IRSE

INSTITUTION OF RAILWAY SIGNAL ENGINEERS

100 YEARS

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Front Cover: Project Engineering is always an important part of any signalling project. Lee Philbin of Signalling Solutions Ltd discusses and reviews one of the Network Rail Western Mainline Signalling Renewal projects with Buddhadev Dutta Chowdhury of Radharani Rail Engineering Services Ltd in Swindon during January 2013. *Photo: Ian James Allison*

NEWS VIEW 186

Understanding Testing

Having been out and about during the festive season in the UK on various signalling commissionings, the opportunity to view individuals and teams in action was seized upon. Whilst some sterling work was undertaken and achieved during this period by many individuals, teams and companies which must be commended, one particular common issue became obvious.

The non-signalling engineers and managers consider what we do as being difficult and *"The Black Art"*. There is no reason why the industry should not communicate and be educated further, in order that those non-signalling engineers and managers leading and controlling signalling projects understand how the building blocks work and fit together. In addition to that, the robust process of testing and commissioning needs to be further understood by the whole of the industry.

The reason why the Tester in Charge needs wheels-free time is not necessarily clear to the other disciplines. However, if you are a principles tester trying to set routes and verify the controls, and unless the railway you are testing is able to be operated with the required signalling equipment installed and set to work, he or she cannot complete the testing and then there can be a delay to the commissioning programme. If delays such as this occur, the Tester in Charge must re-sequence testing activities to maintain the end completion time. He or she does not have the time when this happens to explain and produce a new programme for others to understand what testing remains with only a few hours remaining until the planned completion.

Communication and further education must be considered for non-signalling engineers and managers in plenty of time before any signalling commissioning takes place in the future. This would hopefully prevent or at least reduce the amount of times the Tester in Charge has to be diverted from undertaking the job in hand and be allowed to complete the management of the testing and commissioning activities, in order to sign in to use a safe and reliable railway.

The Editor

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IRSE — INSTITUTION OF RAILWAY SIGNAL ENGINEERS — 100 YEARS

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FEBRUARY TECHNICAL PAPER

The Future of Train Control Systems

By Prof. Roger Goodall, Roger Dixon, Sam Bemment (Loughborough University); Dr Taku Fujiyama (University College, London); Prof. T X Mei (Salford University); Prof. John Preston (University of Southampton); Prof. Alexander Romanovsky (Newcastle University); Dr Markus Roggenbach (Swansea University)

Paper to be read in London on 13 February 2013

INTRODUCTION

This paper gives an overview of the contribution of university-based research to the future development of train control and communications systems. Specifically it provides insight into research being conducted by UK universities to support the development of new train control systems, and includes some of the more radical ideas being investigated.

Context

It is important to recognise where universities fit into the spectrum of research and development activities. In general industry pursues relatively "safe" activities (as much as innovation ever is safe), usually where each activity has its own business case. In contrast university-based research, especially that funded by the research councils, is normally more speculative with ill-defined risks and often simple quantitative or perhaps even qualitative business cases.

With this in mind, and as a result of significantly enhanced industry-university collaborations, a Department for Transport initiative supported by industry stakeholders resulted in the establishment of a "Strategic Partnership" with the Engineering and Physical Sciences Research Council (EPSRC). The first call was titled "*Railway Capacity: Overcoming the Constraints caused by Nodes (Stations and Junctions) on the Rail Network*", with the principal objective that *"the output of this research should help assess the extent of capacity enhancement possible through innovative changes to nodes and the most promising technical approaches to implement such changes"*.

It was also stated that "*the outputs will typically sit at Technology Readiness Level 1-3 (basic principles; technology concepts; analytical studies), commensurate with the role of the Research Councils in funding technology development*", and this message was reinforced in the briefing for the call in which proposers were encouraged to "*challenge the rules*" and to "*think the unthinkable*". The ideas encapsulated are intended to be a step beyond what the industry itself is currently considering, for example as described for the FuTRO project [ref. 1].

The university-based projects each had an industry Project Advisory Group which both helped to steer the project and provided an awareness of current and planned industry practice, thereby ensuring long term focus for the research programmes.

Assessment of Capacity

Knowing the signalling/train control technology (4-aspect, ERTMS, Automatic Train Operation, etc.) the theoretical train capacity for a plain line can be calculated, but as soon as there are any fixed nodes (principally stations and junctions) this is not achievable.

Identification of innovative methods for minimising the restrictions arising from these nodes is therefore the rationale for the portfolio of projects. However, given typical operational requirements in practice, capacity is very difficult to quantify.

In fact the UIC states the following [ref. 2]:

"Railway infrastructure capacity depends on the way it is utilised. The basic parameters underpinning capacity are the infrastructure characteristics themselves and these include the signalling system, the transport schedule and the imposed punctuality level.

"On a given infrastructure, capacity is based on the interdependencies existing between:

- *the number of trains (per time interval, e.g. trains per hour). When train intensity increases, less capacity is left for quality, as expressed in the parameters described below;*
- *the average speed. The braking distance increases proportionally more than the average speed;*
- *the stability. Margins and buffers have to be added to the running time of trains and between train paths to ensure that minor delays are suppressed instead of amplifying and so causing (longer) delays to other trains;*
- *the heterogeneity. When the differences in running time between different train types worked on the same track are great, similarly the capacity consumption of the same number of trains will increase proportionately."*

These observations, and the speculative nature of the research, mean that direct quantification of the research achievements in terms of capacity increase will not be possible. There is however an accepted trade-off between the first and the third dependencies, and a typical trade-off graph is shown on the left in Figure 1, taken from [ref. 2],

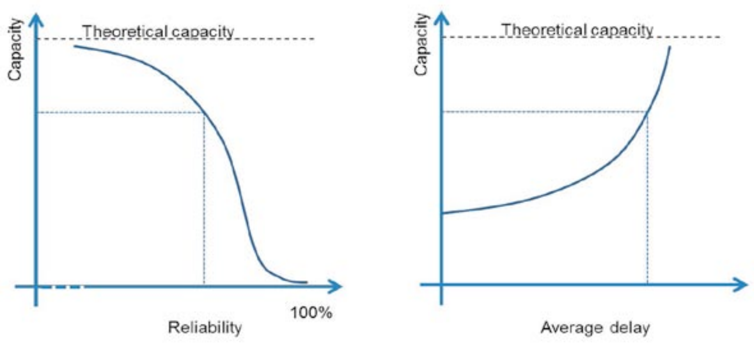

Figure 1 Capacity v. reliability trade-off graph

where reliability could be expressed by a measure such as percentage of trains arriving on time (for example PPM in the UK with a typical target of better than 90% of trains less than 5-10 minutes late). Another way of presenting the trade-off is the right hand graph where the horizontal axis is the average secondary delay across the route/network. See also the discussion about Capacity Utilisation Index (CUI) below.

Direct capacity enhancement will move the trade-off curve vertically, but could also be used to maintain capacity with higher operational reliability; conversely reliability improvement measures could of course also be used to enhance capacity.

Scope

So how can research studies into novel train control concepts contribute to enhancements in capacity? The Conclusion includes a sub-section that attempts to identify the potential combined impact focussed towards improvements in the capacity versus reliability trade-off identified above.

The titles of the five two-year projects that form the Strategic Partnership portfolio are as follows, listed in the order given in the research council announcement:

i. Redundantly Engineered POINTs (REPOINT) For Enhanced Reliability and Capacity of Railway Track Switching;
ii. Overcoming the Railway Capacity Challenges without Undermining Rail Network Safety (SafeCap);
iii. Overcoming Capacity Constraints - A Simulation Integrated with Optimisation for Nodes (OCCASION);
iv. Challenging Established Rules For Train Control Through a Fault Tolerance Approach;
v. Dynamic Responsive Signal Control for Railway Junctions.

A separate, high-level overview of each project is given below, presented in an order that reflects a progressively falling level from the system perspective. The first two are modelling/ simulation/optimisation tools to support system planning (Projects iii. and ii.), the third is concerned with dynamic re-scheduling (Project v.) and the last two are focussed upon the approach rules for and technology of the switches themselves (Projects iv. and i.).

OVERCOMING CAPACITY CONSTRAINTS - A SIMULATION INTEGRATED WITH OPTIMISATION FOR NODES (OCCASION)

This project was undertaken by the University of Southampton's Transportation Research Group, in collaboration with the University's Schools of Mathematics and Management.

Background

The overall approach taken in this project was to investigate and develop means of improving the routeing and scheduling of trains through junctions and stations, thereby reducing capacity utilisation at these locations. This provides an immediate, direct benefit by improving service reliability and robustness; secondly, and more significantly in the overall context of the project, it also releases capacity to enable the operation of additional services, reducing the capacity constraints imposed by the node(s) in question. Increasing the numbers of trains passing through one node is of limited use if adjacent parts of the network cannot accommodate the increased services, and consideration was therefore also given to interactions between adjacent nodes.

Following discussions with the project Advisory Board members, a case study area on the East Coast Main Line (ECML) between Huntingdon and Grantham was selected, including the major (but manageable within the research context) node of Peterborough, the smaller nodes at Huntingdon and Grantham, and varying numbers of tracks between them, and a mixture of commuter, intercity and regional passenger trains and freight traffic. Timetable and other relevant data were provided by Network Rail.

Research Description

Following a detailed literature review that confirmed the value and rigour of the proposed approach, three complementary strands of research were undertaken.

(i) Capacity utilisation measures were extended from network links to nodes, to enable their assessment before and after the interventions developed in the other research strands.

(ii) An optimisation tool was developed, based on the 'Job Shop' approach (whereby trains are modelled as 'jobs' to be processed by 'machines' representing the infrastructure components – [see ref. 4]), to re-route and reschedule train services to reduce capacity utilisation, and introduce additional trains where possible.

(iii) A tactical planning tool was developed, based on a Multi-Commodity Service Network Design model [ref. 5], to consider the interactions between adjacent nodes, and to ensure that proposed service improvements at one node did not cause capacity problems at adjacent nodes.

CUIs for the individual links and nodes (point ends and crossings) comprising the larger station and junction nodes, and intermediate links, are determined by ascertaining the detailed routeing of individual trains through the modelled network, aggregating and sorting the resulting times for all trains by individual node and link, 'compressing' these to the minimum specified headways and margins, and thus calculating the individual and average utilisation indices.

The optimisation tool uses a construction heuristic to generate initial timetable solutions, eliminating scheduled waiting time, and reducing overall capacity utilisation; an insertion mechanism is then used to add additional services; these results are then improved, using a Tabu search metaheuristic, and service frequency variations are minimised using a CPLEX solver*.

Finally, the tactical planning model is used to adjust the 'optimised' timetable to eliminate any congestion at adjacent nodes resulting from the initial solution.

*The CPLEX solver is a high performance solver for Linear, Mixed Integer and Quadratic Programming problems

A timetable graph showing a one-hour extract from the May 2011 morning peak timetable between Huntingdon and Grantham is shown in Figure 2, while the equivalent graph, including additional services identified by means of the optimisation tool, is shown in Figure 3. The CUI results for the May 2011 and 'optimised' timetables are shown in Table 1.

Timetable	Network Element	CUI Values		
		Minimum	Maximum	Average (2-hour)
May 2011	Links	0%	51%	23%
	Nodes	0%	64%	25%
'Optimised'	Links	0%	73%	24%
	Nodes	0%	81%	26%

Table 1: CUI Outputs for May 2011 and Optimised Timetables

Overall, there are 53 train movements through Peterborough in the peak two hours and with optimisation this can be increased to 67, but these additional movements are off the East Coast Main Line towards Ely or Spalding and Lincoln. There are only modest increases in the average CUIs of the 190 nodes and links that comprise the case study area, but more substantive increases in the most heavily used nodes and links. The most important result was that optimisation could eliminate the 24.5 minutes of scheduled waiting time that existing trains face with the current timetable. Sensitivity tests were undertaken to examine the impact of different operating rules (in particular shorter headways) and infrastructure improvements (in particular redesigned switches and crossings). The tactical planning model, which was applied using a hybrid evolutionary algorithm, identified the fast line between Peterborough and Huntingdon as a key bottleneck, with headways needing to reduce to 90 seconds before an additional King's Cross service could be added.

Expected Research Achievements

As described above, three distinct and complementary tools and associated techniques have been developed, together comprising a framework for timetable assessment and amendment to provide additional capacity through existing junctions and stations, while reflecting any constraints imposed by adjacent network nodes and links. The work undertaken has been presented and described at a range of international conferences [ref. 6, 7] and will be published in journal papers.

Industrial Impact

The capacity utilisation calculation methods and tools developed in the course of the project are being used in Network Rail's Capacity Charge Recalibration process, currently underway, and there is scope for their further use, together with the other tools developed, within the railway industry.

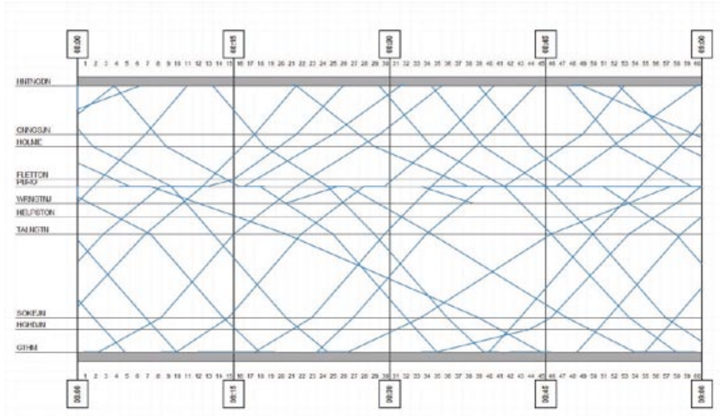

Figure 2 May 2011 Timetable Graph

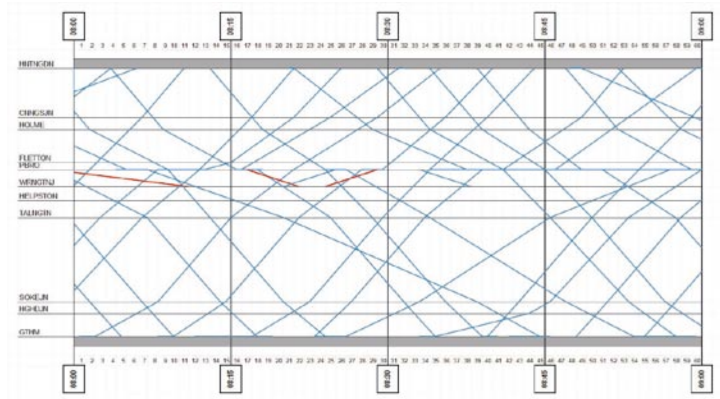

Figure 3 'Optimised' Timetable Graph with Additional Trains

Project Summary

In summary, the approaches identified and the tools developed are worthwhile and relevant to the railway industry, both individually and in combination. To maximise the potential contribution of the research, a more integrated, holistic view is required of passenger and freight service requirements, and of the best overall means of balancing and meeting these competing demands for existing and additional capacity. As Network Rail moves towards a more centralised and automated approach to timetable planning via the Integrated Train Planning System (ITPS), there is scope to incorporate these new methods and tools in the overall planning process, to provide increased nodal and network capacity for additional passenger and freight services, while maintaining timetable robustness and service reliability.

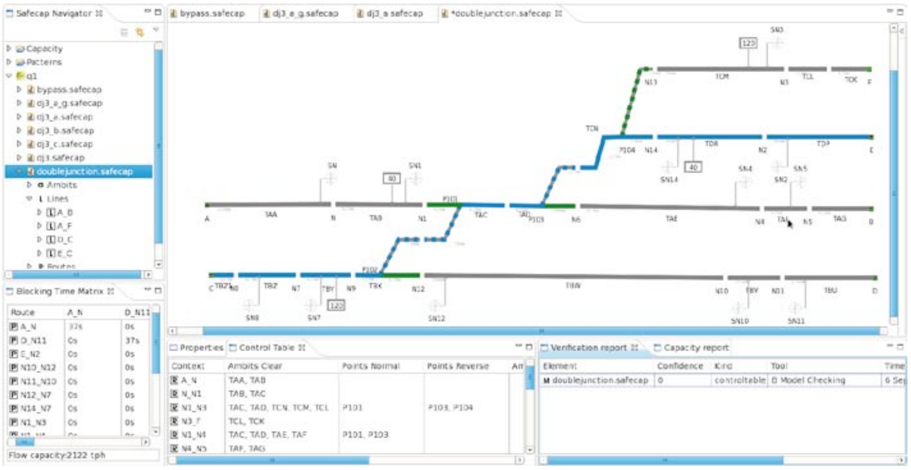

Figure 4 Screenshot of the SafeCap Platform

OVERCOMING THE RAILWAY CAPACITY CHALLENGES WITHOUT UNDERMINING RAIL NETWORK SAFETY (SAFECAP)

This project was a collaboration between School of Computing Science, Newcastle University (project coordinator), Department of Computer Science, Swansea University, Invensys Rail, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan.

Background

Designing railway networks for high capacity is an art; experienced engineers "see" the patterns which lead to success or failure, and they are aware of the "bottlenecks" that their own designs have. However, such an intuitive approach lacks foundations in science, which is the basis of any advanced engineering practice. To this end, the SafeCap project provides a scientifically sound framework in the form of a workbench. This workbench allows the railway engineer to study railway networks as well as design patterns in an integrated way for safety and capacity. To this end, SafeCap sets the following objectives:

- to support safety and capacity analysis of railway networks;
- to develop an intuitive graphical domain-specific language for the railway domain;
- to identify and validate design patterns for improving capacity.

Research Description

Concerning safety, SafeCap provides a set of techniques to automatically prove collision freedom or derailment freedom of a railway design (track plan, control and release tables, and driving rules) [ref. 8, 9]. Modelling languages used include Event-B, CSP||B, and Timed-CSP. While the modelling in Event-B and Timed-CSP builds on earlier work, the SafeCap CSP||B modelling started from scratch. Feedback with motivation coming from our industrial partner Invensys notes the importance of models being immediately understandable and accessible for validation. In various publications SafeCap discusses this criterion with respect to CSP||B, compares CSP||B modelling with other approaches, and shows CSP||B to be fully faithful yet analysable by current verification technologies.

