until shortly before his illness. Sadly, he died on the morning of 29 October in hospital at Leighton hospital in Crewe after a short illness, with his children at his bedside.

His funeral was held at Barthomley church on the 12 November.

Alan Joslyn

Your letters

Telecoms costs and braking

Regarding Aaron Sawyer's editorial in November's IRSE News, how could railways afford to replace telecoms systems at a much higher frequency than at present? Even if the suppliers could cut their prices to (say) 30 per cent of current ones, where investment is reliant on public funds, could we really justify using the decrease in capital cost to replace systems more frequently rather than freeing the money for other uses?

On another subject, how do those who advocate the use of relative rather than absolute braking distance train separation respond to accidents such as Carmont where (post derailment) the affected train decelerated far more rapidly than its emergency braking performance? In making comparison to road transport, has anyone quantified the safety dis-benefits that road suffers from not having vehicles at absolute braking distance separation?

P B Morris

Erratum

In the thoughtful and interesting item about Mike Page's career on page 35 of the December issue of IRSE News reference is made to my memories of Mike in which I am credited with being a past president of our Institution. In the interests of accuracy, I should point out that I did not hold this office. I was however privileged to be appointed as the chief executive of the Institution, following Ray Weedons' well-earned retirement, and served in this capacity from July 1999 until July 2006 when I was succeeded by Colin Porter (who incidentally is a past president!).

Ken Burrage

Signalling alterations York to Harrogate

On the 18 June 1895 my great grandfather, Tom Gall started work as a signalman porter at Poppleton station and signal box. Poppleton signal box is located on the York to Harrogate line in England. He was 19 years old at the time and had moved from Ulleskelf which is a village on the York to Leeds railway line and where his father was a railway track worker. Records show Tom boarding with the Horner family in Poppleton when he first moved, he then married the local publican's daughter, and they lived in Hollins House, Station Road, Poppleton until his death in 1951. From the age of 19 he remained the signalman at Poppleton until his retirement. The York to Harrogate line opened in 1848 and records suggest the signal box Tom worked in was built in the 1870s. At that time, it had an eight-lever frame. Tom may have seen the signal box refurbished in 1941 when a McKenzie and Holland eleven-lever frame was introduced at just about the time he would have retired. The line was a two-track railway with up and down main lines. The signal box of North Eastern Railway design at ground level is located on the up main side of the line and on the opposite side of the Station Road level crossing to Poppleton station. The crossing gates were hand worked and so along with his porter duties the people of Poppleton would have seen Tom most days either opening and closing the crossing or working on the station platform.

I am writing because this week I noticed an article in the York Press announcing the start of commissioning a £9.8m project to increase journey time and capacity on the York to Harrogate route. I understand the project is funded by others and not Network Rail. It may have been time for me to go and have a last look at Poppleton signal box. But, no, the project seems to be keeping to the objective of journey time and capacity increase by the replacement of some semaphore signals with colour light signals, track realignment, and the replacement of token block with token less block. At Poppleton specifically the token block changes to token less block and the up home signal P11 becomes a colour light. Would great grandfather Tom be able to work the current signalling arrangement 125 years after he started at Poppleton? Well since 1941 the section from Poppleton to Hammerton became a single line and the Skelton and then York resignalling projects altered the fringe to and from York, but I think he would. The contrast, between talking to York ROC in the up direction and Hammerton signal box which would be familiar to him in the down direction may come as a shock.

The current project I did note however states that passive provision has been made at Poppleton to convert the level crossing, which now works via mechanical rodding, to an obstacle detector based crossing in the future, so renewal and modernisation is clearly the plan at some point in the future. If the capacity and journey time requirements are met, well done to the current project team for meeting their objectives in an appropriate and minimal manner. I hope the project is successful . For the immediate future the line remains with twelve manned locations controlling the 20 miles of line from York to Harrogate with single line sections which result in significant delays to service if a breakdown or incident occurs on the single line. The York press article did therefore make me think of great grandfather, Tom, and, also how Stephen Dapre's, 'Ruth' would approach any future renewal project along this route.

Stephen Gall

November cover

The cover photo on November IRSE News is great, showing as it does a slice of south east London which happens to be my home ground as I lived in the middle distance. The picture evokes so many memories.

My first school is somewhere there and my first and last technician job was there. The telephone exchange stood just about where the S of system is printed on the cover. I have walked every inch of this yard and near the foot of the lighting tower there was a shunter's bothy where we often had to replace the phone on Monday mornings, as they had smashed it over the weekend so that they could not be disturbed! Happy days.

In the foreground was the site of the Hither Green derailment which took place in 1967 and one of Britain's worst rail crashes see **irse.info/8p3jh**.

Mike Tyrrell

Quick links

IRSE
Institution of Railway Signal Engineers

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon • Planting trees to catch carbon •
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

Membership changes

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Fellow

Paul Rutter, Network Rail, UK

Member

Anthony Beal, Bayside Personnel, Australia
Praveen Gopathi, Hitachi, Australia
Athanacious Makgamatha, PRASA, South Africa
Venkata Satya Mandapati, STE Electronics, Singapore
Steve Maskill, Network Rail, UK
Amr Mohamed, Siemens Mobility, Saudi Arabia
Danny Shave, London Underground, UK
Barry Wilson, Network Rail, UK

Associate Member

Stephen Carey, Network Rail, UK
Ben Johnson, Siemens Mobility, UK
Imran Khan, Riyadh Metro Transit Consultants, Saudi Arabia
John O'Neill, Network Rail, UK
Adam Spawton, Siemens Mobility, UK
Luke Smith, Amey, UK

Accredited Technician

Jeffrey Blackman, Rail For London, UK
Matt Crawford, Crawford Professional Services, UK
Callum Higgins, Siemens Mobility, UK

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Sam Allen, Alstom, UK
Tom McClymont, Siemens Mobility, UK

IEng

Peter Harding, Backlock, UK

CEng

Ian Fury, Arcadis, UK
Rodney Jewell, Volker Rail, UK
David Wheeler, Amey, UK

Past lives

It is with great regret that we have to report that the following members have passed away: Kevin Boyd, Graham (Derek) Brown, David Norton and Ian Page.

Promotions

Member to Fellow

Vijay Kumar, MTR CSW, Australia
Tanya Norton, Arcadis, Australia
Yaw Yuan Thean, HSS Integrated, Wisma MRT, Malaysia

Associate Member to Member

Sorin Milosescu, Broadspectrum, Australia
Shashi Singh, SERCO Middle East, UAE
Sally Wells, Arup, UK

Affiliate to Member

Shui Fung Lau, MTR Corporation, Hong Kong
Matthew Slade, CPC Project Services, UK

Affiliate to Associate Member

Suhel Deshmukh, Alstom, Australia
Tamas Nagy, JMD Railtech, Australia
Nilesh Patel, Department Planning Transport & Infrastructure, Australia

New Affiliate Members

Roman Alberti, Rail Projects Victoria, Australia
Oliver Bos, SNC-Lavalin Atkins, UK
John Carter, Cleshar, UK
Melvin Chand, Hitachi, Australia
Ita Fumiya, Nippon Signal, Japan
Nagji Gohil, Hitachi, India
William Gould, Cleshar, UK
Yushi Hashimoto, Nippon Signal, Japan
Lee Huggins, Network Rail, UK
King Him Hui, SNC-Lavalin Atkins, UK
Scott Huson, SNC-Lavalin Atkins, UK
Tom Jakeman, SNC-Lavalin Atkins, UK
Mamurhomu Kemi, Cleshar, UK
Vikas Khot, Hitachi, Qatar
Damian Maguire, Irish Rail, Ireland
Harish Marimuthu, Siemens Mobility, UK
Benjamin Martin, PM T and A, UK
Josha Ng Kang Xiu, LTA, Singapore
Ryan Pritchard, SNC-Lavalin Atkins, UK
Alex Roberts, Mechatronic Engineering Services, UK
Mustafa E Saquib, AMIE, India
Hariharan Sugumar, SNC-Lavalin Atkins, UK
Matthew Teller, SNC-Lavalin Atkins, UK
Francis Wallis, Cleshar, UK

Resignations: David Brown, Paolo de Jong, Michael Fox, John Gillon and Martin Wiltshire.

IRSE News

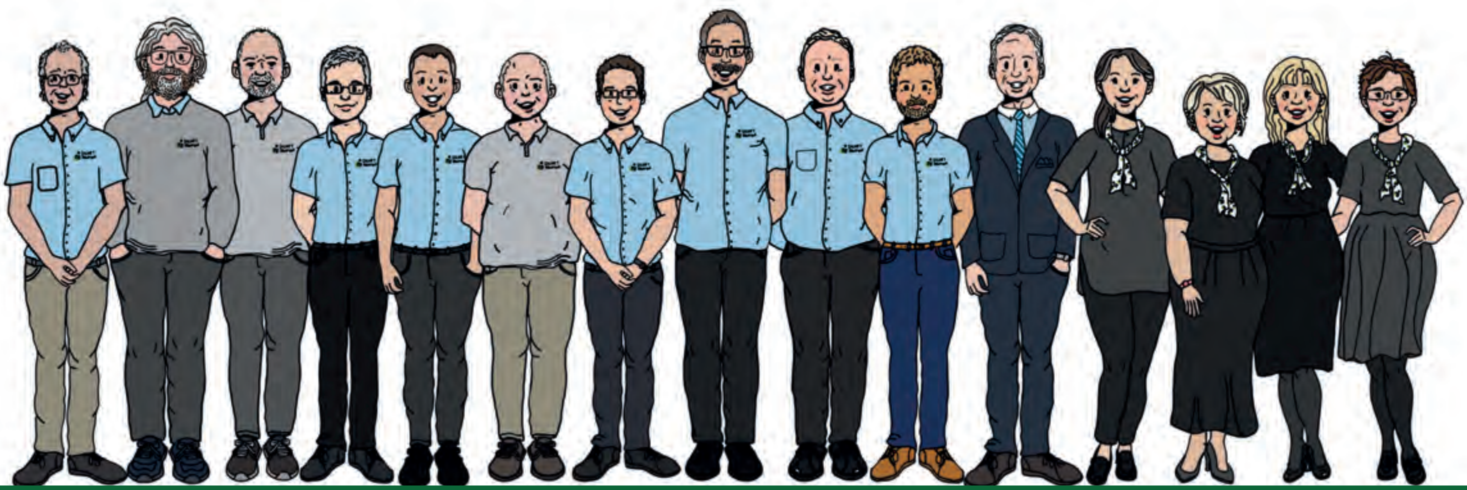
Institution of Railway Signal Engineers

February 2021

Digital resilience
maturity matrix

Lessons learned
from Singapore re-signalling

Compatibility
the return of Ruth



IRSE///
Institution of Railway Signal Engineers

Issue 274
February 2021

In this issue

Feature articles

News and opinion

From the IRSE

Cleaning up our act

As hope of a new world post-Covid starts to grow, governments everywhere are considering how to kick-start struggling economies. A recurrent topic is decarbonisation and moving from fossil-fuelled transport to more sustainable solutions. We are privileged to work in an industry with strong 'green' credentials, moving large loads of people or goods over long distances in an efficient manner, often using zero-emission vehicles.

But technology, innovation and just thinking differently can allow us to play an even greater part in the move to driving out carbon. This applies throughout the lifecycle of railway systems, from construction, through operation, until upgrade or replacement.

When we build command, control, signalling and telecoms systems we have unthinkingly embedded carbon within them and relentlessly used scarce resources. We have poured concrete to act as foundations for signals and antenna masts, trackside location cases and buildings – indifferent to the vast amount of energy needed to create it. We have used steel to erect gantries, we have copper cables to carry power or data. That's changing and we can now use network connections to connect multiple systems over a single fibre optic cable, we can use less power more efficiently, or even generate it locally, and for many railways cab-signalling allows signals, and their supporting structures, to be removed entirely.

Our signalling, data transmission, train control and traffic management systems are all just at the start of their journey to drive decarbonisation. They can make decisions based on the energy consumed network-wide whilst still managing the safe and efficient movement of trains. We can advise drivers – or automatically driven trains – of the optimum speed at which to travel to avoid having to stop and restart unnecessarily, and to ensure right-time arrivals. We can conceivably manage timetables to use energy recovered from braking trains to accelerate departing ones.

Our profession is probably in the most dynamic and exciting phase since its inception in the mid 19th century. We all have a role to play in getting more people to travel on a cleaner, greener public transport system. We can design systems that embed less carbon and use less energy, we can manage trains across entire networks more efficiently, we can use fewer resources and provide greater societal gain. What an opportunity, let's take it.

Mark Glover
production manager, IRSE News

Cover story

BHP Rail Pilbara network, Goldsworthy Junction Australia. A trial by BHP of the Australian designed and manufactured Siemens Easy Access Folding Mast for potential use on its network.

One of many lowering structures in use throughout the world to avoid working at height. What other simple ideas can we introduce to reduce the safety risk to track side signalling and telecoms workers?

Photo Richard Flinders

IRSE
Institution of Railway Signal Engineers

Digital resilience maturity matrix for the railway sector


Alzbeta Helienek and Mathijs Arends

This, the fifth paper of the 2020-2021 presidential programme, was presented online on 20 January 2021.

Cyber security has become a critical part of delivering an efficient and safe railway, driven by ever more digitally connected systems and the evolving threat landscape. Much has been achieved over the last few years but even today the railway finds itself in various stages of cyber security awareness and readiness.

As an industry we range from having developed and integrated security assurance frameworks, allowing safe, secure R&D and project implementations through to no awareness at board level and lack of understanding of responsibility within engineering teams. Our proposed Digital Resilience Railway Maturity Matrix presents a method to categorise, recognise and support organisations with their roadmaps to integrate security into daily operations. It provides a powerful benchmarking tool in a competitive landscape, which in a race to become more effective has also become more vulnerable to today's technological changes.

"Maturity models are used in cyber security to estimate how advanced an organisation's current cybersecurity processes are"

Maturity models are used in cyber security to estimate how advanced an organisation's current cyber security processes are and can be used to provide a clear roadmap to improvement. Usually, these matrices define different domains and define maturity levels that describe how security activities in these domains should take form at the given maturity levels.

There are various maturity matrices in the cyber security field, ranging from the generic Cyber security Capability Maturity Model (C2M2) matrix to more domain specific models such as the Open Web Application Security Project – Software Assurance Maturity Model (OWASP SAMM).

While they are usually constructed on the same underlying principles; their specificity makes them useful in various situations. C2M2 was made with a focus on critical infrastructure but is applicable to most companies with a cyber security programme. While OWASP SAMM contains specific software development processes that most companies will not find to be very relevant, however the companies it does apply to can get a lot of mileage out of the described processes.

These more specific matrices have one very important purpose: translating generic instructions into domain or industry specific processes. Knowing that your company should have business continuity plans is a first step, but the realisation that a company should be able to keep its most vital connections running without IT support is another. A problem that we have observed is that translating classical cyber security matrices into railway specific processes can be quite difficult.

Related work

When developing the Digital Resilience Railway Maturity Matrix, we looked at various models. The OWASP SAMM model served as an inspiration in the level of specificity that it offers to users in its own specific domain. It defines three different maturity levels for different practices where "Each level within a security practice is characterised by a successively more sophisticated objective defined by specific activities, and more stringent success metrics than the previous level. Additionally, each security practice can be improved independently, though related activities can lead to optimisations" (irse.info/ei5wx).

The OWASP SAMM model is a great example of what we want to achieve in a completely different field. The scope of this model is a lot greater than what we are aiming for, but every software developer can identify where their organisation is on the matrix, and it provides a clear way to achieve higher maturity levels.

A more general model that is more applicable in the rail domain is the C2M2 model. The US Department of Energy (DOE) developed C2M2 from the Electricity Subsector Cyber security Capability Maturity Model (ES-C2M2) Version 1.0 by removing sector-specific references and terminology. Due to this model's origins in critical infrastructure, it is a good one to consider in the rail domain and its scope is organisation wide. This defines ten domains, and defines various objectives. Each objective then has three maturity levels. This model is specifically interesting for us since there is a domain specific and non-domain specific version available (irse.info/79cay).

"Developing a maturity model has been done before, so we built our model in line with what already exists"

The Control Objectives for Information and Related Technologies (COBIT) framework is useful for almost any company with an IT infrastructure and covers more than cyber security. It can be divided into five components, one of which is maturity. Moving up the maturity levels in this model means both an increase of scope and an increase of organisation, but the maturity levels do not explicitly tell what these levels should look like in practice. Although the COBIT framework is a very useful one, for our audience and purposes it is simply too broad.

The last framework we want to mention is the US National Institute of Standards and Technology (NIST) framework. This is an amazingly influential framework and almost every security professional must have heard of it. It is a security specific framework with an emphasis on critical infrastructure. It is not a maturity model in itself, but it is possible to assess an organisation's security maturity in complying with NIST using for example a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) review as defined in NIST 800-53. Such a review is large in scope and could be time consuming, which is something we are trying to avoid in our model. See irse.info/cy2z4 and irse.info/y35uf.

Developing the matrix

The five levels

Developing a maturity model has been done before, so we built our model in line with what already exists. The approach of taking various domains and defining different maturity levels in those domains is common practice. When looking at what the different maturity levels mean there seems to be some variations, but it can usually be divided into either:

- Improvements in organisation (documentation, management formalisation).
- Improvements in scope (larger coverage, doing more and better tooling).
- A combination of improvements in organisation and scope.

"For our model we decided to go with the combination of improvements in organisation and scope"

For our model we decided to go with the combination of improvements in organisation and scope. Our maturity levels are characterised as follows:

Level 1

Is the first step on the cyber security journey. The railway organisation recognises the problem and is taking first steps toward dealing with this topic.

Level 2

Basic principles, controls and best practice are being rolled out in the most critical part of the organisation and their digital assets.

Level 3

There is a definitive strategy and roadmap showing how to achieve security maturity throughout the organisation. There are pockets of good practice and areas with a lack of security are guided by an organisational strategy and people feel responsible for securing the critical infrastructure.

Level 4

The organisation knows what is going on in their network, with their people and with their vendors. They have some good supporting tools to help in the quest of managing security and cyber risks. The organisation is prepared and can easily achieve compliance with the EC and UK Networks and Information Systems (NIS) NIS-D legislation and can produce evidence if requested.

Level 5

The organisation actively defends itself against cyber threats. Personnel and vendors are fully aware of their responsibility and contribution to securing the safety integrity and the business of the organisation as well as the whole railway eco-system.

The five dimensions

The dimensions we have developed are based on the experience of working with and analysing various railway and rolling stock organisations. Our purpose in developing this model was not to cover every aspect of a cyber security strategy, but rather focus on a handful of topics an organisation which operates or contributes to national critical infrastructure needs to tackle as a priority. Therefore, we decided on five dimensions that we think are most useful for rail/rolling stock companies, aligning with cyber security best practices, standards, and regulations.

People

People are an organisation's first line of defence and at the same time quite possibly their weakest defence. It is essential that every railway organisation takes its people with it on the journey to achieve higher cyber security maturity, as it is impossible to thrive in any other dimension without getting its people on-board.

Risk

How do you know what to do and do the things you do right? The answer is by managing risk – specifically cyber security risk. Railway organisations should be well equipped to deal with this dimension of the challenge, as the processes are not that different from safety risk and can be very well combined and integrated.

Maturity level / categories	People	Risk	Technical	Safety	Incident
1	A cyber security training and awareness program exists in your organisation.	Your organisation has conducted at least one cyber security threat and risk assessment and therefore knows which assets are critical for safety and which for business continuity.	The organisation's network separates their corporate IT from their safety critical network.	The people responsible in the organisation for safety and security structurally communicate. Security requirements are managed and linked to safety requirements.	There is a formal business continuity plan that describes how to keep trains running in case of a cyber incident The BCP is published and available to everyone in the organisation. We should still think about disaster recovery.
2	Cyber security awareness/ training is based on specific role needs.	A plan has been made to assess in detail the most important company digital infrastructure and most important suppliers.	The network is separated into different zones and conduits. An intrusion detection system can pick up unusual activity in the network.	Created at least one safety case where security issues have been considered and safety testing takes into account malicious actions. The V-lifecycle includes cyber security activities.	The most important lines can be kept operational manually during an incident. Processes in the BCP are included in training.
3	Cyber security trainings are incorporated into HR and can be evidenced.	Cyber risks are actively managed in a company risk management system.	The critical assets and network traffic are monitored and logged. Vulnerabilities are discovered with targeted scans.	Threat and vulnerability and hazard assessments contain at least one representative of both domains. The validation and verification process includes methods of security testing.	Backups are tested regularly. The business continuity plan includes processes for different durations, for example a week or a month. Tabletop crisis management exercises should be conducted at least yearly.
4	Cyber security is included in role descriptions based on your organisation's cyber security needs.	Cyber security risks are known across the whole network including legacy systems.	Security monitoring includes automatic rules and incident alerts that trigger defence response.	Safety and security engineering are integrated as described in CENELEC 50701. Security threats are linked to safety hazards.	Incidents can be contained in such a way that automated process not directly affected by the incident can still be used. The BCP is continuously improved and crisis management exercises are conducted yearly with key staff.
5	Cyber security is a natural part of everyone's job. Part of your organisation's DNA.	Dependencies and triggers for changes in cyber risks are embedded in the risk management process.	A security operation centre monitors, analysis and corrects incidents on digital assets.	Continuously changing security threats are dynamically linked to safety hazards. Safety and security activities are performed by a team with deep understanding of both domains.	There is a dedicated incident response team that will actively work to keep the railway operational during a cyber incident. Crisis management exercises are conducted with scenarios, simulations and multiple stakeholders.

The Railway Cyber Security Maturity Matrix

One considerable difference though is that cyber risk changes constantly, as the attack surface, threats and exploitation of vulnerabilities change constantly. It is vital for a railway organisation to acknowledge that fact and build a continuous cyber risk management framework to be able to make the right decisions about technology, investments, and their infrastructure.

Technical countermeasures

Of course, we are talking about technical countermeasures as the digital threat grows with technology, connectivity, and digitalisation, so naturally the technical frontier needs to be looked at. We focused on the use of specific cyber security tools and methodology to complement the new technology being used in the railway sector.

Integration with safety

Railway signalling technology is safety critical. It is therefore natural that something like a digital threat that can compromise all the safety measures built in this industry over decades needs to be looked at and incorporated into the safety processes. In particular the tension between the safety and security culture needs to be addressed at this point and turned into a productive collaboration, where both sides are involved in the solution.

> "We developed this as a tool for railway executives, safety engineers and any cyber-security interested party to get a quick overview of their situation regarding cyber security"

Incident management

One of the most famous quotes in cyber security is "it is not a question of if, but only when we will be attacked", which we wanted to be reflected in the maturity matrix to promote awareness in an often-underdeveloped dimension. The big difficulty with cyber attacks is that they are constantly changing and evolving, and it is an illusion to believe systems will stay protected against everything and anything. This is especially the case with safety driven industry and large infrastructure which demand a certain stability, adaptations in behaviour, culture, and technology which cannot be achieved overnight. Therefore, it is safe to assume a number of breaches and attacks will hit railway companies, infrastructure managers and railway suppliers. But in a national critical infrastructure it is not only vital for safety and business continuity to be able to react in a crisis and 'keep the lights on', but it is also required by law – in Europe by the national adaptation of NIS-D.

How to use the maturity matrix

We developed this matrix as a tool for railway executives, safety engineers and any cyber security interested party within a railway undertaking to get to a quick overview of their situation regarding cyber security. It should be viewed as 25 simple questions that can be answered by yes or no. Dependent on how many questions an organisation can answer with yes, the higher the maturity level they reach.

It distinguishes itself from a threat and risk assessment conducted by a cyber security professional in terms of both the effort required and detail considered. The maturity matrix does not replace a professionally conducted assessment but gives a quick overview of the railway organisation's cyber position.

It clearly has the potential to be used as an industry wide benchmarking system once enough railway undertakings have asked themselves the 25 questions and have decided to share their maturity results either in full or in part.

The matrix should therefore be seen as a checklist for companies. Experience in supporting railway companies on their journey dealing with this "new" topic of cyber security has shown that knowledge and excellence are quickly developed in one or two dimensions, but sometimes other dimensions are forgotten or underdeveloped, so this gives a company the chance to check what has been overlooked.

Updating and future development

The next crucial part in developing the matrix is testing and validating it with railway organisations. Evidence in usability and relatability will help to improve and develop the maturity matrix, so it fulfils the purpose being understood and used by you, dear railway readers. We hope that this will encourage you to use this matrix, try it out and give feedback.

As in all cyber security processes the objective is to improve with every iteration.

About the authors ...

Alzbeta 'Betty' Helienek is a principal consultant at Ricardo Rail. Betty has 25 years' experience working in the railway and cyber security industry and specialises in combining the two to help solve the challenges safety critical systems face when confronted with cyber-attacks. She is a certified cyber security expert for industrial automation and control systems and developer of products and professional services.

In 2013, Betty introduced cyber security at Research Platform of the European Commission, which has since grown to be the working group for the upcoming CENELEC standard in cyber security for railways. She is also an advisory group member of the UK Cyber Security Council Formation Project.

Betty is currently delivering cyber security consulting for the railway and automotive industry and is co-founder of C4SAM, a European cyber security start-up. She recently joined the International Society of Automation's Smart Manufacturing and Industrial Internet of Things (IIoT) cyber security technical committee to look for solutions, best practices and possibly write a new standard for the IIoT.

Supporting author Mathijs Arends is a Dutch rail IT and data consultant with a focus on cyber security. He is a newcomer in the rail industry and has a background in software engineering for aviation support systems. With broad technical skills in embedded environments in combination with a passion for cyber security he tries to make the railways more secure. Currently he is focusing on cyber security in the rail sector for Ricardo Rail, with a specific interest in autonomous train operation, and supply chain management.

IRSE
Institution of Railway Signal Engineers

Lessons learned from the Singapore re-signalling project

L Y Lam

The North-South and East-West Lines (NSEWL) are the first two metro railway lines built in Singapore. The first section of North-South Line (NSL) from Yio Chu Kang station to Toa Payoh station was put into service in November 1987, the other sections on NSL and East-West Line (EWL) were progressively opened and completed in 1990 with two interchange stations at City Hall station and Raffles Place station.

Further extension of these two lines took place in 1990s with another interchange station at Jurong East station. Having operated for over twenty years, there were equipment obsolescence and reliability issues on the NSEWL's signalling system and it was also difficult to find replacement parts. The Land Transport Authority (LTA) decided to replace the signalling system with a new generation system and the contract was awarded in February 2012. The new signalling system was put into service on NSL on 28 of May 2017 and then followed by EWL exactly one year later. During the first two years of the service, there were quite a number of issues due to software and hardware failures. This paper discusses some of the issues that resulted in train service delays.

Background

The NSEWL resignalling project aimed to replace the fixed block automatic train control signalling system on both lines with a Communication-Based Train Control (CBTC) system. At the time of planning for this replacement project, there was another project to extend the EWL from Joo Koon station to Tuas Link and these two projects were taken into consideration by the Land Transport Authority. Tenders for the EWL Tuas West Extension (TWE) project and the resignalling project were invited at the same time and were subsequently awarded to the same

When originally constructed, the Singapore metro lines used a range of microprocessor based train control and supervision techniques to connect the rapidly developing city state. Technology, and demand, moved on and by 2012 it was time to upgrade. The photo shows the main line and depot entrance at Bishan in the late 1980s. *Photo Westinghouse archive.*

The Singapore MRT network showing the Tuas West extension on the west and proof of concept area on the east of the island.
Image Singapore Land Transport Authority.

contractor in February 2012. The rail map above shows all the railway lines in Singapore and the connection between the NSEWL and TWE. The NSL is coloured red, EWL (including TWE) is coloured green.

The scope of the resignalling project comprises the replacement of the legacy relay-based interlocking system, automatic train protection system (ATP), automatic train operation system (ATO) and automatic train supervision system (ATS) with a moving block CBTC system and a computer-based interlocking (CBI) system. It does not include replacement of trackside safety protection devices, track circuits and point machines. The new signalling system comes with a fallback control system through an emergency control PC at station level allowing trains to be operated at line of sight 'restricted manual' control mode at a maximum speed of 18km/h.

Project implementation

The NSL serves a number of highly populated districts, city centre and central business district area with the highest ridership among all the railway lines in Singapore. The signalling replacement works started with NSL first, followed by EWL. TWE contract started on the same day as the resignalling contract and the work on these two projects progressed in parallel.

As TWE is an extension of the EWL and completed before the resignalling of the existing EWL, it had to be interfaced with the legacy signalling system before EWL was commissioned for full CBTC operation. To achieve this, the switchover between the legacy signalling system and CBTC took place at Pioneer station, one station before the end of EWL, to allow dual-fitted trains to switchover from the fixed-block system to the CBTC system and vice versa.

Proof of concept

For this project, different migration strategies were adopted for different phases of the project. A proof-of-concept (PoC) stage was included in the early phase of the project. This provided a testing ground to demonstrate the design, installation, implementation methodologies, operational concept and migration principles at various migration phases. The PoC took place on the Changi Airport Line. This line branches off from the main EWL located at the east end of the EWL as shown in the trackplan above.

The PoC area consists of three stations separated in two zones and one reception track leading to Changi Depot. It was fully equipped with all the key trackside equipment allowing various phases of migration to CBTC and cut-over methodologies to be demonstrated and tested out. The demonstration included cross zone operation, shadow mode operation for CBTC system reliability data collection while a train is running on the legacy signalling system, CBTC system operation, legacy and CBTC system over and back implementation, mixed mode system operation and switchover to model TWE and EWL operation

The proof of concept area covered the line from Tanah Merah through Expo (seen here) to Changi Airport. *Photo Shutterstock/ Markus Mainka.*

"It is understood that the transition to a complex-software based system would entail certain issues during the initial system operational stage"

with CBTC operating on the extension line and legacy system on EWL, depot train initialisation and launching, system remote control from the operation control centre, fallback mode operation and interfaces with other system-wide systems as well as electromagnetic compatibility.

North-South Line implementation

The NSEWL and TWE consist of 58 stations, with approximately 100km length of track and 198 trains. It is divided into 18 zones and provided with one ATS for the control of the entire CBTC system on NSEWL together with TWE. In each zone, there is a Zone Controller System which consists of a Movement Authority Unit (MAU) and a CBI.

CBTC system deployment started off on NSL. It covered the entire NSL, Bishan Depot and a test track in the depot, 27 stations, 76 trains and 10 locomotives. In order to collect more CBTC system operational data to gauge the system reliability growth, shadow mode running was put into operation as the CBTC system was progressively commissioned zone by zone while the dual fitted trains were running in the legacy signalling system. Under this mode of operation, the legacy signalling system had full control of signals, routes and protection devices and trains were running based on the legacy fixed block speed code system. The CBTC system only collected the CBTC system data through train underframe carried antennae, detectors and Wi-Fi radio for train positioning verification and message integrity and radio roaming transmission monitoring. During this period of time the CBTC system was only running in shadow mode and there was no switching between legacy system and CBTC system while the train was running on CBTC equipped zones.

Major incidents and service interruptions

It is understood that the transition to a complex-software based system would entail certain issues during the initial system operational stage. This was no exception for the NSEWL resignalling project, and subsequent investigations indicated that the root causes of these defects were due to some common software errors.

Loss of radio communication

There was a Wi-Fi radio transmission failure on NSL. The wayside radio units (WRU) started to fail inside Bishan depot (BSD). It propagated to the adjoining stations on the main running line. All trains running in both directions on the main running line next to BSD experienced loss of communications between train borne and wayside signalling systems. Without continuous radio communication, all trains were unable to proceed in automatic mode and needed to proceed in restricted manual mode to the next station.

It was noticed from the Network Management System that WRU failed one after another starting from BSD and extended to the main running line. Further analysis indicated that the WRU failure occurred in the direction of movement of one particular train. This train was immediately withdrawn back to depot for further investigation. All the affected WRU were then reset to resume normal train operation after this rogue train had returned to the depot far end siding.

The root cause of the WRU failure was due to a specific scenario of unexpected data corruption that resulted in data structures being shifted in memory. This resulted in unexpected values in the data structure leading to a constant software loop which can be called a halt. The software was updated to handle unexpected

data corruption by doing more defensive coding. This then results in better error handling and allows the units to continue functioning even after a data corruption. As a lesson learned, it is always good practice to do defensive coding with operations-friendly recovery, to handle unexpected scenarios.

"It is always good practice to do defensive coding with operations-friendly recovery, to handle unexpected scenarios"

Verification of input from other systems

Due to a fault detected in the active central ATS server, the system switched over to the hot standby server. This led to a "ghost train" being created at the zone border. The train associated with this ghost train icon had passed the zone border into the adjacent zone. The ghost train icon was just an icon with no train associated with it so it would not move. The traffic controller tried to resume train service after server switchover and did not notice it was a ghost train icon and routed this ghost train to the adjacent zone. As the actual train was already in the adjacent zone, the adjacent zone MAU used the real train's position to do route check in/check out for verification. As the position did not match it brought the MAU to a halt.

The MAU is a SIL4 system and will halt the system if an unsafe condition is detected. But to reject a route call from ATS due to invalid parameters and raise an alarm does not violate any signalling principles. Not setting a route would not cause any unsafe conditions for train movements within the zone. So there was no need to halt the system because of an invalid input from ATS and the system in the adjacent zone. Halting the system resulted in all trains inside the zone operating in restricted manual mode and operators having to countermand the signals within the zone to maintain minimum train service.

The system is designed with fault detection but not necessarily in a manner that benefits the operator as in some cases the unit instead of rejecting an invalid route call will halt the processing. In any system when the input is not as expected the system can halt or reject the data and continue operation as long as SIL 4 is maintained and this is a tradeoff analysis that needs to be considered. In the context of this problem, each zone has its own MAU and CBI, both are designed to SIL 4. The signalling status from CBI in the same zone must be reliable and any information from other systems or adjacent zone must be screened and verified before it is used and processed by the system. It should always assume inputs from other modules and systems may contain errors. The system should not just detect these errors as in this case but it should handle it without halting so as to not significantly impact operations.

System capacity and response time

The NSEWL is one of the biggest systems delivered by the contractor, in terms of track length, number of stations and number of trains. The ATS design was baselined from previous projects which were relatively smaller compared with the NSEWL re-signalling project. The ATS throughput analysis carried out by the system designer was simply to expand it to the number of trains/workstations required by the system. Another aspect is the added new functionalities for the NSEWL project. The bigger system and new functionalities resulted in significant increase in the ATS system data processing and volume of information transmission between various functional systems within the CBTC system. The amount of data the ATS server has to send to the workstations depends on how many updates required, number of moving trains, commands issued, timetable size, etc. In this ATS system the central server continuously updates all operational status to all workstations installed at stations along the running line, central operation control centre, backup operation control centre and maintenance

Resignalling a system of this complexity brought many challenges, including fitting new transponder antennas to existing rolling stock.

"High volume data transfer should only be sent to those workstations that require it to operate and control the system in normal day to day operation"

centres. This update also includes system overview, live train moving information status and system playback data, timetable and fault logs of various systems.

The replacement CBTC system provides automatic bi-directional and shuttle train operation. A bi-directional area is an area in which two trains can oppose each other and become deadlocked. In this CBTC ATS system, route setting is dynamic. Routes can be set from any point on the line to any other point on the line. A route does not necessarily need to start from a signal to another signal (signal to signal route). This design approach does not allow route locking of this nature to be carried out at interlocking level and must be carried out in a system which has full knowledge of all train movements in the system irrespective of timetable train movements or manual route commanded by operator.

The ATS system provides deadlock prevention mechanisms for turnback areas, bi-directional areas, and terminus areas. When a manual route is commanded by the operator the bi-directional handling trigger refreshes for all trains. This generates a large amount of data and causes internal queue overflow. This slows down the response to commands issued by ATS and by operators, in particular for those critical commands which are supposed to be executed at the earliest possible time.

The problem was resolved by only processing the bi-directional handling refresh trigger for the train concerned, increasing the queue size and data compression for telegram transmission and increasing the network throughput.

The assumption that using exactly the same software will work may not always be valid without detailed evaluation of the requirements and assessment of the scale of application.

The system capacity, the response time performance, the minimum and maximum arrival rates for each input, the communication path, bandwidth and the rate output produced need to be evaluated and size the system provision as appropriate right at the beginning of the project. High volume data transfer should only be sent to those workstations that require it to operate and control the system in normal day to day operation. For other workstations this information should only be made available on demand basis to reduce unnecessary data transfer through the network and reduce the processing load of the central servers.

Door synchronisation at terminal stations

For the NSEWL project, each train is equipped with two Vehicle On Board Computers (VOBCs), one at each end of the train and which are connected to provide head-tail redundancy. There is a requirement to switch the VOBC over at terminals or when a train reverses. After switch-over the newly taking over VOBC should retain all the ATO/ATP/interface control status and data.

It is an operational requirement in Singapore that there is always a train crew in the train cab while it is on the main running line. At terminals, train crew step-back takes place in order to meet the short turnback headway requirement.

Under automatic mode of train operation, a train arrives at the terminal station with train door and platform screen door open control in automatic mode and door close control in manual mode to facilitate train crew control of train door operation before departure. The replacement train crew enters the tail end of train cab and leaves the cab door open to prevent the train from moving off automatically after dwell expired and train saloon doors and platform screen doors are closed. VOBC switchover takes place about 18 seconds before the dwell expires. Shortly before the dwell expires, the front end train crew closes train doors and platform screen doors using the manual button on the cab console after passenger exchange and leaves the cab and closes the cab door manually. As there is no synchronisation between the two VOBCs on board the train the newly active VOBC detects there is a discrepancy in train door and platform screen door, because the cab door of the newly occupied cab is open. It issues a door open command to synchronise both train door and platform screen door. Then all the platform screen doors are open. To close the platform screen doors the train operator needs to operate a manual switch located at the headwall at the platform.

Although this does not pose a safety risk, there is a need to address this synchronisation problem, by updating the passive VOBC on the door command status before switchover takes place. The passive VOBC will memorise the last door command and this becomes the default door command until the train departs from the station. Alternatively, removing the requirement of VOBC switchover at terminals and change-end locations will avoid the issue of VOBC synchronisation from happening unless it so happens that the active VOBC fails at these locations. Separating the cab door and saloon door control and detection is another way to get around this door synchronisation problem.

The issue here is the understanding of operational requirements at terminal stations.

Watchdog switchover triggering control

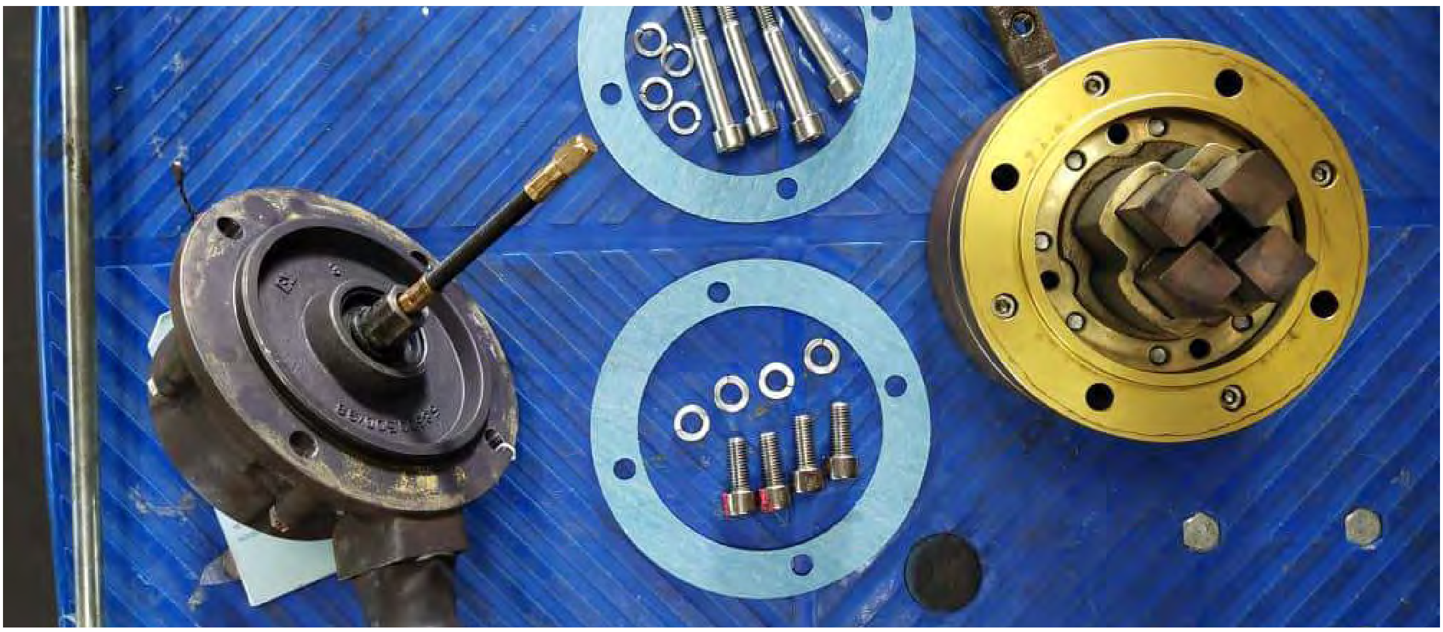
A complete zone went down due to the watchdog monitoring the healthy status of the CBI communication module being unable to detect an intermittent failure of the module, hence it could not trigger the restart of the module and switchover to the passive module.

Due to intermittent failure of the communication module, the MAU in the zone only received intermittent messages from the CBI. Because the messages received were intermittent and incomplete, all messages were rejected. As there was no update from CBI on trackside equipment status MAU closed all tracks within the zone.

Because of this failure, the active communication module could not update the trackside equipment status to the passive module. Failure of synchronisation between the active and passive communication modules led to the passive communication module trying to take over control. However, it was unable to take over as it detected that an active communication module was still running when it initiated the taking over process, so it restarted itself.

The root cause of the failure was due to a hard disk failure. It caused an application to pause while it attempted to read from/write to hard disk. The pause of this particular application software led to software in the watchdog to malfunction and freeze. Apart from the software reset, the watchdog was also provided with a hardware reset. However, this intermittent failure occurred periodically at a time interval less than the hardware reset time of 30 seconds. No switchover could take place until the active communication module failed.

The watchdog design for the CBI communication module includes both hardware and software resets. It is rare to have them both failing to detect the failure of the communication module to communicate with peer module and MAU. It leads to a new look at the architecture and algorithm of the watchdog on the software side. For safety system communication, message integrity, timeliness and sequence compare are normally included. The same approach is adopted to improve the integrity of the watchdog architecture and algorithm. Timestamps are provided to ensure the freshness of the messages exchanged between the watchdog of both active and passive communication modules and to ensure there is no missing cycle between messages. This prevents any short, intermittent failure from remaining undetected.



An example of innovation necessary during the resignalling was the mounting of new tachogenerator speed sensors on an axle used for traction current return.

Singapore LTA's ATS is a complex, service critical system.

"The ATS is a service critical system. Even when input variables/ parameters may be invalid, the system reaction should be considered to not inconvenience operation"

Input parameter verification

A train leaving the EWL main line returned to depot with one VOBC active and the other VOBC passive. The EWL ATS kept an image of the train VOBC configuration of the train. Due to a fibre optic cable failure in the depot, the train could not communicate with the depot ATS. During maintenance work VOBC was switched over. Because the train had never communicated with the depot ATS while the train was inside the depot, its image in EWL ATS was not updated and remained as in its original configuration before it left the main line earlier.

When the train was went back into service, it established communication with EWL ATS at the reception track. It reported a different configuration because of the VOBC switchover had taken place while the train was in the depot. This led to EWL ATS to have two active VOBC registered for this train, one in memory and one during train launching when communication between the train and the ATS was established at the depot reception track. This led to the ATS failure. The watchdog timer was then activated and re-started the ATS and switchover to the passive ATS server.

The ATS is a service critical system. Even when input variables/parameters may be invalid, the system reaction should be considered to not inconvenience operation. The ATS should only halt under extreme conditions where if the execution continued it would cause more operational problems than the halt. However, in some cases a halt is a better design principle if the backup unit can be activated seamlessly.

Data storm

NSL was put into full CBTC revenue service on 28 May 2017, while at the same time installation work was in progress on the EWL. Exactly one month after NSL commenced CBTC service, shortly after the beginning of the evening peak the Network Management System (NMS) showed that all WRU on NSL went down. It was later identified that there was a data storm on the data communication backbone network.

One day before the data storm incident, the WRU ring from Buona Vista station (BNV) and Redhill station (RDH) was brought online with its link to the backbone in BNV disconnected. On the day of the incident, the contractor's engineer uploaded the latest radio software and initialised the network in BNV. The coupling switches at BNV and RDH were running different versions of software. The old version had an issue with the coupling protocol which always activates the link. The new version had properly working coupling protocol and was provided with a function that would not activate when detecting the presence of its peer. However, at the time of incident the new version did not detect the presence of a peer that was running an old version of software. As per configuration it activated itself automatically. The engineer did not know there was incompatibility between the old version and the newly uploaded software version and connected the link together. He then uploaded the remaining part of the ring with the new software at RDH. When the redundant coupling port was connected in BNV, it caused both coupling ports to activate and create a loop in the network. This caused a data storm on the data communication backbone network serving both NSL and EWL until the links connecting the lines together were isolated.

NSL was originally designed with one depot at Bishan. Due to line extension, Bishan Depot does not have the capacity to hold all the trains required for NSL service. Some of the trains are stabled in Ulu Pandan Depot (UPD) on EWL. The ATS and data network of NSL and EWL was then designed to operate as one monolithic system for ease of train movement across these two lines and shared use of UPD depot. Because of this monolithic system design approach any system-wide network issues will have an impact on both lines.

30 years later than the photo at the beginning of this article and Bishan has changed beyond recognition. CBTC is installed along the NSL line and the system is operating reliably. *Photo Shutterstock/ZDL.*

"Operating practices need to be defined at the requirement capture stage to understand how the operator will run the railway and include them in the design specifications"

The root cause of this incident was the incompatibility of the old version and the new version of software as they cannot be connected together in the same ring. In the old version software switches run a ring resolution protocol. One switch in the ring is configured as the redundancy manager. This switch disables one of its ring ports, thus making one link in the ring stand-by. In this way, no loops are created in the backbone. This incompatibility issue was not brought to the attention of the engineers implementing it and was not captured in the installation method statement.

After this data storm incident, studies were conducted to explore the feasibility of uncoupling the NSL and EWL. However, it was found that the modification is complex with high technical risk to segregate the ATS and DCS (Data Communication System). In addition, it would impact the ability for trains to move seamlessly between NSL and EWL. Improvements were made for partial segregation of the DCS network in order to strengthen the robustness of the data communication link.

Conclusion

Today, most of the metro railway signalling system suppliers offer software based CBTC signalling systems. To achieve a highly reliable system, it is important not only to have good quality hardware but also a highly reliable software system.

It is therefore important for the system development and implementation team members to follow good engineering practices to design and develop software and deliver a highly reliable software system. Appropriate procedures and industrial practices as given in international standards and good coding practices need to be adhered to. When reusing software, the working and operating environments and the size of system need to be assessed and specified in the design specifications as appropriate. Operating practices need to be defined at the requirement capture stage to understand how the operator will run the railway and include them in the design specifications.

Halting a non-safety but a service critical system such as the automatic train supervision system should be avoided. Faults and known failure modes should be identified and addressed in design. Detection of these faults and their handling need to be defined in the design specification and managed.

Once the above issues were resolved, and the system reliability improvement program was completed, the NSEWL's new signalling system is now delivering the required performance and reliability.

About the author ...

L Y Lam is a senior engineering consultant in the Land Transport Authority (Singapore). He has over 40 years experience in signalling system design and testing, project management and design management of signalling projects, working in Hong Kong and Singapore, and providing consultancy services elsewhere in the world. He was instrumental in establishing the IRSE local section in Hong Kong, and has served as secretary and chairman. He also acts as a special advisor to the Singapore section, and has published a number of papers with various engineering institutions.

What do you think?

A recent UK Rail Accident Investigation Branch report recommended that the signalling industry should capture and share safety learning from failures of complex software based systems. This article is an excellent example, and LTA Singapore are to be congratulated for their openness in allowing its publication. Do you have any examples of such learning that can be shared in a similar manner? Email us at **editor@irsenews.co.uk**.

"It's only backwards compatible"

Stephen Dapré

We first met Ruth in IRSE News December 2018 issue 250. Ruth is a fictitious signalling project engineer, who followed her grandpa Harold and uncle Bob into railway employment. She now works for a fictitious railway infrastructure manager who is organised into various regions called "Communities".

"Ruthie, why do they go and change things just for the sake of it?"

Ruth was visiting grandpa Harold in his care home. When he moved in, he had brought a few of his electrical appliances with him including a large table lamp, and he had now been asked not to use them.

"Grandpa, the thing is – not everyone here is as technically minded as you are, and they need to ensure you are all safe."

"How does sending electrical currents through plugs with differently shaped pins suddenly make it any safer than the old ones then, tell me that?", with his usual mix of genuine frustration and twinkling eyes looking for a lively intellectual debate.

In the early days of electricity their country had used plugs and sockets with round pins and holes, then some decades ago new standards were introduced, featuring plugs with what most people called square pins (although Ruth and her grandfather knew they were rectangular). For many years thereafter it had been possible to buy adapters to allow round pin plugs to be plugged into modern angular-holed sockets, and that was safe enough. However, it was now so long after the standards had changed that any remaining appliances with round pin plugs were becoming quite old, with all that meant for the condition of their wiring and insulation.

"So, grandpa, what have they actually said about it?"

"Well, I've only been told by the care staff, but according to them someone called Pat goes around testing all the appliances. They say that Pat tested my lamp and it failed. I don't see why, I covered up the frayed bit of insulation with some proper electrical tape so it's perfectly safe. I do sometimes find that when I turn it on, the circuit breaker in the corridor trips, but I have done the calculations and its just because the lady next door always leaves her TV and heater on with the window open so there's too much load on our circuit already."

Although Ruth's knowledge of signalling history was still growing, she was fairly sure that she had seen earth leakage detectors even in the older relay rooms so she decided that Harold would quickly understand domestic RCDs (Residual Current Devices) and how they differed from conventional overload circuit breakers. She brought him up to date with modern wiring regulations and observed that tripping was perhaps a sign that all was not well with his lamp.

After completing their technical discussion, a chat about family news and finishing their cups of tea it was time for Ruth to go. Ruth was about to walk down the corridor when Harold said:

Compatibility, and especially backwards compatability, can be a challenge in many walks of life.

Photo Shutterstock/KoldunovAlexey.

This is a circuit protecting safety device. It is not a light switch.

"Well, at least I now know that if I ever want to turn off the power quickly, I just need to stick my insulated-handled pliers between Live and Earth and it will trip immediately, it saves climbing a chair in the corridor." Ruth froze for a moment until she could see a cheeky grin emerge. She turned and continued, wondering whether her latest upward mentoring session had really been a good idea.

Train service pattern

"Sorry love, this ticket isn't valid on Swirly Spiral trains, its only compatible with Polka Dot services, like that train over there in the other platform."

Ruth sighed. She had got up at silly o'clock to travel in from her hometown in good time to board a long-distance train to her meeting, yet having carefully researched the complex rules on tickets it appeared she had bought the wrong one. Or the right one but boarded the wrong train. She peered through her bleary eyes at the name-badge with unnecessary Swirly Spirals branding, which told her the person standing in front of her was the Customer Experience And Door Closure Sequence Manager (CEADCSM), and that his name was Ed. Ruth felt that just putting "Ed" would have been sufficient (and allowed a larger font amongst the spirals), but that was not going to change the situation. Too tired to debate it, she gathered her belongings and adjourned to the marginally less unpleasantly patterned train on the other platform. She wondered whether travel sickness could be caused simply by décor and patterns.

Once Ruth was settled, she thought about the day ahead. She had been approached by the Binary Railway department several times about the apparent benefits of the new national in-cab signalling system called Universal Train Control System (UTCS). After a series of unfortunate diary clashes, she had finally decided to accept an invitation to a presentation already being given to another Community further afield. She was particularly interested in how compatibility between different versions and suppliers would be managed when it would inevitably take many years for the technology to be applied across all the Communities. She recalled her uncle Bob enthusing about the benefits of relays made to a standard specification by a variety of suppliers which could be individually swapped and serviced, and his frustration with electronic systems that were quickly superseded by minor updates that inevitably required slightly different interfaces and stocks of spares. Although the first computer interlockings had carefully used a modular design with elements from different suppliers being interchangeable, more recently this approach had been diluted when individual suppliers had proposed upgraded versions using their own products. It was a conundrum: insist on consistency which may stifle innovation, or allow new products with improved features such as remote diagnostics at the expense of backward compatibility. Ruth smiled because Bob's unwavering advice for anything involving connecting different electronic systems together was "if in doubt, use a relay interface", and she had seen examples of this herself.

"Teas, coffees, snacks?". Ruth's thinking was abruptly interrupted by the at-seat trolley service. She had recently started using a phone app to pay for small purchases, however it quickly became clear that this train company did not accept that option, and she had no small change with her, so after ordering her drink she and the catering host took several attempts to find a combination of debit/credit cards, machine readers and signal strength before successfully paying.

Open access

Ruth had arrived at her destination, only to find her Polka Dots ticket would not open the exit gate at the station. After queuing to file past a member of staff who was not checking tickets whilst talking to a colleague, she walked across the city to the Community head office.

"Do you have an approved sky-blue lanyard?" demanded the person sitting at what was allegedly a welcome desk.

"No, I work for another Community, but I thought..."

"Only people who are proven to be in this building for at least 27.5 hours a week for a period of a whole year qualify for a sky-blue lanyard, otherwise you are all visitors. You need to sign in and be met by your host."

Ruth compared the height of the access gates with the hurdles she used to jump quite successfully in school athletics, but decided those skills were not transferable to grown-up life. Instead, she joined the back of the queue of other disreputable intruders from outside the city to plead sanctuary. Clearly her railway's various policies on interoperability, compatibility

Traditionally at least some equipment was built to a standard specification by a number of suppliers. This particular example can also be used to interface incompatible electronic devices!

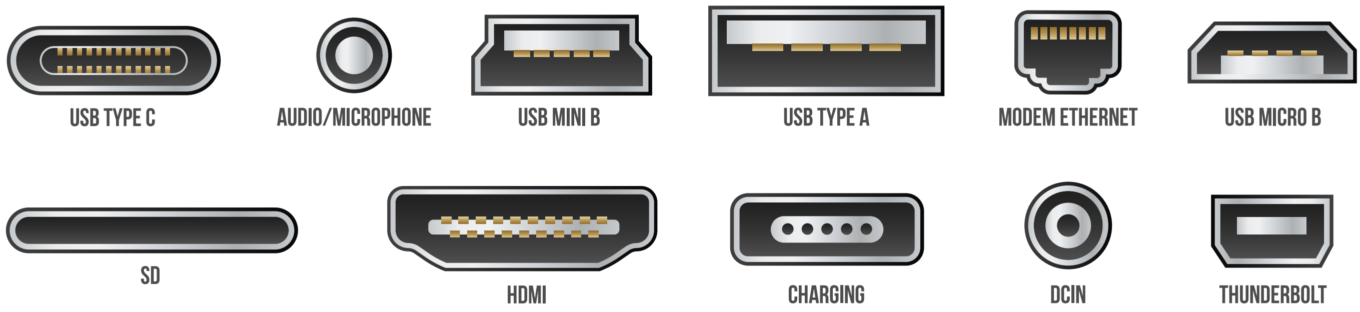


Photo Shutterstock/Mikhail Grachikov.

Even standardised connections can be bewildering.

and inclusivity did not apply to office access. After excelling at the rather less onerous entry requirements for visitors by providing a name that sounded like a name in the visitors book, she then gathered in the holding area to await her host and amused herself by trying to guess who else might be going to the same meeting.

Eventually the mystery was solved when her host announced themselves at reception and several people expressed a degree of interest by way of walking nearer. In a scene reminiscent of a film she had seen about prisons, they all shuffled obediently through beeping security gates and long corridors into a meeting room to await the start. Their host started to prepare by getting their laptop and trying to connect it to the TV screen in the room.

"Ah, does anyone have one of those adapter thingies? My laptop only has the old-style blue multipin socket for plugging in projectors, but this TV uses one of those flat black ones."

Nobody was forthcoming so the host disappeared to seek help, returning after much delay with a somewhat underwhelming adapter that would hopefully improve compatibility. After a quantity of plugging and unplugging, resetting and unfamiliar words in the local dialect, a photo of what was probably the host's partner on holiday briefly appeared on the large screen, hurriedly replaced by a slightly less exciting presentation about UTCS. A further kerfuffle then took place because one attendee had asked to attend remotely from home, however nobody could work out how to allow them to speak to those in the meeting room. Eventually it was concluded that they would listen in and ask any questions by email afterwards. Ruth wondered whether working from home and virtual meetings would ever really catch on...

Forward thinking

Not unusually in Ruth's experience of railway operations, the potential for a brisk and punctual start had gradually lapsed into a belated and tentative jolt to overcome the sheer inertia. After the routine introductions and life histories, the host explained that two key visiting experts had not arrived for some reason (which made Ruth wonder if they had simply felt so unwelcome at the front desk that they had abandoned attempts to enter and gone sightseeing instead). Instead, the host and others did their best to talk through what was on the screen. Ruth listened politely whilst people explained that one of the main benefits of UTCS was that in future all trains would be able to travel everywhere seamlessly because the entire network would be using a fully compatible system. It all sounded very sensible; however, she was still trying to recall something she had heard when she first looked into UTCS a couple of years ago. Suddenly it came back to her:

"Can I just ask, I'm sure when I visited the Community of Rural Song and Sheep (IRSE News Issue 250), they said they were getting some new trains which meant they would need to upgrade the version of the UTCS infrastructure, why is that?"

"Ah, well – I'm not so familiar with that site but I'm told it's only backwards-compatible."

"But what does that actually mean?"

This resulted in a compatibility discussion with an intermingling of forwards, backwards and less precise references in a manner somewhat reminiscent of the Swirly Spirals train she had seen earlier, until the consensus seemed to be that trains using older UTCS software versions would probably work with newer UTCS signalling, but perhaps not the other

The UK's approach to compatibility in the 1980s. Plug compatible units from multiple suppliers. The systems replacing SSI offer much greater functionality and performance, but at the expense of that ability to interconnect. A suitable, yet non-ideal, interfacing device is also shown.

way around. Just as Ruth thought she understood it and was about to ask about how this would work in the future when far more trains and infrastructure had been fitted, the door burst open and two people walked in talking to each other. One then said to the room:

"Aha, glad to see everyone else is even earlier than we are, that means we could start if people are ready?"

