Presidential Address
Future signalling and you

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The IRSE needs active younger members for its future success. What can the IRSE offer to younger members? On joining, many younger members are focused on acquiring knowledge through preparation for taking the IRSE Exam or equivalent. However the IRSE provides other opportunities for personal development, for instance by preparing and presenting on a topic at a Local Section meeting. A presentation is less onerous than having to write a paper and having it peer reviewed, but still needs enough rigour in thought and be delivered with good technique to be of value to both the presenter and the audience.

A Local Section meeting provides an informal setting with the advantage that your target audience is already supportive. Presenting, while initially challenging, does lead to improved confidence in public speaking and ability to convey your messages to the audience. Another path that may suit some people is to consider the opportunity of career development within the IRSE committee based structure. Our committee system relies on volunteer effort to advance the IRSE's work. Our structure is multi-layered, with Local Sections, various Committees of the main IRSE, and ultimately Council.

In Committees, at whatever level, many disparate views are expressed, as it is to be expected of an increasingly diverse multi-national organisation with members having differing subject matter expertise. I have found that while the achievement of consensus can be time consuming, working in Committees generally leads to a much deeper appreciation of an issue or topic. The IRSE needs to continually regenerate and re-invent itself, and having an active base of younger members is essential for our long term health. So I suggest you seek out your Local Section Committee members and offer to present on a suitable topic, and also consider joining a Younger Members Section or group to network with like-minded people around the world.

Peter Symons, President IRSE

Front Cover: The IRSE is committed to Diversity, Equality and Inclusion, and has recently launched a policy on this topic. On p7 of this issue Judith Ward explains our approach, and our front cover celebrates the diversity of our membership at a range of events over recent years.

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In my Presidential Address I talked about the constantly changing environment in which we work, identified some trends, and the potential implications of change for you. This article is a written version of my address and starts off with some speculation on the future.

Looking at the current situation, we can reasonably forecast that rail signalling, telecommunications, train control and traffic management systems, in short signalling systems, all the systems that form part of an operational railway, will have increasingly complex interactions, and that the rate of technological change will lead to much shorter asset lifecycles. Despite best endeavours the likelihood remains that there will be accidents on the world’s railways.

**Accidents and incidents**

Major railway accidents in Australia due to signalling failures are becoming rarer, but human failures continue. I have reviewed the Australian accident statistics and identified that there are influences on the signalling system in the following categories; derailment, collision, level crossing occurrences, Signals Passed At Danger (SPADs), load irregularities, and track and civil infrastructure irregularities. I used the published accident reports and then took a view about how signalling systems could have prevented or mitigated these accidents. Although I did this in an Australian context, hopefully these types of incidents will translate into examples in your particular part of the world.

**Derailment**

To get an idea of the extent of the derailment problem, in the period Jan – Jun 2012 there were 78 running line derailments across Australia [1]. On reviewing accident reports two examples, both from lightly used lines, have potential signalling system solutions. Firstly from 2009, the derailment of El Zorro grain service 8996 near the township of Peak Hill between Narromine and Parkes in New South Wales [2]. To summarise the causal factors in the report, the speedometer was not working, the second person in the cab was incapacitated, the weather was hot, and the wagons were overloaded by 9%. In another example from 2014, the derailment of train 735 near Colebrook, Tasmania [3], the principal cause was that the train was travelling at 65 km/h through a 35 km/h section of line. Both of these over-speed type derailments could have been prevented by a train control system – Automatic Train Protection (ATP).

**Derailment and collision**

In the same period, Jan – Jun 2012, there were six running line collisions and one train to train collision [4]. Looking into the published accident reports the following incident is of particular interest. In 2012, at Bengalla, on the Ulan Line [5], a ballast train derailed within a worksite after colliding with an unmanned ballast regulating machine. In essence there was a failure of manual train regulation within the worksite, with poor communications, piloting of a propelling train, and a failure to use detonators to warn of the ballast regulator’s position. This incident within a worksite could be considered as not being a signalling system problem, however there are signalling system technologies available that could have mitigated this accident.

**Collisions and Level Crossings**

The number of fatalities (disregarding suspected suicides) at level crossings in Australia has reduced over recent years, with only one being recorded for Western Australia in 2014 - 15, in the most recent available data. But there were 23 collisions with trains across a population of around 23,000 crossings.

Looking into an accident in 2016, where there was a collision between a road vehicle and a V/Line passenger train at Pogue Road level crossing, Toolamba, Victoria [6], the car driver failed to stop at the crossing and drove into the side of the train. This was an intersection between a 100 km/h road and a 100 km/h track. Luckily there were only minor injuries and no fatalities. This was a passive road/rail interface. Passive level crossings consist of Stop signs that require road users to come to a stop and check for trains before proceeding. A range of studies have found that providing active warnings reduces crash rates by 48 to 88 per cent [7]. Within Australia there has been an ongoing saga about the development of ‘low cost’ active protection systems for lightly used crossings. The development of such systems have been hampered by the legal issues involved rather than the robustness of the technology.

**SPAD and derailment**

Again using the available Australian data from Jan – Jun 2012 there were 99 SPAD events, plus 138 instances of the signal being replaced in front of the driver. One example of a SPAD was
at 2009 Homebush, Sydney [7], where the driver misinterpreted which signal applied to the line and passed the stop signal. The train was then tripped by the trainstop, and subsequently was deliberately derailed by the catch points, with no resultant injuries. The use of a predictive ATP system rather than a reactive trainstop system would have avoided this incident.

**SPAD**

A more interesting SPAD incident, that thankfully did not do not have a serious outcome, was in 2015 at Upwey and the single line section to Upper Ferntree Gully in Melbourne [9]. The signalling was controlled by a local panel, and when this failed, rail operations reverted to the manual (procedural) safeworking system, that led to an increased risk of human error. The driver tripped past the departure signal at red, then passed a mid-section auto signal and finally the home signal at Upper Ferntree Gully, all without authorisation. Poor communications between the train controller and the driver were a major factor in the incident. Importantly for signal engineers, it would appear that there was a lack of resilience in the signalling system, with what seemed to be a single point of failure in the telemetry systems that led to the manual working.

**Future signalling trends**

Having identified some incidents let us look at some requirements for future systems, along with a generic system architecture to give some context (see Figure 1). This generic diagram deliberately mixes the various PTC, CBTC, ATACS, and ERTMS terminologies, noting that the actual interlocking is now but a small part of the overall system.

In summary a future signalling system would comprise:

- Fault tolerant system architecture.
- Highly available telecommunications.
- Engineered Worksite Protection System.
- Intelligent On Board Systems (with end of train detection/train integrity).
- Minimal Trackside Infrastructure, limited to equipment for points operation, level crossing operation (if not eliminated), and axle counter train detection (if required for fall-back purposes).

Readers will be aware that all these elements exist today in modern PTC, (ATMS), CTCS, ERTMS and CBTC systems. However the bulk of world’s rail control systems comprise of legacy equipment that are not well integrated and which still rely heavily on human based network rules and procedures for operations and for handling fall-back situations.

**Fault tolerance**

A key operational requirement is for business continuity, and one way to deliver the technological contribution to this is to use fault tolerant systems such as self-healing communications networks, duplicated/redundant on-board systems, interlocking override, graceful degradation, alternative safeworking systems etc. All or some of these approaches can help to keep trains moving albeit at reduced speed/capacity, without resorting to manual safe working systems.

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**Figure 1 – Generic signalling system architecture.**
Integration of non-traditional ‘signalling’ functionality

Asset maintenance and protection systems are increasingly being integrated with more traditional signalling system functionality. Such systems monitor both rolling stock conditions (e.g. wheel squeal, hot axles etc), and track infrastructure (e.g. flood stream monitoring). The improvement in data communications permits much more extensive remote condition monitoring and this can be integrated into traffic management systems and Regional Operational Centres (ROC).

Worksite protection

Whilst there still remain items of signalling equipment (point machines and level crossings), permanent way and other infrastructure assets that are located in the rail corridor, there will be a continuing need for systems of worksite protection for track worker safety in order to allow maintenance and renewal tasks to be performed.

With increasing demand for 24 hour operation there is less time available to close the operational railway for projects or maintenance activities. This, together with more general obligations for workplace health and safety, means that technology needs to be highly reliable and requiring low maintenance. When there is an in-service failure of trackside equipment the use of systems such as PTC, CBTC, ATACS, and ETCS can enforce blocks (possessions/occupations) and temporary speed restrictions as part of an integrated approach to working safely.

Asset lifecycle

The asset lifecycle of signalling can no longer be thought of in terms of 40 – 50 years, as was traditional for relay interlocking. Modern systems rely on computers that use less bespoke hardware and more application software, which means that well thought out system configuration and integration is increasingly important. The use of software ‘Apps’ like Airbnb and Uber in other industry sectors should remind us that even within our industry there is the potential for disruptive change.

Abstraction and automation

Interface management and a systematic approach are essential when integrating a modern signalling system. Progressively application engineering has become the configuration of sub-systems (technological black boxes), where the internal operations are not known (e.g. CBI, axle counters, routers etc.), In this new world, different ways of thinking are needed in order to specify functional and interface requirements for equipment and subsystems so that the overall system functions safely and correctly.

The systems being developed for autonomous vehicles on highways, such as collision avoidance, could be relevant to rail signalling systems. The increasing use of Artificial Intelligence Systems (AIS) combined with machine learning means that new thinking is required to deal with increasingly intelligent and autonomous sub-systems – which are not usually designed by railway engineers!

Dealing with service disruptions where there are complex interactions across different transport modes would seem to be a useful application of AIS as part of rail traffic management. The future use of AIS could involve one AIS learning from feedback from a second AIS, its learning perhaps monitored by technical experts, which continually improves the ability of the AIS to analyse and perform complex tasks that are beyond human understanding [10].

We are already seeing increasing use of automated (robotic) systems for train control i.e. unattended trains to Grade of Automation 4 (GoA4). Future development of robotic maintenance systems could also reduce the risk to track workers by eliminating many dangerous and dirty jobs.

Different hazards arise, and new mitigations are required, for the safe operation of these highly automated and inherently complicated systems, which emphasizes the need for methodologies such as Systems Engineering and for practitioners skilled in its use (not just ticking boxes), to assure the system requirements, e.g. RAMS, and other non-functional requirements.

So perhaps the term ‘Human Factors’ should now be extended to include ‘Robotic Factors’. Isaac Asimov has proposed:

“A robot may not harm humanity, or by any inaction allow humanity to come to harm,

1. A robot may not injure a human being or through inaction, allow a human being to come to harm, 2. A robot must obey the orders given to it by human beings except where it would conflict with the 1st Law, 3. A robot must protect its own existence as long as such protection does not conflict with the 1st or 2nd Laws.”

Asimov’s principles should satisfy the safety requirements of SFARP/ALARP. What do we think about this?

This now brings me to the potential implications for you.

You

I am not a number…

You are not a number, you are a unique individual, we are all different and indeed special in our own way.

Members of the IRSE comprise a broad family, with a range of diverse opinions. There are many different personality types that find suitable and fulfilling roles across the whole system life-cycle, from Research and Development, Operations and Maintenance, and Project Delivery (design, install, test, commission).

Amongst us there are some signalling engineers who have always tended to be close to operations and have gravitated towards defining system requirements. Others work in project delivery, integrating technologies for new schemes and upgrades across multiple disciplines to meet the end user needs. We also have many signal engineers and technicians dealing with practical matters of reliability engineering and maintenance.

Increasingly our profession also comprises Technical Specialists who are subject matter experts in a particular technology or sub-system, or who perform systems and safety assurance roles.

All these roles are vital, and together we provide the technological and operational understanding needed for the world’s railways.

The Knowledge

The knowledge that underpins our profession may be gained in a number of ways. These include apprenticeship, traineeship or cadetship, all of which include “on the job” experience. For some people it might also include studying for the Institution’s Examination or an approved equivalent. This involves a significant amount of study time – for instance, to study for a post graduate Diploma the time required would be in the order of 1,200 – 1,600 hours over two years.