In the Timed-CSP language, SafeCap gives a formal definition of "line capacity" and develops a method of how to measure a railway design for capacity [ref. 8]. Models of railway designs in Timed-CSP can be animated within the newly developed Timed-CSP Simulator. Such modelling has been applied to a standard double junction from the UK railway domain. SafeCap has answered, for these models, fundamental questions from railway industry; changing control tables in the way suggested by railway engineers yields a capacity increase without compromising safety. This increase can be quantified; under optimal conditions, after the change there can be one more train every six minutes in the double junction example. Note that this result only holds under the unrealistic assumption that trains accelerate and brake instantaneously, but further adaptations to the research will remove this restriction. Having shown the increases that can be gained via changing signalling rules through the trusted use of Automated Train Protection (ATP), this encourages changes to be proposed to current UK railway regulation.

A common Domain-Specific Language (DSL) for the description of railway designs is necessitated by the desire to apply and compare the differing modelling techniques used in SafeCap to a common set of problems as defined by Invensys. The DSL is meant to satisfy the requirements of a railway engineer, who prefers to see a detailed layout presented in a way as close as possible to the established practice, and a researcher, who needs to work with a relatively small and precisely defined set of concepts. The main influence on this effort is, perhaps, Dines Bjørner's railway domain language. The SafeCap DSL captures, at a suitable level of abstraction, track topology, route and path definitions and signalling rules. By design, the language is extensible; one can dynamically define further attributes for all the predefined language elements [ref. 7].

The SafeCap DSL is at the heart of a modelling environment called the SafeCap Platform - see Figure 4. The environment offers a visual modelling interface that may be used by a railway engineer, not trained in any manner in the use of such tools, to enter and update railway schemas and access a range of verification tools 'by a press of a button'.

The patterns for improving capacity are based on changes of signalling rules through the trusted use of ATP. The patterns include removing overlaps, moving speed limits for passing a point towards the point, removing access control. Applying these patterns to various case studies set by Invensys yields capacity gains whilst preserving safety.

Expected Research Achievements

On the conceptual side, SafeCap offers a variety of generic modelling approaches for railway designs suitable for safety and capacity analysis, utilizing a wide range of modelling languages and supported by automated verification.

On the tooling side, the central SafeCap achievement is an integrated platform to study railway designs for safety and capacity. The platform comes with a graphical interface offering standard notions from railway engineering. The platform offers to check railway designs for safety and capacity with various tools, where the SafeCap DSL serves as mediating language. Various tools established in the formal methods community (Rodin, FDR2, Timed-CSP Simulator, CSP-Prover) are encapsulated in this tooling environment and are ready for automated use. Besides this, SafeCap extended the animation tool Timed-CSP simulator.

Industrial Impact

The SafeCap platform offers various techniques that allow one to check railway designs for safety and to measure their capacity. As demonstrated above, the SafeCap results challenge the traditional signalling rules through a trusted use of ATP. Together with Invensys, SafeCap will work towards a plan for implementation that identifies pathways for technology transfer. Notably, the SafeCap formalisations of capacity carry over to the new ETCS railway standard.

Project Summary

The SafeCap workbench provides a powerful means for safety and capacity analysis. Future work has two directions: on the technology transfer side, to integrate the SafeCap Platform into an actual production process at Invensys; concerning foundations, to develop more powerful abstraction and tools in order to make it possible to analyse richer models.

DYNAMIC RESPONSIVE SIGNAL CONTROL FOR RAILWAY JUNCTIONS

This project was undertaken by the Civil, Environmental and Geomatic Engineering Department at University College London.

Background

Railway Stations and Junctions are vital elements that constrain network capacity. Core strategies need to maximise the use of the existing infrastructure, with signal control system improvements an important aspect to such an approach. Some systems have been developed to support train operators in making decisions at major stations (e.g. Automatic Route Setting), but complex operations still rely on manual control, human judgement and foreseeing future conflicts in addition to higher levels of optimisations which are demanding on unsupported control officers.

This project is to help the railway industry operate with dynamic responsive signal control in order to operate more robustly and efficiently whilst improving the capacity of the railway network. Traditionally, margins have been inserted into timetables in order to maintain reliability. However, the aim is to reduce these margins by introducing dynamic responsive operations which will allow for a more robust and reliable system, allowing more trains to run.

Research Description

This research first analysed the operations of other transport modes which are by nature responsive, such as taxi and airport operation. The purpose of this exercise was to obtain knowledge and experience from them in order for the railway industry to adopt responsive operations. The results of this analysis can be found elsewhere [ref. 10], but one of the main findings is that in such responsive operation, not only the central control centre but also local-level agents (e.g. each taxi driver) optimise their operation based on the information and past operational knowledge; and use of Information and Communications Technology (ICT) can greatly help this [ref. 11].

Using the results of the analysis, we are now in the second part of the proposed research, which is to develop optimisation strategies as well as a simulation model, which allows us to test strategies. Our strategies are that each train optimises the trajectories based on the locations and speeds of other trains. This is in line with the "intelligent local agent" strategy identified in the first part.

The simulation model is a purpose-specific event-based model of train operation. It can represent train sequences at junctions and train movements on track sections and therefore allows us to investigate constraints such as train motion, signalling systems and timetables.

We apply an approximate dynamic programming method in order to reduce the difficulty in forecasting future information and the massive computational burden by using an approximation to represent the value function. Desired train trajectory on block sections is determined as a series of traction and brake applications with various objectives in terms of minimum energy consumption and other performance measures according to signal status anticipation. Figure 5 shows an illustration of trajectory optimisation.

Expected Research Achievements

We have chosen Edgware Road Station on the London Underground as a case study. We set the current timetable as a bench mark. We will input past operational histories, in particular histories when a disruption happened, and see how our optimisation strategies work. Then we will see how changes to margins would affect the operational performance as well as the overall capacity. In addition, the operational strategies we are developing would increase the resilience of the railway systems.

Industrial Impact

Currently, the UK rail industry runs a programme Future Traffic Regulation Optimisation (FuTRO), which develops a platform for future traffic regulation and optimisation in the railway environments. We expect that our results will be used in the FuTRO programme.

Project Summary

The project provides optimisation strategies for railway traffic control. We hope that our results will be a platform for the FuTRO project. As the project currently focuses on one station for metro operation, it would be necessary in the future to test our strategies for stations that deal with a wide range of service including intercity services and freight trains.

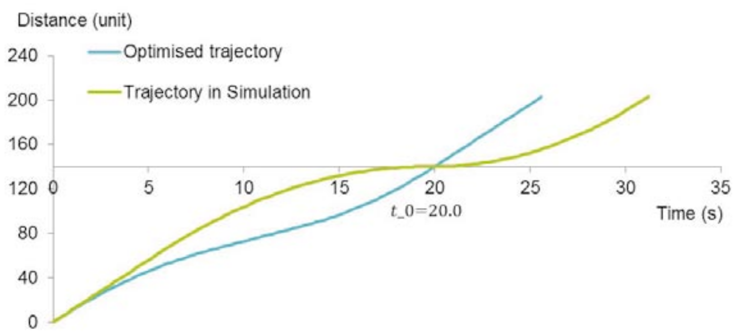

Figure 5 An example of trajectory optimisation

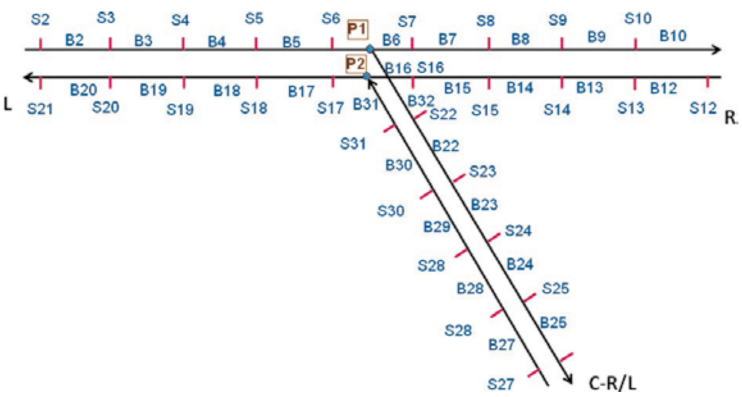

Figure 6 Classical Right Turn Junction

CHALLENGING ESTABLISHED RULES FOR TRAIN CONTROL THROUGH A FAULT TOLERANCE APPROACH

This project was led by the School of Computing, Science & Engineering at the University of Salford in collaboration with the Institute for Transport Studies at the University of Leeds.

Background

The operation of a rail network is safeguarded through the use of train control and protection systems, in particular block signalling and interlocking. To ensure the absolute safety of trains and passengers, the signal at the entry to any track block is set to Red unless the block is completely ready to accept the next train; e.g. the points must be confirmed to be set in the correct directions and the track confirmed as unoccupied. This means that a train approaching such a red signal must start to decelerate and prepare to stop from two blocks in the rear, even though there may be minutes (or at least many seconds) before it arrives at the Red signal, by which time the block ahead will be cleared (as planned) in most normal operating conditions. The use of clearly conservative speed profiles on approaching such blocks has a knock-on effect on other trains and can cause a network to operate at considerably less than its full achievable capacity. In the foreseeable future, train control systems will be replaced by state-of-the-art railway traffic management systems, traditional fixed block signalling will be abandoned and there is scope for intelligent speed adaptation for trains similar to that proposed for road vehicles. Such ICT-led innovations will offer significant enhancement to network capacity, but only if the conservative 'rules of the game' are challenged at the design stage.

This research project studies a fault tolerant approach to the design and operation of the rail network. The term "fault tolerance" is used here in a broad sense, to represent any abnormalities or unexpected events in operations or equipment. Enhanced fault tolerant capability would provide safety assurance so that, in normal operating conditions, trains can adopt much faster speed profiles when approaching a 'to-be-cleared' signal block at stations and junctions than those currently permitted, effectively turning the status of 'be ready to stop' to that of 'proceed with caution'. In the rare event of a "fault" in the system, e.g. a train in front fails to move out of a signalling block as expected or points fail to operate as required, the train would be re-routed to take an alternative path. Relevant scenarios include the management of right-turn junction conflicts, train routeing through complex junctions at station approaches or the re-allocation of trains to alternative station platforms. Increased capacity will be achieved through improved capability to handle disturbances and/or reduced operating constraints, without compromising the overall integrity of the system.

Research Description

The research team has identified a number of junction/station scenarios, including a classical right turn junction, a terminus station and a complex junction with choice of multiple routes, where the fault tolerant principle can be applied to improve the network capacity and the robustness of rail operations to unexpected delays/perturbations to timetables. The research work has been carried out in two main streams by a team of researchers at two universities. The researchers at the University of Salford have concentrated in development and application of fault tolerant rules for railway operations and quantification of capacity gains and robustness improvement of the new rules in comparison with the current operation rules, whereas the researchers at the University of Leeds have been developing a comprehensive evaluation tool by adopting microsimulation methods that have been widely used in road transport studies, to assess/validate the train schedules and new timetables generated from the implementation of the fault tolerant rules.

One of the scenarios investigated by the research team is the classical right turn junction as illustrated in Figure 6. There are four possible routes: (A) trains from left to right travelling straight; (B) trains from left to right (to the curve); (C) trains from right to left straight; and (D) trains from the curve (left) to right. The fault tolerant rules in this case are applicable to the A trains from the left to right (to the curve). Under the Current Rules (CR), an A train can only be allowed to travel at full line speed approaching signals S5 and S6 if the block B16 (between S16 and S17 is clear of a potentially conflicting B train. Under the proposed fault tolerant rules, however, the speed profile of the A train is much relaxed and allowed to travel faster approaching S5 (Moderate Fault Tolerance, or MFTR) and S6 (Ultimate Fault Tolerance, or UFTR) when the conflicting block is occupied by a B train (which is in the process of travelling out of the block), which leads to time savings not only for the A train concerned but also for subsequent trains from this and other directions. In the event of the B train failing to clear the conflicting block in time as planned, the operator has the option to direct the A train to travel straight (hence the fault tolerance), with sufficient time allowed to ensure points A are in the correct position. The latter case would obviously have an adverse impact on the operation of the network as the re-directed A train would have to be recovered through another route to its intended destination, but the probability of such incidents (i.e. for re-direction) is expected to be low and can be outweighed by the benefits of getting the vast majority of trains through the junction with reduced time. In addition, the speed profile increases could be moderated to leave sufficient time to stop the A train before S6 if operators find a more measured operation may be more desirable.

A calculation of the theoretical capacity shows that the number of trains through the junction can be increased from 52 to 54 per hour under the proposed fault tolerant rules compared to the current rules (for trains in the cycle of two A trains followed by one B Train in one direction; and two C trains followed by one D train in the opposite direction and for the track parameters and train speed used in the study). A similar capacity increase is expected for more realistic/relaxed time tables, where increased headways are used to account for perturbations.

The performance gains of the proposed fault tolerant operation can also be measured by the improved operation robustness/punctuality to train delays. Figure 7 shows the impact of the delay by 60 seconds (y-axis) to one train on following trains (x-axis). Under the current rules, the delay of one train leads to the same/constant delays for all subsequent trains as if the full theoretical capacity were used for a timetable. For the same timetable, the knock-on effect on other trains can be seen to be gradually reduced if the fault tolerant rules are applied, and the timetable can be recovered after 24 trains. The implication of such a robustness improvement (with more realistic/relaxed timetables) is that network operation can recover much faster under the proposed fault tolerant rules.

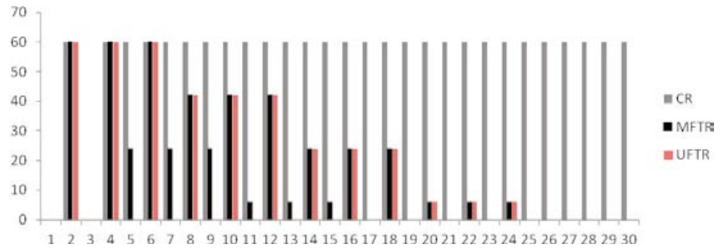

Figure 7 Impact of one minute delay to one train upon other trains at the classical junction

Expected Research Achievements

The research team is currently working on the scenario of a four-platform terminus station, which will be followed by study of operation of high and low speed trains and a complex station with multiple routes. Initial findings of the study show a similar pattern of improvement in capacity and operation robustness/punctuality. In some cases, additional gains may be obtained by making changes to track layout and/or locations of signal boxes to take full advantage of the fault tolerant rules. For large networks (connecting a number of junctions/stations such as those studied in the project), the planned work includes use of artificial intelligence methods to optimise timetables in the implementation of the fault tolerant rules. It is expected that studies will confirm the general trend of performance gains, but also demonstrate that the safety of rail operation will not be compromised by the proposed more radical (or aggressive) operation regime [ref. 12].

Industrial Impact

The potentials of the fault tolerant operations in terms of increased rail capacity, reduced travel time and improved punctuality are clear from the findings so far as described in the previous sections. The research programme also includes work packages on performance evaluation and risk assessment to ensure that the research results are clearly quantified. The new methods of rail operations are expected to offer direct benefits to rail network operators and train operating companies, who can expect increased revenues from the capability to handle more trains on the network with more reliable/robust timetables, and to passengers and freight transport users at large for shorter times for travel and/or delivery of goods.

Project Summary

This study proposes a novel approach for train control and protection, which has shown substantial performance gains. Technologically, some changes/upgrading to the signalling/interlocking controls will be required to enable the fault tolerant operation. However, such a radically new approach challenges traditional operation and safety rules in railway and questions the way of thinking, so its acceptance will need changes in the conservative mindset in rail operations to take advantage of the great potentials in improving rail network capacities.

The project is being undertaken within the Control Systems Group, School of Electronic, Electrical and Systems Engineering at Loughborough University.

REDUNDANTLY ENGINEERED POINTS FOR ENHANCED RELIABILITY AND CAPACITY OF RAILWAY TRACK SWITCHING (REPOINT)

Background

Points in railway networks are essential to allow multiple routes between different destinations. However they are also performance-limiting parts of the network in terms of capacity, as a switch failure will almost always lead to extensive delays, re-routing and cancellations. In order to ensure safety, there are necessarily very conservative rules on the control of vehicles approaching switches. Historically this has not generally been an issue, and only presented a problem at the most congested of locations. The solution to capacity issues used to be 'build more track' – nowadays it is a little more complex than that!

With increasing traffic now vying for the same piece of railway, new solutions need to be found. This becomes even more pertinent with the advent of moving block signalling systems. No matter how many trains we can theoretically squeeze down a section of plain line, switches still represent a fixed, stationary obstruction, and consequently become the primary limiting factor in the theoretical vehicular capacity of that network.

Railway signalling pioneered the 'fail safe' principle, but the historic focus has been upon safety – and rightly so. However this has been to the detriment of performance in some instances. Other industries have adopted the 'fault tolerant' approach to safety-critical systems requiring high availability, yet rail has been slow to adopt. For example, aircraft control surfaces typically have quadruple independent actuation. This is sufficient to justify a safety case to enable them to take off. The 'fault tolerant' principle prevalent in other industries has made only minimal inroads in recent years, and even then not into switch and crossing designs.

Research Description

REPOINT is investigating ways in which the performance of switches can be improved, by exploiting ideas which are commonplace in other industries such as fault tolerance and redundant actuation. Looking to the future from a signal engineer's point of view, the ultimate goal might be to have switches which were as safe and reliable as plain line, enabling moving blocks to pass through unhindered without additional junction margin - consequently releasing the true theoretical capacity of adjoining track.

The aim of the research is to address the question, "Could a fundamental re-think of railway track switching ease some of the current route-setting constraints to provide higher capacity, and provide a significant reduction in operational unreliability arising from failures in switches?"

Hence the main thrust of the project is concerned with generating and demonstrating new concepts for track switching. Much like track switches, the project sits at the interface of several disciplines and is therefore multidisciplinary in nature. The main research activities are: identification of suitable track sections for case study; understanding current operational requirements and constraints, and their effect on the case study sections; development and demonstration of redundant switching concepts; and quantifying the benefits in terms of capacity and reliability compared with current practice.

The project is in the final six months, and at this stage it is clear that significant benefits can be obtained. It has been found that replication of existing technology can offer some incremental benefits in terms of reliability on some routes. The most exciting part of the research has been that concerned with generating new concepts; this has led to the development of a transformational switching technology, which in principle enables significant changes to the rules of train control around switches. As each junction is unique, two case studies have been selected at different ends of the spectrum, in order to quantify the potential benefits. A 'simple node' – a typical HS2 Junction; and a 'complex node' – Waterloo Station Throat.