They were greeted by a mixture of bemusement, murmurs and comments which soon conveyed to the newcomers that they were not in fact early.

"But the invitation in our calendars say 10:00, it is clearly wrong?"

"Ah, but was that 10:00 in local time or in Universal Time?" said the host.

It suddenly dawned on the experts that because they had travelled from afar, their calendars had not allowed for the minor detail that the meeting time was quoted in local time, which made sense for most attendees but not for them. They were therefore almost one hour late.

After some clanking of chairs as the original attendees made space for those subconsciously labelled as latecomers, the room settled down. At least the arrival of the experts might mean Ruth could better understand the backwards compatibility situation. She had even decided to use the term "migration strategy" in her question, if only for her own satisfaction. Just as she was about to ask her question, the door opened again and a face appeared.

"Sorry, we have this room booked now, please can you find somewhere else."

"I don't think so, we booked this room over two months ago on the system."

The face smiled knowingly. "Surely you know that the old system was unreliable and incompatible with our calendar software, so it was replaced a fortnight ago and old bookings are no longer valid? We have followed the new process and we have people waiting outside, could you please ask reception for a different room."

After an embarrassing pause, the attendees in Ruth's meeting realised that once again today they were not welcome, so they packed up their belongings and filed out, being careful to avoid eye contact with the other attendees queuing triumphantly outside. They all huddled in the office kitchen while their host checked with reception. Upon return it was clear it was not good news.

"The only spare room they could find is in…the other building" said the host, with the tone clearly implying the other building was a place of unspeakable pain and torture.

"…but – but, that is the far side of the city centre?!" said one attendee.

"And that's no good, my sky-blue lanyard won't work there, they have purple ones instead – they might expect me to sign in as a visitor!" said one of the local attendees.

Having left home in darkness to travel half the length of the country, Ruth could not really see what was so challenging about walking to another building, however it became clear that it would be too traumatic for those normally based in the building in which they were currently not having their meeting. The host instead proposed they would stand in the kitchen to summarise and agree next steps. They did so for a few minutes until people got fidgety and then dispersed, with Ruth's question left unanswered.

Diverse routing

For the homeward journey Ruth was careful to find a Polka Dots service to suit her ticket and found a comfy seat in the first carriage immediately behind the driver's cab. She often chose to sit there: partly because there were usually more empty seats at the end of the train, also because her railway family genetics naturally attracted her to be within earshot of any interesting cab alarms or conversations that might inform the success of her journey. Before long, her decision was rewarded with a sequence of warning noises for caution signals ending with a complete stop at a signal surrounded by fields several miles from nowhere. This was a sure sign of trouble…

After the traditional pause of a few minutes to create a sense of drama and tension, complete with tantalising muffled snippets of the driver talking to someone on the radio to dilute the silence, a crackly announcement explained that due to a train failure somewhere ahead they would be held at their current unspecified location for an undefined period of time. After passing on this crumb of information, the traincrew met up next to the internal cab door for a team chat.

"Eh then driver, why don't we just couple up to that Swirly Spirals train and push it forwards to the next station?"

"Ah well, we could have done that a few years ago when these trains were new, but when Swirly Spirals took over some of the fleet they did a refurbishment that meant theirs are no longer compatible with ours. I think one of their auto-coupler circuits now carries data about seat reservations and entertainment whereas on ours the same contact pins do something more useful and powerful."

Train interconnection works nicely when the two trains are of the same type, from the same manufacturer, with the same couplers and software.

London Underground embodies many of the complexities of compatibility. Although the fare collection system, telecoms and traction power supply are (more or less) common across the network, there are multiple types of rolling stock and signalling systems leading to different operating procedures. The lines have a mixture of platform heights and even tunnel sizes. Most lines (i.e. the services depicted on the Underground map) have interconnections to at least one other line, some platforms and tracks are routinely used by trains from more than one line (or main line trains), and some Underground trains use Network Rail main line infrastructure to reach outer London destinations.

This leads to safety-critical requirements such as making sure that a big train doesn't try to go into a small tunnel.

Photo Shutterstock/Mark Broomfield.

"How about we ask to take the diversionary route via the branch line down the valley then?"

"Ah, these trains are no longer permitted that way, our axle loads are too heavy for some of the underbridges."

"Or what about that freight line? Surely that can take us?"

"I haven't driven that way for years, I don't know the road anymore, don't have route knowledge."

Ruth was thus able to deduce well before the other passengers that they would be in for a long wait. She unpacked her earphones from her bag to listen to some music, until she realised she had only brought the pair for her work phone which had a different connector to her personal phone where her music was stored. She instead passed the time by amusing herself with other incompatibilities on the train: how the rolling stock designers had carefully designed the window sizes and seat spacings to maximise the scope for window pillars blocking views from seats, and how the overhead luggage racks were fractionally smaller than the widely recognised (and thus incredibly popular) dimensions of airline hand baggage, hence various hand baggage cases could be found on seats, under tables and in the larger floor-mounted racks. And then there were the seats themselves: Ruth felt she was a human of average dimensions in all directions, yet she knew the prolonged journey would soon make her ache.

Ruth was finally arriving home after her long tedious journey and a busy week, so was looking forward to a glass of wine to start the weekend. Upon arrival she was somewhat surprised to find a large parcel inside the porch, so she decided to open that first. It was from her mum, with a note saying: "Grandpa said you might like one of these so I bought it for you xx". She carefully unwrapped the parcel and found a small table lamp inside. Very grandpa, she smiled to herself. Now, to try it out she just needed to find what at work she would always call a lamp (she got told off for not calling it a lamp in her very first week) but in the safe privacy of her own home it really was just a light bulb.

Having rummaged around to find a spare bulb in the cupboard, she tried installing it – only to discover the table lamp had a screw thread fitting, unlike all the existing light fittings in her house which used bayonet fittings. Hmm, this lack of attention to boring technical detail suddenly felt more like mum than grandpa, she thought. She was too tired to phone either of them that night to thank them, only to have to explain the complication. Instead, she found the corkscrew in the drawer, chose a new bottle of wine that looked rather appealing, fumbled with the top until she realised it was a screw top bottle, unscrewed it and poured herself a glass. Ruth finally sat down exhausted and quietly digested the symbolism of the screw top lid and unnecessary corkscrew in front of her, and relaxed.

What do you think?

Have you had similar experiences to Ruth when it comes to compatibility in all of its different forms? Do you think that we as an industry have taken the wrong approach? Perhaps it is different in your country or on your railway and you have managed to deal with backwards compatibility. Maybe initiatives like EULYNX offer a way forward, or maybe you think that standardisation can stifle innovation?

We'd love to hear your views and share them with other IRSE News readers. Email us at **editor@irsenews.co.uk**.

About the author …

Stephen Dapré started his career with British Rail Southern Region. He then moved to Reading, working for Interlogic/Adtranz in construction/commissioning roles and MHA/Lloyd's Register in consultancy. Between 2005 and 2020 he worked for Network Rail's in-house design group on a variety of projects ranging from Reading remodelling and Crossrail to Liverpool Lime Street. At the end of 2020 he returned to his roots, becoming asset strategy manager (S&T) for Network Rail's Southern Region! Stephen is a long-serving member of the IRSE Examination Committee.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

JR East to trial driverless trains

Japan: JR East has announced plans to use a 12-car Series E7 high speed trainset to undertake a series of driverless test runs in October and November 2021 as part of its Change 2027 programme. The trials are intended to test automatic operation to support the railway's longer-term objective of running driverless trains in revenue service on the Shinkansen network.

The tests will also assess the potential transmission of high-definition video using local 5G wireless networks, with a view to future use on the national network.

High speed rail for North America

USA: The US High Speed Rail Association (USHSR) has announced a five-point High Speed Rail Plan for the new president Biden administration. The plan has recommendations for the high-speed rail programme including specific high-speed rail projects. It includes:

Creating a new High-Speed Rail Development Authority to direct and coordinate the national programme. This new Authority would be tasked with initiating new high-speed rail projects, conducting route studies, filing for permits, land acquisition, hiring contractors and consultants, and hiring concessionaires to operate the trains. This includes streamlining the approvals process by allowing simultaneous approvals, shortened timelines, and single agency approvals.

Selecting the top five high speed rail priority projects, designate them "Special Projects of National Significance" and fast-track each to completion with the full support of the federal government. They are California High Speed Rail – $60bn. Texas High Speed Rail – $20bn. iNEC upgrade, New York City tunnels – $50bn. Cascadia Ultra-High-Speed Rail (Pacific NW) – $40bn. Florida High Speed Rail (Tampa-Orlando) – $2.5bn.

Selecting second-tier projects and immediately fund and assist them into early works – planning, route studies, permits, land acquisition, and pre-construction works. These include Chicago-Milwaukee high speed rail – $8bn. Atlanta-Charlotte high speed rail – $18bn. Louisville-Nashville high speed rail – $15bn. Denver-Albuquerque high speed rail – $40bn. Chicago – St. Louis high speed rail – $18bn. Tulsa-Oklahoma City high speed rail – $8bn. Chicago-Detroit high speed rail – $30bn. Nashville-Memphis high speed rail – $15bn. Kansas City – St Louis high speed rail – $19bn investment. Chicago-Indianapolis high speed rail – $17bn investment.

Working with airlines and airports to replace short-haul flights with high speed rail, and extend high speed rail connections to major airports. Encourage partnerships with airlines on combined tickets for trips with part of the journey on a train and part on an airplane.

The US High Speed Rail Association is a membership organisation that has been promoting a national state-of-the-art high-speed rail network since 2009, showcasing the many benefits high speed rail will bring to America. The previous transportation secretary Anthony Foxx said, "there is no such thing as a Democratic or Republican road, bridge, port, airfield or rail system. We must work together across party lines to enhance this nation's infrastructure."

10-year investment plan for Portugal

Portugal: Prime minister, António Costa, has announced a €10.5bn (£9.5bn, $13bn) for 16 rail projects over the next 10 years. The plans include a new Lisbon – Porto high-speed line, with a travel time of 1h 15min; a new cross-border Porto – Vigo line with a one-hour travel time; modernisation and complete electrification of the network by 2030; an increase in capacity in urban areas; and new rolling stock.

€290m (£272m, $352m)has been allocated to increase capacity for suburban services, including increasing the frequency of passenger and freight services in Lisbon and Porto, while another €270m (£244m, $328) has been allocated to implement ERTMS.

Another €370m (£334m, $449m) will support a safety, renewal and upgrade programme, which focuses on noise reduction and climate change protection. The plans include the removal of 155 level crossings and the automation of a further 79, improvement to crossings at stations, the installation of train radios, and the implementation of noise mitigation measures.

City railways

3D augmented reality navigation for passengers

Taiwan: Railway and bus stations in Taiwan are launching a 3D "immersive" augmented reality (AR) navigation system to display schedules, announce delays, facilitate remote electronic payments, provide travel guides and tips, and to lead passengers to their booked seat. The system is being provided by Taiwan's Industrial Development Bureau's "Smart City Taiwan 360" and combines Multi-Access Edge Computing (MEC) servers and beacons to provide precise positioning and navigation services. The system can be viewed inside the station precincts via augmented reality and can be seen at www.smartcitytw360.com.

Communication and radio

Allocation and harmonisation of FRMCS frequencies

Europe: The UIC (International Union of Railways) has announced that the Electronic Communications Committee (ECC) has approved the draft for the official recommendation allocating 5.6MHz in the 900MHz band and 10MHz in the 1900MHz band for Future Railway Mobile Communication System (FRMCS). The decision grants specific conditions of usage, protecting railway operations and providing relevant levels of emissions, thus reducing levels of infrastructure investment in comparison to conventional telecoms networks.

The UIC says it is an excellent and valuable achievement for the entire railway community, and demonstrates that unified objectives and actions in the railway sector can result in highly positive outcomes, even in the event of difficult and sometimes controversial situations, such as fierce competition between industries to obtain 5G frequencies for their own usage.

With this major step forward, and the official launch of the 5G Rail European project to build and test the first 5G prototypes adapted to rail operations, UIC say the FRMCS is well on its way and is becoming increasingly tangible, paving the way to further train digitalisation.

FRMCS demonstrator

Europe: A demonstrator version of the Future Railways Mobile Communication System, as a successor to current GSM-R technology is under way. The 30-month 5GRAIL project has eight work packages with an overall budget of €13m (£12m, $16m). It will be funded through the EU's Horizon 2020 research programme,

The International Union of Railways is in the lead as project co-ordinator. UNIFE represents the supply industry, along with communications and IT specialists Nokia, Kontron, Alstom, Thales, Siemens, CAF and Teleste. Infrastructure managers are represented by DB Netz, SNCF Réseau, SBB, ÖBB and Infraestruturas de Portugal, while the academic and research partners are IFSTTAR-Université Gustave Eiffel from France and DTU from Denmark.

5GRAIL will liaise closely with Shift2Rail, as well as regulatory and standardisation bodies and co-ordination with the EU Agency for Railways will check that FRMCS is compatible with the requirements of the Technical Specifications for Interoperability for Control Command & Signalling.

The development will be based on UIC's Version 1 of the Functional and System Requirement specifications, including interfaces, using 5G to 3GPP Release 16. 5GRAIL aims to validate the draft specifications and have a production version available in 2025, so that railways can start their own national pilot projects, based on the future 3GPP Release 17. The 5GRAIL prototypes will be tested in laboratories and real-world conditions, to ensure FRMCS will be able to support ETCS data, voice group calls and railway emergency calls. The project will also look at cross-border scenarios and coexistence with road-based intelligent transport systems.

Research & Development and Universities

New railway research centre at the University of Birmingham

UK: A new purpose-built centre to deliver specialist research in digital railway engineering has been opened at the University of Birmingham. The university has partnered with the UK Rail Research and Innovation Network (UKRRIN) to commission the facility, with £16.4m (€18m, $22m) in funding from Research England, which will be called the Centre of Excellence for Digital Systems

The centre sits within the Birmingham Centre for Railway Research and Education (BCRRE) and is set to unite existing academic and industry capabilities to innovate and support transformational change within the rail technology sector, globally. It is the first phase of construction work for a £46.5m (€52m, $63m), School of Engineering development. The 3,000m^2 facility offers a variety of contemporary and flexible design and research spaces.

The facility also has project labs, light labs and state-of-the-art equipment including cab simulators, signalling control centre, cybersecurity test lab along with electronic fabrication and technology assets to enable high quality, fast-paced research, through to proof-of-concept and testing. The centre will house specialist research in digital railway engineering, focusing on railway control and simulation, data integration, cybersecurity, condition monitoring and sensing, and improved methods for technology introduction.

Safety

Level crossing near miss due to railhead contamination

UK: On 24 November 2019, the barriers at Norwich Road Automatic Half Barrier (AHB) level crossing, near New Rackheath, Norfolk, England, lifted as a passenger train from Norwich to Sheringham was approaching. The control system at the crossing is a 'constant warning time' type used extensively in the USA but is relatively unusual in the UK. Two road vehicles crossed the railway in front of the train, which reached the crossing less than half a second after the second road vehicle was clear.

The investigation found that there was contamination of the railhead in the area caused by leaf-fall and atmospheric conditions. This contamination had not been removed because there were no railhead treatment trains on the Norwich to Sheringham line at weekends. The narrow band on which trains' wheels were running on the contaminated railhead, which was a consequence of the introduction of new trains, left the wheel-rail interface vulnerable to a poor electrical contact in the event of contamination.

This caused the level crossing equipment to misinterpret the position of the train, and consequently it opened the crossing to road traffic while the train was closely approaching. Since the incident Network Rail have altered the configuration of the control system to reduce the risk of this happening again. The investigation has made three recommendations regarding the planning of autumn railhead treatment, guidance on the introduction of new trains and the configuration control of signalling equipment. The report also identified two learning points concerning the investigation of incidents and the signalling design process and can be found along with a video of the incident at irse.info/tyodr.

Safety in the future

Switzerland: An interesting white paper looking at safety in the future has been published by the International Electrotechnical Commission (IEC). Using real life examples, the paper addresses safety in the future by referencing current social trends and initiatives such as the UN Sustainable Development Goals and various real-life examples of projects, works and companies that are pioneering innovative safety solutions. Common to such solutions is the underlying realisation that the concept of safety will be delivered in an integrated system in which humans, machines and the environment must collaborate.

The paper also introduces a collaborative framework called the "tripartite system for safety". This concept facilitates a systematic approach to examining key elements of safety. The recommendations make interesting reading for rail signalling and telecom engineers, and the paper can be found at irse.info/ps9n0.

Government, regulators, trade bodies and economy

European Year of Rail 2021

Europe: The European Parliament Committee on Transport and Tourism (Tran) has accepted a proposal to dedicate 2021 as the European Year of Rail. This is to support the delivery of its European Green Deal objectives for transport, which calls for accelerating the shift to sustainable and smart mobility. While transport accounts for a quarter of the EU's greenhouse gas emissions, the EU is targeting a 90 per cent reduction by 2050.

As part of the Green Deal, the European Commission (EC) has called for a substantial amount of the 75 per cent of inland freight currently carried by road to be shifted onto rail and inland waterways. While rail share has increased to 7.6 per cent of the passenger market, its share of the freight market has dropped from a peak of 19 per cent in 2011 to 16.65 per cent in 2017.

The Year of Rail will include a number of initiatives across Europe, including:

- Initiatives and events to promote debate, raise awareness and facilitate citizens, businesses and public authorities' engagement to attract more people and freight to rail.
- Exhibitions, information, inspiration, education and awareness-raising campaigns to encourage changes in passenger, consumer and business behaviour and to stimulate an active contribution of the general public to achieving the objectives of more sustainable transport.
- Sharing experience and good practices of national, regional and local authorities, civil society, business and schools on promoting the use of rail and on how to implement behavioural change at all levels.
- The undertaking of studies and innovative activities and the dissemination of their results on a European or national scale.
- The promotion of projects and networks related to the European Year, including via the media, social networks and other online communities.

Competition in the UK signalling market

UK: The rail regulator, the Office of Rail & Road (ORR), is to investigate whether the market for the supply of signalling systems in the UK is fair and competitive. A previous study closed in April 2020 to enable the ORR to focus on the impact of the coronavirus pandemic.

The new study will build on ORR's previous work in the signalling market, including its work with the European Commission on the subsequently abandoned plans for a merger of Siemens Mobility and Alstom. The ORR were concerned that a merger would significantly reduce competition and increase costs.

It will focus on the supply chain for the delivery of major signalling projects, looking at competition and incentives to compete. It will investigate whether there are any barriers to innovation, market entry and the introduction of new technology, and look at the ability of the supply chain to build up capacity for the rollout of Network Rail's digital railway programme. Signalling accounted for more than £4bn of Network Rail's spending between 2014 and 2019, and is forecast to significantly increase as ETCS is rolled out across the network.

ORR has invited submissions from interested parties and will publish a market study report setting out its findings and any actions which it proposes to take no later than November 11 2021. Studies such as this can lead to a variety of outcomes including no action, referral to the Competition & Markets Authority for an in-depth investigation, consumer or competition law enforcement action, recommendations to the government to change regulations or public policy, actions to improve the quality and accessibility of information, or to encourage self-regulation.

European harmonisation

Europe: The EU Agency for Railways (ERA) is now the single certification body for train operators and rolling stock in Europe, as well as for the approval of ERTMS trackside equipment.

31 October 2020 was the formal deadline for EU member states to transpose into domestic legislation the railway safety and interoperability directives that form the technical pillar of the Fourth Railway Package, adopted by the European Parliament and Council in 2016.

Previously, train operators and manufacturers had to apply for separate vehicle authorisations and safety certificates in each member state. ERA has now been given additional responsibility to manage the harmonised procedures with a view to reducing the cost, time, and administration for obtaining approvals. Under the simplified procedure, a single application must be filed through the agency's "One-Stop Shop". This is also expected to reduce the time-to-market for emerging technologies.

ERA executive director Josef Doppelbauer said, "Having started our new role of European authority with initially eight member states in June 2019, we are now crossing the finish line. We have already taken more than 1000 decisions and authorised more than 10 000 vehicles. With the extension of our competence to the whole EU, we reach another milestone on the way to the Single European Railway Area."

Long-term importance of rail

UK: The Railway Industry Association (RIA), the trade body for the UK rail supply community, has called for the Government to consider the long-term importance of the rail network, publishing ten reasons why rail investment should continue, in light of the debate over the impact of Coronavirus on the future of transport.

1. Rail is a long-term game – Investments in infrastructure or rolling stock are usually delivered, and create continuing value for passengers and the wider economy, over years.
2. The reduction in passenger numbers is likely to be temporary – Based on previous economic slumps in the 1980s, 1990s and post-2008, as well as past health crises, passenger numbers have always recovered to continue their pattern of growth.
3. Rail is not just for passengers – It is also vital for freight, with over 4 billion tonne-km being delivered annually before Coronavirus.
4. Rail travel is clean and safe – A study undertaken by RSSB in August 2020 estimates that the risk of infection per passenger journey is 1-in-11 000 journeys, with similar results found in other countries.
5. Investment can support the whole of the UK – The rail network touches almost every part of the country and has the potential to unlock a new generation of talent.
6. Rail can lead the green recovery – It is not possible to meet zero carbon goals for transport without rail. Rail is a green mode of mass transit, contributing just 2.5 per cent of greenhouse gas emissions from transport and only 0.6 per cent of total UK emissions.
7. Rail cannot easily be mothballed – Once rail infrastructure is decommissioned it is not easily reopened.
8. Rail investment has a knock-on economic impact – For every £1 spent on the rail network, £2.20 value is delivered in the wider economy.
9. Investment cannot wait – Much of the rail spending planned cannot be postponed, in order to meet our decarbonisation and digitalisation targets.
10. There is a clear window to get work done – The Covid-19 pandemic has provided an opportunity to get work done with less impact on services, which should be capitalised on before passenger and freight numbers return.

Education, skills and training

Western Australia signalling training facility

Australia: A purpose-built training facility for rail has been completed in Western Australia (WA) to address a critical skills shortage in the rail industry. The Metronet Trade Training Centre at North Metropolitan TAFE's Midland campus is now complete and is focused in addressing the lack of rail signalling engineers. Students at the facility will progress through courses in railway signalling and associated electrical systems qualifications.

News from the IRSE

Blane Judd, Chief Executive

It's a Digital World

When circumstances demand rapid change, the outcomes are frequently beneficial, hastening developments that would usually take far longer to achieve. They say, "necessity is the mother of invention".

That has certainly been the case here at IRSE. The pandemic challenged us all to up our game, and the speed with which our staff, sections, committees, members, and volunteers stepped up to the plate has been impressive.

As engineers we are natural problem solvers, but It is fair to say that if someone had said that within a few short months we would be running a full programme of presidential paper webinars, holding our Professional Examination online and running virtual section meetings we would have applauded the optimism but doubted the reality!

But it is a reality. Whilst Covid has of course had a devastating effect on the world, it also opened up opportunities for us to further raise the profile of the Institution amongst a far wider audience, building on the work we had already started last year with the Future Integrated Railway Think Tank (FIRTT). In a first for the IRSE we collaborated with three other professional institutions (IMechE, IET and PWI) to run the very successful paid-for online Rail Automation seminars in September and October. As major industry events had to be cancelled, organisers moved quickly to set up virtual conferences. Under normal circumstances conference programmes are set up to a year in advance, but the last-minute nature of these digital events put us in a good position to offer our president, Dr Daniel Woodland as a speaker. As a result, he presented at both the 2020 Next Generation Train Conference and the ERTMS & ETCS: The Future of Railway Signalling Conference and was a panellist in the Railway Gazette Rail Broadcast Week.

We hope face to face meetings and events will be able to resume as soon as possible, but the learnings from the past months have been invaluable. Now we have the technology and experience of using it successfully, all future presidential papers will be presented as an online webinar for those members unable to attend in person, opening up the events to our full international membership with the option to watch in real time or on demand later.

Council elections

All associate members, members and fellows will have received their voting papers for this year's Council elections. Voting opens at 0900 GMT on Monday 8 February and closes at 1700 GMT on Friday 5 March. If you would like another copy of the voting form it can be obtained by contacting **electionservices@civica.co.uk**.

Please ensure you vote as it is important that the IRSE Council is representative of all our members. Council members make decisions on the strategic direction of the IRSE, act as trustees of the IRSE charity and ensure that the IRSE's charitable objectives are progressed. Council members also appoint the directors of IRSE Enterprises, the company which, amongst other things, operates the licensing scheme.

Professional Examination

The 2021 date for our professional exam is Saturday 2 October. If you are, or you know someone, planning to take modules B, C or D in October 2021, please note that you must be an IRSE member. For your membership application to be processed in time for you to apply for the exam, please email your application to **membership@irse.org** by 12 February. For details on membership see **irse.info/membershipoptions**. Applications to sit the exam will open soon, keep an eye on the exam page **irse.info/irseexam** for announcements and details.

Merit award

At the Council meeting held on 3 December it was agreed that Mark Glover should receive a Merit Award in recognition and as a sign of appreciation for his voluntary service in the creation of numerous publications, including the annual report, the IRSE Proceedings, IRSE News, publicity material for major events, and the updated CS&TE booklet. The award plaque will be presented to him just as soon as social distancing rules allow. Mark is a fellow of the IRSE and head of strategy support & marketing at Siemens Mobility Limited. He has been a member of the Institution for over 30 years.

Merit Awards were introduced in 2007 In order to recognise meritorious service to the Institution by a volunteer or staff member. The award is made by the Council following receipt of nomination from peers. Meritorious service is defined as making a substantial contribution to the Institution's work over a period of time by organising activities or carrying out specific tasks which have furthered the Institution's aims and objectives.

Presentations competition

The Midlands and North Western section is to launch a short presentations competition in March with prizes for the winner and runners-up. The final will be at the first meeting of the 2021/22 session for the section in September. For full details visit the MNW section page on the website. Visit **irse.info/nearyou** for information about all section activities.

IRSE Council

Daniel Woodland, President

The IRSE is an international global organisation and professional institution for all those around the world engaged in or associated with railway signalling and telecommunications, train control, traffic management and associated professions. While our headquarters is in UK, we are immensely proud of our international organisation, with members in 54 countries, and we are passionate in establishing and maintaining a diverse and inclusive membership. The IRSE is committed to a policy of equality and inclusion for all its members and recognises the value and importance of increasing diversity in the workplace. January IRSE News explained the review of the governance of the Institution which is under way and the need to do all we can to advance the science of railway signalling and communications around the globe.

The governance review will consider how we ensure there is a measured representation across the membership at Council, the governing body of the Institution. We are always mindful that 47 per cent of our members are from outside the UK and it is important the Institution allows all its members to be involved in how it is run.

Council members are elected by the corporate members of the Institution, i.e., Fellows, Members and Associate Members and you will shortly receive an invite from Civica Election Services (formerly Electoral Reform Services) to vote for members standing for election to Council in April. The IRSE is not just for 'signal' engineers and our members include engineers involved in research and development, design, installation, testing, asset management, maintenance, technical support, software, system engineering, telecoms, safety assurance, cyber-security, training, and much more. The organisations they work for include infrastructure managers, train operators, light rail, large manufactures, SMEs, consultancies, heritage railways, universities and training organisations. Therefore, the Council must represent all Institution members wherever they are in the world and in the wide range of activities related to command, control and communication systems. We therefore request members to vote in April for the Council nominations they believe will best represent members in achieving these objectives.

Why not consider standing for Council yourself next year? Being a member of IRSE Council will assist your continuing professional development and you will have the opportunity to develop new skills, make new friends, gain networking opportunities with fellow professionals, and contribute to the objectives of our truly global international Institution. Council meetings have been held remotely via video links for many years and long before Covid -19. It is therefore not a new feature of the Institution and we have developed techniques to ensure all Council members are involved in key decisions. The time difference can be a challenge for Council members located in the east of the world, but we try and vary the time of meetings to accommodate as many Council members as possible.

A Council member's view of the April 2020 meeting with participants from Australia, Hong Kong, Japan, The Netherlands, Singapore, South Africa and the UK. Why not join us?

Professional development

Why is the IRSE Professional Examination important?

John Alexander

As a society we use exams for a number of purposes and most people will sit a variety of these in their lives. Each examination has a different purpose and the emphasis or the focus of these changes depending on one's progress through life.

Many tests are of knowledge – what has been learnt and can it be regurgitated on request. Other times it is skills which need to be proven through practical demonstration, but the most common objective is to assess the application of the skills and knowledge. As children progress through school they see their tests evolve from pure memory to being able to use a range of facts and skills in a particular scenario.

So, what are exams for? Well we use them to confirm that people have reached a minimum acceptable level of knowledge or ability in an area – for instance the UK Standard Attainment Tests (SATs), which are designed to check children have reached an acceptable educational standard at key points in their academic development. A driving test is another example. They can also be used as a means of selection – are you sufficiently advanced in a subject to be able to move onto a higher level of study/qualification, or have you achieved an entry standard for a career or role? And, of course, they are used to rank individuals where opportunities are scarce either in education or the workplace.

What makes the IRSE Professional Exam different from the exams discussed so far? It is the addition of the word 'professional' which you will also see in the legal, medical, accountancy and other professional careers. It is about moving on from testing learnt knowledge, acquired skills and the regular application to the understanding of the reasons behind principles and the ability to develop and justify new solutions. It is often said that professionals make the rules for others to follow.

Each of the IRSE Exam papers tests a variety of areas of knowledge, application, and the underlying principles – whether you are considering the application of standard equipment or the development of a new signalling or telecoms system. Whilst confirming that candidates know "what" should be done, the top marks go to those who can also think "why" it should be done and apply that analysis to new or novel situations and solutions.

Module 3 has for many years addressed signalling principles and the questions have focused on the "why". This emphasis is deliberate to move future lead engineers out of their comfort zones and start them thinking as the professionals of tomorrow.

One exception in module 3 has always been the control tables which are almost purely a demonstration of knowing the rules and being able to apply them in a new, but constrained, situation. The approach taken in marking a candidate's control table is generally to deduct marks for the mistakes and omissions since, with plenty of practice, almost anyone should be able to provide a near perfect answer. When I started marking this module the control tables were the equivalent of two questions, but I never felt they really distinguished the budding professional from the thorough engineer who had learnt the process.

Exams are often regarded as being separate to the workplace – how many of us can list more than a few things that we learnt in higher education which we still use in our daily work? I still use the four Newton equations of motion and occasionally Ohm's law, but other than that I struggle to think of anything else. That does not mean that a degree was a wasted experience because the techniques learnt of research, analysis, discussion, documentation, and justification are very relevant in a role as a professional engineer. What we have examined in module 3 should be equally applicable to the challenges faced in the workplace (and as the more astute will have noticed, some of the questions reflect debates which are taking place – for instance, around cab signalling).

Let us turn to one of the questions from the 2020 paper and see how it is designed to evaluate how far a candidate is on the route to being a professional, chartered engineer.

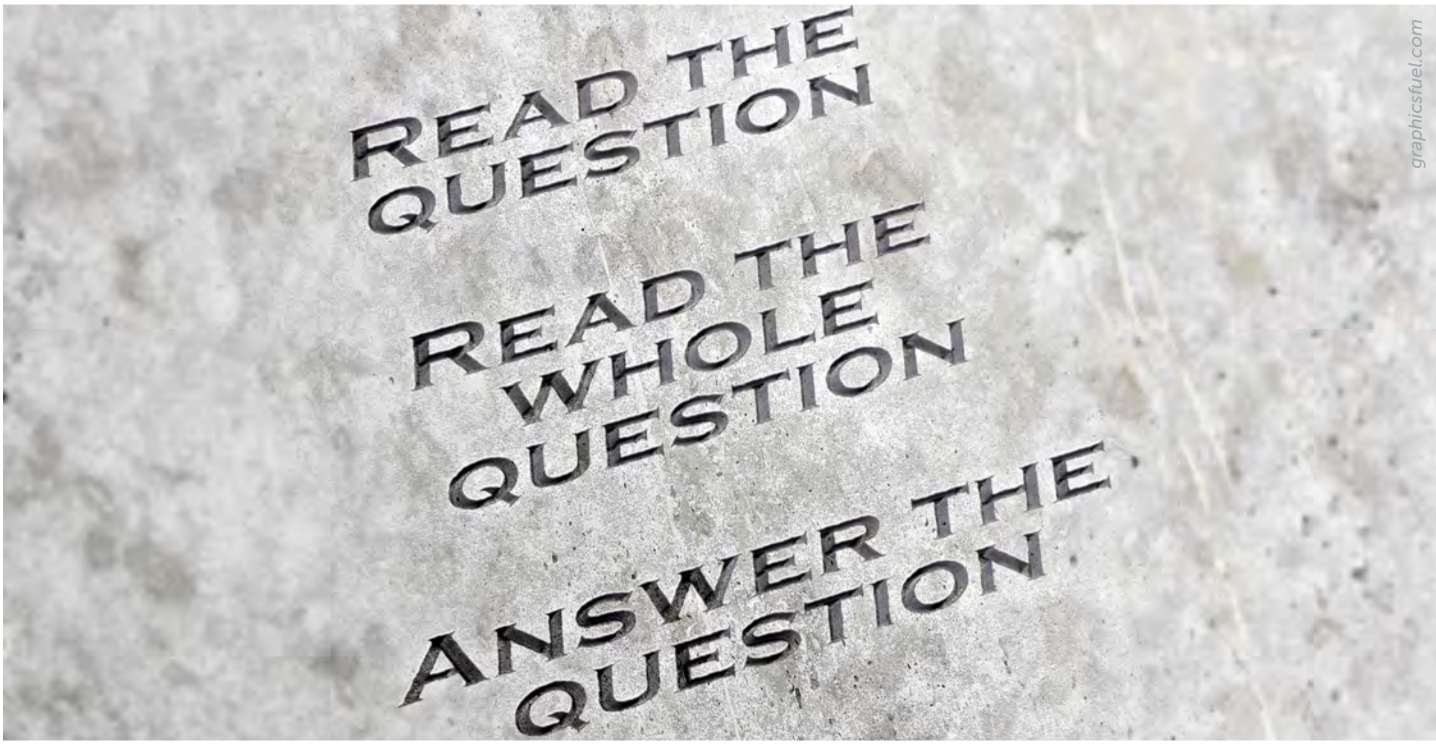
Question 8

There are many signalling systems in use including semaphore, colour light three-aspect, four-aspect, distance based, speed based and cab signalling.

a) For two signalling systems/arrangements you are familiar with describe how a transition between them should be arranged (in both directions) giving reasons. [10 marks]

b) A railway is progressively introducing cab signalling. Considering particularly drivers and signallers, what issues need to be considered where train journeys are mainly in a cab signalled area? [7 marks]

c) In an area of lineside signalling adjacent to the cab signalling area, the frequency of signals passed at danger rises. List possible reasons for this and discuss potential mitigations. [8 marks]



The rules of exam success are set in stone.

The question looks at a common challenge experienced by engineers working on upgrades of an existing railway where there will be times that you have to interface one signalling system to another. With so many potential combinations to be considered, there are not many rules that one can rely on so the professional needs to work out what matters.

Part a) is asking for a description of how two signalling systems could be managed at an interface. Whilst not implicitly stated, to describe the transition you also need to describe the key features of the two systems. With 10 marks on offer a candidate should be considering a description of the technical rules, the driver's experience, degraded situations and, as requested, explain why the arrangement is appropriate.

Looking at the answers submitted for this question a common failing was to describe how the transition would be arranged but very little thought given to the driveability, where the transition should be placed or the hazards associated with such a transition (and hence how they are mitigated).

If we took a UK semaphore transition to UK colour light – as some candidates did – then there are a number of issues to consider including that one is normally moving from Absolute Block rules and principles to those for Track Circuit Block. I was always concerned when reviewing scheme plans where semaphore signals were being replaced by colour lights but retaining the Absolute Block principles. Would a driver less familiar with a route seeing a colour light in the distance at night remember it was an outer home and not part of a three aspect sequence?

The obvious area for consideration is the "aspect" sequence in each direction which will also lead you to thoughts on where any transition can sensibly take place. Going from semaphore to three-aspect one would probably want it to be a clear boundary with a physical separation between the two systems. By completing the signalling for one block post and then, after a distance, starting a three-aspect sequence with a colour light distant could provide a clear demarcation for the driver, helping them to adjust their driving style and also avoid any messy sequences or controls.

The same could be applied for the opposite direction but now we do have some extra considerations. If you have been driving for some time with modern colour lights and you suddenly enter an area of signalling where the semaphore spectacles are lit relatively dimly, then the risk of late detection of signals is high. This can be made worse if the distant signal for the semaphore area is colour light and so consideration needs to be given to providing some form of intensified lighting, the effectiveness of warning systems, such as AWS, and whether the risk of SPAD needs mitigation.

Hopefully, you can see that part a) is not just about stating some rules but is applying the type of analysis a scheme engineer needs to follow when developing a project solution. The reasons for the arrangements and the issues to be considered are what makes the difference between a pass and a credit or distinction.

Part b) addresses a live issue for Network Rail and the GB network – as we progressively move to cab signalling then it is going to affect many people who work on the railways. Obviously, drivers will see different things, but we must also consider the changes for the signaller and for maintenance staff.

Any engineers who have attended the exam reviews will know that the mantra of RTQ (Read The Question), RTWQ (Read The Whole Question) and ATQ (Answer The Question) has been consistent from the examiners of all the topics. RTQ is the first stage in getting some marks and it is disappointing that we often get answers where it is obvious that even if the student has read the words they have failed to think about what they are being asked. In the work environment this is equally important – do you understand what it is that you are being asked to do? If not, then before starting it is important to obtain that clarity and a good professional will challenge and test the remit, establish the stakeholders and what are their real needs compared to their perceived needs, and make sure that it is clearly documented.

RTWQ could be relevant to the question being considered. Many of our exam questions have lead candidates through a series of steps towards the key issues of the syllabus that we are examining. Reading The Whole Question before you start can often prevent you getting into a trap or blind alley. It can also save you effort since if your answer is working progressively towards a goal then there will be less need to repeat information and fewer chances you will confuse yourself or the reader. In a work environment it is equally important that we understand the bigger picture but also that as professionals we break the problem down into a number of stages where we can stop, review and get buy-in from stakeholders before we move on.

In the case of Question 8, several scripts started off by talking about semaphore to colour light but then, in part b) moved on to consider cab signalling. That did mean that, perhaps with time pressures, some of the issues about the arrangement and location of transitions did not feature and they missed an opportunity to demonstrate their understanding of the issues when planning progressive staged deployments.

Probably the biggest failing with this part of the question was that students did not 'answer the question'! This is often witnessed as an answer to the question they would have preferred to have been written, but in this case it was frequently some technical issues totally ignoring the drivers and signallers.

We often encourage young professionals to look at transferring knowledge or experience from outside signal engineering to their work challenges and our IRSE questions. In this instance a good real-life example would be driving along the motorway for a couple of hours and then turning off into a town where the items to monitor and react to change dramatically. Can this be used to think about a driver in a cab signalled train just monitoring the cab display and not having to search for, identify and interpret information outside? What are the risks when the context changes, how can that be mitigated?

So, part b) is a very real challenge for projects about how many stages to have, where to put the temporary boundaries, how to make sure the temporary transitions are as robust and safe as the final ones, how to liaise with all the affected stakeholders, the training needed, etc.

Moving on to part c), this is a good example where reading the whole question (RTWQ) can be to a candidate's advantage since it gives a suggestion of a consequence of the scenario in part b). We received a lot of answers about managing signal sighting, provision of a protection system, such as TPWS, signallers managing route setting, but very little on human factors.

A professional should not be a 'one trick pony' but have a diverse knowledge of disciplines around their core skill set. The ability to identify that there are things that one does not know and then undertake the research is a key part of a professional engineer's behaviour. As discussed earlier, taking your personal experience in another context and applying it to a situation can help to identify hazards or potential problems.

In the answers submitted there was a lot on the potential mitigations but very little on the causes of the problems – without being able to identify what may be going wrong, how can we hope to select the most effective measures? Another key role of the professional is not to accept the status quo but to be continually asking ourselves whether things could be done better, whether things are still necessary, and what is the balance of the effectiveness of the different policies being applied.

This is of particular relevance to signal engineers when applying for a deviation from a standard or justifying a non-compliance. What is the reason for the rule in the first place? What risks is it meant to address? Is the context in which it was formulated applicable or consistent with the situation in which it is being applied? As a mitigation how good is it and are the potential downsides balanced by the benefits?

Hopefully I have managed to explain why the IRSE Exam is not just any old test which you can revise for and then answer almost automatically, but a challenging and stimulating exercise to demonstrate to yourselves and others that you have the core qualities of a professional engineer. I also hope that you have gained an insight into how the questions explore the behaviours which apply equally to the working environment. The questions are tough, but professionals are a tough breed and need to be able to handle adversity in a positive way.

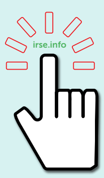
The article above is equally relevant to the new advanced modules B, C & D being introduced for the 2021 examination. The style, format and standard of the questions will remain the same. The time allowed will not change. The examiners will give candidates credit for the same things. Only the grouping of the questions will change. For example, module 3 questions will appear alongside module 4 questions in the new module C. As now, candidates will be asked to answer three questions. The 2021 questions have not yet been set, but it is expected that four of the available 12 questions will concentrate on signalling with four on telecoms. A further four questions could be answered from either speciality or would be based on the application of knowledge that either a signalling or telecoms professional should know.

About the author …

John Alexander is a principal engineer working for Network Rail and has been volunteering on the IRSE Examination Committee for the last 15 years. Module 3 (in the pre-2021 format) concerns signalling principles and John has been the lead examiner for the last eight years. Attendees at the Younger Members Exam Review will recognise the emphasis on understanding why we do things rather than blindly following what has been done in the past.

He is currently developing Network Rail's policies on the implementation of ETCS where the challenges are what needs to be achieved and how do you demonstrate that what is being done meets the safety targets. This involves a detailed challenge of why the ETCS subsets say what they say.

Keeping it snappy with irse.info



Remember when you see an irse.info link in IRSE News, this is your easy way to visit a webpage. Instead of having to type a long, sometimes very long, address just put the irse.info address (e.g. irse.info/irseexam) into your web-browser, or click on the link if you're reading the magazine online, and you'll be at the right site in no time.

Midland & North Western Section

Suitable and sufficient risk assessment at level crossings

Report by Ian J Allison

IRSE
Institution of Railway Signal Engineers
MIDLAND & NORTH WESTERN SECTION

On the evening of Wednesday 18 November 2020 the Midland & North Western Section had its largest attendance to a virtual meeting to date with more than 150 viewing the live event. Andrew Allen of AEGIS Engineering Systems Ltd, based in Derby, United Kingdom, delivered his technical presentation entitled "Suitable and sufficient risk assessment at level crossings" with ease and confidence.

There are approximately 7,500 level crossings in the United Kingdom. Network Rail manages around 6,000 of these, with the others located on metro systems and industrial/heritage railways. Andrew started the presentation explaining the definition of a level crossing and why the management of level crossing risk has become so important. As level crossings account for nearly half of the catastrophic train accident risk on the United Kingdom's railways, he reminded us that the Office of Rail and Road believes that the safe design, management, and operation of level crossings can reduce risk, have a positive effect on user behaviours and so reduce the number of fatal and serious incidents.

Andrew continued to explain the different types and requirements for level crossings, including the difference between an "occupation crossing" and an "accommodation crossing". He explained about manually controlled gated crossings, manually controlled barriers with closed circuit television and now with obstacle detection. Automatic barrier crossings were covered with a mention as to how the automatic barrier crossings of various types work. He continued with a review of user worked crossings and the various types currently in operation with miniature warning lights and telephones. Following a brief review of the Power Operated Gate Opener (POGO) system and the challenges of their introduction, Andrew expanded to talk about footpath and bridleway crossings.

Having provided pictorial examples of specific sites for the many types of the level crossings described, Andrew changed his direction to discuss risk assessment and the requirement that it should be suitable and sufficient when considering the use of each level crossing and any proposed changes to them. This includes consultation with those who may be affected, dealing with obvious significant risks, ensuring the precautions are reasonable and the remaining risk is low, to ensure the level of detail in the risk assessment is proportionate to the risk and appropriate to the nature of the work.

Andrew then talked about how he applied the processes and procedures used within AEGIS and how his organisation applied the Network Rail All Level Crossing Risk Model (ALCRM). This included discussion regarding the level crossing order, current asset condition, planning information regarding potential future rail and road traffic, along with specific data capture applicable to each level crossing. Data capture can include (but is not limited to) photographic evidence, position of the sunlight at certain times of the year, potential flooding, local school access, local authority strategic planning, sectional appendix information and a traffic census for a defined period of time.

Tragically train vs car always has one winner.
Photo Network Rail.

Continuing with this, Andrew explained about how the ALCRM output provides a simplified alphanumeric risk categorisation to assist with evaluating the potential risk reduction options against the legal requirement to reduce risk "as far as is reasonably practicable". This includes calculation of the collective risk to the exposed populations and is expressed in fatalities and weighted injuries (FWI) per annum, along with the calculation of the individual risk to the user which is expressed as a probability of a fatality per year (based on 1 in 100,000). For the purposes of calculating the financial safety benefit, FWI is used, which allows ALCRM to provide the safety benefit and cost ratio as an output.

Whilst reference to the level crossing risk management tool should always be considered in the United Kingdom, optioneering and workshop participation of relevant responsible roles in connection with a particular level crossing is vital before any level crossing decisions are to be made. Andrew walked through two case studies of how AEGIS and Network Rail have applied these processes and tools, and how they came to the final decisions for changes at Brook level crossing and the closure of Matlock Bath pedestrian level crossing.

Whilst there were one or two technical inaccuracies in the presentation, Andrew delivered a robust presentation for somebody who is not trained as an S&T Engineer. The Midland and North Western Section would like to thank Andrew and AEGIS Engineering Systems Ltd for presenting their work and their opinion regarding this interesting subject.

London & South East and Midland & North Western Sections

Interlocking principles and infrastructure data for ETCS

Report by Ian Mitchell

IRSE Institution of Railway Signal Engineers LONDON & SOUTH EAST SECTION

IRSE Institution of Railway Signal Engineers MIDLAND & NORTH WESTERN SECTION

Since the Covid-19 pandemic has prevented face to face meetings, IRSE sections have been moving their activities online. This has turned out to be very successful, with much larger number of participants from a wider geographical area. By coincidence, two of the UK sections recently heard presentations linked to the same ETCS project in the UK, a level 2 overlay onto existing lineside signalling between London Paddington and Heathrow Airport.

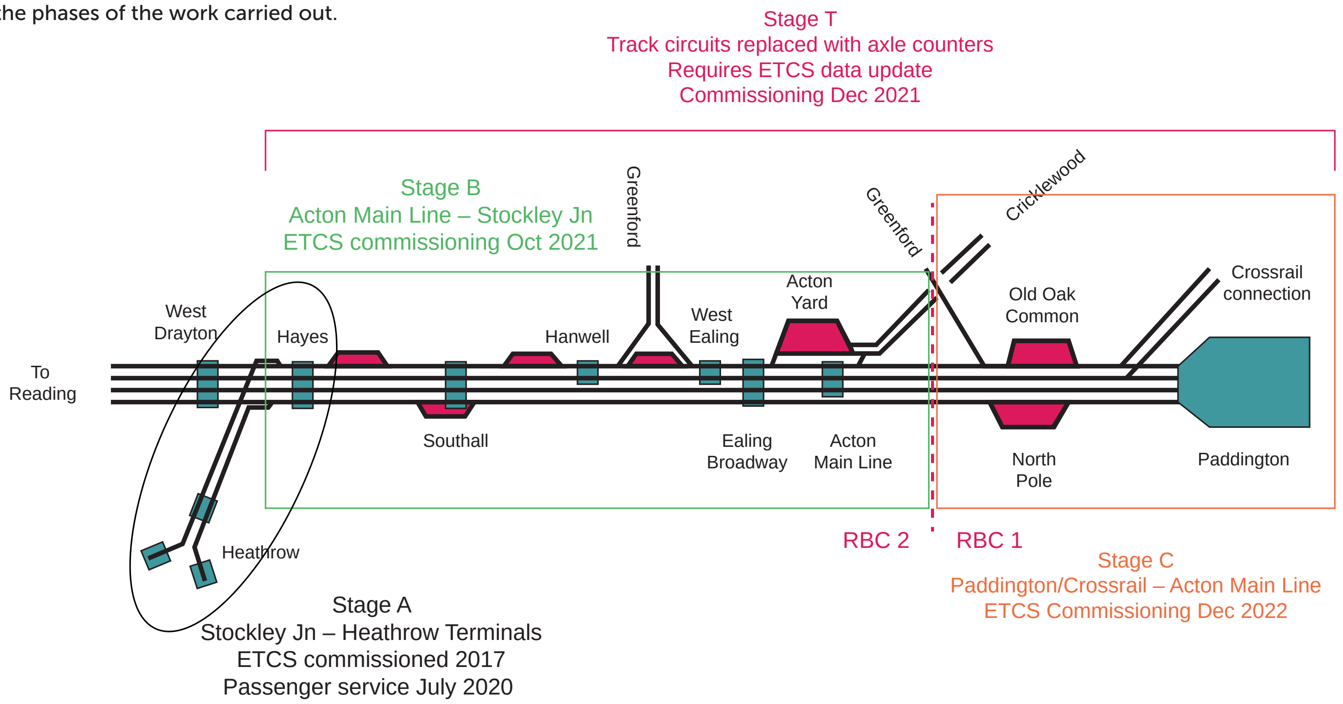
Interlocking principles on the Paddington to Heathrow ETCS project

The London & South East Section talk on 26 November was by Aidan McGrady of Network Rail. Aidan explained the project arose because Crossrail (Elizabeth line) trains to Heathrow Airport will operate through tunnels constructed in the 1990s that were equipped with the obsolete Great Western ATP system. Installation of ETCS level 2 as an overlay allows the large fleet of new trains to be equipped with standard ETCS onboard equipment. The project is being commissioned in three stages, the first stage covering the Heathrow branch is already in service, and the complex section of route along the main line into London follows in 2021 and 2022.

The ETCS onboard system and track to train interfaces are standardised, but the Radio Block Centre (RBC) and its interface to the interlocking needs to be adapted to national signalling principles, especially in an overlay application where there is an existing layout of lineside signals and train detection systems. Aidan described several examples where careful consideration was required on how to configure the new ETCS functionality to work with the existing interlocking principles, and the data to be exchanged between the interlocking and RBC.

Approach locking ensures that if a signaller cancels a route in front of an approaching train, the route remains locked unless it can be proved that the train will stop before entering the route. In conventional UK signalling this is achieved by a timer which maintains locking for the time taken for a train running at line speed to come to a stand, by which time either the train has been able to stop at the signal, or it has entered the route. In some locations this is supplemented by 'comprehensive' approach locking release logic which checks the train detection sections on all possible approaching routes and allows the route locking to be released immediately if there is no train within braking distance of the route entrance. In a complex area, this function can be difficult to specify and test rigorously, so it is used sparingly.

The Great Western Main Line approaches to Paddington showing the phases of the work carried out.



The ETCS equivalent to this function is to send a 'Request to shorten movement authority' to the train. The ETCS onboard equipment then calculates whether the train can stop within the shortened movement authority and responds to grant or refuse the request; if the request is granted the route locking can be released immediately, mirroring the comprehensive approach locking functionality. This is a significant improvement over the conventional approach, as it is tailored to the actual speed and braking performance of the approaching train, and avoids complex interlocking logic, but for an overlay project, it is necessary to consider how to combine this with the existing system.

At first sight the implementation of this ETCS function may seem simple, if a request to shorten the movement authority is granted by the ETCS train, then the conventional interlocking logic can be overridden, and the route can be released. If the request is not granted, then the standard approach locking timer can apply. But what if there was a loss of communication with the train when the signaller cancels the route? The train will not receive the shortened movement authority, and the information the driver sees on the cab Driver Machine Interface (DMI) will display a less restrictive condition than the lineside signals, until the onboard system recognises the loss of communication and applies the brakes. If the driver follows the cab display and not the lineside signals, the ETCS train may brake later than a conventional one would have.

The time to recognise loss of communication is defined by the ETCS 'national value' T_NVCONTACT, which must be chosen carefully – too short a value risks an unnecessary intervention for a short loss of communication – too long a value means the train response to a shortened movement authority is not compatible with the existing approach locking timers in the interlocking. This required the project to review and if necessary, adjust the existing approach locking timers in the interlocking to ensure the following equation is always satisfied:

T_NVCONTACT + Longest time to brake to a stand < Approach locking timer

Aidan finished by looking forward to future ETCS applications without lineside signals – the issue described for approach locking timeout would still apply, but other complications in existing interlockings such as approach control of junction signals would no longer be needed.

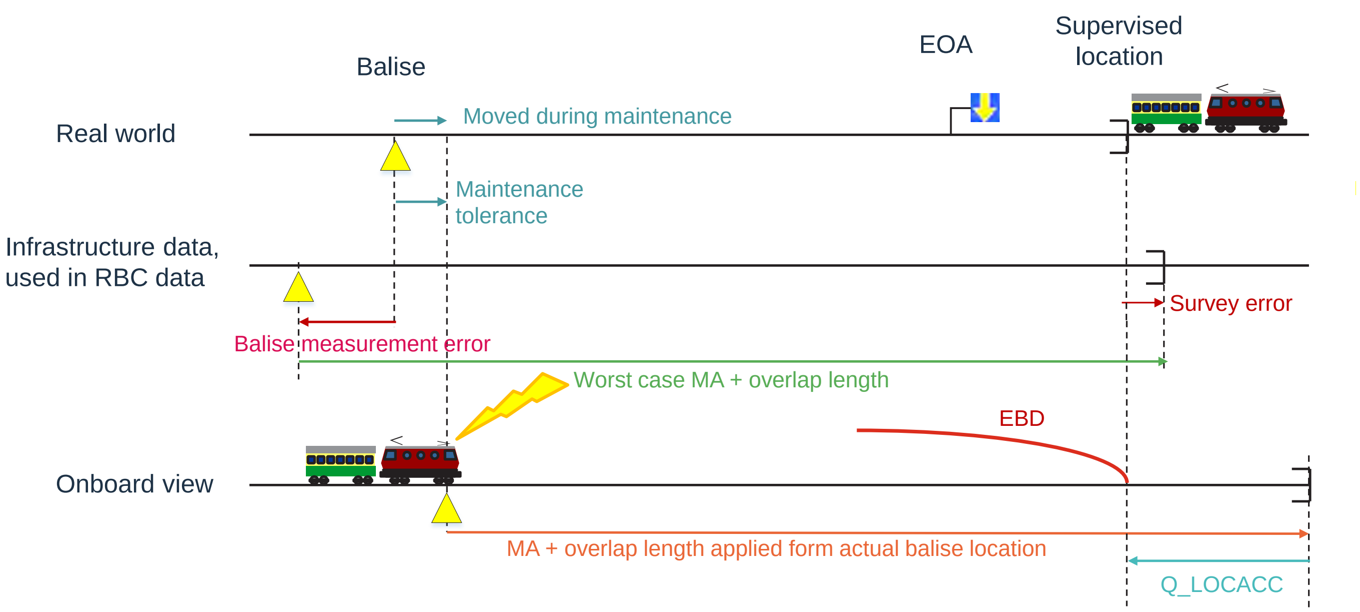
Infrastructure data for ETCS

The Midland & North Western Section talk on 9 December was by Tom Corkley of Alstom, who are the suppliers of the interlockings and ETCS trackside equipment for the Paddington-Heathrow project. He started by explaining the scale and complexity of the project, with 251 signals, 584 balise groups and 658 ETCS routes, and delivered in parallel with other infrastructure works including replacement of track circuits with axle counters and enabling works for HS2 at Old Oak Common.

Infrastructure data is required to ensure the ETCS movement authority sent to a train accurately matches the track over which the train is running. The data needs to be referenced to distances measured along the centreline of the track, taking curvature into account.

- Asset data – position of assets that are relevant to ETCS, e.g., points, signals/marker boards, train detection sections, buffer stops.
- Gradient data – vertical profile of the track, which is converted into gradients
- Speed data – positions at which there is a change in permissible speed

The starting point must be an accurate survey of the existing track, but how accurate? The calculation of position by the ETCS onboard system includes a data accuracy factor Q_LOCACC . This is combined with the cumulative odometry error to calculate pessimistic values for the train front end and rear end locations. But survey accuracy is not the only factor to be considered. All the positioning is with reference to the location of the balises in the track, and there needs to be an allowance of how accurately they can be installed, and for subsequent movement because of track maintenance.



Q_LOCACC > Survey error + Balise measurement error + Maintenance tolerance

The balise measurement error is itself dependent on the survey accuracy of the reference point used to measure balise position for installation, and a rounding error due to the RBC resolution. For the Paddington-Heathrow project Q_LOCACC is set to 3 metres, and this is compatible with the achievable survey accuracy of +/-0.1 metres.

The correctness of infrastructure data is crucial to the safety of the delivered system. Verification and validation of the trackside ETCS is predominantly laboratory based, and the correctness of test results is referenced back to the original data. On site testing with a test train cannot exhaustively test every route and stopping point, and in any case, errors may only be apparent in specific operational circumstances. It is therefore important to maintain integrity of data throughout the design process. For instance, when data is being transformed by manual processes, a 'double branch' approach can be used by which two people independently complete a task and the results are compared. When automated tools are used, there needs to be a diverse process with another tool or a manual check to verify the transformation. File integrity checks to guard against corruption of data or use of a wrong version are also necessary.

Challenges occur when the infrastructure is changing during the project – assets that do not already exist cannot be surveyed, and installation tolerances may be too great to simply use as-designed positions. There may be a need to accept a lower accuracy for some assets that are installed at the same time as the ETCS commissioning and follow up with a new survey and update to RBC data later. Maintaining data during the lifespan of the signalling system will be essential – there needs to be a clear understanding of which changes to the infrastructure may require an update to RBC data.

Tom finished by considering how infrastructure data can be managed in the context of the Network Rail ETCS long term deployment plan, which envisages 600 miles of ETCS installation every year – Paddington-Heathrow is just 16 miles. For this to be achievable further automation of the survey process will be needed, together with standards for infrastructure data, such as RailML. The adoption of BIM (building information modelling) standards across all the engineering disciplines may be the way ahead.

These were two fascinating talks, looking into some of the practical detail of ETCS applications, but pitched at a level to be understood by engineers who have not yet worked on this type of project. There are now a few hundred more people in the world who know about T_NVCONTACT and Q_LOCACC. If your local section has had a presentation about ETCS please provide a write-up for IRSE News and tell us about your favourite ETCS variables.