Continuing Professional Development in order to maintain the knowledge is typically specified by Professional Engineering Institutions (PEI) as requiring 50 hours a year.
The Learning Cycle

Referring to Figure 2, the learning cycle provides a useful model for how learning is mastered. We all start in a state of ‘Unconscious Incompetence’, i.e. we don’t know what we don’t know. As you learn a new skill (or behaviour, ability, technique, etc.) you start to realise the boundaries of your knowledge – and move to ‘Conscious Incompetence’.

As you regularly practice a new skill you eventually can discard your ‘L’ plates and become skilful, and so become ‘Consciously Competent’. After some time you might even move to a level of mastery where you exercise your skill in a routine way, achieving ‘Unconscious Competence’.

What happens when you achieve this state of Unconscious Competence? Do you become an enlightened master or expert? Ideally, a real master or expert is capable of imparting his or her knowledge to others so that they can go through their own learning cycles and apply their skills in a consistently good way. Many senior IRSE members believe this to be a vital role, one that is facilitated in part through the IRSE by writing and presenting papers.

But (and there is always a but!) it also could be argued that learners who become masters often then cease to continue learning. In one respect this is a statement of the obvious, but a more subtle appreciation of this status is that people at this stage of expertise can be vulnerable to complacency, believing they know all that needs to be known, and so learning ceases. The Unconscious Competence state may in time become characterised by an ignorance of or blindness to new methods, technologies, etc., and so the expert becomes once again Unconsciously Incompetent. This is why, for all of us, Professional Development needs to be both continuous and ongoing.

Mastery

So how much effort do you need to perfect your skill to the point where others regard you as an expert or master?

The answer, according to Malcolm Gladwell in his book Outliers, is around 10,000 hours of "appropriately guided practice". That works out to be 10 years at three hours per working day! Malcolm has his detractors but his book is worth a read, by the way. If mastery is your goal then perhaps you should review the adequacy of your typical 50 hours of CPD per annum!

Taking a post-graduate Certificate, Diploma or Masters course might help accelerate your progress, but these are not the only ways of learning.

Lifelong Learning Lifecycle

As we move through our careers we are likely to be at different levels of competence for our portfolio of skills. Looking at a simplified timeline, Figure 3, we should expect to move through the learning cycle multiple times.

In summary, my advice is to recognise where you are at in your career life-cycle, and reflect and recalibrate when you reach each level of expertise. Avoid the risk of regression – going backwards because you are not continuing to learn. Be aware of that moment when mastery of a skill etc. passes, perhaps through lack of practice, recognise that you are no longer up-to-date, and resolve to restart your learning cycle.

It is interesting to note that the 2014 IRSE Survey response indicated that many of experienced engineers were not maintaining CPD records. Is this an indicator of perhaps reaching a somewhat complacent state?

Is your job at risk?

The boiling frog syndrome is well known. The premise is that if a frog is put suddenly into boiling water, it will jump out, but if it is put in cold water which is then brought to a boil slowly, it will not perceive the danger and will be cooked to death. Ref. Figure 4 overleaf. This story is often used as a metaphor for the inability or unwillingness of people to be aware of or react to or threats that rise gradually. Most of us apparently believe we’re irreplaceable in our job!

As outlined previously I consider that there are emerging threats to some signalling roles from automation and AIS. There are considerable benefits to society if automation is used to remove people from hazards in rail corridors. Also tasks that lend themselves to automation, such as automated data preparation
and testing, lead to improved efficiency and reduced costs. This technical substitution is not so good if you are working in one of those roles, however! So it is important to be prepared for change to seize other job opportunities that arise.

For those of you who have been in the industry for some time and may be concerned about your future, the good news is that railways have a lot of inertia and are inherently slow to change. For newer entrants to the profession, you will be faced with increasingly frequent disruptions due to technology shifts during your career, which will bring fresh opportunities for you provided that you keep your wits about you to avoid your knowledge and experience becoming obsolete.

**Personal Attributes**

The IRSE has members practicing in many specialities across the signalling, communications, command and control spheres. A researcher, for instance, requires different skills to that of a maintainer. You may be a generalist (with wide experience) or a specialist, and indeed some persons are generalists who may have evolved from specialist practice.

I suggest that it is important to know your personal preferences and behavioural style, using a tool such as Belbin, Myers-Briggs, OPQ etc., as these can help you decide your best fit for a particular role.

So what is the future role of an IRSE member, remembering there is no such thing as a typical member - we are all different and are at different phases of our career life-cycle. I suggest that IRSE members have the necessary attributes and attitude to play an increasingly important part in the integration of rail systems. We have inherent advantages over our colleagues in civil, track, electrification etc. through understanding how the total railway system works. As I have indicated, the application of System Engineering techniques and methodologies will become of increasing importance.

For all of us, it will be increasingly important to break away from the signal engineer stereotype, and become autonomous self-managed professionals responsible for our own development and learning, always being mindful of the water temperature!

![Figure 4 – Boiling frog syndrome.](http://irse.info/4p0ou)

**References**

[9] [http://irse.info/4p0ou](http://irse.info/4p0ou)

My program for this year encompasses many of the themes from my address. There is more detail on the back cover of this issue of IRSE NEWS, and some dates for your diary. Highlights of the year will include:

- Our International Technical Convention, IRSECON17, hosted by the North American Section in Dallas, including presentations from eminent members of the IRSE International Technical Committee.
- The first ASPECT Conference to be held outside of London, in Singapore (including an extension for the Australasian Section Technical Meeting).

And Presidential Programme Technical Papers to be presented around the world in London (UK), Brisbane (Australia), Birmingham (UK), Utrecht (Netherlands) and York (UK).

I look forward to meeting you, and hearing your views.

Peter
‘Diversity’, ‘Inclusion’ and ‘Equality’ are frequently in the media, and are hot topics in many workplaces for numerous people. The future success of the railway signalling and telecommunications, train control, traffic management and allied sectors will depend in part on making more and better use of a diverse workforce to address complex challenges.

To ensure that IRSE demonstrates commitment to diversity, equality and inclusion, not only as a professional engineering institution, but also as a provider of services such as events and IRSE licensing, and as an employer, the IRSE Council have approved a Diversity, Equality and Inclusion Policy for all IRSE members, staff and volunteers.

The Policy says:

The IRSE is committed to a policy of equality and inclusion for all its members and stakeholders. We oppose all forms of unlawful and unfair discrimination and recognise the value of diversity in the workplace.

The IRSE provides services which embrace diversity and promote equality of opportunity. Our goal is to ensure that the Institution’s commitment, reinforced by its values, is embedded in its working practices with its staff, volunteers and other stakeholders. The IRSE believes that the principle of equal opportunities should govern every aspect of its work, and that all staff, applicants for jobs, volunteers, and members should be treated equitably and fairly.

It is our policy to:

i. increase awareness of diversity, equality and inclusion through member activity and through appropriate publications and media.

ii. reduce obstacles to equal opportunities and challenge/highlight discrimination if it occurs.

iii. support activities and initiatives that address the importance of diversity.

iv. share examples of good practice.

v. monitor and keep under review our policies and practices to ensure the promotion of equal opportunities.

This policy applies to IRSE members of all grades, employees, applicants for jobs, and other stakeholders. We also want to encourage you, as IRSE members, to follow a similar approach to equality, diversity and inclusion in your workplaces.

In making this Policy statement we recognise that, taking into account the IRSE’s wide geographical spread of members around the world, the application of this policy needs to be applied in a contextually and culturally sensitive manner.

The Hewlett-Fisher bursaries allow younger IRSE members from across the world to travel to major events such as our International Technical Convention or the ASPECT conferences. This is just one example of our commitment to equality, diversity and inclusion.

In the UK and in many other countries, it is against the law to discriminate against anyone because of age; disability; gender; marriage and civil partnership; pregnancy and maternity; race; religion or belief. In some countries and regions the legal definition may vary, and unlawful discrimination may include other classifications such as criminal record, citizenship status and social class/status.

Now the Policy is in place, the work begins to ensure that it is put into practice. The IRSE’s Strategy Implementation Plan contains actions that are relevant to diversity, and we will be talking with other professional bodies and organisations who can provide assistance, such as the UK Royal Academy of Engineering (RAEng) as well as working on measuring and improving our performance in the areas of diversity, equality and inclusion.

Actions need to cover all areas of IRSE’s activity, and the RAEng and UK Science Council have developed a framework help institutions assess their progress, identifying the following eight areas in which institutions work and for which the topics of diversity, equality and inclusion are relevant:

(1) governance and leadership.
(2) membership and registration.
(3) meetings, conferences and events.
(4) education, training, accreditation and examinations.
(5) prizes, awards and grants.
(6) communications, marketing, outreach and engagement.
(7) employment.
(8) monitoring and measuring.

More detail on these can be found at http://irse.info/4v8eb. IRSE is also a signatory to the Royal Academy of Engineering’s “Diversity Concordat”, and therefore pledges commitment to equality in the profession.

You will see more about diversity, equality and inclusion on the IRSE website (including our policy at http://irse.info/djkeh) and IRSE NEWS over the coming months. If you are interested in assisting us on this journey, whether you have ideas about good practice or you can spare time to work with us on some initiatives, please get in touch with me in the IRSE London office (judith.ward@irse.org).
Integration of traffic management and train automation for the main line railway

This article is based on a presentation made at the seminar “ATO - The Future of Main line Railway?” organised by the IRSE and the Institution of Mechanical Engineers (I MechE) at London on 16 February 2017, the article “A new rail optimisation model by integration of traffic management and train automation” published on Transportation Research Part C in 2016 (Rao et al., 2016) and the PhD dissertation “Holistic rail network operation by integration of train automation and traffic management” (Rao, 2015).

Motivation

Nowadays, more and more railway experts and engineers are making their own efforts to optimise railways whether it involves increasing capacity, saving energy and reducing costs. However, the experts from different fields have their own intention, method and evaluation on optimisation. We tried to analyse these differences systematically in order to build a more holistic optimisation method, with special focus on two specific areas: traffic management and train automation.

The current process of manual rail operation is based on a superimposition of two closed control loops (Lüthi et al., 2007), as shown in Figure 1. The outer control loop supervises the status of traffic and infrastructure, detects deviations and conflicts, develops a new schedule (rescheduling) and transmits it to train operation. This rescheduling mainly depends on the expertise of the dispatcher. The inner control loop is responsible for executing the production plan, which depends on the expertise of the driver.

Currently, the focus of railway optimisation is either on improving efficiency for the dispatcher by providing resolutions for traffic conflicts in the outer control loop or on improving driving performance for the driver by providing driver assistance or introducing train automation in the inner control loop.

Traffic management can predict and resolve traffic conflicts by using centralised train data in its controlled railway network, but it can neither avoid the inaccuracy of conflict detection due to incomplete train data and untimely data transmission, nor guarantee that each train will execute the conflict resolution as accurately as expected. Train automation has the most complete and updated train data to minimise the deviation between control targets and the supervised train states, but it depends on two supports. One is an additional onboard support to provide train’s over-speed protection and to keep a safe headway between trains, such as the Automatic Train Protection (ATP) system. The other is infrastructure support to provide dynamic traffic regulation to avoid traffic conflicts, such as the Automatic Train Supervision (ATS) system used in metro railways. Since the main line railway has much more complicated infrastructure situations, currently train automation is mainly applied to metro railways.

The optimisation strategies of traffic management and train automation are complementary. Therefore, for the main line railway, we propose to build up an integrated optimisation model to combine the strength of traffic management and train automation. An initial concept of this model is illustrated in Figure 2, which highlights bidirectional communication between traffic management and train automation.

Challenges

Building the integrated optimisation model is not as simple as just implementing traffic management and train automation in parallel, but it faces challenges in several aspects:

Integration

To integrate traffic management and train automation, it is necessary to detail their functions separately and to specify the exchanged information between the two. In addition, a demonstrator is required to prove the feasibility and its benefits.