Work on the simple node evaluation is largely complete and shows promising results. A combination of mechanical design changes and control changes has been evaluated. The results are compared to the published HS2 Plain-line and converging junction (limiting factor) capacity in Figure 8, in which the REPOINT options are:

- L1: No signalling changes, REPOINT switch fitted to current track design;
- L2: No signalling changes, track alignment modified to allow high-speed turnout route;
- L3: Signalling design changes and modified track alignment.

If the network is designed from scratch for the inclusion of REPOINT switches, with full ETCS Level 3 and ATO, then 99 second minimum signalling headways are theoretically achievable. This translates to eight extra operational train paths per hour above the current in-service specification.

Expected Research Achievements

Novel switch designs have been proposed which remove all the most common failure modes of existing designs. These designs are at a concept stage and soon to be constructed as a scale demonstrator. The parameters of the designs will be simulated using industry standard software to demonstrate what gains in operational reliability and capacity are possible, in simple and complex scenarios. This will include the use of perturbed timetables to give an indication of service quality improvement.

Industrial Impact

At deployment, a significant increase in switch availability would be expected leading to a corresponding increase in service quality. This is delivered firstly through an increase in reliability via the fault tolerant approach, and secondly through reduced downtime due to the heightened maintainability of the design; most maintenance tasks, including replacing actuation units, could take place during operating hours. The modular nature of the proposals would also serve to keep whole life cost to an acceptable level. However, the main impact comes from the step change in capacity through the relaxation of the junction control rules with the deployment of a switch which is always in a safe state. The magnitude of this increase differs at each particular node; our simulation work seeks to clarify the exact level of capacity increase achievable.

Project Summary

The project investigates the use of novel track switching approaches, some of which incorporate ideas from other industries such as redundancy of actuation. An investigation into replication of subsystems using existing designs demonstrates extra asset availability can essentially be purchased [ref. 13]. However, for the step change in capacity which the project seeks, a complete redesign of the switching mechanism would be necessary. Concepts have been proposed to provide this functionality and are awaiting intellectual property protection before further dissemination. The work additionally looks into how these changes would affect two case study nodes – a junction on HS2, and Waterloo station throat. In the near future it is planned to construct a laboratory scale demonstrator.

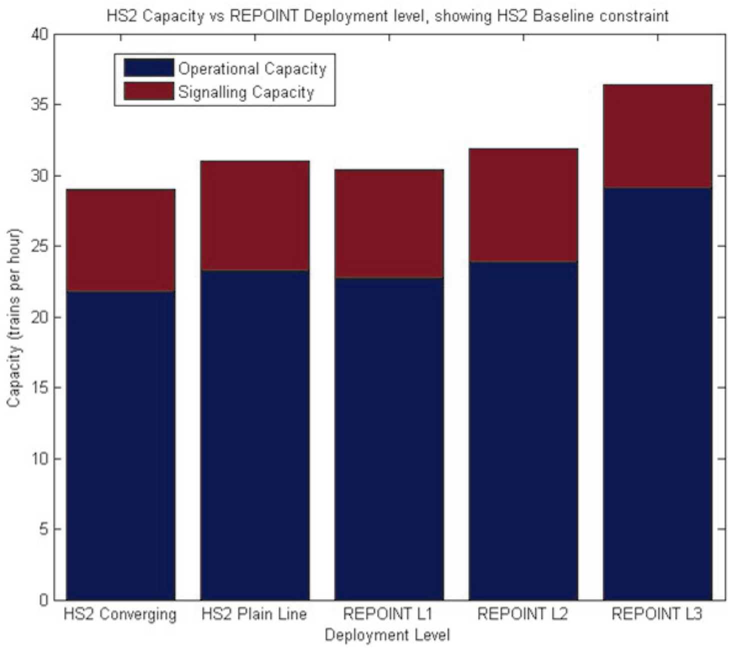

Figure 8 Expected nodal capacity at a converging HS2 junction

CONCLUSIONS

The set of projects explicitly has long-term speculative objectives, and it is certain that further work is required to develop the ideas. In addition, at the time of writing most of the projects are unfinished and so the paper is based upon anticipated outcomes. Nevertheless it is important to provide an overall commentary upon what has been achieved. Also, as explained in the Introduction, the quantification of capacity is not straightforward, and so five potential aspects have been identified in order to bring together the outcomes of the portfolio of projects:

- direct increase of theoretical capacity;
- increase in operational capacity;
- direct increase of asset reliability;
- improved resilience to disruption;
- improved tools and techniques for design and planning around nodes.

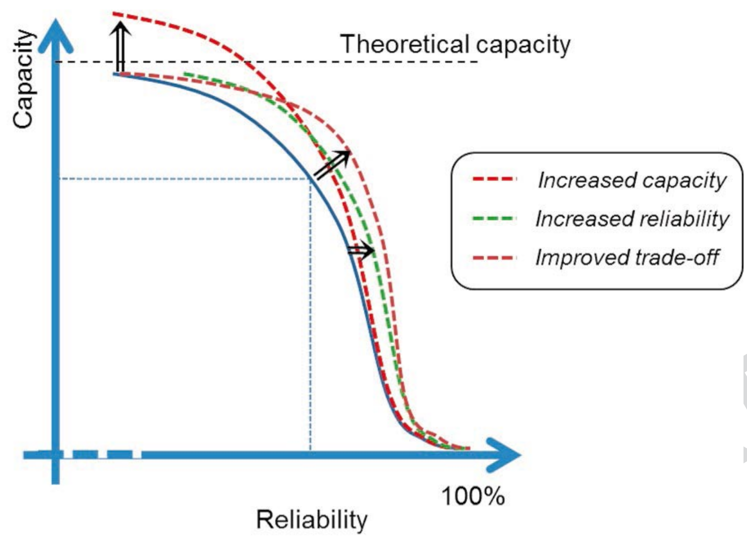

Figure 9 Changes to capacity-reliability trade-off curve

Figure 9 shows, in a non-quantified and relatively simplistic manner, the impact of the first, third and fourth upon the capacity-reliability trade-off. Note that improved resilience increases neither theoretical capacity nor intrinsic reliability. Instead it provides a more favourable relationship around the normal operation conditions, which can improve either operational capacity or reliability.

Main Research Contributions

The key contributions are summarised below by a short statement for each project and Table 2 sets these in the context of the five outcomes listed above:

- OCCASION: a new planning tool incorporating sophisticated optimisation in order to identify opportunities for additional train paths;
- SafeCap: a formal definition of capacity underpinned by new design/planning tools to evaluate capacity enhancement scenarios whilst incorporating formal proof of safety;
- Dynamic Responsive Signals: improvements in network following disruption resilience (and hence operational capacity) by means of real-time dynamic optimisation of train trajectories and sequences ;
- Fault-Tolerant Rules: exploitation of alternative paths through junctions to provide greater resilience and enhanced capacity;
- REPOINT: novel, high-reliability track switching concept that maximises operational availability and capacity.

Project	Increased Theoretical Capacity	Increased Operational Capacity	Increased Reliability	Improved Resilience	Design/ planning tools
OCCASION		✓			✓
SafeCap	✓	✓			✓
Dynamic signals		✓		✓	
FT rules	✓	✓		✓	
REPOINT	✓	✓	✓		

(Shading shows the principal target for each research project)

Table 2 : Contributions towards capacity-reliability trade-off

Overall Impact

Two overall objectives of the strategic research initiative were included in the Introduction: these are repeated below with comments against each.

To help assess the extent of capacity enhancement possible through innovative changes to nodes:

- The projects have each provided a quantification of the possible improvements. Unfortunately it is not straightforward to determine what might be the combined capacity enhancements. A simple summation is not appropriate, partly because some of the benefits may be mutually exclusive, but more fundamentally because the methods of quantification are not all the same and they are applied to different examples of nodes. Further research is therefore needed to assess the overall outcome, including an appraisal of whether applying some of the techniques together might bring additional benefits.

To help identify the most promising technical approaches to implement such changes:

- Software: the technical requirements of most of the projects relates to sophisticated design, planning and optimisation software, including the capability for real-time optimisation in order to handle dynamic re-scheduling. It is possible that the different approaches, particularly those corresponding to the first three projects, could be usefully brought together in a single complex software tool;
- "Hardware": REPOINT identifies specific changes to the structure and technology of switches that would bring about substantial benefits, but full exploitation particularly at complex nodes would also require this new software;
- Rules: this is not directly a technical requirement, but benefits arising from re-thinking the existing rules are a consistent theme in the set of projects.

Final Remarks

Although existing software tools were considered by the research teams for modelling and simulation studies to assess benefits, none of the projects was able to take advantage of them, for a variety of reasons. Therefore a key overall conclusion is that there is a need to develop an integrated tool that can simulate the system at a variety of levels ranging from the highest-level operational aspects through to the hardware details of the infrastructure and train control system. This might be something completely new, but an alternative approach might be a software environment that can bring together a number of the existing software systems, for example as has been done to enable system-level assessment of vehicle-track interaction with VTISM (Vehicle/Track Interaction Strategic Model) [14].

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Siemens agrees to buy Invensys Rail

Siemens AG confirmed on 28 November 2012, that it had agreed to purchase Invensys Rail, the signalling arm of the UK-based industrial automation group Invensys. Valued at €2·2bn, the deal is expected to be completed by mid-2013, subject to regulatory approval and endorsement by the Invensys shareholders at a General Meeting in December.

With revenues of approximately £800m a year, Invensys Rail will extend Siemens' presence in the signalling and automation market. The Invensys Rail activities, including the long-established Westinghouse, Dimetronic and Safetran brands, will be integrated into Siemens' existing Rail Automation Business, which forms part of the Mobility & Logistics Division of the company's Infrastructure & Cities Sector. Headquartered in Berlin, this business unit has around 6500 employees and an annual turnover of €1·4bn.

Both companies are currently reviewing their portfolios, and Siemens has announced its intention to dispose of several loss-making activities, including its postal sorting and baggage handling businesses and its domestic lighting subsidiary Osram.

Invensys had been looking to reduce its pension fund deficit of around £490m. Invensys plans to reserve up to £625m of the sale proceeds against current and future pension fund liabilities. A similar amount would be returned to shareholders through a special dividend payment. Invensys shares rose 27% on news of the sale, amid speculation that the company may also sell its industrial controls division.

'The combination of the regional activities, portfolios and customer offerings of Invensys Rail und Siemens will ensure profitable growth opportunities worldwide', said Jürgen Brandes, CEO of Siemens Rail Automation, adding that the company *'has a strong footprint and a well established reputation with customers in the UK, Spain, the USA and Australia. In recent years, Invensys Rail has also successfully expanded its business into fast-growing emerging regions.'*

Siemens highlighted potential synergies between the two product ranges, including Positive Train Control (PTC) for the US market; Invensys Rail's range of lineside equipment is expected to complement Siemens' recently-developed Trainguard PTC On-Board Unit. Further synergies are envisaged in the urban sector, where both companies are active in supplying Communication Based Train Control systems.

Indian metro CBTC contract

Thales has announced a 'landmark' contract to supply PPP contractor Larsen & Toubro with SelTrac Communications-Based Train Control (CBTC) along with integrated communications and supervision systems for the future Hyderabad metro lines 1, 2 and 3, totalling 72 km and 66 stations in India. CBTC will support driverless operation with on-board attendants.

The integrated communications and supervision element of the contract covers systems including voice and data transmission, passenger information, fault reporting, CCTV and access control.

Why is Innovation so Difficult in Railways?

Edited on behalf of the IRSE International Technical Committee by Markus Montigel

A contribution by the International Technical Committee to the IRSE Centenary theme "100 Years of Facing the Future"

Railways, and signalling in particular, are not generally well-regarded for being innovative. Talented job applicants with a high-tech back-ground, such as software engineering, are predictably surprised when told that mechanical computers (i.e. interlockings) are still widespread in the railway system, even if not a mainstream technology, and that relay-based interlockings are still regarded by some as "modern", and in certain respects are considered to be superior to ones based on electronics.

To an outside observer who is familiar with the fascinating potential of modern technology, the pace of innovation in railways might well be perceived to lag behind other industries just a bit too much. This observation applies not only to signalling but also to the speed of change in railway telecommunications, when compared with commercial and consumer telecommunications

When railways were first introduced, they represented an industry where cutting edge innovation occurred. For instance, when the first mechanical interlocking was installed in 1843 at Bricklayers' Arms Junction, England [1], it was in fact a state-of-the art logic computer, occurring at a time when Charles Babbage was working on his mechanical computing machines [2]. The mechanical technology for conquering arithmetic problems is long gone, yet mechanical interlockings are still here.

So it is reasonable to ask the seemingly simple question – why is that? Why are mechanical interlockings still being renovated? If in fact there is a business case for such an activity (compared with using lean IT technology with its associated potential for efficiency improvement in operating the overall system) – then should we not ask if something has gone wrong with the innovation process in railways, and if so what and why?

To avoid confusion about what is meant precisely by "innovation" for the purpose of this article, we should distinguish between "innovation", "invention", and "technological development/improvement". For the remainder of this article, the following definition and distinction is adopted:

"Innovation is the development of ... different or more effective products, processes, services, technologies, or ideas that are readily available to markets, governments, and society. Innovation differs from invention in that innovation refers to the use of a novel idea or method, whereas invention refers more directly to the creation of the idea or method itself. Innovation differs from improvement in that innovation refers to the notion of doing something different (Lat. innovare: "to change") rather than doing the same thing better." [3]

No one would claim that there is a general absence of innovation (or inventions or technological improvement for that matter) in railways. The European Train Control System (ETCS), Positive Train Control and Speed Advisory Systems for instance, can clearly be considered as being innovations, based on various inventions and making use of general technological development.

To illustrate the differing ways in which innovation is perceived, some people consider that relay-based and electronic interlockings are just "doing the same thing better" than mechanical ones. Others point out that the range of safety functions implemented in modern software-based interlockings, e.g. relating to overlap and flank protection, is much more advanced; not to mention the potential for improved efficiency by remote control and automation that they offer. They would therefore claim that these advances are "innovative" according to the definition given above.

There is one factor above all others that governs the speed of introduction of innovation on rail systems, namely the "scale" on which the innovation has to be applied in order to be worthwhile. Thus, for instance, Disneyland had moving block in the 1970s; and some metro systems have driverless trains. But these are localised applications.

These advances have occurred not because the engineers in those areas are any better or more innovative than signal engineers working on large railway networks. On the contrary, one could argue that maintaining a large quantity of heterogeneous technology across a large and distributed infrastructure network with such a high level of safety and reliability is an art mastered by no other engineering discipline to the same extent. The longevity of mechanical interlockings could be claimed as proof of the signal engineer's far-sighted design, rather than being a criticism.

It is however apparent that the scale (size) of a railway network, and the large number of people/bodies that need to be aligned in order to introduce any change, seem to pose more challenges to the innovation process than in other contexts where localised innovation is possible. A further difficulty with innovation may be that railways are a mature industry, so that innovations do not easily offer returns on the investment made.

In addition, there appears to be a number of more subtle reasons for the failure of innovative ideas in our engineering domain, including:

1. The new idea does not fit with the existing (often aged) infrastructure;
2. The new idea does not fit with the culture of the corresponding railway/country;
3. The new idea does not fit with existing regulations and operational proce-dures;
4. The idea does not meet a real need, in the opinion of railway experts;
5. The originators of the idea are not trustworthy and/or do not have the right background, in the opinion of railway experts;
6. The originators of the idea (or the organisation they work for) are not considered to be likely to be around for long enough to support the innovation through its whole life cycle, right through to obsolescence (50 years or more);
7. In the opinion of railway managers, there might be no business case for the idea;
8. There might be a business case on the global level, but local application within a fragmented industry prevents the potential benefits from being realised;
9. The market potential is seen too small for investment by railway suppliers, because the application circumstances differ too much from country to country;
10. The idea is innovative at a component level, but there are no standardised non-proprietary interfaces to enable replacement of the old version with the new one, without renovating the systems of several other suppliers at the same time;
11. Safety approvals appear too difficult to obtain, or there are other liability issues that cannot be overcome;
12. No sensible roadmap can be constructed upgrading the entire network.

Having established this list of plausible reasons for the failure of new ideas to reach the implementation phase, the fact that innovation appears to lag behind in the railway industry seems less surprising.

However at the strategic level, it should be clear to all stakeholders that any system that consistently lags behind in its application of technology will lose its competitiveness sooner or later and hence be removed from the surface of the Earth, or be banished to the museums at best! Given the current cost base of our industry, one main goal of innovation must be to lower the whole life cycle cost of systems and thereby make change more attractive.

As stated earlier, this article does not suggest that engineers in other comparable industry sectors are better than those in our own. On the contrary, other systems that comprise a large collection of existing infrastructure, such as air traffic control, seem to have similar struggles. For instance, the introduction of new generations of transponders into aircraft fleets takes some 40 years. In comparison, the 20 or so years that it took for ETCS to move from concept to its first reasonably efficient introduction in a project (the Lötschberg Base Tunnel in Switzerland) seems surprisingly fast.

Cleary, no one can imagine a quick technological, "i-phone-like" revolution in railways. On the other hand, at the very least evolutionary innovation should and must be possible. True innovation needs a clear vision as to how we want to operate our railways and rail transit systems in the future, and needs pioneers/champions committed to take on the challenge of delivering that vision fast enough, such that the investments pay off.

Looking again at the "12 reasons" stated above it should be obvious that we need to distinguish between "valid reasons" that hinder innovation – intrinsic and unavoidable in the system "railway", and "other reasons", which would cease to obstruct innovation if the right structural changes were made at the strategic level. For example, considerable progress with the standardisation of interfaces in road traffic control systems (see reason 10 above) – another strong competitor of the railway – seems to have been made already. If, as a consequence of such advances, this reason were no longer apply to apply in the rail sector, it might also remove other obstacles (e. g., nos. 1, 6, 8, 11).

Based on this example it seems worthwhile establishing a more comprehensive list of reasons for relative scarcity of innovation in our industry, and to perform a cause-consequence analysis in order to understand the underlying mechanisms better. However, that would be part of the next step, i.e. answering the question "How do we make railways more innovative?", which lies beyond the scope of this article.