Past lives: Joe Noffsinger

Sadly, Joe Noffsinger FIRSE of Lee's Summit, Missouri, USA died aged 69 on 29 November 2020.

Joe joined the IRSE as a Fellow in 1993, and served for many years as a member of both the North American Section Local Committee and the International Technical Committee. He was a second generation railroader and put himself through college studying electrical engineering at Case Western Reserve University by working as a brakeman on a short line railroad in Cleveland, Ohio. After graduating, he started his career with Conrail in the Communication and Signal department. He rose through the department to become regional chief engineer, assistant chief engineer and chief engineer, C&S. He served as chair of the Communication and Signal Division of the Association of American Railroads in 1995-1996. He later joined Harmon Industries as vice president of Engineering and led Vaughan Harmon, the UK based subsidiary of Harmon Industries and later GE Transportation.

After returning to work in Grain Valley, Missouri, Joe held various positions at GE Transportation including having responsibility for strategic planning, signal products, and market and product development. He retired in May 2016.

Joe was a licensed engineer and the holder of many patents. He travelled all over the world and was a very innovative engineer with an excellent reputation worldwide. He was a lover of French wine and food and spoke French fluently. He enjoyed many hobbies amongst them, car restoration, growing grapes, making wine, photography. He very much enjoyed attending IRSE International Conventions with his wife Helga as they combined his love of both communications and signals with their love of travel.

Joe will be missed by his many friends and colleagues.

W J Scheerer, HonFIRSE

Your letters

Swiss C-DAS experience

After reading the article of C-DAS in the December 2020 issue of IRSE News I would like to give some feedback based on my experience. I have seen many discussions about C-DAS in last 10 years and I think a technical clarification (or classification) of what 'C-DAS' is would help the article.

1. There are different ways of updating the train with information, including:
   a. Raw data: i. Dynamic train (onboard) information from systems belonging to the Railway Undertakings (RUs) e.g. onboard sensors, TCMS (Train Control Management System). ii. Dynamic trackside information from systems belonging to the Infrastructure Manager (IM) e.g. trackside sensors, digital map, TMS (Traffic Management System), GNSS. iii. A combination of train information and trackside information from systems belonging to both RU and IM.
   b. Processed data with actions for i. speed control, ii. traction/brake control and iii. door control.
2. The processed data for the core calculation of C-DAS (e.g. train speed profile) can be calculated in several ways.
   a. Calculated trackside by the IM and the result transmitted to the train.
   b. Calculated onboard by the RU based on raw data received from the trackside.
   c. Partially calculated trackside and partially calculated onboard the train.

Many products are called "C-DAS", but they have fundamental difference in architecture meaning. They could be C-DAS-Central(IM), C-DAS-Onboard(RU), or C-DAS-Integrated(IM+RU). When it is C-DAS-Central or C-DAS-Integrated, part of the core calculation is redundant with TMS functionality.

I think a clear definition or the classification of C-DAS is needed and defining the requirements, architecture and interfaces is essential for interoperability. 2.c is very close to the current ATO specification workshops in Shift2Rail. Because the trackside (TMS) calculation might be the same, only the execution on the train is different, which is done either by driver (DAS) or automatically (ATO).

3. The other concern is about "frequency":
   a. How frequent should the information for the driver be sent?
   b. How frequent should the system update the driver if he does not adhere to the advice?
4. When the C-DAS model is the type 1.b + 2.a/2.c, it is necessary to analyse why the driver is not adhering to the advice. The reasons could be:
   a. the inaccuracy of advice calculated from trackside, for example, the practical train maximum acceleration is not taken into consideration by TMS.
   b. The inappropriate display of the advice on DMI or other GUIs.
5. The architecture design of C-DAS should consider additional future technical possibilities, for example interfaces to other systems.

Xiaolu Rao
Senior project manager ATO
Swiss Federal Railways

Safe software

In the article "Configuring safe software driven systems" by Rod Muttram in December IRSE News, the author has rightly emphasised the catastrophic consequences of incorrect input data provided by a single source in a safety critical system. Irrespective of how much defensive architecture we employ and how much redundancy is provided in the architecture, if the input data itself is corrupted, the system is likely to produce wrong output which may be unsafe too. In the case of the recent crashes of Boeing 737 MAX discussed, although the aircraft had two angle of attack sensors, the flight control system continued to rely on the output of the defective sensor; this was a problem of the Redundancy Manager system, which should have detected the error in the defective sensor and brought in the good sensor to service, or it should have shut down the Manoeuvring Characteristics Augmentation System (MCAS), given an alarm to the pilot and let the pilot control the aircraft inclination. After all MCAS, similar to Automatic Train Protection (ATP), is not critical for the flight operation; the pilot can very well manage the function manually. Perhaps this was the intention behind providing only two sensors in the Boeing aircraft, while its competitor, Airbus, has 2oo3 architecture for the sensor.

Can this happen in railway signalling? Well single source of input data cannot be avoided in case of railway signalling. For instance, track circuit relays, point indications (NWK and RWK), Signal ECRs – they all provide single source data. Their correctness up to the point of relay contacts is time tested and considered to be fail-safe as a 'grandfather's right'.

What happens at the interface of the relays with the electronic subsystem? We either convert the relay status into two orthogonal inputs by reading both the front and the back contacts of the relay and check the consistency of the inputs, or take the front contact and use reactive safety techniques for verifying the integrity of the electronic part of the circuit. Both techniques are considered to be fail-safe and are compliant with the safety requirements of the CENELEC standards. Where the inputs cannot be fail-safe, like the one coming from the tachometers, we employ two independent sources for the input. For instance, in CBTC/ETCS level 2, Doppler radar/accelerometers are used as the second source of the speed data. Although the main reason for using the second source is to correct the error arising out of wheel slip/slide, I am sure, data consistency and plausibility checks between the two sources must have been included in the software. If not already done, we must learn the lesson from the accidents of Boeing 737 MAX and include this feature in the software.

On a different note, the various architectures of safety systems explained in the article, brought back the fond memories of early 1980s when electronic interlocking systems were being developed by various railways/companies around the world. While the then British Rail, in association with Westinghouse (-> Invensys Rail -> Siemens) and GEC (-> Alstom), and Japan National Railways (JNR) were developing 2oo3 hardware redundancy. Ericsson (-> ABB -> Bombardier) and Union Switch and Signals (-> Ansaldo -> Hitachi) were relying on single hardware/diverse software architecture. At the same time, Indian Railways were developing a loosely synchronised 2oo2 architecture, which allowed, at a given time, one unit in active mode and the other in self-check mode, thus utilising a common shared bus and associated hardware. Their outputs would be compared after the full cycle when both the processors had completed the processing.

It was interesting to listen to the arguments put forth by the hardware and software redundancy lobbies. The former argued that any fault in one of the units of hardware, would be detected in time and the system would perform a reconfiguration or safe shutdown before occurrence of any unsafe event, while the software redundancy lobby would argue that the independent and diverse versions of the software would not only detect the random faults in the hardware, but the systematic faults of the hardware as well as software, as the two versions of software were using inverted data and inverted logic. However, the claim of independence and diversity of the software versions should not be taken at face value; it should be examined critically as the software designers/programmers tend to adopt similar procedures and are liable to make similar mistakes. Experiments conducted on this subject have shown that software programs developed by 'independent' agencies are not adequately independent.

Reliability as well as safety comprise a long chain of too many links where strength of the chain is finally determined by that of the weakest link. We need to be careful to strengthen each link from data input, processing, redundancy, redundancy management and data output to get the desired reliability and safety levels. The instance cited by the author, where all the three channels of a 2oo3 system were powered by a single source (the other power supply catering to the fans) is a good example where the weak link of the shared power supply would largely annul the RAM benefits of the 2oo3 architecture.

Mukul Verma, India

Re Lessons from a different railway

Thanks for the December edition of IRSE News. Just a couple of comments about Karl Davis's article:

He mentioned that "One characteristic of railway work is repetitive routine.....". This is not a novel idea, indeed, historically, it was well understood with regard to the deployment of the AWS on the former Southern Region. There was a fair bit of opposition to it on the grounds that there were many normal situations where drivers had to respond to it frequently. There was even some experimental work done to develop a more sophisticated system that could differentiate between double yellow and yellow aspects (SRAWS – **irse.info/f6rj8**), but it was abandoned around 1975 . There were (and quite likely still are) many situations where anything better than double yellow was unusual.

Worth noting that the implementation of more complex arrangements using 'flashing yellow' displays, such as that at Colwich junction, increased over time. On the front cover, there is an image of the well-known HST which, kind of, led to the development of this arrangement in the first place, on account of the improved braking system operation, and the need to make best use of the available layout. I think the first location where it was used was a 125/70 mph junction (Wootton Bassett – not "Royal" in those days!). The continued use of "route signalling", rather than "speed signalling" was the real issue, perhaps, but it was necessary to enhance the performance of the available system. The interface between permanent way design, traction, and that of signalling was often a significant factor. Not much point in building something that could not be used; it would be a waste of expenditure.

With regard to the development of TPWS, it might be worth noting that there are quite a few failure modes which result in its absence altogether. Quite controversial at the time, but as the article says, it's a much cheaper alternative. A philosophical shift led to its implementation to a large degree, so 'something was done'. In this context, the other article which mentions the definition of Safety Integrity Levels (1-4) is relevant.

John Keepin, UK

Possessions and blockades

It was gratifying to read the article by Frank Heibel in the December IRSE News. At least one engineer seems to have a conscience about the disruption and heartache that prolonged blockades can cause to the travelling public.

In the UK, the situation seems to be getting worse and the recent blockade on the East Coast Main Line (ECML) is sadly typical of what has become the norm. Network Rail, the infrastructure Manager in Great Britain has a slogan "Put Passengers First". Well, they have a funny way of showing it.

It never used to be like this so what has changed? To have put forward blockade proposals that shut main lines for days on end would never have been contemplated at one time. There were line closures when a major resignalling took place, but these would have been restricted to an overnight Saturday/Sunday possession with services needing to be restored by late Sunday afternoon. It might have been granted longer if alternative routes were available or if two lines of a four-track railway were kept operational. I lived on the ECML during the 1970s when the resignalling at Kings Cross took place. The station never closed during the entire remodelling work with the station operating in two halves. The train service was cut back slightly, and use was made of the connections to and from the lines to Moorgate. Admittedly that option is no longer there but instead the Thameslink lines to St Pancras in London now exist to offer a service from Finsbury Park if the main line trains must be terminated there.

It seems to me that the engineering ethos these days is one of 'how long a blockade dare we take'? Much of it I know is driven by the reduction in cost that a full closure allows. The civil engineer is dominant in this thinking and regards even the most straightforward relaying as needing a full blockade over a weekend. What has happened to single line working? Are the relaying machines so complex that both tracks of a two-track railway are needed? Or is it just laziness on the part of the engineer to take the easy way out? Signal engineers are not immune from this paralysis and when things go wrong, lines can be shut for weeks on end, viz the Manchester South resignalling closed the main line from Cheadle Hulme to Crewe for months whilst the new signalling was being made fit for UK conditions.

Some will claim it is enhanced safety rules, but overzealous safety is as bad as insufficient safety. What happens to the elderly who must cross bridges and clamber up steps into buses often with heavy luggage? Is this a safety risk in itself? Never mind all the anxiety and worry as to whether 'meeters and greeters' will be in the right place. Does the travelling public really accept these conditions without being put off rail travel for future journeys?

I look forward to the day when engineers only ask for blockades as a last resort and do everything within their ability to keep the train service operational during engineering work. As Frank Heibel says, it is all a question of mindsets and at the moment, the mindset is completely wrong.

Clive Kessell, UK
past president IRSE

December issue

Thank you for the shorter articles published in the December 2020 IRSE News. They are super informative but also readable as simple two-page articles. Perfect to read during a coffee or lunch breaks. I hope that the IRSE continues to provide articles just like these, short but informative. Instead of 8 or 10 page articles which are really time consuming which I never get to finish reading. Thanks very much for your service.

Sri Sai Moulya Chandra Bose, UK

Editor: We try to provide both shorter, easy to read, articles and longer, more academic papers. If you have anything you would like to share with other members email me at editor@irsenews.co.uk.

RePast Lives: Michael Page

I worked with Mike Page on KCR, and recognise the picture at University South – because I took it!

I used to come into my office in Hung Hom goods yard to find a 'Post-it' note signed "IMP".

I also worked for David Norton in the Westinghouse R&D department – after KCR – though he had signed my IRSE application form some years earlier – when he probably did not know who I was.

So a sad issue of many memories.

Nicholas T Smith, UK

Quick links

IRSE
Institution of Railway Signal Engineers

The IRSE Knowledge Base, an invaluable source of information about our industry.

Our sections, IRSE activities taking place near you.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

IRSE News

Institution of Railway Signal Engineers

March 2021

Automation
in control centres

Driver fatigue
and automatic train operation

Rail and the IoT
intelligent railways

At Signet Solutions we are proud to be supporting essential national transport infrastructure through our key worker training. Our covid-secure training centre remains open for business for essential in-person training, and wherever possible our training is now available in online delivery format for your maximum peace of mind. This is helping you, in these challenging times, to develop your most valuable resource - YOUR PEOPLE!

+44 (0)1332 343 585

enquiries@signet-solutions.com

www.**signet-solutions**.com

Signet Solutions

Raising the Standard in Development

IRSE///
Institution of Railway Signal Engineers

Issue 275
March 2021

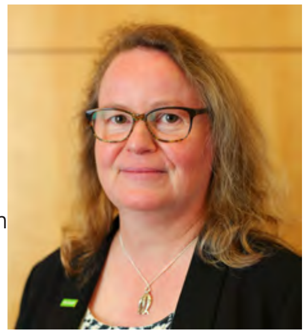
In this issue

Feature articles

News and opinion

From the IRSE

Keep learning



We all have had a lot of change over the last 12 months or so, within our personal and professional lives. Some of this has been positive whilst other changes have been devastating. This 'news view' is looking at the positives, but I would like to use this opportunity to thank all within the industry who have kept vital passengers and freight moving throughout these challenging times, and to acknowledge those friends, family and colleagues who are no longer with us – we miss their friendship, knowledge, and experience.

Travel and lockdown restrictions have led to some local sections' technical talks and the Presidential Programme lectures now being successfully delivered online. These, along with the Younger Members' online exam study workshops, have reached out beyond those who would normally come to events in person, enabling many to come to the 'live' event or watch the recordings via our Vimeo channel (**irse.info/vimeo**). Of course, we are looking forward to meeting with people again, but hopefully we can find a way of continuing the online option for those who still can't attend in person.

Consideration of current legislation for charities and businesses has led to a working group of Council members reviewing the memorandum and articles for both IRSE Charity (the institution) and Enterprises (the company wholly owned by the charity). They are taking proposed changes to Council, and if accepted, these will be taken to the AGM to be voted on. When considering these changes, remember to ask yourselves the why, what, how, who, when, where questions, for example "why are these changes taking place", "what's this got to do with me" or even "what would happen if these changes don't take place?"

"Be curious and keep learning" is my motto. Throughout these challenging times there are numerous ways of developing your professional knowledge with the IRSE, through attending our online technical talks, sitting our online exams in October and not forgetting reading IRSE News!

Judith Ward
director of operations, IRSE

Cover story

Freight rail transportation is important in all parts of the world to help move goods sustainably with less emitted carbon than other forms of transport.

This month's cover shows the Alyth flat switching yard in Calgary, Alberta on the Canadian Pacific Railway. From start to finish, the yard was completed in just three months at the end of 2018.

It is a 168-acre (0.68km^2) Class 1 railway facility and the railway's busiest yard in Western Canada.

The facility is designed to handle approximately 2200 rail cars at capacity, and is supported by satellite yards in Ogden Park, the Industrial Yard Office (IYO) and the Calgary Intermodal Facility at Sheppard.

The design uses dual-controlled hydraulic switch machines with LED indicators, axle counters for train detection, and vital processors as controllers.

Photo David Thurston

Automation in railway control centres


Ian Mitchell and Nora Balfe

"What should we automate?" and "How should we automate?"

This article is based on the sixth paper of the 2020-2021 presidential programme, which was presented online on 4 February 2021.

When automation is considered in the context of transport, automatic driving of the individual vehicles first comes to mind. On railways we have over 50 years' experience of metro trains with a variety of 'grades of automation', and the highest grade GoA4 'unattended train operation' is now routine for new lines. This experience has clearly demonstrated that the combination of a high capacity signalling system such as ETCS with automatic train operation (ATO) is the way to maximise capacity, and this is increasingly seen as a 'game changer' for main line railway networks as well as metros.

The other side of transport automation is in the management and co-ordination of the vehicle movements, and again there is a long history of this in the railway industry. Automatic signalling systems to control train separation on plain track have been around for over 100 years, and these were followed by electro-mechanical systems that could be programmed to set routes through simple junctions. By the 1980s what we would now recognise as a modern railway control centre was emerging with automatic route setting (ARS) by an electronic computer. But even today, we still have a human in the loop, we may call him/her a signaller, operator, dispatcher or controller, and the human and the computers have to work together to manage the operation of the railway.

At the IRSE's ASPECT 2015 conference our current President, Daniel Woodland, was one of the authors of a paper with the title Automation in Railway Control Centres: avoiding the 'bridge too far' [1]. For his Presidential Year, he has set us the challenge of looking in more detail at the current state of the art in railway control centres, and asking the questions "What should we automate?" and "How should we automate?". In doing this, we have been supported by the IRSE's International Technical Committee, whose members have completed a questionnaire about the state of the art in main line and metro control centres around the world.

Key functions of a control centre

The range of functions carried out within a signalling control centre can vary a great deal between operators, but for the purpose of this paper we will consider two key functions:

1. Managing train movements through the network.
2. Managing access to the track

The first of these is what we initially think of as the traditional 'signaller' role in a system with minimal automation. The location of each train needs to be monitored, and routes set through the track network so that it can proceed on the planned route, in step with the timings set out in the timetable for the day. ARS is now the norm in modern large control centres, which means that the role of the operator is one of monitoring the progress of trains and intervening if a delayed train or infrastructure incident means the timetable used by ARS becomes invalid. The facilities available to the operator vary between systems, but typically it is possible to switch off ARS for one train or for all trains at a specific junction or station, and then set routes manually to manage the incident. For a more detailed description, see a recent IRSE News 'back to basics' article on Operator Interfaces [2], and an earlier article with more detail about the specific implementation of ARS in the UK [3].

The second task may seem to be a secondary one, but it is just as vital. Access to the track is required for trackworkers to undertake maintenance activities, and by members of the public to cross the track at a level crossing without an automatic protection system (known as a 'user worked crossing' in the UK). The control centre has to respond to these requests, and co-ordinate the granting of access permission with the train movements. In contrast to route setting, this is often an entirely manual process. Requests for access to the track from staff and public are by means of a telephone call to the control centre, and the operator in the control centre has to establish the location where access is required, apply 'reminders' to the interlocking to prevent both manual and automatic route setting in the area, and give a verbal authorisation to allow access. A paper form-filling process is often used as a prompt to ensure the correct procedure is followed and provide a record.

Other functions such as fault and incident management, control of electric traction and plant such as moveable bridges, monitoring of safety and security at stations, or customer information may be co-located with the core functions listed above or may be handled elsewhere; in this paper we focus on the two key functions above.

"Trust in automation (as between people) is notoriously difficult to build and very easy to destroy"

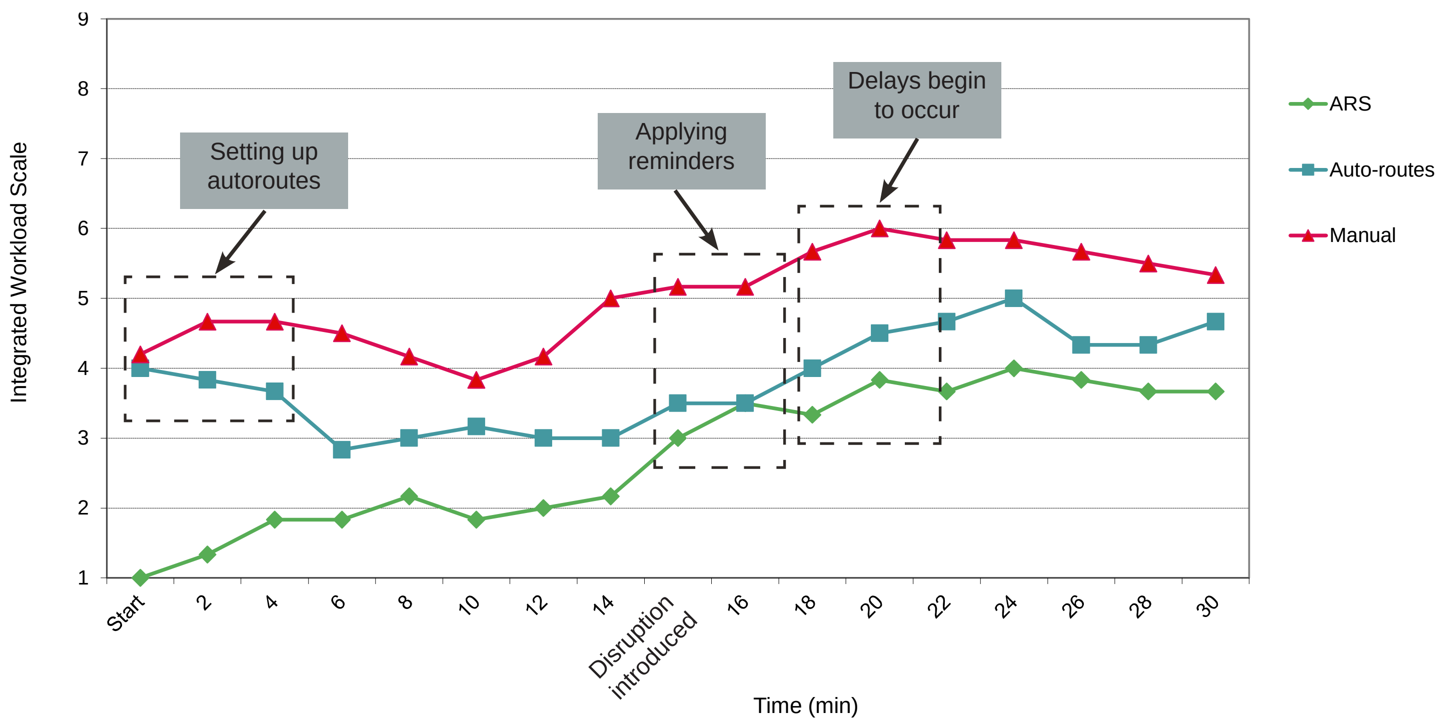
Issues that arise with existing level of automation

The level of automation described above is now well established – we have over 30 years experience of ARS on the UK main line railway – so what has been the experience and where is the need for improvement? In this section we will look at three issues that have arisen: workload of the operators, trust in automation, and human reliability issues that have led to safety incidents.

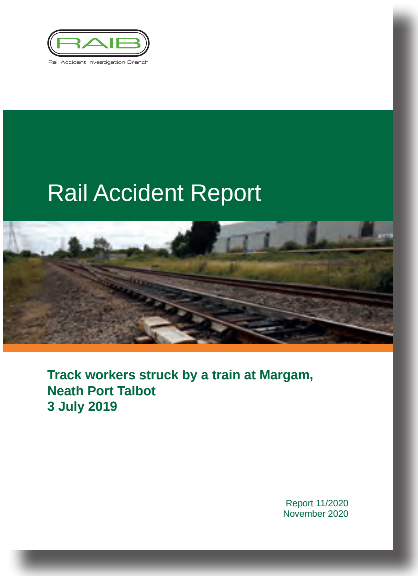
Research has found that ARS does effectively reduce signaller workload, but the effect is most apparent during normal operations and under disrupted conditions signallers can experience a very sharp increase in workload as they deal with both manual route-setting, interaction with ARS and the communications for dealing with an incident. As control areas under ARS tend to be larger than manually controlled areas, signaller workload can be very high under failure conditions. ARS also increases mental workload, as signallers try to predict what actions it will take. This can result in signallers switching off ARS because they are unsure whether it will route trains as they anticipate. The lack of trust in the system also increases signaller workload.

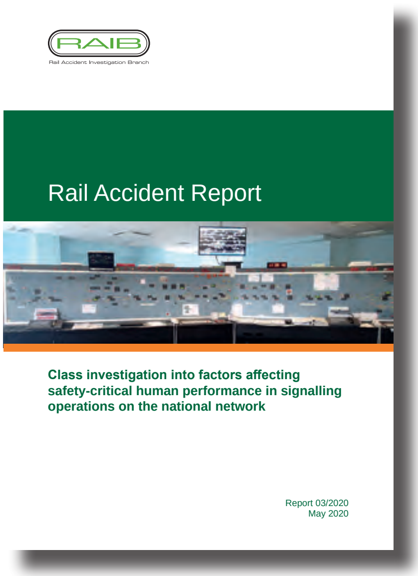
ARS, as implemented on the UK main line network, suffers from a lack of feedback to the signaller on its planned actions. Although there is an ability to query planned routings, this is a cumbersome activity and since ARS constantly reviews routing options, it may not reflect what actually occurs. Signallers can perceive this as ARS 'lying' to them, and it serves to reduce trust in the system. Trust in automation (as between people) is notoriously difficult to build and very easy to destroy – a single poor regulation decision by ARS can reduce a signaller's trust in the system and the result of poor trust is that the signaller becomes less willing to use and rely on ARS [4]. This is in contrast to interlocking systems, which are extremely reliable and typically considered inherently trustworthy by signallers.

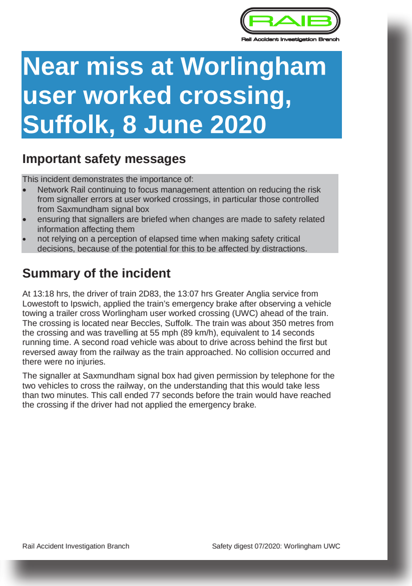
While the interlocking is extremely effective at preventing unsafe routing and ARS provides support in maintaining train performance, the signalling role still includes tasks which are vulnerable to human error. These include operation of level crossings, providing access to the railway for maintenance, and providing authority for trains to pass signals at danger. There is little automated support provided for these tasks and the lack of user centred design in signalling systems can serve to reduce human reliability in their performance, for example due to deficiencies



With ARS signaller workload is low in normal operations but rises significantly when disruption occurs. [9]






RAIB
Rail Accident Investigation Branch

Near miss at Worlingham user worked crossing, Suffolk, 8 June 2020

Important safety messages

This incident demonstrates the importance of:

- Network Rail continuing to focus management attention on reducing the risk from signaller errors at user worked crossings, in particular those controlled from Saxmundham signal box
- ensuring that signallers are briefed when changes are made to safety related information affecting them
- not relying on a perception of elapsed time when making safety critical decisions, because of the potential for this to be affected by distractions.

Summary of the incident

At 13:18 hrs, the driver of train 2D83, the 13:07 hrs Greater Anglia service from Lowestoft to Ipswich, applied the train's emergency brake after observing a vehicle towing a trailer cross Worlingham user worked crossing (UWC) ahead of the train. The crossing is located near Beccles, Suffolk. The train was about 350 metres from the crossing and was travelling at 55 mph (89 km/h), equivalent to 14 seconds running time. A second road vehicle was about to drive across behind the first but reversed away from the railway as the train approached. No collision occurred and there were no injuries.

The signaller at Saxmundham signal box had given permission by telephone for the two vehicles to cross the railway, on the understanding that this would take less than two minutes. This call ended 77 seconds before the train would have reached the crossing if the driver had not applied the emergency brake.

Rail Accident Investigation Branch — Safety digest 07/2020: Worlingham UWC

There have been several recent reports from the UK Rail Accident Investigation Branch highlighting issues relating to track access and user worked crossings.

in the information provided, gaps in procedures, or time pressure to complete safety critical tasks. A recent report from the UK Rail Accident Investigation Branch has analysed a number of recent incidents where this was a factor [5].

Strengths and weaknesses of computers and humans

In considering how to deal with these issues, it is important to understand the strengths and weaknesses of computers and humans. Computers are good at fast and accurate processing of large amounts of information, provided the data is available in a machine readable format. They will always make the right decision if the criteria are clearly defined and correctly implemented in the software, and the information is available and correct. They can take action rapidly and accurately, without any risk of distraction by other events in the control centre. Humans, on the other hand, can deal better with missing data, or make use of information not known to the computer. They can deal with uncertainty and poorly defined decision criteria, learn from experience and one another, and adapt to changing priorities over time.

> "Computers are good at fast and accurate processing of large amounts of information, provided the data is available in a machine readable format"

So how well do our existing systems and processes for the two key functions we identified above exploit these capabilities?

> "Humans, on the other hand, can deal better with missing data, or make use of information not known to the computer"

The train routing function is already highly automated. The execution of route-setting is always automated and protected by the signalling system via the interlocking, irrespective of whether the decision to set a route is taken by the signaller or ARS. ARS additionally automates the decision on which route to set and when. The decision making process is simply based on the timetable when all the trains are running on time, but when conflicts arise as a result of a train deviating from the plan ARS uses an algorithm to decide which train to give priority. This may be a simple rule such as 'first come, first served' or a more sophisticated one using more complex rules and the data in the timetable and train movement reports. However, there are situations where a signaller can make a better decision using additional information or experience that is unavailable to ARS, and will set routes manually. This requires the signaller to continuously monitor the ARS and predict what it will do, so as to decide when to intervene. This is not always easy, and ARS can sometimes set a route that confounds the signaller's plan – sometimes the human and computer end up working against one another rather than collaborating.

By contrast, the track access function has very little automated support. There is a lot of reliance on voice communication and paper records. The train location information provided by the signalling system is designed around the requirements of interlocking and route setting – a user worked crossing or track access location can be in the middle of a very long train detection section. While the signalling system provides a 'reminder' function to inhibit route setting and points movements, the signaller has to decide what protection is required for a particular track access and apply each element manually. The lack of automation can result in high workloads at the start and end of service where multiple line blockages are being taken or returned, or during harvest periods when farm traffic over user worked crossings is high. Limits have been imposed on the number of concurrent line blockages in an area to manage signaller workload, and this can result in trackworkers opting to use less safe systems of work such as a lookout warning system on a line that is open to traffic [6].

So what are the areas for improvement?

For train routing, we already have a high level of automation, but it needs to be recognised that there is a continuing requirement for human involvement – the improvements we need are processes and systems that foster collaboration between human and computer to exploit the strengths of both. We will return to this issue of collaboration at the end of the paper.

"For track access, there is very little automation and almost total reliance on manual decision making and actions"

For track access, there is very little automation and almost total reliance on manual decision making and actions, and this is reflected in the issues of workload and errors that are documented in the RAIB and other studies that we have described above. We need to invest in tools and processes that will automate where appropriate and bring this area of activity up to the level of sophistication already achieved within the route setting function.

Automating track access for maintenance

An example of what is possible in this area can be found in Japan, where JR-East has provided track access functionality in the ATOS (Autonomous decentralised Transport Operation control System) traffic management system [7]. The workzone location and start/end times for each access requirement are entered into a maintenance work database which becomes part of the daily schedule alongside all the train movements. This allows the system to verify in advance that there are no conflicts between the track access and train service requirements, or make adjustments to the plans to achieve this.

At the time the track access is required, the maintenance worker uses a portable work terminal to request that the planned access is granted. If the request is for the expected time and location, the system will check that the trains scheduled before the beginning of work have actually passed, and there are no other trains approaching the workzone. The interlocking will then lock the related equipment to prevent route setting. A message that it is safe to access the track is then displayed on the work terminal in a failsafe manner. When the work is complete, the maintenance worker uses the work terminal to hand back the workzone, the interlocking removes the locks on equipment, and automatic route setting re-commences.

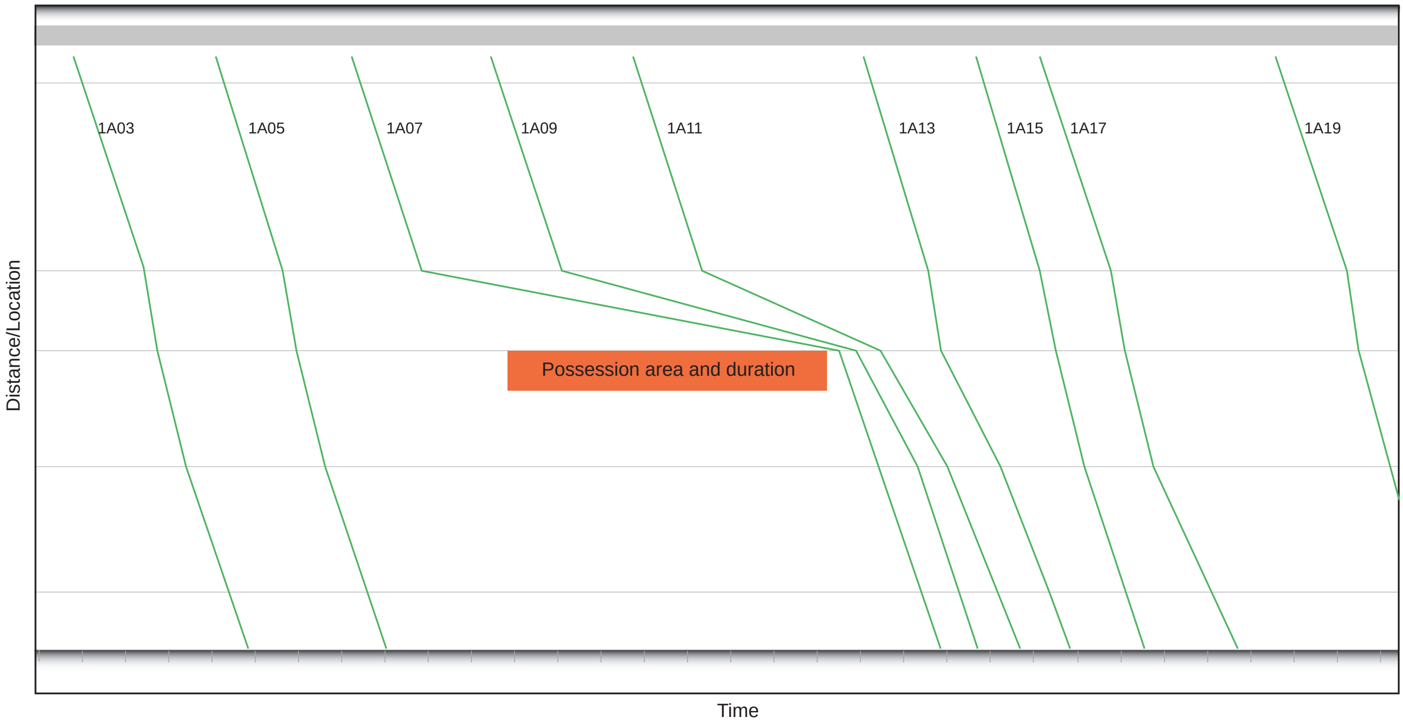
If everything runs according to the plan, there is no workload for staff at the control centre – track access is automated in the same way as ARS for route setting. The dispatchers in the control centre only become involved if the plan needs to be adjusted, for example if a late running train requires to use the time slot allocated for maintenance, or unplanned access is needed to rectify an equipment failure.

Support for user worked crossing management

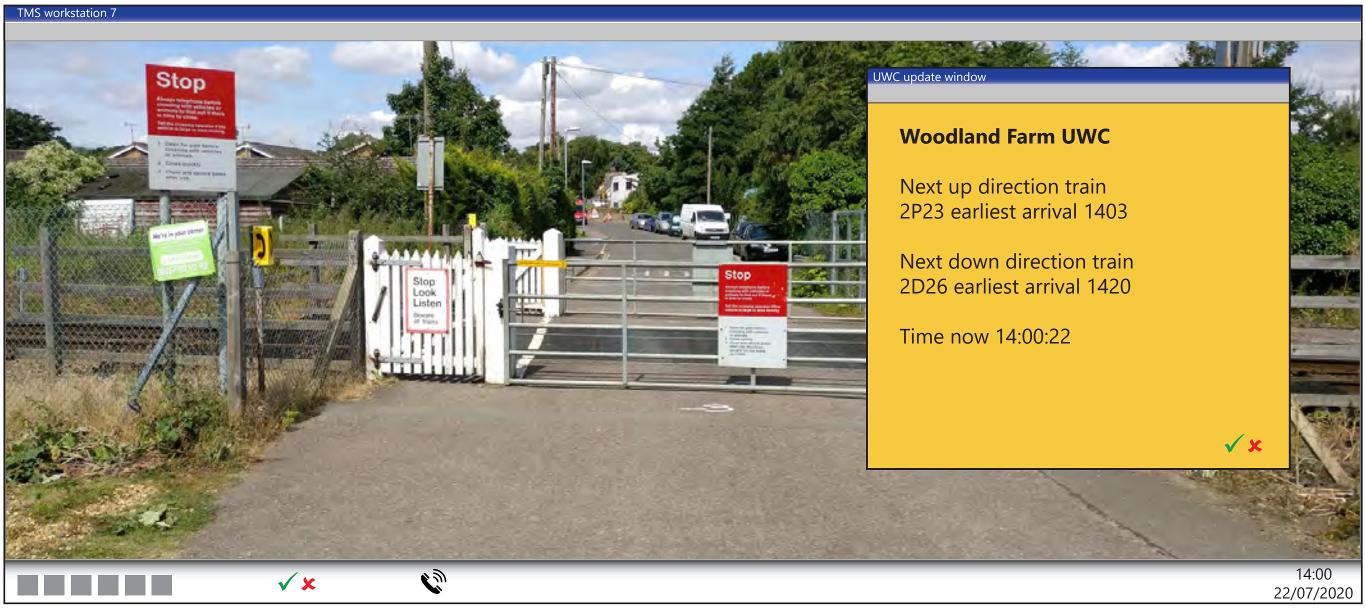
The issue of user worked crossings seems to be a particularly British problem – in some other parts of the world unprotected rural crossings on secondary lines are more generally accepted. Ideally, these crossings would be given automated protection via indications to the crossing user, triggered by the signalling system or another local means of detecting approaching trains, and there have been various initiatives to try and find a cost-effective means of achieving this.

However, it is still worthwhile considering how the management of these crossings could be automated while retaining the existing user interface, i.e. a telephone at the crossing. The decision making process for a signaller who receives a request to use a crossing is based on knowledge of which crossing the request has originated from, the location of this crossing with respect to the train detection sections on the control centre displays, and the current location of trains in the area. Based on this information the signaller will estimate an arrival time for the next train and decide whether it is safe to authorise the use of the crossing.

This logic could be incorporated into an automated system, triggered by a telephone call from the crossing, and providing the signaller with a direct display of the predicted arrival time



By planning track access using a traffic management tool it can be incorporated into a dynamic train plan and protection applied automatically in the same way as ARS sets routes for trains.



Signallers have to estimate when a train in a long track section will arrive at a level crossing – an automated calculation based on the time of each approaching train at the last train detection boundary would be more accurate.

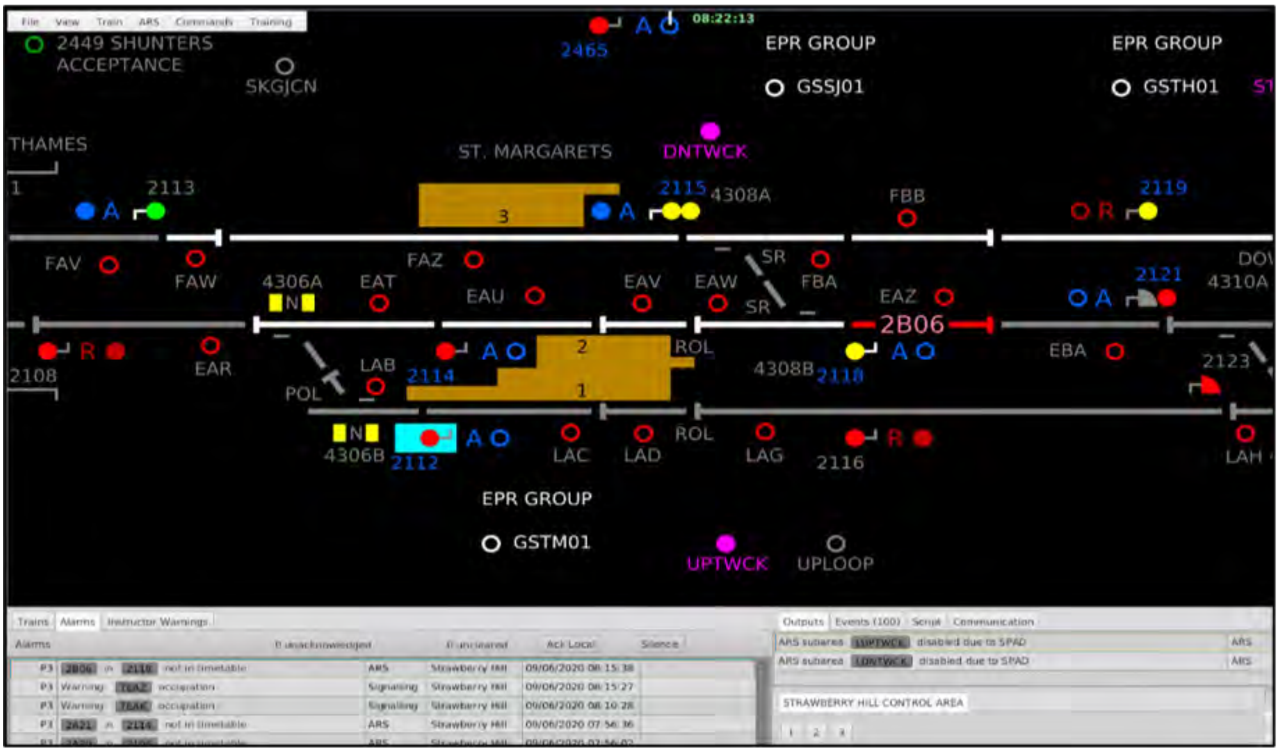
at the crossing. This would eliminate many of the sources of human error that have resulted in accidents and near misses, such as confusion regarding which crossing the user is calling from, and where long train detection sections require the signaller to rely on perception of elapsed time since the train entered the section [8].

A further step would be for the system to respond directly to the telephone call from the crossing user with a recorded message advising whether or not it is currently safe to cross the line, with the option of waiting to speak to the signaller if there is need to cross with a slow moving vehicle or animals. A system like this would reduce workload in the control centre, as the majority of calls from user worked crossings would be handled automatically. It would also benefit crossing users, who would get an instant response to their calls without waiting for the signaller to respond, and this could improve compliance with the instructions for safe use of the crossing.

An obstacle to this approach is that this would clearly be a safety critical system, but it could be prohibitively expensive if implemented to highest safety integrity level (SIL 4) standards. But even if developed to a lower SIL, such a system could be more reliable than the human – do we have a double standard that we tolerate a higher risk from a task undertaken by a human than from one that we have automated?

Sharing and visualisation of information

Returning to the topic of route-setting, we have identified the need for better collaboration between ARS and the human operators. The fundamental issue here is how to share and visualise information.



The traditional operator interface for a signaller is a computer workstation with a visual representation of the railway that has largely been inherited from the previous generation of technology, i.e. a mimic diagram showing a schematic track layout with indications of the current states of signalling equipment and location of trains. This provides all the information needed for manual route setting, but the only information about ARS are the inputs that constrain automatic route setting, i.e. which trains and geographical areas are in and out of ARS control. There is nothing on the screens to visualise the ARS decision making process.

"What is missing from the traditional interface is the fourth dimension of time"

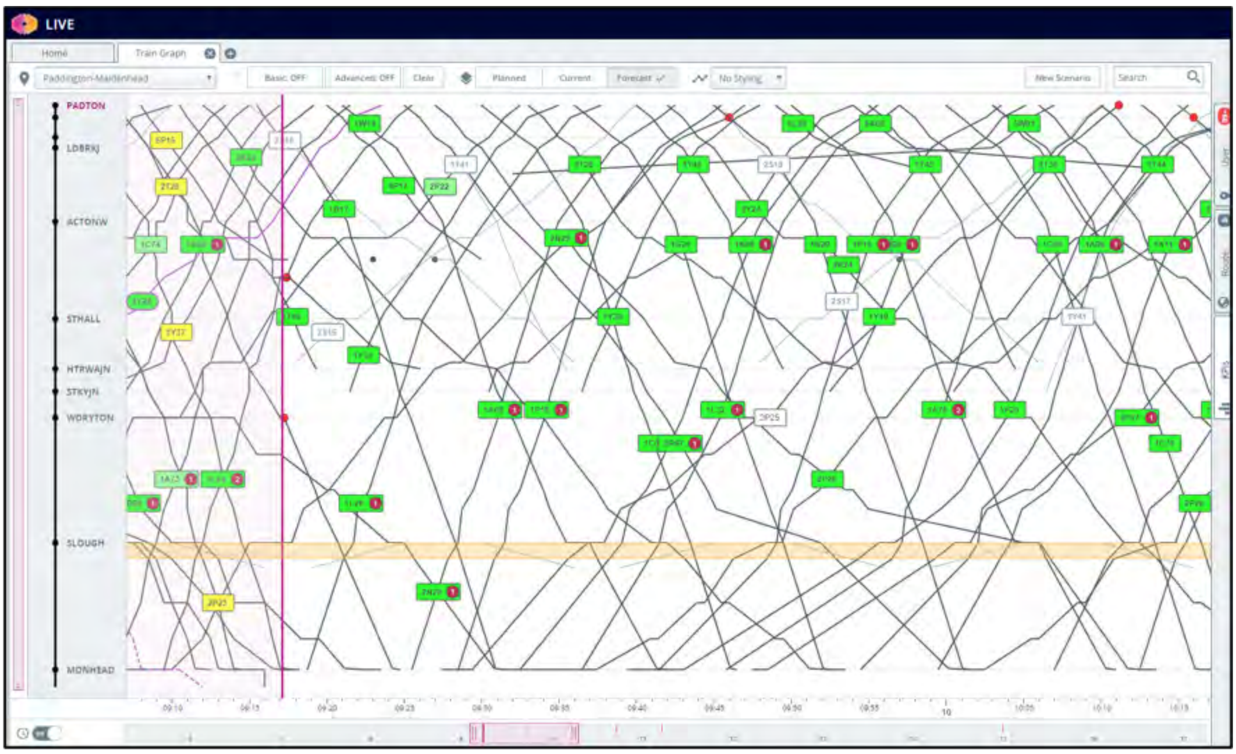
What is missing from the traditional interface is the fourth dimension of time. It simply shows a snapshot of the current situation, whereas the decisions being taken by the signaller and ARS are all about managing future train movements. The signaller has to use a mental model to extrapolate the past and present movement of trains into the future, estimate the impact on ARS decision making, and form a view on whether a manual route setting intervention would give a better result.

Visualising the future

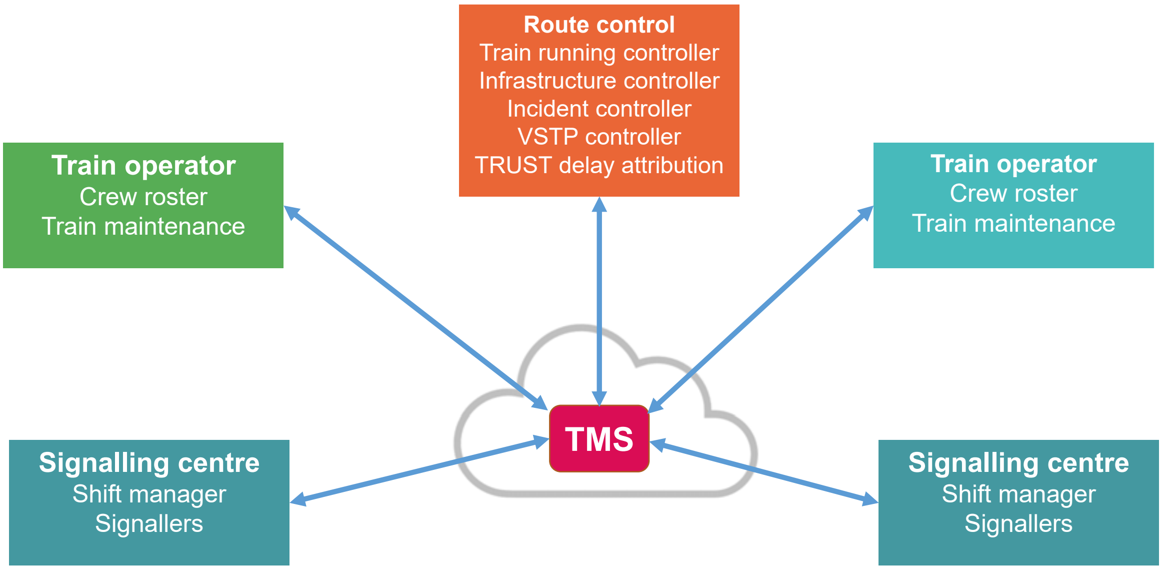
Fortunately, we do have a well-established alternative user interface that incorporates the time dimension – a train graph that plots each train movement along a line of route as a line on a two-dimensional graph, with distance along the route and time of day as the two axes. This representation of train movements originated as a pencil and paper tool for managing the use of passing places on long single line railways. It was subsequently adopted for timetable planning software and is now the basis for a new generation of control centre systems generally referred to as 'traffic management'.

In a traffic management application, the train graph display will typically show the actual movement of a train up to the present point in time using information reported from the signalling system, and the predicted movement of the train in the future calculated by the traffic management system. The gradient of the graph represents the speed of the train, and an intersection between graph lines for two trains on the same track represents a conflict that will further delay one or other train. There are a number of possible approaches to the prediction of future train movements – the easiest option is to use the running times in the timetable plan, as this is data that is readily available, but could deviate from real life for a number of reasons. A more sophisticated approach is to model the train dynamics, but requires comprehensive data on the train traction, braking, mass and length, together with route information such as gradients and speed limits – some of this information may not be available, or may be inaccurate, e.g. due to a fault on the train. The model also has to make an assumption about driving style, which may vary unless automatic driving (ATO) applies. Another option is to base the prediction on past history, i.e. the running times that are typically achieved for similar trains. The problem with this is that we want to make predictions when the train service is being disrupted, so the 'typical' values may not be relevant – this approach could be most useful if it could match the emerging situation to a scenario that has previously occurred – artificial intelligence (AI) techniques that can analyse years of previous performance data potentially have a role here.

A simple train graph will identify conflicts where the graphs for two trains cross, but a more sophisticated one will take account of the



A traditional signaller workstation display (left) is infrastructure focused – only the current location and running number is shown for each train. A traffic management display (right) focuses on the trains and shows the past and predicted future movement on a time dimension. *Images from Resonate*.



A traffic management system 'in the cloud' provides a tool for collaboration between people in different organisations and locations.

"A key facility to support the human decision making is a 'what if' facility to allow alternative scenarios to be defined and evaluated before committing to a new plan"

headways and junction margins to determine when converging trains begin to interact, and model how the ARS will respond to the situation so that the movement of the trains can be predicted beyond the point of conflict. Ideally the ARS decision making algorithm should be incorporated into the traffic management system, or at least a good model of how it behaves.

A useful feature of a train graph display is that it also provides a means of visualising the impact of line blockages for track access. A line blockage is represented as a rectangle on the graph, and a predicted train movement that intersects with the rectangle will be delayed. Temporary speed restrictions or reduced performance of a train can also be visualised – this will be a change in gradient of the graph for any train running slower than expected.

Another means of visualising future train movements is the platform occupation chart. This focuses on an individual station – the time of day axis is identical to the train graph, but the other dimension lists the platforms or through tracks that can be occupied by a train in the station. The arrival and departure of each train appears as a bar against the platform used by the train. A conflict in platform occupancy will appear as an overlapping of the bars for the trains concerned.

All these visualisations help address the human factors issues described earlier; workload is reduced as signallers do not have to mentally predict the automation's future actions. Human reliability is improved by providing decision relevant information in a more user-friendly format, and the improved visibility of the planned actions of the automation helps build trust.

Route-setting via re-planning

The train graph display provided by a traffic management system not only provides a visualisation of future train movements, it facilitates a new means of collaboration between the signaller and the ARS. Traditionally, ARS would receive the timetable it needs once or twice a day from a timetable planning system, with perhaps a facility for additional trains to be added during the day. When ARS is linked to a traffic management system, the timetable used by ARS can be dynamically updated during the day. By providing signallers with the means to edit the timetable and visualise how the change will be interpreted by ARS, the factors that are known to the human but not the computer can be captured in an updated plan that will then be reliably implemented by the automated system. The role of the human becomes one of planning ahead, using the early indications the traffic management system provides to foresee and fix problems in advance, instead of monitoring and intervening at the last minute.

A key facility to support the human decision making is a 'what if' facility to allow alternative scenarios to be defined and evaluated before committing to a new plan. This is often provided as an additional 'layer' on the train graph or platform occupation chart with a facility to select one or more trains and modify their timing or routing. The means of interaction may be to pop up a timetable editor to amend the plan for a train, or 'drag and drop' on the graph to extend station dwell time or move a train to a different platform. The predicted train movements will then show the impact of the changes that have been made in this scenario. Alternative scenarios can be defined and compared with one another and with the default option of remaining with the original plan. The tool may also support this comparison by calculating key performance indicators (KPI) for each option, e.g. train delay minutes incurred, or number of trains exceeding a delay threshold at which commercial penalties will apply. These indicators will then allow the operator to take the decision based on the most important optimisation criteria in the given situation.

Again, these improvements in interaction help address human factors issues. The ease with which routing decisions can be amended in advance reduces workload and improves trust while the what-if analysis supports better decision making and therefore improved human reliability, leading to improved operational performance.

Tools for collaboration

One of the challenges for adopting this way of working is the question of how well it fits with the existing roles of signallers and other staff. When traffic management tools are provided to signallers, the platform occupation chart is often the most immediately useful feature, as it clearly falls within the area of responsibility of an individual signaller. On the other hand, a train graph for a useful length of route will typically straddle a number of conventional signaller workstation areas. One approach has been to give the traffic management tools to staff at a regional or route control centre who are responsible for train service management at a more strategic level. Traditionally these staff have not had the tools to directly influence train running, and any decisions that they make had to be relayed to the signallers to be implemented. Using the traffic management system to replan the dynamic timetable at a line of route level makes a lot of sense, but could be worrying for signallers who perceive this as impinging on their responsibility for trains in their workstation areas.

> "One approach is to treat the traffic management system as a facilitator for collaboration between staff"

One approach to this problem is to treat the traffic management system as a facilitator for collaboration between staff, by providing access both to signallers and route management level staff. Providing the same graphical view of the train service to everyone involved opens up the possibility for a collaborative style of decision making that balances local and regional considerations, and transcends control centre boundaries.

The trend in recent years has been to concentrate control in larger and larger control centres, but the rapid increase in use of virtual meeting technologies to facilitate homeworking during the Covid-19 pandemic has shown that having everyone in one room is not essential for good decision making. With the right facilities for collaboration, a more distributed model with staff located locally and systems 'in the cloud' may be equally effective and less vulnerable to single points of failure.

There could also be the possibility to break out some of the activities traditionally undertaken by a signaller and address some of the workload issues that arise when we expect one person to undertake everything for a fixed workstation area, e.g. a limit on the number of possessions that can be planned in a workstation area. The concept of a 'level crossing desk' to manage closed circuit television (CCTV) monitored level crossings is well established, and in Ireland this concept has been taken further with a dedicated level crossing control room for a large number of crossings at a location quite separate from the main signalling centre – could the same concept be applied to managing access to the track?

> "Until the human strengths mentioned are no longer necessary ... the humans will have to remain in the loop"

Another dimension to collaboration is between the signallers and controllers who work for the infrastructure manager and the staff who work for the railway undertakings that operate the passenger and freight trains. Again, the traffic management toolset can provide the means to facilitate this, by ensuring that both groups see the same evidence of current train running and future predictions. This element would be strengthened with an exchange of data between the traffic management system and the railway undertakings' in-house data systems, for instance those that allocate crews and rolling stock to each train in the timetable, but in practice there are many technical and commercial obstacles to achieving this.

Do we still need the human in the loop?

In the sections above we have described railway traffic management systems as they typically exist today, i.e. tools to enable human operators to dynamically re-plan a train service that can then be delivered automatically by ARS. Some might say that this is unambitious – over the years there has been a lot of academic research into optimisation of railway traffic, so do we still need to rely on humans in the loop?

Further automation is certainly possible using the processing power of modern computers to automatically identify, evaluate and compare all the potential re-planning scenarios to recover from a disruptive event. With even a moderately complex railway network, the number of possible combinations of decisions rapidly escalates, but there are clever mathematical techniques such as neural networks which can analyse the complexity. With the advent of 'artificial intelligence' and 'big data' techniques, there is also the potential for automated decision support based on past experience, matching the current situation to similar previous events and how successfully they were managed.

With this technology, we could leave the human out of the loop, and treat the system as a more sophisticated form of ARS, but unless it is possible to eliminate the human operator entirely, the issues of trust and confidence in the system that we see today will only become greater as the automated decision making becomes more complex. There is experience in other industries where an 'artificial intelligence' approach has resulted in decision making which is quite opaque to an observer, without even the possibility of analysing why a certain decision has been reached. It also ignores the fact that in many of the more serious situations the human may be aware of information or consequences that are unknown to the computer, and so the automatically selected solution is not actually the optimum one. Until the human strengths mentioned at the start of this paper are no longer necessary, particularly in terms of working under ambiguity and dealing with unanticipated situations, the humans will have to remain in the loop.

A more fruitful way forward is to extend the concept of collaboration between human and computer, helping the operator by rapidly identifying and ranking options for intervention, but allowing the human to make the final decision. If this can be combined with an approach that takes into account the results of decisions taken in previous similar circumstances, and this is made visible to the operator, there is the potential for both the human and the computer to learn from previous experience. This way of working could also help the learning process for new operators, as the system will have learned from the good decisions made by their more experienced colleagues.

This approach need not rule out the possibility of some re-planning decisions being made fully automatically, when the learning process reaches the stage where for a particular scenario, the system is always advising the same solution, and this is consistently being accepted by the operator. As an interim step, there could be a mode of operation whereby the operator is alerted that the system has identified a re-planning decision which will be implemented unless over-ridden within a short time window. The important thing is that additional automation takes place in line with building of the confidence that the operators have in the system, and one way this can be achieved is through following a user centred design process which includes operators in the development of the system and aims for a collaborative system from the beginning.