Optimisation goals

There are multiple optimisation objectives to achieve, such as increasing capacity, reducing energy consumption and improving operational quality. The first challenge is to quantify each optimisation objective appropriately. The second challenge is to calculate the priority of each optimisation objective according to different optimisation demands. The third challenge is to balance these multiple, at times contradictory, objectives.

Interoperability: Automatic Train Operation (ATO) on main line railway

ATO is applied in almost every metro system. ATO is not just eye-catching technology to urban residents, but it is a necessity for efficient metro operation. Metro railways have a frequent stop-and-go operation mode. The introduction of ATO has reduced the burden of train drivers with repeated operation (train start, accelerating, cruising, coasting and braking) and it has helped to avoid manual errors.

Some metro stations are equipped with platform screen doors, which can be seen as one main challenge for train drivers but it is easier for ATO to achieve a precise train stopping. Compared to the main line railway, metro railways have a much simpler timetable design and infrastructure topology. In many cases each metro line is independent of other lines and the trains of metro lines are very homogeneous sets of vehicles. In most cases, there is little influence on the braking capabilities of trains by the weather and the danger of obstacles on the track is considered much lower than on an open line.

ATO has not been applied in the main line railway primarily for several reasons. First, there are two safety concerns. One is to detect obstacles on the track. Another is to detect passenger safety while exiting and entering trains. Most main line railways are open lines and their stations are not equipped with platform screen doors. Therefore, additional solutions are required for these two safety concerns. Second, the main line railway has a much more complicated situation than metro railway, because it...
has multiple undertakings and it varies in infrastructure topology, signalling system, locomotive types, timetable and many other aspects. Therefore, interoperability is important for introducing ATO to the main line railway.

Review and classification of railway optimisation schemes

Before introducing the new integrated optimisation model, we need to review and compare current railway optimisation schemes systematically. The comparison results will explain the necessity of combining traffic management and train automation for the main line railway.

**Optimisation schemes in traffic management**

Traffic Management System (TMS) comprises all functions necessary for enabling trains to run safely and efficiently on the railway infrastructure (Lochman, 2009). With the growing demand for transportation, more trains are expected to be in service. It is a challenge for the main line railway to increase rail capacity and improve service quality at the same time. A more functional TMS is required to reduce the impact of traffic conflicts by applying different real-time automatic solutions.

To take this challenge, two optimisation schemes are implemented. The first is Decision Support System (DSS), which is prevalent today and shown in Figure 3. DSS is used to reschedule the traffic when the current timetable is detected with a conflict. The solution is to find a new conflict-free schedule by train reordering, re-routing or re-timing.
The second is Driver Advisory System - Central (DAS-C), as shown in Figure 4, which is another solution to reduce the impact of traffic conflicts by generating train speed advice for the driver. DAS-C computes the optimal train running trajectory to avoid the predicted unplanned train stops. Based on the trajectory, a series of train speed advice is generated and sent to the train. The speed advice can inform the driver to reduce train speed in anticipation of the conflict detected ahead, and to increase train speed in anticipation of the conflict resolved. Therefore, the driver’s knowledge of traffic conflict is extended to avoid predicted unplanned train stops by optimising train speed.

It is noted that the unplanned train stops can be discovered earlier than train delays at destinations or route conflicts between trains within block sections. This provides possibilities to resolve potential traffic conflicts by optimising train speed without changing the current schedule.

So far, DAS-C has often been seen as supplementary to DSS but not a substitute for it. A practical example of DAS-C is the commercial product Automatic Function (AF) applied in the Lötschberg Base Tunnel in Switzerland. This application increases capacity and saves energy costs (Mehta et al., 2010). To our knowledge, this is the first practical application of DAS-C in a mixed-traffic main line railway.

Optimisation schemes in train automation

Train automation is applied to reduce the loss of capacity due to manual train operation. The basic functions of train automation include automatic train speed control (accelerating, braking, cruising and coasting), precise train parking and door control.

The International Association of Public Transport (UITP) defines the Grades of Automation (GoA) depending on the distribution of responsibilities between the staff and the train automation system itself. However, it seems that those definitions tend to fit better for metro railway, but less so for main line railway, where train drivers can be supported by Driver Advisory System (DAS). DAS is actually an automation level between GoA 1 and GoA 2. It provides drivers with additional driving advice to keep the train at the optimum speed. Therefore, an updated GoA table is proposed in Table 1.

Apart from the DAS-C scheme in traffic management, Driver Advisory System - On-board (DAS-O) is a similar scheme but installed onboard. ATO is another optimisation scheme onboard including GoA 2, GoA 3 and GoA 4, which controls train speed automatically.

DAS-O, as illustrated in Figure 5, is an alternative approach to generate train speed advice for the driver. DAS-O which is installed on the train concentrates on improving train driving behaviour rather than resolving traffic conflicts. DAS-O has a predefined train speed profile, which is a standard driving guidance for riding accuracy, riding comfort, energy saving and other onboard optimisation goals. DAS-O can generate a series of speed advice to minimise the deviation between the predefined train speed profile and the observed train states (train position, speed and time).

<table>
<thead>
<tr>
<th>Grade of Automation</th>
<th>Type of train operation</th>
<th>Train speed control</th>
<th>Train stopping</th>
<th>Train door control</th>
<th>Operation in event of disruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>GoA 0</td>
<td>On-sight by driver</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>GoA 1</td>
<td>ATP with driver</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>GoA 1.5</td>
<td>DAS</td>
<td>Driver with advice</td>
<td>Driver with advice</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>GoA 2</td>
<td>STO</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>GoA 3</td>
<td>DTO</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Train attendant</td>
<td>Train attendant</td>
</tr>
<tr>
<td>GoA 4</td>
<td>UTO</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
</tbody>
</table>

Table 1 – Grades of Automation (upgraded).
DAS-O is often used as a complement to the driver training system for practising and improving driving skills. Currently, most existing DAS belong to DAS-O with the focus on energy-efficient driving, such as Computer Aided Train Operation (CATO) system in Sweden (Yang et al., 2013), InLineFAS in Germany (Albrecht and Dasigi, 2014) and GreenSpeed in Denmark (Bergendorff et al., 2012). In short, DAS-O can be seen as an interim step to achieve ATO.

ATO, as illustrated in Figure 6, generates a series of train control commands to adjust train speed directly, rather than the speed advice for the driver. The train control command can decide how much train force (tractive and braking force) is inserted. Moreover, ATO has to resolve the Multi-objective Optimisation Problems (MOPs) with two or more (often conflicting) objectives. This can be achieved with various intelligent control algorithms, such as fuzzy logic control, expert control, predictive control, neural network control, genetic algorithm, differential evolutionary algorithm and integrated intelligent control methods (Rao et al., 2012).

**Comparison of optimisation schemes**

In order to better distinguish these schemes, Table 2 overleaf compares their features in several aspects.

DSS and DAS-C are installed in the traffic management centre so that they can prevent traffic conflict by analysing the traffic network data. However, DSS and DAS-C offer no improvement for onboard functionality as the dynamic calculations for all trains are carried out in the traffic management centre. When the conflict case grows to a certain extent, there will be a concern about whether traffic management centre can handle such a heavy computing workload. Additionally, the computation of DSS and DAS-C is based on the transmitted data in the outer control loop. In this regard, another concern is about whether the transmitted data is complete, accurate and updated in real-time. Therefore, the lack of advanced onboard functionality and the quality of transmitted data are seen to be the main obstacles for the further development of traffic management.

DAS-O and ATO are installed in each train with enhanced onboard functionality. Each train carries on with its own dynamic calculation. The train states are measured and transmitted in real-time in the inner control loop. Therefore, the increased onboard computing power and the improved quality of data transmission are seen as the advantages of DAS-O and ATO. However, DAS-O and ATO cannot avoid unplanned train stops because they need external support for traffic conflict prediction.

The comparison result shows that the optimisation schemes applied in traffic management (DSS and DAS-C) and train automation (DAS-O and ATO) are complementary. Therefore, we propose to integrate their optimisation advantages into a new optimisation model. This model is expected to have bidirectional communication between traffic management and train automation. Trains can avoid potential traffic conflicts by reacting to the proposals from traffic management, while traffic management can improve its calculation according to the real-time feedback from train automation.
Table 2 – Comparison of railway optimisation schemes.

The proposed integrated optimisation model

Overview

Based on the review of different optimisation schemes, the new integrated optimisation model combines four optimisation schemes (DSS, DAS-C, DAS-O and ATO) into one, as shown in Figure 7.

DSS is mainly applied in ‘condensation’ zones (i.e. with high traffic density) to deal with major disruptions, while DAS-C is mostly applied in ‘compensation’ zones (i.e. with low traffic density) to prevent potential traffic conflicts at an earlier phase. In compensation zones, the choice of appropriate train speed profiles is the most important degree of freedom to be exploited (Caimi, 2014). Therefore, the focus of DAS-C is to explore the flexibility in generating different train running trajectories to prevent potential traffic conflicts. Based on the trajectory, a series of control-target points (position, time and speed) can be generated as discrete information sent to the train in real-time, rather than sending a complete train running trajectory or sending only train speed advice (Rao, 2016).

The choice of DAS-O or ATO depends on the practical requirements of GoA. The core function, optimised train speed control, is the same for both DAS-O and ATO. The deviation between the received control-target points and the observed train states is calculated onboard. According to the deviation, DAS-O can generate corresponding advice for the driver (either train speed advice or additional train control command advice), while ATO can implement train control commands directly to adjust train speed automatically.

Highlights

The proposed integrated optimisation model has two important highlights. The first is the decision-making procedure to decide the most attractive output from the set of optimal trajectories and the set of train control commands (Rao, 2015). The second is the bidirectional communication between traffic management and train automation, as illustrated in Figure 8. The function of traffic management delivers the control targets to train automation, while the function of train automation provides real-time feedback of train dynamics information to traffic management. The importance of this bidirectional communication was discovered during a case study. The details can be found in Rao (2015) and Rao (2016).

Conclusions

For the current main line railway, there are two focuses for traffic optimisation. The first is to improve the efficiency of traffic management by providing conflict resolutions, while the second is to improve train driving behaviour by providing driver assistance or introducing train automation. This paper reviewed and classified these two focuses into different optimisation schemes. Based on this classification, this paper proposed combining the optimisation methods of traffic management and train automation into an integrated optimisation model.

Insight into the future railway optimisation

Figure 9 gives an insight into the future optimisation. It describes the development of railway optimisation from the current situation to the visions of future railway optimisation.

Today’s railways are improving the efficiency of traffic management and train operation separately. The two will work collaboratively in the very near future, because there will be more and more demands for such collaboration. For instance, conventional rail lines will be updated with new systems, which will ask for optimisation of train behaviour based on the enhanced onboard computing power. The high-speed lines will no longer be dedicated lines but mixed with conventional lines, therefore, the traffic conflicts are foreseen to be increased and the traffic management will be highly required. Moreover, the strict limits between metros and main line railways tend to disappear, which will require an integration of train automation and traffic management.
Figure 7 – The integrated optimisation model combining optimisation schemes of DSS, DAS-C, DAS-O and ATO.

Figure 8 – The highlights in the integrated optimisation model: the decision-making procedure and the bidirectional communication between traffic management and train automation.

Figure 9 – Insight into the development of railway optimisation.
Since it is almost certain that the integration of train automation and traffic management will happen in the future railway optimisation, the arising interest would be how to fully utilise the bidirectional communication channel between train and traffic management in order to reduce the cost for optimisation. Moreover, it is expected that more and more Information Technology (IT) will be introduced into railway systems to support various optimisation algorithms in the near future.

References and recommended reading


INDUSTRY NEWS

In order to bring IRSE NEWS readers the latest global signalling, telecomms and train control information, we have teamed up with the Railway Gazette International (www.railwaygazette.com) to supply brief summaries of major news in our industry. We will of course also publish items of news from other sources when we receive them.