Some people might argue that this article delivers no real news and that there are other underlying obstacles to innovation. For instance, during the development of ETCS the standardisation of interfaces on the vehicle had been proposed, but was declined by industry, suggesting that the difficulties with innovation may also be attributed in part to conflicts of interests. This may be true, but nevertheless a fundamental review of the mechanisms of innovation in our industry still seems to be a crucial step for long-term success.

Clearly, no single stakeholder in the rail industry would be able to remove a sufficient number of hindrances to innovation. Therefore it would seem necessary for governmental agencies, railway companies, suppliers, research bodies – and indeed the IRSE – to collaborate and to establish roadmaps for removing obstacles for innovation in the railways, while taking into account the particular interests of each group.

Given the IRSE Centenary theme of "Facing the Future", if the vision for the future and the pioneers/champions committed to implementing this vision do not reside within a body such as the IRSE, then where do they reside?

[1] *http://en.wikipedia.org/wiki/Interlocking*
[2] *http://de.wikipedia.org/wiki/Charles_Babbage*
[3] *http://en.wikipedia.org/wiki/Innovation*

The Challenge of Hanzelijn

By Ron de Croon, Francois Hausmann, Paul Visser, Peter Musters and Adrick Broeils, edited and updated by Wim Coenraad

On 9 December 2012, Queen Beatrix opened the Hanzelijn and on 12 December commercial service started. This marked the conclusion of a successful project, in which 40 km of the line connecting Lelystad to Zwolle were equipped with ERTMS Level 2 in a dual signalling configuration with the existing Dutch Automatic Train Protection (ATP) system. This article aims at updating IRSE NEWS readers with this project and is based largely on an article previously published in the Signal & Draht magazine.

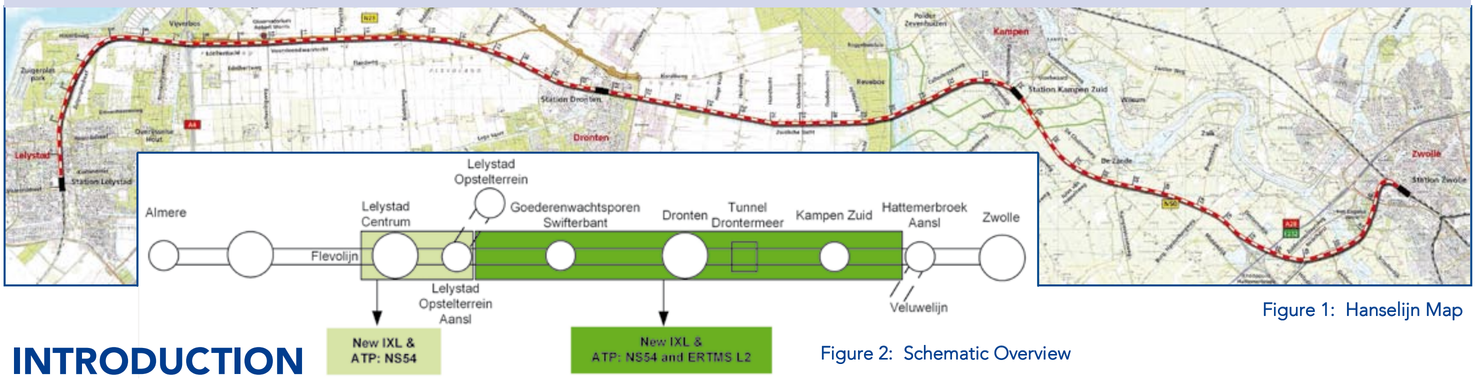

Figure 1: Hanselijn Map

Figure 2: Schematic Overview

INTRODUCTION

In May 2009, ProRail awarded a contract to the HanzaRailTeam group for the construction of the Hanzelijn railroad connection. This is a new mainline track between the cities of Lelystad and Zwolle, connecting the north of the Netherlands to Schiphol Amsterdam Airport. The new line will reduce travel time between these two regions as well as traffic on the busy, existing Veluwelijn railroad line. Parts of the corridor between Zwolle and Amsterdam have been prepared for a speed of 160 km/h, whereas Hanzelijn, designed for 200 km/h, has been designated as a high-speed line. The challenge of Hanzelijn was to design and construct a line for 200 km/h, using not only existing components for track and catenary, but also track circuits and so on, to preserve compatibility with the existing Dutch ATP. The maximum speed allowed according to the current Dutch design standards is 140 km/h. (Figure 1)

The Hanzelijn signalling has been designed as an overlay system combining the national ATP system with ERTMS Level 2.

HanzaRailTeam (HRT), a consortium of Alstom, Arcadis, Volker and Strukton, met this challenge together with their customer ProRail. Early on in the project, extensive discussions took place between HRT and ProRail in which open communication, transparency and trust were keywords. Below are some examples of the requirements discussed:

- Conditional emergency stop;
- Transitions to ERTMS Level 2 and;
- Interface with tunnel technical installations.

The requirements were discussed in detail and ProRail's expectations of these functions were clarified, limiting any development risks.

The project entailed not only a new line built in a Greenfield environment, but also the re-signalling of Lelystad Station. ProRail decided that the same type of interlocking should be implemented at Lelystad Station as will be used for the Lelystad-Zwolle connection.

Although in theory a single interlocking computer could be used for the entire line, two separate systems were installed for the simple reason that they are controlled from different dispatching centres, namely Amsterdam and Zwolle. Another important reason for implementing two systems concerned the migration strategy. Over the course of a single weekend in September 2011, Lelystad Station was switched to the new interlocking. This was also the starting point for the integration tests on the new track with the overlay system, which lasted about one year. (Figure 2)

The requirements for this project were quite extraordinary: ProRail has integrated the specifications of the interlocking functionality with those of the ERTMS functionality into a single set of requirements, called SPES for short. SPES is based on Euro Interlocking (the predecessor of the INESS programme) and ERTMS 2.3.0d.

Use was made of the experience gained during several Dutch projects. In 1998, ProRail started on the first ERTMS pilot projects and today, with Betuweroute and the high-speed line to Belgium and France as examples, ProRail already has gained several years' worth of experience with ERTMS Level 2 tracks in commercial operation. One aspect where Hanzelijn differs from Betuweroute (also an Alstom project) is that on the Hanzelijn the 'track ahead free' function is disabled, but the SPES specific-ations also define other differences.

From September 2011 until June 2012, an intensive System Integration Test (SIT) campaign took place. The first part of this period was taken up by the SIT2 programme, testing the whole of the signalling system, including track, catenary and signalling, followed by SIT3, testing operational procedures, leading on to the route familiarisation programme for NS drivers.

All tests results were integrated into the infrastructure safety case produced by HanzaRailTeam for the entire infrastructure. This was perhaps the most spectacular challenge of the project.

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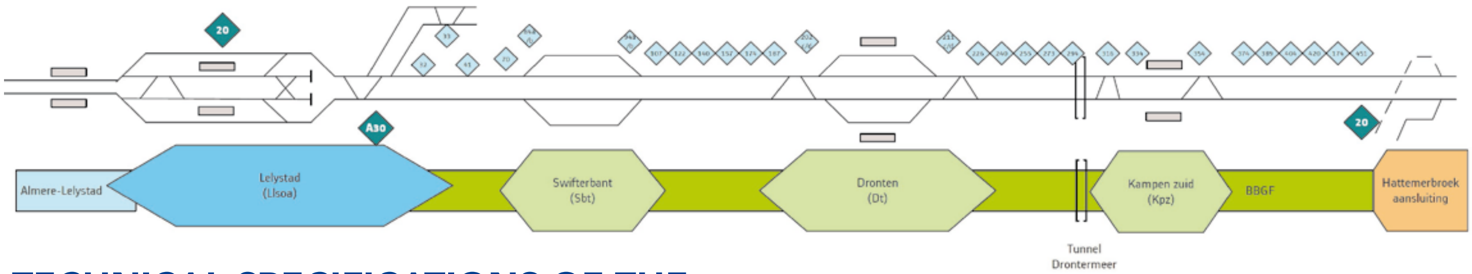

TECHNICAL SPECIFICATIONS OF THE SIGNALLING SYSTEM

ProRail's requirements in dealing with signalling were mainly functional in nature. In addition, the contract includes documents defining the signalling system in a non supplier-specific way. To accomplish phases 3, 4 and 5 of Cenelec EN 50126 (Risk Analysis, System Requirements and Apportionment of System Requirements), engineering consultancy company Arcadis specified the requirements in more detail and drafted them into an integral rail traffic design with emphasis on the placement of signals.

The technical specifications describe the signalling system in relation to the other track systems. They provide functional descriptions of those designs that differ from the standard ProRail design rules. The specifications are divided into two parts: the first part covering the conventional signalling principles of the Netherlands, using wayside signals and Dutch ATP, the second part describing specific ERTMS principles, including transitions with adjacent signalling systems.

The technical specifications of Hanzelijn contain several novelties, some of which are described further on in this article.

THE ARCHITECTURE OF THE SIGNALLING SYSTEM

The signalling architecture and equipment used by Alstom for Hanzelijn is essentially the same as that implemented on the Betuweroute [Ref 1]. They consist of (see Figure 3):

- Smartlock interlocking (SML300T);
- ERTMS Radio Block Centre (RBC);
- Interface servers (VIS) to dispatching centres (VPT);
- Track worker safety ensured through the use of HHT (Hand-Held Terminals).

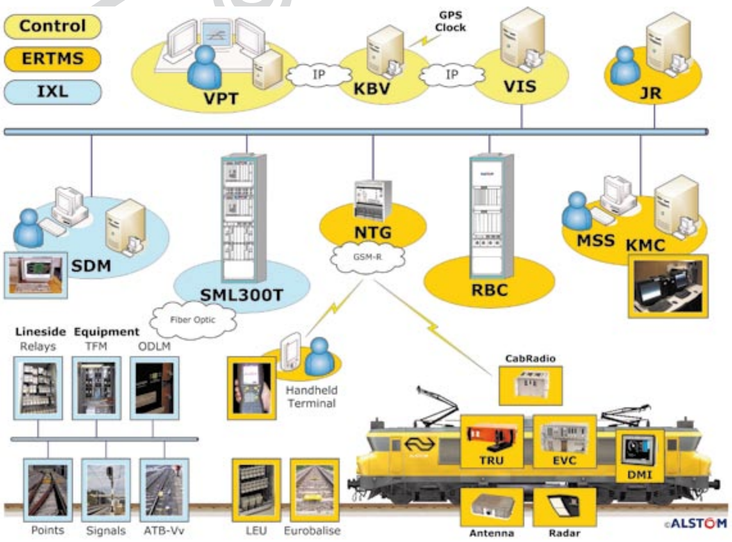

Figure 3: Signalling architecture

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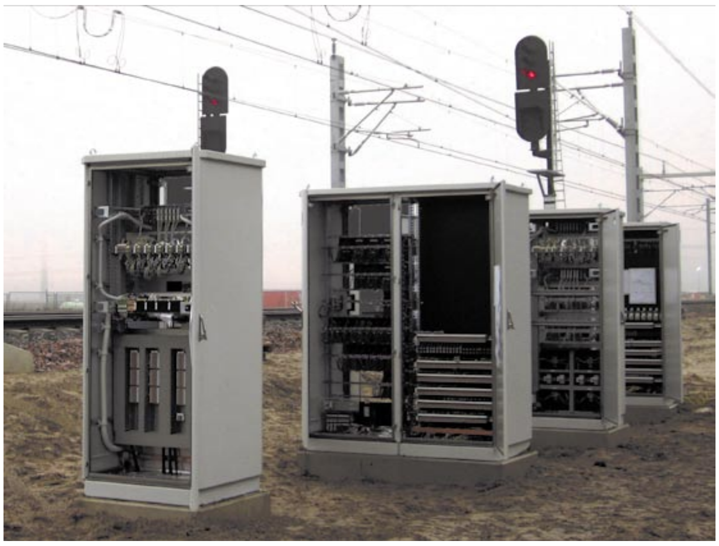

Figure 4: Line layout with interlocking object controller cabinets

Figure 5: New Hanzelijn track showing equipment cabinets

Figure 6: Signalling cabinets with object controllers

The central computers (RBC, SML300T and VIS) are installed in a relay house near Lelystad Station. The interlocking system communicates by means of a duplicated optical fibre network with the object controllers (Trackside Functional Modules, or TFM), which are installed along the line in new standard-design outdoor cabinets. The interlocking system interfaces with the Amsterdam and Zwolle VPTs via VIS computers (VPT Interface Servers) and uses a redundant ATM network via a dedicated optical fibre link.

Track worker safety is ensured through the use of HHT (portable PDAs, or Hand-Held Terminals), allowing workers along the line to take possession of work areas.

The HHT system communicates with the central interlocking system through GSM-R and via the RBC. (Figures 4, 5, 6)

IMPROVED SIGNALLING FEATURES ON HANZELIJN

Software Evolution

The following features are included in the software release applied to Hanzelijn, providing improved performance for the signalling operators.

On-line Key Management

In ERTMS Level 2 applications, the RBC and the ETCS On-Board Unit (OBU) must know their respective ETCS identity in advance and must share an authentication key. If new ERTMS-equipped rolling stock is to be allowed on the line, the corresponding tables in the RBCs will have to be upgraded accordingly.

With the Hanzelijn application, it will be possible for a user to download from the RBC updated lists of ETCS OBUs and their related keys. This allows the addition, removal and modification of train keys without the need for out-of-service periods or support from the RBC supplier.

Train Category Management

The behaviour of the signalling system has been adapted to the train categories assigned by the ERA ERTMS Unit. It treats trains in the Freight category (brakes operated in "P" or "G" position) differently from trains in the Passenger category. The freight train line speed is maximised at 100 km/h while the passenger train line speed is maximised at 200 km/h.

In addition, the RBC is configurable to send Temporary Speed Restrictions (TSRs) and text messages depending on train category. For example, only the drivers of passenger trains will receive text messages announcing the next station.

Enhanced Route Release

Specific functions have been implemented to speed up the route release process for ERTMS trains.

The Smartlock interlocking continuously informs the RBC about the status of the route setting, on which basis the RBC generates Movement Authorities (MA) to the associated ETCS trains and informs the interlocking system when a MA that allows the train to pass the signal has been sent to the train.

When a route cancellation occurs, the interlocking uses this information to determine whether the train approaching the revoked signal is running under conventional ATB (Automatische Trein Beïnvloeding – the Dutch ATP system) or under ERTMS Level 2. In the case of a train running under ATB, the route release uses the conventional process based on track occupancy within the signal approach distance in combination with a route release timer.

If the train is running under ERTMS, the RBC will ask the OBU to confirm via a Cooperative shortening of MA whether the train is able to stop in rear of the revoked signal. If the RBC transmits a positive answer from the OBU to the interlocking, the route will be released immediately. In the case of a negative answer, the RBC will inform the interlocking that the route may be released when it detects that the train is at standstill and the MA has been reduced on-board.

Conditional Emergency Stop Used as Flank Protection

For ERTMS Level 2, in case of a route revocation due to a safety violation, the relevant signal will be reset to danger and a Cooperative shortening of MA and an MA shortened to the revoked signal will be sent to the train (see under *Enhanced Route Release* above). When a train passes a signal and a safety violation occurs in the block on which the train is running, a mechanism has been introduced to send a Conditional Emergency Stop (CES) to stop at the start of the track circuit that needs to be protected. Alstom and ProRail have analysed the Hanzelijn's track layout to determine on which track circuits the mechanism should be implemented. They found that it should be implemented mainly in the track circuits in points. Refer to the example in the CES Flank Protection Figure below: route 2502-2534 is locked and used by Train A, so if the track circuit covering point 2517 is occupied (in this case it is occupied by Train B), a CES will be sent to Train A. (Figure 7)

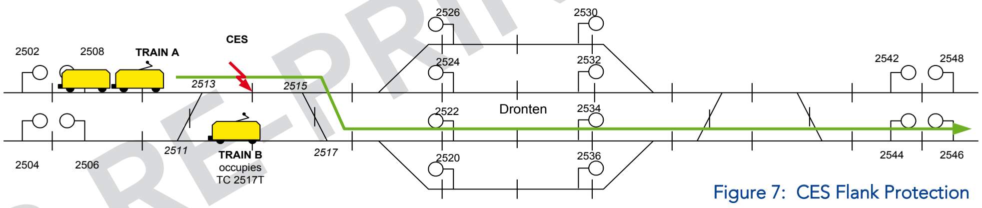

Figure 7: CES Flank Protection

Transition to ERTMS Level 2

The Hanzelijn has dual signalling: Dutch ATP and ERTMS Level 2, which means that the transition to Level 2 has been designed in such a way that the level transition order to Level 2 will be sent to the train by the RBC, rather than via balises. The idea behind this is to enable the transition in case of degraded mode: if, for any reason, a train equipped with ERTMS is not able to connect to the RBC (e.g. GSM-R mobile failed to register on the GSM-R network), the train can continue its journey in ATB mode, since it has not received any order to force the level transition to Level 2. In case the transition is announced by a balise group, the train will be forced to switch to Level 2 and will apply the brakes, since there is no connection with RBC.

The only exception to this is a situation in which the 'entry' signal of the ERTMS Level 2 area displays a red aspect. In that case, a balise group located at the signal will give a level transition order to Level 2 so as to force a train passing this signal at danger to apply the brakes (safety reaction).

Visibility of Wayside Signals used for the Dutch NS54 Signalling System

Because Hanzelijn has been designed for the future use of 25 kV a.c. electrification (although currently 1500 V d.c. power is applicable) and for running at 200 km/h, it uses a modified version of a Dutch standard catenary system. During the drafting of the technical specifications, special attention was paid to the visibility of signals alongside the track in relation to the new catenary system. To show that visibility will be guaranteed, signalling and catenary experts worked together in producing drawings of the lines of sight in six typical situations that are true for almost all of the Hanzelijn signals. 3-D video simulations were created because some structures and stations seemed to be positioned in the line of sight of signals. (Figure 8).