"The important thing is that additional automation takes place in line with building of the confidence that the operators have in the system"

Automatic Train Operation (ATO)

So far, we have been considering the issue of automation in a control centre for a railway with manually driven trains, where the only means of managing train movements are via the signalling system or voice/text messages to train drivers. The situation is slightly different where trains are fitted with ATO as this requires the schedule for the train to be communicated from the control centre to the onboard system. The same applies to a connected driver advisory system (C-DAS); the functionality is very similar to ATO, except that instead of directly controlling the train's traction and braking, the system works by providing advice to the driver. Introducing C-DAS systems can be seen as an intermediate step towards an ATO-managed network. Depending on the system, the train may receive a timetable for the day before it enters service and rely on this unless it receives an update, or it may request a schedule at the start of each journey. The information is basically the same as that used by ARS, and when a traffic management system is introduced to dynamically re-plan the timetable, the changes will need to be sent to the trains as well as to ARS.

The default mode of operation of ATO or C-DAS is usually to manage the speed of the train to avoid early arrival at stations and junctions. This delivers significant energy savings compared with manual driving and avoids having to slow on the approach to a junction which is still occupied by the preceding train, which in turn reduces junction occupation time and improves capacity. But of course, this advantage is negated if the planned path for the train is not available due to late running of another train, or a re-planning decision in the control centre. For this reason, an important feature of ATO (and the 'C' part of C-DAS) is a link from the control centre to the onboard system so that the schedule for the train can be dynamically updated. This could be to slow down, to arrive at a junction later to follow a late running train, or to speed up if a decision has been taken to give this train priority at the junction. In either case, the update will be in the form of a new target arrival time at the relevant timing point (and subsequent ones), and the onboard system will then calculate a new speed profile for the train to achieve this. The same mechanism will apply if there are bigger changes to the train's schedule, e.g. re-routing or a new station stopping pattern.

From the control centre viewpoint, a significant advantage of ATO over conventional manual driving is that trains will follow the timetable more accurately and so the prediction of future train movements in a traffic management system becomes better. This in turn improves the prediction of conflicts and the downstream consequences of re-planning decisions. It may also be possible for the train to advise the control centre of additional information to improve the accuracy of the predictions, e.g. if a fault on the train means it is running at reduced speed or power.

ATO or C-DAS linked to traffic management is likely to be adopted for future high speed lines such as HS2 in the UK. *Image HS2.*

"The combination of traffic management and ATO or C-DAS means that a train is actively managed to avoid a conflict"

There is also a subtle change that improves the effectiveness of re-planning decisions. The ATO or C-DAS system will be updated with the new plan as soon as it is chosen, so the train can be driven accordingly. Contrast this with the conventional situation, in which the driver is unaware of the change until an adverse signal aspect is encountered. The combination of traffic management and ATO or C-DAS means that a train is actively managed to avoid a conflict, instead of allowing it to run free of restriction until a conflict is inevitable and then using the signalling system to stop it.

The operator interface in the control centre is generally via the traffic management system, which will communicate either directly to the onboard systems of the trains, or via a server provided by the ATO or C-DAS supplier. The operators are still taking the same re-planning decisions to avoid conflict, the difference being a greater confidence that the trains will be driven in accordance with the updated plan.

"The key to future developments is to recognise that the automated systems and the human operators have to work together in harmony"

ATO with a driver in the cab is referred to as 'Grade of Automation level 2' (GoA2). Higher grades of automation may have further implications for control centre functionality and automation. In particular GoA4 (unattended train operation) requires a method of dealing with any decision making and actions that would normally be undertaken by staff on the train. The method of working is usually for normal operations such as driving the train and opening and closing of doors to be automatically dealt with by the on board systems, but in degraded modes of operation there will need to be an intervention from the control centre to restore normal operation or take the train out of service. An important facet of this is communicating with the passengers onboard the train, so this tends to be another task for the control centre operator using facilities such as public address loudspeakers and video cameras inside and outside the train, rather than an automated system.

Conclusions

We manage railway traffic today from control centres using a combination of automated systems and human operators, and this will continue into the foreseeable future. There are significant opportunities for further automation, especially in bringing the support for track access control up to a level of automation more akin to that we currently provide for route setting. However, the key to future developments is to recognise that the automated systems and the human operators have to work together in harmony, and we need to design the systems with this in mind. The focus areas of human interaction and operation will evolve with the introduction of enhanced functionality but will not be made unnecessary in the foreseeable future. A user interface that fosters this collaboration between human and computer also has the potential to support collaborative working between humans at different locations. Traffic management systems are starting to provide this type of facility, and their effectiveness will improve in the future if we also deploy ATO or C-DAS on to trains.

References

[1] Woodland, D, 2015. Automation in Railway Control Centres: avoiding the 'bridge too far'. IRSE ASPECT 2015 Conference.

[2] Mitchell, I, 2020. Back to Basics – Operator Interfaces. IRSE News 269, September 2020.

[3] Savage, M & McGuire, M, 2018. What happened to 'Tactical Agility'? IRSE News 248, October 2018.

[4] Balfe, N, Sharples, S, & Wilson, JR, 2019. Understanding is key: An analysis of factors pertaining to trust in a real-world automation system. Human Factors, 60(4), 477-495.

[5] UK Rail Accident Investigation Branch, 2020. Class investigation into factors affecting safety-critical human performance in signalling operations on the national network. Report 03/2020.

[6] UK Rail Accident Investigation Branch, 2020. Track workers struck by a train at Margam, Report 11/2020.

[7] Ito, K, 2011. Development and Update of ATOS, JR EAST Technical review No.20, 52-55.

[8] UK Rail Accident Investigation Branch, 2020. Near miss at Worlingham user worked crossing. Safety digest 07/2020.

[9] Balfe, N, 2010. Appropriate automation of rail signalling systems – a human factors study, University of Nottingham PhD thesis.

About the authors ...

Ian Mitchell has 45 years' experience in the rail industry, in British Rail Research and its post-privatisation successor companies – AEA Technology Rail, DeltaRail and Resonate. He has worked on interlockings, train detection, ETCS, traffic management, driver advisory and simulation systems. He retired as professional head of signalling in 2011, but still does some consultancy for his previous employer as well as acting as one of the editors of IRSE News and as a member of the International Technical Committee. He is a Chartered Engineer and FIRSE, and this is the third time he has presented a Presidential Paper, his previous examples were in 2003 on signalling control centres and in 2009 on driver advisory systems.

Dr Nora Balfe is a Human Factors Specialist working in the Irish Rail Directorate of Health and Safety. Nora holds an MSc in Human Factors and Safety Assessment from Cranfield University and a PhD in Railway Human Factors from the University of Nottingham. She has over 15 years' experience of the application of human factors in safety critical industries, including rail, aviation, automotive and process industries. The majority of her career to date has been in the rail sector and her PhD was on the topic of human centred design of railway signalling automation. She is a Registered Member of the Irish Human Factors and Ergonomics Society and a Chartered Member of the UK Institute of Ergonomics and Human Factors.

IRSE
Institution of Railway Signal Engineers

Effects of automatic train operation on regional train drivers


Lucie Pannecoucke and Roger Dällenbach

Within their Automatic Train Operation (ATO) project, Switzerland's Schweizerische Südostbahn AG (SOB) has performed a systematic human factor study of the effects of Grade of Automation 2 (GoA2) on regional train drivers. With this level of automation, tasks such as accelerating and braking are removed from the driver's workload and are performed by an automated system. New tasks are created such as additional visual supervision and taking over control in the event of issues arising. This human factors study aims at researching effects of the automation on train drivers' fatigue, workload and performance.

This study was performed in collaboration with AWK Group and the ZHAW (Zürcher Hochschule für Angewandte Wissenschaften – Zurich University of Applied Sciences).

State of research: fatigue in train drivers

Prolonged manual train driving has been significantly researched (Filtness and Naweed, 2017, Stein and Naumann, 2016). It can lead to cognitive underload (Filtness and Naweed, 2017). This underload leads to passive fatigue (theory from Desmond and Hancock, 2001), in which continuously low workload increases the fatigue of the train driver. The negative effects of fatigue on the performance of train drivers have also been established (Filtness and Naweed, 2017).

The automation of train driving leads to more vigilance tasks such as information acquisition and visual monitoring (Branderburger & Hörmann, 2016) whilst reducing the control tasks. It therefore contributes to a further underload of the train driver, as automation takes over handling the accelerating and braking tasks from the train driver. With automatic train driving, the train driver is required to perform monitoring tasks rather than directly driving the train.

It has been established that performance in monitoring tasks can decrease after 30 minutes (Mackworth, 1948). In the case of train drivers, it has been shown that the "performance in degraded operations decreases if train drivers execute their operational tasks with high level of automation compared to low levels of automation" (Brandenburger and Jipp, 2017).

In summary, the current state of research raises a risk that with increased automation, the train drivers might experience a cognitive underload that leads to passive fatigue and under-performance. Yet these studies do not fully answer the needs of train operation companies today, as two main operational characteristics of the SOB lines differ from the conditions used in the research environment:

- The degradation of performance is calculated between manual train operation and GoA2 level. In most modern trains, today's drivers are already using a certain level of automation with the use of a speed regulator.
- The degradation of performance is researched on high-speed trains, whereas the SOB is operating regional services. With urban trains, tasks such as opening and closing doors remain allocated to the drivers and occur every 4 minutes on average, compared to every 30 to 60 minutes for high-speed trains. Train driving in urban operation therefore represents a higher task load than for high-speed trains, the effects of which on the fatigue and performance have not yet been established.

The project's targets and method

The SOB study aims to verify the degradation of performance of train drivers by adding a comparison between driving with GoA2 and driving under the current operating conditions; GoA1 with speed regulator. In addition, this study focuses on train operation representing urban trains with regular stops.

For this study, 31 train drivers were divided into three groups as represented in Table 1.

In all three groups, automatic train protection ETCS L1 Limited Supervision (LS) was active.

A train simulator was used (Figure 1) and the track Biberbrugg – Arth Goldau (back and forth) was video-recorded and used for the simulated drives. Each driver underwent six or seven drives as follows:

Figure 1 – The simulator used for the research.

Group	Driving mode	Description	Participants
1	GoA1 without speed regulator	The drivers in this group drove without automation of the driving and braking system. Driving and braking were tasks manually performed by the drivers, as well as the opening and closing of the doors.	9
2	GoA1 with speed regulator	The drivers in this group drove with a speed regulator: the train driver chose a target speed and the automatic system takes over the task to accelerate or brake to reach and maintain target speed. The traction force was chosen by the driver. The driver performed the tasks of setting-up target speed, setting-up traction force, opening and closing the doors. In addition, the driver remained responsible for the train operation and monitored the speed regulator and was ready to take over control in case of deviations to the expected behaviour.	10
3	GoA2	The drivers in this group drove with the highest level of automation in the study: GoA2. In this level, the target speed was read directly from the ATO trackside and balises (simulated on the simulator). The train driver performed the tasks of authorising the ATO system to start and of opening and closing the doors. The traction force was calculated automatically by the ATO system. The train driver remained responsible for the train operation and monitored the GoA2 system, ready to take over control in the event of deviations from the expected behaviour. In this group, the drivers had the choice to drive with or without a commercial radio receiver. The radio programme was a free choice of music, news or other types of programme. The radio system was linked to the simulator and automatically attenuated in case of a system signal. All drivers driving with the radio on voluntarily agreed to do so.	12

Table 1 – The driver groups and their tasks.

Drivers of the groups 1 and 2 underwent six drives of approximately 25 minutes each:

- The first two drives were acclimatisation drives for all groups, no event was provoked and no measurements were made.
- During the third drive, a first event was provoked (defect of the catenary dropping to 0V) and the reaction time of the drivers was measured.
- A 20-minute break occurred.
- The fourth and fifth drives were uneventful.
- During the sixth drive, two events occurred in random order: a main signal became closed (after passing an open approach signal) and a defect of a crossing barrier was announced. Reaction time of the driver to brake, take over the system or acknowledge the defect was measured (whichever reaction occurred first).

Train drivers of the group 3 underwent a seventh drive in which the ATO system missed a stop due to wrong journey profile. Reaction time of the drivers was also measured.

During the break, multiple human factors were measured such as:

- Fatigue using the Karolinska Scale: self-evaluation by the participant with a measure between 1 (extremely alert) and 9 (extremely sleepy, fighting sleep).
- Workload using the NASA-Task Load Index (TLX) Scale. This scale uses self-evaluation by the participants and is based on six factors contributing to workload: mental demand, physical demand, temporal demand, overall performance, effort, and frustration level.

The simulation occurred in three shifts (morning shift from 7am to 11am, afternoon shift from 11:30am to 3:30pm and evening shift from 4pm to 8pm). The participants were randomly assigned to a driving group and to a shift, ensuring the shift would not interfere with the measurement of fatigue in the different groups.

The hypotheses to be verified

Using the measured factors, following hypotheses were verified:

- [H1]: The fatigue of the train drivers increases with time, in all automation levels.
- [H2]: The fatigue of the train drivers increases more with a higher automation grade (GoA1 with speed control and GoA2), compared to a lower automation grade (GoA1 without speed control).
- [H3]: The reduction of workload of the train drivers is higher between GoA1 without speed control and GoA1 with speed control, compared to GoA1 with speed control and GoA2.
- [H4]: The performance of the train drivers is similar under GoA1 with speed control and GoA2 driving modes.

Results

H1 The fatigue of the train drivers increases with time, in all automation levels.

Out of the 31 participants, the level of fatigue increased after the simulation for 28 participants. The participants for whom the fatigue decreased were in different automation groups, two of the three participants had been allocated to the morning shift and one to the evening shift. The results are shown in Table 2.

It can be observed that the fatigue of the drivers increases on average in all three groups by 1.23 points. Hypothesis 1 can be confirmed from this experience.

H2 The fatigue of the train drivers increases more with a higher automation grade (GoA1 with speed control and GoA2) than with a lower automation grade (GoA1 without speed control).

The average increase of fatigue in the first group shows the highest value (+1.43), whereas the increase of fatigue in the second and third group show similar values, respectively +1.10 and +1.08. This is shown in Figure 2.

It appears that driving under GoA1 with speed control and driving under GoA2 both lead to a lower increase of fatigue than driving under GoA1 without speed control. Therefore, the second hypothesis is rejected. This is a surprising result in this study, as considering the researched studies before designing our simulation, we had expected a greater increase of fatigue in higher automation groups. To deepen our understanding of this result, the workload of the drivers under each automation mode must be analysed (our third hypothesis).

H3 The reduction of workload of the drivers is higher between GoA1 without speed control and GoA1 with speed control, compared to between GoA1 with speed control and GoA2.

The workload of drivers was measured after three drives and after the overall simulation. The six dimensions of workload are self-evaluated by the drivers and results are combined to assess the overall workload, graded from zero (low workload) to 100 (high workload).

The dimensions of the NASA-TLX Index are defined as follows:

- Mental Demand: How much mental and perceptual activity was required? Was the task easy or demanding, simple or complex?
- Physical Demand: How much physical activity was required? Was the task easy or demanding, slack or strenuous?
- Temporal Demand: How much time pressure did you feel due to the pace at which the tasks or task elements occurred? Was the pace slow or rapid?
- Overall Performance: How successful were you in performing the task? How satisfied were you with your performance?

Figure 2 – Increase of fatigue before and after the simulation.

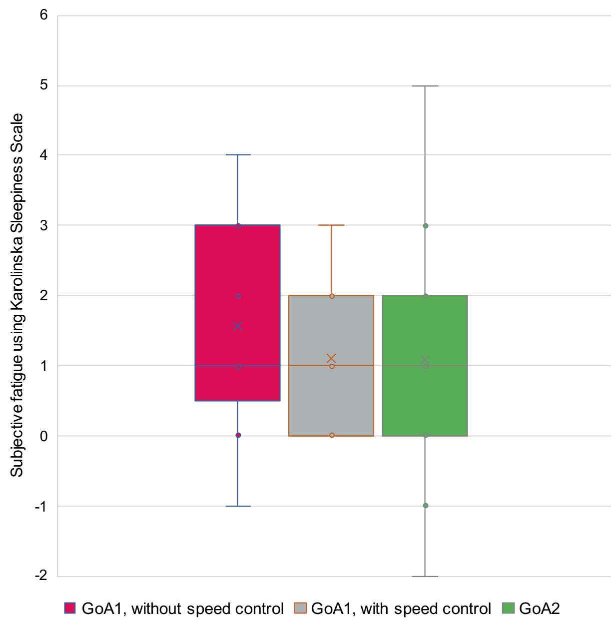


Table 2 – Fatigue of the drivers before, during and after the simulation.

Group	Average fatigue during the simulation	Average fatigue during break	Average fatigue after the simulation	Increase of fatigue between before and after simulation
1: GoA1 without speed control	2.67	3.56	4.22	+1.56
2: GoA1 with speed control	3.10	3.40	4.20	+1.10
3: GoA2 overall	3.58	4.08	4.67	+1.08
GoA2 with radio	4.28	4.28	4.71	+0.43
GoA2 without radio	2.60	3.80	4.60	+2

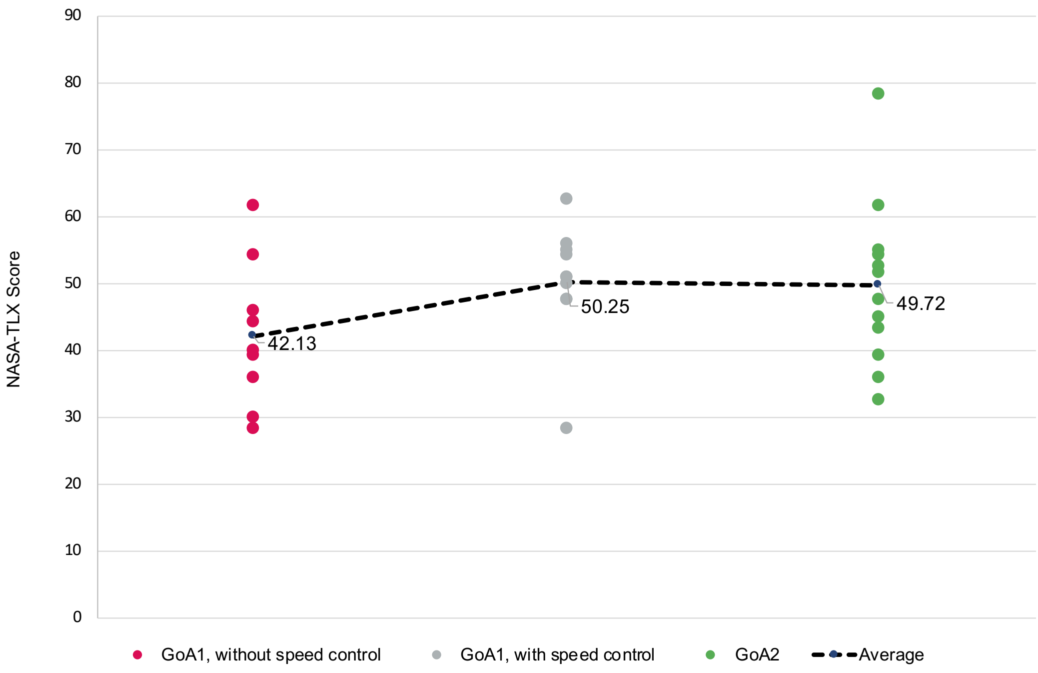


Figure 3 – Workload in all groups at the end of the simulation.

- Effort: How hard did you have to work (mentally and physically) to accomplish your level of performance?
- Frustration Level: How irritated, stressed, and annoyed versus content, relaxed, and complacent did you feel during the task?

The results in Figure 3 show that the workload of the drivers is lower in the first group (average 42.13 points) in comparison with the second group (average 50.25 points), despite a higher level of automation with use of the speed regulator in the second group. Between the second and third group (average 49.72 points), a similar level of workload can be observed. It seems that the increase of automation such as introduction of the speed regulator or GoA2 does not lead to a reduction of workload compared to GoA1 without speed regulator. To understand this result, the single dimensions of the NASA-TLX scores were analysed.

In comparing GoA1 without speed control to GoA1 with speed control, it can be observed that the introduction of speed control leads to:

- A significant increase in the dimension "Mental demand" (+4.96 points).
- An increase in the dimensions "Overall performance", "Temporal Demand" and "Effort" (respectively +2.16, +2.34 and +2.68 points).
- A decrease in the dimension "Physical Demand" (-1.92 points).

Although the overall index results are similar between GoA1 with speed control and GoA2, the detailed assessments of each index show significant differences. The introduction of GoA2 compared to GoA1 with speed control leads to:

- An increase of the dimensions "Effort" and "Frustration" (respectively +1.43 and +3.47 points).
- A decrease of the dimensions "Mental demand" (-2.40 points).
- A significant decrease of the dimension "Temporal Demand" (-3.15 points).

To assess our third hypothesis, the increase of workload occurring between the break time and the end of simulation were assessed, i.e., during the second part of the simulation. The results are shown in Table 3.

It can be observed that the workload provoked by driving is higher in the second and third group compared to the first group. Considering all three groups started their shift with the simulation, the influence of an earlier workload in the day can be disregarded. Hypothesis 3 is rejected.

Linking our results of the previous paragraph and this one, it appears that the group with the lower increase of fatigue is the group with the highest increase of workload, and vice-versa. The lower increase of fatigue in higher automation groups (GoA1 with speed control and GoA2) compared to GoA1 without speed control might be explained by the higher workload in these two groups, hence moving away from underload spectrum and passive fatigue.

Table 3 – Workload of the drivers at break time and at the end of simulation.

Group	Average workload during the break (after three drives)	Average workload after simulation	Raise of workload between break and end of simulation
1: GoA1 without speed control	39.35	42.13	+2.78
2: GoA1 with speed control	45.92	50.25	+4.33
3: GoA2 overall	44.79	49.72	+4.93
GoA2 with radio	42.14	48.10	+5.95
GoA2 without radio	48.5	52.00	+3.5

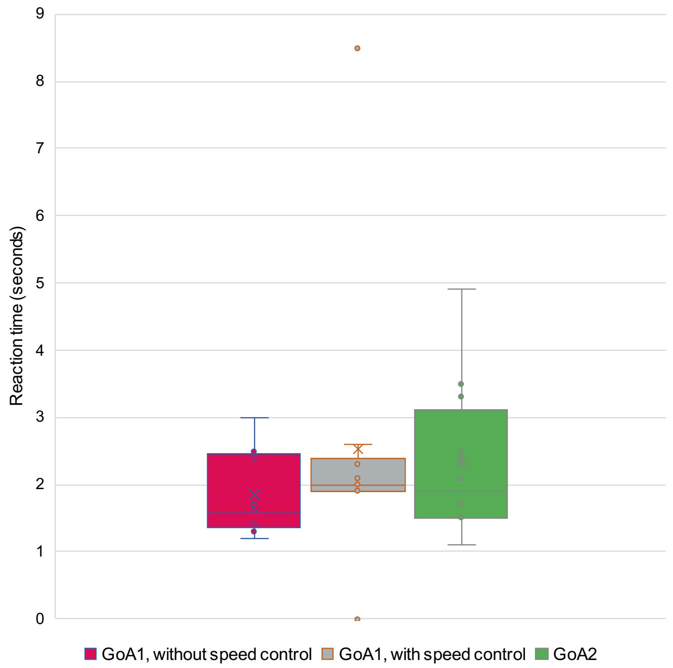


Figure 4 – Reaction times after second event.

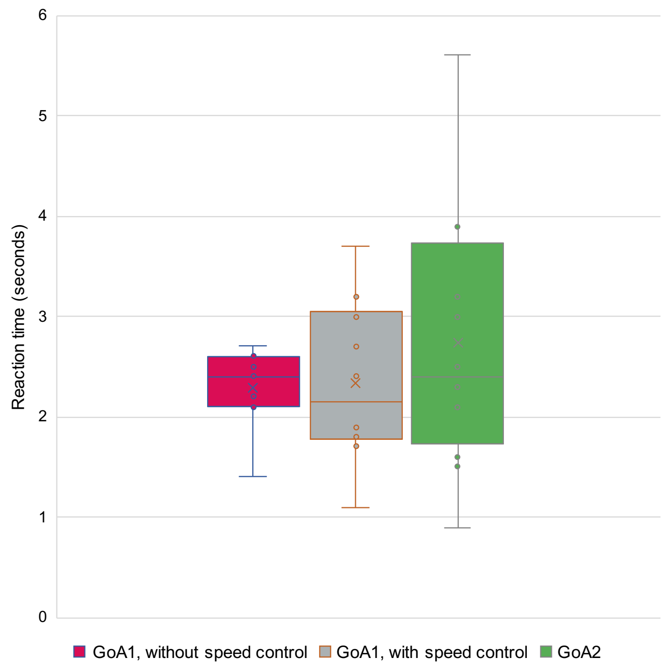


Figure 5 – Reaction times after third event.

H4 The performance of the train drivers is similar under GoA1 with speed control and GoA2 driving modes.

To assess this hypothesis, only the second (signal closure) and third events (crossing barrier defect) were used. This is due to results for the first event (catenary voltage dropping to 0V) being reported by locomotives are furthest away to the reality of train driving on a real track and results provide a wide range of possibilities with low statistical probability. Indeed, in real driving, in case of a catenary voltage dropping to 0V, the main switch of the train opens and the noise of the HVAC fans in the cab disappears. In the simulation, this change to the soundscape was not audible by the locomotive drivers, hence the event being missed or misinterpreted.

Reaction times of the drivers in all three automation groups for the second and third events are shown in Figures 4 and 5.

In the second event, drivers of the third group were slightly faster than drivers of the second group whereas in the third event, the contrary occurred. The differences of reaction times between the second and third group are -0.2 and +0.4 seconds respectively, which can be considered similar, hence a confirmation of Hypothesis 4.

The effect of having an activated commercial radio receiver can be observed: in both events, drivers of the third group who chose to listen to radio are faster than drivers who chose not to.

Applications and outlook

With this study, the influence of automation on the fatigue and performance of train drivers seems to differ from the results obtained in high-speed trains. Indeed, with hypothesis 2, we observed a lower increase of fatigue in the drivers who were performing in highly automated environments (GoA1 with speed control and GoA2) compared to drivers performing under GoA1 without speed control. According to hypothesis 3, this seems to be explained by the higher NASA-TLX workload when driving under GoA1 with speed control and GoA2, compared to GoA1 without speed control. Indeed, it seems the introduction of speed control has led to a higher workload for the train drivers, and the introduction of GoA2 will lead to an even higher workload as per the NASA-TLX index.

Therefore, the introduction of higher automation grades does not seem to negatively impact fatigue nor performance of the S-Bahn train drivers compared to the already widely introduced driving mode with speed regulation.

Yet, while the introduction of GoA2 significantly reduces time pressure for the train drivers, the component of the NASA-TLX index most raised by this new technology is the frustration. This finding must be carefully considered while introducing GoA2. In the frame of this study, an interview of S-Bahn train drivers was performed with 28 participants from Switzerland to assess the acceptance of introducing GoA2. While the initial answer without accompanying measures was rather low (rated on average with a 2.2 out of 10), the acceptance was raised significantly when the locomotive drivers were consulted to optimise the frequency of drives and widening the geographical area of driving under GoA2 (with an average of 5 out of 10). Additionally, the interviews showed that the introduction of a commercial radio receiver under GoA2 could potentially further raise the acceptance of train drivers. In our study, we could not show any negative effect of introducing radio under GoA2, but we observed a much lower increase of the frustration occurred while driving with radio.

We conclude that while the introduction of GoA2 compared to GoA1 with speed regulation for S-Bahn drivers does not lead to an increased fatigue nor decreased performance, it could lead to a dissatisfaction and disengagement of the train drivers. To support the train drivers in their acceptance of the new technology, adapting the frequencies of driving, widening the geographical area of driving and listening to radio. We are strongly convinced that for the industry to fully benefit from the introduction of GoA2, the personnel affected most, the train drivers, must be fully considered and supported by accompanying measures.

About the authors ...

Lucie Pannecoucke, senior consultant, AWK Group AG, Zürich, Switzerland

Lucie is an experienced project and people manager with more than 12 years of experience in the development of railway systems. She has managed complex industrial projects for delivering complete locomotives, and control and command system upgrades to various national operators and private customers. In this study, Lucie leads human factor studies to assess the effects of automation on the train drivers, collecting existing theoretical knowledge, writing and performing interviews, designing and evaluating the simulation and assessing overall results.

Roger Dällenbach, Schweizerische Südostbahn (SOB), Zürich, Switzerland

Roger has gained a broad range of experience in project management during his career. Over the past 14 years, he has managed several high-volume fleet procurement projects (newly designed passenger trains as well as complex maintenance vehicles). Before moving into the rail industry, he worked for 14 years in the field of aviation as metrology and avionics engineer and purchasing manager. This study is a part of the ATO pilot project currently in progress at SOB, in which Roger occupies the role of the senior project manager.

Contributor: Dr Céline Mühlethaler, ZHAW, Centre for Aviation, Winterthur, Switzerland

Céline is a senior lecturer and head of the human factors research team. She and her team have provided the methodology, instruments, and research advisory as well as consulting support.

What do you think?

Are you surprised by the findings of this research? Perhaps you have experience that entirely backs up what Lucie and her team have discovered? Maybe your railway or organisation has carried out its own research into the human impact of automation, or maybe you have experience in another field, perhaps aviation or road transport.

Why not share your experience with other IRSE members? Email us at **editor@irsenews.co.uk**.

Managing risk

Paul Darlington

Risk is inherent in all engineering activities and all engineers and technicians involved in Control Command and Signalling (CCS) have a significant role in managing and limiting risk. Professional engineers and technicians have a responsibility to society to deliver safe systems and must always maintain and develop their professional competency. By reading IRSE News and this article you are carrying out Continuing Professional Development (CPD) and the IRSE can always help members with CPD.

In managing risk engineers and technicians must apply professional and responsible judgement and take a leadership role. They must adopt a systematic and holistic approach to risk identification, assessment, and management. Complying with legislation and industry standards is paramount, but we must also always be prepared to implement further improvements. Good communication with others in managing risk is vital, so that there is absolute clarity on who is doing what and there are no 'assumptions'. Engineers and technicians must not adopt a 'silo mentality' and assume safety is someone else's role. Systems are required to provide for scrutiny and checking and where appropriate engineers and technicians must contribute to the public awareness of risk, and act ethically and for the public good.

The safest railway is one where no trains run, so there will always be some risk in an operational railway. Engineers must therefore also be aware of becoming too risk adverse and putting unnecessary barriers in the way of innovation and creativity – "Don't let perfect be the enemy of good". The key therefore is managing risk as professional engineers and technicians and to demonstrate ALARP (As Low As Reasonably Practicable). ALARP is often used in the regulation and management of safety-critical and safety-related systems and for a risk to be ALARP it must be possible to demonstrate that the cost involved in reducing the risk even more would be grossly disproportionate to the benefit gained. An extreme simple example is that to spend £1m to prevent five staff suffering bruised knees is grossly disproportionate; but to spend £1m to prevent a major accident capable of killing hundreds of people would be proportionate.

Gaining the trust of stakeholders and operators is another key requirement of being a professional engineer/technician and managing risk. If someone perceives something to be of high risk, those responsible for introducing and controlling the risk must gain trust to help mitigate the concerns. Conversely, a lack of trust can lead people to oppose a solution, even if the scientific and engineering evidence indicates the risks are low.

Five characteristics to help achieve trust are:

1. Competence. Make sure you know what you are talking about.
2. Objectivity. You need to demonstrate the source of information is independent.
3. Consistency. Ensure that you demonstrate a track record of dealing competently with similar situations.
4. Openness. Make sure you are willing to disclose information and are not secretive – but maintaining commercial confidentiality. If you cannot disclose certain information be clear on why you can't and look for ways around the problem e.g. a confidentiality or non-disclosure agreement.

Photo Shutterstock/Alex Danila.

5. Empathy. Always accept the validity of any concerns and make sure you listen and consult.

The following is an example of a situation where many factors in a project, including risk management and gaining trust, went terribly wrong. It is not a railway engineering project; but as professional engineers and technicians we must look and learn from all aspects of engineering.

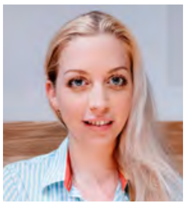
In June 2017, 72 people tragically lost their lives in a fire at a high-rise residential building called Grenfell Tower in London. Throughout 2020 a public inquiry heard evidence on why the building became covered in combustible materials when it was refurbished a few years ago. So far, the public inquiry has identified the following:

- The building's management organisation did not comply with competitive tendering regulations and hired lead architects who had never clad a high-rise residential building before. The architects made no checks to see whether the combustible materials were compliant with building regulations. Three fire safety strategies were produced, but none of them acknowledged that the refurbishment involved cladding the outside of the building. One fire safety strategy said "assumed" 19 times in a 16-page report.
- The inquiry heard an insulation manufacturer 'lied for commercial gain' when launching its product. An insulation product passed a test in 2005 but the product was changed a year later, and the company continued to sell its product using the 2005 test certification. Subsequent tests identified the product as causing a "raging inferno". Another supplier successfully tested a piece of foil attached to its insulation thinner than a millimetre and then advertised their whole insulation product as passing the required test. It was suggested at the inquiry that using this interpretation of the regulations a stick of dynamite wrapped in the foil could also be advertised as being non-combustible.
- The lead architect for the project had never heard the phrase "limited combustibility" – the standard recommended for insulation on high-rise buildings. 17 companies worked on the refurbishment through a complex web of contracting and subcontracting, with many witnesses saying they thought other companies were responsible for fire safety. A specialist cladding contractor sent its drawings to another firm of architects and thought they were checking that their designs met regulations, but the architecture firm said it thought it only had to examine the building's aesthetics and 'functional utility'. In 2009, an employee of one of the cladding suppliers called their polyethylene cores "dangerous". In 2015, while cladding was being installed on Grenfell Tower he wrote: "We really need to stop proposing PE [polyethylene] .... We are in the 'know'."
- Construction professionals relied on meetings with sales staff to decide whether a material was suitable for use. One marketing department wrote that those most likely to buy its insulation included "anyone who wasn't aware there were restrictions on which materials were permitted for use on high-rise buildings".
- After the fire numerous errors were found on how the cladding had been installed. Many cavity barriers – intended to stop fire spreading through cladding – were poorly fitted or installed in the wrong place. Some were attached back to front, stopping them working. New windows were fitted during the installation and a subcontractor was instructed to fill gaps around the windows with combustible insulation. They said they did not know it was combustible. On the night of the fire, this was the main route for the flames to spread into the cladding.
- The local building control department officer responsible for checking the work did not notice that cavity barriers had not been designed around the windows to stop flames spreading to the outside wall and he failed to recognise the cladding materials were not suitable for use on high-rise buildings. He told the inquiry that as a result of local authority cuts, he was overworked with up to 130 projects to approve. A clerk of works was hired to inspect the work carried out on the cladding, but said his remit was not to check whether the work met regulations, or matched architects' drawings, and he only checked that the work was "neat and tidy".
- The management organisation said they consulted residents about plans for the building and claimed there was "no concern from residents about cladding the building". But that was based on a meeting which only one resident attended and information about fire retardancy was not given to any of the residents.

The inquiry will continue throughout 2021 and the recommendations may incorporate some of the processes and systems we already use in the rail industry. But we must never be complacent and always look to improve. The UK Engineering Council has produced an excellent guide for professional engineers and technicians managing risk, available in full at irse.info/et72w. It recommends the following six principles.

1. Apply professional and responsible judgement and take a leadership role. Engineers should demonstrate by example a commitment to safety, reliability, and ethical conduct through the professional management of risk. Engineers at all levels should clearly demonstrate the standards by which they expect risks to be managed, thus setting an example to others.
2. Adopt a systematic and holistic approach to risk identification, assessment, and management. The factors that give rise to risk are interdependent and cannot be examined in isolation. It is vital in managing risk to be aware of this interdependency, and rather than dealing with risks one-by-one as they arise, use approaches that deal with whole systems.
3. Comply with legislation and codes, but be prepared to seek further improvements. Regulations and codes are generic. They can only deal with anticipated events, and cannot predict every possible situation. Engineers should take a measured, yet challenging approach to potential risks, whether or not regulations apply.
4. Ensure good communication. Shortcomings in communication are present in nearly all failures in the management of risk. Communicating effectively with customers, clients, suppliers, subcontractors, and colleagues is important to ensure that risks and their implications are properly understood.
5. Ensure that lasting systems for oversight and scrutiny are in place. They should be challenging, and carried out with independence from those creating the risk or attempting to control it.
6. Contribute to public awareness of risk. Engineers have an important role in raising awareness and understanding about the real levels of risk and benefit, and helping to prevent misconceptions.

Commonwealth Youth Parliament 2020



Daisy Chapman-Chamberlain

Transport challenges are global, particularly in the contexts of social mobility, accessibility, and global climate change. Daisy Chapman-Chamberlain, rail knowledge transfer manager at Knowledge Transfer Network (KTN), and a UK representative at the Commonwealth Youth Parliament 2020, looks at how international collaboration can meet some of these needs.

Transport systems around the world vary widely; and are perceived differently within this global context. Those who use public transport systems on a regular basis are certainly far more likely to have more detailed opinions on their function than a tourist who may only use a system once; but whilst some of these views naturally carry more weight, they must all be considered for the establishment of truly world-class transport systems. Similarly, people of all backgrounds and with different needs and accessibility requirements must be consulted, to ensure that systems are truly reflective of all users. More than 70 per cent of the rural population of African nations are estimated to have been left unconnected due to missing transport infrastructure and systems. In urban areas, where an additional two billion people are expected to be living in cities by 2045, the growth in population is far outstripping the growth in public transport, thus limiting access to economic and social opportunities (Global Mobility Report, 2017).

One key element of the development of these outstanding systems lies in the value of international collaboration and the sharing of best practice (and lessons learned) via organisations such as the IRSE. Whilst not all technologies, projects and principles are internationally uniformly applicable learning from almost every transport network can, and should, be shared. It is important not to make assumptions about which messages may be useful; those at a local level are best placed to make judgements and to extract useful information.

This is especially relevant in the context of global economic recovery from Covid-19, through enabling businesses to market and sell their products and innovations internationally. Following Brexit, the UK looks to build stronger relationships outside the EU, including within the Commonwealth. Recently through the Commonwealth Youth Parliament, representatives from a variety of nations discussed international transport development needs and opportunities, specifically amplifying the views of young people.

Decarbonisation is a key focus in transport around the world: transport emissions, including road, rail, air and marine transportation, accounted for more than 24 per cent of global CO2 emissions in 2016. In the context of global climate change, and the varying contributions that different nations make to emissions, we must all work to address this crucial need to help those nations most at risk from the catastrophic impact of climate change (including India, Sri Lanka, Kenya, Canada and beyond). This has the impact of improving lives around the world in every nation, regardless of risk, safeguarding those in the global community. Development of sustainable transport is ongoing internationally, including hydrogen train development in the UK with HydroFLEX, sustainable stations, ETCS with ATO, developments in Canada, where the University of New Brunswick is researching lightweight trains and boats using aluminium, and the University of Carleton is developing a database for precise measurement and assessment of the health impacts of pollution from aviation. The outputs and learning from all this work must be shared internationally, to reduce duplication of effort, and to ensure the most impactful practice is enacted in nations around the world.

For both improved connectivity and sustainability, development of better integrated networks and transport systems is crucial. Giving passengers in a wide range of communities greater choice and ensuring door-to-door connectivity is essential in effecting the modal shift from private to public transport. David Salmon, representative for Jamaica at the Commonwealth Youth Parliament 2020, focussed on bus services, commenting that, "... public transport is essential for communities in order to provide integrated and comprehensive development that factors the needs of all citizens" and that priorities for improvement include punctuality, as well as "...making buses more accessible for the disabled community and to decrease waiting times". He also commented that "public transportation is important as it can serve as the mechanism to link respective communities. Due to the zoning plan in Kingston, several persons have to commute for long distances, thus a viable public transport system is

Erasto Richard Magamba talked about the use of public transport to replace boda bodas in Uganda.

essential. To build viable communities, public transportation is necessary". Adam Tate, representing the UK, particularly highlighted the regional disparity of public transport across the nation, with transportation in London being much more reliable and accessible, whereas outside the capital it can be "irregular, overpriced and old". For national improvements, Mr Tate feels that, "Integrated transport planning is essential, to provide a more robust national infrastructure and systems which are conducive to use focussed on sustainability and health benefits", particularly to reduce isolation of rural communities and to meet carbon reduction targets. Mr Tate identified Amsterdam as a key example of a well-integrated city, illustrating how the sharing of learning is particularly key for international transport development; for Amsterdam, active travel facilities and connectivity by bicycle provide a superb example for other smaller cities around the world.

For larger cities and for those in more rural communities and suburbs, however, rail and light rail development is essential for full access to all opportunities. Erasto Richard Magamba, representing Uganda, firmly believes there is a need to improve railway transport within the nation. He uses boda bodas (motorbike taxis) regularly, in an effort to avoid traffic. Boda bodas are also a common source of income, especially for young men, but have recently been banned from carrying passengers in Uganda to reduce the spread of Covid-19, and can only carry cargo. This has a significant impact on connectivity in the nation, he said, "... public transport is very important when it comes to business transportation because it goes beyond... to cater for an ordinary person deep down in rural areas to connect with urban areas". Pubali Bezbaruah, representative for India, echoed this development need in rail and light rail, commenting that "Metro in almost every state is needed so that much of the time and money is saved". The Very Light Rail development in Coventry, UK, may well hold the key to some of these communities' needs, enabling connectivity without the need for major infrastructure development and reducing costs, timescales and disruption.

Across this, accessibility and inclusion come to the fore, and must be considered and included for development of public transport of all types. Maria Ovcharenko, representative for Canada, feels that the transport system in her nation is effective and efficient, as well as inclusive, "...most, if not all, buses and LRT systems are wheelchair accessible" but that this inclusion needs further development, particularly in ensuring women feel safe travelling alone at night, and that "Edmonton specifically... has begun implementing measures to address this on a superficial level, such as hiring security personnel". This consideration of inclusion in the widest possible context is vital for building safe transport networks which inspire public confidence; in the UK, initiatives including Visible Platform are working in this space, highlighting the needs of women and ensuring that the inclusion agenda goes beyond physical access.

It is clear that international collaboration across innovations and transport development can address some of these significant challenges. Collaboration is fundamental to the ethos of the Commonwealth, and KTN works to enable this international communication, including through work such as the UK Rail Innovation Covid-19 brochure, which highlights innovations applicable in a global context for rail recovery (download at irse.info/3yw4r).

Adam Tate, representing the UK, commented "...the UK suffers with competing political agendas and is reliant largely on Victorian era infrastructure. There needs to be shared and equitable spending across the UK, looking at methods of creating green and sustainable funding models for public transport". Ensuring transport is developed for the needs of people at every level – from tiny rural communities to the international climate change context – is essential to equal access and inclusion. This can be achieved through consultation with communities, working with experts in transportation and through collaboration with international groups.

Daisy can be contacted at **daisy.chamberlain@ktn-uk.org**.

Maria Ovcharenko talked about the effective, efficient and inclusive transport system in Canada, and the opportunities for improvement that remain.

Intelligent railways

Paul Hendriks and Mark Witvoet
on behalf of the IRSE International Technical Committee

The economy is highly dependent on the modern railway as we know it. People commute daily to their work and during the weekend they use these trains for leisure. Freight carriers also use the railway heavily during the day and night.

Due to demographic and economic development it is to be expected mobility will grow by more than 50 per cent over the next 30 years. Additionally, the Paris Climate Agreement and the European Green Deal call for urgent action to further reduce the carbon footprint. As railway transport is one of the most sustainable ways of travelling, the expectation is that the demand will rise even more. For the Netherlands it is expected that within ten years from now the railway demand will grow by 27-45 per cent. The predicted increase in demand is accompanied by an increased need for highly reliable and available railway infrastructure. These high requirements for railway transportation mean there must be a high reliability and availability of the infrastructure. Unplanned equipment downtime will significantly impact daily operations and reduce asset performance, which must be avoided. At the same time, a discrepancy is observed in the increase in transportation demand and the available budget. This forces the rail sector to increase operational efficiency. We need to make use of new ways of working within the sector to ensure that our infrastructure and assets can still deliver the promised and demanded performance.

To reach the necessary capacity we can choose high capacity trains (double decker, longer), or more track and higher availability of infrastructure (less disturbance, less maintenance, fewer trackworks). Control command and signalling can play a role and we need to think of different ways to monitor our infrastructure and assets while keeping costs low. We must go from corrective (and preventive) maintenance to an "intelligent" predictive maintenance way of working within the railway sector. Combining intelligent predictive maintenance and advanced ways of analysing data can help to reach this target. This intelligent predictive maintenance can be delivered by new technologies such as Internet of Things (IoT), big data and data analytics.

Sensors for tracking freight wagons

IoT sensors together with smart cameras are used in a test to monitor axle passages and point movements in shunting yards to track and trace individual wagons. For operational reasons signallers/controllers need to know where locomotives or wagons are situated, but there is no need for regular, safe and expensive means of train detection to prevent collisions. By using sensors the location of wagons in a shunting area can be monitored in real time and more accurately. We can create a digital twin of the shunting yard using the assets in the real world to provide data, and this digital twin can exactly determine where the wagons are on the shunting yard and even predict the track occupancy with artificial intelligence. This innovation is an initiative from Paul Kootwijk, program manager Innovation at ProRail.

Sensor mounted on to an existing treadle in a shunting yard.

Almost everyone has already heard something about IoT. However, what is IoT and how can this be applied in the railway sector? IoT is described by Gartner as a network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or external environment (irse.info/t0qc8). In the railway sector this means that assets and the track will be part of a rail IoT network. For example, a sleeper can be part of this IoT network by putting or embedding a sensor on/in the sleeper and connecting the data of the sleepers of a certain corridor to monitor the infrastructure.

These IoT sensors and devices that can be put in the railway infrastructure produce massive amounts of data. This data will be stored in the "cloud" such that historic data will be available and can be analysed. IoT will enable continuous monitoring of assets allowing display of real-time asset performance. Currently, assets are only monitored occasionally (once or twice a year). By having this new level of detail at each given moment in time we are able to monitor our assets 24/7. We can even address them before they are at a critical point of failure. This leads to less unforeseen downtime and less money spent on maintenance. However, to make this possible you also need to have a solid base for your data infrastructure.

Efficient wireless protocols will allow monitoring equipment to be operational for years on a single battery. Therefore, a big plus of some IoT devices compared to traditional monitoring systems is that there are no wires needed for energy and connectivity. Additionally, it can increase speed of deployment in the infrastructure and reduce investment. Installing traditional monitoring systems can take 18 months due to taking the track out of service. This is due to regulations, coordination with all stakeholders, and having available access to perform the digging and installation. This creates disruption for the railway users and can be very costly. By using sensors that can be clipped onto a rail within seconds there is almost no need to have the track out of service, provided that the infrastructure compatibility of the sensor has been proven.

The sensors that are used in the infrastructure at ProRail make use of wireless communication over the LoRa network of KPN (a public mobile network provider). This is a so called Low Power Wide Area Network, which allows long-range communication at a low bit rate among things, such as battery operated sensors.

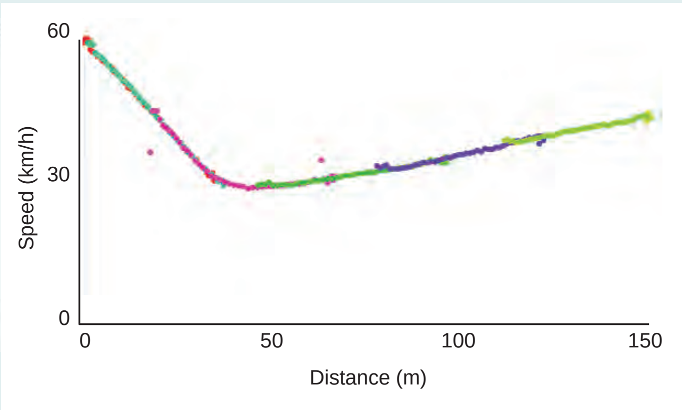
However, to embed this new way of 24/7 monitoring in our almost 200 year old railway DNA we need to have a change of mindset, technology and way of working. Within ProRail we are in the early phase of embedding this new way of monitoring to increase our performance and reliability so that we improve the perceived quality of rail transportation on our network.

When real time monitoring is taken to the next level and all kinds of sensors are embedded in the track you can create a digital twin of the complete rail network and assets. Then we will be able to predict and plan maintenance in a better way because, in this digital twin, the complete environment and movement is monitored, as long as the correct data is provided. Examples of such a digital twin can already be found in real estate to connect the physical world and the digital world by processing sensor information. This information can then be used for predictive maintenance purposes or to determine what the CO_2 level or the temperature is in each room. Employees can then find the perfect space for them to work which can increase productivity (irse.info/5zgly).

In the railway sector, there are endless possibilities to monitor the assets by connecting all kinds of sensors with each other and thereby creating a digital twin. For example combining data from smart sleepers with sensors on trains we can predict where on the track long-term degradation takes place. This long-term degradation is not visible by a visual inspection of a location once or twice a year but with the help of sensors this could be possible. It may even be possible for these sensors to be used for train detection, or as a fall back for when the existing track circuits or axle counters fail. Multiple sensors providing a large amount of data could be combined with sufficient statistical methodology resulting in the required safety level.

Sensors for train speed and braking measurement

To reach the required capacity we are forced to look for novelties that can be applicable on the current infrastructure. One of them is to reduce the prescribed braking distance of 400m of a train that goes from 40km/h to 0km/h to 300m. After a thorough risk assessment study with positive outcome, simulations with train drivers were done to determine whether this can be done safely and controlled in real life. However, in reality not all locomotives and train sets are equipped with sufficiently accurate GPS to measure the braking curve and determine if the braking distance can be reduced. Thus, another system is needed to measure the braking curves. IoT sensors are a suitable solution. On different places in the track sensors are placed to measure the passing of a train. By using advanced algorithms the data from the sensors is transformed in such a way that the braking curve could be calculated. The algorithms even detected what type of rolling stock and which train set passed the sensor. Having these simple and low cost smart devices, easy to adapt in our infrastructure, could help to monitor, e.g. braking behaviour by train drivers. Having an application like this in place, an infrastructure manager is able to monitor in more detail operational safety. It could contribute to analysing signal passed at danger (SPAD) or level crossing incidents. This feature will become available in ETCS, our case study shows that braking curve analysis can be available at a low costs for class-B systems.

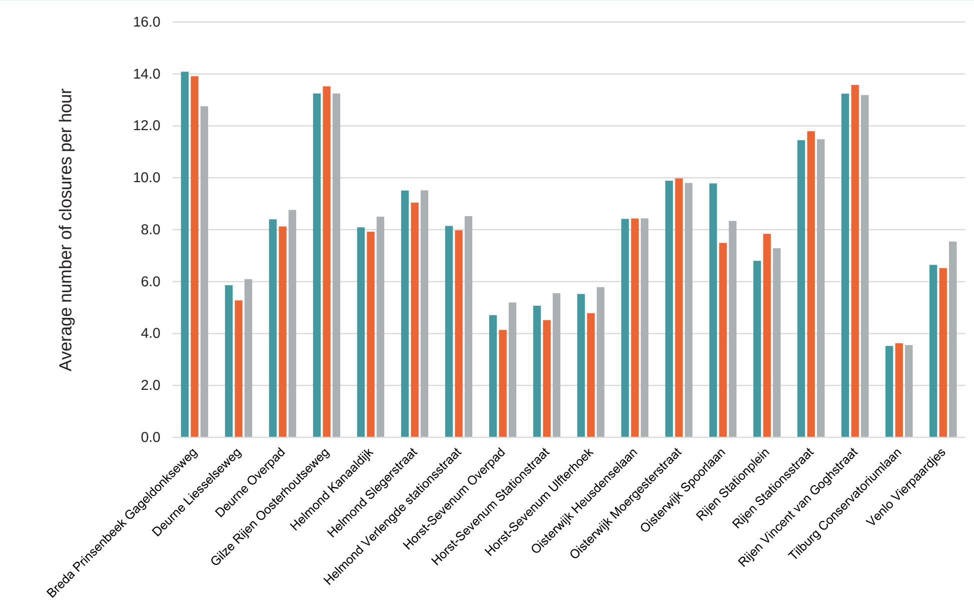


This graph shows the train speed based on data from IoT sensors in the track. The train is slowing down running at a red signal and after 50m, in the last 200m before the signal, the signal has changed to green and the train starts to accelerate. The algorithm produced the speed-distance graph.

Sensors for level crossings

We first started with sensors that provided data about the closing times of our level crossings and cross checking them with the warning data from the interlocking. Based on this data ProRail was able to increase traffic on specific tracks without changing or even closing level crossings. This has avoided massive investments in infrastructure to allow railway undertakings to run more trains. We also measure the lowering and raising time of the barriers. If this time is not within the norm a message will be sent to the data platform. This can be used in the future for monitoring purposes, decreasing downtime and failure rate. Currently ProRail is investigating how IoT sensors can monitor the barrier machine behaviour. Prorail expect that creating a digital twin and collecting and analysing this data could increase time between maintenance, avoid unnecessary refurbishment and decrease maintenance costs.

Sensor mounted on a level crossing barrier.



An example of the data available from the sensors. This chart shows the average number of closures per hour for a number of level crossings on the line from Breda to Venlo. This data was used to support discussions with local authorities about the impact on road traffic from a more frequent train service on the line.

Conclusion

New technologies such as IoT sensors in our systems do have promising outcomes, but to implement these technologies into the signalling infrastructure successfully you have to select tangible needs to be analysed and define a proper set of requirements. The common practice in signalling to follow a structured engineering approach to develop new functionality and/or components will be a critical success factor. Trial and error projects often turn out not to deliver as promised and will lead to disappointment, and even worse disinvestment .

In the case studies, standalone dedicated sensors are added to the installed base. Future developments in this field have to consider case by case if sensors should be embedded in the systems or added as standalone sensors. Flexibility, costs, sustainability and temporary or long-term application will be criteria needing to be analysed. The technical and economic lifespans of the system and the sensor have to be involved in this evaluation (e.g. a sleeper with a technical lifespan of over ten years with an embedded sensor with a technical lifespan of three years).

A third factor to take into consideration is the data of IoT. Determining the specific need and selecting a dedicated or general sensor are critical. However, the model to collect and analyse the data is key. To be effective and successful, modelling the behaviour of the system and the algorithm to analyse the vast amount of data produced is essential to create a digital twin that provides information needed to correctly interpret the results.

And last but not least, to apply these innovations in safety related functions, we have to understand how to provide a solid safety case based on a large amount of data and statistical methods. This approach will possibly lead to new hazards and also requires an innovative but robust approach.

What do you think?

Do we make enough of existing technology such as the Internet of Things within the rail industry. Should we be monitoring more by connecting to more assets? Perhaps you think we should be monitoring fewer assets but using statistics to infer more information. Maybe your view is that we have managed for 150 years without the technology, so why adopt it now! If you have an opinion or experience that would be of interest to IRSE members, let us know, email **editor@irsenews.co.uk**.

This article is an excellent introduction to the theme of Ian Bridges Presidential Year starting in April, which will be "The age of the intelligent railway".

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

More UK rail freight

UK: At the end of 2020 UK Infrastructure Manager Network Rail explained how they have been working with freight operators during the Covid-19 pandemic to increase the movement of freight on the network.

With reduced demand for passenger travel, trains have been rescheduled to allow more often longer freight trains to move through the network to unlock benefits for rail freight customers and the UK economy. Examples cited included lengthening trains on freight routes such as Southampton to Leeds, Manchester to Birmingham and Daventry to Grangemouth to 775m, allowing 12-14 more containers to be carried per trip.

Eight aggregate trains from the Peak District and Herefordshire have seen a 10 per cent increase in capacity, and steel trains between Scunthorpe and Teesport have been extended to allow a further 1000 tonnes to be carried on each train. A daily service from Mossend (near Glasgow) to Daventry (in the East Midlands) is seeing a one-hour journey time reduction. The Mossend to Daventry train utilise the Class 88 electric locomotive to carry the equivalent of 38 lorry loads of goods the 310-mile distance with zero exhaust emissions, making it the greenest way to transport goods, say Network Rail.

It will be interesting to see how this change in the balance of railway usage continues post-Covid-19, but it is likely that command, control and signalling will play a major part in clearing train paths in the future. ETCS fitment will allow longer heavier trains to run to profiles better adjusted to their weight and performance. Traffic Management and online timetable planning will allow more dynamic adjustments to be made to day-to-day operations to create train paths and keep all trains running, whilst reducing waiting times for freight trains and causing less disruption to passenger services. Connected Driver Advisory Systems (C-DAS), and ultimately Automatic Train Operation ATO, should further optimise the use of the network. Whilst the UK network is behind some other countries, this is an essential step on the path to getting freight off the road and onto the railway and driving decarbonisation.

Bane Nor Eulynx ERTMS standardisation

Norway: Eulynx ERTMS standardisation as part of a rollout of ETCS on the Roa – Hønefoss line has been implemented by Bane Nor, the infrastructure manager. It is the first infrastructure manager to use the standard for interfaces between the Traffic Management System (TMS) and track-side signalling system. Eulynx is the 13 European infrastructure managers initiative to standardise signalling system interfaces and elements.

Three suppliers have been selected to install ETCS on the Bane Nor network: Alstom is supplying onboard equipment, Siemens Mobilty the trackside element, and Thales the TMS. Eulynx will standardise the interface between these systems. This should make it easier to replace subsystems without replacing the entire system, and to improve competition between suppliers.

Bane Nor has been testing components over 12 months at Haugastøl, Røros, Bodø, and Romeriksporten and first installed ETCS along the Østfoldbanen Eastern line between Ski and Sarpsborg in August 2015 as a pilot project ahead of the roll out across the rest of the country. ETCS Level 2 Baseline 3 is now due to begin operation on the Nordland line from Grong to Bodø in October 2022, followed by the Gjøvik line from Roa to Gjøvik a few weeks later.

They say that an essential part of this renewal is standardisation. Today they have 336 signalling systems with more than 15 different variants. With ETCS, it will be one system for the entire Norwegian railway which will be both easier and cheaper to maintain.