Pesa and Bombardier sign ERTMS framework

[RGI] POLAND: Bombardier Transportation has signed a five-year framework agreement to supply rolling stock manufacturer Pesa Bydgoszcz with its EBICab 2000 automatic train protection equipment for installation on new vehicles for the Polish market. The equipment will be delivered from Bombardier’s Katowice site.

In 2015 Bombardier became the first supplier to obtain Polish certification for both lineside and onboard ERTMS equipment. It currently has four ERTMS projects completed or underway in the country.

“As the first approved ERTMS onboard safety system supplier in Poland, we look forward to delivering our integrated technology which will improve services for passengers”, said Sławomir Nałęwajka, Bombardier’s Head of Rail Control Solutions, Poland, on 2 March.

Frauscher joins Alstom Alliance

FRANCE/AUSTRIA: Frauscher and Alstom deepen their relationship in a long-term leading supplier agreement. Frauscher has joined the Alstom Alliance, the strategic partnership program of Alstom. The charter was signed by Olivier Baril, CFO Alstom, and Michael Thiel, CEO Frauscher Sensor Technology. Alstom Alliance acknowledges around 30 companies who work closely with Alstom in terms of business development, industrial excellence as well as products and innovations.

“It is a key objective of Alstom to fulfill customer’s expectations of quality, excellence, innovation and costs. Therefore we are sure that it is more important than ever today to attract and develop jointly rewarding, long-term partnerships with suppliers who have proven ability in the increasingly competitive global railway market. Companies who are known to deliver the highest quality, most innovative and cost-efficient products to market in a reliable, ethical and timely fashion are acknowledged and supported through Alstom Alliance. Frauscher fits perfectly with these requirements and we are looking forward to a close cooperation”, said Olivier Baril.
On 16 February, the IRSE and the Institution of Mechanical Engineers (IMechE) jointly hosted a seminar in London on the topic of automatic train operation (ATO) for mainline railways. The event was generously sponsored by Siemens Rail Automation, and attended by almost 120 delegates.

Keynote Session
The seminar opened by Andrew Simmons who introduced Wouter Malfait of the European Union Agency for Railways (ERA) to speak on Automatic train operation in a European context. He described the ERA vision that the business drivers for evolution of the railways in a European context are capacity increase and cost reduction, and the game changing technologies to achieve these goals must include ERTMS/ETCS level 3 and automatic train operation. The ERA is strongly supporting the development of standards for ATO which will include a ‘plug and play’ interface between ATO and onboard ETCS equipment so that a rolling stock owner is not constrained to purchase both components from the same supplier.

The following speaker in the keynote session was Andrew Simmons himself, presenting ATO in a Great British context, on behalf of David Waboso (Managing Director of Group Digital Railway, Network Rail). Passenger miles on the UK mainline railway have doubled since 1995, and another doubling in the next 25 years is predicted. Other transport sectors have demonstrated capacity enhancements through technologies such as Smart Motorways and Digital Air Traffic Control, and recent London Underground upgrades to trains and signalling have delivered up to 40% more capacity. To achieve similar benefits on a complex mainline railway several digital components will be required – ERTMS/ETCS level 3 can allow trains to run closer together, and Traffic Management can dynamically replan the schedule to react to incidents, but without Automatic Train Operation to drive all the trains in a uniform and predictable manner in response to the plan, the full benefits will not be realised.

Setting the Scene for ATO
The second session was introduced by Aidan McGrady (Network Rail). The first speaker was Dr Xialou Rao (Systransis, Switzerland) who presented her paper Holistic rail network operation by integration of Train Automation and Traffic Management describing how ATO and Traffic Management need to be integrated to deliver the best results. You can read this paper in full elsewhere in this issue of IRSE News.

The next speaker was David Dimmer (Thales Transportation Solutions) on The Next Generation Train Control Project (NGTC) – common ATO for urban and mainline. He reminded the audience of the successful introduction of ATO on metros, where moving block signalling and unattended train operation are now the norm. The NGTC project was a European Union (EU) funded research project that set out to analyse the commonalities and differences between state of the art metro systems and ERTMS/ETCS mainline signalling to identify common and differing requirements. The outcome of the project was an agreement on system architectures for urban and mainline systems, sharing many common elements. The project provides many useful pointers on how ATO experience in metro applications can be applied to the mainline sector.

Benoit Bienfais (Alstom Transport) spoke next on ATO/ DAS over ETCS: the way towards unattended operation on main lines. He reminded the audience of the ‘Grade of Automation’ categories that had originally been defined in the IEEE standards for urban systems, but are equally applicable to mainline ATO, and proposed an additional category GoA1+, which would be a driver advisory system (DAS) over ETCS, i.e. optimised manual driving. He went on to describe the system architecture for ATO over ETCS and outlined plans for test bench and pilot line demonstrations as part of the EU funded Shift2Rail project. The plan is for an early demonstration of GoA2 level automation (ATO with driver), with a further demonstration of GoA4 (unattended operation) towards the end of the project.

Case Studies
The third session was introduced by James Collinson (Network Certification Body), and began with Jonathan Hayes (Network Rail) describing ATO over ETCS on Thameslink. He described the background to the capacity upgrade of the cross-London railway to support a 24 trains/hour service on the core section through central London. To allow a margin for recovery from perturbations, an operational headway of 120 seconds is needed and this can only be achieved by very consistent driving. He went on to describe the system architecture for ATO over ETCS, and how to upgrade trainsets for ATO and DAS. He then went on to discuss the on-going work with Siemens Rail Automation to develop ATO preexistence on-board ETCS systems, with a particular focus on the GoA4 (unattended) system.

The procurement approach was for the train supplier to specify the ATO system – the constraints being that it must be compatible with the ETCS trackside installation and communicate using packet 44 application specific messages within the standard ETCS track-train communication protocol. The system integration task was slightly simplified when the train and trackside signalling contracts were independently awarded to Siemens, by the UK government and Network Rail respectively. System testing commenced in June 2013, and makes extensive use of a dedicated system integration laboratory and Network Rail’s ERTMS National Integration
Facility (ENIF) test track to reduce the amount of testing on the heavily utilised Thameslink core. The first run with ATO through central London took place in October 2016, and the programme is on track to go into service from December 2017.

The next speaker was Dr Mirslav Obrenovic (DB Cargo) on Innovation strategy at DB Cargo: Automation and digitisation in European rail freight business. He described how the railway freight business was threatened by the rapid development of driverless road freight transport, and needed to exploit digital technologies for planning, dispatching, fleet control and maintenance. In the long term driverless operation of freight trains should be the goal (GoA4), but by 2019 the aim is have an ‘autopilot’ to drive the train under supervision of a human driver. The first step towards this will be further automation of shunting locomotives in marshalling yards.

The presentation included an video of a freight locomotive on a test track, demonstrating sensor technologies to detect obstacles on the track and for coupling up to freight wagons.

Ray Clifton (Siemens Rail Automation) spoke on Evolution of the Siemens product line: Metro, Passenger, Freight, giving a supplier’s view of the emerging market for ATO on mainline railways. He compared the system that Siemens is supplying for the Thameslink project with the proposed European standard in Shift2Rail. The main differences are that Shift2Rail is proposing a separate track to train communications channel (not ETCS packet 44) and standardised form fit and function interfaces (FFFIS) between ETCS and ATO onboard. In future ATO on mainline railways need not be limited to high density routes, as high speed lines, low density regional routes and freight can all benefit. Dedicated mining railways are already moving to GoA4 unattended operation. In fact the additional functions to go from GoA2 to GoA4 are nothing to do with ATO – they are more about communication with passengers, door operation etc.

The final speaker in the case study session was Graham Neil (London Underground) on Metro Case Study: London Underground ATO experience. He described how London Underground was a pioneer of ATO with the Victoria line in 1969, and there were now 4 lines operating at GoA2. Two different system architectures are employed, with fixed block signalling and onboard intelligence on the Central and Victoria lines, and a moving block system with most of the intelligence trackside on the Jubilee and Northern lines. The extension of ATO operation to lines that run on the surface for some of their length has revealed the need to be aware of low adhesion conditions, and where necessary to reduce the acceleration and braking rates demanded by the ATO system to avoid having to revert to manual train driving in some circumstances. This is particularly critical for moving block systems where train location relies on accurate odometry. Careful consideration also needs to be given to the action to be taken when a passenger or platform emergency alarm is operated. LUL’s philosophy is that if a train is entirely in tunnel it is safest to continue to the next station, but what is the best response if a departing train is still partly in the platform?

Gives and Gets: the Rolling Stock

The final session illustrated the benefit of the seminar being organised jointly with the IMechE, as it focused on the implications of ATO for rolling stock owners and suppliers. The first speaker was Euan Smith (Angel Trains) on Rolling Stock: the ROSCO perspective. Angel Trains is one of the UK based rolling stock companies (ROSOCs) that finances the construction of new trains and then leases them to train operating companies. As UK train operator franchises are typically shorter than the life of the rolling stock, a significant part of the business is the life extension, refurbishment and enhancement of existing trains so that they can be re-leased to a new operator.

A significant risk for the ROSCO arises if trains have to be fitted with expensive equipment to meet the needs of the train operator that leases them from new, and this equipment has to be subsequently upgraded or replaced when the train moves to a new operator later in its life. ATO is an example - the train fleets under construction for Crossrail and Thameslink have unique ATO solutions which will be tied to those routes for the life of the train. If ATO is to become more widespread on the network standardised track to train interfaces, and an easy upgrade path to upgrade existing trains to ATO will be needed.

The second speaker in this session was Jack Ratcliffe (Bombardier Transportation) on Maximising train performance within an ATO system, who described the implications of ATO for a rolling stock supplier. As well as the obvious electrical interfaces with the train’s traction and braking interfaces, there are mechanical interfaces with the ATO/ATP speed measurement and position reference devices which often have very prescriptive installation accuracy requirements that need to take into account the range of vehicle suspension movements. The consistency of train performance is also critical. This is especially so with regard to braking where ATO needs consistent performance irrespective of how the train braking system is blending electrical regenerative/rheostatic and mechanical friction braking across the full range of speeds and adhesion conditions.

The final speaker was Richard Feasby (Network Certification Body) on Authorising the ATO system. He described how the legal and regulatory requirements for placing railway systems into service applied to trains and infrastructure fitted with ATO systems. For current projects the emphasis is mainly on demonstration of safety by means of the Common Safety Method, but when standards for ATO systems interoperability are established there will be a need to undertake independent assessment of compliance with these by a Notified Body. To make this an efficient process, it will be important that the specifications are written with verification and validation in mind. The assessment bodies will also need to develop their competence and skills to undertake these activities.

Discussion Session

The seminar ended with a discussion session with a panel of several of the session chairs and speakers, led by IRSE Chief Executive Francis How. The discussion ranged widely over the factors that determine capacity of a railway, including rolling stock seating and door layouts, and passenger flow onto and along platforms. Human factors issues were raised, including how to ensure drivers remain vigilant when a train is running under ATO, and what should be done to maintain competence in manual driving.

Overall it was a very successful seminar, with an interesting mix of speakers and attendees. The IRSE and IMechE organisers are to be congratulated, and hopefully this can be the model for more joint activities in the future.
The future of train tracking is all about providing valuable information to operators by detecting and tracking trains and events. The conference will focus on state-of-the-art solutions based on wheel detection, axle counting and Distributed Acoustic Sensing (DAS), as well as further tracking technologies.

THE FUTURE OF TRAIN TRACKING

4–6 October 2017
Austria Trend Hotel Park Royal Palace Vienna

The future of train tracking is all about providing valuable information to operators by detecting and tracking trains and events. The conference will focus on state-of-the-art solutions based on wheel detection, axle counting and Distributed Acoustic Sensing (DAS), as well as further tracking technologies.