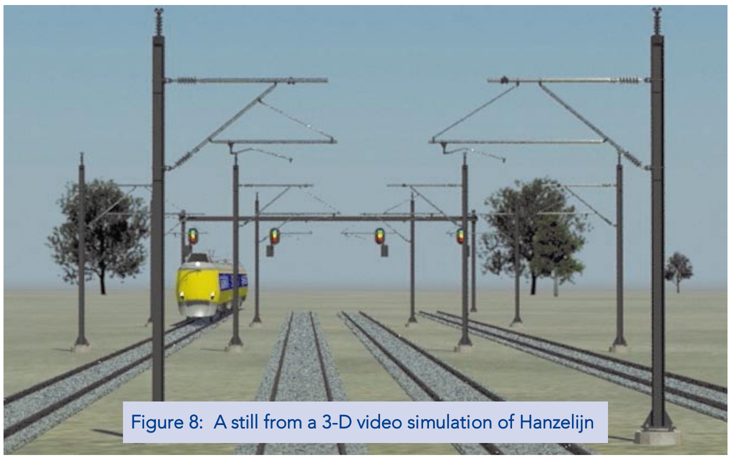

Figure 8: A still from a 3-D video simulation of Hanzelijn

Flank Protection

ProRail's views on risk assessment and control have evolved over the years. As a consequence, the perceptions of, and Dutch regulations for flank protection (in particular for new lines), have changed during the Hanzelijn technical specifications drafting process. As a result, at three locations between a signal and the next set of points, an overlap had to be implemented. Consequently, when a train passes a signal at danger, it is guaranteed that access from the adjacent tracks onto the overlap is prohibited by means of a red signal on the adjacent track. To make sure the desired functionality is achieved; track circuit joints have been defined as fouling joints, even though they are out of gauge of the adjacent track.

Tunnel Safety and Signalling

One part of Hanzelijn is in the form of an 800-metre tunnel underneath the Drontermeer. The tunnel is equipped with a Tunnel Technical Installation (TTI) that generates an alarm in case an emergency condition is detected. The signalling system supplies the TTI with information about routes, track occupation and work zones and the TTI provides the status of the tunnel alarm to the signalling system.

Several calamity scenarios have been defined in the technical specifications, depending on the aspects of the entrance signals and the position of approaching trains. The underlying idea is that a signal reverting to danger upon detection of an alarm condition in one tunnel tube, should not lead to a train coming to a standstill in the other tube, as this is to be used for evacuation purposes as soon as possible. This implies that either the train must be stopped before reaching the signal protecting tunnel, or it must be allowed pass the tunnel without stopping.

GEOGRAPHICAL INTEGRATION OF SUBSYSTEMS

The Arcadis tool Insite was used to check how the various products combined. Insite is a geographical information system that consists of a central database and can be filled with the products of all the systems involved in the design (track, catenary, signalling, cabling, etc.). The result is a chart viewer in which all the individual objects can be identified and checks can be carried out to make sure they do not interfere with each other. In addition, it can be used to identify bottlenecks. It can provide detailed information, figures and drawings of each object, so designers can make sure that the changes they want to implement are permitted. For signalling, special attention was paid to ERTMS balises to make sure they could be placed at the locations presented in the technical specifications. Checks were carried out to ensure there is no interference by large metal masses etc.

The locations of balises and all other signalling objects were determined using GPS coordinates. This process differs from that of most of the other projects in the Netherlands, as the locations are usually determined using reference distances. After installation, the locations will have to be checked using GPS. This means that an extra check will have to be carried out on the data of the signalling system. GPS reference has also been used during the design process of Hanzelijn, meaning that the signalling data will not have to be adjusted after the objects have been installed.

TRACK WORKER SAFETY AND POSSESSION MANAGEMENT

As indicated above, hand held terminals are used to allow workers to take possession of their work zone using the RBC and interlocking, to reserve the track and protect trains from entering it, unless authorised by the work gang's safety leader. Concurrently a temporary speed restriction is imposed on the adjacent track to the work zone, the prevent ERTMS equipped trains form passing the work zone at a speed higher than the regulation limit of 140 km/h. For this reason the use of other means to protect work zones, such as track circuit operating devices is not permitted on the Hanzelijn. In addition special care had to be taken in modifying the procedures for setting up and signalling temporary speed restrictions in general as the differences between ATB and ERTMS equipped trains had to be taken into account, as well as ensuring that at level transitions between ATB and ERTMS, the TSR is not lost or forgotten. The resulting TSR processes were tested extensively during the SIT3 test phase and were found to be quite complicated and involves (too) many parties. Although the process has been demonstrated to work, the need for standardisation between similar processes on other ERTMS and dual signalled lines has been identified.

CONCLUSION

As a result of the joint efforts of HRT and ProRail, a quite advanced signalling system has been implemented, incorporating the latest ideas on the way both ETCS and existing signalling should be designed. Despite all efforts described above, the SIT2 and 3 tests have revealed a number of instances where balises had to be moved and a new release of the RBC software has been required. Other that that, the commissioning of the Hanzelijn signalling system was a smooth process, when compared to previous ERTMS projects and can be taken as evidence that ERTMS is progressing nicely along the maturity curve, towards a "works right out of the box" system.

REFERENCE

Ref 1: Implementing ERTMS on the Betuweroute, SIGNAL+DRAHT, 2007, Heft 3.

Younger Members Technical Visit to Budapest

By Vivich Silapasoonthorn and Deepak Paretha

So there we were in sunny Budapest for the 2012 Young Members International Technical visit, quite pleased with ourselves for having escaped the rainy shores of the UK. The event was kindly sponsored by Siemens (represented on the visit by Péter Faragó and Wilhelm Breiter).

The event kicked off when the delegates convened on the quiet streets of Budapest looking for the well-hidden Absovent restaurant. We assumed this was our first challenge, as finding the place needed a keen eye and excellent map-reading skills. We received a very warm welcome before being given the chance to meet our hosts on the first evening. This event would not have been possible without the assistance of Istvan Gal, who had worked tirelessly to arrange the fully packed two-day programme for us.

The floor was opened by Istvan who welcomed the Younger Members to the city and gave brief details of what to expect in the coming days. This was followed with a welcome dinner of fine Hungarian delicacies and wine, during which we all got to know each other.

DAY ONE (FRIDAY 15 JUNE 2012)

Budapest Underground Railway Museum

Our first destination was the Budapest Underground Railway Museum which was a convenient 20 minute walk away from our hostel. The Museum was opened in October 1975 and told the story of the first underground railway line to open on the European mainland, displaying the original carriages. It is situated by Budapest's Deák Ferenc tér Metro station. We were met there by Áron Pálvölgyi and Rita Brazovits-Dunai and were privately shown around by the curator.

Much of the following information can be found in the Museum Handbook. Budapest came into being in 1873 with the administrative union of Buda, Pest and Obuda and promptly entered a period of rapid development. Parliament had already approved the plan for a radial avenue to link the centre of Pest with City Park. The initial application to build a surface line along the avenue was rejected. This paved the way for the idea of building underground infrastructure instead – duly applied for by the engineering firm Siemens and Halske with the electric tramway company BVVV in 1894.

Like London Underground the cut-and-cover method of tunnelling was used. The tunnel was 6 m wide and only 2.85 m high, to fit over the main sewerage drains beneath. Ten special metal-clad and wooden-clad motorised carriages were built to carry the passengers. To fit the low tunnel, they had curved, swan-neck longitudinal supports for the bodyworks and special squat current collectors, sprung vertically and hardly protruding above the roof.

The underground railway was completed on schedule and opened on 2 May 1896. Under a provisional timetable, the electric trains ran at four-minute intervals daily, from 06:00 to 23:00. The line was 3688 m long, of which 3225 m was tunnel and the rest above ground. There was an average distance of 375 m between stations. The standard 1435 mm gauge was used. The track used the Banovits system of iron sleepers with asymmetric Vignole's flat bottom rail. To carry the overhead current in the tunnel, a 50 mm mine rail was installed. As planned, ornate halls were built over the staircase at most of the stations.

The Budapest Underground railway became a success commercially and operationally. A single ticket was valid initially for the whole journey. Later the line was divided into two fare zones. Season tickets were introduced in 1900. This line is currently in operation as Metro Line 1 (M1).

Control Room

Our second destination was the control room for Metro Line 2 (M2), a short walk from the main interchange station for the future Metro Line 4 (more on this later). The control room was located in a tall building resembling an office block.

We saw the centralised station control room first, providing an overview of the operation of Line M2. The control room can interact with the particular station area should any perturbation arise. The Service Control Centre (SCC) was located nearby. The signalling control room had an impressive semicircular mimic panel with easy access behind for maintenance. We also had a chance to see the signalling equipment room located on the floor below the SCC. Metro Line M2 uses geographical relay interlocking built in the 1960s. The relays were neatly arranged as geographical modules, with associated cost savings in design, installation and testing.

Our next destination was the new Metro Line M4 project. On the way, we noticed the customer information displays with a digital clock on the platform. Interestingly, it seemed to show the time elapsed since the previous train had departed rather than the expected arrival time of the next train. It seemed to work for the public in Budapest, but was not what we were used to. This initiated a good discussion and we noticed the white safety line on the platform was much wider (closer to 60 cm), unlike the 30 cm used on London Underground. It was experienced first-hand by one of our party members, who accidentally stepped into this zone to have a look while walking through. To our surprise, the station PA then announced in Hungarian, and the public also started waving at us, trying to tell us something but we could not work out what. Only when our Hungarian host come to our aid and said that we had stepped into the "banned" platform edge zone did we understand!

Metro Line 4 Project

Budapest currently has a three-line metro system – M1, M2 and M3, with all lines meeting in the city centre at Deák Ferenc tér station. Metro Line 4 (M4) is currently under construction, the first section is scheduled to open in 2014. We were fortunate enough to see the construction site at the busy junction of Kálvin Tér.

The group were led by the M4 project team, to the lower levels of the construction site, descending several ladders from the platform level of the existing line. These ladders led us to the new M4 platform. The main station box was impressively constructed and although there were some building materials still on the platforms, the structural and civil works were mostly completed.

Line M4 will have platform safety sensors to protect passengers if they accidentally fall on to the track. The sensor will prevent the approaching train arriving at the station, which would allow the staff to assist passengers back to safety. There were also vents along the tunnels and above the platform area (on the tunnel wall) to extract any smoke from the vicinity should a fire occur. A great system to have when you are planning a completely new line.

1 - Welcome Dinner @ Absolvent Restaurant

2 - Line M2 Control Room

3 - Line M4 tunnel under construction

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We were allowed to walk along the track, the majority of which had been installed, and walked to the next station and back. A lot of work, such as cabling, installation of the side walkways and trackside equipment was still outstanding.

After our technical visit was completed, some of us went sightseeing and stumbled into difficulty when we were caught out with unvalidated metro tickets. Luckily, some friendly banter and an invitation to see the London Underground resolved the situation.

DAY TWO (SATURDAY 16 JUNE 2012)

TranSys Simulation & Hungarian Railway presentation

At the TranSys headquarters, the second day began with a presentation by Dr. István Hrivnák about the TranSys simulation works for a number of high-profile clients around the world. Later, we were given a chance to operate the simulator and to meet the staff developing various systems. TranSys specialise in railway simulation systems for training, interlocking planning support, capacity examination of stations and railway lines and verification and validation of operating plans. It was particularly

Name of line	M1	M2	M3	M4
First operation	1896	1970	1976	(due) 2014
Signalling and Control System	Fixed block	Fixed block New Siemens 3-aspect signal	Fixed block	Automatic (CBTC/ ATC) Siemens moving block
Train length (m)	30	100	130	80 (79.8)
Number of carriages / train	3	5	6	4
Number of trains	23	22 (Alstom at end of 2012)	36	15 (2014)
First operation of Rolling Stock (year)	1973	Soviet 1970 (New) Alstom by end of 2012	Soviet 1976	Alstom 2014
Passengers Capacity	189	960	1152	807
Air Conditioning	No	No	No	Yes
Length of line (km)	4.4	10.3	17.1	Phase1 (7.4) Phase2 (3.2) Phase3 (2.1)
Number of Stations	11	11	20	Phase1 (10) Phase2 (4) Phase3 (2)
Theoretical Headway (s)	90	105	95	90
Headway (s)	100	140	150	150
Ave Speed (km/h)	21.3	32.8	30.9	32.2
Max Speed (km/h)	50	70	80	80
Traction Voltage	600	750	750	750
Upgrade	1995-1996	2003-2007	--	--

Table 1: Technical details of the Budapest Metro system, information courtesy of BKV Zrt – Budapest Metro, with thanks to Lajos Darai and Rita Brazovits-Dunai for providing and checking this data.

interesting to see that TranSys also develops interfacing emulators for other systems (CTC, ETCS, timetable planning) to meet the bespoke requirements of their clients.

Following these demonstrations, Peter Toth, Signalling Engineer for Hungarian State Railways, gave delegates a presentation on the railway signalling technology in use across Hungary's mainline railways.

Hungarian Railway Museum

In the afternoon, the group visited the Hungarian Railway Museum and met Mr Zádori, a leading expert in Hungarian railways, locomotives, and of the equipment and machineries in the Museum. The group visited a model railway and got to race two of the trains around the track which was great fun for all. We were also able to sit on a small scale, battery powered shuttle train that toured around the museum grounds.

The museum also included an excellent collection of steam engines from various eras, which were positioned around a magnificent turn table. This is still in use today and we experienced a 360 degrees turn on it. We even had a hand-powered wagon race and drove a diesel locomotive, after which we were issued with a certificate to confirm that we all passed the test!

By the end of the second day, we had a deeper understanding of both historical and current Hungarian railways, and most of all, we had great fun during the visit.

Technical Visit Dinner

The closing dinner (sponsored by Siemens) was held at Menza restaurant in central Budapest. During dinner, former YM chairman Martin Fenner thanked Istvan for helping, supporting and organising the fully packed and highly educational technical visit to Budapest. He presented Istvan with a signed thank you card by the members together with a small gift as a token of our gratitude. Thanks were also given to Siemens as the sponsors of this visit – without whom the trip would never have materialised. In addition, thanks were also offered to all the hosts of the individual visits, including Rita Brazovits-Dunai and Lajos Darai.

It was time for the YM to finally say Köszönöm (thank you) to our fantastic hosts for the great opportunity to visit the lovely city and Viszlát (good bye) to Hungary and the YM 2012 International Technical Visit.

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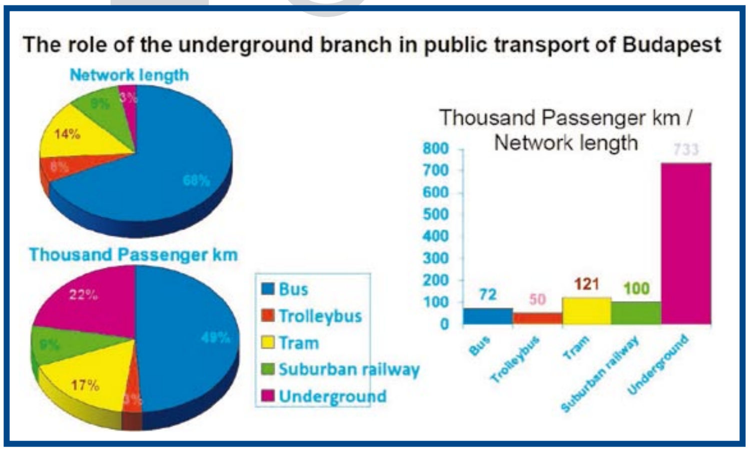


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4 - Public transport modes in Budapest

5 - Younger Members in the sun

6 - Transport included

7 - Younger Members taking a spin

8 - The group enjoying the variety of locos on show

IRSE MATTERS

PRESIDENTIAL DUTIES

All IRSE Presidents face the challenge of combining the 'day-job' (Technical Director of the Railway Industry Association in Great Britain, in my case – ***www.riagb.org.uk***), and their duties as President. It makes for a very full year. I have been asked to write this short article for those of you wondering what my Presidential duties involve during our Centenary Year.

PRESIDENTIAL STATISTICS

If Presidential activities could be measured in purely numerical terms, this is more or less what my year will look like by the time I hand over to David Weedon in April 2013:

Speeches and presentations 36
Countries visited 10
IRSE Local Sections visited 12
IRSE Council meetings chaired 6
IRSE Committee meetings attended 19
Articles and interviews for journals (exc. IRSE NEWS) 4
External (non-IRSE) events attended 10

I haven't tried to count the numbers of hands shaken!

PRESIDENTIAL VISITS

If all goes according to plan, I shall by the time I complete my term of office (at the end of April 2013) have visited all but one of the Local Sections of the IRSE around the world. The first visit was to Switzerland in March (although strictly speaking this was as Senior Vice President), followed in July by Indonesia and India. Indonesia does not yet have a Local Section, but has plans to do so by April 2013. In October I visited the Dutch section, and at the end of October and in early November I visited South Africa. I was due in Toronto (North American Section) in early December but couldn't make it due to family illness. Next stop Australia in March 2013 and, although the planning is in its early stages, in April I am due to return to Indonesia to inaugurate their Local Section, afterwards continuing on to Malaysia, Hong Kong and Beijing. In the UK, I have so far visited the York, Western, Plymouth and Scottish Sections, and the Younger Members' annual Seminar.

These visits combine many different functions. Meeting with members of the Sections is clearly important, to offer support where needed and to understand the particular issues facing them. During these visits I am usually asked to speak at meetings, often involved in discussions on topics such as the role of the IRSE, invited to see technical installations, meet with representatives of companies, and participate in social events. I am, of course, most grateful to the many people who make the arrangements for these visits and events, and I hope they find my participation as valuable as I do.

SPEAKING ENGAGEMENTS

As I have said, all these visits involve making presentations and delivering speeches, in addition to which I find myself asked to speak at non-IRSE events in the UK. The challenge of saying something different on every single one of the 36 occasions is of course too great, so regrettably some of you will occasionally have a feeling of "déjà vu" if you hear me speak more than once. I have endeavoured to tackle a range of topics, including the Rail Technical Strategy for Great Britain, the environmental impact of train control systems, university-based rail research, human error and behaviour in relation to train control systems, professional development and competence, the business basis for ERTMS, and more. In addition, of course, there are many occasions on which I have spoken about the significance of the Centenary and our theme of "100 years of Facing the Future" - at the ASPECT Conference, Convention and at other events.

