Logo and name etc

Presidential Address

of

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Sustainable Signalling

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Wim Coenraad

Controlling time to market and cost of system acceptance for CCS systems

Summary

Control and Signalling (CCS) systems are expensive to develop, and are even more expensive in terms of system assurance activities and system acceptance. Yet they are developed for a mature market where innovation or product development does not create significant new revenue, neither for suppliers nor for operators, unless they provide improvement in speed, capacity or indeed safety. Typically new products only replace existing product lines. This is true even for ERTMS/ETCS.

The increased speed of technological development and innovation leads to a shorter technical life expectancy. Changing demands for transportation services imply a need for more flexible technical systems, able to adapt “rapidly” to changing performance needs (throughput/capacity, reliability and robustness etc.)

Hence CCS systems will need to be able to be adaptable and upgradeable. The signalling industry/profession cannot hope to meet the demands of its clients, i.e. the train- and rolling stock operators, (local-) governments etc. and perhaps even survive, if the lead-time for development and acceptance and the associated costs are not brought under control.

One of the objectives of the ERTMS/ETCS project is to address this issue, in part, by specifying a harmonised system, for a larger market, applying the principles of interoperability and mandatory cross-acceptance of constituents.

In this context it should be interesting to examine ERTMS/ETCS, a system development that started in late 1989 with the founding of UIC/ERRI A200 and is now, more than 17 years onwards, starting to see its first deployments in commercial projects. Whilst specifications are still being finalised, a common factor in the first deployment projects appears to be that none, or not many of them, were completed in time and on budget.

In an effort to learn from the collective experience of both the suppliers, the infrastructure operators and the ultimate users, the passenger and freight operators, I would like to centre the theme for the 2007-2008 technical meetings, the international convention and the technical visits around lessons learned and paths forward towards better control of the cycle time for system development, system and product acceptance and deployment.

For this year’s international convention in the Netherlands, this is the theme chosen for the visits to the Dutch projects.

Characteristics of the Signalling Market

A Mature Market

We operate in a mature market. Although we have the high speed railways and the light rail and rapid transit railways, where new lines were built and network expansion has occurred, railways are probably not foremost in the minds of people when asked to name growth markets and booming businesses, or give examples of the creation of shareholder value. We have not had our internet hype but neither did we suffer the subsequent burst of the bubble. We do not have our Bill Gates or Steve Jobs, we have to be content with Sir Richard Branson dipping a toe in.

Suppliers of S&T equipment usually are part of a larger industrial conglomerate, only able to break even or produce a modest profit. But we are not the jewels in our corporate headquarters crown, but sometimes we rather are the pawns to be traded with another large corporation, and hopefully not sacrificed in a larger gambit.

Innovation does not bring increased revenue

Firstly, how do we define innovation? In my opinion, innovation is not about “doing things differently, just because we can”, it also is not about “creating solutions looking for a problem”. The curiosity of the academic mind should be satisfied in academia. Society pays its universities and scholars from the taxes we pay and we should not ask for business cases for fundamental research. However we who work in companies that have shareholders and employees, each of which expect some form of compensation for their efforts, would not invest money in innovation projects if we did not see a potential return. Or would we?

So how then do we distinguish hype, or solutions looking for a problem, from real, productive innovation? Only with the benefit of hindsight perhaps.

Real innovations, i.e. those of a revolutionary character are rare. I define these as the introduction of technologies and products that radically change the way in which we lead our everyday life, do our work etc. With hindsight, they can be recognised because they also usually:

1. create new markets or revenue streams,
2. are associated with new players, industries and suppliers that emerge
3. and often new “famous names” and/or wealthy persons emerge.

The personal computer, the mobile phone and the internet are some examples of such real innovations. Microsoft, Apple, Bill gates, Steve Jobs are names no one knew before the 1980’s. They are icons for the personal computer revolution, just as Stephenson and Brunel are the names associated with the innovation of the 19th century called the railway. And that comparison really illustrates my point. In railways, signalling and telecommunications probably were the innovations that allowed the railways of the day to “take the next step”. Let’s also not forget that and telecommunications, in the form of the telegraph, preceded signalling. Semaphore signals, interlockings and train detection systems probably count as innovations meeting some of the criteria identified above, as well as remote control of points and signals. All these breakthroughs date back a century or more.

Since those days, with the possible exception of automatic train protection, we have not really innovated the railway, but at best we have introduced new technology to replace outdated systems, in an ever increasing pace, but not fundamentally changing the way we operate our railways. We may

have expanded our scope of control, both geographically and in terms of complexity. And of course, we have increased safety and enabled efficiency gains through reduction in manpower, centralised control centres etc, but this is organic growth, or evolution rather than revolution. They are examples of “doing things differently, because we can”, with a business justification. Or, as we say in Holland: “pouring old wine into new bags”.