DAY 1
Wednesday 4 OCT
GET TOGETHER
Keynote speeches and networking evening

DAY 2
Thursday 5 OCT
TECHNICAL DAY
Presentations regarding future challenges, latest research results and best practices followed by a dinner

DAY 3
Friday 6 OCT
TECHNICAL DAY
Additional panels with presentations followed by a networking lunch

Current programme available online at: www.wheeldetectionforum.com
ETCS LEVEL 3

Validation of hybrid ETCS Level 3
Dr Ir Bob Janssen
Siemens, The Netherlands

Introduction
In the March IRSE Presidential Paper, Nicola Furness, Henri van Houten, Laura Arenas and Maarten Bartholomeus described the architecture and benefits of Hybrid Level 3. This article builds on their work and describes the way in which Siemens validated the theory behind Hybrid Level 3 in a lab environment.

We briefly describe the ideas that lead to Hybrid Level 3 and then outline the advantages with respect to the other ETCS Levels. Next the paper outlines how the theory was rigorously reviewed and tested. Finally, we sketch how one can migrate a Level 2 line to Hybrid Level 3.

The three levels of ERTMS
ERTMS is an example of open European Union (EU) specification that allows suppliers to serve a huge rail market and allows infrastructure managers to buy standard equipment from competing suppliers. It’s no coincidence that ERTMS is a worldwide hit, just like GSM in the 1990’s.

ETCS, the train control part of ERTMS, distinguishes three levels of train control. In short, intermittent track-to-train communication characterises Level 1 whilst Level 2 introduces continuous bidirectional communication between track and train. Level 3 enables the discard of Trackside Train Detection (TTD) relying instead on trains reporting vital information allowing the Radio Block Centre (RBC) to determine vital front- and rear train position. Thus, the RBC can apply the moving block principle and allocate movement authorities to safely separate trains.

Signalling engineers want to get as many trains on the track with a minimum number of signals, cables and TTD devices. Whereas ETCS Level 1 and Level 2 can do without lineside signals, they still rely on TTD. Level 3 can remove the need for trackside train detection. As such, Level 3 promises maximum capacity at lowest cost. Yet, the question arises whether fully discarding TTD is a good idea.

Degraded scenarios and Hybrid Level 3
This section describes the reasons behind the distinctive features of Hybrid Level 3 which is to combine Virtual Subsections with (sparse) TTD.

Handling failure scenarios becomes excessively complex without some form of TTD. The worst imaginable scenario is prolonged loss of radio communication so the trackside loses sight of the whereabouts and integrity status of trains. After such a failure, one typically sends a train on a ‘sweep-run’ at low speed to reset the vacancy status of the track. TTD supports this process by excluding the presence of unknown trains so one can more quickly resume normal operation.

On the other extremity of the degraded spectrum, an individual train may (transiently) fail to confirm its integrity so the rear-position cannot be ascertained (Figure 1). One may have to assume that this train lost a wagon that subsequently started rolling backwards. The safe solution is to declare track in rear of the train occupied. TTD would detect the wagon and limit the backward propagation of this safety region.

The degraded scenarios have in common that trackside cannot safely ascertain which train occupies which piece of track. It is easy to see that TTD helps localising trains, albeit coarsely, and reduces the impact of degraded scenarios.

Also, discarding blocks from signalling is a big step conceptually, operationally and computationally. Railway personnel will welcome the fact that Hybrid Level 3 mostly retains familiar block signalling principles.

The essence of Hybrid Level 3 resides in retrieving the occupancy status of Virtual Subsections (VSS) by merging train-reported positions with TTD readings. The state machine that governs this algorithm is substantially simplified by splitting TTD sections into discrete VSS. This is a tried and tested approach in CBTC systems.

Technically, introducing shorter VSS has minimal impact on the functions of a conventional ETCS Level 2 RBC. This is because an abstraction layer hides from the RBC and interlocking whether a section is virtual or real (Figure 2). Both Interlocking and RBC are unaware of the technology used to establish section occupation.

Figure 1 – Virtual Subsections and train integrity.
The RBC doesn’t care whether occupancy status was established by track circuits, axle counters, or based on train position reports only.

Hybrid Level 3 is a technically and operational compromise because it allows us to apply tried and trusted algorithms. Hybrid Level 3 bridges the gap between traditional fixed blocks and moving block.

Why do we want Level 3?
Lower headway for high capacity lines

ETCS Level 2 and Level 3 by design improve capacity. Trains receive movement authority (MA) telegrams with detailed information about track ahead that allow them to safely travel within the given speed profile.

ETCS Level 1 is a spot transmission system implying that trains receive intermittent updates to their MA. This is a drawback for dense and heavily used networks. Thus, a driver may see a signal open but his MA forces him to approach slowly until he reaches a balise that extends his MA beyond the signal. This is likely to frustrate drivers and operations on densely used networks. ETCS Level 2 removes this drawback by maintaining continuous communication with the train. Thus, when a signal ahead opens, the driver quickly receives an update to his MA. Yet, ETCS Level 2 still relies on blocks that must be vacated before the next train is granted entry. Longer blocks are detrimental to capacity because of the simple fact they take longer to clear. The obvious solution is to shorten TTD blocks but this can be prohibitively expensive.

How does Level 3 compare to Hybrid Level 3?
Moving block, the distinctive property of ETCS Level 3, can be regarded as a block signalling system with infinitesimally short blocks. But apart from being a computational challenge, an infinitesimal block barely contributes to capacity (Wendler & Limmer, 2007). ProRail (the Dutch infrastructure organisation) found that virtual blocks of approximately 250 m are good enough for the major part of its congested network.

The Hybrid Level 3 approach splits TTD sections into VSS which is a matter of configuration. When more capacity is needed on an existing network one can shorten the Virtual Subsections without any cabling works. As pointed out before, TTD is still useful if tracks can’t unequivocally determine train position, for whatever reason.

Less cabling costs can save regional lines

Track circuits or axle counters require cabling that is expensive to build, maintain and are vulnerable to failure and theft. Cabling costs can tip the balance towards closure of low-frequency lines. The business case for removing trackside train detection, another feature of Level 3, seems obvious. This doesn’t contradict our argument that Hybrid Level 3 shouldn’t fully remove TTD, the TTD layout can be made sparse. TTD sections can be stretched, e.g. to one single TTD section between two yards. One could install axle counter heads at yard exits towards open line and at selected positions such as level crossings. A sparse TTD layout is far cheaper to maintain than a dense network of track circuits. The possibility of back-up operation that a sparse TTD network offers largely outweighs the costs and reduces risk of long outages. It is unwise to fully discard train detection because otherwise a single failed train radio would knock out operation of the line.

The promise and compromise of VSS

Virtual Subsections allow us to optimise block lengths which promises improved headway. The RBC can ascertain the rear end position of trains that have a Train Integrity Monitor (TIM).
We assume at this stage that the train length is also safely determined. Thus, trackside can allocate trains that carry a TIM to one or more virtual sections. The RBC can’t safely ascertain the rear position of trains without TIM. This often applies to freight trains that are ad-hoc arrangements of many heterogeneous cars. Figure 1 shows what happens to Movement Authorities when there’s a mix of ETCS trains that report and don’t report integrity.

The figure shows how a TTD divides into multiple VSS. As opposed to conventional signalling systems in normal operation, more than one train can occupy a single TTD section.

A train that fails to report integrity, i.e. the red freight train in the figure, can still use the line but the trackside system will allow the next train to enter the TTD section only when this non-integrity reporting train leaves the section. This is because only the TTD can safely determine that the freight train has cleared. This compromise allows the continued use of the line by trains equipped for ETCS Level 2 but without TIM. One takes for granted the fact that passage of such a train hinders following trains. This also indicates that a line frequented by many non-integrity reporting trains would benefit from shorter TTD sections. Inversely, lines that mainly carry integrity-reporting trains can cope with very long TTD sections.

The above paragraphs suggest that trackside train detection won’t disappear overnight, firstly to act as a backup for degraded situations and secondly to allow use of the line by non-integrity reporting trains. However, the signalling system relies less and less on TTD as an increasing number of trains report their position together with integrity status and train length.

The system architecture

Firstly, we enhance the trackside system with a ‘virtual block detector’ (VBD) (Figure 2).

Figure 2 shows the Information flow when using Virtual Subsections. The Virtual Block Detector is the only new software.

Note that the Interlocking merely relays Trackside Train Detection occupancy status to the Virtual Block Detector (VBD). The interlocking does not use TTD information for route setting and releasing.

The VBD receives train messages via EuroRadio. The VBD knows the position of the train’s front and rear so it can determine which VSS the train occupies. The rules for synthesizing VSS occupancy status from TTD status and train position reports are laid down in the state machine that was tested.

Now, the interlocking receives information about VSS track occupancy that it uses for route setting. The changes to the interlocking are that it now relays TTD information to the VBD and in exchange receives synthesized VSS occupancy status. The interlocking is unaware of the technology that is used to acquire VSS occupancy status. In IT-terms, the VBD acts as an abstraction layer that hides the underlying nature of train detection from the interlocking.

The VBD state machine

The role of the Virtual Block Detector is to determine occupancy status of the VSS according to:

1. Train position reports.
2. Train integrity reports.
3. TTD occupancy status.

For this purpose, the VBD implements a state machine that is at the very heart of the implementation of Hybrid Level 3 with VSS.

Running integrity-reporting trains in Level 3 is fairly straightforward if all works well. However, it is a well-kept secret that signalling engineers spend most of their time analysing cases where things go wrong. We need to answer what-if questions like “what happens if a train radio fails?” or “what happens if a fast moving train briefly loses radio contact such that the VBD never notices its presence in a VSS?”.

The state machine had to be tested against possible degraded situations. By running tests in the UK of a state machine implementing principles that were written in the Netherlands against test cases written in Germany added confidence that the documentation is robust, unequivocal, complete and portable.

Principles design and review

ProRail initiated the design of Level 3 with VSS. Siemens then submitted an unsolicited proposal to validate these principles against a number of test cases in a lab environment. A team of signalling experts in Braunschweig designed a series of test runs for a hypothetical track. These test runs where then executed on a test rig in Chippenham. This ‘many eyes’ approach created a truly European test environment which met our objective that the principles be general, i.e. apply everywhere.

The authors of the test cases had to critically analyse the principles paper (ProRail, 2015) which lead to a number of amendments. This analysis sharpened the quality of the principles document and removed ambiguities that might otherwise have led to variations in implementations.

Lab test

The test rig in Chippenham was based on a Westrace interlocking combined with a Futur RBC (Figure 3). The software was expanded to include the VBD and the state machine that implements the Level 3 principles.

The test rig runs on PC-based host that emulates the control, train and trackside environment. The architecture reproduces the blocks shown in Figure 2 as faithfully as possible. The interlocking, RBC but in particular the VBD are considered the subsystem under test.

Tests were designed to validate the L3 concept focussing on VSS state transitions as well as a set of typical operational scenarios. Performance, in terms of headway or capacity was not investigated. Nor was the control interface a subject though some valuable observations were made. For instance, a train that stops reporting integrity can be seen ‘to stretch’ as the VSS in rear of the train retain the occupied status. Such observations are helpful when assessing strategies for displaying the track occupancy state on the control interface.

The team in Chippenham translated the test cases into scripts that alter the state of the track and simulate the behaviour of trains.

A grand total of 83 tests were run. Figure 4 shows a screenshot of a test run. No blocking errors were found but some recommendations for improvement were made e.g. train integrity status should also be represented in a state machine. Furthermore, the definitions were improved as a result of the rigorous interpretation by the test script developer. For instance, the term “train disconnects” seems unambiguous at first glance but was improved to “End-of-Mission or the detection of loss of communications after the mute timer expires”. This kind of improvement as a result of an actual implementation reduces room for interpretation that typically haunts specification ‘from the ivory tower’.

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Figure 3 – Overview of test rig system architecture.