COMMON THEMES

I hope you will, therefore, by now be well aware of my oft-repeated messages about our technological future, the need to broaden the appeal of the Institution, and our obligation to work for the benefit of the public. But in my travels and meetings the need for the IRSE to address other issues as well has become apparent. They include:

- The need to encourage more people to consider a career in railway engineering, and in train control and communications in particular. In places as diverse as the UK, South Africa and Indonesia the message is clear – how can the IRSE help to open people's minds to this possibility when they are at school and university? This is not something that the IRSE can address alone, but through collaboration with companies, universities and other professional bodies it might be possible to make a difference;
- Related to this is the need to strengthen our role in supporting the professional development of engineers, particularly in the early stages of their careers. I often get asked what training the IRSE provides. The answer, of course, is not much, because that is not our primary role, although there are of course exceptions, notably the substantial work that the Australasian Section has done with the Central Queensland University in developing and running their post graduate courses in signal engineering. Of course we do endeavour to meet educational needs in the broad sense through publications, papers, seminars and conferences, and specifically in assisting people preparing to take the IRSE Examination by the provision of study workshops. The question is, should we be doing more, particularly for countries in which the IRSE is active but where the current published (and online) knowledge base about railway signalling and telecommunications is relatively sparse?;
- That brings me to another frequently raised topic, namely can the IRSE do more to enable people taking the annual Examination modules to offer answers based on their own country's signalling philosophy, technology and procedures? There seems to be widespread agreement that this is long overdue, and I am hoping that the Examination Sub-Committee will give further attention to this matter in 2013;
- Finally, we need to do more to support the "learned" side of being a professional engineering Institution. The IRSE's International Technical Committee produces insightful material based on multi-national experience, challenging the boundaries of conventional wisdom and pointing the way forward on key issues. But it is constrained by the availability of experts. We also need to engage more closely with universities in different parts of the world, working with them to generate new understanding and knowledge.

Francis How

ASPECT 2012

By Ian Mitchell

Every few years the IRSE organises a 2-3 day international conference in London under the ASPECT banner – Automation, Signalling, Performance, Equipment, Control, Telecommunications. However ASPECT 2012 was special as it marked the launch of the IRSE's Centenary celebrations, and was linked with the annual International Convention, also based in London on this occasion. There were three days of conference sessions from Monday 10 to Wednesday 12 September at the Queen Elizabeth II Conference Centre in Westminster, together with social events on the Monday and Tuesday evenings. The Convention then commenced on the Wednesday evening, with technical visits and more social events from Thursday 13 to Saturday 15 September. All in all it was a busy week – this article is the first of a series to record the events for posterity in IRSE News, and focuses on the ASPECT conference itself.

About 200 people attended the full three days of ASPECT, with another 50 attending one or two days. It was a very international audience, 50% from outside the UK, representing 24 different countries. As seems to be the norm these days, there was a rush of last minute bookings, which was very welcome as it pushed the finances past the break-even point.

The highlight of the first day was of course the formal inauguration of the Centenary Year in the presence of Her Royal Highness The Princess Royal, which was described and illustrated in IRSE NEWS 183. Last minute changes to the Princess's schedule meant that we were juggling the time-table as the day progressed, but it all worked out well in the end.

By lunchtime on the first day, a number of suppliers had set up exhibition stands in the catering areas outside the main auditorium. A good selection of products and consultancy services were on show (as detailed in the table), and the programme allowed plenty of time for networking and discussions.

Over the three days, 33 papers were presented, covering a wide range of topics in the field of railway control and communications. With the centenary in mind, a few papers deliberately looked back to the history of the profession to identify lessons learned, but in the main the focus was firmly on the present and the future. All the authors have prepared a written paper as well as their presentation. These were distributed on paper at the conference and together with the presentations on a DVD mailed after the event. By the time you read this, they will also be available to all IRSE members via the Knowledge area of the IRSE web site. If you didn't get to the conference, go to the web site and catch up what you missed – there will be something there of interest to anyone involved in the profession.

It is impossible to go into detail about all the papers presented, but two deserve special mention, and not just because they were the oldest and youngest speakers at the conference:

Oskar Stadler had the slot immediately after the centenary launch with Princess Anne in the audience (until she had to rush off to undertake Olympic duties). His superbly illustrated paper described 100 years of evolution of the signalling systems at Oerlikon station in Zurich, describing how the technology has evolved to satisfy the dramatic increase in traffic demand in Switzerland over the period;

Hari Shankar Radhakrishnan was the winner of the Younger Members Paper Competition held this year for his paper "Aiming for a Successful Design Office". As well as a £500 cash prize, he received a free place at the conference and a travel bursary, which were very well deserved as the quality of the presentation was well ahead of that of some much more experienced speakers.

At the end of the conference, attendees were asked to fill in a feedback questionnaire, and there was a fantastic response, with 50% of the forms returned. The results indicate a high level of satisfaction, with strong demand for the IRSE to continue organising ASPECT conferences on a regular basis, but also a lot of detailed comments and suggestions that the IRSE will be taking account of for future events.

All in all, ASPECT was a highly successful event, but from the point of view of the organisers there were two disappointing factors. Firstly, despite our attempts to publicise the event outside the IRSE via Railway Gazette and other channels, those attending are over-whelmingly IRSE members (85%). Secondly, with the exception of the younger members who had been awarded IRSE Hewlett-Fisher Travel Bursaries to attend ASPECT and the Convention, and a group of Network Rail apprentices, there were very few young engineers at the conference.

The range of topics presented at ASPECT, and the networking oppor--tunities it provides, make it an ideal opportunity for professional development for engineers at all stages in their careers – how do we get this message across to those who would benefit from attending – and perhaps more importantly, to their employers?

ASPECT exhibitors

- *Altran Praxis*
- *Balfour Beatty*
- *DeltaRail*
- *ERA Technology*
- *Findlay Irvine*
- *Frauscher Sensortechnik*
- *Frequentis*
- *Henry Williams*
- *Interfleet Technology*
- *Invensys Rail*
- *Park Signalling*
- *Railway Gazette International*
- *Signalling Solutions*
- *Variable Message Signs*

THE PAPERS:

KEYNOTE ADDRESS – DAY 2

2.01 Systems Engineering as Strategic Approach for Standardisation of Signalling Systems
Michael Leining & Bernd Elsweiler, DB Netz AG, Germany

DELIVERING ERTMS/ETCS

2.02 Challenges to Build an RBC Interface to Existing Interlocking Systems
Laura Järvinen, & Lassi Matikainen, VR Track Oy, Finland

2.03 SAT.VALID - a New Data Validation Tool for Communication Based Train Control Systems such as ETCS
Benedikt Wenzel, Alexander Wolf, Prof. Jörg Schütte, Dresden University of Technology, & Steffen Jurtz, Signon GmbH, Germany

BEYOND EUROPE AND BEYOND ETCS

2.04 ERTMS Regional and North American Dark Territory: A Comparison
George Raymond, Railweb GmbH, Switzerland, Ron Lindsey, Communication Architecture, USA, Jörn Pachl, Braunschweig Technical University, Germany

2.05 Communications Based Signalling for the Australian Non-Urban Network - The Operations Benefits
Trevor Moore, Australian Rail Track Corporation, Australia

2.06 Automatic Train Operation: the Mandatory Improvement for ETCS Applications
Benoît Bienfait, Patrick Zoetardt, Alstom, Belgium and Bob Barnard Signalling Solutions, UK

PROJECT FOCUS

2.07 Resignalling Auckland
Noel Burton, Invensys Rail, New Zealand

OPERATIONAL CHALLENGES

2.08 The Battle Against Overcrowding - Do Longer Trains Necessarily Need Longer Platforms?
Michael Toher & Carl Gallafant, Halcrow Group Limited, UK

2.09 The Changing Role of the Control Room Operator in Rail Automation and the Challenge of Maintaining Situation Awareness
Suzanne Heape, Invensys Rail, UK

2.10 Legacy train control system stabilisation
Dr. Reinhard Galler, EQUIcon Software GmbH, Germany
Karl Strangaric, Metro Trains Melbourne, Australia

QUEST FOR SAFETY

2.11 How to Increase Track Worker Safety and Productivity
Jos Fries, ProRail, Netherlands

2.12 Booms Go Bust – Sensible Safety at Level Crossings
Peter Hughes, Derwent Group Pty Ltd, Australia

2.13 Leadership, Safety Culture and Catastrophe: Lessons from Case Studies in 7 Safety Critical Industries
Xavier Quayzin, Invensys Rail, UK

KEYNOTE ADDRESS – DAY 3

3.01 Sustainability for Signalling and Control Systems Projects, Is it Worth the Candle?
Peter Symons, Tritun Pty Ltd, Australia

MAINTENANCE AND TECHNOLOGY TRANSFER

3.02 Finnish Practices of Signalling Maintenance – 100% Outsourcing and Collaboration with Original Signalling Suppliers
Aki Härkönen, Finnish Transport Agency, Finland

3.03 Performance of New Technologies in Signalling over Indian Railways
G. K. Dwivedy, Indian Railways, India
Paper presented at the conference by Sunesh Appyuni, Atkins, India

SAFETY PRINCIPLES AND PRACTICE

3.04 The Safety Technology of Railway Signalling: Its Most Distinctive Features and its Wider Application
Yuji Hirao, Nagaoka University of Technology, Japan & Masayuki Matsumoto, East Japan Railway Company, Japan

3.05 Independent Verification of Light Rail Systems - What, When, How and Why?
Steve Boshier, Hyder Consulting, Australia

3.06 Data Recording, Analysis and Corrective Action System (DRACAS) for shared systems
Richard Barrow, David Fletcher, Rail Safety and Standards Board, UK
Richard Cundy, Network Rail, UK & Derek Jackson, ATOC, UK

PROJECT FOCUS

3.07 Dubai Metro Signalling & Train Control System
Shiv Mohan, Serco Dubai Metro, United Arab Emirates

FUTURE TECHNOLOGY

3.08 The Future Challenges of Axle Counting
Martin Rosenberger, Frauscher Sensortechnik GmbH, Austria

3.09 Message Broker Technology for Flexible Signalling Control
Daren Wood & Dave Robson, DeltaRail Group Limited, UK

3.10 Next Generation of Railways and Metros Wireless Communication systems
Eric Bernard & Alain Bertout, Alacatel-Lucent, France

3.11 CBTC Suppliers Watch Out: Metro Railways in India Opening Arms
Nikhil Swami, Kolkata Metro Rail Corporation Limited, India

RESERVE PAPERS NOT PRESENTED AT THE CONFERENCE

3.12 Maximizing the Return on Investment from ETCS Overlay
Dominic Taylor, Invensys Rail, UK

3.13 Lightning Risk Analysis for Railway Signalling Systems from Observation of Lightning Over-voltages on Signalling Cables and Rails
Yuto Ono, Hideki Arai, Hiroyuki Fujita, Railway Technical Research Institute, Japan

3.14 A Proposal of Autonomous Decentralised Software Architecture for Safety-Related Systems and its Application to a Railway Signalling System
Takashi Kunifuji, Hiroshi Ito, Masayuki Matsumoto, East Japan Railway Company, Japan

Report by Wim Coenraad

The Future of Dutch Signalling: A Mini-Symposium on the Occasion of Jan Oonincx's Retirement

In May 2012, Jan Oonincx stood down as chairman of the Dutch section and recently also as the Dutch Country Vice President. On 29 November Jan also ended his active career. To commemorate Jan's retirement, his employer Arcadis organised a mini-symposium in which three speakers debated the future of Dutch Railway Signalling. The venue for the symposium was the 3rd class waiting room in Utrecht's Railway Museum.

The Dutch Ministry of Environment and transport has recently confirmed its intention, announced in June 2012, to go ahead with the roll-out of ERTMS, in response to the report produced by a parliamentary enquiry, known as the Kuiken report. As this was just before the newly formed government announced its proposed budget cuts, including a €250 million cut in the transport budget, the symposium seemed to offer an excellent opportunity to get updated on the rail sector's plans.

To set the scene, let us remind readers that the Kuiken report stated that a long term view should be taken by the government; relay technology and conventional Automatic Train Protection (ATP) should be abandoned and that consequently ERTMS should be rolled out without further ado. Furthermore, after extensive consultations with the sector, its authors were convinced this could be done with a budget of around €900 million, whereas previous ProRail estimates, were in the range of €2.6 billion.

The first speaker, Mr Eric Mink is a senior project manager within the Ministry, tasked with producing an ERTMS Dutch roll out "railmap". As the parliamentary decision-making process was still on-going, obviously Mr Mink could not enter into much detail about this future railmap, except to recall some details of the ERTMS pilot application planned for the Utrecht-Amsterdam line in 2013. As the Dutch Railway network already has three ERTMS lines in full commercial service (the HSL-Zuid, the Betuwelijn and the Hanzelijn), readers might be excused for believing an operational pilot comes as somewhat of an afterthought. However, the next speaker, Mrs Esmé Kalshoven, NS Passenger's head of infrastructure management, explained that the pilot is all about gaining operational experience, its main objective being to assess what happens when ERTMS is introduced in the network. In order to facilitate this pilot, NS will exercise the contractual option to have some 20 recently delivered Sprinter Light Trains (retro-) fitted with ERTMS. Aspects of this pilot are the re-certification of these already homologated trains after adding ERTMS equipment, the need for amended operational rules, driver training as well as the effects on the robustness and reliability of the train service. That is one of the reasons why the pilot is being held on the most heavily used corridor of the Dutch network, of which two of the four tracks have been dual signalled with Level 2 equipment supplied by Bombardier.

The third speaker, Jorn Pruntel, ProRail's professional head of signalling, provided some interesting background to ProRail's broader future signalling plans. To begin with, he reminded the

1. Mrs Conny Oonincx and Jan Oonincx, with Paul Hendriks on the right, listening to the presentations
2. Jan expressing his view during the panel discussion
3. The symposium chairman, Mrs Kalshoven, Jan Oonincx, Mr Ming and Mr Pruntel during the panel discussion

Photos: Simone Klaver

audience that the invested capital in signalling, some €3.4 billion, can be split up into some 10-20% for interlocking (in which about 240 000 B-relays are still employed), 10% for signals, 30-40% is accounted for by train detection and ATP and some 5% went into equipment housing. Earlier studies, known as BB21, revealed that replacing the ageing relay interlockings with computer based ones, would raise the associated invested capital from roughly €600 million to 1.8 billion, without adding any functionality. Whole lifecycle costs would also increase significantly. Therefore his department has embarked upon a strategy which can mainly be characterised as a reduction in the number of systems and suppliers for strategic systems, competition between engineering consultancies, competition in maintenance and ownership and management of strategic engineering data by ProRail. Through these initiatives the aim of returning to standardised functionality, giving economies of scale whilst ensuring continuity should be reached. A first result of the strategy is the recent commissioning of a PLC based interlocking, developed jointly by ProRail and Movares.

During the panel discussion Jan Oonincx stated as his point of view that ERTMS, in its present form, does not really deliver any benefits beyond the standard ATP functionality, which already exists on most railways and certainly in the Netherlands. This therefore, in itself does not justify a roll out programme. In his view, ERTMS should be used as an opportunity to reduce the inherent complexity of today's signalling technology and signal aspects. Only if we seize this opportunity Level 3 will offer increased capacity. Combining Level 3 with Automatic Train Operation (ATO) might reduce the effects of human error and offer better driving performance. Employing this combination of ETCS Level 3 and ATO, we will be able to take the step towards the High Frequency Railway concept, according to Jan. Rolling out ERTMS in its present form, whilst also implementing budget cuts; will certainly not bring the High Frequency Railway concept into reach in his opinion.

SWISS SECTION

Report by Silke Schulz

Onboard Information Platform for Swiss Public Transport Vehicles

Do you know the announcement "- *soon we will arrive on the next station with no delay, please disembark on the right side of travel direction* –"? Yes! The IRSE Swiss Section now even know where this information comes from!

On 23 November 2012, more then 20 members and guests of the IRSE Swiss Section attended a fascinating afternoon session in Gümligen near Berne. We were warmly welcomed by Swiss Section chairman Markus Montigel.

Michael Matthias of SBB's Passenger Division presented the development of an onboard software platform for the SBB, but also other railway and bus companies. It provides a highly available server platform for a variety of on-board applications. These include a passenger counting system, passenger information displays and announcements, surveillance and rear-view cameras, seat reservation displays, SOS intercoms to contact police, vehicle location tracking and GPS calibration of the train's odometer. In the future, the platform will host an application that will detect chip-carrying passengers when boarding and alighting in order to invoice their trips.

The on-board server platform includes application diagnostics and is linked with a centralised office platform that monitors and handles the applications. The vehicle platform can be extended to new applications as needed. Communication within the train is via a multimedia Ethernet network with a cable powerline connection between vehicles. The encrypted communication with the central office server is via GPRS, including firewalling and protocol management.

To illustrate the theory, we visited SBB's test laboratory for the vehicle platform. The laboratory is now testing all components of the on-board software platform for the new DPZ generation of trains for Zurich's metropolitan-area (S-Bahn) network, including all passenger-information screens and displays inside and outside the train, and the user interfaces for crew members. A simulated S-Bahn run impressively demonstrated the behaviour and functions of the vehicle platform.

Although the presentation and demonstration were not directly related to railway signalling safety, they provided informative and expert insight into another family of railway solutions. Also impressive were the cost savings through video surveillance to reduce vandalism on trains.

Markus Meyer of the company *emkamatik* (**www.emkamatik.com/index_en.html**) presented current work on the interaction of traction current and track circuits. The complex power equipment in electrically powered rail vehicles produces parasitic currents in a changing and nearly endless variety of frequencies whose range and strength can be reduced but never eliminated. Problems can arise whenever a rail vehicle's power equipment emits a parasitic current at a frequency that is the same or a multiple of the track circuit's frequency. Such parasitic currents can threaten the reliability and in some cases even the safety of rail operations. Working with the European EUREMO project and the CENELEC working group A4-2, the European Railway Agency (ERA) is seeking to harmonise these standards and the underlying frequency management scheme to facilitate international cross-acceptance of rolling stock. But this is difficult because of differences in each country's infrastructure, existing fleets and service patterns.

Markus Montigel reminded attendees of the IRSE Swiss Section's technical visit on 14-16 March 2013 in Zurich and Landquart, which will focus on signalling in the new Gotthard base tunnel and operations control on the Rhaetian Railway. The visit is open to the first 100 IRSE members from any country who register. Although a specific partner's programme is not foreseen, partners are most welcome.