"Thales, together with Siemens, designed and implemented the new SCI-CC interfaces between Thales' TMS and Siemens' interlocking (IXL) and Radio Block Centre (RBC) systems," says Yves Joannic, vice-president, main line signalling, with Thales. "This was done together with Bane Nor under the scope of Bane Nor's ETCS National Implementation Programme and following Eulynx recommendations. This is a totally new solution for the market, which will bring major benefits to the entire railway community."

First semi-autonomous train on French national rail network

France: On 29 October 2020, a locomotive travelled between Longwy and Longuyon in eastern France, in GoA2 partial autonomy under real operating conditions, with 100 per cent automated acceleration and braking functions. Two years after the launch in 2018 of a consortium, composed of Alstom, Altran (a company of the Capgemini group), Apsys, Hitachi Rail, Railenium and SNCF, a Prima BB 27000 locomotive has been operating on a line equipped with ERTMS, under the supervision of a driver. A video of the first autonomous train run on the French national rail network can be seen at irse.info/54ayk.

The next key step in the project will be operation of a train with the same level of autonomy on a line equipped with conventional signalling at the end of 2021, without any modification of the infrastructure. This will allow SNCF and its partners to provide partial autonomy, regardless of the type of signalling system.

Engineering work will also continue to develop the various functions necessary for full GoA4 autonomy such as obstacle detection and environmental monitoring. Twelve test sessions are scheduled and will allow the necessary functions to be added gradually to increase the level of autonomy. The consortium's ultimate objective is to run a test with complete autonomy in 2023.

Level crossing action plans

USA: The Federal Railroad Administration (FRA) has issued a final rule revising the agency's regulation on level crossing action plans to require 40 states and the District of Columbia to develop and implement, and update if applicable, the FRA approved action plans.

The final rule came into effect 13 January and requires the ten states that already have developed action plans, as was required by the Rail Safety Improvement Act (RSIA) 2008 and FRA's implementing regulation, to update their plans and submit reports to the agency describing the implementation actions taken.

Under the RSIA, Congress directed the secretary of transportation to identify the ten states with the highest average of level crossing collisions from 2006 through 2008 to examine specific solutions for improving the safety of these high-risk crossings. The 10 states with the highest average of level crossing collisions are: Alabama, California, Florida, Georgia, Illinois, Indiana, Iowa, Louisiana, Ohio, and Texas.

KTCS-2 signalling system trial

South Korea: National operator Korail has awarded Hyundai Rotem a contract to verify the stability and compatibility of the Korea Train Control System 2 (KTCS-2) signalling system, which will be used to standardise signalling across the country. KTCS is intended to provide a lower-cost alternative to ETCS.

The system will use an LTE-R system provided by Nokia, to include voice, video, text, images, and positional information. The trial, to be completed in 2022, will take place on the 180km Iksan – Yeosu section of the Jeolla Line. Hyundai Rotem has been developing the KTCS-2 signalling system since 2015, and has obtained SIL 4 certification from TÜV SÜD.

Hyundai Rotem says it expects the market for the KTCS-2 signalling to grow to Won 400bn (£50m, €54m, €$66m) by 2024. Korail has also awarded Hyundai Rotem a Won 9.6bn contract to trial KTCS-M, the urban rail equivalent of the signalling system, on a 6.6km section of Seoul Metro's Ilsan Line. Hyundai Rotem says the KTCS-M market could be worth up to Won 550bn by 2024 and that they are also developing KTCS-3, a wireless signalling system that could support ATO.

Communication and radio

Multi-access Edge Computing (MEC) services

UK: Vodafone is partnering with Amazon Web Services (AWS) to become the first telecoms operator capable of offering Multi-access Edge Computing (MEC) services in Europe. MEC delivers cloud computing closer to customers, reducing the time it takes for devices to respond to commands. Multi-access means customers can access the service over mobile, Wi-Fi or fixed line services.

Whenever an application is used on a mobile network, the signals must be sent back and forth between the device and the server where the application is hosted. This latency is usually 50 to 400 milliseconds. Therefore, for example, it is difficult to perform a musical duet in real-time over a video call as the latency causes the sound to become unsynchronised. With a centralised cloud-based system, the further away from it, the longer it takes for the signals to pass back and forth, therefore bringing computing to the edge of the network rather than keeping it at the core, reduces latency.

Many remote applications perform better with real-time responsiveness, so reducing latency is useful, and combining the faster download speeds of 5G with the responsiveness of MEC results in supporting real-time applications. For example, mapping and location data company HERE Technologies is testing a real-time hazard warning service, and And Unleash live has designed a video analytics platform powered by artificial intelligence to automate real-time video monitoring and alerts for industries and utilities. Very low latency will also make wireless virtual reality experiences much more pleasant with a reduction in motion sickness and making augmented reality services faster and more intuitive to use.

Vodafone say they will be embedding AWS's Wavelength servers in its UK data centres which will reduce the latency to below 10 milliseconds. This has already been achieved between Newbury in the south of England and Birmingham in the Midlands, about 100 miles (160km). MEC will initially be hosted in a London commercial centre, to provide near real time latency to customers in London and locations such as Oxford, Cambridge and Birmingham. Over the remainder of 2021 additional commercial centres will expand the coverage zone for MEC services.

Research & Development and Universities

Research project to reduce delays and improve passenger experience

UK: A new research project aimed at improving railway navigation technology to reduce train delays and increase passenger experience has been launched at the University of Birmingham. The project aims to tackle how to pinpoint the accurate location of a moving train.

The University of Birmingham-led UK Quantum Technology Hub Sensors and Timing and the University of Birmingham's Birmingham Centre for Railway Research and Education (BCRRE) are joining forces for the project.

Both centres will collaborate to develop a system for quantum-enabled navigation, which is a standalone system capable of capturing highly accurate measurements without reliance on Global Navigation Satellite Systems (GNSS), which they say will help to ensure the health of the railway track and passenger ride comfort.

"The system we are developing will have gravity map-matching capabilities, allowing engineers to understand what is happening underneath the track as well as the train's movement," explains Professor Clive Roberts, director of BCRRE at the University of Birmingham, co-investigator for the Navigation work package at the Quantum Technology Hub, and IRSE Council member. "The quantum sensors will provide highly accurate measurements that will help to detect the rate of change of the track, and subsequently, any deteriorations which might lead to faults."

Professor Costas Constantinou, Chair of Communication Electrodynamics and Director of Research and Knowledge Transfer at the University of Birmingham's College of Engineering and Physical Sciences, said: "Our dependence on GPS can leave navigation systems vulnerable to spoofing or, more frequently, loss of positioning due to weak network signals – a particular challenge when trains are moving through tunnels, for example. "Our standalone navigation system does not rely on satellite signals and is therefore not exposed to the same external risks experienced by GNSS."

As part of the project, field tests will take place on the test track at Long Marston in Warwickshire early next year, where sensors will be installed on a purpose-built stabilisation platform in a train. Industry collaboration is central to the Quantum Technology Hub's goal of translating science into real-world applications, and Hub academics are working with Network Rail and other international railway organisations to bring precise navigation to the rail sector.

Government, regulators and standards

Management of Packet 44 applications in Great Britain

UK: The UK Rail Safety and Standards Board has published a Rail Industry Standard to set out the requirements for managing packet 44 applications in GB. Packet 44 applications use data transmission facilities included within European Train Control System (ETCS) for functions other than those required by ETCS.

The use of packet 44 applications has increased in recent years. The applications are used to support range of functions in GB such as Selective Door

Opening (SDO), Correct Side Door Enable (CSDE), Automatic Power Change Over (APCO), Automatic Train Operation (ATO) and Automatic train Supervision (ATS). The requirements for managing packet 44 applications as provided in RIS-0784-CCS help prevent proliferation of bespoke applications that provide the same functionality and result in repeating the installation and transmission of the same data. RIS-0784-CCS defines a variable NID_UKSYS as part of the GB packet 44 data structure. This can be used to identify specific packet 44 applications and support their management. The standard can be accessed using the following link irse.info/8nwk7.

ROGS review

UK: The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) are a set of rules that provide the regulatory regime for rail safety in UK.

ROGS took effect in 2006 and transposed the EU safety directive. They are a central part of health and safety legislation which ensures safe operation of not just the main line railway, but other transport systems such as Tyne and Wear Metro, London Underground and heritage railways. Every five years, there is a legal requirement to carry out a post-implementation review to make sure that they are still meeting the original objectives.

The UK regulator, the Office of Rail and Road (ORR), is carrying out the review, which will look at whether ROGS provides the appropriate level of regulation and to check that any burdens or costs on business are still proportionate to the objectives.

Although the key focus of the post-implementation reviews is on how well the rules are currently working, the ORR will also look at how ROGS could look in the future, although they say they are certain that ROGS will remain a key asset despite the end of the UK transition period for leaving the EU. The review will be completed by August 2021.

Cyber security checks for critical railway systems

UK: The Office of Rail and Road (ORR), the regulator for the railway in the UK, has been working in collaboration with the National Cyber Security Centre (NCSC) and the Department for Transport's (DfT) Cyber Compliance Team to look at risks to the safe operation of software-based high integrity equipment.

The ORR is not the enforcing authority for cyber security issues in the UK, the DfT has the lead on the Security of Network and Information Systems Regulations. But the line between safety risks caused by poorly designed, operated and maintained software-based systems and cyber security is narrow and will depend on the circumstances. The ORR say they have worked with other regulators and railway industry experts to conduct a risk assessment and risk ranking exercise on systems.

This has fed into the planning for future inspection work and target resource to look at the most likely risks and in 2021 the ORR plan to look at two issues: failure to properly manage patching and modification; and failure to manage foreseeable obsolescence of software systems.

Sustainable and Smart Mobility Strategy

Europe: The European Commission (EC) has unveiled its Sustainable and Smart Mobility Strategy. The aim of the strategy is to outline how the EU transport system can achieve its green and digital objectives and increase its resilience to future crises. The overall aim is a 90 per cent cut in emissions by 2050, which is to be delivered by a smart, competitive, safe, accessible and affordable transport system.

The strategy has several milestones that can measure how on target the European transport system is with these objectives. With regard to rail, the milestones are as follows:

2030: an increase of 50 per cent in rail freight traffic, a doubling of high-speed rail traffic, and rail intermodal traffic competing on an equal footing with road only transport.

2050: a doubling of rail freight traffic and a tripling of high speed rail traffic, and rail supporting 90 per cent reduction in greenhouse gas emissions.

For this vision to become a reality, the strategy identifies ten flagship areas with actions to guide policy, of which five in particular have rail-focused suggestions.

- 1: Boosting the uptake of zero-emission vehicles, renewable & low-carbon fuels and related infrastructure.
- 3: Making interurban and urban mobility more sustainable and healthy.
- 4: Greening freight transport.
- 6: Making connected and automated multimodal mobility a reality.
- 8: Reinforcing the European Single Market.

The Commission has reaffirmed its commitment to the European Rail Traffic Management System (ERTMS). Further efforts towards developing train automation are needed, it says, e.g. through joint undertakings like Shift2Rail. The Commission wants to update the technical specifications for interoperability (TSIs) to enable rail automation and traffic management on cross-border main lines. These TSIs are to cover technologies such as 5G and satellite data. All of this will also help with the Future Railway Mobile Communication System (FRMCS).

High-speed rail projects such as the Paris-Brussels-Amsterdam and Cologne network as well as the Øresund bridge connecting Denmark and Sweden highlight the need to complete projects such as Rail Baltica, Lyon-Torino, Y-basque, Fehmarn, Brenner, Dresden-Prague, Vienna-Bratislava-Budapest, Seine-Scheldt and many others without delay.

The Commission also says it will look into the current rules on track access charges and whether they offer the right incentives

Delivery and surveying

5G ADIF aerial surveys

Spain: An ADIF (Administrador de Infraestructuras Ferroviarias – the state-owned railway infrastructure manager) partnership led by Telefónica and including Huawei and Ineco are undertaking a programme using drones and 5G communications to survey rail infrastructure in Galicia. The initiative is co-financed from the European Regional Development Fund and a grant from the Ministry of Economic Affairs & Digital Transformation.

Two Unmanned Aerial Vehicle (UAV) bases have been established in Ourense and Pontevedra, with the latter flying in Beyond Visual Line Of Sight (BVLOS) mode.

The drones are fitted with 360° vision cameras with zoom lenses capable of taking very high-resolution images and transmitting them back to the two bases in real time via the newly installed 5G low-latency network. Two 10km sections of ADIF's main line from Vigo to Ourense and Monforte de Lemos, are being surveyed following the Minho and Sil valleys close to the Portuguese border.

ADIF hopes the system methodology could help it to inspect remote sections of line. It will also enable more rapid remedial action to be taken in the event of intervention being required and reduce the overall cost of infrastructure maintenance.

Big data and Internet of Things

AI based points condition monitoring

Germany: Deutsche Bahn (DB) has awarded KONUX, a contract for the condition monitoring of points on its network. The long-term framework agreement is for an initial 1300 sets of points at a cost of €15m (£14m, $18m). KONUX's cloud-based SaaS (Software-as-a-Service) solution will deliver predictive maintenance capabilities to DB's DIANA asset management and diagnosis platform, which already monitors the motors on 28 000 points.

KONUX say their system uses IIoT (Industrial Internet of Things) devices and (AI) artificial intelligence to improve network capacity, reliability, and cost-efficiency. It continuously and autonomously monitors the health of key switch components to forecast how the condition of the switches will develop over time, allowing the prevention of failures and to optimise maintenance planning.

Part of the acceptance testing includes DB's "ice shooting test", in which the device must remain fully fixed after being hit three times by a four-kilogram block of ice at a speed of 290km/h.

Cyber-security

Ransomware attack on Vancouver public transportation agency

Canada: A ransomware attack has crippled the operations of TransLink, the public transportation agency for the city of Vancouver. The attack took place on 1 December 2020, and left Vancouver residents unable to use their Compass metro cards or pay for new tickets via the agency's Compass ticketing kiosks. The attackers had sent the ransom note to be printed by the agency's printers.

According to a copy of the ransom note published online by a local reporter, TransLink had its systems infected with a version of the Egregor ransomware. TransLink says it quickly restored access to its Compass kiosks so customers could resume using its Tap to Pay feature to pass through fare gates and that the incident did not affect any of its transit routes.

A previous case was reported in South America after the same Egregor affiliate group also hit Cencosud, a major retail store chain, and its printers printed the ransom note in full view of store employees and customers. The Egregor gang is also known for stealing data from hacked networks before encrypting their files.

Education, skills and training

Rail skills shortage

UK: According to the 'Back on Track' report published by City & Guilds and the National Skills Academy for Rail action needs to be taken now to prevent a serious escalation of skills shortages in the UK rail industry over the next five years. The report says systemic pipeline issues have created a shortage of trained and talented employees, and collaboration is needed to address problems including a short-term approach to skills development, an ageing workforce and reliance on overseas and 'third-tier' workers on short fixed-term or zero hours contracts.

The seven key recommendations outlined in the report are to:

- Build lifelong learning commitments into project specifications for national rail projects, starting with apprenticeships.
- Transform the rail industry into a career destination, especially for young people, including educating the public about what a career in rail 'really looks like'.
- Develop strong career paths to attract and retain talent and maximise productivity.
- Make mid-career entry to the industry and skills transfer more frictionless.
- Build greater participation at a local/regional level.
- Government and relevant partners should consider a perception and awareness raising campaign.
- Utilise the 'green agenda' to attract a new generation of people to the industry.

The research found that 28 per cent of workers in the rail industry are aged over 50, and some 15 000 people could be due to retire by 2025. Meanwhile, Brexit could reduce access to overseas workers; from 2016 to 2018 the proportion of EU workers in the rail sector dropped from 17 per cent to 15 per cent a trend which is predicted to continue. Between 7000 and 12 000 additional people will be required every year over the next five to 10 years, with peak demand around 2025.

The report says lack of upskilling opportunities and reputational problems including concerns about unsociable working hours and regularly travelling far from home mean that the industry continues to struggle to attract candidates, with just 32 per cent saying they would consider a career in rail. This is particularly acute amongst women, young adults, and people from BAME backgrounds 16 per cent of the current rail workforce is female, and 24 per cent of women would consider a career in rail compared to 41 per cent of men. The report found that disinterest in rail careers could be fuelled by misperceptions, and a lack of awareness about the wide range of roles and career opportunities. Of those who said that they would not consider working in the rail industry, 42 per cent said they don't know enough or anything about careers in the sector, whilst 35 per cent said they do not have the skills required.

Companies and products

Cognitive Pilot autonomous driver assistance system

Russia: Autonomous driving developer Cognitive Pilot, has announced it will launch mass production of its Cognitive Rail Pilot artificial intelligence (AI)-based driver assistance system in 2021, with plans to manufacture more than 2000 units.

Cognitive Pilot, a joint venture of Russia's Sberbank and Cognitive Technologies Group, says it expects the units to be used by Russian Railways (RZD), as well as operators in France, Denmark and Germany.

The system consists of: a video camera, high-resolution millimetre-wave radar, high precision Global Navigation Satellite System (GNSS) sensor, a high-performance industrial-grade computing unit – providing 65 teraflops of mixed-precision processing power, AI-algorithms, a power protection and failure control system, and a traction and braking system integration unit. Launched as a pilot project with RZD in 2019 with installation on ČME3 locomotives, the system is being tested in various locations around Russia including Vologda and Ufa.

During these tests, Cognitive Pilot examined how the autonomous system worked in various weather and lighting conditions, as well as with and without wagons. The system also undertook shunting operations such as stopping, smooth running, coupling, and working movement inside stations. The tests also simulated preventing the train passing a signal at danger, running through turnouts, preventing collisions with other trains as well as pedestrians and animals.

With thanks and acknowledgements to the following news sources: Railway Gazette International, Rail Media, Metro Report International, International Railway Journal, Global Rail Review, and Railway-Technology.

News from the IRSE

Blane Judd, Chief Executive

It is now nearly a whole year since we had to leave our London head office building in Birdcage Walk which we share with several other professional engineering institutions. Since then, staff members have been working from home, aided hugely by our new VoIP (Voice over Internet Protocol) telephone system which, in addition to facilitating significant financial savings, has also enabled us to retain all direct dial HQ telephone numbers and operate as normally as possible. At the time of writing we have no date on the horizon for our return, so we ask that you continue to bear with us.

I'd like to extend my thanks to all our staff and volunteers who work tirelessly under far from perfect conditions to keep our Institution running through these difficult times and express hope that a return to normal life may be just around the corner.

Council elections – Have you voted?

Voting for Council elections closes at 1200 UTC on Monday 8 March. All associate members, members and fellows should have received their voting papers for this year's Council elections. If you would like another copy of the voting form, please contact **electionservices@civica.co.uk**.

Your vote is important as it ensures that the IRSE Council is representative of all our members. Council members make decisions on the strategic direction of the IRSE, act as trustees of the IRSE Charity and ensure that the IRSE's charitable objectives are progressed. Council members also appoint the directors of IRSE Enterprises, the company which amongst other things, operates the Licensing scheme.

IRSE Annual General Meeting 2021

At an IRSE Council meeting held on 4 February, it was agreed that, due to the ongoing worldwide pandemic, this year's AGM is to be held virtually via GoToWebinar on 22 April 2021 in full accordance with the Companies Act 2006. Details on how members can register to 'attend' the AGM online will be on the website soon, and a dedicated e-bulletin will also be issued.

Governance changes

Among the items on the agenda for the 2021 AGM is a proposal to amend the Institution's Memorandum and Articles to reflect the international nature of our organisation and better meet the needs of today's IRSE. A survey on the proposed changes has been emailed to the membership. Please see the flyer included with this issue of the IRSE News for more details.

Awards

Normally the President has the pleasure of presenting the annual IRSE awards in person to the recipients at the AGM. Sadly, once again this will not be possible this year, but details of the winners will be published on the website and in a subsequent issue of IRSE News. Certificates will be awarded to the winners in lieu of the physical awards which will be formally presented just as soon as lockdown is lifted.

A reminder of award categories follows, together with the name of a 2020 winner. We extend our congratulations once again.

Thorrowgood Scholarship Award. Not awarded in 2020. Under the terms of the bequest of W J Thorrowgood (Past President), the scholarship is awarded to a young member who has excelled in the Institution's Exam.

IRSE-Signet Award. 2020 winner Jonathan Farrell of Irish Rail for achieving 90 per cent in module 1 (safety of railway signalling and communications). This award is made jointly by the IRSE and Signet Solutions Ltd to the candidate achieving the highest marks in any single module of the Institution's exam.

Dell Award. Not awarded in 2020. This award is made annually under a bequest of the late Robert Dell OBE (Past President) to a member of the Institution employed by London Underground Ltd for achievement of a high standard of skill in the science and application of railway signalling.

Presentations competition

The Midland & North Western Section (MNWS) has launched a competition for developing engineers and is inviting entrants to register to participate. The competition is aimed for Younger Members and members working towards professional registration. The competition has two stages. Initially entrants will need to submit a synopsis of their proposed paper and presentation. Three finalists will be then be selected to submit a paper, and to make a presentation and participate in a discussion on their presentation at the section's meeting in November.

The subject material is open to the entrants but must reflect and demonstrate their involvement in and contribution to a project, product or system development, maintenance, asset management, research, or standards development.

The winner of the competition will receive a free place on an ETCS course, kindly donated by Signet Solutions, and the MNWS is offering £250 which the winner can either use towards their travel and accommodation expenses to attend the ETCS course, or towards other professional development expenses. There will also be cash prizes for the runners-up and, at the judges' discretion, for any synopses which did not make the final stage, but included good content.

Entrants should register via the IRSE website from 1 April 2021. Synopses will need to be submitted by 30 June and finalists will be notified by 31 July.

The finals evening will take place on 24 November. This will provide any entrants for the IRSE October exam time to complete their paper, presentation and rehearse. If possible, finalists will be invited to present in person at a location in north west England, with the event also run on-line.

Swiss Section

IRSE
Institution of Railway Signal Engineers
SWISS SECTION

Filling a missing link among COTS components

Report by Patrick Sonderegger and George Raymond

Many railway signalling suppliers are shifting away from proprietary systems and towards the integration of Commercial Off-The-Shelf (COTS) components. But the transition to COTS can be easier to preach than to practice. This is especially true, for example, when designing a safe interface between an interlocking and the signals and points it controls.

On 6 March 2020, 21 members and six guests of the IRSE Swiss Section visited an interlocking in the town of Châtel-Saint-Denis that incorporates a new solution for the interface between COTS components in an interlocking and those in the field. The interlocking's maker had to design the interface from scratch, but now hopes it can take a place on the shelf of COTS components available to other system integrators. Swiss Section member Patrick Sonderegger organised the event with Christoph Lerch and project manager Marc-Oliver Pellaton of the interlocking's builder, Swiss company Bär Bahnsicherung.

Collaboration across two language zones

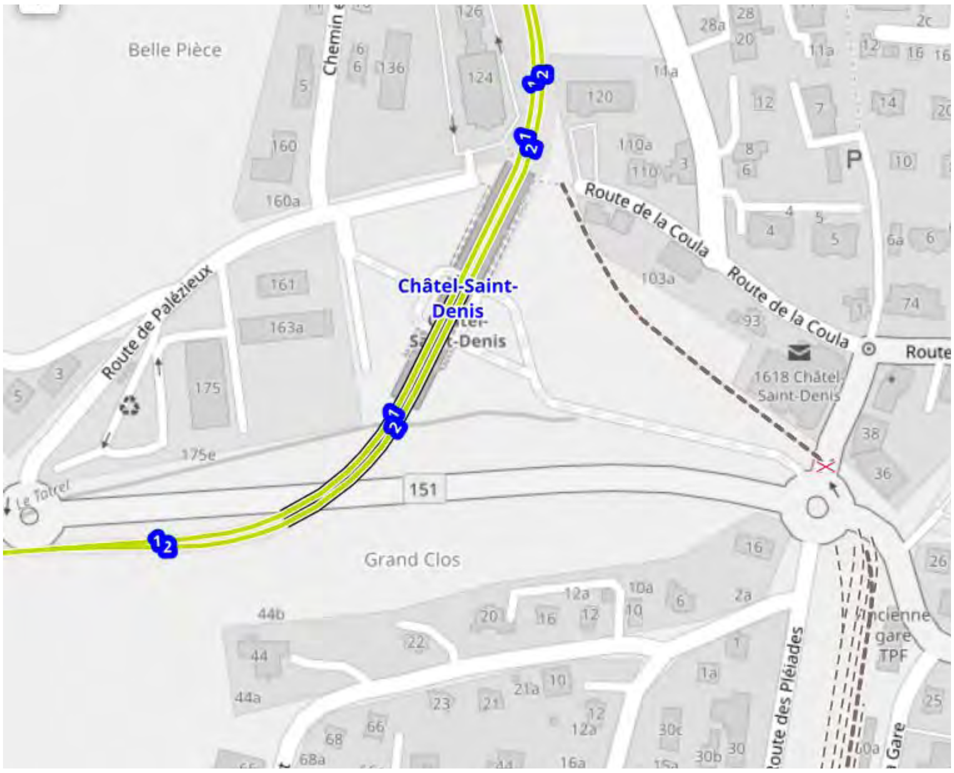
Châtel-Saint-Denis is in French-speaking Switzerland, about 15km north of Montreux. The company's main development centre is in German-speaking Olten. This has meant collaboration across two language zones. This is rarely a problem in Switzerland. Châtel-Saint-Denis is on the 43km metre-gauge Palézieux-Bulle-Montbovon line of Fribourg Public Transport (TPF), who graciously facilitated our visit.

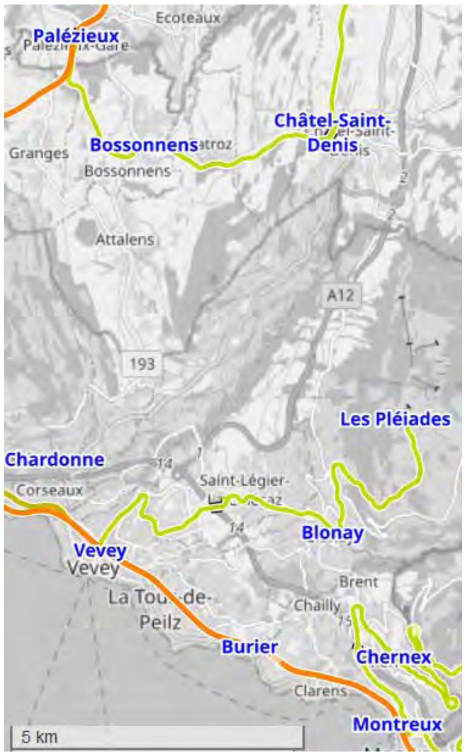
Following two years of tests, the interlocking in Châtel-Saint-Denis had entered commercial service in December 2019 along with two others at adjacent Bossonnens and Palézieux.

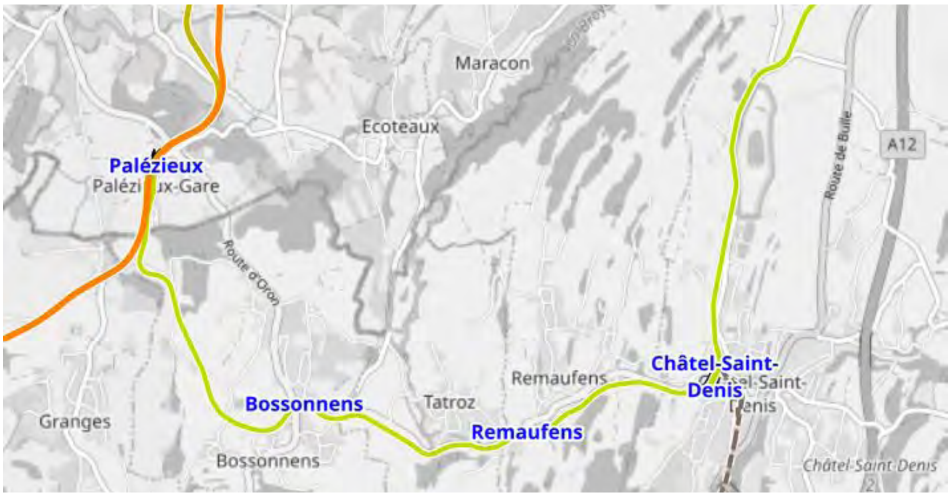
Advantages of COTS components

For proponents of COTS components, their advantages over proprietary systems

Châtel-St-Denis station on 6 March 2020. Some construction was still under way.
All photos Daniel Pixley except as noted.







Top left: The line from Châtel-Saint-Denis south to Lake Geneva is unusual for Switzerland in having been lifted, in 1969. The resulting stub station in Châtel-Saint-Denis has now been rebuilt into a through station. This has shortened trips by three minutes. Trains call in each direction every half hour.

Left: Châtel-Saint-Denis is on the west end of TPF's single-track, metre-gauge Palézieux-Bulle-Montbovon line.

Above: Châtel-Saint-Denis, north of Lake Geneva.

Source: OpenRailwayMap/OpenStreetMap and contributors.

in industrial control have long been clear. These pluses include open interfaces, manufacturer-independent standards, the opportunity to have dialogue with several suppliers during project development, faster development, greater availability, flexibility when adapting to customer-specific requirements, and lower initial and maintenance costs.

Makers of railway interlocking systems have been seeking to enjoy these advantages. In railway signalling, another advantage of COTS is the potential for harmonisation among different interlocking systems and their components.

With three decades' experience building relay interlockings in Switzerland, in early 2015 Bär decided to develop a new electronic interlocking it called Eurolocking together with the Dutch company Movares, which markets an interlocking bearing the same name. Both companies used the same Programmable Logic Controller (PLC) and faced similar challenges.

Users of COTS components benefit from a network of existing users and can have dialogue with suppliers about improvements. This speeded development and enabled a medium-sized Swiss company with 130 employees to develop its own interlocking within three years. The new interlocking first entered commercial service at Bellevue (La Chaux-de-Fonds) on the Swiss metre-gauge Jura Railway in September 2018.

Key requirements for the new interlocking were:

- CENELEC SIL 4 conformity.
- A safe and secure network for communication among components.
- Compactness to fit in the limited space typical of urban settings.
- Concentration of processing within the interlocking so as to simplify connections with outdoor elements and neighbouring interlockings.
- Ease of configuration.
- Maintenance-free, hot-swappable components that quicken the system's return to operation.
- Moderate training requirements for maintenance technicians.
- Minimal spare-parts inventory.
- Cost optimisation thanks to all these features.

The new interlocking's components and functions

The new electronic interlocking in Châtel-Saint-Denis sets each train's route by assembling a series of elements, notably signals, points and track sections. A programmable logic controller (PLC) hosts the interlocking's 1-out-of-3 architecture. Axle counters prove track vacancy. SIL4 interface cards connect the interlocking to point machines, derailers, signals, axle counters and adjacent interlockings. Each of these devices transmits its state to the interlocking via two redundant ethernet channels. Faced with any fault, the interlocking ensures that the system enters a safe state.

Indoor boards of a single basic design control both shunting signals and line signals. The indoor boards also feed power to signal lamps and point machines.

Signals

An advantage of designing a new interlocking from scratch was that old functions and signal types, such as signals with moving parts, could be ignored. This made for fewer interface types.

The interlocking controls LED signal lamps meeting current life-cycle standards. The indoor boards supply each signal with 100V AC at night or 150V AC during the day, no matter how far away. At each signal, a converter transforms this into 8V AC (night) or 12V AC (day) for the LED signals. The interlocking's logic tells the indoor board the appropriate aspect; the outdoor signal controller then lights the corresponding lamps. The design of the signal control is fail-safe. For railways with blinking (flashing) signals, blinking and its frequency can be set in each indoor signal board.

Some suppliers of COTS components

At the time of the new interlocking's design, the PLC, axle counters, uninterruptible power supply, LED signal lamps and point machines were each available on a COTS basis from several suppliers. The German maker Paul Hildebrandt supplied the PLC. Frauscher supplied the axle counters and ethernet protocol, Benning an uninterruptible power supply and Zelisko the LED signal lamps. The customer railway, TPF, specified Siemens KCA point machines. An electronic block interface from maker Mauerhofer-Zuber links the Châtel-Saint-Denis interlocking with the one at Semsales, 6km to the north. This allows the interlockings to request tracks and exchange information on track occupancy.

On 29 November 2020, a remote station that is part of Châtel-Saint-Denis' interlocking went online at Vuadens, 16km to the northeast.

The missing link: object controllers

All these components qualify as COTS. A missing link remained, however. No COTS Object Controllers (OCs) were available to control and monitor point machines and signals. Proprietary OCs were not an option because their makers neither designed nor intended them for use outside their own systems. And no open, non-proprietary network protocol was available for SIL 4 communication between the COTS components. The proposed interfaces of EULYNX, the European initiative of 13 railway infrastructure managers to standardise signalling interfaces, were not yet mature enough.

This meant that building the new interlocking would not just involve integrating COTS components. The interlocking's designers would also have to design their own OCs for the point machines and signal lamps.

Besides meeting the general requirements for the interlocking, the OCs for the points and signals also had to:

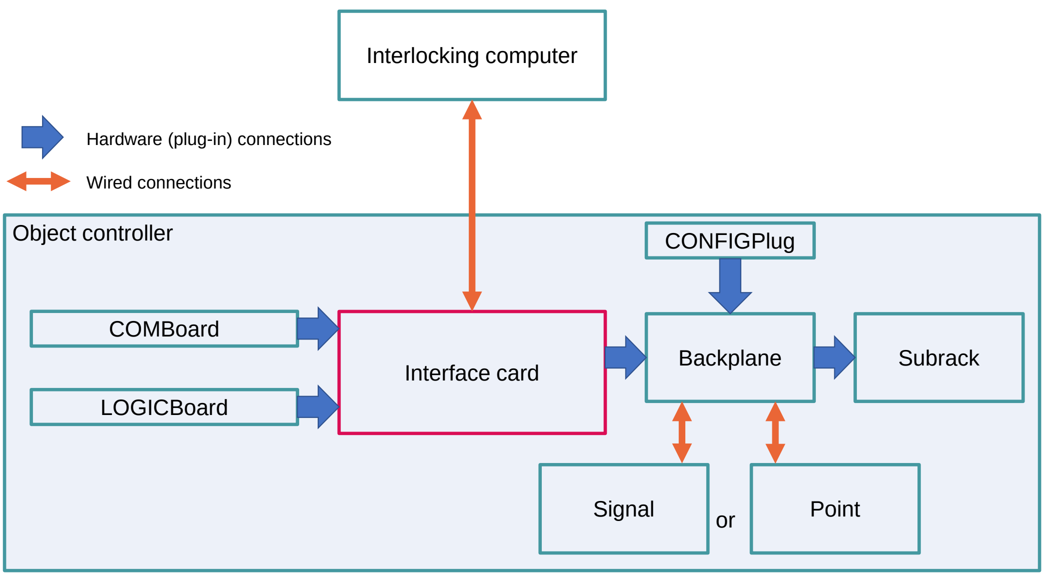
- Provide a digital (not relay) connection between the COTS components.
- All be of the same, small size.
- Be easy for small supplier companies to produce in small batches.

In line with their experience as system integrators, designers divided the OC into functional components, then evaluated different COTS solutions for each. This resulted in one OC design for point machines and another for signal lamps, each consisting of a sub rack, a backplane and an interface card.

Communication between the interlocking computer, the OC and the outdoor elements required a secure network protocol. At the time, the Rail Safe Transport Application (RaSTA) protocol was still an industry pre-standard. The risk of applying RaSTA too early was considered too great and its implementation in the PLC too time-consuming. Based on their experience with the integration of components from different COTS manufacturers, designers opted for Frauscher's Safe Ethernet (FSE). An expert had already certified that FSE was at SIL 4. And the designers had already implemented FSE within the PLC environment to connect it with the axle counters.

Within the OC, a separate component for each function

To ease future adoption of protocols like RaSTA, the designers implemented the OC's communication on a separate, pluggable circuit board called the COMBoard. It plugs into the OC's interface card. Modifying the communication protocol requires replacing the COMBoard, but not the interface card. After a software update, a removed COMBoard is ready for reuse. In

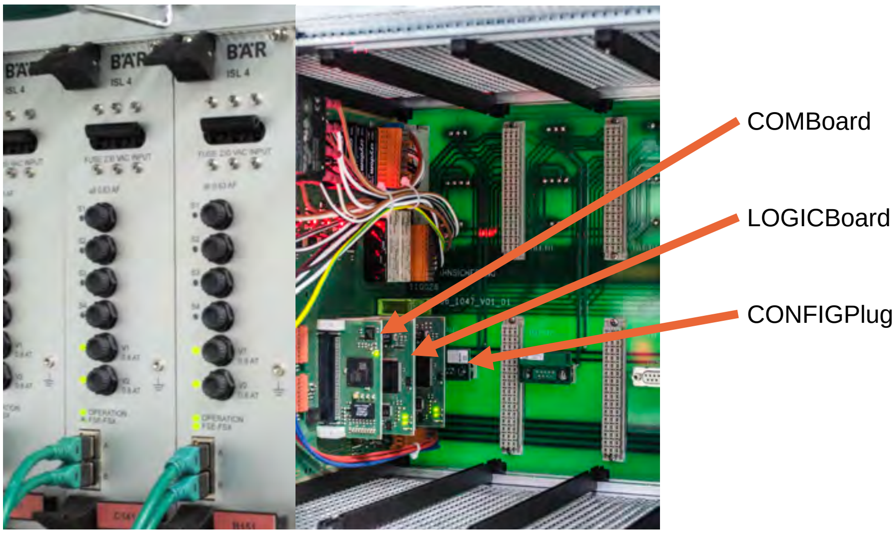


Components surrounding the interface card of the object controller for signals and points. *Diagram Christoph Lerch and George Raymond.*

Right: Interface cards for object controllers, including plug-in boards for communication, logic and configuration.
Photo Bär.

Below: Part of the indoor installations at Châtel-Saint-Denis including the new interlocking, relay interfaces to adjacent blocks, level crossing controls and cables to outdoor equipment.

Below right: Interface cards of the object controllers for points.



the future, this will ease implementation of the standardised EULYNX interface specifications for outdoor elements.

Another component, the LOGICBoard, also plugs into the OC's interface card and stores its basic generic functions, such as continuous end-position monitoring of the point machine. Extension and reuse of the LOGICBoard with more such functions is possible.

Configuration means telling each OC's interface card the functions that its field element must perform. For a signal, this includes signal type, lamp arrangement and fail-safe states. To ease configuration of new and modified installations, configuration data resides on a separate element, the CONFIGPlug. A maintenance technician can use a laptop to prepare and test the CONFIGPlug before installing it. This feature greatly reduces the number and variety of required spare parts.

The components of the signal and point OCs are reusable. Both plug into the same subrack and accept the same COMBoard and CONFIGPlug. The only difference between the two OCs is the backplane, the OC interface card and the LOGICBoard plugged into it.

Designers worked with TÜV Süd Rail to ensure SIL 4 conformity of the system.

Minimising downtime

The customer railway, TPF, has a round-the-clock service to handle interlocking problems. For fault analysis, a diagnosis system is usable remotely. A separate system can diagnose the axle counters.

The CONFIGPlug does not plug into the OC interface card, but rather into the backplane. This means that a technician can immediately replace a faulty interface card with another of the same type. The interlocking then reads the CONFIGPlug and restores the configuration in less than a second. Not requiring the maintenance technician to configure a new interface card

Left: A line signal and shunting signal and the connection box for both.

Above: 6 March 2020, a few days before the first lockdown, Swiss Section members including former IRSE president Markus Montigel (left) gathered in Châtel-Saint-Denis.
Photo Patrick Sonderegger.

before installing it reduces interlocking downtime, technician training costs and misconfiguration risk.

Within the interlocking, different cable colours provide an easy overview if a cable needs replacing. For example, fibre-optic connections are yellow and connections to the PLC are blue.

The interlocking has two independent 230V AC 50Hz power supplies, as is customary in Switzerland. Batteries allow the interlocking to run up to six hours without mains power. An uninterruptible power supply provides DC power at 24V for the interface boards and the interlocking, and also 60V for the links, supplied by Kummler+Matter, to level crossings and the blocks leading to adjacent stations.

Fabricating the OCs

As a system integrator, Bär asked specialised suppliers to fabricate the relatively small number of OCs needed. For each OC component, the production process required intensive dialogue with the supplier and early planning and procurement. As always, quality control was central, especially for SIL 4 certification.

The company says that the new OCs were the last piece of a puzzle that has yielded a complete, modern electronic interlocking system consisting of industrial components that is on a par with current proprietary systems in terms of functionality, safety, reliability and availability.

Five years after the start of development, four of the new interlockings were in commercial operation by August 2020. Their OCs control a total of 104 signals and 17 sets of points.

The open and adaptable design of the interlocking's OCs means that they can take their place on the shelf among COTS components available to other system integrators in the railway signalling field. The OCs' developers can support such companies in integrating the OCs within their system architecture.

Remote control and automatic train protection outside SIL 4

Regulators at a control centre at Givisiez, 43km to the northeast next to Fribourg, control the Châtel-Saint-Denis interlocking. A Kummler+Matter system links Givisiez with Châtel-Saint-Denis and with K+M and relay interlockings at other stations on TPF routes. One feature is automatic route setting. The Châtel-Saint-Denis interlocking also implements the ZSI-127 automatic train protection system that is largely standard on Swiss metre-gauge lines. Both route setting and ATP are independent of the interlocking's SIL 4 functions.

Tour of Châtel-Saint-Denis station

After the presentation in the interlocking room, our IRSE group toured the installations at Châtel-Saint-Denis station, where we watched the signals and points in action and inspected the links between the interlocking and the field.

AGM – and a last dinner together before the lockdown

We then rode a TPF train about 20km northeast to Bulle for the Swiss Section's annual general meeting. We dined on specialties of the Fribourg region. Some of us stayed overnight before returning to German-speaking Switzerland. We would later recall that the first lockdown was only a few days away.

This article is based on the IRSE's visit to Châtel-Saint-Denis and on Christoph Lerch's article in Signal + Draht (112) 9/2020.

Professional development

What is happening with the ASPECT conferences?

Steve Boshier and Alex McGrath

Rhythms and traditions of local, national, and international conferences and meetings have been the heartbeat of our institution. In recent years, the international events of IRSE ASPECT technical conferences and Conventions have been held in alternate years. So, in October 2019, when ASPECT 2021 was proposed by the Australasian section to host in Melbourne, Australia, there seemed no reason to think that the tradition wouldn't continue.

Then Covid-19 came along and has re-shaped our daily lives. The changes are moving differently depending on where you live, but the overall picture is that our ways of working, travelling, and living are smaller, more modest, closer to home. In Melbourne we are just coming out of four months of staged lockdown, Australia's borders are still closed to visitors and returning citizens must undertake a quarantine period. The changes move differently in other parts of the world: the UK and Europe, China, Asia and South East Asia, the Americas, the Middle East, and Africa all have different experiences, risks, and restrictions from this pandemic.

It sounds like a small voice in a cacophony, but our members have been enquiring – "What's come of our ASPECT 2021 conference?" To answer that question up front: We will not be holding an IRSE ASPECT 2021, although a face-to-face conference in Melbourne is still the intention for 2023 instead.

Early on in 2020, the IRSE leadership and conference committee understood that it would be ill-advised to continue to plan ASPECT as an in-person international conference in 2021. The incumbent and upcoming IRSE presidents, Blane Judd the CEO, and the chairs of all the proposed Conventions and ASPECTs put our heads together and brought this problem back to first principles.

Why do we hold conferences? The IRSE's objectives (in our Articles of Association) provide part of the answer, stating that the Institution's purpose to be: The advancement for the public benefit of the science and practice of signalling (which for the purpose of this document shall mean the whole of the apparatus, electrical, mechanical, or otherwise, methods, regulations and principles whereby the movement of railway or other traffic is controlled) by the promotion of research, the collection and publication of educational material and the holding of conferences, seminars and meetings.

What the IRSE's Articles of Association do not talk about (possibly due to the era in which it was written) is that the IRSE runs conferences to build human connections. The in-person international, national, and local gatherings provide an opportunity to meet face-to-face, reconnect with long lost colleagues, form bonds over a dinner which can span continents and last decades. Conferences, seminars, and local meetings bring the tribal element into our professional identities. You come away feeling like you are welcome; like you belong; like these are your kind of people.

In a time of loss, uncertainty and reduced face-to-face contact, our professional identities and professional networks are even more important. IRSE has put a lot of thought into how to support its members, provide a "CPD home" and the support, connection, knowledge sharing and collaboration that we need, as professionals and as human beings. This year has been full of experiments: combined conferences, virtual lectures and seminars, international presenters joining local meetings, masterclasses, quizzes, and virtual younger members activities.

The IRSE is actively working on some new and exciting things for 2021 which can still achieve our core role of "the advancement of the public benefit of the science and practice of signalling" within the volatile, uncertain and messy post Covid-19 world.

Let us also not get too nostalgic about in-person professional conferences. For every interested person who was able to attend an IRSE ASPECT or Convention, there were tens more who could not get funding or leave from work, and potentially hundreds more who were unaware of or had dismissed the conference opportunity. Conferences often struggle to draw representatives from the full diversity of the professional body's membership base, and the IRSE is no exception. One of the papers that resonated at the 2019 Delft conference spoke of 'cognitive diversity' – something all of engineering still struggles with.

It remains to be seen whether this break in the Institution's traditions is temporary (and if so, we could well see you in Melbourne in 2023!) or whether we can use digital connectivity to come up with new ways of meeting, virtually or in local hubs, to provide the international connection we need. We will keep looking at the needs of our membership, we will seek to reach deeper into local sections, we will link with partners – not just within signalling and telecoms but across transport and outside.

We would like to draw on you as well, the readers of IRSE News. Do you have a clever idea which we have not picked up yet? If you have a wish or resources to contribute, or if you have found ways to keep those international networks and friendships alive and growing during this difficult period, we would be pleased to hear from you. We welcome submissions from training providers, local sections, commercial and government organisations, or individuals.

Email us at **irse.aspect2021@gmail.com**.

Your letters

C-DAS systems

The December article on the KeTech development of C-DAS describes an encouraging commitment to enhanced methods of train control. The C-DAS concept genuinely improves traffic movements because it aims to avoid trains stopping and will thereby reduce delays and assist service recovery. It is also interesting to note that it is being undertaken by a specialist IT company and uses publicly available data and systems. A successful development would be of value to a train operating company in recovering delays caused by its own operational failures, and to an infrastructure owner who was responsible for delays, and of course to the travelling public.

Although C-DAS is an obviously worthwhile concept the practicalities of its implementation significantly detract from its effectiveness. Interventions should be taken early, but will rely on assumptions about subsequent train running which may not be appropriately accurate and will require recalculation and allowances which will negate some of the beneficial effects. In terms of making savings of time and energy it is most beneficial in averting pathing conflicts of high speed and heavy trains which may represent a small proportion of potentially conflicting movements.

Most significant is the question of the information given to the driver. The article states that the C-DAS does not require high safety integrity because the train will be controlled by the lineside signalling system. In this context any information provided to the driver by in-cab C-DAS equipment must not contradict, confuse, or distract from the lineside information, including Emergency Speed Restrictions (ESRs). There have been two recent RAIB reports into incidents where drivers were distracted from correct train control by other in-cab information systems (admittedly one was illicit). In view of this it is difficult to see any safety authority accepting a 'non-safety-critical' in-cab display which has the potential for displaying any information that is less restrictive than the applicable lineside information. Having an in-cab C-DAS display which could indicate "accelerate" or "target speed 70 mph" after passing a single-yellow aspect would be an ergonomic disaster. This is evidenced by the fact that on routes fitted with ATO and lineside signals the signals are either extinguished or controlled to ensure that an ATO train does not pass a red aspect. There have been historic problems with drivers failing to drive appropriately after repeated AWS cancellations and so anything that can cause ergonomic problems in the cab would be very problematic. This means the C-DAS display needs to be 'safety-critical' or only able to display indications which are no less restrictive than any lineside indications.

This does not undermine the concept of 'non-safety-critical' design of C-DAS. The default condition of train driving is to accelerate to route/train speed. There is little point in having line speeds, or train maximum speeds unless you intend to use them. You do not need a C-DAS display to tell you this.

Because the concept of C-DAS is to advise the driver that slowing down now will result in the avoidance of more adverse delays in the future the indications only need to be restrictive. The indications would be to 'coast' or to 'brake' (at a rate that the driver would readily interpret). Even so it would not be appropriate to give a 'coast' indication when the lineside signals require a train to be braking. Furthermore the prediction of a train path under 'coasting' would be problematic as it would be affected by factors such as gradient, wind, and loading. This leaves a 'brake' instruction – but at what rate? It would have to be a readily identifiable brake application such as a 'notch' or a 'service' rate. Then there is the question of how long the 'brake' application would be made for and what speed the train would be assumed to have achieved when the 'brake' indication is removed. After this, does the train hold its speed, or accelerate in accordance lineside signals?

These uncertainties and inaccuracies inherent in such a 'non-safety-critical' C-DAS application mitigate against its beneficial effect. A detailed analysis of the operation and benefits of such a system would require a technical paper, but suffice to say that even such an obvious situation as Wootton Bassett Junction (high speed passenger and heavy mineral trains) suffers significant losses of the potential gains.

The answer I believe is 'safety critical' C-DAS with accurate train position and speed information continuously evaluated by a control centre which then controls the paths of the trains. I suppose that this would be a sort of ETCS Level 3 + ATO which would be an ideal academic research project.

On the other hand the relatively inexpensive access to train running information and the readily available ability to send data to trains could justify a sub-optimal 'non-safety-critical' C-DAS. So good luck to KeTech in developing their system and gaining acceptance for its installation in the cab. They are doing proper R&D. You have to get something in work before you can really determine its capabilities and its costs. When they have had it operating for a while it would be most interesting to hear how the various problems have been addressed and overcome and what advantages have been demonstrated.

Dave Bradley

C3RAIL

The IRSE is to be a sponsor in kind for the C3 Rail conference on command, control and communications for Asia Pacific rail operators and authorities.

The online event starts at 1130 SGT (UTC+8) on 23 March. It is dedicated to the safe and efficient movement and operation of trains on the railway, with half a day of key content which can be watched live or on-demand.

It will feature four interactive live panel sessions with rail signalling, communications and systems leaders, including Robert Cooke of the IRSE International Technical Committee, who will be sharing their expertise and taking questions from the audience.

Attendance is free for IRSE members. For more information and to register visit **irse.info/c3rail**.

Quick links

IRSE
Institution of Railway Signal Engineers

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

Our website, for information about the Institution and all its activities worldwide.

Our sections, IRSE activities taking place near you.

Membership, everything you need to know about being a member.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

The IRSE Knowledge Base, an invaluable source of information about our industry.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the editors listed.

If you have a view about something you've read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster,
London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

Membership changes

Elections

We have great pleasure in welcoming the following members newly elected to the Institution:

Fellow

Arvind Bhatagar, AECOM, Philippines

Member

Thirunavukkarasu Balakrishnan, KL Consult Associates, Malaysia
Thibaut De Piedoue, Alstom, France
Ian Graham, Laing O'Rourke, Australia
Derek Granger, Rail for London, UK
V S S Ramana Murthy Korupuri, Powersys, India
Prabukumar Marimuthu, Downer Group, Australia
Dirk Meyer, Siemens Mobility, Germany
Masayuki Miyamoto, Hitachi, Japan
Makoto Murakami, Hitachi, Japan
Taishi Ohmi, Hitachi, Japan
Kiwamu Sato, Hitachi, Japan
Naoki Watanabe, Hitachi, Japan
Jianpeng Yan, Bombardier Nug Signalling Solutions, China

Associate Member

Mark Jones, Siemens Power Generation, UK
Darren Kemp, Network Rail, UK
Jerim Tharamuttam, Alstom, Singapore
Bill Wilkinson, Crossrail, UK

Accredited Technician

Nigel Worrall, DIT, Australia

Professional registrations

Congratulations to the members listed below who have achieved final stage registration at the following levels:

EngTech

Callum Higgins, Siemens Mobility, UK
James Fielding, Network Rail, UK
Adam Plant, Siemens Mobility, UK
Ashley Newman, Colas Rail, UK
Luke Smith, Amey, UK

IEng

Scott Montgomery, Siemens Mobility, UK

CEng

Markus Van Hesse, Mott MacDonald, Netherlands
Phil Baker, Infrastructure Nation, Australia
Robin Lee, Park Signalling, UK

Past lives

It is with great regret that we have to report that the following member has passed away: Joseph Noffsinger.

Promotions

Member to Fellow

Edward Burch, Tactix Group, Australia
Douglas Milligan, SNC-Lavalin Atkins, UK
Mohan Sankarasubbu, Hitachi, Australia

Associate Member to Fellow

Paul Percival, Network Rail, UK

Affiliate to Fellow

Nicholas Taylor, Network Rail, UK

Associate Member to Member

Subramanian Krishnan, Queensland Rail, Australia
Robert Nicklin, Network Rail, UK

Affiliate to Associate Member

Emily Bramble, Alstom, UK
Artem Glybovskii, Siemens Mobility, Germany

New Affiliate Members

Akinkunmi Adegbenro, Siemens Mobility, UK
Yasir Bhatti, Hitachi, Saudi Arabia
Keeley Cooke, Ove Arup, UK
Jack George, Network Rail, UK
Evgeny Granovsky, Stantec, Canada
Jonathan Harris, Network Rail, UK
Wai Pong Kao, MTRC, Hong Kong
Nikhil Kapoor, Bechtel, India
Smiriti Kumari, WSP, India
Bancha Lutrakulwattana, Bombardier, Thailand
Anthony Poncia, Network Rail, UK
Birol Salicioglu, Australian Rail Track Corporation, Australia
Manjot Singh, SNC-Lavalin Atkins, UK
Alejandro Suarez, SNC-Lavalin Atkins, UK
Jin Ho Tay, Land Transport Authority, Singapore
Iain Taylor, Taylor Commercial Management, UK
Ferdi Van Den Brule, Hima, Netherlands
Ross Waddington, Talyllyn Railway, UK
James Wilkinson, SNC-Lavalin Atkins, UK
Chun Fung Timothy Wong, Siemens Mobility, Hong Kong

Resignations: Rathindra Dam, William Grant, John Horner, Andrew Jones, Bernard Kernan, Raymond Luk, Stuart Paul, Brian Rice, David Smith, Calvin Trill and Hans Weidmann.

Are you at the right grade of membership?

Is it some time since you last changed grade of membership with the IRSE?

Have you gained additional relevant experience that may allow you to be promoted to a higher grade?

Why not make sure that your membership accurately reflects your achievements and experience and demonstrates your professional development?

Visit **irse.info/membershipoptions** to find out more.

IRSE /// News

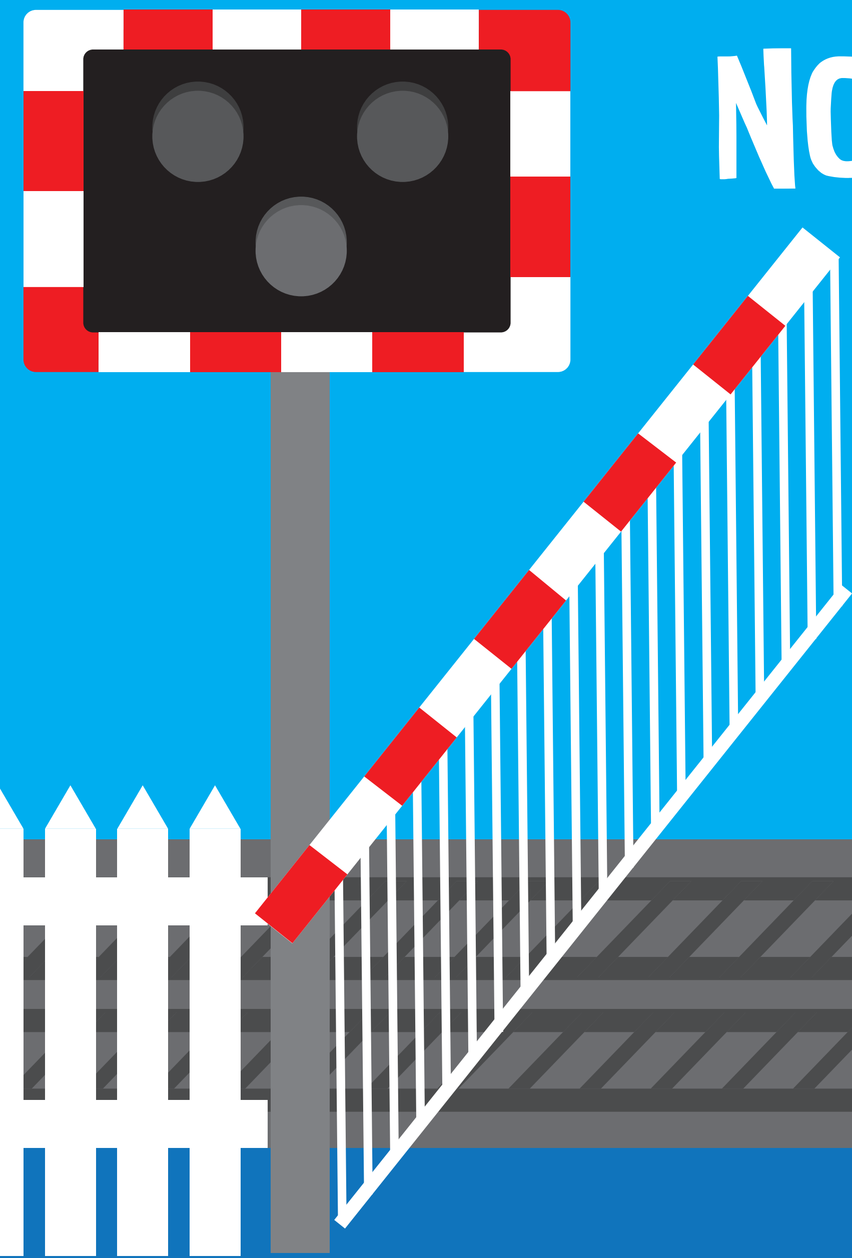
Institution of Railway Signal Engineers

April 2021

Level crossings
back to basics

Crossing predictors
the UK experience

Architecture
getting it right



NO BARRIERS TO YOUR FUTURE

WE PROVIDE THE SOLUTION TO YOUR TRAINING IN LEVEL CROSSINGS

Discover our range of Design, Maintenance and Testing courses on our website. We can tailor our courses to suit your Level Crossing needs.

Get in touch today for more information.