Figure 4 – A screenshot of the simulator during a test run. The state of VSS and trains are constantly visualised.
ETCS LEVEL 3

Migration in the field

This section explains how we can stepwise migrate ETCS Level 2 to Hybrid Level 3. Signalling engineers know that upgrading existing signalling systems is painful. It impacts the traffic management, asset configuration and operational procedures. The use of proven technology relieves much of this pain. This reasoning motivated the very idea behind Hybrid Level 3 and a carefully prepared ETCS Level 2 system can be upgraded to Hybrid Level 3 without any trackside works.

Figure 5 sketches the suggested steps from legacy light signalling via ETCS Level 2 to a fully-fledged Hybrid Level 3.

1. Legacy signalling system with track circuits and light signals

2. Migration to Level 2 where SMB signs replace signals.

3. Migration to Level 3 where TTD sections are split into VSS.

4. One single axle counter section operates in parallel to the track circuits

5. The track circuits are removed

In step 4, we install axle counters on the line that may initially prove themselves in shadow-mode. Note that track circuits are often limited in length but axle counter based TTD sections may be many kilometres long. Once proven, the Virtual Block Detector (VBD) combines the axle counter readings plus the train position reports to determine the occupancy status of the individual VSS.

Finally in step 5, we disable the track circuits in favour of a sparse axle counter layout. This is when one reaps the second benefit of Hybrid Level 3, i.e. reducing the number of TTD devices.

Conclusion

Hybrid Level 3 with VSS has been shown to work. The specification has been made complete and unambiguous by the robust ‘distributed pan-European’ testing procedure. This approach contributed towards stability.

A Level 2 system can be stepwise upgraded to Hybrid Level 3 at minimal risk.

Next steps

Lab tests by nature lack some real life factors of uncertainty. Because behaviour of humans and, to a lesser extent, technology is quite unpredictable, one must take the system out to the real world and equip a test line. This will widen the perimeter of the system under test to include factors of uncertainty ranging from trains, drivers, signal men up to the adverse weather conditions. Finally, such field tests will increase our confidence in how to migrate to Hybrid Level 3.
Annual General Meeting
The IRSE’s Annual General Meeting was held on Friday 21 April 2017 at the IET, Savoy Place, London, following which our President for 2017-18, Peter Symons, delivered his Presidential Address (which you can read elsewhere in this edition of IRSE NEWS).

There will be a report on the AGM and the Annual Dinner that followed in next month’s IRSE NEWS, but in the meantime our congratulations to those who won, and were presented with, IRSE Awards at the AGM:

- **Duncan Robb** of SNC-Lavalin, UK, who won the Thorrowgood Scholarship for his exceptional performance across four modules in the 2016 Examination.
- **Luke Reger** of Alstom, UK, who won the IRSE-Signet Award for the highest marks in any single module in the 2016 Examination.
- **Ron Skillett** of London Underground for winning the annual Dell Award.
- **Andy Knight** of Signet Solutions Ltd was presented with a Merit Award for the support he and Signet have provided over many years to candidates preparing for the IRSE Exam.

Council members for 2017-18
The result of the ballot for the election of IRSE Council members for 2017-18 was announced at the AGM on 21 April. The Council now comprises:

- **President:** Peter Symons
- **Vice-Presidents:** Markus Montigel, Gary Simpson
- **Members of Council from the class of Fellow:** Peter Allan (UK); Steve Boshier (Australia); Ian Bridges (UK); George Clark (UK); Yuji Hirao (Japan); Andy Knight (UK); Jane Power (UK); Alan Rumsey (Canada); Daniel Woodland (UK); Philip Wong (Hong Kong).
- **Members of Council from the class of Member:** Rob Burkhardt (USA); Martin Fenner (UK); Ryan Gould (South Africa); Lynsey Hunter (UK); Simon Eastmond (UK).
- **Members of Council from the class of Associate Member:** Helen Kellaway (UK); Firas Al-Tahan (Canada).

Buddhadev Chowdhury
As this edition of IRSE NEWS went to press, we learned of the untimely passing of Buddhadev Dutta Chowdhury. He had been unwell for some time with cancer, and knew he did not have long to live, but nevertheless his death came as a shock and with great sadness to all who knew him. He was a passionate supporter of the IRSE, and devoted a great deal of time and effort supporting people in their professional development, and in encouraging and supporting the growth of the IRSE. He was also a valued member of IRSE Council. Buddhadev was a delightful, warm person, a real pleasure to know, and a friend to many people, and he will be greatly missed. There will be a tribute to Buddhadev in a forthcoming edition of IRSE NEWS.

Annual Report
The IRSE’s Annual Report for 2016 was published last month. Members who receive a hard copy of IRSE NEWS in the post should also have received a copy of the Report. For those who use e membership, you can download and read the Report from the IRSE website – you can find it on the About page. It is well worth reading, to understand better the role, strategy and activities of the Institution – whether you are a long-standing member or relatively new. It contains an introduction by Charles Page, reflecting on his year as our President.

The 2017 Convention will take place in the Dallas/Fort Worth area of the USA from 25 to 29 September. Details of the Convention (including the programme), the Booking Form, and the Hotel Booking Form are all now available via the links below. We are offering Early Bird rates for people booking by 30 June.

We have produced a “template business case” which you might wish to make use of if you need to persuade your employer to support you attending the Convention, also available via the link below.

For the first time we are also opening the Convention to non-members (at a higher rate). If you know of work colleagues who might be interested in attending, please show them the information about the event.

Find out more by visiting:
- the special Convention website, [http://irse.info/dallas](http://irse.info/dallas).

Members Annual Lunch
The 19th Annual Members’ Luncheon will take place at the Gascoigne Room at the Union Jack Club, Sandell Street, Waterloo, London, SE1 8UJ (near Waterloo station) on Wednesday 14 June 2017. It is hoped that as many members as possible, from younger to older, will attend. It’s a great way of networking and meeting up with both current and former colleagues in an informal social setting. All who have been to previous Luncheons have enjoyed themselves greatly.

Please register now to attend, using the application form available on the IRSE website ([http://irse.info/f39ls](http://irse.info/f39ls)). Applications must be received not later than 31 May 2017.

Minor Railways Section AGM and Technical Visit
With the kind permission of the Ffestiniog and Welsh Highland Railways, and with the support of PRB Consulting, the IRSE Minor Railways section is arranging a Technical Visit and holding its Annual General Meeting in Porthmadog on 12 – 14 May. For more information and the booking form, see [http://irse.info/k826o](http://irse.info/k826o).
The IRSE Australasian Section chose steam and sail as its means of transport for the 2017 AGM and technical conference in Sydney. The social program was first to board, with partners and friends joining the Riverboat Postman for a trip along the Hawkesbury River. Meanwhile those of more technical inclination (or less social opportunity) gathered at the Starting from the Maritime Museum on Sydney’s Darling Harbour to be exhorted and informed. The following day, the group travelled to Wollongong by heritage railway and returned to Sydney on the Pacific Ocean, having a swell of a time. Setting sail on a Tall Ship on Sunday, the delights of Sydney Harbour were explored on a crystal clear day.

Long time IRSE supporter Tony Howker was delighted to travel on a train hauled by a 36 Class steam locomotive, almost as delighted as he was to receive the IRSE Chairman’s Award from Chair Glenn Miller. Continuing the nautical theme, Glenn described the award as a “Captain’s Pick”. (Students of Australian politics will recall another occasion on which a “captain’s pick” caught the headlines, however the IRSE is unable to offer knighthoods.)

Friday’s proceedings began with a keynote address from the CEO of Sydney Trains, Mr Howard Collins. This was a fascinating insight into the directions in which he is planning to move Sydney Trains; the rapid increase in capacity that is being demanded of the railway and the way Sydney Trains is embracing technology. There are interesting times ahead! The IRSE is really about people, not technology, and it was a delight to have Noel Reed reflect on the beginnings of the IRSE in Australia. Noel reflected on his regret that he was unable to attend the initial IRSE Australia meeting in 1947 but has sought to atone for that by attending nearly every meeting in the following 70 years. The welcome and acknowledgement that Howard Collins gave Noel reflected both Howard’s true interest in people and Noel’s standing in the community. (Some of us suspect that Howard Collins might have been the recipient of more than one of Noel’s email suggestions on improvements that might be made to the New South Wales railways.)

Peter McGregor, a past chair of IRSE Australasia, achieved an outstanding response from sponsors of the meeting, encouraging them to provide trade displays as well as their generous contributions towards the costs of the meeting. One of the quiet achievers of the IRSE, it was Peter’s calm attention to detail that ensured that many aspects of the meeting ran smoothly.

Technical papers were of course presented on Friday. Along with the rest of the Australasian papers since 1947, the technical papers are available to all at irse.org.au. The papers
were varied in their approach and presentation, with Wayne McDonald’s seemingly incongruous combination of apples, oranges, a banana, several rams and a bull stealing the show. Steve Boshier provided an interesting slant on asset management, highlighting the application of virtual reality and augmented reality to better manage railway assets. Trevor Moore challenged some traditional thinking, claiming that signalling safety is not an absolute. The application of software defined networking and some thoughts on the digital railway were discussed, along with product presentations for a signalling design package and a variation of ERTMS for suburban operation.

Messrs Byles and Calcutt were very much in evidence in the early days of the IRSE and have not been forgotten, as there is an award for the best paper presented at a national meeting by a younger member. The criteria for this award are quite stringent and quite often no award is made. So Thomas McPeake deserves recognition and congratulations for winning the 2016 Byles & Calcutt Award. Thomas gave his award winning presentation at the April 2016 AGM in Adelaide, discussing the application of axle counters in single line sections.

The Australasian section consists of Australia, as well as New Zealand, with meetings held in both countries. A consistent and enthusiastic supporter of the IRSE in New Zealand, Allan Neilson was rather surprised to find himself made an Honorary Fellow of the IRSE at this meeting. Presenting the award to Allan, IRSE President Charles Page emphasised the impact that Allan has had on the IRSE in Australasia and the continued commitment Allan has demonstrated throughout his career.
Ian Mitchell welcomed over 40 members and guests on Thursday 2 March 2017, and explained the recent name change from DeltaRail to Resonate. The new branding reflects the company’s digital age skills and solutions that are finding applications outside of rail, across transport markets and beyond. Nevertheless, railway applications, and specifically signalling control and traffic management systems, remain the largest part of the business and these were the focus of the presentation.

Resonate’s current signalling control product ‘Scalable’ incorporates all the proven functionality of the Integrated Electronic Control Centre (IECC) originally developed by British Rail Research, on a modern hardware and software platform with a radically improved user interface. The evolution from what is now known as IECC Classic took place in two stages.

The first stage of Scalable development put the existing functionality onto the new hardware and software platform. The hardware incorporates commercial off the shelf (COTS) processors, routers and port servers that are used in other critical applications where high reliability and a long support life are required. The hardware for a complete system controlling up to 12 SSI-equivalent interlockings now fits in one cubic instead of several required for an IECC Classic. The software is based on the Linux operating system, with new code written in Java. A COTS message broker software component is used as the basis for communication internally, and with modern IP based external systems. The traditional IECC user interface with a trackerball and fixed screen views was initially retained, and this allowed the pilot trial for Network Rail product acceptance to be a like for like replacement of the existing IECC Classic at Swindon B control centre in 2012. Since then there have been installations at Thames Valley Signalling Centre, Edinburgh, Cambridge (the Ely-Norwich modular signalling scheme) and Harrogate.

Further development has exploited the capabilities of the new digital platform to challenge the traditional user interface for signallers, which was established with the first IECC applications in 1989. Back in those days, computers had very limited processing power and graphics capability, and users had no experience of interacting with a software based system. Over 25 years on, it was time for a review of the signaller interface to adopt modern methods of interaction that users are now familiar with, to abolish the technical limits on workstation capacity, and provide a platform for additional productivity tools to be incorporated. This initiative was enthusiastically supported by ergonomics and operating staff in Network Rail, and the first upgraded workstations were commissioned at Marylebone Control Centre in 2015. The new workstations are interfaced to the rest of the system by a ‘Middleware’ layer of software which allows any workstation in a control centre to be interfaced to any interlocking.