An aperitif and dinner pleasantly closed the Gümligen session.

Upcoming IRSE Swiss Section events

- 14 – 16 March 2013, International Technical Visit, please see IRSE NEWS Issue 184 / December or the IRSE-Web-Site/Events
- 24 May 2013, Paper Session

In November 2012, more then 20 members and guests of the IRSE Swiss Section enjoyed some fascinating presentations of on-board communications systems.

The presentations (in German) can be requested from Heinz Walser at walser@irse.ch.

MINOR RAILWAYS SECTION

Report by Clive Kessell

The Foxfield Railway – Heritage with a Difference

Many Heritage Railways claim to be different in order to attract new customers. The differences are usually insignificant in terms of the train ride experience and relate perhaps to unusual items of rolling stock or different ways of marketing. The IRSE Minor Railways section visited the Foxfield railway on 17 November and saw for itself what 'difference' really means.

The line is near Stoke on Trent and accessed by a short walk from Blythe Bridge station. Built originally in 1894 to serve the Foxfield colliery at Dilhorne, the line took a circuitous route so as to avoid upsetting the local Lord of the Manor and necessitated some sharp curves and vicious gradients. The colliery closed in 1964 and a society was formed in 1967, achieving a purchase of the line in 1970. Its main line connection at Caverswall was severed in 1971 due to the high cost charged to the society for keeping this, although the line remains in situ to where the connection was.

Although intended as a route to Cheadle, the railway never got that far and hence never had a passenger service so preserving it for passenger use was one early difference.

THE RAILWAY AND ITS OPERATION

The operational hub is Caverswall Road station, a newly built traditional style terminus on green field land that gives a favourable first impression of how a station should look. This is around a half mile from where the line originally commenced. Inside the station building is the usual ticket office, refreshment room, bar (with some splendid real ales on offer), toilets and admin offices. At the rear is a two road museum shed with steam, diesel and electric industrial locomotives on display. To the right of the station is the single platform from where passenger trains depart together with berthing sidings. Further on the right is the somewhat cramped locomotive repair workshop, equipped with enough machine tools and equipment to be almost self-sufficient.

To the left of the station is the locomotive running shed, a carriage workshop and a collection of sidings for carriage and wagon storage. The perils of keeping rolling stock in the open are there for all to see, thus confirming the normal heritage situation of acquiring carriages being easy but with an uphill struggle always required to keep them in good condition.

From the platform, the single line descends to a valley bottom in a north easterly direction, over a level crossing at Cresswell Ford and rising again at 1 in 30 to Dilhorne Park station where there is a run round loop. Passenger services are normally only allowed to go this far at the moment, special permission being required to proceed onwards to the colliery site. The reason for this becomes immediately obvious with the line swinging round to a south east direction and down a gradient of 1 in 21 average and short lengths of 1 in 17 to the site of the erstwhile pit. Here the colliery buildings and pit head gear have been repaired and rail sidings re-laid, the intention being for it to be developed into a mining museum. A platform has been built in anticipation of a regular passenger service.

SIGNALLING THE LINE

In its operational days, the line was operated on a 'one engine in steam' principle with various special rules to protect against runaways on the gradients. Points at the colliery were hand worked. Trains were loaded to a maximum of 6 wagons going up the hill to Dilhorne Park.

It was evident however that to operate a passenger service and obtain HMRI (Her Majesty's Railway Inspectorate) sanction would require a proper signalling system.

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1. Caverswall Road (formally Hockley) Signal Box
2. Caverswall Road Lever Frame (former LMS Tappet Frame)
3. A unique Independent Block Signal between Cresswell Ford and Dilhorne Park
4. Group picture taken at the Foxfield Colliery site alongside a unique three position set of points
5. The headstocks which are planned to be restored at the Foxfield Colliery site
6. Locomotive shunting at the Foxfield Colliery site

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The main challenge has been signalling Caverswall Road station and sidings. A signalbox was acquired – the ex North Staffs box from Hockley – and equipped with an London Midland & Scottish Railway (LMS) type frame made during World War 2. Other box equipment has been purloined from Finsbury Park and Croes Newydd. Having a mix of London North Eastern Railway, LMS and Great Western Railway equipment was a lesson in non-compatible pin sizes!

The box has 20 levers of which 16 are in use controlling eight signals, four points, three Facing Point Locks (FPLs) and one king lever, more on that later. There are a mixture of signal types, both main line and shunt, these controlling a train to and from the 'main line' and most yard movements. On usual operating days, a 'one train working' operation exists but on gala days there can be up to eight engines in steam and four trains in service. Even on normal days, the various private owners of locomotives can require lots of shunting moves in the yard, and thus safely separating all of this from passenger carrying trains is a pre-requisite.

A signalling methodology had to be devised that gave the right level of protection at an affordable cost. HMRI required full route indication within station limits and a solution based on colour light ground signals was devised with green indicating the main route and yellow indicating a subsidiary route at each turnout. This applies to trains coming from the single line into either the platform or the yard sidings.

Another challenge has been what relays to use; on UK main line practice, totally different technology exists between signalling and Traction & Rolling Stock applications. Train borne electrics usually have systems employing standard industrial control technology; typically these use metal to metal contacts that are much cheaper compared to the traditional signal relays and circuit controllers. Thus the relays and lever switches in Caverswall Road box are all standard industrial products.

The box locking was initially designed as would befit an electronic system and then converted back into a mechanical locking table. To ensure this would work, a ¼ scale wooden model was built and tested before work commenced on altering the tappet frame. Although track circuits, fouling bars and even axle counters have been considered, these would be expensive and/or complicated and thus other ways of detecting train position have been devised. The locking will not permit any FPL to be moved unless all signals are at danger. Similarly any signal cleared for an inbound movement will lock at danger any signal controlling an outbound movement.

Occasions arise where no signalman is on duty even when a train service is operating in which case the King Lever is operated. This frees the locking for inbound and outbound signals but prevents any depot move. Train staff can use the box to control run round moves but must not pull any FPL until it is proved that the complete train is clear of the points.

An incident in 2011 took place where, although the train was temporarily stopped, the FPL and point were changed, which resulted in a minor derailment when the train moved forward. As a result, a system using an Acceptance Lever has been devised. When reversed, this lever is locked electrically and it then allows the entry home signal to be operated but restricts all other lever movements. Once in the platform, the guard presses a plunger to indicate the train is complete, and this releases the Acceptance Lever and thus the frame for further movements to take place. This is a rudimentary example of route holding and approach locking.

SIGNALLING DOWN THE LINE

Conventional semaphore signals protect outgoing and incoming movements from the single line, the latter with both an outer and inner (colour light) home signal. Once underway, the first significant feature after a long straight is Cresswell Ford level crossing. From the time the railway was built, this rural road had to be suitable protected. It is increasingly busy so conventional gates are provided that are manually closed for train movements with protecting stop signals in each direction, one on the top of a 1 in 30 gradient. Future developments here may include the use of flashing white signals interlocked with the gates to show 'crossing clear' to an approaching train.

Arrival at Dilhorne Park station has required yet another novel Foxfield feature to be devised. Where a controlled home signal would normally be sited, there is instead a sign in the form of a white trapezium on a black background. Here, trains may only proceed if the line is visibly clear and no other stop indication (e.g. a red flag) is being shown. This is termed a 'Condition of Entry' signal and has been inspired by German (DB) practice for lightly used lines. The loop points are controlled from a ground frame and locked conventionally with an FPL. Once the train is safely at a stand, the points and FPL are operated to allow the locomotive to run round. The onward journey to Foxfield colliery is not yet passed for passenger service and much thought is being given to what signalling is required at the terminus and whether any special requirements will be needed for train control on the 1 in 21 gradient.

One idea also being investigated is the replacement of conventional FPLs with claw lock spring points as used on many main line European railways. This is a much simpler arrangement that fulfils the same basic task whilst being cheaper both in installation and maintenance.

Originally the railway was operated on train staff and ticket but this has been replaced with a Tyers Key Token plus paper tickets if needed. When Santa specials are operating, these heavier trains need a banking engine to assist with the gradients either side of the level crossing. An Intermediate Block Section (IBS) system has been devised using voice radio to co-ordinate banking engine movements and with the IBS section marker being the yellow and blue marker board as found on high speed lines. This makes use of an available sign design used for the same purpose but at much lower speed.

REALITY AND THE FUTURE

Although one of the earliest heritage railways, the Foxfield Railway is not in the heritage big league. Its control of finances has to be strict and little money is available for signalling systems and equipment. Much of the kit has been acquired from second hand sources and only around £1000 has been spent on signalling throughout the railway's many years of operation. Ingenuity has been the order of the day but this in turn has led to an interesting debate with the Railway Inspectorate regarding the interpretation of guidance documents.

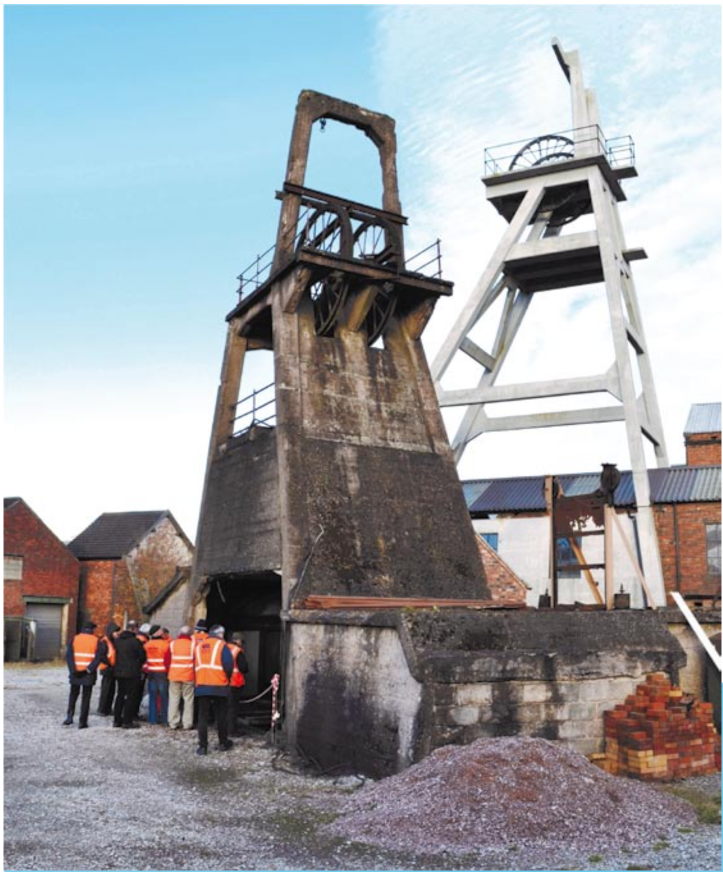
There is mutual recognition that a 15 mph (~24 km/h) railway does not require the standards that apply to a main line or even one of the busier heritage lines. Current interpretation of some guidance within the ROGS regulations (The Railways and Other Guided Transport Systems (Safety) Regulations 2006) implies that changes to the route indication displays are required and this will be achieved by replacing the colour lights with an adapted standard three position shunt signal to show two upright white lights to indicate proceed straight and two diagonal white lights to show proceed diverging. This also is reminiscent of European practice.

Platform entry control also needs changing as currently a green signal is the last aspect before the buffer stop end. An intermediate signal on the platform capable of clearing only to yellow will therefore be installed that will read to a red on the buffer stops.

Grateful thanks are extend to Ron Whalley who is both the Operations Director and S&T Supremo on the railway for explaining so enthusiastically the signalling challenges that have been encountered and overcome, to other members of the Foxfield railway staff who guided us around the Caverswall Road site and fed us a delicious lunch plus making available a three brake van long special train top and tailed by industrial diesel engines.

Altogether a day out with a difference and proof of a very different heritage line.

Photos: Ian J Allison



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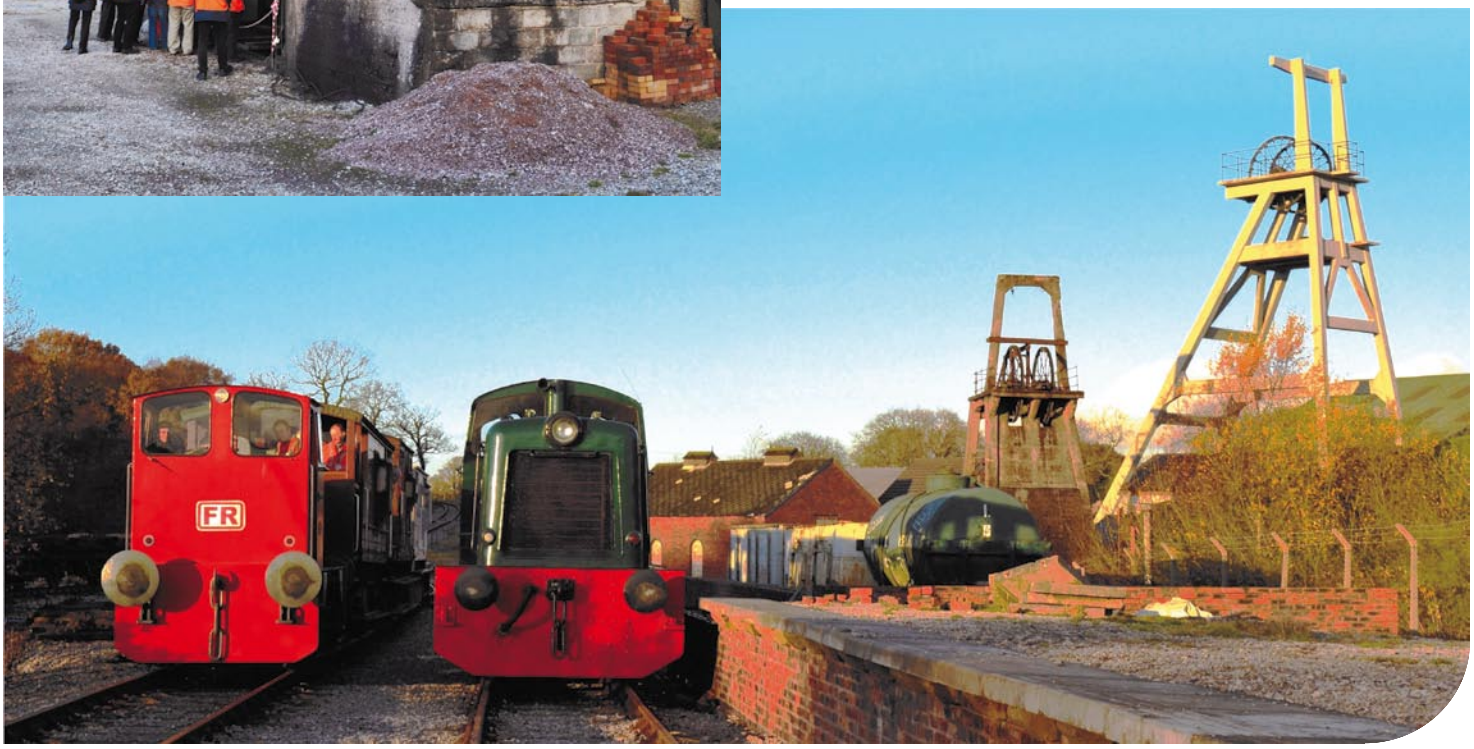

NORTH AMERICAN SECTION

Report by David Thurston

Toronto Railway Club Meeting

The 2012 North American Section hosted its first Canadian Open House presentation for anyone interested in learning more about the organisation prior to the Toronto Railway Club annual holiday event at the Fairmont Royal York Hotel in downtown Toronto, Ontario Canada, on 7 December, 2012.

The Open House consisted of a series of presentations about industry topics and the IRSE itself. The agenda for the event is shown below, and the event started in the Territories Room of the Hotel.

15:00-15:10 - *Meet & Greet*

15;10-15;25 - Speaker – Francis How – President IRSE

Introduction to Institution of Railway Signal Engineers (IRSE)

15:25- 15:50 - Speaker – Dave Thurston – Chairmen North American Chapter IRSE

Introduction to The North American Chapter of the IRSE

15:50-16:10 - Speaker - Richard Moura, GO Transit, Railway Corridors Signal System Engineer EIT

The Protection of Critical Signal Infrastructure from Cyber Security Threats

16:10-1630 - Speaker – Pete Tomlin, TTC – Senior Project Manager

Yonge University Spadina (YUS) ATC Resignalling Project

16:30-16:50 - Speaker – Dave Thurston – President NA Chapter IRSE

Update- Positive Train Control (PTC) Initiative in the US

16:50-17:00 - *Closing Remarks and Group Picture*

The Open House was called to order by Mr. John Leonardo, present Committee Member of the North American section. John discussed the agenda and the introduced the speakers for their presentations.

John also expressed the regrets from IRSE President Francis How, as a family emergency forced him to cancel his plans to attend and speak at the Open House. Dr. Thurston, NAS Chairman filled in for President How, speaking on his behalf as well as providing information to the attendees on the IRSE and the North American Section and activities.

Next to speak was Richard Moura, of GO Transit. Go Transit is the Commuter Rail operation in the greater Toronto area, operating diesel hauled trains with bi-level cars. Richard's presentation was "*The Protection of Critical Signal Infrastructure from Cyber Security Threats*", and was very well received by the attendees. On more than one occasion, mention was made of the difficulty in getting proper sleep with all of the potential threats to the Train Control system from cyber attacks. As a relatively new area for the S&C engineer, it highlighted the fact that our profession and the Institution needs to adapt to these conditions and provide the options for the best defence against both intentional and unintentional threats to train operation.

The next presentation concerned the Communications Based Train Control Project currently underway on the Toronto Transit Commission Yonge-University-Spadina subway. Pete Tomlin, Senior Project Manager for the project explained the current state of the project as well as the previous projects that have been deployed. The underlying trip stop based signalling will be retained for a backup system, while the existing Speed Control and interlocking system will continue to perform their functions. The Transit Commission has mixed multiple vendors for each system to provide all of the required functionality for the subway, and work is continuing to progress.