+44 (0)1332 343 585
enquiries@signet-solutions.com
www.**signet-solutions**.com

Signet Solutions
Raising the Standard in Development

Institution of Railway Signal Engineers

Issue 276
April 2021

In this issue

Feature articles

News and opinion

From the IRSE

From our Sections

Global, adaptive, resilient

Ten years ago while I was on the graduate scheme at Network Rail in the UK, my mentor approached me with – "I'm fronting a great new team to deliver ETCS for the Thameslink Project, I think you'd love it, fancy giving it a go?". From there, the rest is history. That chance opportunity sparked my interest in complex rail signalling and systems projects.

Now, six years after moving from London to Sydney, I am privileged to take on a role as the first female chairperson of the IRSE Australasia Section. I consider myself extremely lucky to be able to learn from the latest developments within the IRSE community and to mentor future minds. I often wonder where I would be now if I had not been as fortunate to have a forward-thinking mentor, who was committed to investing in our younger members to drive industry development.

2020 saw us adapt our working methods faster than anybody could have comprehended if we had been forewarned in 2019. I am proud of how the IRSE has demonstrated resilience in its response to 2020's challenges. We adapted the ways in which we inform and grow our capability; the IRSE Australasia held a webinar featuring a presenter in Canada, viewed by members across the globe! Additionally, the year brought opportunities for reverse mentoring and highlighted the value and contributions of our future leaders within the global community.

Going forward, it is our responsibility to embrace this momentum for change, not just within the Institution, but within our everyday work. We are gradually diversifying our membership; my appointment as chairperson is a great example of this. To maintain this momentum, we must ensure our emerging professionals are not isolated by lockdowns, but instead afforded the opportunity to challenge and grow our capability.

As 2020 has shown, the IRSE is a global, adaptive, resilient organisation and I look forward to seeing our continued success in 2021 – regardless of whether we are able to leave our home!

Georgina Hartwell
Chairperson, IRSE Australasian Section

Cover story

This issue of IRSE News includes a 'back to basics' article on level crossings and a detailed review of a near miss at Norwich Road Automatic Half Barrier (AHB) level crossing between Cromer and Norwich in England. Our cover photo is Three Horse Shoes No 1 AHB level crossing located between Whittlesea and March on the Ely North Junction to Peterborough line in England.

Photo Network Rail Air Operations

Back to basics: Level crossings

BACK TO BASICS

Ed Rollings

In this, our latest, "back to basics" article we look at how signal and telecoms engineers have to consider more than just the movement of trains around the network. The article makes reference to factors which should be considered in the provision and operation of level crossings, although legal and cultural differences prevail in many countries which may override the generic principles set out in this article.

Why do we need level crossings?

In some countries the railway came before roads while in others the construction of the railway divided land and roads where other rights had been established. Either way, it created the need for road and rail to cross each other. Level crossings vary considerably in type, often on the same railway, but members of the public may not appreciate the differences in operation as they just require a place to cross the railway safely if a bridge or underpass cannot be provided.

Terminology

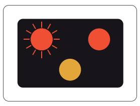
There are many different terms used to describe features of a level crossing around the world. Table 1 lists some terms associated with level crossings along with a description. Throughout this article we shall refer to 'level crossings', but they are also known as 'grade' crossings and 'rail' or 'railroad' crossings.

What is a level crossing?

So having determined the need to cross the railway on the level we can start to define this as a 'level' crossing. The form of this crossing may involve simply designating a place using signs, for example, where visibility is good to see trains approaching. Railways in many countries do not have continuous boundary fences, so it is important to designate safe places to cross the tracks. Although not usually part of the signal engineer's responsibility, the levelling up of the ground from the railway boundaries up to and in between the rails gives strength to the definition

Road crossing application and technology varies enormously around the world. This is one of several different types of half barrier crossing in the UK. Half barrier crossings are less expensive than full barrier crossings and prevent users being trapped inside the barriers. However there is a risk of crossing users 'weaving around' the closed half barriers.

Table 1 – UK signalling terminology.



Active warning	Warning or protection devices for road users which are activated by a train or railway staff.
Deck	The support and surface area of a crossing which carries users and/or their vehicles.
Full barrier crossing	A crossing fully fenced between road and railway when the road is closed. May use a single boom on each side or two half booms or equivalent equipment, e.g. gates.
Grounding	A vehicle stranded by coming into contact with the crossing surface/deck. Occurs when a long wheelbase vehicle traverses a crossing with a severe vertical curve or hump. This is often denoted by the sign on the left.
Half barrier	A crossing with a barrier closing the entrance lane(s) of each carriageway only.
Humped	The vertical profile of a crossing where it rises in the centre – see also 'grounding'.
Level Crossing	A designated place where the public can cross the railway safely on the level. May also be known as a grade crossing, rail crossing or railroad crossing. It may include a sign or other equipment to assist the user.
Passive crossing	A crossing where the user is responsible for assuring their own safety by checking for the approach of trains.
Protecting signal	A railway signal used to authorise train movements over a level crossing.
Saltire	St Andrews Cross or Crossbuck, commonly used to signify the presence of a railway crossing. This is shown to the left.
Wig-Wag or flashing light signal	A road traffic light signal with twin flashing red lights to warn road users of the approach of a train. May be used alone or in combination with barriers or gates.

of 'level crossing'. By contrast many footpath crossings do not have a built-up deck, relying instead on users to step over the rails. Vehicle crossings mostly need a deck to reduce the risk of vehicles getting stranded. The design of the deck will be informed by the types of vehicle or traffic using it, especially the vertical curvature or hump which could lead to vehicles becoming stranded where the body of the vehicle between axles comes into contact with the crossing surface (that is, becomes grounded).

"Some countries insist on measures to manage risk of collision with a train"

What does the law say?

Some countries insist on measures to manage risk of collision with a train, leaving the specific arrangements for the level crossing designer to decide based on risk. Others prescribe arrangements in detail; often a blend of these regulations will apply. In some countries it is the policy of the railway companies not to provide equipment unless required to do so by a government entity, as litigation may result where other similar crossings are not so equipped if there was an accident.

In some cases, the costs of provision and maintenance of a crossing fall on the railway authority, sometimes the government or other public body will require actions and fund those, in other cases costs may fall to the private user or be shared.

In some countries there are many different parts of law which can apply, especially where highways and road traffic is involved. Often different laws will apply for pedestrian crossings or for crossings between privately owned land such as farmers' fields or access to a single house.

Safety

Accident statistics demonstrate that level crossings are high risk sites for railway operators as well as contributing to large numbers of near-miss events. The reasons for this high level of risk should be obvious to railway professionals who are familiar with recognising hazards, but level crossing users come from a broad spectrum of society who may not be familiar with the characteristics of a train operations, where long stopping distances are normal, and trains are unable to deviate from the line of travel. Monitoring of crossing use is important as patterns of use (and therefore levels of risk) can change significantly over time. In recent years, for instance, there have been major changes of traffic pattern in some areas due to the use of satellite navigation devices and the popularity of home delivery courier services.

Selection of system

Where the law requires protection or warning systems to be provided, or the railway or other authority chooses to fund provision of equipment for their benefit or the benefit of the public, care should be taken in choosing the right combination of equipment to be safe and effective. Increasingly, convenience is being recognised as an important factor in system selection. Delaying users or trains has consequences, such as cost penalties either directly or in productivity loss and can lead to frustration which may result in users circumventing warnings.

Some railways have risk modelling tools to help choose equipment configurations that give the most effective risk reduction. Such tools also help to support a financial case for investment

An unprotected crossing in Chile. The safety of road user and the railway is very much dependent on the signs being obeyed.

in risk reduction and may include benefits to society through a reduction in lives lost or injuries incurred.

A key input to the selection process is understanding the use of a crossing both by the railway and by users. A census of use taken over several days is helpful to identify all of the different types and numbers of users, and their characteristics. It is important to understand how long they take to traverse the crossing and whether users can pass safely if they meet on the crossing. What are the approaches like, can vehicles stop easily? Do vehicles approach at speed, or is there a likelihood of becoming stranded on the railway?

"Some railways have dedicated level crossings specialists and in others it is a general signal engineering responsibility"

On the railway how many tracks are there? Do all trains pass through at line speed or are there some trains passing at slower speeds? Is there a station or junction nearby which affects speeds? Do trains pass in the area or closely follow each other and therefore keep the crossing closed for long periods? Can visibility of approaching trains and therefore warning time be improved by removal of lineside vegetation?

Pedestrian user characteristics may include mobility, hearing or sight impaired people; people with luggage, pushing cycles, or children/young adults or those with cognitive impairment who are less risk aware. Distraction factors such as mobile devices or moving in groups should also be considered.

When level crossings are renewed these factors may have changed considerably so it is vital that a thorough assessment is made whenever a change is proposed to a crossing.

Historically many crossings were operated by railway staff. Automation is now common on some railways which makes crossings cheaper to operate and manage but this relies on increased knowledge and discipline on the part of users. Understanding human behaviour factors and the interpretation of warnings is a necessary part of selecting the best combination of equipment to assist users.

Some railways have dedicated level crossings specialists while in others it is a general signal engineering responsibility. Level crossing management extends to engaging with users to educate them how to use level crossings safely, especially when changes are proposed or implemented. This may be through school visits, media campaigns or local meetings with individuals or groups.

Proposals to change a crossing or sometimes to renew it, may require consultation with stakeholders who have an interest. Typically, people representing interested groups such as the traffic authority, disability groups, the emergency services, planning authorities, or political representatives may contribute to these consultations and expect their views to be taken into account. Consultees may express views about safety, convenience, appearance, noise, lighting, accessibility, disruption during work, to list just some of the factors.

Technical protection or warning systems

The level crossings engineer has a lot of equipment available which can be configured to provide an appropriate solution. At the simpler end there are warning signs, or instructional signs. At the complex end there are complete barrier installations with sophisticated obstruction detection devices, which can identify people or objects on the crossing. These should have a high reliability and assurance of safe operation which allows them to automatically confirm the crossing is clear.

Crossings may have gates or barriers. These are operated either by the railway or by the road user. The road may have lights, usually twin flashing red, which are accepted as an absolute stop signal, even by emergency services. Sounders may be provided to reinforce a warning and to assist vision-impaired users. The use of surface markings on a road or path to identify the safe place to stop is another feature along with signs and other carriageway markings to help the user navigate a crossing. Where railway signals are provided, they may be controlled to only allow trains to proceed when the crossing is closed and clear; they may also be interlocked to prevent the crossing being opened for road users once a train has been signalled until it has passed through or safely stopped.

In some countries telephones are provided at some types of crossings to enable members of the public to seek permission to use a crossing. These are normally provided where the warning time obtained by visual means is less than the time needed to cross safely, and no other active protection or visible warning is provided. The telephones need to be protected from water ingress, vandal damage and located in a position of safety and with clear instructions on their use to cross safely. The telephones are normally 'direct lines' to the controlling signaller. The signaller must only be able to talk to one crossing at any one time, and the crossing name must be displayed to the signaller throughout the call. There must be no overhearing, so that one crossing user cannot hear instructions intended for another crossing and the voice quality must provide clear communication. The identity and location of the crossing from which the call is being made must be clearly and accurately displayed to the signaller.

"In some countries telephones are provided at some types of crossings to enable members of the public to seek permission to use a crossing"

There are number of problems with telephone crossings. The signaller may not have an accurate knowledge of where trains are in relation to the crossing. This can lead to misunderstanding of messages and increases the workload for the signaller. Signallers are trained to use 'safety critical communications' protocols but communicating with the public requires an additional skill set. The crossing user may not bother to use the telephone or may misunderstand the message being given and cross with a train approaching. With signal control areas getting larger and potentially more telephone crossings per signaller the risks become even greater.

At some types of automatic crossing telephones are provided for users to alert the signaller if the crossing becomes occupied with a failed road vehicle. In such situations the telephone is the only way of protecting the crossing from an approaching train, assuming there is a protecting signal in the right place, or an emergency radio call can be made to the approaching train with time to stop. Such telephones must operate at all times and self-reporting fault monitoring can be provided to check the telephone is working.

Where a crossing is supervised the signaller may confirm the crossing is safe to allow trains to proceed by direct observation from the signal box or Closed-Circuit Television (CCTV) from a remote location. A crossing attendant may be employed to operate barriers or gates; this person would be provided with an indicator or other information to advise when a train is expected.

Automatic crossings may not have signals interlocked with the crossing and instead rely on highly dependable safety features to ensure the crossing operates for each train. It is important that when a crossing operates there is not too much time before a train arrives, or an inconsistent time between the arrival of trains, which might otherwise encourage poor discipline by users who may attempt to circumvent the protection or ignore the warning.

Automatic crossings are activated by the approach of a train and rely on train detection equipment; treadle, track circuit, axle counter or prediction device placed an appropriate distance from the crossing to guarantee timely operation. A crossing control device may be configured to deal with trains approaching from more than one direction.

Quad barrier crossing in the USA.

Above, open crossing with lights in New Zealand.

Right, a pedestrian crossing in Melbourne, Australia.

Sometimes automatic crossings are provided with an escape route or clear exit to avoid users being trapped if the crossing operates when they are part way across. Unfortunately this leaves an opportunity for malicious or unsuspecting users to enter the crossing from the opposite direction when a train is approaching.

“On some lines it can be useful for train crew to operate a crossing”

On some lines it can be useful for train crew to operate a crossing, typically where line speed is low and only infrequent and less time-critical services operate. This introduces additional hazards, similar to where a signaller has to push gates across a road; this is really only suitable where road speeds are low and traffic infrequent. Train drivers may also be required to observe a crossing is clear after it has activated automatically but before passing over it. This is only practical where train speed is low and there is good visibility approaching the crossing, allowing them time to stop short if there is an obstruction.

In-cab signalling

Systems such as the European Train Control System (ETCS) in-cab signalling presents both opportunities and challenges for the operation and management of level crossings.

Initially ETCS was only planned for high-speed lines where level crossings do not exist. As the use of ETCS has become more widespread, lines which have quite high populations of level crossings have been fitted. One feature of level crossing operation is the critical timing required. As ETCS transmits a movement authority to the train and the train reports its position there can be a small delay or even a loss of transmission in a message.

While this can be accommodated in the course of normal train movement it becomes important where reporting the position of a moving train in relation to a crossing is concerned. A slight delay in triggering an automatic crossing could result in the crossing not being closed for sufficient time before the arrival of the train.

Restrictions of speed can be embedded in the permitted speed profile to ensure that where users need a given number of seconds clear sight of an approaching train in order to cross safely this can be enforced precisely and cost effectively without additional line-side infrastructure.

A lightly used, yet fully equipped, crossing in Switzerland.

"Any prediction of the future will almost certainly prove to be wrong"

Automatic train operation

Automatic train operation is commonly associated with metros and other high density urban railways which do not have level crossings. Some heavy haul freight railways now use automatic operation of their trains over long distances. With remote management of the operation and driverless trains it is important that level crossing use does not impact the safety of the rail operation. Automatic operation of the level crossings is preferred. This is achieved, in some railways, through the use of predictor technology which allows for adequate warning times for road users and also ensures that the level crossing is open long enough for road users to clear the crossing once they have committed to crossing it. Obstacle detection equipment is used to identify any problem with the level crossing and in particular where road and rail intersect, which informs the train control system and revokes the movement authority through an emergency brake application. Where braking distances may be 2km or more advance notice of any problem is essential to manage the train to avoid a conflict. The ability to stop a train before a level crossing needs to occur outside the minimum stopping distance. Anything less than that is a situation that raises the likelihood of a collision.

Future opportunities

Any prediction of the future will almost certainly prove to be wrong. However, there are a few foreseeable developments which will impact the future of level crossings. The introduction of Future Railway Communications System (FRMCS) may allow more use of wireless technology in the control and operation of crossings, with 5G likely to be used both for FRMCS and autonomous vehicle operation. Artificial Intelligence (AI) could be harnessed to allow learning from current operations and to improve our understanding of user behaviours. The use of AI derived solutions could prove challenging to safety validate. Self-driving autonomous vehicles may have a significant impact on safety improvement where messages transmitted from the crossing may give advance notice to the road vehicle of the imminent operation of a crossing, possibly enforcing a controlled brake application. Radio communications could also be used to alert an approaching train if the crossing is occupied. These developments could reduce or eliminate human error or misunderstanding which contributes to many level crossing incidents.

About the author ...

Ed is a Chartered Engineer and Fellow of the IRSE with a MSc in Railway Systems Engineering and Integration from the University of Birmingham. His career began in 1977 as a signal and telecommunications trainee and he held various roles in British Rail Signal and Telecoms department including maintenance, design, and project support.

In 1993 he joined Railtrack as part of a team preparing for privatisation before becoming signal engineer for the Midlands Zone on its inauguration as the infrastructure owner.

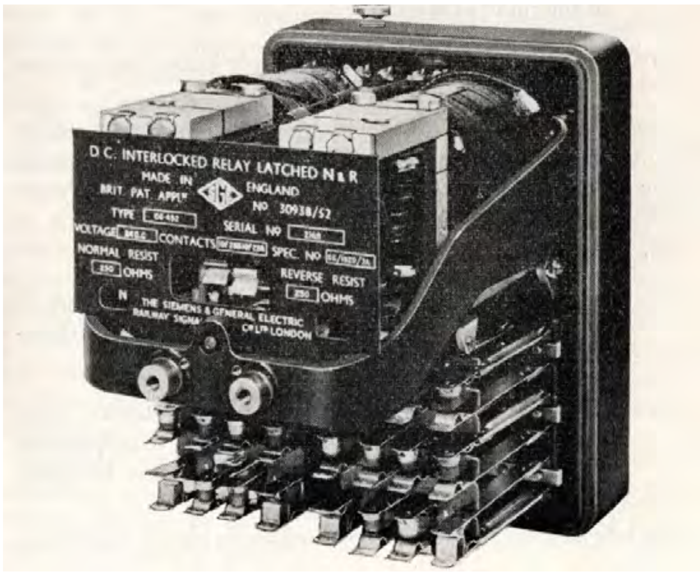
His involvement with level crossings began in 1985 undertaking scheme development for signalling and level crossings projects.

Ed held the post of professional head of signalling and technical lead for level crossings engineering with Network Rail, the GB main line railways infrastructure owner. Today he runs a company providing signalling and level crossing systems engineering consultancy. He also edits IRSE News Presidential Papers.

Back to basics: using latched relays

BACK TO BASICS

John Alexander



This article continues the IRSE News series on 'back to basics' and looks at the different uses of latched relays. It is based on relay signalling practice in the UK which does differ elsewhere around the world. There is also a good chance there are errors or missing reasons in what follows so I expect the next issue of IRSE News to have a full postbag. IRSE News would also like to hear of other examples of circuit design from around the world.

Some research and consulting with Derek Hotchkiss suggests the concept of latched relays was first introduced by SGE in the 1930s as part of their relay interlocking systems and were enhanced for schemes delivered on the Great Eastern in the 1950s. To quote from IRSE Green Book No 22 "The latched interlocking relay has been the centre of all SGE systems because it conforms closely to lever frame principles which remain the sound basis of all good signalling practice".

These relays were effectively two latched relays with the two armatures interlocked mechanically to prevent both the Normal and Reverse relays being 'energised' at the same time. For a set of points, they mimicked the lever with the Normal relay latched up representing the lever in the normal position, the sequence was then for the Normal relay to be unlatched so that both were unlatched (similar to a lever mid stroke) and then the Reverse relay to be latched up to represent the lever in the reverse position.

Types of relay

Relays come in many forms including neutral, biased, dual wound, AC immune, slow to operate, slow to drop and latched. With the exception of the latched types, they all share a common characteristic that when you remove the feed to the coil(s) the relay will revert to a de-energised state, sometimes with a short delay measured in up to several hundred milliseconds. The latched relay is different in that it remains in the state that it was last changed to by energising one of the coils in the unit.

For those of you more familiar with electronic technology and computing, a latched relay is the equivalent to non-volatile memory whereas the other types are more like random access memory in that when the power is lost the memory is lost too.

The BR930 series of railway safety relays, for example, comprise many different arrangements of coil, operation and contacts with some common characteristics. A first principle is that (except in the latched case) when the power is removed from the coil(s) it can be guaranteed that normally open (front) contacts will break and normally closed (back) contacts will make – the contact material is designed so that they should not weld and the armature is designed so that gravity assists its return to the de-energised position.

This ability to go to a known, safe state is used in many safety circuits to detect that all the conditions are met continually to display proceed aspects or to keep automatic level crossings open to road users. If the power is lost and then restored, the state of all the relays is predictable and where there could be a "race" between different parts of the system then a timer can be used to allow key inputs to stabilise before the inputs are combined to make safety critical decisions such as releasing route locking or clearing signals.

So back to the latched relay and why it is different. The first thing is that like your light switches at home it remembers the state it was last moved to. If you experience a power cut all the lights go off but when the power is restored those which had been on come back. For those of you who have experienced a fuse blowing or an MCB (Miniature Circuit Breaker) tripping in a distribution board, finding out which circuits are switched on, especially if they have two switches at top and bottom of the stairs, can be a challenge.

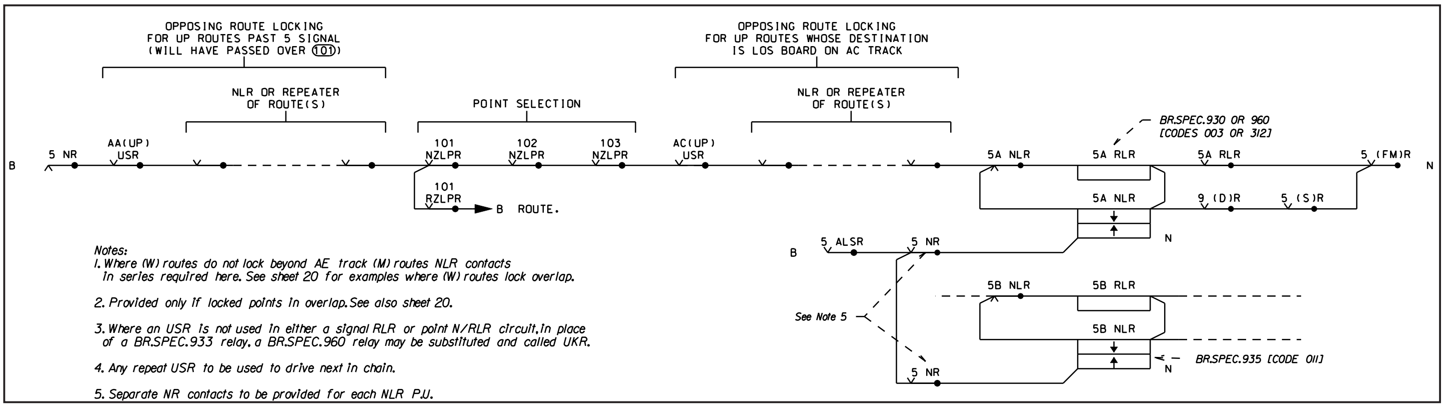


Figure 1 – Route relays. *All diagrams Network Rail.*

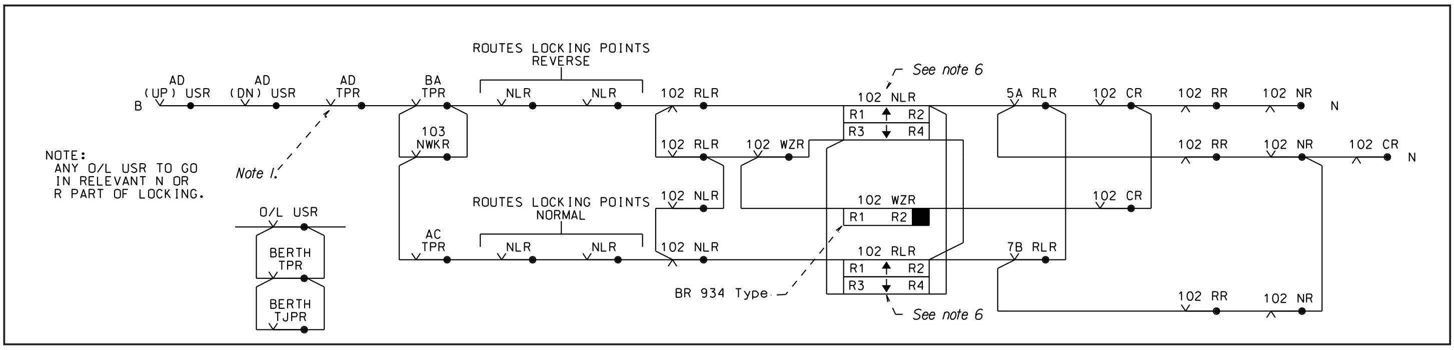


Figure 2 – Point control relays.

In a signalling system, if the power is lost the latched relays will remain in their last state and when the power is restored it is much harder to predict what the state of the system will be. However, it is that memory effect which can be very useful as it can record key states of the system to prevent changes after the power failure from compromising safety. A good example would be that if a route is set and a train authorised to take the path then, in the event of a short power outage, the train will still be committed and the points would not be moved or opposing routes set. The non-volatile memory of a route not being "unused and free" provided by a latched relay is therefore very useful.

Unfortunately, the fact that latched relays remember their state without power has also led to a number of incidents over the years where maintenance staff have caused unexpected behaviour and safety events. If a latched relay fails, or needs to be removed for any other reason, then maintenance staff need to be careful that the relay they re-insert is in the correct state. If not, a route may be released, points may move in front of a train or other controls activated or lost.

After that quite long introduction, it is time to consider how latched relays are used in signalling circuits and what precautions to take against staff errors or the memory effect. The two key options available to designers are to use a single latched relay – like a light switch, or a pair of relays where only one is in the latched state at a time. The question is which to choose!

Route relays

The first example, Figure 1, (taken from the BR-SW67 circuits but similar principles apply in other relay interlockings) is a route NLR (Normal Lock Relay) which is used to record, when in the latched position with front contacts made, that a route from a signal or origin has not been set. Unlatching the relay as part of setting a route prevents other conflicting routes being set and records that the route has been locked. Proving the route has been set and locked sufficiently to move on to issuing a proceed aspect/authority is typically done through a neutral RLR (Reverse Lock Relay) which is only energised while all the conditions are met.

When a route is to be cancelled the feed to the RLR is broken preventing a further proceed aspect being issued but the NLR remains in the unlatched position until it is safe to latch it – typically after the approach locking release conditions have been met. It is not uncommon for the RLR circuit to be configured so that it can only be energised once for the passage of a train and requires signaller action to reset it for a second train.

Point control relays

A second example, shown in Figure 2, is the control of points where a pair of latched relays is used – NLR (Normal Lock Relay) and RLR (Reverse Lock Relay). The control to move the points requires one of the two in the Latched position and the other in the Unlatched position. To move the points the currently latched relay needs to be unlatched and then, when proved in that position, the other relay can be latched. This sequential process reduces any risk that, as the relay changes state, both the latched and unlatched contacts could be made driving the points to both positions at once.

The change of state of points also often includes a timeliness function – the request is only valid if everything else was proved immediately prior to the request being made. The WZR (Point Special Relay) is often included to check that the points were not locked by the point key or a route immediately prior to them being requested to change state. The WZR, a slow to drop relay, allows the circuit to prove the point key was in the central position immediately before being keyed normal or reverse and that the other conditions are satisfied.

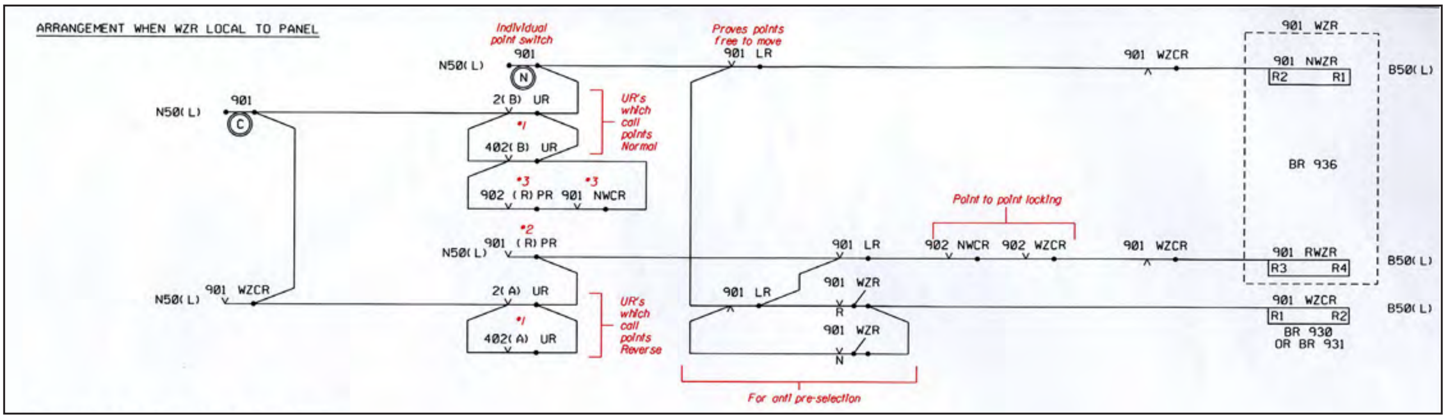


Figure 3 – An excerpt from the Network Rail standard WZR circuits.

The circuit to unlatch the current relay proves that the points are not required by any route, that there is a request to move the points (either point key or a route being set) and that the WZR is energised. Having unlatched the current relay, the other relay will be free to latch and the points to move.

Having done some analysis, and with the help of Derek Hotchkiss's memory, it appears the reason that points have two relays is mainly because they derived from the SGE circuits and relays mentioned earlier and were intended to mimic the action of a mechanical lever including the mid stroke where the motor would not be driven normal or reverse. Having undertaken some analysis it does not appear that there is a significant safety benefit in having two separate relays and it may have been a good ploy by some suppliers to sell extra relays. As far as I can ascertain there was little challenge to a tried and tested arrangement even when the physical interlock was no longer provided as in the SGE relays with it being achieved in the circuitry.

By now there will be a group of signal engineers based to the west of Paddington in the UK scratching their heads wondering what all this fuss with pairs of latched relays is all about. The E10k circuits used on the Western region use a single latched relay for points which is allowed to change state when a lock relay proves it is safe to do so. The WZR (shown in Figure 3) is a magnetic stick, subtly different from a mechanically latched relay, but fulfilling the same role. It acts as a bistate relay with the two coils commanding the normal and reverse positions.

Conclusion

A latched relay is a useful tool because it remembers the state it has been placed without a continuous feed as one would have for a stick relay circuit. It makes it easy to have different sets of conditions to trigger the change of state. Do you need a pair of latched relays to control points (based on the SGE interlocking relay) or can you use a single relay – well once again I have to accept that my colleagues on the Western may have got it right – I'm gutted!

About the author …

John volunteers at the Great Cockcrow miniature railway in Surrey, UK. Recently he was teaching colleagues at the railway as they collaboratively designed some new circuitry and the subject of how latched relays worked and should be used came up. This article is the result of John's research looking at Network Rail's typical circuits. John was a former member of Network Rail's Signalling Circuit Standards Working Group and has over 40 years of railway experience. He has also served on the IRSE Exam Committee for many years.

Back to basics

We hope you've found this, the most recent in the IRSE News 'back to basics' series, useful.

If there's a 'back to basics' that you'd like to see – or better still, one you have particular knowledge on and would like to write about – do let us know.

Email **editor@irsenews.co.uk**.

IRSE News carbon capture

For the last two years IRSE News has been printed on carbon captured paper. Carbon capture is a method of mitigating CO_2 emissions and paper produced in this way is a reduced carbon solution for magazines such as ours. The scheme also assists with creating native woodland and habitats for wildlife, and green spaces.

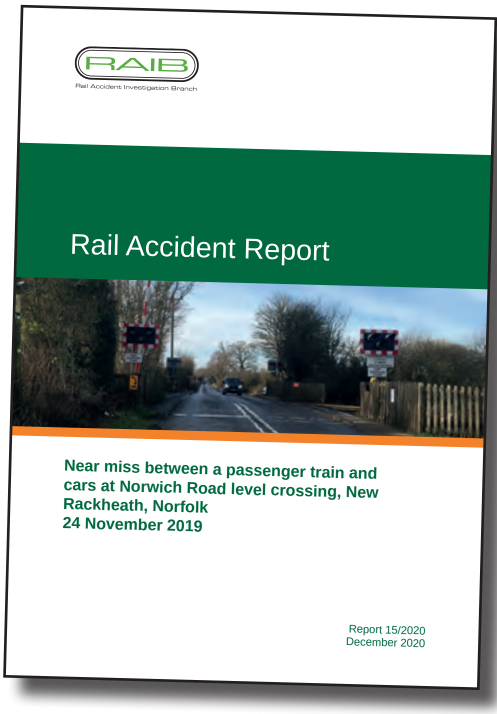
The average amount of CO_2 emitted from the manufacture and distribution of a tonne of paper is calculated and verified by the UK Woodland Trust using Carbon Trust and the Department for Environment Food & Rural Affairs (DEFRA). A charge is then determined and paid directly to the Woodland Carbon & Woodland Trust registered charity to support their work planting trees to capture CO_2 in new native woodland.

In the three years the scheme has been running it has captured 66,712 tonnes of CO_2 and raised over £1.1 million for the Woodland Trust with over 266,000 trees planted (166.78 hectares). That is enough to stretch over 142 miles – if planted in a straight line.

Planting trees to catch carbon • Planting trees to catch carbon •
9444263
Printed on Carbon Captured paper

Near miss at Norwich Road AHB level crossing

Robert Wood


RAIB
Rail Accident Investigation Branch
Rail Accident Report
Near miss between a passenger train and cars at Norwich Road level crossing, New Rackheath, Norfolk
24 November 2019
Report 15/2020
December 2020

During the evening of Sunday 24 November 2019, a passenger train from Norwich to Cromer and Sheringham (known as the "Bittern Line") was approaching Norwich Road Automatic Half Barrier crossing (AHBC) at around 45mph (72km/h). The crossing lights and barriers initially operated correctly, stopping the road traffic. When the train was less than 200m from the crossing, the driver saw the barriers rising ahead of the train and applied the emergency brake. The train just missed (by half a second) one of two cars crossing at the time.

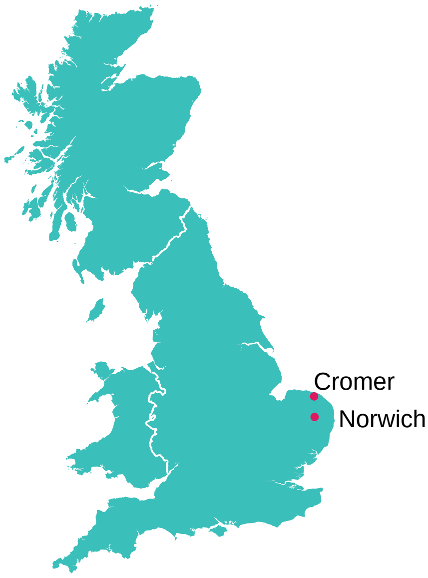
The driver noticed that the amber road traffic lights came on just before the train reached the crossing. Fortunately, no collision occurred, but there was a period of around eight seconds when the crossing was open to road traffic and the train was closely approaching. In the UK, there is of course no requirement for road users to slow down or check for the presence of trains, neither is there a requirement for the train driver to monitor the lights and barriers: all that is necessary is that road users obey the warning lights and signs, and the train does not to exceed the permitted speed.

The incident was investigated by the Rail Accident Investigation Branch (RAIB), part of the UK Department for Transport, and their report was issued in December 2020 [1]. This report concluded that the incident occurred because there was contamination of the railhead caused by leaf-fall and atmospheric conditions. This was compounded by the rapid introduction of new rolling stock with a different wheel profile to the existing stock, and the lack of railhead treatment at weekends.

The AHBC control systems on this route are HXP-3 Grade Crossing Predictors (GCP), designed and manufactured in the USA but approved for use in the UK. The term "grade crossing" is simply the American term for a level crossing. There are six crossings of this type on the route – three on double track and three on single track – and they have now been in use for 20 years.

Grade Crossing Predictors – background and basic principles

A little explanation is necessary, as although GCPs are common in the US, Canada, and Australia, they are not widely used elsewhere, and UK readers may not be familiar with their operation. They have evolved from an original design in the 1960s developed by the Marquandt Corporation, and are now produced by two railway signalling companies. Both companies' predictors are used in the UK: the HXP-3 is supplied by Alstom (previously GE Transportation, Vaughan Harmon, and Harmon Industries), whereas the GCP3000 (known as the WESTeX Level Crossing Predictor in the UK) is supplied by Siemens Mobility (previously Invensys Rail Systems, Westinghouse Rail Systems in the UK, and Safetran Systems in the USA). Both predictor systems provide a similar



function, however the terminology used to describe the various modules and parameters is often different. I've deliberately kept the explanation here very brief, so the reader can understand the basic principles of a predictor that relate to the incident at Norwich Road: the basic HXP-3 manual runs to well over 200 pages, and the GCP3000 UK manual runs to over 300!

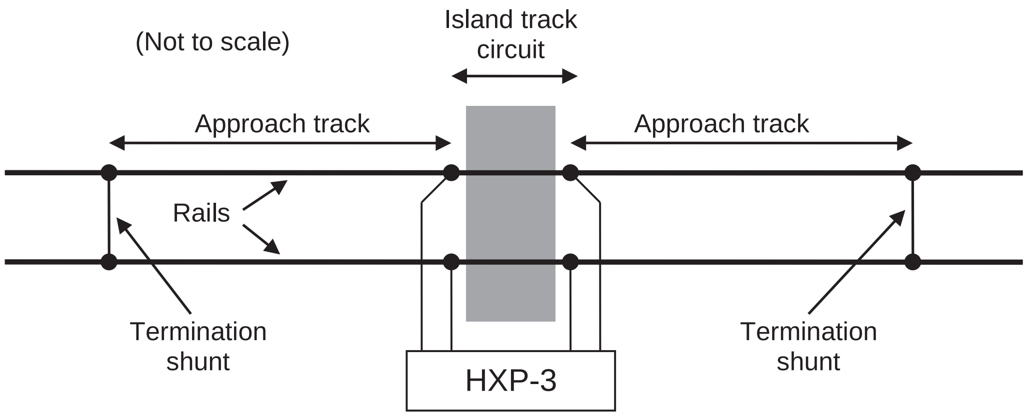


Figure 1 –General layout of a GCP, showing a single track.

The pilot installation of 6 HXP-3 crossings on the Bittern Line was commissioned in 2000, and at the time of the incident 10 HXP-3 crossings were operational on Network Rail, installed between 2000 and 2016.

The principal purpose of a predictor is to detect trains approaching an automatic level crossing and to provide a suitable control to the crossing equipment (road traffic lights and barriers) so as to always, as far as reasonably practicable, close the crossing at a time calculated to provide sufficient warning to road users, without excessive road closure times for slowly approaching trains. The departure of a train from a crossing is also detected, to permit the crossing to re-open.

The GCP operates by detecting impedance changes in the track as a train approaches the crossing. The rail circuit is largely inductive, whilst ballast is largely resistive, so changes in ballast resistance can be identified and allowed for. The predictor linearises these impedance changes to provide a software variable that can be used to calculate the position and speed of the approaching train, and uses this to determine the optimum time to initiate the crossing warnings (among other things, this linearisation corrects for the two approach tracks being connected in parallel in a bidirectional configuration). In the case of the HXP-3, this software variable is referred to as “RX”.

In its simplest form, a GCP installation comprises a hard-wired termination shunt at the extremity of each approach track, and connections to the rails either side of the crossing. One pair of connections is used to inject a low frequency (less than 1 kHz) ac constant current signal into the track; the other pair is used to measure the voltage across the rails resulting from this signal. The connections are also used to inject and receive a higher frequency coded ac signal acting as a short overlay track circuit (the “island”) covering the crossing area. This is shown in Figure 1.

The key benefits of GCP crossings for UK applications are:

- Broadly constant warning times for varying train speeds.
- All connections between the predictor and track are located at the crossing, and no cables are required to any other part of the approach tracks.
- Crossings can be very simply overlaid on existing track circuits or other GCP approach tracks, using wideband or tuned termination shunts, which may also be used to bypass insulated rail joints.

The approach track length is determined by adding the following distances travelled at the maximum permitted train speed in the following times:

1. The required minimum warning time (typically 27 seconds for an AHBC in the UK).
2. Any extra warning time required due to the crossing width (e.g. a skew crossing), to allow slow vehicles and pedestrians the extra time required to clear the crossing.
3. In the case of a double track crossing, an additional 10 seconds for Minimum Road Open Time (MROT).
4. Acquisition time – the time required for the GCP to detect a moving train and calculate its speed (typically 4-7 seconds).
5. Any extra allowance deemed necessary to cover overspeed, acceleration, or poor shunting conditions.

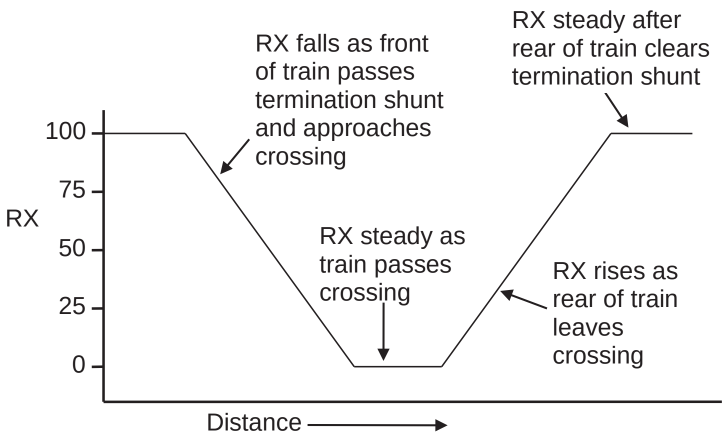
Note that unlike a conventional track circuit-based crossing, the actual warning time is not directly determined by the approach length, but the approach length must be at least sufficient to allow the programmed warning time to be achieved. This means there is little disadvantage in providing a longer approach than is actually required, in fact all the predictor crossings on the Bittern Line were designed for a maximum permitted speed of 75mph (120km/h), whereas the actual permitted speed is in some cases only 45mph (72km/h).

Initially the system will be calibrated so that with no train present, RX will be 100. When an approaching train passes the termination shunt, the voltage measured at the crossing will start to fall, causing a corresponding reduction in RX. When the train arrives at the crossing, RX will have fallen to zero, and the island track circuit will be showing “occupied”. As the rear of the train clears the crossing, the island track circuit will clear and RX will start to rise, until it reaches 100 when the rear of the train passes the termination shunt. This is shown in Figure 2.

The predictor uses the value and rate of change of RX to determine the position of the train and its speed, and uses this to calculate the RX value at which the crossing warning needs to be initiated. The crossing will remain closed until RX is seen to rise and the island track circuit has cleared.

A predictor must necessarily assume that once the crossing warning has been initiated, the train will not accelerate: doing so means the train will arrive at the crossing sooner than predicted, thus reducing the warning time below the minimum required. The predictor can however allow for a train that is already accelerating before the crossing warning is initiated, and will assume it will continue to accelerate at the same rate. In the US and Australia, acceleration close to the crossing is largely covered by rules, regulations, and signage for train drivers, to ensure that a train does not arrive at the crossing before the road traffic has received the full warning sequence and any traffic has cleared the crossing. In the UK, this is instead addressed by adding a few seconds to the warning time, and by using a feature called “Positive Start”: this ensures that regardless of train speed and acceleration, the crossing will always close when RX falls to the Positive Start value. This will, of course, slightly extend warning times for slow trains.

Figure 2 – The variation in RX as a train passes through the controlled area.



An option is available to maintain the crossing warning if a train, having been acquired (i.e. detected as an inbound movement) and initiated the crossing warning, subsequently disappears due to severe railhead contamination. This option – Loss of Shunt (LOS) – can be programmed to maintain the crossing warning for up to 99 seconds in the event of complete loss of detection. It is important to note that a sudden shunting and clearing of the track not preceded by detected inbound movement can also be detected, but uses a completely separate algorithm intended to identify an infrastructure fault. Similarly, an outbound train movement that leaves a short circuit behind (referred to as a "false shunt") will initially appear as a train that has stopped. This may be detected as a false shunt if it persists, however if it coincides with a noisy received signal it could be interpreted as a train that has stopped and then returned towards the crossing, causing the crossing warning to be restarted. Various programmable options are available to prevent this happening and ensure that train movements and faults are correctly identified and are handled correctly.

Although the rail-to-rail voltage is very low (typically less than half a volt), this is not normally an issue because:

1. The GCP does not require the received voltage to fall below a preset threshold in order to detect a train, but instead is merely looking for a small but measurable downward trend in the voltage measured at the crossing.
2. In the UK, a track circuit assister (TCA) fitted to a train will improve the train shunt in the presence of a rolled rust film in the same way that it will improve operation of a conventional track circuit.

In common with all conventional track circuits, a predictor cannot operate reliably if the wheel/rail interface is very heavily contaminated with dry leaf residue. A test I carried out many years ago on a wheel/rail test rig simulating a 10 tonne axle load showed that two leaves rolled then left to dry for only a minute were completely insulating to a 150V test voltage.

What went wrong?

The Bittern Line leaves the Norwich to Great Yarmouth line at Whittlingham Junction, and Norwich Road AHBC is about 4 miles from Norwich and 2 miles past the Junction. According to the RAIB report, the maximum permitted speed in the Down direction is 55mph (88km/h) for multiple unit trains, and 45mph (72km/h) for other trains. The normal traffic on this part of the route is a regular hourly passenger service, but occasional freight trains also run, taking tankers of gas condensate from a gas pipeline terminal at North Walsham.

Until the introduction of the Stadler Rail Class 755 electro-diesel units, passenger services were operated by Class 153, 156, and 170 ("Turbostar") diesel multiple units generally running in a shorter formation than the Stadler units. RAIB confirmed that both the Class 153 and 755 units had comparable wheel profiles and axle loads, however the Class 755s all had identical new wheels, whereas the other units would have wheels worn to various degrees. The rails in the area were 70 years old and worn, but still within acceptable tolerances. The earlier units would therefore have had varying wheel profiles that had probably "bedded in" to the worn rail profile. RAIB showed that when centred on the track, the Class 755 units ran on a much narrower band on the railhead than the Class 153, and when the units were displaced laterally (for instance on curved track), the two units ran on different parts of the railhead. The improved suspension on the later unit would probably have improved the riding to such an extent that it would have consistently run on the same very narrow band of railhead at the same location and speed.

The narrow band of railhead on which the Class 755 unit ran is clearly shown in Figure 3 taken from the RAIB report, using a photo taken by Network Rail shortly after the incident. Unfortunately, although a sample of the contamination was taken by Network Rail it was not retained for further analysis.

Since 2016, Network Rail had run a Railhead Treatment Train (RHTT) on a daily basis during the autumn, as railhead leaf contamination had been identified as an issue on this route. For reasons which are not entirely clear, the RHTT only ran on weekdays, and it is pertinent that the incident at Norwich Road happened on a Sunday evening, 57 hours after the last RHTT run, and after 48 hours of dry weather: this gave an ideal opportunity for leaves to be picked up and deposited on the railhead. The rails were also treated manually close to Norwich Road AHBC on the afternoon of the incident, as an earlier right side failure had been attributed to leaf contamination (this followed a train movement in the opposite direction to the incident train). The RAIB report does not provide any further information about the cause of this earlier failure.

The incident train was being driven by a trainee driver and instructor. The permitted speed for this class of train at the crossing was 55mph (88km/h), and the train was travelling at approximately 45mph (72km/h) on the approach. The crossing appeared to operate normally, initiating the crossing warning sequence when the train was 66 seconds away from the crossing. The predictor lost detection of the train when it was 28 seconds from the crossing, and 16 seconds later, after the LOS timer expired, terminated the crossing sequence prematurely and opened the crossing when the train was 12 seconds away. Due to the commendably quick response of the driver and instructor, an immediate emergency brake application was made, and the horn was sounded. The crossing closure sequence was subsequently

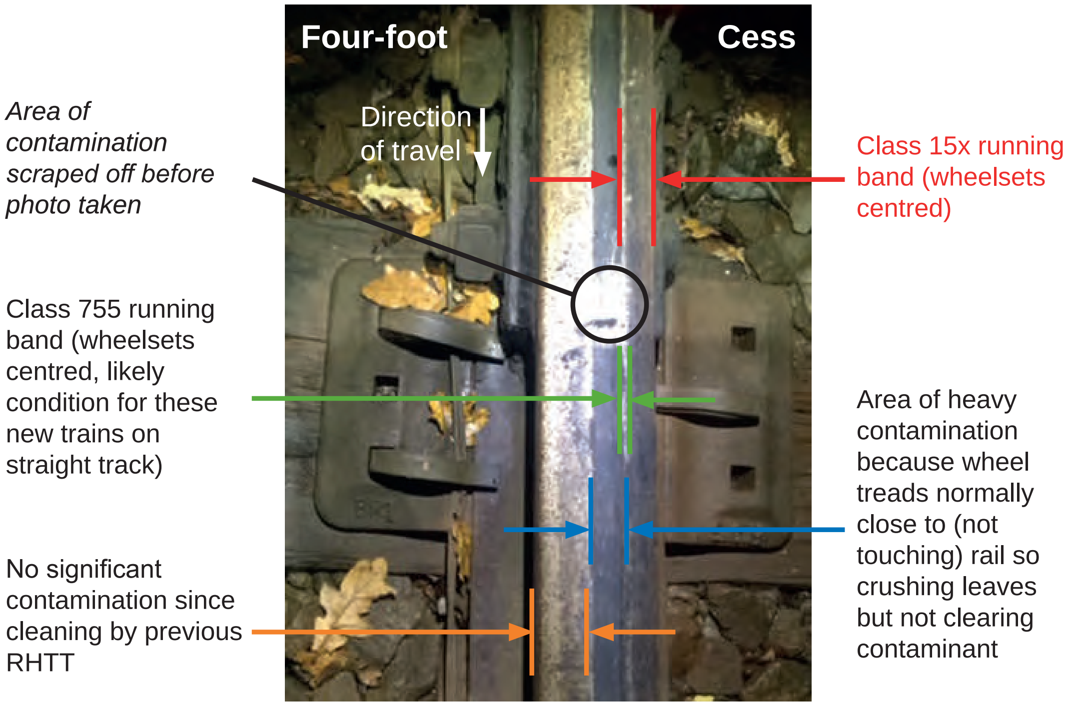


Figure 3 – Figure 14 of the RAIB report [1] shows the railhead on the night of the incident with positions of contact patches for class 755 and other stock.

restarted when the train was 4 seconds away. The emergency braking of the train did not initially achieve the expected high braking rate, as there was a 10 second delay between the brake application and operation of the automatic sander: this was due to a train design error which has subsequently been corrected.

The RAIB report includes lot more detail about the incident and subsequent investigation (including monitoring by the Atkins Technical Investigation Centre).

Actions taken, and recommendations made

Following the incident, RAIB reported a number of actions that have been taken, or are already addressed in existing instructions. These include:

- LOS timers on all HXP-3 crossings on Network Rail have been set to 99 seconds (this value has been used in all subsequent GCP installations in the UK, but had not been applied retrospectively on the Bittern Line).
- All HXP-3 crossings on Network Rail have been fitted with pairs of reinforcement treadles at the equivalent of the strike-in point for the fastest train.

Other actions include the removal of wheel flange lubricators fitted to the new trains, along with changes to the sanding equipment controls, and the frequency and pressure of wheel scrubber blocks (auxiliary tread brakes) have been increased. Although not directly relevant to the investigation, these actions should reduce the probability of wheels being heavily contaminated by any insulating film.

The recommendations made by RAIB are:

- Network Rail should take account of changes in rolling stock since the previous autumn, when planning autumn railhead treatment.
- Network Rail should provide additional guidance to accompany the standards on technical compatibility between vehicles and infrastructure, including risks associated with the introduction of new rolling stock with wheel/rail interface characteristics that, although compliant with standards, differ from the existing rolling stock.
- Network Rail should review and enhance its processes so that earlier installations are modified to reflect safety improvements implemented on later installations.

Please see the RAIB report for the full text of the actions and recommendations.

Reflections on the incident and its aftermath

This section reflects the author's personal view of the incident and the use of grade crossing predictors, and does not directly reflect the RAIB report.

Loss of Shunt (LOS) setting

The LOS timeout on the HXP-3 is sometimes used for purposes other than allowing for poor shunting in the USA (hence the wide variation in allowable values). It was not initially seen as an issue for UK applications, particularly as heavy railhead contamination had been dismissed for the Bittern Line by stressing the need for good and continuing vegetation management. The 16 seconds was later identified as being too short for general use. Current practice is for a much longer timeout to be used, in fact the UK GCP3000 manual (where LOS is called Pickup Delay Prime, and has a default value of 15 seconds) clearly states "under no circumstances must Pickup Delay Prime be left at 15 seconds for UK applications", despite the US manuals recommending it should generally not be changed. However, there was no retrospective action to update the Bittern Line installations: RAIB have noted that a retrospective change to 99 seconds on all HXP 3 installations has now been effected.

The current Network Rail signalling design manual for level crossings [2] includes a section on predictors (as an alternative to track circuits with treadles, and axle counters), so this would seem to be the place to provide more detail on generic UK predictor requirements, including an extended LOS setting.

Use of treadles

It is my understanding that treadles were originally used at strike-in points on conventional AHB crossings to mitigate a perceived timing issue: they ensured that in the case of poor shunting, the track circuit would drop immediately, as poor shunting could cause the relay operation to be delayed by a few seconds, causing a reduction in warning time. Only later were they deemed to be a protection against severe railhead contamination that could cause a complete loss of warning resulting from a total wrong side track circuit failure.

The use of treadles with a predictor is entirely different. They cannot be used to supplement the operation of the predictor train detection function directly, as it does not have a simple two-state output that a two-state device can duplicate. In some limited circumstances treadles can, however, increase the probability that at least the minimum warning time is provided in the event of severe railhead contamination. A predictor relies on "acquiring" a train by detecting inbound movement in order to determine when to initiate crossing closure. It can detect faults such as short circuits, but uses different algorithms to do this. A treadle shorting the track partway along the inbound approach will, if the predictor has not detected inbound train movement, probably be treated as a fault: the predictor can be programmed to detect this type of fault either immediately or after a short delay, and initiate crossing closure. If there has been some noisy inbound movement detected in the previous 4 seconds then it may just treat the short circuit as part of the inbound movement, and won't necessarily initiate the crossing warning at that point. If the treadle is located within the Positive Start region, it will however cause the crossing warning to be initiated immediately, provided inbound motion has been detected in the preceding 4 seconds. Only if the predictor has detected inbound motion and the crossing warning has been initiated by that inbound motion will the LOS function maintain the warning if the train ceases to be detected: if the warning is initiated by a treadle mimicking a short circuit fault, removal of that short (by the treadle resetting after the train) may well allow the crossing to re-open.

If a train operates treadles on the outbound approach (that have been designed to cover opposite direction movements), further steps will need to be taken to ensure the crossing warning is not restarted inadvertently.

A method developed for the GCP3000 predictor used treadles to disconnect the termination shunt. If a train is not shunting the track as it passes the termination shunt, its disconnection will be immediately detected (in HXP-3 terminology) as a "High Signal" fault, and will initiate the crossing closure. Other factors will need to be considered if this is used as a further mitigation.

If treadles are used with a predictor, maintenance staff need to be made aware that some recorded faults are not actually faults, but are caused by treadle operation without movement being detected. Extended warning times later followed by fault codes indicating treadle operation could be used to identify increasingly severe contamination at the wheel/rail interface and allow urgent remedial action to be instigated.

Wheel/rail compatibility

The effect on wheel/rail contact of different wheel profiles is well known, for instance over 40 years ago Iarnród Éireann (Irish Rail) took delivery of their Class 071 6-axle diesel locomotives [3]. These locomotives, weighing in at around 99 Tonnes, were delivered from the USA with wheel profiles suitable for the 1 in 40 rail inclination used in the USA, instead of the 1 in 20 used in the UK and Ireland. They failed to operate a number of track circuits even on a heavily used route, when travelling as a light engine.

It is understandable that providing new rolling stock with broadly the same wheel profile as existing stock could be considered a safe prospect, however the rapid change from worn to new wheel profiles and worn rails on the Bittern Line does appear to introduce risks that have unfortunately (and quite understandably) been overlooked. This issue was partly addressed by a Railway Group Guidance Note [4], but this has since been withdrawn and its replacement only covers on-track machines. This guidance note would appear to have gone some way to addressing RAIB's recommendations.

Vegetation management and railhead treatment

The RAIB report, in my opinion, has correctly identified the primary cause of the incident, namely that the severe contamination of the wheel/rail interface by dry leaf film prevented the HXP-3 from maintaining continuous detection of the train on the inbound approach to the crossing. The effect of leaf contamination can vary considerably from year to year: in a good year, the leaves will fall steadily throughout the autumn; in a bad year, good weather followed by a sharp frost coupled with strong winds can cause most trees to shed their leaves over a very short period. A good year will lead to only minor issues with train detection, but may still have a noticeable effect on adhesion. A bad year can cause sudden and pronounced adhesion problems if the weather is wet, or sudden and pronounced train detection problems if the weather is dry – and these problems may only be significant for a few days.

When the HXP-3 was introduced on the Bittern Line, extensive testing and analysis was carried out. It was well known that severe insulating railhead contamination would prevent safe operation, but this was ruled out on several counts. Firstly, the route was not shown in the Sectional Appendix as a leaf fall risk area. Secondly, historical evidence showed that no wrong side track circuit failures had been reported on the route (albeit there were not a large number of track circuits). Thirdly, although RHTTs were available for use in the area, none had ever been required to operate over the route (in those days they merely laid Sandite on the rails, and did not have water jets to clean the rails). Sandite is a mixture of sand and metallic particles suspended in a gel. When applied to the railhead it improves adhesion whilst maintaining satisfactory track circuit operation. Fourthly, a full lineside vegetation survey was carried out by ADAS (specialists in tree and vegetation management), examination of which confirmed that, subject to some remedial work being undertaken, the level of lineside vegetation was unlikely to cause a problem with train detection. Following this survey, this remedial work was undertaken, and Network Rail (then Railtrack) knew that the vegetation had to be maintained to an acceptable level for safe operation of the predictors. Finally, all the crossings were fully monitored during the first autumn.

During the preparation for the installation of HXP-3 predictors on the Bedford-Bletchley scheme in 2004, GE Transportation reported that in-service monitoring on the Cromer line had proven the HXP-3 to provide better detection of trains than DC track circuits, and simulations showed even the worst shunting trains will be acquired. They nevertheless recommended that, in areas of heavy vegetation, programmes of defoliation should be undertaken. This again highlights the requirement for good vegetation management where predictors are used. Was this forgotten in the intervening years, or just ignored?