Resonate’s current projects on Network Rail focus on the migration of control to Rail Operating Centres (ROCs). The biggest application is the Thames Valley Signalling Centre at Didcot which is now the Western ROC. Eleven of the latest Scalable workstations now control the whole route from Paddington to Bristol Parkway. The statistics are impressive – 65 interlockings, 1107 track km, 2850 signal equivalent units (SEU). Further workstations are due to be commissioned for Bristol Temple Meads and Oxford in the coming years. At Edinburgh, the ROC for the East and North of Scotland, the control area is progressively being extended as part of the Edinburgh Glasgow Improvement Project. Two scalable workstations were installed for recontrol of the former Cowlairs area in 2013, and these will be upgraded to the new user interface when Greenhill Junction, Larbert, Carmuirs and Grangemouth Junction are added to the control area at the end of 2017.

The Company is also working on delivery of a new rail traffic management system for Nexus Tyne and Wear Metro. This will replace the existing panel and a vehicle based route setting system with Scalable workstations and a timetable based automatic route setting system, interfacing to existing relay interlockings via a renewed time division multiplex (TDM) remote control system. This application requires a number of additional interfaces that are not found in Network Rail applications, such as platform information and public address systems, and a radio link to train cabs to allow the driver to enter a train description and ‘ready to start’ at the beginning of a journey. The new system architecture has facilitated the development of these interfaces, as the ‘Middleware’ decouples them from the safety related core of the system.

The meeting finished with a visit to the demonstration area and testing facilities where there was a chance to see the new workstation interface and hardware, with Network Rail and Nexus applications running under simulation.
The North American Section (NAS) was formed on May 24, 2002 to support the goals of the Institution in North America, and presently has over 70 members. 2016 was an important year for the Section. We saw an increase in membership as well as record attendance at all of our events. These included our Annual General Meeting (AGM), as well as annual short conference event held at the site of the Toronto Railway Club in December. We also added a Communications-Based Train Control (CBTC) conference to the schedule.

Annual General Meeting

The 2016 Railway Systems Suppliers Inc (RSSI) exhibition held at the Gaylord Grapevine Convention Center in Grapevine, Texas on 28 June was the location for our AGM. We were delighted to see an overflow crowd of over 60 attendees for our technical presentations. The NAS AGM was held the day before the RSSI exhibition opened, allowing for a large number of Signal and Communications Engineers to learn about the IRSE as well as enjoy some technical presentations. The AGM also hosted the regular business of the Section.

At the AGM IRSE North American Country Vice President WJ “Bill” Scheerer, spoke about the purpose of the IRSE and the benefits of IRSE membership.

The next presentation was from the BNSF Railway. Andrew Crouch discussed the promising results of alternative detector technology for use in Slide Fences. Traditionally, these devices relied on rock and other material interfering with a normally closed circuit running along the railroad to detect obstacles to normal train operation. These systems have suffered from reliability and heavy maintenance issues since their inception, and this research showed that acoustical methods as well as fibre optic cables buried along the right-of-way can be used to mitigate these issues while providing acceptable results in detecting slides.

Dr David Thurston, NAS Chair, then presented on “Standards and their Organizations Impact on the Rail Industry”. This was a detailed study on the standards used in North America for rail and transit systems. Included in the discussion were organizations such as the Institute of Electrical and Electronic Engineers (IEEE), the American Railway Engineering and Maintenance-of-Way Association (AREMA), as well as owner standards. David also covered how consensus standards are created and revised for practical applications within the industry while not being influenced by any one type of organization.

The final presentation came from Pat Sullivan from the Federal Railroad Administration (FRA). Mr Sullivan dealt with activation failures at highway-rail grade crossings. Activation failures occur when the warning devices at the crossing do not operate at the approach of a train. As an obvious safety concern, research in this area is vitally important to every signal engineer. The study categorized the types of failures, their frequency of occurrence, and possible explanations to the hazards. Loss of shunting of track circuits was a major concern, with a majority of the nearly 300 failures attributed to this in 2015.

The success of the event was primarily driven by the timing of the event before the actual RSSI product show Future conferences will follow the same format.

The AGM and Conference meeting room was graciously provided by the Railway Systems Suppliers, Inc, who also provide the NAS with booth space at the annual RSSI Communications and Signal Exhibition and Product Show in the days following the AGM. A special thanks to Vic Babin and Rob Burkhardt for once again setting up the booth and organizing our efforts there.

The First Annual North American Conference on CBTC

Our second activity was conducted on 1 - 2 December at the Royal York Hotel in Toronto, Canada. This was the IRSE Council-supported Conference on Communications Based Train Control, and was the first fee-based conference held by the NAS. By all measures, the two day event was a huge success with over 115 attendees. A total of fourteen speakers were present for topics that ranged from Cyber Security to the history of CBTC. There was several discussions of continuing the conference next year to coincide with the opening of the Toronto Transit Commission line extension that will be CBTC only.

Full details of the event can be found in the February 2017 issue of IRSE NEWS.

The NAS would like to thank the Planning Committee of Dr Alan Rumsey, Dr David Thurston and especially Conference Chair Yousef Kimiagar who really made the conference what it has become. We are intending to hold a further CBTC Conference at the end of 2017.
Annual Canadian Meeting

The third activity for 2016 was the 5th Annual Canadian Meeting held in conjunction with the Toronto Railway Club holiday dinner on 2 December. There were over 80 attendees to this event, the most ever. It included raffles for IRSE materials and speakers on a wide range of railway topics.

The main event featured presentations from rail and transit experts from around Canada as well as IRSE President Charles Page. Shawn Robinson of CP presented on the “Engineering Performance Monitor”, Naeem Ali from CBTC solutions talked about safe braking models and Duwayne William from Transport Canada spoke about Grade Crossing regulations and funding. The meeting was wrapped up with a presentation of Ryan Janzen from Transpod on the Hyperloop project.

The presentations are available for download on the IRSE NAS web page at http://irse.info/9oiev.

The Section thanks John Leonardo for organizing this event. It is the third event in this series and we expect to continue with this format in the future.

Plans for 2017

2017 promises to be another pivotal year for the Section. We are planning a brief AGM in Indianapolis, Indiana during the massive Interchange Product show and AREMA conference in early September. Immediately following this, the 2017 IRSE International Technical Convention (IRSECON17) will be hosted by the NAS in Grapevine, Texas. Planning for this event has been going on for some time and it is shaping up to be an excellent venue and opportunity for technical growth for the attendees.

We will also continue the tradition of the December Toronto, Canada Conference that precedes the Toronto Railway Club holiday dinner. In addition, we will host another Canadian CBTC event at about the same time.

There has been interest in conducting individual meetings around North America in between these events and planning in now underway to achieve this goal.
March Technical Meeting: X-NetTE Video Codec, latest applications and developments

Tony Pinkstone

On 23 March Chairman Doug Gillanders welcomed members and guests to the technical meeting of the York Section. He then introduced Mark Marriage of Digital Barriers, who would give his paper on X-NetTE Video Codec, with details of the latest applications and developments.

Digital Barriers were well-known in the rail industry under their former name of Coe Ltd. They had been involved in the supply of CCTV systems for MCB-CCTV level crossings and other railway applications for many years, with both fibre optic and FTN transmission. They now provided large scale CCTV systems, On-Board CCTV, and video Transmission equipment. A recent application in Queensland, Australia has been provided for On-Board recording and Off-Board live video, triggered by an emergency alarm on the train, transmitted from the vehicle involved. The Singapore Metro (LTA) has an installation using 8000 cameras from 70+ stations. On the North-East Line, with its driverless trains, real-time video can be streamed form anywhere on the network using EdgeVis Live, with recording of events. EdgeVis Live enables simultaneous re-distribution of surveillance content to multiple personnel with mobile phones, tablets and in control rooms. The output can give secure local recording of high definition video, audio and other data for forensic and evidential use. The system has ultra efficient transmission at bandwidths as low as 9kbps, i.e. 60% less bandwidth compared to standard-based systems.

Recent applications include output from cameras and body cameras, via servers, to control rooms, smart phones or mobiles. Video enhancement techniques can be used to zoom in on car number plates, faces, or trackside equipment. Body worn video can operate with a 1 second latency with a recording capacity of 345 Megabits per shift.

Most existing CCTV level crossings are analogue and X-Net Codecs move the transmission of analogue signals to the IP domain over Ethernet networks, both wired and wireless. IP networks are ubiquitous worldwide and form the bedrock of the internet. The ability to use these networks for mixed-signal type transmission is most useful for large scale systems where the migration to digital cameras (IP) is cost prohibitive. H262IP video codecs ensure low-latency transmission while high performance video servers offer reliable operation in complex environments. They provide real-time analogue video transmission over wired and wireless IP networks. Serial data, audio and contact closure channels are included for PTZ cameras and PA, intercom and general communications links. Camera selection and video blanking can be incorporated into the interface unit, HD camera to HD Monitor.

Mark then gave a live demonstration of the systems by dialling up on his mobile phone a live video picture from a camera pointing out of the company office window in Arlington, Virginia showing traffic on the road outside.

With the present controversy in the UK over Driver Only Operation, the ability to transmit high quality video from platform to the driver’s cab is of great importance.

Mark then introduced the application of seismic sensors to detect the presence of trains for simple level crossing warning, or using the seismic sensors to switch on CCTV. The sensors can distinguish between different vibration profiles such as trains and road vehicles.

The vote of thanks was given by Simon Prins, who thanked the speaker on behalf of those present for his account of current developments in a field of rapidly advancing technology. Among those taking part in the questions and discussion which followed were John Maw, Simon Prins, Grace Nodes and Quentin Macdonald.

For more information on IRSE activities visit our website

The best place to visit for information on institution membership, activities, publications and up-to-date news is our website at www.irse.org.

Also look out for our tweets at @IRSEHQ.

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Thanks for checking!
After a safety brief and a check that everyone had the correct personal protective equipment for the visit, John Batty gave us a short presentation about Great Western Railway’s (GWR) Train Care Depot. It is responsible for the maintenance of London and Thames Valley trains and has three connections to the mainline from the depot named A, C and E (E is the most frequently used connection). There were originally to be five but it was decided that B and D were not going to be used and hence the naming.

Once the presentation was finished delegates were split into three groups and a tour given by John Batty, Ian Blondel and Sutopa Paul, who are all Depot Engineering Manager Technicians. In their day jobs work as technical engineers performing various function of production support and have been working at GWR between one and five years.

The aim of this new train care depot is to provide maintenance facilities for the current fleet of Diesel Multiple Units (DMUs) until they are phased out and replaced with new Electrical Multiple Units (EMUs), which will run on the GWR when electrification is complete.

Train Maintenance

The depot currently maintains Class 150/0, 165/1 and 166 DMUs which require a number of maintainers with various skills in order to carry out all the work on the different stock types. However, as the new EMUs are gradually phased in, this variability will reduce and the maintenance will be simplified.

The depot operates around the clock, with their busiest times being at night and between the am/pm peaks when service requirements are low. Cleaning of trains (internally and externally) happens daily and they are refuelled, on average, every two days.

Full carriage washing facilities are provided, through which the trains pass and then reverse back due to layout restrictions. Trains will eventually be able to run through without needing to reverse, which will lead to an increase in the amount of vehicles that can be washed in a given period.

There is a staggered maintenance program with servicing being carried out every 15k miles. All the maintenance activities are broken down into work packages that can be achieved in one shift rather than having to take a train out of service for a number of days/weeks. For instance the brake maintenance would be scheduled into one night shift and transmission in another reducing the time the train is out of service and also allowing for preventative maintenance.

Trains have four lifting points on each carriage to allow it to be removed from the bogies using jacks (shown in the pictures on p31).

There are four maintenance roads in the shed into which DMUs are able to drive into; three of the roads have overhead line equipment (OLE). If an EMU needs to be brought into the non-electrified road a battery powered mule is used to pull it into position and out again as required.