The final presentation of the day was provided by Dr. Thurston for an "*Update on Positive Train Control (PTC) Initiatives in the United States*". Laying out the basic

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1. John Leonardo welcomes the attendees to the first annual NAS Canadian Open House
2. Richard Moura, of GO Transit and
3. Pete Tomlin, of the Toronto Transit Commission give their presentations at the Open House
4. Dr. Thurston (NAS Chairman) discusses the details of Positive Train Control
5. The "Group Photo" turned out to be a challenge with so many present

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North American Section

6. The Open House was "standing room" only for the entire session

requirements for PTC, Dr. Thurston continued with a detailed description of the Metrolink Project. This will be the first commissioning of I-ETMS type PTC in the United States when it is cut-in in the summer of 2013, and is considered a test bed for several commuter rail agencies.

The Open House was very well attended with over 120 interested attendees. All present enjoyed the presentations and offered several questions after each speaker finished.

It should be mentioned that John Leonardo was the local North American Section representative, and organized the entire event. The hope is that this will become an annual Open House for the Section in addition to the Annual General Meeting, and the concept was well received by those present. Also worth mentioning is sponsorship support provided by PNR RailWorks that provided the meeting room, and Audio/Visual equipment for the Open House.

Three of these presentations are available on the IRSE NAS web page for download at: ***http://www.irse.org/nearyou/publicnam/namericansection.aspx***.

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FEEDBACK

Rail Technical Strategy 2012

We refer to the papers about technical strategy published in the October and November issues of IRSE NEWS and their presentations in London. The growing prominence being given to Traffic Management Systems and customer information is welcome, and we would certainly support the inclusion of these topics in an effective technical strategy.

Unfortunately, the presentation of the first paper on 17th October and the high-level technical strategy described were extremely disappointing. The laudable aspirations sounded fine (albeit offering nothing particularly new) but emerged as little more than motherhood and apple-pie, hidden in a plethora of words, unexplained acronyms and tautology.

We noticed that, in their review of developments over the last century, the authors chose to ignore the many innovations from BR Research in the '70s and '80s – solid state interlocking, intelligent automatic route setting, the first computer-assisted timetable enquiry system, and many others. Perhaps these developments were deemed invalid because they did not need a 'Technical Strategy framework' with all its supporting paraphernalia and zillions of man-hours spent in committees and working groups?

Turning to the strategy's more specific details about traffic management as outlined in the November paper by Andrew Simmonds and Ed Rollings, which Ed ably presented on 13 November, we welcome their acknowledgement of the contributions made over more than two decades by the 'world-leading' IECC, with its intelligent Automatic Route Setting (ARS), and more recently by the Control Centre of the Future. And we support their view that the railway is at or, we would suggest, well past, the point at which the next major advances should be made.

A key issue which the paper rightly identifies is to work out how the local optimising capabilities currently exemplified by ARS can be extended to cover a much wider area. We have considerable reservations about attempts to solve this problem solely by ever more efficient algorithms. The competition between the factorial explosion of complexity as the control area widens and the merely exponential growth of computing power with time ('Moore's law') means that any purely algorithmic approach, however clever, is eventually doomed to fail. Rule-based methods which limit the solution space, with perhaps the ability to self-modify in the light of experience, must also have a role, as must the division of optimising capabilities into layers as the paper suggests. However, the idea of having the local decisions passed upwards for ratification would completely negate the last-moment decision making which is essential for effective local optimisation. Instead, the high-level system should make the strategic decisions as soon as information about changes or disruptions becomes available, passing these down to the tactically agile local system along with such constraints as are needed to prevent the 'local hero, global fool' syndrome to which the authors referred.

We remain optimistic that the UK rail industry can nurture and apply further world-leading developments over the next 30 years, provided that a meaningful technical strategy goes hand-in-hand with tactical agility.

Malcolm Savage, Director Savoir Limited
Mike McGuire, Senior Engineer Savoir Limited

Rail Strategy and Technology

In the 'Preview of Rail Technical Strategy' published in IRSE NEWS last October, I was surprised and disturbed to find no mention of Safety, not even in the list of 'universal concepts'. I could only assume that a primary requirement for future systems, namely to continue to protect against collisions and derailments, was considered too obvious to need mentioning in our safety-aware profession.

However, the follow-up paper in December 'Future Technology on the Rail Network' leaves no room for doubt as to why safety wasn't mentioned. Paragraph 2 of the paper lists the four primary goals of the Rail Technical Strategy, known as the **4Cs**, and goes on to say: 'You might wonder why safety does not feature on this list. The reason is that Britain's railways are amongst the safest in Europe, and although it is always important to look for ways of improving safety, that is not our most important priority in terms of achieving a major improvement'.

Whilst it may be true that an improvement in the current high level of safety is not essential, that level has been hard won through many decades of design and experience, including lessons from major accidents, and will not carry over automatically from today's technology to tomorrow's. Therefore the achievement of at least the existing level of safety should be spelt out loud and clear as a primary goal of the Rail Technical Strategy. Furthermore, to allow for the additional risks and uncertainties introduced by complex new technology, the design safety target should be set higher still, to ensure that the required level is actually achieved.

So I suggest the list of **4Cs** be expanded by a fifth one, to represent the **C**ontinuity of today's safety performance into tomorrow's systems. This would be a fitting replacement for the current invisible fifth **C**, which seems to me to be **C**omplacency.

Terry George

Is all this 'IP' a Good Idea?

Regular readers of the IRSE NEWS can hardly fail to notice the frequency with which the familiar 'IP' acronym appears within its' pages.

Having studied for (although not yet completed) the widely-recognised *Cisco Certified Network Associate (CCNA)* qualification, I have learned something of the basics of contemporary data communication technology - by which I mean primarily packet-switched networks. The question arises whether 'protocols' such as IP will be suitable for widespread adoption for S&T purposes - as so many people have suggested and is indeed already underway.

The view I hold at present is that there could well be grave security risks associated with widespread adoption of Internet Protocol (and its numerous companion protocols) for S&T purposes; but that to do other than board the bandwagon is probably futile: and so S&T engineers must accept the need to *master* the new technology, and to mitigate the associated risks.

It goes without saying that I would be fascinated to read the views of other IRSE NEWS readers.

Martin Bowie

Audio Frequency Track Circuit Reliability Investigation

As one who was heavily involved with the original design of the TI21 track circuit in the early 1980s, I was most interested in Alexander Walsh's recent article in Issue No.185 paper. With reference to the original TI21 units I would comment as follows:

- I found the analysis of the tuning units a little confusing because the three different types of make mentioned tend to use different tuning units (TU). In particular TI21 uses TUs with two branches. One branch incorporates a transformer for insertion of power from the transmitter and collection of signal for the receiver. The turns ratio on the transformer is such that the input impedances of the receiver and the output impedance of the transmitter have a very significant effect on the performance of the tuned area.
- It is correct to assert that the cables from the tuning units to the track play an important part in the performance of the tuned area. That is why a specific length was specified by the supplier and that they should be bound together. Using long TU-to-track cables has little effect on the track voltage at the feed end. However using longer and/or smaller diameter cables has a potentially disastrous effect on the track voltage at the other end of the tuned area. This practice results in a significantly increased risk of feed–through to the next track circuit but one. Therefore the performance of the series-tuned circuit in each tuning unit (the so called "zero") is crucial. Great efforts went into reducing the losses of this branch to the absolute minimum. The use of specially wound polycarbonate capacitors with a very low loss (of approximately four milliohms) was a significant factor in this. These capacitors were also chosen so as to minimize the overall temperature coefficient of the tuning units. They were expensive!

I have little comment to make on the reliability tests that the author conducted on the transmitters and receivers other than to say that they were never designed for operation to 70 centigrade. Also some of them may well be approaching the end of their design life (manufacturing started in 1981 with a projected life of 25 years).

With reference to the analysis of the currents and frequency response of the tuned areas, the curves look about right but it is important to remember that the currents flowing round the tuned area are quite considerable (typically of the order of 25 A). Furthermore the series-tuned part of the TU is designed to pass any out of balance traction current at the adjacent track circuit frequency – thus protecting the track circuit from excessive amounts of transverse traction interference. Hence the large cables that were specified.

The author has obviously expended considerable effort to analyse the problems being experienced in service in Australia and is to be congratulated on the comprehensive nature of his article.

Peter Cross

Another Centenary?

We may have missed the opportunity to celebrate another Centenary!

The Great Western Railway's ATC (Automatic Train Control) was the world's first widely used train control system. Patented by CM Jacobs and RJ Insell in 1905 and designed at Reading, the Great Western Railway was a true pioneer – nothing like it existed elsewhere and it was adopted as standard, not merely experimental, from 1913.

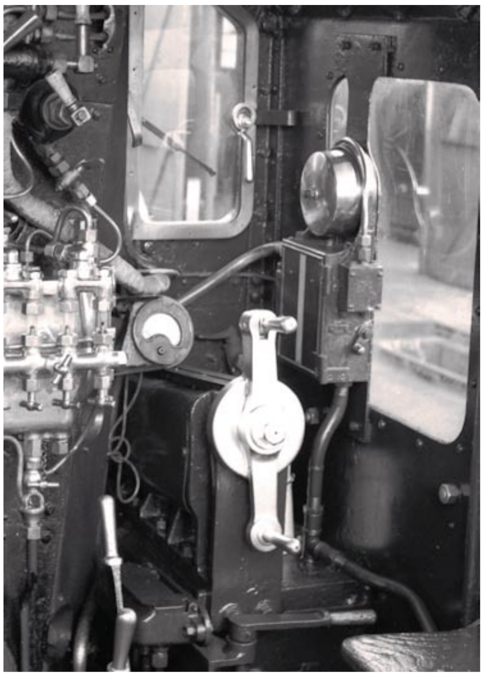
The objective was to alert each engine driver as he approached a distant signal and to impose a brake application if a warning alarm was not acknowledged when approaching that signal in the caution position.

As a much abbreviated description, the system required two sets of equipment, one set on the engine and one set on the track. The track equipment comprised a sloping metal ramp some 44 feet (13.5 m) long, mounted between the rails, 440 yards (400 m) to the rear of each distant signal. It was connected electrically to a circuit which was energised only when the distant was proved to be in the `off` position.

A contact shoe mounted beneath the engine would rise up over the ramp and disconnect a circuit onboard maintaining an armature in position. If a current was detected at the ramp, this armature would stay in the energised position and a loud bell would sound. If however, no current was detected at the ramp, the armature would fall to a de-energised position and allow air to enter the braking system via a (noisy) siren. This could only be silenced, and the brake application cancelled, by the driver manually resetting the armature. This was considered an important reminder to the driver that he, and only he, was in control of his train.

The first major introduction of the system was on the main and relief lines from Paddington to Reading by December 1908, an area well known for its winter fogs and river mists. It comprised 168 ramps over the 144 track miles (230 track km) but further major installations were postponed until after World War 1.

However, the GWR accorded a high priority to investment in extending the system and by 1938, the mainlines of the Great Western Railway had all been



Top: **showing the Contact Shoe and Cab Equipment**
Below: **three pictures showing the ramp**

equipped with ATC. Indeed, precedence was given to ATC over some other forms of signalling investment, such as colour-light distant signals, the first of which did not appear until the 1950s.

The success of ATC was demonstrable and reflected in the railway's reputation for good timekeeping in conditions of poor visibility and in its good safety record. Anyone who has travelled on the footplate at night with semaphore signalling using only oil lamps will understand the popularity of the ATC system with the drivers. I have personally travelled on the footplate at speed in fog with a visibility of only 100 yards (91 m). The driver was relying totally on the ATC, not something strictly legal but impossible to achieve otherwise.

Elsewhere in UK, on the London, Tilbury and Southend line, in late 1938, trials were taking place with the Hudd intermittent inductive train-stop-system. These trials were suspended throughout World War 2 and recommenced in 1947. This work was taken over by BR and later became the standard Automatic Warning System (AWS) and preserved most of the features of the Great Western system, from the driver's viewpoint.

The ATC system continued in service until the 1970s, well into the period of Western Region signalling modernisation which commenced in the late 1950s. Those resignalled areas commissioned before the withdrawal of steam traction in Jan 1966, like Reading, Cardiff, Plymouth, Birmingham, Port Talbot, Newport, Slough and Old Oak Common, retained the ATC ramps.

In 1966, dual-fitted diesel traction units were introduced and later new signalling installations were equipped with BR AWS magnets from the outset. The ATC ramps elsewhere on the mainlines were progressively replaced by magnets until the last ramp was removed in 1976.

In the 1990s, the increasing incidence of Signals Passed At Danger and pressure to introduce Automatic Train Protection (ATP) and thereby conform with a major feature of ERTMS, resulted in an adaptation of the BR AWS to become the present Train Protection and Warning System (TPWS), now widely applied throughout the UK.

I have to thank Ken Burrage, Dave Collins, John Jenkins, Adrian Vaughan and Alf Wilks (M&EE), for their help in preparing this piece.

M I Page

The Future of Control, Command and Communications Technology on Britain's Rail Network

It is incorrect to describe ARS as routing trains according to the timetable alone. (IRSE NEWS December 2012). To debase its intelligence in this way might almost be to call it moronic. Such a system could not credibly have been capable of automatically operating many of the busiest locations on the rail network for 25 years.

I am increasingly dismayed by the number of people within the Rail industry who deny the capabilities of Automatic Route Setting (ARS) installed in the IECCs on the network. Based on his recent article in IRSE NEWS, it now appears that the IRSE President, Francis How, should be added to the list. The type of system described in his IRSE article (i.e. essentially a moronic ARS system) could not credibly have been capable of automatically operating many of the busiest locations on the rail network for 25 years.

The UK ARS is an intelligent system capable of making decisions on train sequences and route changes across the network in order to minimise delay and reduce congestion. Trains are routed automatically irrespective of how far outside their scheduled window they are running. Its strength comes from making decisions based on current conditions and at the times they are required to be implemented. All trains involved are considered in the decision making process.

In my published article, (ref. *UK Transport Projects, 1999*) I stated that "*in the time it took to read my article, ARS would have set around 750 routes, each route setting requiring a decision to be made by the ARS computer and therefore 750 decisions will have been automatically made and automatically implemented*". *Furthermore, I suggested that "ten years earlier in 1989, this was visionary, six years on it was a bold experiment. Now in 1999, it is a proven reality*".

This success has grown with the introduction of additional IECCs since 1999. The performance of some more recent installations has been allowed to fall. However, this has arisen not through new deficiencies in ARS, but from poor source data and the initialisation of the built in decision strategies from outdated operations specifications.

I welcome the presence of Traffic Management Systems in such a prominent position in the strategic plans of Network Rail. However, I would like to see the experience of the current ARS used as a foundation for future developments rather than being discarded through apparent ignorance of its capabilities.

Tony Annis, Savoir Limited

Editor's Note: Regrettably lack of space in Issue 185 prevented us from including this with other 'Feedback' items on the same subject, so apologies to Tony Annis.

More Feedback from an Associate

I urge readers of the IRSE NEWS to devote time to browsing through past copies - for it is a practice that can unleash all kinds of riches. Issue 177 contains *A Word with Francis How* - the then President-Elect - and there is much in it to digest. Where does our President see the IRSE in 100 years? This must be a fruitful question upon which to meditate, given that there is now precisely 100 years of history to learn from; and poses as its corollary the equally fruitful question: where do *you and I* see the IRSE in 100 years? At the risk of being unmannerly, I would like to offer my view first.

The IRSE will without doubt still exist in 100 years - unless there is some worldwide catastrophe (such as nuclear 'Armageddon') that might, as our President so laconically puts it, "blow us off course". But as an incorrigible optimist I'm inclined to believe that all will be well.

I foresee that the IRSE will come to be recognised more and yet more as being an oasis of intelligent and broad-minded savvy in a world that many would have us believe to be riddled with insoluble riddles. That is to say, that the work of arranging for the safe and graceful operation of the railways of the world, with the attendant demands for humility and modesty in the face of the daunting technological and organisational difficulties, will have the inevitable effect of promulgating the recognition that there is something utterly unique and very special about the IRSE.

Long live the IRSE!

Martin Bowie

ANNOUNCEMENTS

Inspiring the Next Generation of Engineers

The week of 11-15 March 2013 will see an unprecedented number of engineers going into schools within the UK to give inspirational talks to students about the work they do and how they chose their careers. We want you to get involved and to sign up to the **Inspiring the Future** programme.

This week is important for engineering with many high profile events happening. First, the inaugural winner of the global Queen Elizabeth Prize for Engineering (QEPrize) will be announced. The QEPrize celebrates an engineer responsible for a groundbreaking innovation in engineering of benefit to humanity and will provide a great opportunity to raise the profile of engineering in the UK. We hope that the prize will inspire and engage the next generation of young people to take up careers in engineering.

A unique alliance of organisations: EngineeringUK, the British Science Association, *Speakers for Schools* and its sister programme *Inspiring the Future* along with the Royal Academy of Engineering are developing a programme of activities in March, to coincide with other Science, Technology, Engineering & Mathematics events such as *The Big Bang fair*, the first Global Grand Challenges Summit and *National Science and Engineering Week*. As part of that programme, and to mark the award of the first QEPrize, we are inviting engineers across the county to visit state schools in order to share their passion for engineering with young people.

The winner of the £1 million Queen Elizabeth Prize for Engineering will be selected by an eminent panel of international judges who are leading engineers and scientists. They will visit the UK in March and have been invited to join the programme of engineering activities, including visiting schools to engage and inspire young people in engineering. Joining them will be some of the top engineers in the UK who are fellows of the Royal Academy of Engineering. Over half of all secondary schools in England have applied for a speaker through the *Speakers for Schools* programme and many are keen to hear these prominent engineers and scientists talk to their students.

A similar number of schools have signed up for the sister programme *Inspiring the Future,* which aims to recruit 100 000 people at all stages of their careers – from apprentices to CEOs – to go into local schools to talk about their work and career route. The leaders of engineering firms employing large numbers of engineers will be asked to encourage their employees to take part in *Inspiring the Future*.

We want you to join us and inspire the future.

For more information:
Inspiring the future: **www.inspiringthefuture.org**;
Queen Elizabeth Prize for Engineering: **www.qeprize.org**;
Speakers for Schools: **www.speakers4schools.org**.

C. Porter

RECRUITMENT

CAPTION COMPETITION

and now another Presidential Position :

If you have read page 21, you will know that your President has been getting up to some extraordinary things in his presidential year.

Here he seems to be getting <u>down</u> to something instead.

What do you reckon he is saying or thinking?