In the intervening 20 years, it would appear that vegetation has not been managed as well as it should have been, and in several areas on Google Earth images, trees can now be seen completely obscuring the view of the track, which are much less evident in earlier photographs. The introduction of the RHTT in 2016 implies that leaf contamination was becoming an issue even with the original rolling stock on the route, and the vegetation was not being adequately maintained for safe operation of the HXP-3 installations.

The HXP-3 is well able to cope with a noisy input signal, and in this situation is designed to err on the side of initiating the crossing warning early (as seen when the incident train initiated the crossing warning at 66 seconds for a designed

The Class 755 Stadler FLIRT train of the type involved in the incident. Modern trains with smooth-riding suspension pose particular problems for traditional train detection systems. *Photo Shutterstock/Peter R Foster IDMA.*

warning time of 34 seconds), but like a track circuit it cannot cope with a lengthy section of insulation between wheel and rail. Had the incident train been running over a conventional track circuit, the train would have been completely lost for at least 20 seconds.

Given that the RHTT was deemed to be necessary for safe operation of the route, and would almost certainly have prevented the incident had it been run at weekends, I cannot understand how a decision not to run at weekends was ever arrived at – it's a bit like telling car drivers that they only need to wear seat belts on weekdays, and by Sunday can turn off their airbags! I do feel, however, that the RHTT is very much a second best solution to proper vegetation management, and had this taken place, the incident would almost certainly not have happened.

An afterthought

It is my view that the incident may have been made a little more likely by the trainee driver just possibly driving slightly more cautiously on the curve approaching the crossing, causing the train wheels to take up a slightly different lateral position on the railhead and providing further opportunity to build up wheel (as opposed to rail) contamination shortly before the crossing. This could not, of course, have been foreseen or prevented. I see it as possibly "the straw that broke the camel's back".

References

1. Near miss between a passenger train and cars at Norwich Road level crossing, New Rackheath, Norfolk, 24 November 2019, Rail Accident Investigation Branch, Report 15/2020, December 2020. irse.info/wldkf.
2. Signalling Design: Module X02 – Level Crossings: Common Design Requirements, Network Rail, NR/L2/SIG/11201/Mod X02, Issue 2, 2 June 2012.
3. Train Detection by Track Circuit – the Effect of the Wheel/Rail Interface, R A Wood (AEA Technology Rail), IRSE ASPECT Conference, London, September 1999.
4. Guidance on Vehicle Requirements for Reliable Track Circuit Operation, Rail Safety and Standards Board, GM/GN2576, Issue 1, August 2003 (withdrawn 2013).

About the author ...

Robert retired from full-time employment in 2011, after nearly 40 years in railway signalling design, research, and consultancy. He specialised in wheel/rail and train interface issues for train detection systems, and was an independent safety assessor for the introduction of the HXP-3 predictor on the Cromer and Bedford-Bletchley schemes, and for the GCP3000 predictor in the UK. He spent much of his career with British Rail Research in Derby (which after privatisation became AEA Technology Rail then DeltaRail), before moving to Westinghouse/Invensys Rail Systems (now Siemens Mobility) in York, to provide support for the application of the GCP3000 predictor in Europe, including training courses for maintenance staff.

What do you think?

Do you agree with Robert's assessment of the incident? Perhaps you have experience of the use of Grade Crossing Predictors in other countries that either supports or counters the analysis. Let us know, email editor@irsenews.co.uk.

IRSE
Institution of Railway Signal Engineers

French point machines with Network Rail standards – a unique challenge

Nathaniel Reade

High Speed 1 (HS1) previously known as Channel Tunnel Rail Link (CTRL), is a 67-mile (108km) high-speed railway linking London with the Channel Tunnel. Crossover 2361/2362 forms part of the Eurotunnel infrastructure, near Cheriton on the English side of the Channel Tunnel. Network Rail HS1 are contracted to inspect and maintain the crossover in accordance with Network Rail standards. What happens when the crossover drive and detection systems need to be replaced, in compliance with both British and French standards? This article explores the challenge.

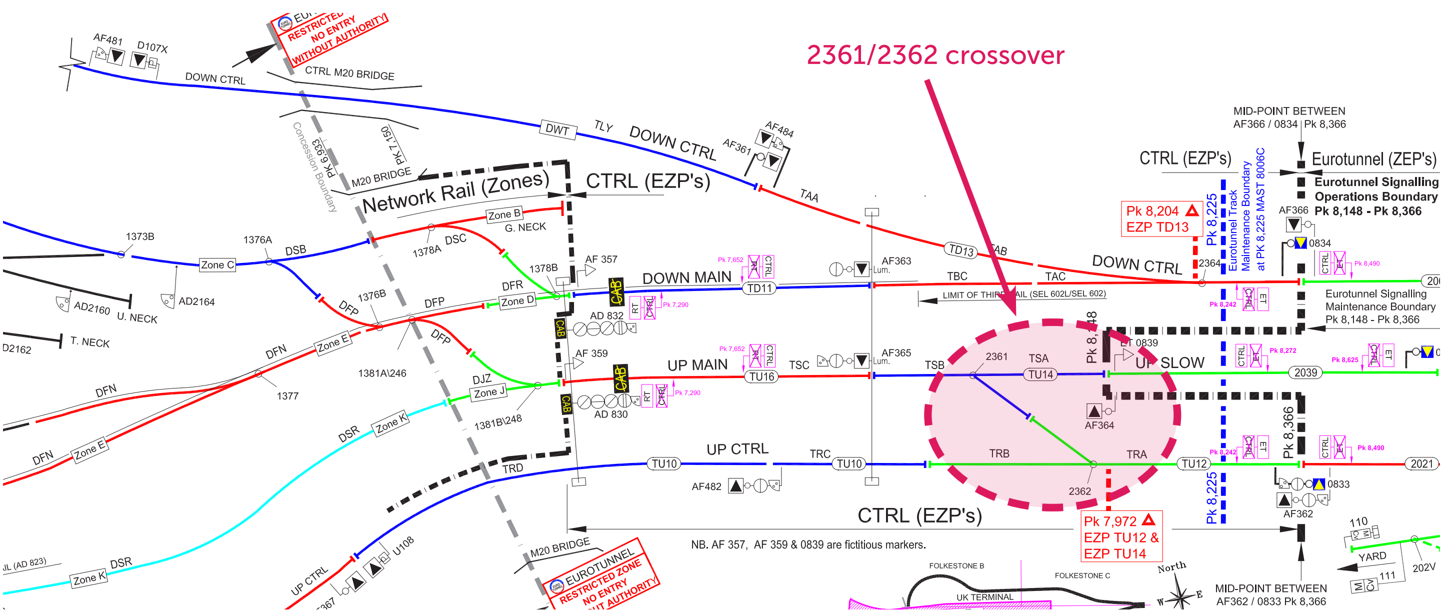
Background

The crossover, which used HW2121 point machines installed in British Rail days, was taken out of use in January 2019 following deterioration and subsequent failure. The complex nature of the interface area is shown in Figure 1, with 2361/2362 points in the middle of the Network Rail, HS1 and Eurotunnel area.

The loss of 2361/2362 crossover had an impact on the flexibility of operations in the area and restricted the availability of routes, as well as increasing the demand on the local maintenance and inspection teams. This was the only HW2121 point machine in the HS1 maintenance team area, so the decision was taken to renew 2361/2362 crossover and to convert the existing drive and detection circuits to utilise French MCEM91 machines. These are 400V three phase AC machines that are used on HS1 and Eurotunnel.

As Network Rail HS1 maintenance organisation did not have a dedicated project renewals team, the project was managed by the Switch & Crossing (S&C) South Alliance. Due to their previous experience and expertise in working on HS1 infrastructure, Amey Consulting was engaged ten weeks ahead of the planned commissioning to produce and deliver the designs, and to install, test and commission the signalling aspects of the S&C renewal.

Figure 1 – The Network Rail/Eurotunnel interface, showing location of 2361/2362 points.



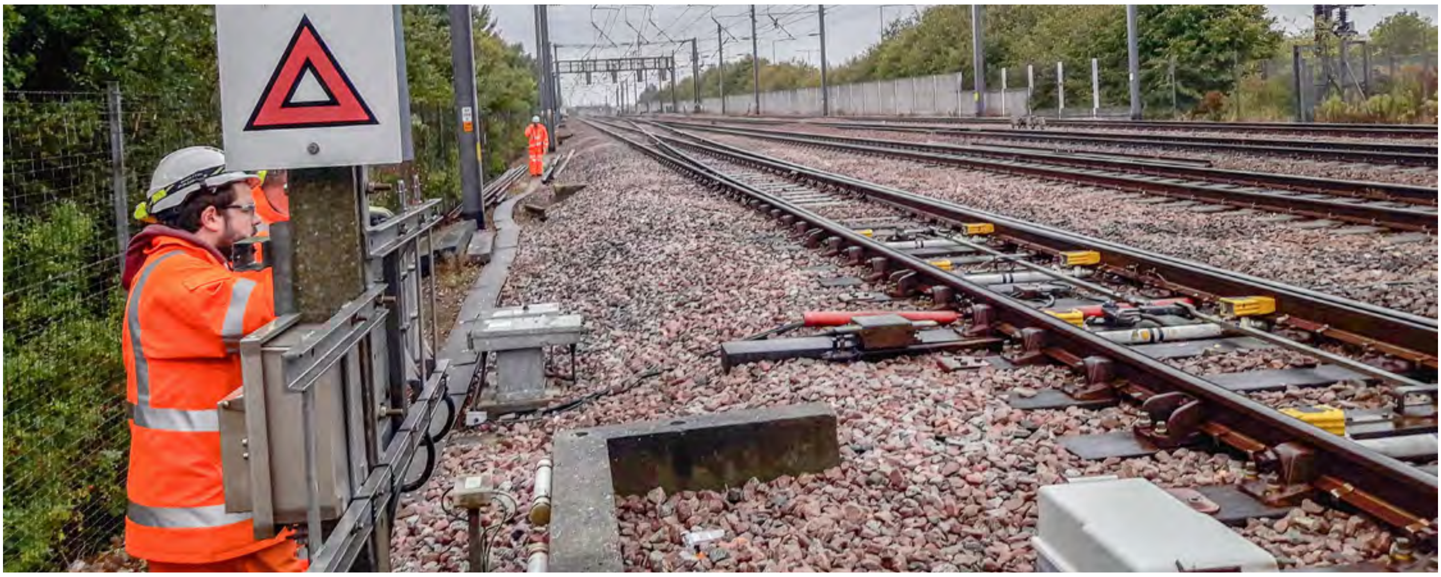


Figure 2 – Previous 2361/2362 crossover with HW2121 point machines and supplementary detector.

Technical challenges

In addition to the technical challenge of converting the existing 120V DC drive circuits to 400V three phase AC circuits, the location of the crossover at the interface, between HS1, Network Rail and Eurotunnel infrastructures, presented a number of unique challenges to be overcome. Many stakeholders were engaged throughout the design process to ensure the proposed solution met the client's needs, fulfilled the compliance requirements for use on railways in the UK, complied with the French regulations for powering and detecting the new point machines, and was also possible to build and maintain. Particular concerns were raised around the interfaces between the French and British methods of drive, detection and indication circuits, with difficulties ensuring the designs would be compliant with all relevant standards. Achieving either one of these was relatively simple, achieving both considerably less so!

Following previous experience of working on HS1, and with established relationships between all stakeholders, the design team was well placed to assist with the smooth management of the interactions between all involved parties and to resolve any issues associated with conflicting requirements as and when they arose. This experience was also used to apply the correct conventions and methods of presentation required for both Network Rail and HS1 infrastructure.

The first obstacle to overcome was the compressed timescales. The possession date had been firmly set ten weeks after the design team was engaged to complete the design activities. It quickly became apparent there was insufficient time to develop the unique design solution that would be required and to complete the essential engineering assurance processes. The design team instigated an engineering workshop with all involved parties to collaboratively outline the best way to complete the project given the tight timescales and challenging interfaces. The result was a two stage design and commissioning strategy:

- Stage 1: Use the existing possessions to lay in the S&C, clip and padlock (C&P) the crossing normal and provide point detection through the new MCEM91 point machines and Paulvé detectors.
- Stage 2: Commission the point control from the existing Ansaldo SEI interlocking.

At Stage 1 the existing crossover and point machines could be recovered and physically replaced with the new assets on site which would then be clipped and padlocked out of use. This approach provided enough time for the new drive and detection circuits to be completed ahead of the Stage 2 commissioning that would bring the renewed crossover into use. However, even with the extended timescales there were still a number of technical issues that needed to be resolved.

The HW2121 machines that had been in use at 2361/2362 crossover contained integral detection elements and circuitry, as per the usual arrangement for point machines of this type, with an additional supplementary detector for each point end. This is shown in Figure 2.

Whilst common on SNCF infrastructure, the MCEM91 point machine is not used in the UK outside of HS1. This machine requires external detection via Paulvé units, manufactured by Vossloh, in place of the integral detection in the HW2121, and also in place of each of the supplementary detectors. Paulvé detectors are a rotary system, with an arm connected to the switch rail that mechanically rotates the detection elements as the points move back and forth. A Paulvé detector is shown in Figure 3.

Figure 3 – Paulvé detector.

Figure 4 – Internal Paulvé detector connections.

The latest Paulvé detectors are designed to be used in conjunction with preformed tail cables, as shown in Figure 4. However, the manner in which these tail cables split the detection current paths between the detectors, and return the detection circuits to the interlocking, does not comply with the Network Rail standards and requirements. There was not sufficient time within the project programme for the circuits with preformed tail cables to pass through the circuit review committee and so it was decided to apply the design used for the existing HS1 Paulvé detector circuits, which used dedicated cables. Additionally, the new Vossloh style of preformed tail cables provided with the detectors (similar to the 'paddle' used on clamplock detectors) was a recent alteration to the French detection method that had not been encountered on any project before, either in the UK or in France. To complicate matters further, it was not possible to comply with Network Rail Notice Board 180 (which requires separate detection circuits for each detection element) whilst also complying with the SNCF detection circuit requirements.

As a compromise, the design team proposed a solution where the detection cables returned to the location case between each detection element, but without providing individual relays for each Paulvé detector unit. This enables simpler maintenance and fault-finding capabilities without breaking the continuous detection circuits required for the Paulvé detectors. These detection circuits were successfully installed and commissioned at Stage 1, in line with the ambitious timescales set out at the beginning of the project.

Stage 2 of the commissioning brought the new MCEM91 machines into operation, and the control and detection circuits fully migrated to the existing interlocking in Cheriton Signalling Room. The existing BR Spec relays driving the HW2121 machines had been taken out of use at Stage 1 and the new circuits were designed and commissioned using French style NS1 relays. Although fundamentally they perform the same function, the design and installation conventions are different – front contacts became 'travail' (working), armature became 'milieu' (middle), and back contacts became 'repos' (sleeping). Contact arrangements also changed drastically, with the analysis sheets referring to the hole in the trunking that the wires pass through, rather than corresponding to the rear of the relay.

As well as containing the sheet number the contact appears on, and the wire count, the French style contact analysis also contains the details for the other end of each wire. To correspond with this, the position of the relay on the rack is also presented beneath the relay contact shown in the wiring sheets. To complicate things further, the French numbering convention starts with Terminal 1 at the bottom of the row and works its way up – a subtle change to the British convention but another potential pitfall when designing and installing!

As with every S&C renewal, it was vital that full communication was maintained between the signalling designers and all other disciplines throughout the project. Careful consideration was given to the required power consumption for the new 400V AC three-phase point machines to ensure there was sufficient capacity. Although the required load was less than the HW2121s they were replacing, the three-phase supply came from a separate feeder so it was not possible to simply offset one against the other and assume a net reduction in power consumption.

The position of the Intermittent Transmission Loops (ITLs) – a key component of the in-cab signalling in use on HS1 – was also crucial, so close coordination was required with the track engineer to ensure the new layout and slewed area did not interfere with any of the existing positions.

The responsibility for providing points heating falls with the signalling designers and installers in France, so full communication was required throughout this project to ensure the power supplies were adequate, and documented within the signalling drawing set.

The team was able to provide the design, installation, and testing resources to successfully commission this challenging project in time, drawing from previous HS1 experience and maintaining full communication with all stakeholders throughout. The ability to interpret the requirements from different and often conflicting standards, and to provide a workable and compliant solution, enabled the crossover to be brought back into use thereby increasing the capacity and efficiency of the infrastructure and providing a common point machine for the HS1 maintenance team.

About the author ...

Nathaniel has been working in the UK signalling industry for 14 years. He is a senior systems engineer and has worked in the Swindon design office of Amey Consulting for the last four years. He has an engineering degree in innovation and design, and in addition to signalling design management is also a part-time author specialising in military fiction.

What do you think?

What is your experience of introducing systems and components to a country or railway for the first time, even though they are widely used elsewhere? How have you coped with issues such as acceptance, different design principles and asset management regimes? Have you found it straightforward to train installers and maintainers, or have you found challenges, perhaps to do with the way that messages are shared, different terminology, or even issues with translation?

We'd love to hear your views and experience so that we can share with other IRSE members as part of our ethos of inform, discuss, develop. Email us at **editor@irsenews.co.uk**.

The many aspects of architecture and their impact on system performance: Part 1

Rod Muttram
on behalf of the IRSE International Technical Committee

At the start of his Presidential year in 2019 George Clark asked me to write a paper on the importance of good architecture. It has taken some time but has now evolved into three parts in which we (the ITC) have tried to give as broad a perspective as possible. Our hope is to inform, particularly younger engineers who may not have encountered some of the issues yet in their careers, and to jog the memory of more experienced engineers who probably have but maybe not recently. We certainly will not have covered everything but hopefully enough to prove useful.

So, what do we mean by 'good architecture'?

The dictionary defines architecture as the process of planning, designing and constructing buildings or systems. Most lay people would associate architects with buildings or structures; and note the first dimension is planning; more on that later.

To most people it would be self-evident that an architect's job is to design buildings which are structurally sound, fit for purpose and safe. Many successful architects also design buildings and structures that are visually appealing; although while "beauty is in the eye of the beholder" and the visual appeal of some modern architecture can be a matter of taste, few can argue that structures such as the tower known as the "Gherkin" in London, or the Millau viaduct in France, are not striking and very impressive in looks, scale and achievement.

The architect's role later in the lifecycle is an interesting question. Many structures are maintained long beyond their original design life, to what degree is the original architect or design team then still responsible? A recent tragic example is the collapse of the Morandi bridge (named after its famous architect) in Genoa in Italy with 43 fatalities. The failure is thought to have been caused by a combination of corrosion in parts of the structure and much heavier traffic that anticipated when the bridge was designed in the 1960s. Maintenance and maintainability are also questioned with some parts being hard to inspect due to Morandi wanting the bridge to have 'clean lines'.

In rail we have many impressive physical structures particularly bridges and stations. Some of these have faced significant maintenance challenges. Few realise the huge maintenance backlog that Railtrack inherited after British Rail's later cash-strapped years, with iconic structures such as the Forth Bridge and Brighton station examples of those that were under severe threat prior to major renovation projects. Even the replacement Tay Bridge, re-built to be 'super strong' after the Tay Bridge disaster of 1879, needed more work when subjected to modern finite element analysis techniques.

But it is not 'civil' structures that are the subject of this paper; it is intended to focus more on the structure of control, communications and power systems – the 'systems' element of the definition.

It became clear in discussing a draft of the paper with the ITC that 'architecture' in that context exists at several levels, and I am particularly grateful to Rob Cooke for his help in bringing that out more clearly. There is the design and architecture of individual components and subsystems and then the overall architecture of the system, or 'system of systems' that delivers the desired service or outputs.

It is the second of these facets that tends to be more thought of as the 'system architecture' but such 'big systems' are critically dependent on the first element being correct if they are to deliver the reliability and safety performance required.

The ITC therefore decided to split the paper into three parts, the first (this part) covering aspects related more to the good design basics of components and sub-systems, focussing on hardware; the second covering software, normally distributed throughout the hardware of a bigger system but also having critical architectural dimensions; the third covering the bigger system and system of system issues. The three parts interact and are critically dependent on each other so those distinctions may not always be strictly maintained.

For the third part, certainly historically, a true 'system architect' was not always visibly involved. Many of our systems have not so much been 'planned and designed' at the overall system level as 'evolved' or simply happened as a consequence of other factors such as piecemeal renewal as assets became life expired.

Rail assets tend to be long lived. What were relatively simple systems in mechanical and electro-mechanical days have become increasingly complex and money is certainly not always abundant, so piecemeal and partial renewals have been common. This can mean that architectural choices are severely constrained, and the implications of some of the more subtle system level interactions or maintenance impacts may not always be immediately apparent.

With increasing system novelty and complexity, the importance of good architecture at all levels to being able to predict and assure system behaviour and maintainability cannot be overstated. As we move ever more towards software driven systems good software architecture is also a key part of facilitating approval, introduction, maintenance, updating and safe service. More on that in part 2.

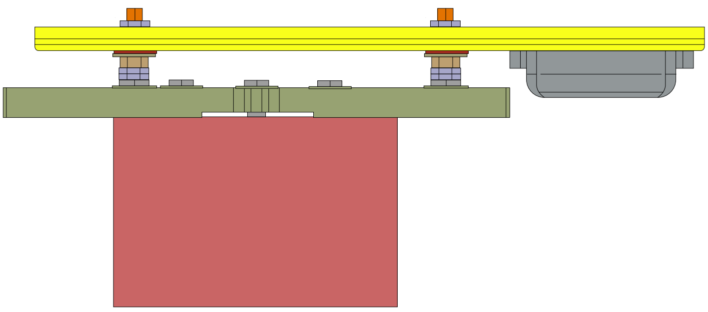
So firstly, in this part 1, let us consider hardware which is concentrated in the components, sub-systems and the communications between them.

Hardware architecture

So, what constitutes a good hardware architecture? Each sub-system needs be considered for and in its (maybe unique) operating environment. Most of what we cover next should be well known, and much is covered by standards and good practice but it is remarkable how many times in my long career I have seen things missed and errors not only made but repeated. Corporate memories can be remarkably short.

Structural, functional and environmental factors all need to be considered. Certainly, as a 'rule of thumb', it is always good practice to minimise complexity and the number of interfaces. These need to be considered together as minimising interfaces may involve additional complexity in each of the elements – there is always a trade off, and the optimum solution needs careful analysis. Hardware will have many requirements, some of which will likely come into conflict, and the simplistic application of specifications without considering a broader system context will often end in problems. But for 'generic' component and sub-system design sometimes that can mean working to a theoretical 'envelope' as the end system usage may not be fully known at the time –an important role for standards.

The well proven Serial balise has been in use for decades in EBICab and KVB ATP systems with no issues (shown yellow in the cross section of the mounting arrangement below) . When subjected to enhanced AREMA levels of swept sine vibration for the US PTC project a structural resonance occurred which caused cracking. Whilst no functional failures occurred modifications were necessary to ensure no long term moisture ingress could occur.
Photo Bombardier RCS.

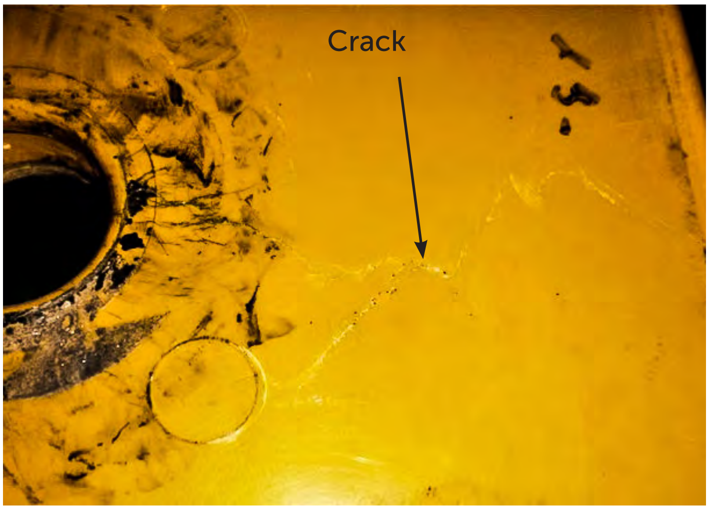


Thermal and environmental management

Hardware is the main element in securing temperature performance but it is important not to forget that in software driven systems, software can affect power dissipation and therefore temperature too. Software may also be used for some more complex aspects of thermal management. Designing and testing a piece of hardware to meet a specified temperature range in its own right is a fairly complex task but when we consider its application in a system it becomes even more complex. If several elements are combined in a cabinet, maybe from different manufacturers, then there can be interactions that lead to problems. Adding specific hardware like fans or air conditioning has cost, reliability and maintenance implications. It is also important to consider 'de-rating'; it is always tempting to choose a lower cost component or sub-system which just meets the power rating required, but that component/ sub-system may run hot and affect others around it both in terms of performance and life. Including air conditioning or force cooling to remove that excess heat may solve some of the problems but it is quite likely that the item concerned will still have a reduced life perhaps compromising a reliability requirement. It may be better in life cost terms to use a component/sub-system capable of coping with higher power which runs cooler so may not require force cooling and/or be longer lived – this process is sometimes known as 'de-rating' because components are used at a lower rating than the maximum for which they were designed. A simple but classic example is to choose a transformer with a higher current rating. Wound with thicker wire it will run at lower temperature at the required level.

In Singapore the LTA now requires signalling suppliers to conduct thermal analysis of complete ATC cubicles during the design stage to consider the different operating scenarios including when air conditioning may not be available. It matters in thermal management terms where particular units are placed in a rack – higher power units such as power supplies are often placed near the bottom for weight distribution/centre of gravity reasons, but heat rises and may affect units above.

This is the first example of a very important principle that for any project or change there should be a clearly defined system integrator. Historically in the railway industry this was the client, but with increasing 'contractorisation' and the advent of contracts for Design, Build, Maintain (DBM) and DBMO (adding Operation) and Public Private Partnerships (PPP), it can be a contractor. That is fine if properly executed by a competent contractor with a long-term interest but we have



seen too many projects where the issue has been 'fudged'. For instance, some clients have attempted to get the cost benefits of competing different elements of a project separately and then, once the contracts are placed and companies committed, either told one of the suppliers they must take the integration role, without the full capability or funding; or simply told all of the contractors to 'sort it out between them'. We shall return to the subject of system integration in part 3 of this paper but suffice it to say we consider the above approach to be highly unsatisfactory and likely to lead a bad outcome for one, more or all of the parties.

Another important environmental factor is shock and vibration. This will involve not only the inherent capability of the components but also how they are mounted and the overall nature of the physical structure within which they sit and the way that structure is mounted in the overall system. With good design amazing performance can be achieved (I was once involved in the design and production of a system that reliably survived a 120,000g shock) but get it wrong and mechanical 'Q' factors can multiply inputs at the component level by many times and lead to failures. Shock and vibration may cause intermittent as well as permanent issues – this is particularly important for electromechanical components like relays, buttons and switches where shock and vibration can cause contacts to open, or even sometimes close, intermittently. This can even affect components designed specifically for safety applications and the author has witnessed a case where a multiple failure case, dismissed as 'incredible' in a Failure Mode and Effects Analysis (FMEA) report, happened on a shock test due to multiple contacts opening simultaneously under high shock. In terms of signalling such factors are particularly important for on-board systems, but can affect trackside assets too which are not immune from adjacent events such as track maintenance. Good architectural practice might include not only the overall structural design and the use of shock and vibration absorption features such as resilient mounts, but could also extend to measures such as consideration of mounting relays in the same circuit in different orientations to avoid common mode shock effects.

It is also necessary to consider issues such the IP rating (International Protection, also known as ingress protection). Sealing the unit may make the thermal management issues discussed more difficult but some dusts can be quite conductive and damaging to electrical as well as mechanical features. Conformal coatings or even encapsulation can help with both IP and vibration and shock performance but also make repairs much more difficult and should be used only where really necessary.

In, or close, to a marine environment the presence of salt can make corrosion and material compatibility issues worse, and of course those need to be considered anyway. Metals have very different electrochemical potentials; as a result, when they come into contact with one another in the presence of moisture, humidity or any other potential electrolyte, significant corrosion of the 'less noble' metal can occur. This is why steel boat and ship hulls are fitted with 'sacrificial anodes' which corrode whilst protecting the hull. Steel screws are often used for strength but in aluminium structures the difference in electrochemical potential can lead to rapid corrosion. This may lead to maintenance difficulties or even structural failures. Plating the screws with zinc, which is similar in potential to aluminium may reduce the effect considerably (historically cadmium was used which is even closer in potential but this is now banned for other reasons but there are still a lot of old cadmium plated parts in service). The corrosion properties of alloys are very hard to predict and may require empirical tests.

Another approach is to use insulating 'barrier' materials between incompatible components or exclude moisture by the use of measures such as conformal coatings. Aluminium components such as heat sinks are often 'anodised' to give them a tough corrosion resistant coating – but as soon as a hole is drilled after that process then a potential vulnerability is introduced. Similarly, steel chassis components are often plated or hot dipped in zinc (galvanised). Barriers must be capable of lasting the life of the system and not be subject to wear or damage, otherwise unexpected secondary issues may occur. A well-known example is the Statue of Liberty where the interface between the iron frame and the copper skin was protected with shellac which eventually degraded necessitating remedial action to prevent severe corrosion in the salty air of its estuary location. Copper is another commonly used material in electronic and electrical components. Material selection is often dictated by the component supplier but needs to be fully understood by the equipment designer.

Electromagnetic Compatibility (EMC) design (covered later) may require additional components such as filters as well as constraining the physical design in terms of wire/track lengths and routing and many require things like conductive seals on covers (which also need to use compatible materials). All of this may seem quite obvious to an experienced engineer, but it is remarkable how some engineers seem to think they can just buy parts and put them together without such considerations. It is often a highly complex trade off. A good physical architecture will minimise such issues both by selecting compatible materials and, where it cannot, keeping incompatible materials apart in a secure and sustainable way.

Power supply

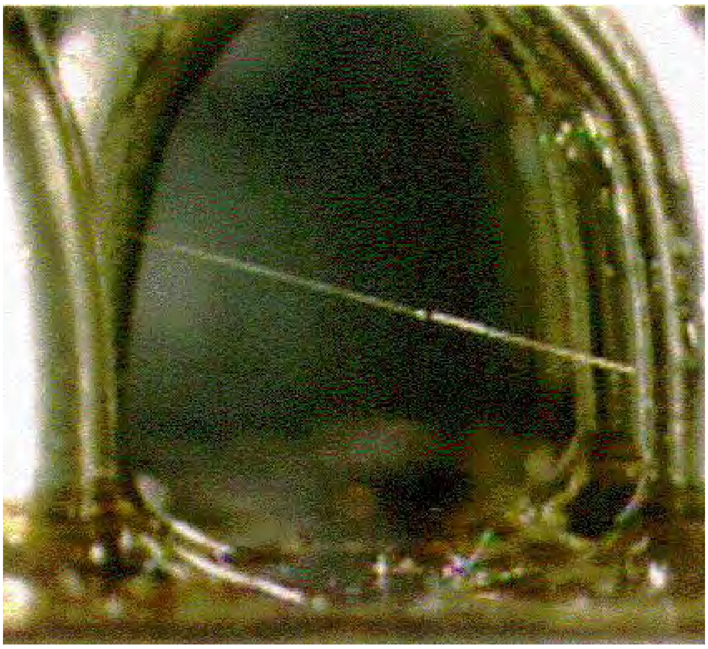
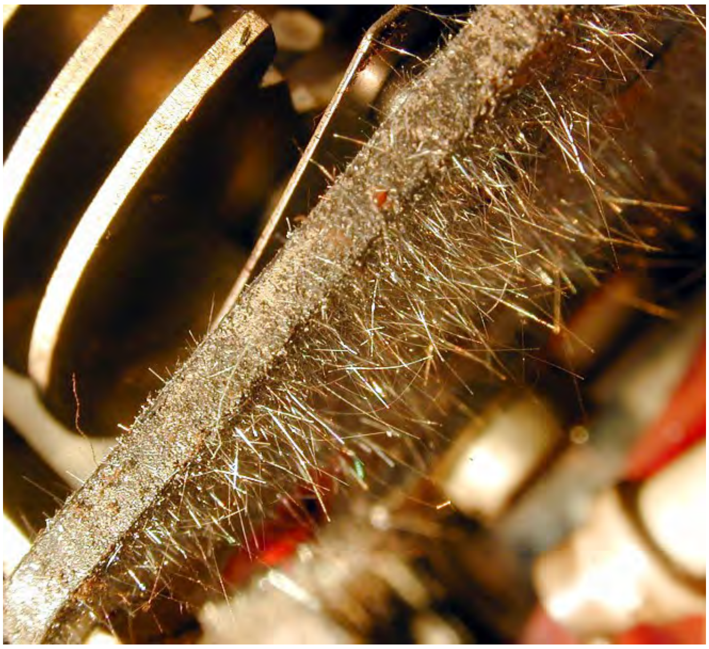
Too often an afterthought, simply a 'bought in' sub-system (not that there are not some very good power supply products out there) power supply is a critical part of the hardware for reliability and thermal management and EMC. So, if it is bought-in its specification is critically important. It is pointless having high reliability hardware if the power supply is a single point of failure and of course that also means determining where the system boundary is and whether provision of dual incoming supplies or a local Uninterruptible Power Supply (UPS) is needed. Power Supplies will be the subject of a separate ITC article which will be published in a future issue of IRSE News.common

Electromagnetic Compatibility (EMC)

Electromagnetic compatibility is an area which critically depends on both sub-system and overall system design. This is true both for susceptibility (the potential for the system to be interfered with) and emission (the possibility that the system will interfere with something else). Also, the interconnections (communication systems) between units offer a mechanism by which radiated signals can be converted into conducted interference and visa-versa. Whether common or individual sub-system power supplies are used they will play a critical part in conducted EMC resistance and particularly resistance to transients on the incoming supply (both overvoltage and short interruptions).

To handle both conducted and radiated susceptibility and emissions at the unit/sub-system level often requires both good internal configuration and an enclosure that offers good shielding. Where connections pass through the enclosure wall filters may be necessary to prevent though transmission in either or both directions.

Good EMC performance requires more than just compliance with the standards. Many clients may require higher levels either in specific instances or more generally, so check the

These two images show a tin whisker bridging soldered wire terminations and a veritable forest of whiskers on the end plate of an air-gapped variable capacitor. *Photos NASA Electronic Parts and Packaging (NEPP) Program,* ***irse.info/d3y9q***.

contract. There are often local issues, requiring lower emissions or greater immunity than the standards mandate (and older infrastructure will often not comply with modern standards in this regard), more on this in part 3 to follow in a later issue.

Electrical insulation

Another important architectural consideration, particularly in safety systems, is electrical insulation and safe separation distances between conductors including printed circuit board tracks (depending on operating voltage). European and US standards contain parameters for the safe separation between circuit board tracks for safety applications but again considerations like the environment and particularly things like humidity and coastal environments high in salt must be taken into account as well as the particular characteristics of certain materials, and not only the insulators themselves.

How many in the rail industry now remember silver migration? British Rail and Railtrack in Great Britain spent millions of pounds replacing Bakelite relay bases because the silver used to plate the contacts to give low contact resistance 'crept' across the surface of the base and caused or risked short circuits which could compromise the integrity of the signalling system. The author has been told that silver migration has also caused power supply issues on the International Space Station (ISS).

Another example involves tin. For environmental protection reasons lead has been phased out of solder in favour of pure tin. But how many engineers know that in the right environmental conditions pure tin can grow conductive 'hairs' or 'whiskers' several millimetres long? In high power circuits this often does not matter as the 'hairs' simply get 'blown away' like a very thin fuse wire, but in a high impedance signal circuit a false connection can result and it has been known for a high current arc event to be initiated. The author has seen this issue result in several million pounds of re-work being required on a defence project due to shorted out crush switches on units that had been in unpowered storage. The addition of even a very small percentage of lead suppresses this effect (NASA recommend a minimum of 3 per cent to ensure at least 0.5 per cent locally) but pure tin is still usually specified. An issue to be aware of in storing spares, as it is environment (particularly humidity) dependent, although the mechanism is not fully understood and is thus hard to predict. This issue affects not only conductors and solder joints. Earlier we covered the plating of components for material compatibility reasons. Both Zinc and Cadmium can also grow whiskers, indeed there may be a 'carpet' of them on a sheet metal component which if disturbed by a shock or by maintenance handling may result in an electrically conductive shower onto any circuits below causing single or even multiple failures.

Historically some insulation issues were handled by using isolating transformers or opto-isolators but many modern techniques such as Internet Protocol (another IP) do not lend themselves easily to those methods. Nonetheless these issues remain very important, particularly for countries with a high prevalence of lightning leading to high levels of surge voltage.

Maintenance and producibility

In addition to such design configuration issues, for maintenance the physical architecture will be very important; can a part that needs maintenance be easily accessed? Can the required maintenance be carried out in a timely manner without the need for special tools, or if special tools and/or equipment are needed have these been identified and provided? If a part fails, can it be changed without specialised equipment and/or excessive disruption or risk to the rest of the system either in terms or interrupted functionality or secondary damage? During design and manufacture techniques such as 'select on test' for certain components may appear attractive for cost or reduced complexity reasons but through the life of the equipment may prove very much less so if the necessary equipment for setting up again after a repair is not available to the maintainer. Modern assembly techniques for electronics with multi-layer boards, surface mount components and very high complexity integrated circuits can be very hard to repair without specialised knowledge and facilities. This can create a lot of ill feeling in clients if they feel it leads to 'opportunity pricing' by suppliers, long turnarounds and the necessity for high spares stocks.

Obsolescence

This is another issue requiring careful through-life management and careful consideration at the start of any design/project not just when the equipment is in service or when a part becomes unavailable. The use of complex highly specialised components may seem very efficient at the beginning of the lifecycle but once such components become obsolete it may be very difficult, if not impossible, to find an equivalent to replace them. It may be possible, with careful planning, to lay down stocks of such components for future use but where components have a 'shelf-life' this may still be difficult. Specialist companies can sometimes produce components no longer made by their original suppliers, but at very high cost, particularly for small quantities. Hardware obsolescence can also have implications for software – if a component needs to be changed will the software still be compatible? Semi-conductor manufacturers often revise their designs to improve performance or to reduce production cost without changing part numbers – this can lead to software execution issues. An example witnessed by the author was the die (chip) size of a microcomputer being reduced by 20 per cent. This was facilitated by improved fabrication techniques and was intended to reduce costs and improve speed. But changed timings caused by a photographic mask error led to software halts on what was previously very well proven software. A major project was delayed several months as a result costing several million pounds; and microcomputer manufacturers limit their warranties to component replacement.

Safety considerations

For hardware an FMEA is a key tool for ensuring that single failures cannot lead to unsafe conditions and that the probability of multiple failures doing so is acceptably low. There will be many architecture/configuration options to achieve that outcome. Of course, underlying component selection issues are also important such as:

- Using components with known low failure rates.
- Designing with appropriate reserves mechanically and electrically (see de-rating above).
- Applying components with known safety characteristics (e.g., a preferential failure mode).
- Using components with 'non-volatile' characteristics (e.g., memories that retain their data through a power failure).

This of course also assumes that factors such as possible structural failures, sneak circuits or intermittencies resulting from issues like those described in the sections above have all been adequately considered and either the reserve factor is sufficiently high (for structural issues) or the mechanism has been eliminated or mitigated.

A very important class of components with known failure modes for railway control applications are safety relays. (It is for discussion whether a relay is a component or a sub-system). These are important in both trackside and on-board applications (for things like a fail-safe brake interface). Specifically, 'gravity drop' relays use gravity rather than springs to provide the force that will move them to a known state in the event of an energisation failure; and relays with 'force guided contacts' have an internal architecture that ensures that they can never have both a normally open and normally closed condition simultaneously. Should one contact become welded or stuck the internal design keeps any other contacts, whether normally open or normally closed, from changing states. Both these types can be very useful in safety applications but such designs are not immune from the problems of shock and vibration already discussed.

The above factors relate to all hardware but, (as will be explored more fully in part 2) when hardware is driven by software additional considerations often apply. For safety systems the objective should be to ensure that, to the required level of confidence (often expressed as a Safety Integrity Level [SIL] for particular functions), both random and systematic failures are controlled sufficiently well for the required integrity to be delivered for their safety functions. SILs are often erroneously applied to pieces of equipment but it is 'end to end' safety functions that should be analysed and secured. This requires detailed knowledge and analysis of the hardware, software and human interactions with the system. Any single component or piece of equipment cannot have a SIL (unless the safety function concerned is wholly executed within it), it can only have a failure rate capable of supporting a certain SIL when correctly incorporated into a system executing the safety function in question. Too often we see individual pieces of equipment advertised as being of the highest category (SIL4) and people making the erroneous assumption that if they connect several of them together they will get a SIL4 system.

For software driven systems with defined safety requirements 'special' hardware architectures are often used to provide protection against random failures. Two out of two (2oo2) systems use two processing channels that constantly 'cross-compare' with one another and shut the system down safely if they disagree. To secure this additional safety assurance whilst maintaining a high level of availability a third processor is sometimes added to make a two out of three (2oo3) architecture with a 'voting' system where if two processors agree and the third does not the two 'good' processors can safely shut down (or even blow the power fuse of) the 'bad channel'. The remaining two channels then carry on functioning as a 2oo2 system whilst issuing an alarm that maintenance is needed. This architecture was popular when electronic hardware was expensive as it needed only three processor systems; as hardware has become cheaper duplicated 2oo2 systems with 'hot standby' decision logic that rapidly changes over systems in the event of the primary system failing have become increasingly popular as whilst these use four processors the failure management is simpler to execute and analyse. Regardless of the architecture chosen considerable attention to detail is needed in the supporting hardware (such as power supplies, communications and I/O) which must also be protected from single point failures. Systematic failures must also be managed in the software as will be discussed in part 2.

In the now very well-known case of the Boeing 737 Max Manoeuvring Characteristics Augmentation System (MCAS), each part of a multi-lane system was fed from a single sensor (Angle of Attack sensor) with reversion to a second sensor dependent on manual intervention. The arrangements for managing data inputs, command outputs, data combination rules and failure management for multi-lane systems are all extremely important or such systems can become false friends. The IRSE ITC published a detailed article on the potential pitfalls of multi-lane systems in January 2020 (issue 273) so we will explore them no further here.

With the right hardware architecture and software techniques and architecture it is wholly possible to build a SIL 4 platform using Commercial off the Shelf (COTS) computer hardware rather than needing expensive custom-built platforms. This is very good for upgrading and obsolescence management as the relatively cheap hardware can be 'swapped out' for newer and/or higher performance models 'porting' the software with little or no change thus preserving what in many systems is now the highest value asset in terms of development cost.

Photo Rod Muttram.

Photo Rod Muttram.

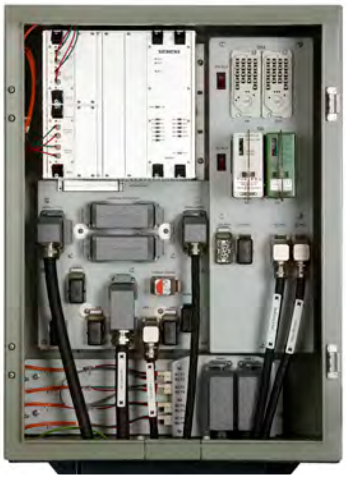


Photo Siemens Mobility.

The technology of early mechanical interlockings necessitated them being decentralised. Modern computer based systems allow highly centralised control desks (top) and interlockings (top left) with distributed 'object controllers' (above) optimising operational, maintenance and acquisition costs.

With that discussion of these special 'systems within systems' to support safety critical and related computing let us then start to look at some of the more interactive issues between sub-systems and components as we move more towards consideration of the 'bigger system' issues in part 3.

Centralised vs de-centralised architecture

Whilst this is a 'whole system' or 'system of systems' issue it is covered here under hardware because decisions about it are primarily hardware driven, with software and civil matters consequential upon them. Decentralised hardware requires de-centralised software for the software operated elements. Similarly, the number of equipment rooms or locations follows the hardware architecture. Making it fit existing buildings falls into the 'force fit' category along with pre-existing hardware and software designs from other jobs, but may sometimes be justified by cost or 'heritage' considerations.

A centralised architecture can have advantages in terms of required operational manpower, maintenance manpower, maintenance equipment provision, spares access and repair response times. It is, however, more vulnerable to catastrophic damage from fire, flooding or terrorism. A decentralised architecture is less vulnerable and potentially has reliability benefits if configured in a way where parts of the system can operate independently in the event of a failure elsewhere. The geographical size of the overall system concerned will also be a consideration and, as always, timings and latency will impact available headway and thus capacity. Other factors are cost, power demand and cyber security; a centralised architecture may be easier to protect in terms of the number of interfaces through which an attack can be mounted but a decentralised structure potentially has more options for protection and recovery. A common architecture for signalling is rather 'hybrid' in that it centralises the interlocking where redundant power supplies and specialist maintenance and spares can be on-hand, but de-centralises object controllers for things like point machines to keep power cable lengths short and voltage drops low. Interconnects between the central location and the object controller cabinets using optical fibre are fast, have no voltage drops, are not vulnerable to EMC and are not attractive to thieves, unlike conventional copper. For metro systems where reliability and availability are an absolute priority it is not uncommon to have two complete 'centralised' control and interlocking systems in different locations – thus getting the 'best of both worlds' in technical terms but obviously at higher cost.

Other factors and combined effects

Depending on application, other parameters may be important at the equipment level. Examples are weight which will be particularly important for on-board equipment, and flammability and smoke/toxic emission which will be important in tunnel and other confined locations.

All of these factors can interact requiring trade-offs which may require considerable analysis and several iterations to get all of the many factors within specification.

For example, in high frequency electronic equipment there is usually a need to keep connection distances short to avoid stray inductance which may affect performance, but the need to dissipate heat generated by high power components may make it desirable to mount these on heatsinks on the outer skin of the equipment. Meeting those two design objectives simultaneously may prove challenging, particularly when other requirements are overlaid on them.

Sometimes it may not be possible to meet all of the requirements and then an informed discussion is needed with the client about which area, if any, could be subject to derogation. Usually unwelcome but much better than a nasty surprise at commissioning or in service.

Once again this presents a strong argument for having a knowledgeable and powerful system integrator, and on that thought I will close part 1. More on the software that configures and operates much of the hardware in part 2, and on the bigger system issues in part 3 which will feature in future issues of IRSE News.

Evolution of the railway RAMS management process



Vladimir Romanov, Zinan Cao
and Aryldo G Russo Jr

Since the official approval of the first version of EN50126 in 1998 the standard has undergone a number of important modifications leading to the current version approved in 2017. The changes have made the standard more consistent and efficient for managing the RAMS process for railway systems.

The purpose of this article is to analyse the evolution of EN 50126 in order to identify the development trends of the RAMS management process.

The current version of the standard [1], [2] has undergone content changes and has been restructured in comparison with the previous version [3].

The first and second parts of the current standard have become normative, whereas in the previous version only part one was normative. When CLC/TR 50126-2 [4][5] was approved in 2007 it was as an informative part of EN 50126 -1:1999 and aimed to provide guidance on methods and tools to achieve safety; for more information refer to page 2 “Foreword” and page 8 “Introduction” of CLC/TR 50126-2. In the current version of the standard EN 50126-2:2017 the main part is normative and annexes are informative, as stated on page 6 “Introduction”. This means the current version of the standard has two mandatory parts [1][2]. It is also worth mentioning that CLC/TR 50126-3:2008 is not superseded and is still applicable.

This article examines both the normative and informative content of the standard for a more comprehensive assessment of the RAMS management evolution process.

The article addresses three elements of the EN 50126 standard: factors influencing railway RAMS, safety assessment and risk management. Other changes to the content of the EN 50126 including the number and name of the lifecycle phases, system tailoring, impact analysis, safety case, etc. will be discussed in a second article to be published later.

Railway RAMS factors

During the system lifecycle, performance may be negatively affected by factors that cause failures. Analysis of factors affecting the system characteristics is a very important stage in the specification and design/development process, the result of which is a list of requirements or characteristics for the system. Possessing the required characteristics, the system would be immune to the effect of failures. To analyse the factors that affect the system, the standard suggests using lists of factors, as well as a diagram approach, to determine the factors and their effects.

One of the improvements made in the current version of the standard is the description of the categories of failures caused by the negative effects of railway factors– see clause 5.6.2 of part one. In addition, the checklists for identification of the railway specific influencing factors and human factors were modified.

Comparing the superseded version of the standard with the current one, we can see that systematic failure definition has changed and a random failure definition has been added. A definition of systematic failure was given in clause 3.42 of the first part of the superseded standard and CLC/TR 50126-2 in the clause 3.1.11 provided an alternative definition. A new definition of the system failure is proposed in the current version of the standard in clause 3.79. In this definition the word “safety” is excluded. That means the standard has started to consider RAM equivalents, not just hazards that impact safety, as it did in the previous version. RAM equivalents are defined in clause 6.3 of the first part of the current standard: “RAM equivalent to hazard is a condition that could lead to commercial loss related to RAM”. That means the failure may lead to an unintended event that is not safety related.

The new version allocates railway specific influencing factors in four categories instead of five as in the superseded standard. Even though the categories were reduced the content was significantly extended. Clause 5.6.3 in the current standard corresponds clause 4.4.2.10 of the superseded standard, demonstrating this point.

The current standard also regrouped checklist categories and added new factors. Two separate categories "system operation" and "failure categories" were merged to form one category "system definition and system design". The "environment" category does not exist anymore. The content of this category is fully included in the "operation conditions" category. In turn the "operation conditions" content was moved to the "applications conditions" and "maintenance conditions" categories.

The names of factors in the current version of the standard are still exactly the same as the superseded version except one: the "trackside-based installation conditions" has changed to the "installation conditions".

A more visual comparison of the railway specific influencing factors checklists is provided in Figure 1. The figure shows two lists of factors that affect the system's RAMS. On the left side is a list from the superseded version of the standard, on the right side is a list from the current version. Connecting arrows between the two lists show the change in locations. New added factors are shown in black and the word "new" is added in parentheses .

Human factors are described in clause 5.6.4 of the first part of the current standard and corresponds to the first part of the superseded standard clause 4.4.2.11.

The human factors content was also modified: the checklist of clause 5.6.4 has been extended by adding two items on page 34, point e): "human reaction under different operation modes" and point f): "verification and validation". In the current version of standard attention is concentrated on human factors that may arise from maintenance and operation processes.

Figure 1 – Comparison of the checklists for railway specific influencing factors.

Safety assessment and ISA

Safety assessment was mentioned in the first part of the superseded standard and then CLC/TR 50126-2 introduced the concept of the independent safety assessment. The current version of the standard provides more details on the application process for both the safety assessment and the Independent Safety Assessment (ISA) in part one and part two.

Requirements for safety assessment are mentioned in the superseded EN 50126-1 clause 6.2.3.4 "System definition and application conditions" paragraphs f) and p). Furthermore clause 6.6.3.5 "Design and implementation" and the clause 6.9.3.3 "System validation (including safety acceptance and commissioning)" require a summary of the safety assessment activities in the safety case. However, the superseded version of the standard does not define how and by whom the safety assessment should be performed. The guide to the application of EN 50126-1 for safety [4] in clause 9.7 has additional information about the scope, independence and competence required for safety assessment. Clause 9.7.1 describes several kinds of safety assessment activities and their content and 9.7.2 provides the concept of independence of the assessor: "a safety assessor should not belong to the same organisation as the project team, the verifier or the validator". Clause 9.7.3 introduces qualification requirements for the safety assessor.

The current version of the standard continues to develop the safety assessment objectives. The requirement to conduct safety assessment is included in clause 7.3.2.3 point n) of the current standard and is actually the same as clause 6.2.3.4 point p) in the old standard. It requires the inclusion of safety audits and safety assessment in conformance with the safety plan. The project manager is responsible for fulfilment of the standards requirements, see Table G5 point 3) which states "allocate sufficient number of competent resources in the project to carry out the essential tasks including safety activities, bearing in mind the required independence of roles".

The first part of the current version of the standard defines the purpose of the ISA (clause 6.8) and provides more details on the content of activities. The independence of the assessor is outlined in the current version in clause 7 and the responsibilities of the assessor are defined in Annex G4. Furthermore, the ISA is included in the system lifecycle of the EN 50126-1 phase 3 (clause 7.4.3 point e) and phase 10 (clause 7.11.2 point b and clause 7.11.3). Independent Safety Assessment and the role of the assessor are both critical for ensuring system safety and are more detailed in the current version.

Although the circumstances when an independent safety assessment should be carried out are not specified in the standard, paragraph 6.8.1 of the current EN 50126-1, reasons for such assessment may be requirements of the project contract, legal requirements or specific standards. However, two general conditions requiring safety assessment can be derived from the definition given in paragraph 3.33 where it is clear that such an assessment should be carried out whenever it is necessary to determine the system meets the safety requirements defined for it and whenever it is necessary to decide the system is suitable for a specific area of use from a safety point of view.

It is important to note the standard gives some freedom as to which entities that can conduct an independent safety assessment, Clause 7.3 of EN 50126-2. These entities can include component suppliers, Railway Undertakings, and Infrastructure Managers. This is acceptable if the experts conducting the assessment are independent of the project manager, belong to another organization and if there are no additional legal or contractual requirements for accreditation (e.g. accreditation in accordance with the ISO 17020 standard). If the requirements for accreditation are presented, then the independent safety assessment activities should be performed by an accredited ISA body. The way the standard is drafted means there is the potential for contradictory interpretations between paragraph 7.3 and Appendix G4 where accreditation in accordance with ISO17020 is defined. However, the author of this article believes the above interpretation is correct.

Risk

The current standard offers a risk based approach for managing RAMS activities (refer to the clause 5.8 of the first part). The purpose of the approach is to identify risks, identify relevant requirements, and apply measures to eliminate or mitigate the risks. The risk based approach applies not only to safety but also to reliability of the system. In addition, the risk of harm to the environment must be taken into account.

The risk definition given in the part 1 clause 3.34 of the superseded standard was corrected in the CLC/TR 50126-2 clause 3.1.8. The current version of the standard extends the scope of the term risk by changing the word "harm" used in the definition of risk to the word "loss". Thus, the current standard implies the use of the term applies not only to system safety for people and the environment, but also in terms of reliability for calculating the frequency of the commercial loss.

RAP and RAC

The definition of the risk acceptance principles (RAP) and the risk acceptance criteria (RAC) has been changed. Comparing content of the superseded and current versions of the standard, we can see that ALARP (As Low as Reasonably Possible), MEM (Minimum Endogenous Mortality) and GAME (Globalement Au Moins Equivalent) methods for calculating level of risk were called risk acceptance principles in the old version of the standard. The current version of the standard defines the ALARP, GAME and MEM as methods to define risk acceptance criteria (see annex A of the second part of the current standard).

As for the risk acceptance principles, in the current version of the standard they are defined as: Code of Practice, Explicit Risk Estimation and Reference System. In the earlier version risk acceptance principles were named as strategies for demonstrating safety, with particular names: safety demonstration when using technical standards as a reference, safety demonstration by complete system analysis and risk calculation and safety demonstration by using an existing system as a reference.

In the new version of the standard, the names and contents of risk acceptance principles were unified with the Common Safety Method (CSM) [6] regulation. The direct linkage of the risk assessment principles described in the CSM with the risk assessment principles described by CENELEC allowed an improved correlation of risk assessment results. For example: Assessment Body (AsBo) under CCS TSI [7] certification is allowed to use the CENELEC standards (see Annex A, Table A 3 of the CCS TSI) to assess the risks associated with components or sub-systems.

Risk assessment

The risk assessment process described in clause 5.3 of the guide to the application of EN 50126-1 for safety CLC/TR 50126-2 is better described in the current version of the standard, see clause 5 of the EN 50126-2. The boundaries and tasks inherent in the processes of: risk assessment, risk analysis and risk evaluation are more clearly described. Relationships between these terms may be easily understood from the definitions of each of them given in part one of the current standard.

The second part of the new standard in clause 5 provides an hourglass model that clearly shows the inputs and outputs of each process, as well as their relationship. Furthermore clause 8 of the second part gives detailed information about risk analysis, selection of risk acceptance principles and their application. The information provided in clauses 5 and 8 is essential for the risk management process. Systematic presentation of this information has a positive impact on the performance of the risk analysis conducted by users of the standard.

Risk model

The content set out in paragraph 5.2 and Annex D of the CLC/TR 50126-2 has been revised. The current version of the EN 50126-2 in clause 8.2.2 focuses on barriers as a means to reduce the frequency and consequences of hazards. Barriers used in the risk model to reduce the negative impact of hazards should be recorded. Another difference concerns the fact that the old version focused on the risk impact for human beings, while the current version does not mention this, implying risk can be applied not only to people but also to physical objects causing commercial loss.

Risk reduction strategy

Risk reduction was often mentioned in the previous version, but a theoretical basis describing a sequence of risk reduction processes was not provided. The current standard specifies the theoretical basis, describing steps to eliminate risks or to reduce risks to an acceptable level.

Clause 5.9 of the first part of the current standard describes an approach to minimize risks related to safety (refer to the clause 5.9.2) and to RAM (clause 5.9.3) and step by step recommendations are given to eliminate risks or decrease them to an acceptable level.

Sensitivity analysis

In the CLC/TR 50126-2, of the superseded standard paragraph 5.4.5 sets out requirements for conducting a sensitivity analysis to evaluate the results of quantitative risk calculation. If the quantitative risk assessment contains assumptions with a high degree of uncertainty, then it is suggested the application of a factor from 2 to 5 to numbers used in the assumptions. If this makes a material difference to the level of risk, then it is necessary to review the assumptions in more detail, or confirm that the existing barriers are sufficient to control the risk.

In the current standard, the concept of sensitivity analysis has been changed. If there is a large amount of uncertainty in the risk calculation, then the following methods should be used: "Worst possible scenario", "Reasonable estimates" or "Reasonable worst case", see EN 50126-2 paragraph 8.4.2.

Hazards lists

Hazard identification should be carried out systematically. The approaches described in the third phase of the RAMS lifecycle of the current and superseded standards are the same. However, the CLC/TR 50126-2 introduces the concept of hazard clusters or c-hazards. The essence of this concept is grouping hazards according to the same cause or same consequence (refer to the clause 4.4.1), which allows for a more rational analysis, as well as the distribution of hazards by key safety functions. Also, clause 5.5.2 suggests grouping hazards according to the needs of interested parties. To avoid repetition, since hazards can be grouped according to different principles, the superseded CLC/TR 50126-2 proposed unified lists for c-hazards in Appendix B2, as well as the distribution of hazards by functional principle and the principle of inherent properties in Appendix B3. These lists are given as examples and are not comprehensive, but the lists can be used for additional verification of the completeness of the list of hazards as recommended in paragraph 5.5.3 of the CLC/TR 50126-2.