A wheel lathe is currently being built in the depot that will be able to turn two axles at a time; currently trains have to use the facility in Old Oak Common Depot near Paddington.

A Bombardier team is co-located at Reading Depot with GWR whilst the EMUs are being introduced in order to provide the relevant support as the new trains are phased in. GWR has a number of different train types; some train manufacturers maintain their own trains such as Siemens, Alstom and Bombardier.

The new EMUs will come fitted with Driver Operated Door Opening controls and associated CCTV for safe door operation. An onboard train management system will collect diagnostic information that can be accessed onboard the train with faults requiring immediate attention being reported to Maintenance Management in Swindon. These faults can then be assigned to the relevant company i.e. GWR or Network Rail.

Train Identification and Control

RFID is available in the depot, but not currently utilised, however it will be used to identify and manage train movement. There is also lineside acoustic monitoring facilities to monitor wheel bearing condition.

Train Movements

The Train Movement Controller (TMC) located in the main depot building uses a Siemens Controlguide WESTCAD system to monitor and control train movements within the depot. A TIMIS system is also provided which is an overview of the reading area and is a direct feed from Thames Valley Signalling Control (TVSC).
The synchronised lifting jacks being used to raise a Class 166 DMU.

The TMC is also provided with Integral, which is the timetable management system, and a Simplifier is also provided to show a view of where trains are on the mainline along with CCTV of the depot.

The backup depot control system is paper based i.e. the yard sheet which the TMC maintains and displays the consist of trains and their location.

Management of the movement of trains between the mainline and the depot are via slotted signals and audible alarms to alert the TMC. This provides the interface with TVSC to handover a train from the mainline to the depot and vice versa.

Movement of trains between the depot and the train sheds are managed via verbal communications between the Maintenance Team Leaders and the TMC. Train protection for routes out of the depot onto the mainline and from the depot into the maintenance shed is provided by de-railers.

Once a train in located in the shed a depot protection panel stops team leaders from moving trains when maintenance teams are logged on as working on the train. All maintenance team members have to be logged out of the system before the signals out of the sheds can be cleared.

Operation
Drivers bring trains into the depot boundary and then hand them over to maintenance drivers who drive the trains once inside the depot. Movement authority is indicated to the drivers via ground position light signals.

Facilities
The main depot building contains all the facilities for depot staff such as offices, mess facilities and classrooms.

Maintainer Safety
The new EMUs will be powered via OLE and the ability to safely isolate this in the maintenance sheds is provided via access lockouts to overhead working areas. An OLE protection panel is provided which is interlocked with the key for gantry access. The OLE has to be off before the key can be removed from the protection panel and entered into the lock for the OLE gantry access point. The OLE cannot be reenergized until the key has been returned.

Capacity
The new EMUs streamline planned maintenance and improve the reporting, management and fixing of faults and also reduce overcrowding as they are longer and can carry more passengers.

Thanks go to John Batty, Ian Blondel and Sutopa Paul, and GWR for taking time out of their busy schedules to give delegates a tour of the depot.
Some years ago, the UK National Railway Museum (NRM) Advisory Committee investigated the nature of literature and publications on railway signal engineering and operations. Their findings revealed a gap between the technical papers produced by the Institution of Railway Signal Engineers for those employed in the industry and the books produced commercially for railway enthusiasts.

The Friends of the National Railway Museum considered that there was scope to produce publications that would provide readers, in an understandable manner, a greater insight into the major historical, technical and political developments in signal engineering. To strike a balance, authors would be sought from the profession and from enthusiasts with an in-depth knowledge of signal engineering.

Rather than attempt to compress everything into one book, it was decided to produce a sequence of volumes, each concentrating on a specific topic. Relying entirely on volunteer labour, speed of production since volume one in 2000 has inevitably been limited.

Volume four - Level Crossings - is the latest production. The authors are Tony Pinkstone, a career signal engineer with British Railways and Mike Peart who has had a life-long interest in all things railway.

Level crossings have been a ongoing problem for railway management from the earliest days to the present day. A level crossing was a low cost alternative to a bridge and, not unnaturally, the railway pioneers wished to contain the costs of a proposed railway. Slow moving and infrequent road traffic would not, they calculated, be inconvenienced by having to await the passage of a train.

Quite the opposite was the outcome. The road rail interface was soon place of conflict with fatal accidents happening all too often. Government action was necessary and, in 1835, the Highways Act became law. Many more railway related Acts of Parliament were to follow. Accidents were reduced but the downside was leaving the railway companies for over 100 years with the high costs of operating gated level crossings. Replacing the heavy timber gates with their complicated operating linkages with light weight power operated barriers only became possible in 1954 with the passing of the British Transport Commission Act. A chapter is devoted to a description of the mechanism required to move gates and secure them in position. Photographs and engineering drawings assist the explanation of how this was achieved for an amazing range of gate permutations. Signalmen carried the responsibility for the safe operation of both road and rail movements, and, of course, they had to have the strength throughout his turn of duty to turn the handle that moved the gates.

Enhancing level crossing protection has been a continuing process since the first recorded accident at Thornton Lane in 1833. Fifty incidents spanning 180 years, many with fatalities, are described along with the modifications that were subsequently applied.

A recent and alarming occurrence has been suicide where a car is deliberately placed across the lines at an automatic half barrier crossing. In 2005 six passengers died when a High Speed Train was derailed by a car. Radar scanning to detect obstacles on automatic crossings has become yet another addition to the equipment required to manage risk.

Automatic barriers have reduced waiting times for road users though the increase in road traffic over the past 50 years has brought problems. Accidents, nearly all of which are caused by road user indiscipline, continue to be a concern.

Another area of concern is the more than 4000 footpath and farm crossings where user protection is no more than a simple warning sign. Installation of a low cost train operating system that triggers warning lights is under way but will take many years to complete.

The story of the level crossing from 1833 to 2016 is comprehensively described in this book beginning with the Acts of Parliament and the requirements of the various Government bodies that oversee rail safety.

This book is a worthwhile addition to the library of those interested in the complexities of railway management. Level crossings have long been a neglected subject. Now, at last, it has been tackled and the authors deserve congratulations for the thoroughness of their research and the ability to present it in a manner that does not require a reader to be technically minded to enjoy and understand.

Robin Nelson
Antony Rowbotham BSc, FIRSE
1940 – 2017

Tony was Deputy Editor of IRSE NEWS for twenty-six years and 200 issues. He was a very knowledgeable, kind and true gentleman, who was an inspiration to myself and many others within the world of signalling and telecommunications. He aspired to perfection in everything that he undertook and achieved it regardless. He always gave the time and patience to all those who showed interest in music, railway signalling, Swiss railways and model railways. He was a violin player and met his wife Mary through their shared love of music. He had a great sense of humour and was always keen to help and develop others.

Like most school boys in the 1950s, Tony was interested in railways. Whilst still at school in South London he attended a short seminar run by British Railways, designed for school children, on the subject of signalling. It must have done a good job, for those few days determined the rest of his life. He obtained his Electrical Engineering degree at Kings College, London University and obtained a Graduate Apprenticeship with AEI (Associated Electrical Industries), parent company of one of the then signalling companies, at their vast complex in Trafford Park, Manchester.

The first area he was posted to for his apprenticeship was actually the product development section of the signalling company AEI-GRS (a joint company between AEI and the American signalling company General Railway Signal), which was based just off the main complex. At that time, the standard BR930 series of miniature relays were being developed, and the very widely used vital ‘Reed’ Frequency Division Multiplex system was brand new technology. He was then posted to various other departments in the complex at Manchester including the Training School, along with many site learning experiences and visits. His last placement was again with AEI-GRS, but in their London Schemes Office, including helping with the testing of Nuneaton on the West Coast Main Line. This was one of the first installations of the rather basic AEI-GRS Geographical Interlocking System.

After this he began testing duties at the new Watford Junction Power Signal Box, again on the West Coast Main Line. This was followed by a somewhat smaller scheme between Cheadle Hulme, to the south of Manchester, and Grange Junction just short of Stoke-on-Trent. Around the time when GEC (General Electric Company) finally took over the whole of the AEI-GRS now combined with SGE in the 1960’s, the London Midland Region of British Railways had awarded two large contracts. These were Trent, a large area around Nottingham) to AEI-GRS, and Saltley (most of the non-electrified lines around Birmingham) to SGE. It was decided that both would be engineered to the same standards and the more sophisticated SGE Geographical system was chosen. However, uniquely, all the interlockings for each scheme were housed in the appropriate signal centre with the controls and indications transmitted to the outside world through vital and non-vital ‘Reed’ Frequency Division Multiplex systems. This eliminated the cost of all the Remote Relay Rooms. Tony was given the task of engineering all those for the Trent scheme. He then progressed on to the original Paisley re-signalling in Scotland and then was made responsible for engineering the interlockings on the Southern Region Dartford area re-signalling.

His next job was the largest and one he was very proud of, being responsible for the interlockings on the Eastern Regions Kings Cross scheme. This included the complex of lines as far north as Sandy, about 75 km from the Cross. The panel involved five signalmen and was said to require 14 000 filament lamps!

After this contract was completed, Tony became more involved with administration type work including quality, standards, document control and licensing followed by training within the now GEC-GS. He had around two hundred pupils for his Introduction to Signalling course in one year! The training notes subsequently formed the basis of the Introduction to Railway Signalling text and in part to the Introduction to North American Railway Signalling (note the American spelling) books published by the IRSE. Tony was also involved with Alstom (who had now bought the GEC interests in GEC-GS and the signalling part of the General Signal Corporation) with the large multi-national team set up to develop the scheme to install ETCS Level 3 on the whole of the West Coast Main Line before retiring in the early 2000’s.

Tony’s work gathering material and producing IRSE NEWS began in 1989 with John Francis. It was Past President Cy Porter, who was Tony’s boss at the time, who suggested to him to take on the task. Tony had found the task most enjoyable over the years and enjoyed hosting a yearly editorial team gathering at his house in Park Street in Hertfordshire on numerous occasions with his wife, Mary. I do remember Tony getting a little frustrated at times regarding the quality of submissions to the magazine, however, as a team we always managed to resolve the problems together with the authors. He was always pleased when seeing the appreciation of IRSE NEWS in the many membership surveys. The magazine you see and read today is truly down to his many years of hard work and support.

Tony passed away on Sunday 26 February 2017 at his home in Park Street. A service of thanksgiving was held at the West Hertfordshire Crematorium on Monday 27 March 2017, when family, friends and IRSE colleagues gathered to celebrate Tony’s life. It was appropriate that Past President and Tony’s former boss, Cy Porter gave a moving and uplifting eulogy regarding Tony, detailing his strong character and his many achievements.

Tony will be sadly missed in the world of railway signalling and telecommunications.

Ian James Allison
In 2017-18 our Presidential Programme will be ‘on the road’ more than ever in our history with papers presented in the UK, The Netherlands and Australia. We will hold our major ASPECT conference in Singapore for the first time, and our International Technical Convention will be in the Dallas/Fort Worth area of the USA. This reflects the global spread of our membership.

**Presidential paper**
Brisbane, Australia, 14 July 2017
“An engineer’s journey to becoming consciously competent”
Cassandra Gash

**Presidential paper**
Utrecht, Netherlands 25 January 2018
“Potential effects of ‘Brexit’ on signalling and control systems”
Andrew Simmons

**Presidential paper**
York, UK, 8 February 2018
“Continuous improvement for lifelong learning”
Judith Ward

**Presidential papers**
London, UK
12 October 2017
“Disruption”
Speaker to be confirmed
15 March 2018
“Track worker safety”
Rod Muttram and Wim Coenraad

**Presidential paper**
Birmingham, UK, 6 December 2017
“What follows GSM-R?”
Clive Kessell and Paul Darlington

**Presidential paper**
ASPECT 2017
Singapore
27-30 November

IRSECON17
Dallas/Fort Worth, USA
25-29 September 2017