The current EN 50126-1 in paragraph 7.4.2.1 recommends using structured hazard/RAM equivalents lists, but it does not provide sample lists of hazards as was done in the superseded standard. The understanding of the authors of this article is that the lists of hazards were removed to prevent erroneous use, such as taking the list as final or complete and failing to identify specific hazards inherent in each project. The idea of the new standard is to stimulate the project owners to use the hazard lists already used for similar systems or products in their project.

Such lists are available in every company that develops a new version of a product or system and usually applies part of the solutions from the previous version, or the hazards lists can be obtained from the project stakeholders. Based on the hazard lists obtained from similar products or systems, and taking into account the system definition and application environment of the newly developed product, a new hazard analysis should be conducted for the new version of the product or system. This approach of the current EN 50126 standard allows the project owner to focus on the features of the new system, without losing sight of the main hazards inherent in systems and products of a similar type; this is similar to the approach described in the international Engineering Safety Management good practice handbook [8].

Conclusion

Based on the comparative analysis of the EN 50126 standard's content that was conducted for factors influencing railway RAMS, safety assessment and risk management processes, it can be concluded that the standard has become more mature in terms of systematic presentation of the content.

Factors affecting the RAMS system parameters have been revised and extended in content. This will allow them to more comprehensively form requirements for the characteristics of the system, creating a system with greater immunity to both safety related and non safety-related failures.

More detailed information is added about the independent safety assessment.

The EN 50126 has become more unified with CSM for risk evaluationand that allows use of the standard not only for RAMS management, but also supports effective application of the standard to the TSI (Technical Specification for Interoperability) certification of projects.

The approach based on risk management is described more thoroughly, allowing more effective control of the risks that affect the safety and reliability of the system.

What do you think?

Do you think that the new version of EN50126 achieves what it is required to do? For example, do you think that the changes made, for example the renewed description of risk management or the increased relevance to the use of TSIs are appropriate and sufficient? What would you like to see in future updates? Indeed do you think that the standard is still relevant and fit for purpose?

Let us know so that we can share your views with other IRSE members via the 'Our Letters' section. Email us at **editor@irsenews.co.uk**.

References

[1] CENELEC, EN 50126-1: 2017: Railway Application – The Specification and Demonstation of Reliability, Availability, Maintainability and Safety – Part 1: Generic RAMS process, Brussels: CENELEC, 2017.

[2] CENELEC, EN 50126-2:2017 Railway Application – The Specification and Demonstation of Reliability, Availability, Maintainability and Safety – Part 2: Systems Approach to Safety, Brussels: CENELEC, 2017.

[3] CENELEC, EN 50126-1: 1999 Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Part 1: Basic requirements and generic process, Brussels: CENELEC, 1998.

[4] CENELEC, CLC/TR 50126-2: 2007 Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Part 2: Guide to the application of EN 50126-1 for safety, Brussels: CENELEC, 2007.

[5] CENELEC, PD CLC/TR 50126-3: 2008 Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Part 3: Guide to the application of EN 50126-1 for rolling stock RAM, Brussels: CENELEC, 2008.

[6] European Union Agency for Railways, Commission Implementing Regulation (EU) No 402/2013 on the Common Safety Method for risk evaluation and assessment, Valenciennes: European Union Agency for Railways, 2013.

[7] European Commission, "Commission Regulation (EU) 2016/919 of 27 May 2016 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union," Official Journal of the European Union.

[8] Technical Programme Delivery Limited, The international Engineering Safety Management Good Practice; Volume 2; Issue 1.2, Technical Programme Delivery Ltd, 2018.

[9] European Union Agency for Railways, "ERA 1209/063 V 1.0 Clarification Note on Safe Integration," European Union Agency for Railways, Valenciennes, 2020.

Industry news

For more news visit the IRSE Knowledge Base at irse.info/news.

Main line and freight

Full Implementation of Positive Train Control in USA

USA: At the end of December 2020 the U.S. Department of Transportation's Federal Railroad Administration (FRA) announced that positive train control (PTC) technology was in operation on all 57 536 required freight and passenger railroad route miles, prior to the statutory Congress deadline of 31 December 2020. In addition, FRA had certified that each host railway's PTC system complied with the technical requirements for PTC systems. All effected railways also reported that interoperability has been achieved between each applicable host and tenant railway that operates on PTC-governed main lines.

PTC systems are designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zones, and movements of trains through switches left in the wrong position. The announcement was the culmination of over a decade of sustained and direct engagement and collaboration among FRA and the 41 railways subject to the statutory mandate, including seven Class I railways, Amtrak, 28 commuter railways, and five other freight railways that host regularly scheduled intercity or commuter rail passenger service.

The FRA said the accomplishment encompassed thousands of hours of testing and deployment, innovative technological solutions, and a tremendous amount of coordination among nearly 100 host and tenant railways, railroad associations, material suppliers, and service providers.

The Rail Safety Improvement Act of 2008 (RSIA) mandated the implementation of PTC systems on Class I railways' main lines over which five million or more gross tons of annual traffic and certain hazardous materials are transported, and on any main lines over which intercity or commuter rail passenger transportation is regularly provided. RSIA and FRA's implementing regulations also require PTC systems to be interoperable, meaning that the locomotives of host and tenant railways operating on the same main line must communicate with and respond to the PTC system, including during uninterrupted movements over property boundaries.

For additional information, please visit irse.info/przm3. To view related FRA correspondence, visit irse.info/mydgx.

ATS in Artengina

Argentina: TAI (Argentinean Trains Infrastructure) has completed the installation of an Automatic Train Stop (ATS) system on the 26km line between Buenos Aires and San Miguel.

The system was supplied by Marubeni and manufactured by Nippon Signal, Japan, under a $63m (£46m, €52m) contract awarded in 2016. The system comprises of track-based device, an onboard device, and a trackside unit, which indicates whether to stop, go, or reduce speed. ATS had already been installed on the Maipú – Delta Tren de la Costa commuter line and the Roca commuter line, with work still ongoing on the Miter, Sarmiento, San Martin and Belgrano Sur lines. Belgrano Norte is scheduled for completion in the near future.

ETCS fitment for ELECTROSTAR trains

UK: Bombardier Transportation has announced it has signed a framework agreement with rolling stock company Porterbrook, to fit ETCS signalling to Bombardier ELECTROSTAR trains in the UK. Under the framework agreement, Bombardier will deliver the design work needed for the fitment of ETCS equipment, and the Bombardier EBI Cab 2000 onboard Automatic Train Protection (ATP) system, to all ELECTROSTAR fleets in the UK – the most numerous Electric Multiple Unit type currently operating on Britain's railways.

The initial agreement is worth £11.3m (€12m, $15m), to design and fit First in Class (FiC) ETCS equipment to a Porterbrook-owned Class 387 ELECTROSTAR train operated by Govia Thameslink Railway (GTR). Once the FiC unit receives regulatory approvals, all other ELECTROSTAR train owners and operators will then be able to obtain the EBI Cab 2000 for their trains under the same framework agreement.

Transport Canada amended Crossing Regulations

Canada: There are approximately 14 000 public crossings and 9000 private crossings along the 40 000km of federally owned railways in the country. The Crossing Regulations and the Crossing Standard will require railways, highway authorities and private owners of existing crossings to comply with the requirements of the Regulations by 28 November, 2021.

Over the past year, stakeholders have begun to express concerns about the approach to compliance time and their ability to meet it. Many public crossings still require improvement and they say with less than a year left to comply the deadline is at risk. There has been difficulty identifying private crossing owners, which has delayed their assessment of the work to be done and there are concerns with the costs and access to properties in the future, and say it is unlikely that all private crossings will be compliant on time.

Transport Canada has reviewed the situation and is considering a risk-based approach to making changes to the Regulations. They say this will help to address stakeholder concerns, while ensuring that the originally planned safety objectives are maintained. This is planned to change the scope of the Regulation so that crossings deemed low risk do not have to meet all requirements and the compliance time will be extended using a risk-based approach. Transport Canada proposes to extend the compliance period by one year for high-risk crossings, and three years for all other crossings. A measurable criterion will be developed for determining whether a crossing is high risk.

Egypt high-speed rail system

Egypt: Siemens Mobility and the Ministry of Transport of Egypt have signed a Memorandum of Understanding (MoU) – together with local companies Orascom Construction and The Arab Contractors (Osman Ahmed Osman & Co) – to design, install and commission Egypt's first ever high-speed rail transportation system. Siemens Mobility will also be providing maintenance services. The agreement is for a 1000km rail system network, with the first stage being a

460km high-speed line to connect the city of El-Alamein on the Mediterranean Sea to Ain Sokhna on the Red Sea, passing through the New Administrative Capital. The line will also be capable of operating freight trains to foster economic growth in the region. Siemens Mobility is to provide both high-speed and regional trains, locomotives, rail infrastructure, system integration and other services as part of the MoU.

Sleeper night train services

Europe: Four European rail companies have announced plans to revive night train services. Deutsche Bahn and main national train operators in France, Switzerland and Austria say the routes from Vienna to Paris, via Munich, and Zurich to Amsterdam, via Cologne, will be re-established starting December 2021. Further international connections from Vienna and Berlin to Brussels and Paris will be created in 2023, and a Zurich to Barcelona sleeper will begin rolling in 2024.

Night services were successively shut down due to lack of demand and cheaper and faster budget flights. However, sleeper services and train travel are now more sustainable than flying so the routes are being reintroduced. Leonore Gewessler, Austria's transport minister, said "Night trains are the future of climate-friendly mobility in Europe".

ERTMS and ATO for Stuttgart rail freight hub

Germany: The European Commission has approved a €200m (£178m, $244m) scheme to upgrade the area of Stuttgart with European Rail Traffic Management System (ERTMS) and Automatic Train Operation (ATO). The financial support in the form of direct grants to owners and operators of trains will last until 2025.

Although ERTMS and ATO are part of the development of railways in Europe, the area of Stuttgart is undergoing a specific development. The German Transport Ministry has launched a programme, which aims to transform the Stuttgart metropolitan region into a digitised rail hub. The overall investment is in the order of €500m (£445m, $609m).

The upgraded network will include a new central train station and more than 100km of route provided with ETCS train control and ATO to support full automated operations. The plan is to invest in interoperability and digitalisation so that rail freight can acquire a better position in the transport market, and impact a modal shift from road to rail and help the country and Europe reach their climate goals.

Hybrid Level 3 ETCS for India

India: Alstom has been awarded a €106m (£94m, $129m) contract from the National Capital Region Transport Corporation Ltd. (NCRTC) in India to design, supply and install the signalling, train control, platform screen doors, and telecoms systems for the 82km Delhi – Ghaziabad – Meerut Regional Rapid Transit System (RRTS) Corridor.

NCRTC is a joint venture between the government of India and States of Delhi, Haryana, Rajasthan and Uttar Pradesh. RRTS is a semi-high speed rail route and the scheme will reduce the journey time between Delhi and Meerut to 60 minutes from the current 90-100 minutes. The line speed will be up to 160km/h and the route will be the first in India to adopt ETCS hybrid Level 3 signalling system.

Metros and city railways

New fully automatic driverless GoA4 line in China

China: With the introduction of five routes exceeding 160km, China's fourth largest urban rail network is now in Chengdu; one of the three most-populous cities in Western China with a population of over 10 million. Four new metro lines and one express metro extension have taken Chengdu's network to 558 route-km, including two suburban 40km tram lines.

The new routes include Line 9 which is equipped for fully automatic driverless operation to GoA4. Line 9 orbital line loops 22.2km around the southwestern quadrant of the city centre, running from Huangtianba near Chengdu Xi main line station to Financial City East. It serves 13 stations of which 11 are interchanges to other routes, with a dedicated depot at Wuqing. The line is equipped with signalling and train control systems provided Alstom, who also provided the traction system.

CRRC Changchun, a Chinese rolling stock manufacturer, have supplied a fleet of 25 eight-car Type A trainsets for the line. Each is fitted with more than 6000 sensors, including CCTV cameras, obstacle, and derailment detectors. Line 9 connects at Financial City East with Line 6 northwest – south which opened on the same day. Running 69km from Wangcong Temple to Lanjiagou, this is believed to be the longest metro line in China to be opened at one time, serving 56 stations and has three depots.

Line 8 runs for 29.1km, linking Shilidian in the northeast with Lianhua in the southwest, serving 25 stations including 14 interchanges. Two extensions are expected to open in 2024, running northeast from Shilidian to Guilong Lu and southwest from Lianhua to Longgang. CRRC Changchun has supplied 43 140m long six-car Type A trainsets for Line 8.

Communication and radio

Private LTE/5G radio networks

USA: A new report from International Data Corporation (IDC) says worldwide sales of private LTE/5G infrastructure will grow from $945m (£691m, €776m) in 2019 to an estimated $5.7bn (£4.2bn, €4.7bn) in 2024 with a five-year compound annual growth rate (CAGR) of 43.4 per cent. This includes aggregated spending on Radio Access Network (RAN), core, and transport infrastructure.

Private LTE/5G infrastructure, which will include the Future Railway Mobile Communication System (FRMCS), is any 3GPP-based LTE and/or 5G network deployed for a specific industry that provides dedicated access. It includes networks that may utilise dedicated (licensed, unlicensed, or shared) spectrum, dedicated infrastructure, and private devices embedded with unique SIM identifiers. Private LTE/5G infrastructure carries traffic native to a specific organisation, with no shared resources in use by any third parties.

"Private LTE infrastructure is already used by select verticals worldwide to solve mission-critical networking challenges. However, the barrier to consumption has remained high, limiting adoption to organizations possessing in-house competency and access to dedicated spectrum," said Patrick Filkins, senior research analyst, IoT and Mobile Network Infrastructure. "With more spectrum being made available for enterprise uses, coinciding with the arrival of commercial 5G, interest has grown toward using private LTE/5G solutions as a basis for connectivity across a multitude of mission-critical, industrial and traditional enterprise organizations."

Many organizations are deploying private LTE today, and a select few are beginning to deploy private 5G in limited instances. While many of these verticals overlap in both use case and network needs, the market opportunity can be categorized in three segments:

Mission-critical: Verticals that require 'always on' connectivity addressable through redundancy and dedicated resource, as well as the clear need or desire for mobile site connectivity. Loss of connectivity would likely result in significant negative business or operational outcomes.

Industrial: Verticals whose primary focus is process and industrial automation for Industry 4.0. It also generally involves providing high-capacity and ultra-reliable low-latency communication (5G URLLC) either with time-sensitive networking (TSN), or as an alternative.

Traditional enterprise or "Business-Critical": These are verticals that require deterministic wireless networking beyond traditional Wi-Fi, but where redundancy and automation needs are lower. These include "business critical" applications, where loss of connectivity could result in loss of revenue.

Old trains – extremely fast wireless!

UK: A video by FirstGroup showing their Blu Wireless 2.5Gbps train connectivity trial on the Isle of Wight can be seen at **irse.info/nu03b**.

This took place at the end of 2020 using the 82-year-old Class 483 trains on the Island Line. The Class 483s have travelled more than 3 million miles, but have now been retired – with one going to the Isle of Wight Steam Railway and another unit to the London Traction Transport Group for use on the Epping Ongar Railway. The 1938 trains were first used on the London Underground network before transferring to the Isle of Wight in 1989.

Before retirement, the trains trialled the First Group mmWave 5G beamforming technology. This is capable of delivering 2.5Gbps for passenger and train connectivity. The trial took place on a ten-mile (16km) stretch of Island Line with the trains equipped with antennas on the front and rear roof sections. Masts were located every 400m to 2km depending on the topology of the track, to deliver 'line of sight' beamforming to the train. The line side base stations were connected by a single fibre cable and only required 40W of power. Blu Wireless say in future the base stations will be self-powered.

Research & Development and Universities

First transmission of 1 Petabit/s using single-core optical fibre

World: The National Institute of Information and Communications Technology (NICT, Japan), NOKIA Bell Labs (Bell Labs, USA) and Prysimian Group (Prysimian, France) have succeeded in the world's first fibre transmission exceeding 1 Petabit per second in a single-core multi-mode optical fibre. 1 Petabit per second = 1000 Terabits per second = 1 Million Gigabits per second. See **irse.info/2514w**.

The study demonstrated the possibility of combining highly spectral efficient wideband optical transmission with a current industry standard 0.125mm optical fibre and a coating diameter of 0.245mm, guiding 15 fibre modes. This was enabled by mode multiplexers and an optical fibre supporting wideband transmission of more than 80nm over a distance of 23km. The study highlights the large potential of single-core multi-mode fibres for high-capacity transmission using fibre manufacturing processes similar to those used in the production of standard multi-mode fibres.

Compared to multi-core optical fibres, multi-mode fibres can support a higher spatial-signal-density and are easier to manufacture. However, using multi-mode fibres for high-capacity space-division multiplexed transmission requires the use of computationally intensive digital signal processing. The study increased the current record transmission in a multi-mode fibre by a factor of 2.5.

French and UK wireless track monitoring

France: SNCF Réseau and UK technology company Senceive, who provide wireless structural and geotechnical monitoring solutions, have agreed a R&D contract to evaluate the technology on French railways. If it proves suitable for robust rail infrastructure inspection, SNCF say the technology could be rolled out across their network. The trail will mainly focus on Senceive's triaxial tilt sensors, a technology that could measure and control the condition of unloaded tracks (as distinct from dynamic measurement during the passage of a train).

Senceive say their rapid and continuous measurement sensors (sampling every second if necessary), could make track monitoring more reliable and be particularly useful when a risk of ground movement or structural disturbance has been identified. In the long-term, the wireless solution could facilitate more efficient track maintenance interventions. It is estimated that with one measurement per half hour, with little maintenance/calibration required, a battery durability in the order of 15 years may be possible. The result of the trial is expected in December and SNCF Réseau say if successful could lead to national deployment.

Safety and approval

Learning from Ladbroke Grove

UK: The Ladbroke Grove rail crash (also known as the Paddington rail crash) was a rail accident which occurred on 5 October 1999 at Ladbroke Grove in London, United Kingdom. With 31 people killed and 417 injured, it remains one of the worst rail accidents in 20th-century British history and was caused by a Signal Passed At Danger (SPAD). Dr Greg Morse is the Rail Safety and Standards Board (RSSB) lead operational feedback specialist and he extracts and shares learning from a variety of sources, rail and non-rail, GB and non-GB. He is also RSSB's single point of contact with Rail Accident Investigation Branch (RAIB), using this position to try to shape investigation reports for the good of learning and the good of the industry.

A video presentation by Greg looking at the causes of the SPAD at Ladbroke Grove can be found at **irse.info/cwm9l**. Greg looks at driver training, signal sighting, the management of change and the failure to learn from previous incidents. In doing so, he points to the need to learn from the past when we consider the future, and promotes in particular the value of getting into the detail of previous accident reports.

Government, regulators and standards

"Only with the railways will we achieve our climate goals"

Germany: Angela Merkel has been chancellor since 22 November 2005 and she plans to leave office after the German parliamentary election in 2021. She has recently given her thoughts on the rail industry.

"For many people, day-to-day life would be very difficult to manage without the railways. They wouldn't be able to get to work or school as they are accustomed to, or see friends and relatives. But the railways are more than that. In normal times, when we are not in the midst of a pandemic, the railways can also satisfy our longing to travel – something we are all really missing at the moment."

"The railways also have a special role to play in helping us to achieve our climate protection goals. We want more people to shift from cars and planes to the railways, and we want to transport greater volumes of goods by rail. To do that, we need a modern railway network and an improved service offering. We (in Germany) are investing 86 billion euro in maintaining and modernising the railway network over the next ten years. The German Rail Masterplan lays the foundations for a timetable coordinated throughout Germany, more freight on the railways, innovation and digitalisation, as well as better noise and climate protection. And that doesn't stop at the border. With the expansion of the trans-European networks, we want to make the railways attractive for everyone in Europe."

"It is very important for our society that trains run and that goods transport flows – the coronavirus pandemic has served as a reminder of that. Railway personnel are doing tremendous work for the common good in these times, and my gratitude goes to all those involved. The railways get people to work safely and keep the necessary supply chains going. Rail transport is and remains the backbone of sustainable mobility and logistics. It is essential in achieving our climate goals."

"Shorter travel times and rapid expansion of the railway network are important to encourage more passengers to shift from planes to trains. There is still room for improvement in terms of digitalisation because signalling and communications technology is currently lagging far behind the technical capabilities. According to the railways' calculations, around 20 per cent more traffic could be handled on the network by deploying digital solutions more efficiently. This would also help to improve punctuality".

The interview is available in full in DB MOBIL's anniversary edition and can be found at irse.info/dx1p4.

Blueprint for levelling up the UK with transport investment

UK: The New Green Age; A Step Change in Transport Decarbonisation by Alstom, calls for a £10bn (£11bn, $14bn) investment programme in UK rail and mass transit systems, after research revealed that the UK is lagging behind in comparable infrastructure. France has over double the number of mass transit systems (light rail, trams and underground trains) as the UK, while Germany has four times as many.

Alstom say investing in mass transit schemes would help boost many regions of the UK which are struggling with the pandemic, and which the government have promised to 'level up'. Leeds is the largest city in Europe not to have a mass transit system, while other areas like Tees Valley, Hull, Doncaster, Leicester, Bristol and South Wales, are all identified as places which require investment.

As well as the economic benefits, the report reveals the true scale of the environmental advancements that such schemes bring, including tackling carbon emissions, cleaning air, and supporting modal shift. Transport is the most carbon emitting sector in the UK and to support green transport options the report also calls for rolling out fleets of clean, zero emission hydrogen trains to replace polluting diesels. 300-400 hydrogen trains could be launched with a like for like replacement of diesels and would deliver huge environmental benefits. As well as investment in hydrogen, the report calls to speed up electrification projects as well as existing initiatives such as Northern Powerhouse Rail and Midlands Engine Rail. These will all serve the multiple purposes of benefiting the economy, jobs, commuters, and the environment.

Emerging technologies shaping the future of communications

UK: Telecoms regulator Ofcom has published a report that takes a look at some of the emerging technologies that could shape the future. See irse.info/z8vqr.

Ofcom carried out interviews and invited technology experts from around the world to contribute to their report and to provide an insight into a range of new technologies for the future.

The 96-page report highlights potential future developments such as:

- Innovative technologies that will help providers to roll out better mobile and broadband services by using automation and robots.
- Satellite technology that can be used to provide connections for hard-to-reach areas.
- Developments in the broadcast sector, such as enhanced, bespoke coverage of sporting events that could provide custom crowd noise, dedicated commentaries, and user selectable camera angles.
- New immersive technologies to bring a sensory element to communications services, enabling people to 'touch' – and even smell – while they interact at a distance.
- Immersive virtual environment technology (VET) for education. While on average, a regular student can remember 30 per cent of what they hear and 20 per cent of what they see, statistics indicate that students remember 90 per cent if taught using VET.

Regulator proposes new guidance for level crossing safety

UK: The Office of Rail and Road (ORR) has proposed simpler and more accessible guidance on level crossing safety in Britain to support the industry, traffic authorities and local authorities in their decisions about level crossing safety. The draft proposals in the new principles for managing level crossing safety are designed to improve risk assessments at level crossings and provide practical advice on how to identify and manage risks that affect the safety of people who use them.

The proposal moves away from the current, more prescriptive document and aims to give industry greater confidence in putting forward innovative designs to reduce risks. It focuses on the need to consider how level crossings are actually used and encourages a whole system approach by considering the user, railway, and highway.

The principles also emphasise the importance of collaboration to remove and manage risks and explains how cost benefit analysis can be used in decision making to allow for consideration of all relevant costs and benefits. Consultation on the new principles closed at the end of February with formal publication planned for the end of April. For more information on the new guidance see irse.info/5c4dm.

Companies and products

Programmable Logic Controller based level crossing

UK: SELLA CONTROLS and Amey Rail Signalling & Systems are undertaking a trial of a safety PLC controller-based level crossing. They have been developing a Commercial Off The Shelf (COTS) safety PLC based level crossing solution for over four years, based on a range of safety PLCs. They say using standard industry safety PLCs in level crossings and railway signalling is a logical step and has been done by railway administrations in other countries.

The main advantages are significant cost reductions and increased system performance. Use of safety PLCs simplifies the design and testing. PLCs have significant design tools to simplify the design process and further reduce costs, and the function block logic used in PLCs is easily suited and understood by signalling engineers.

Amey Rail and SELLA CONTROLS have produced the Generic Application Safety Case (GASC) for the introduction of a safety PLC into the UK and the Specific Application Safety Case (SASC) for application to Network Rail level crossing work.

The purpose of the trial site is to gain Network Rail Product Acceptance which will then allow the PLC control system to be used by Network Rail and tier one contractors to renew relay-based level crossing systems.

News from the IRSE

Blane Judd, Chief Executive

IRSE subscriptions renewal

We will shortly be getting in touch with all members to invite you to renew your IRSE subscription. Please check that all your contact details are correct online **irse.info/details** (requires login) or by contacting the team directly (see below).

Accurate email, postal address and telephone contact details are essential for us to deliver the best service possible to you and all our members.

Now is also the time to tell us about any changes to your circumstances or subscription preferences. If you wish to change to / from an e-member (receiving IRSE News via e-bulletins only) then please change this online or contact us. If you have retired recently then please contact us to discuss whether you are eligible for a concessionary subscription rate.

Annual General Meeting

In another 'first' for the Institution, because of Covid 19 social distancing restrictions and by order of the Council, the AGM this year will be held online starting at 1730 UTC, adhering to strict procedures as advised by our lawyers.

The meeting will be chaired by IRSE president Dr Daniel Woodland and included in the business to be conducted is a special resolution "To adopt the recommended changes to the IRSE Memorandum and Articles of Association." All members are welcome to 'attend' but only corporate members (Honorary Fellows, Fellows, Members and Associate Members) are eligible to vote.

Our incoming president for 2021-22, Eur Ing Ian Bridges (professional head of signalling & engineering director, Balfour Beatty) will be inaugurated, and his address will be available to watch online during the live AGM or later via the IRSE website. To attend please register online at **irse.info/2021agm**.

Council elections

Thank you to all members who took the time to return your ballot form in this year's elections to make it another excellent year for the number of votes received by post and online. Results will be announced at the annual general meeting.

Signalling striders

Members of the London office team at the Institution of Railway Signal Engineers are taking on a 'virtual' walking challenge to raise funds for the Neurology Department at Charing Cross Hospital. This is in support of Hilary Cohen, a long-standing member of our team, who some of you may know. Hilary suffered a serious stroke in November last year.

Hilary is making good progress in her recovery thanks to the world class treatment and outstanding care she received at Charing Cross. Her journey has inspired her colleagues to raise funds for this highly specialist national/regional Unit which brings cutting-edge research to the bedside. All funds raised will be used across the Neurology Department.

We hope to raise £1000 by walking 1000 miles as a group, using the World Walking website and app. We have chosen to walk along the 'Wonders of the UK' route and will be taking the opportunity to check out UK railway stations and landmarks and check in with IRSE local sections as we pass by. We will be following Covid 19 guidelines and each of us will count our daily steps and add them to the cumulative total.

We will be saying a virtual "hello" to section representatives as we virtually pass their area. Look out for your invite to give the team a virtual wave as we make our progress. We would also like to collect messages of support for Hilary as we pace the length and breadth of the UK.

If you would like to support our efforts by sponsoring our walk and leaving a message you can do so through our JustGiving online page **irse.info/h6zm1**.

British Railways Telecommunications Engineers

In 2010, Ken Burrage, the last director of signal & telecommunications engineering before British Rail (BR) was privatised in 1995 and a former chief executive of the Institution, produced a booklet entitled Chief Signal and Telecommunications Engineers of the BR era. It was published by the IRSE in 2010 and revised, updated and re-published in 2019.

The booklet researched all the senior S&T engineers over the period 1948 to 1994 who had held the title chief signal & telecommunications engineer either at BR HQ or the BR regions and covered the various regional re-organisations including the phases to dismember BR under the Railway Privatisation programme in the 1990s.

Clive Kessell, who was the last holder of the post assistant director (telecoms) of BR (effectively heading up the telecom discipline at BR HQ), has now written as similar booklet "British Railways Telecommunications Engineers from 1948 until privatisation in 1994". This can now be downloaded from the IRSE website at **irse.info/yza75** along with the original signalling version.

Minor Railways Section

Institution of Railway Signal Engineers
MINOR RAILWAYS SECTION

Minor Railways S&T Technician of the Year returns for 2021

The IRSE Minor Railways Section was set up over ten years ago with one of its main aims to encourage the transfer of knowledge to those working in signalling and telecoms for the various minor railways, but who might not be professional signal and telecoms engineers. These aims include the purchase, preservation, restoration, installation, maintenance and operation of signalling and telecommunication and associated equipment, installations and buildings.

To further the aims, the Minor Railways Section undertakes technical visits, technical seminars, and technical training workshops to support and further the aims of the IRSE within the minor railway and heritage S&T community.

Dominic Beglin, second from left, receiving the award in 2011, Dominic is now Chair of the Minor Railways Section. Also shown, left to right, are Mike Tyrrell, Charles Hudson, John Francis and Dave Helliwell. *Photo Ian J Allison.*

The section provides for a transfer of knowledge in the format of technical guidance notes on S&T subjects and a range of training workshops and through an award scheme for all those working in the S&T sections of minor railways, either as volunteers or paid staff. The guidance notes are freely available on the section's pages of the IRSE web site at irse.info/mrs.

The award for the sections Minor Railways S&T Technician of the Year, recognises the role of the S&T engineer and is open to candidates nominated by any of their peers, to receive the award and the trophy for the year. This year's award will be a cheque for £250, a place on one of the sections training workshops together with a small sum to help with subsistence, membership of the IRSE in an appropriate grade for one year, and of course a small miniature trophy and certificate to hang on the wall.

But to identify our candidate we need nominations, it is simple to do, it can be for an individual or a team, it can be the boss or the new recruit and anyone on the minor railwaycan nominate, not just S&T people. There is a form with all the points described that you can fill in. Anyone over 16 years of age working in S&T on a minor railway can be nominated and we are now accepting nominations for the minor railways S&T staff members. All the necessity information can be found on the Minor Railways section of the IRSE website at irse.info/0xp2o.

The award will be presented at the Minor Railways Section's seminar in November and nominations will close in the middle of September.

Quotes from past winners

Geoff Harris, winner 2015

"I was Initially shocked and then proud to be mentioned as to what I/we have done. I certainly felt that I had achieved recognition for the work I'd done and that of my colleagues, but also to put the 'telecoms' part on view.

"I still would like to pass my skills on, I feel that it's worth doing as we see so much waste because the culture of "buy a new one", or "it can't be repaired" when using often simple techniques, you can fix quite a few failures. Working through a failure keeps the brain active, teaches you to fault with knowledge and logic together (and occasionally illogic).

"I was pleased, proud and putting the "telecoms" up in lights, I still feel that the Minor Railways Section is worthwhile and people on both sides have a lot to give and equally learn from our peers. I still love it and am still proud to been able to mix and be part of that organisation".

Rolland Johnson, winner 2017

"I am not sure what I think about my friends and colleagues who nominated me, if you asked me before winning it I would have thought it was some kind of wind up as all I have ever done, is my job to the best of my ability and lent a hand here and there when people have asked for the specialist knowledge I have.

"I have always been more than happy to help others out and pass on my knowledge to others as they grapple with their signalling and locking conundrums. I feel delighted to have been considered for the award, overwhelmed by winning it and humbled that there are those in my peer group (who are all pretty handy themselves with S&T matters) that think I deserve it. Thanks to all of you".

Professional development

Results of the 2020 exam

We are pleased to announce the results of the 2020 IRSE Professional Exam modules and to congratulate all those listed, especially those who have now achieved the IRSE Professional Exam and the Advanced Diploma in Railway Control Engineering.

As previously mentioned within IRSE News, 2020 was the first year that candidates could sit the Certificate in Railway Control Engineering Fundamentals (Module A) and the last year they could sit up to four modules from the numbered module exam structure. All modules were sat remotely for the first time in the history of the IRSE Professional Examination. At present, arrangements have not been made for Signalling the Layout (Module 2) to be taken online.

Thank you to all those who have supported candidates through their studies by organising study groups, acting as sponsors, and running the exam forum. Thanks also to the examiners for the considerable amount time involved with setting and marking the papers. Without your time the IRSE Professional Exam would not be the success it is.

The successful candidates for each module are identified in the tables below. In each case 'P' indicates a pass, 'C' a credit and 'D' shows that the candidate passed with distinction.

The exam review was held on 9 February and the videos of this can be seen at irse.info/oxp03.

Certificate in Railway Control Engineering Fundamentals and Advanced Diploma in Railway Control Engineering results

The table below details the candidates who have not only successfully passed the Certificate in Railway Control Engineering Fundamentals (Module A) but who have now completed their exam journey, having previously passed a combination of three numbered modules (see irse.info/exam). These candidates have therefore achieved the Advanced Diploma in Railway Control Engineering, the new name for the IRSE Professional Examination. Jehad Mahmoud and Matthew Slade had previously passed the IRSE Professional Examination before taking this module.

Name	MA
Emily Bramble	P
Robert Gunn	P
Tsz Yin Law	C
Andrew Laz	C

Name	MA
Jehad Mahmoud	C
Matthew Pylyp	C
Matthew Slade	D
David Snelling	P

Name	MA
Kwok On Wong	C
Feng Zhang	P

The table below details those who have successfully passed the Certificate in Railway Control Engineering Fundamentals (Module A), a stand-alone qualification and the start of the new Advanced Diploma in Railway Control Engineering journey.

Name	MA
Shalini Aithal	P
Osama Ali	P
Mozahir Anwar	P
Divya Aramalla	P
Daniel Barton	C
Robert Baxter	P
Muhammad Komail Bin Akram	P
Daniel Bowen	P
Peter Briton	P
Michael Brouder	P
Ewan Burns	P
Scott Cao	P
John Chaddock	D
Ching Yin Chan	P
Cho Yee Cheung	P
Tsz Hei Cheung	C
Ka Kwan Chu	P
William Clark	C
Martin Cooper	C
Agnes Darazsi	C
István Darázsi	C
Chetan Devikar	P

Name	MA
Malcolm Dobell	C
Neal Dodge	C
Philip Dubery	C
Veera Duggirala	P
Richard Fisher	P
Dominic Fleming	P
Gareth Fussell	P
David Gardner	P
Emily Glover	C
Stephen Goodwin	C
Russell Grinham	P
Paul Gueneau	C
Harry Hammond	C
Stephen Hatton	C
Hongyang He	C
Anthony Hewitt	P
Ming Hsia	P
Dani Indrianto	P
Joe Inniss	P
Mukul Jetmalani	C
Christopher Johnson	C
Rhiannon Jones	P

Name	MA
Manroshan Singh Jusbir Singh	P
Akash Reddy Kankanala	C
Gaurav Kaushik	C
Jonathan Kelly	P
Timothy Kelman	C
Atif Khan	P
Yiu Nam Kwok	P
Yung Ho Lam	P
Chun Yeung Law	P
Tsz Ki Lee	P
Man Cheng Lei	P
Joseph Little	P
Hiu Tung Lo	C
Virun Lokavirun	P
Stuart Maddock	C
Oliver Marshall	D
Gregory Martin	P
Diatta Mbaye	P
Ian McNerlin	P
Paul McSharry	P
Israel Mendez Tovar	P
Paul Morris	D

Name	MA
Stanley Mudyawabikwa	C
Ashley Murray	C
Mehmet Narin	P
Paul Naylor	C
Siamak Nazari	C
Alfred Ng	P
Daniel Oakes	P
Henry Pang	P
Stuart Park	P
Toby Parker	P
Karthik Raja	P
Simon Read	C
Aneurin Redman-White	D

Name	MA
David Roebuck	P
Nicholas Rook	C
Ian Ross	P
Daniel Scourfield	P
Davelia Sihombing	P
Shashi Singh	P
Trevor Stevens	P
Mark Styles	P
Arvind Kumar	P
Vangelis Tsiapalas	P
Tajamal Tuffail	C
Ayberk Ustaoglu	P
Ben Vallely	P

Name	MA
Tanay Verma	P
Vikrant Vishal	C
Robert Watson	C
Robert Wheeler	P
Bill Raymond Wilkinson	P
Hiu Tung Wong	C
Man Lok (Wilson) Wong	C
James Wood	C
John Woods	P
Richard Wright	C
Li Xie	P
Rui Zou	C

Results for the IRSE Professional Exam and passes in numbered modules

Candidates in the table below have successfully passed the IRSE Professional Exam by being successful in Safety of Railway Signalling and Communications (Module 1) and three other modules from the numbered module exam structure available up to and including October 2020. We would particularly like to congratulate Ewan Campbell, Kin Sum Lee and Hey Man Joshua Ma for not only passing the examination, but also successfully passing five modules. Colin Hamilton-Williams had previously passed the exam but has also now passed five modules, and Aaron Sawyer who had also passed the exam previously, has now been successful in six modules.

Name	M1	M3	M4	M5	M6	M7
Martin Allen	C			P		
Ewan Campbell		P		P		
Clare Crooks		P				
Colin Hamilton-Williams			P			
Kauser Ismailjee	D					P
Elliott Jordan	P			P		
Peter Kelly						P
Michael Kingston		P				P
Praveen Kumar				P		
Ching Yin Lau	P					C

Name	M1	M3	M4	M5	M6	M7
Kin Sum Lee		P		P		
Hey Man Joshua Ma	C			P		P
Aaron McConville		P				
Rory Mitchell		P				
Michael Murphy		P				
Gabor Nemeth	P	C				P
Aaron Sawyer			P		P	
Phuoc Tran						P
Susannah Walker						P
Jordan Wallis	C					P

The table below shows those who have successfully passed modules in 2020 but have not yet achieved sufficient passes to complete the exam. Candidates will be able to continue their exam journey by passing a combination of new modules, see **irse.info/exam**.

Name	M1	M3	M4	M5	M6	M7
Kevin Banks		P				
Paven Bhatti	P					
Arjun Chauhan	P					
Chong Lam Cheong			P		P	P
James Darlington				P		
Shane Dowling		P				
Thomas Franklin	P					
Sean Gorman		P				
Alex Grant	P					
Kieron Hadlington	D					
Oliver Hains	P					
Jordan Harris		C				
Ho Ka Man	P					
Harshvardhan Kodam						P
Dabi Laniyan						P

Name	M1	M3	M4	M5	M6	M7
Ka Seng Lio		P				
Samuel Loveless						P
Sam Mitchell		P				
Aisling O'Connor		P				
Antonis Phasouliotis						P
Andrew Plumb		P				
Hiu Chun (Jack) Pun		P				
Suhanya Saenthan	C					
Chou Tek Sam Ti			C			C
Ming-Tak Shum	P					
James Stanley	D					
Natcha Sujaritworakun	P					
Mark Williamson						P
Hai Tao Wu				P		

The next opportunity to sit the Certificate in Railway Control Engineering Fundamentals and modules for the Advanced Diploma in Railway Control Engineering will be Saturday 2 October 2021, for further details see **irse.info/irseexam**. The IRSE Younger Members are organising study workshops, so keep an eye on **irse.info/events** for further details.

Your letters

To blockade or not to blockade

Clive Kessell's letter in the February edition of IRSE News has prompted me to write agreeing with his sentiments regarding total shutdowns of railway corridors.

This has been occurring in Melbourne, Australia since privatisation of the previously government owned and run railway system and the outsourcing of the majority of its labour force.

When the Victorian Railways completely reworked the inner metropolitan system to accommodate the Melbourne Underground Rail Loop, the works were all carried out by in-house labour, accustomed to working in a 'railway' environment with generally only weekend shutdowns.

Yes, the staging was complicated and required a considerable amount of cross-discipline planning, but it worked!

We even managed the replacement of more than one interlocking, each over a weekend. (After last service Friday and before first on Monday morning.)

The other 'difficulty' which has occurred with the outsourcing of technical staff, is the reduction in the breadth of railway operational knowledge of the current technical staff, not just engineers, but also technicians and other non-professional staff and the loss of 'corporate memory'.

In light of all the above, it is all too easy for project managers to just shut the service and hire a fleet of road coaches and add the cost of the bus hire to the cost of the project, ignoring the 'hidden' cost of alienation of the travelling public.

Richard Bell, Australia

Learning from another railway

The article from Karl Davis in December's IRSE News, particularly in relation to the (UK) signal engineers' seeming predilection for approach control of signal aspects, does resonate with me. I have long had concerns about this practice and its increasing complexity over the years, which, unfortunately, will clearly be with us for many years to come until phased out by one form of cab signalling or another. I fully agree with Karl that approach control sets traps for train drivers – as was revealed at Colwich and – to some extent – at Ladbroke Grove, as well as eroding network capacity, by making trains progress more slowly through block sections than the maximum speed those block sections are designed for, and certainly at a lesser speed than a driver might wish to adopt given his route knowledge about the state of the line ahead, and the type and capability of the train being driven.

I think the practice of approach control as has been practised in the UK has detracted from the safety benefits that have otherwise accrued from the replacement of mechanical signalling by colour light signalling, due to the apparent difficulties in conveying adequate information to train drivers as to the route set ahead as a train approaches a facing diverging junction. Only generally providing that route information explicitly at the last stop signal approaching the facing points (and under some rules which stop signal can be up to 880 yards from the junction facing points) is not exactly, in my view, effective communication of the state of the line ahead. It seems to me that approach control has been used as a form of "patch" applied to cover a gap in which the UK colour light signalling system has long been deficient, and never properly addressed at a system level. I fear this situation may also have been compounded (as Karl suggests) by the various types of approach control having been developed in (what used to be) smoke-filled rooms full of signal engineers, with perhaps not so much consideration for the impact on the end user, i.e., the train driver, or on the capacity of the railway, of which we are now aware (painfully.)

Near where I live in the south west suburbs of London, there is a triangular junction between two different railway routes, the main route along the base of the triangle and the other route joining at the tip of the triangle being subject to 60mph speed restrictions, and the divergences along each side of the triangle being subject to 20mph speed restrictions (due to the curvature). Each of the two routes, the main route and one side of the triangle are used regularly by both passenger trains and freight trains, and the third side of the triangle is used by passenger trains only. When semaphore signalled, there was a signal box at each point of the triangle, each route on the approach to the triangle having "splitting distant" as well as "splitting homes" (despite the 60mph/20mph difference in speed at each junction) so that it was clear to a train driver which way the route was set at the junction ahead at braking distance from the junction. In consequence a train driver was able to select the appropriate speed to approach the junction, depending on the type and braking capabilities of his train, without further "interference" from the signalling system. The driver was also in a position to bring his train to stand before the junction if he became aware from the distant signal the signalman had selected the wrong route for his train. When this arrangement was replaced with 4- aspect colour light signalling in the 1970s, the junction colour light "home" signals were subject to "approach release from red," meaning that as the train approached the junction there was no equivalent exact confirmation of the route to be taken equivalent to the "splitting distant" that used to exist with mechanical signalling until the junction "home" signal cleared "in the driver's face." This arrangement means that a train using one of the 20mph divergences has to creep up to the junction signal under the prevailing train operating company's defensive driving policies (not that the existence of defensive train driving policies was initially much known about in the signal engineering fraternity either) with the consequent impact on line capacity, although at least the installation of TPWS has assisted with a train driver anticipating the usual clearance of a junction signal from red, on the odd occasion when it doesn't.

The basis of UK railway signalling since the middle of the 19th century can be summarised as "how far you can go" plus "where you are going", and does not explicitly convey any speed requirements at all to a train driver. System safety on the approach to junctions has traditionally – to a greater or lesser extent – depended on being a function of factors such as the driver's route knowledge, the capability of the train's braking system, the integrity and quality of the information given to the driver by the lineside signalling system – including the drivers comprehension of the signalling information- and the quality of the adhesion between the train's wheels and the rails. As is clearly indicated in Karl's article, the only element of system safety that the signal engineer should get involved in is the means of conveying information to the train driver – although interestingly having provided information on how the signalling operates to the operators, in the UK the signal engineer has rarely, if ever, formally been directly involved in the actual interpretation and dissemination of information on signalling system functionality to train drivers (although we are well aware of many informal communication lines between signal engineers and train drivers!).

I remember being responsible for the development of the signalling arrangements at Saltwood Junction (between Ashford and Folkestone – where the "Continental Main Line" towards Eurotunnel diverges from the Charring Cross to Dover Route) as part of the HS1 Channel Tunnel Works- where it was necessary to make sure there were sufficient safeguards in place for the four available routes at that junction to make sure a Eurostar Train towards Paris or Brussels didn't head off towards Dover, or a humble Electric Multiple Unit from Charing Cross to Margate via Sandwich didn't have an unintended excursion towards Paris or Brussels (!) It was also necessary to manage a further situation that applied where Class 92 electrically hauled Freight Trains for the Continent had to coast for a length of the reception siding in Dollands Moor Yard just after Saltwood Junction without power applied due to the transition between 3rd Rail and 25kV power in Dollands Moor Yard. Following considerable debate with the operators concerned, the (then) Railtrack professional head of signalling and RSSB, the solution developed was a pair of "four way" preliminary routing indicators (PRI) overlaid over the four-aspect signalling on the approach to Saltwood junction combined with a Main Aspect Approach Release from Yellow on Saltwood Junction "home" signal. The PRI application was a development of that at Southall on the Great Western Main Line for the approach to Airport Junction. The PRIs are positioned just ahead of the double yellow and single yellow aspects on the approach to the junction signal at Saltwood Junction – so that the driver could see them soon after the aspect – but was not distracted by them from reading the aspect. Provided that the junction signal at Saltwood junction was "off" and junction indicator alight (except for the route to the Down Main), the preliminary routing indicator would show an arrow corresponding to Junction Indicator Position 3 (Dollands Moor Yard), Junction Indicator Position 2 (Through Passenger Line), Vertical (Down Main), Junction Indicator Position 4 (Folkestone Central). If the junction "home" signal was on or the junction indicator is not proved alight, the PRIs are blank. The train driver therefore has sufficient information about the route ahead to be able to manage the train appropriately without "interference" from the signalling system. I believe this installation to have met its objectives (although there was a dispute between signal engineers about the suitability of the installation even during commissioning!) and was accepted by train drivers of at least three different nationalities – and other installations of preliminary routing indicators have been made elsewhere since, although I would accept PRIs can be a somewhat expensive addition to the signalling system when capital costs are considered, so possibly need to be applied sparingly. However, when life-cycle costs are considered, particularly making better use of line capacity by enabling train drivers to use their trains' capabilities better, they may well be more cost effective than might appear at first sight.

With Junction Signalling in the UK with approach control, "we are where we are", and with the advent of cab signalling, we could be in sight (excuse the pun!) of not needing it – however if the transition from colour-light signalling to cab signalling is as long as the transition from mechanical to colour light signalling (which hasn't been completed yet!) it might be a good idea to have another think about it- and open the door to "end users" when we do it!

Ian Harman, UK

CBTC interoperability

With regards to the article on CBTC interoperability, IRSE News issue 268 July – August 2020 Dr Frank Heibel. The international working group of IEC for IEC 62290 believes the article contains errors and inaccuracies in the analysis of the CBTC market and related standards. The article does not accurately reflect our working group and standard series, which we would like to correct.

CBTC is only considered in the article through the perspective of interoperability, which for urban networks is not the core priority. Interoperability underpins an operations principle. If this principle is not applied for the daily operations of a line or network (or not possible due to the topology of the network), then CBTC system interoperability is not the main expected outcome. What is expected by urban network operators is an exceptionally reliable system, providing extremely high performance in terms of RAMS (all the more for GOA4 systems), achievable minimum headways, and procurement competition. This being achieved with a reduction of purely proprietary solutions through standardisation initiatives and the approaches applied (for example) in New York and Paris.

The IEC is not a European but an international standards organisation, acting at worldwide level, covering all topics related to electrotechnology, except those related to telecoms which are covered by ITU (International Telecom Union) and topics such as mechanics and services. The development of the IEC 62290 series of standards has been done by WG40 of TC9 with experts representing many countries all around the world (15 countries being represented in WG40). Part 1 was published initially in 2006, and revised in 2014. Part 2 was released in 2011, and then maintained in 2014. Part 3 was published in September 2019.

Currently an update of the full series is in progress and is expected to be completed in 2022, as the standardisation work is based on consensus and it takes time to meet the needs of different stakeholders.

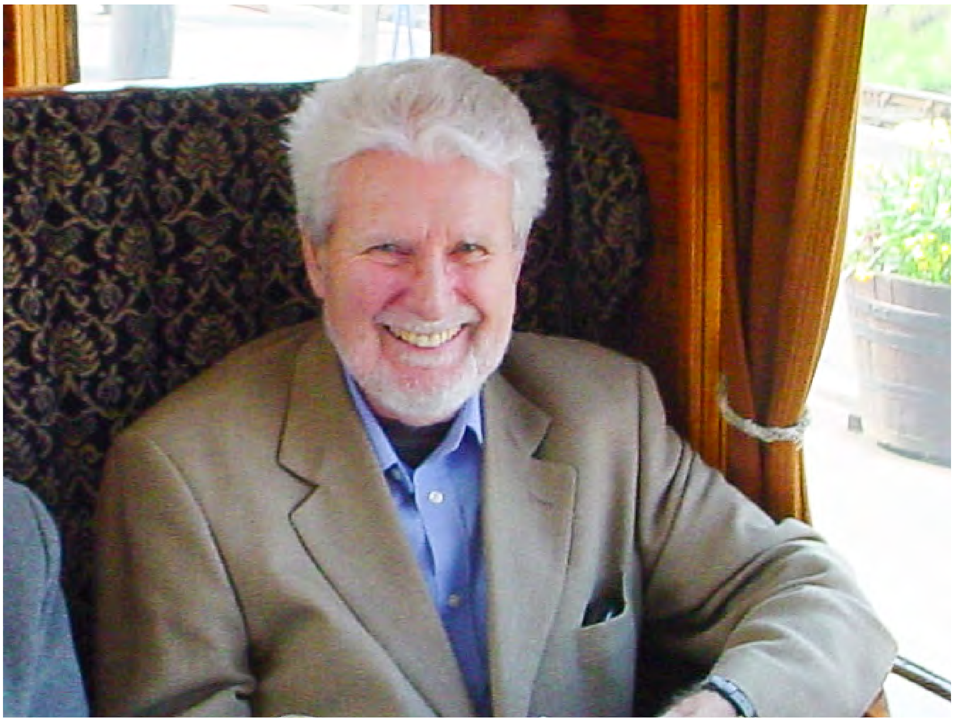
A division between "established CBTC suppliers" and Chinese suppliers is suggested in the article, whereas the CBTC market is an open one, already involving many manufacturers. This market and these actors are constantly evolving, especially with merging/ acquisition of companies (the last one having occurred recently with Alstom and Bombardier, and previously Hitachi and Ansaldo STS). No doubt this will continue in the future, with suppliers from China, or some new international players from some other parts of the world or industry.

The main drivers for CBTC are the market and requirements such as high level of performance, availability, safety, innovative functionalities, and lifecycle costs. It has to be noted that operating a network through interoperability principles has to be assessed on all aspects, including economic ones, as interoperability generates additional costs for development, commissioning, and certification of related products.

MTA in New York has promoted interoperability involving three suppliers, which was related to work done by the IEEE . For the RATP Paris network a set of interchangeability documents (three interchangeable subsystems: onboard, wayside and data communication system) has been developed with the involvement of three different suppliers. This corresponds to the CBTC generic program called OCTYS (GOA2), with the 1st revenue service in 2010 (line 3), and which is now deployed on several lines (line 5, 9, and in progress on lines 6 and 11).

Stéphane Dubois,
convenor of IEC/TC9/WG40 experts

Past lives: Brian Hesketh



Brian Hesketh, FIRSE. 1932-2021.

Brian Hesketh was born 5 March 1932. He was educated at Crewe Grammar School and joined the British Railways signalling engineers department Crewe in August 1948 as an engineering apprentice. He quickly became a thoroughly professional, competent signal engineer and in all aspects of railway signalling engineering. Many good engineers specialise in one area of signal engineering, but Brian is remembered as being good at everything!

The engineering apprentices were then paid weekly, not monthly like engineers, and received no paid holidays or pension. The starting rate was 10 shillings (50p) a week at 16 years of age, rising in increments to £1 at twenty.

The 1950s and 60s was a time of railway modernisation, and Brian was involved with signalling design and testing of signalling on the West Coast Main Line (WCML). Not only did Brian become an exceptional signalling designer, but he also mastered the roles of logistics, planning, contract management and finance. He became assistant chief draughtsman Manchester, chief draughtsman Crewe, signal engineer works Crewe, and assistant divisional signalling and telecoms engineer Crewe.

He joined the IRSE as a Student Member in 1953, and was elected as a Technician Engineer 1960, Associate Member April 1970, and a Fellow October 1987. Brian is also remembered for mentoring, encouraging, and developing many young engineers, and was always looking for opportunities to achieve the potential he saw in them.

In the 1970s Brian instigated and implemented many minor schemes, especially along the Trent Valley section of the West Coast Line, by abolishing signal boxes and extending the control areas of those remaining, with the ultimate aim of creating small Power Signal Boxes (PSBs). This was all within the local divisional budget and by working closely with all other local departments he created and drove a united strategy from which all would benefit.

In 1977 he delivered an IRSE paper in London called "The lifeline of control, communications and power – cable routes". The paper is as relevant today as when it was produced 44 years ago. Brian explained "the increasing complexity and importance of the vital link provided in modern communications and data control schemes by the cable network, and the integrity and value of these cables, is only as good as the protection provided by the cable route. In addition to signalling controls and telephone conversations, data is transmitted in connection with finance, stores control, traffic movements and pay. The engineering operative who severs the lineside cable with his excavator may be severing the data used in the calculation of his personal pay for the ensuing week."

Brian was instrumental in leading innovative and complex projects, such as the major remodelling and resignalling of Crewe in 1985. This was achieved in just seven weeks. Similar projects today can take months to implement. All the extensive track layout and signalling was removed and replaced. Plug couplers were used to enable clamp lock tail cables to be prepared and tested, and quickly installed in the relatively short blockade. Today, the use of plug-coupled cables is common.

In December 1985 he moved to Birmingham and was promoted to become responsible for all signalling new works activity on the London Midland Region. In May 1989 he was appointed as British Rail HQ signal engineer (projects) in charge of all signalling projects for the whole of BR, a role which he performed with considerable success and distinction. Creative schemes such as the IECC at York, Marylebone and Newcastle were commissioned during this time, and he created a new signalling project office in Birmingham, and a new major works depot at Swanley, specifically to undertake work for the Channel Tunnel project.

His final task after his retirement in 1991 was to undertake a review and inspection of all the major signalling installations on the whole of BR and to produce a report on their condition and likely timescale for renewal. This was a major study carried out with meticulous care and attention to detail, which came to be known as the ‘Hesketh Report’. This was a valuable source of information on the signalling asset condition before Railtrack was created and the railway privatised in 1994.

He also came back to Birmingham to help teach the next generation of signal engineers. Many working today still value the considerable knowledge and experience that he passed on.

Outside of the rail industry in his youth he was a keen motor cyclist and took part in competitive hill climbs. Brian was also an excellent mechanical engineer and produced many engineering models of locomotives and road vehicles, which included a 3 1/2” track gauge model of the steam locomotive “Llywelyn” from the Vale of Rheidol Railway. This was created with no drawings available. He also built and sailed, with his brother-in-law and other railway enthusiasts, a superb Ferro-Cement Ketch yacht with twin masts. Cars were another favourite; a fan of the Lotus 7, he built several Westfields and Caterhams.

Many in the industry remember Brian as a loyal, supportive colleague and they are extremely grateful for all he contributed to the industry. He passed away on 10 February after a long illness and his funeral took place on 22 February.

With thanks to: Barrie Ashmore, Ken Burrage, Alan Fleet, Brian Hassall, Alan Joslyn, Ron Richards, Mike Simpson, and Mike Stubbs.

Quick links

IRSE
Institution of Railway Signal Engineers

The IRSE Knowledge Base, an invaluable source of information about our industry.

Our sections, IRSE activities taking place near you.

Our examination, the ultimate railway signalling, communication and control qualification.

Licensing, our unique scheme to help you demonstrate your competence.

Use your mobile phone in camera mode to read the QR codes above and go straight to information relevant to you.

IRSE News is published monthly by the Institution of Railway Signal Engineers (IRSE).

Website

For latest information about IRSE events, news and how to become a member, visit our website at www.irse.org. We welcome all those who are interested or involved in the fields of railway control systems, communications, data management or systems engineering.

Contributions

Articles of a newsworthy or technical nature are always welcome for IRSE News. Members should forward their contributions to one of the editors listed.

If you have a view about something you’ve read in IRSE News, or any aspect of railway signalling, telecommunications or related disciplines, please write to the editor at editor@irsenews.co.uk.

Chief Executive, IRSE

Blane Judd e-mail: blane.judd@irse.org

Managing Editor, IRSE News

Paul Darlington e-mail: editor@irsenews.co.uk

Contributing Editors

David Fenner e-mail: david.fenner@irsenews.co.uk

Ian Mitchell e-mail: ian.mitchell@irsenews.co.uk

Ed Rollings e-mail: ed.rollings@irsenews.co.uk

Assistant Editors

Harry Ostrofsky (Africa)
e-mail: thehzos@icon.co.za

David Thurston (N America)
e-mail: thurston@temple.edu

Mukul Verma (Asia)
e-mail: mrverma@gmail.com

Allan Neilson (Australasia)
e-mail: allanecneilson@gmail.com

Alexander Patton (Local Sections)
e-mail: alexander.patton@siemens.com

David Stratton

Production, typeset and layout

Mark Glover
e-mail: mark.glover@irsenews.co.uk

Printed by Herald Graphics, Reading, UK
www.heraldgraphics.co.uk

Planting trees to catch carbon • Planting trees to catch carbon
9444263
Printed on Carbon Captured paper

IRSE
Institution of Railway Signal Engineers

London Office

IRSE, 4th Floor, 1 Birdcage Walk, Westminster, London, SW1H 9JJ, United Kingdom

Enquiries – Membership or of a general nature

Tel: +44 (0)20 7808 1180
Fax: +44 (0)20 7808 1196 e-mail: hq@irse.org

Licensing

Tel: +44 (0)20 7808 1191 e-mail: licensing@irse.org

Institution of Railway Signal Engineers

IRSE, 5th Floor, 1 Birdcage Walk, Westminster,
London, SW1H 9JJ, United Kingdom

www.irse.org

Design, typeset layout by Polunnio Ltd, www.polunnio.co.uk. V0.1, September 2022.