In railways then, the only real innovation “in our lifetime” has been the introduction of high speed passenger traffic. Japan pioneered this development and introduced the Shinkansen. The French were next. Interestingly, at least in the case of the French developments, this was not so much the result of a major technical breakthrough, but rather the clever and dedicated application of then state of the art technology, giving us the TGV, and in our field TVM300, to a perceived new market. It has opened up a new market segment, led to the creation of a high-speed network. In fact it allowed Alstom, RFF and SNCF to set the world speed record for trains at 574.8 kph just recently (using a simple telephonic block, my sources tell me) and although I do not know of any new French railway billionaires, the fact that Richard Branson takes an interest in railways now even gives it some of that “Bill Gates” iconic quality.

In the field of railway signalling, I am afraid neither ERTMS nor GSM-R score any points on the “revolutionary” scales. Both have replaced or are intended to replace existing technology and products, such as LZB, TVM300/430, ATB and the previous more or less standardised UIC radio system. The Eurobalise technology is basically an upgrade of the Ebicab/KVB balises and the main aim of ERTMS/ETCS is to provide a harmonised, interoperable, ATP/ATC system. Does ERTMS/ETCS create new business or markets? Not for the signalling suppliers, I would imagine, since it only replaces existing product lines and gives us a technology update. And for the foreseeable future, Level 3, which would have introduced the principles of transmission based signalling with its anticipated associated benefits, is put on hold.

ERTMS level 2 at the time it was defined, was intended to be nothing more than a transition step in the migration from “old fashioned” intermittent ATP called level 1, to the “paradise” of level 3. It combines the cost drivers of level 1, as we are obliged to keep all lineside signalling equipment in place, but delivers none of the life cycle cost advantages expected of level 3, except perhaps the removal of lineside signals and thus improving the man-machine interface to the driver. And to achieve this of course, we require rolling stock to be fitted with yet another set of train borne equipment, in addition to all the STMs or bespoke ATP systems, for the foreseeable future. It delivers no capacity enhancement to the railway when compared to a properly designed conventional signalling system using existing technology. There are possibilities for innovation using the transmission system parts of ERTMS, one that comes to mind is possession management using hand-held terminals as we do on the Dutch Betuweroute and perhaps this can even be implemented using dedicated RBCs on non-ERTMS lines. But again we are mostly still waiting for them to be implemented.

Long Lead Times

Our industry suffers from extremely long development cycles. ERTMS/ETCS development started late in 1989 when the UIC founded the ERRI A200 working party to produce specifications for ETCS, drew up a project management declaration and started to work with the European Commission and the suppliers. The work was driven forward by Peter Winter, now a Companion of the IRSE, and I am proud to have been present from the start. Our first planning said we would introduce ERTMS in the railway by 1996. By that time however, only the first development contracts were let, pilot projects were entering a tender phase, the EEIG or ERTMS users group was set up, the suppliers were

grouped as UNISIG and the commission had its fourth framework project to support us. Now in 2007, ERTMS/ETCS has started commercial operation in various countries. Since 2004/2006 ERTMS based systems are operational in Austria-Hungary, Bulgaria, Germany, Italy, Luxembourg, Spain and Switzerland. Soon other countries, including Holland, where two weeks after our convention commercial service on the Betuweroute is planned to start, will join.

Over 500 vehicles of more than 20 completely different series are in operation (Levels 1 and 2). We have seen a number of pilot lines. In all, there are now over 60 commercial projects, not only in Europe but also in the rest of the world, that have been won by the 6 UNISIG suppliers. We are now at version 2.2.2 of the System Requirements Specification or ERTMS/ETCS baseline and, if no new problems are detected, version 2.3.0 of the baseline, available by the end of this year should allow us to achieve real interoperability. Meanwhile the State of the Netherlands has to invest an additional 30 million Euro in the HSL Zuid signalling system to upgrade it to version 2.3.0 and stands to lose 400 million Euro in delayed revenue from the concession for commercial services, caused by an (additional) 9 months delay in opening the line. By that time, the high speed trains that were ordered some years ago will not have been equipped and / or delivered and the operator and manufacturer blame the lack of stable ERTMS specifications for this. Commercial service on that high-speed line will therefore start with rented loc-hauled rolling stock, at 160 kph. When we compare this performance to the world of the mobile phone manufacturers and operators, from whom we have borrowed the concept and technology of GSM-R, our track record as an industry is less than impressive. Even if we accept the argument that railways are an “old industry” and that we should compare ourselves with the world of capital goods such as aircraft or power plants, as well we might in the case of rolling stock and permanent way engineering, is that also true for signalling equipment?

No market growth

The signalling supply industry operates in a market that on the whole does not grow. Innovation takes the form of product development and renewal and the only way to increase turnover is therefore to increase market share, or the only way to increase margins is to reduce the cost of projects, of which the actual cost of the hardware is only a small proportion. Signalling supply industry clients historically expected product lifecycles to be in the order of 40 years and today typically still require products to be “in the catalogue” for 10 years and specify systems must be supported for at least 20 years after delivery of the final installation, even if that is on the basis of functional equivalent plug compatible units. Given the rate of change in industrial products you understand the challenge. If you think your national railway museum does not offer much in the way of signalling equipment, just visit your supplier’s system test facility where all generations of equipment still in use on his clients’ railways are kept for testing, fault finding etc should it be needed. Yet, seen from the point of view of an infrastructure manager or operator, even a 10 year delivery plus 20 year support lifecycle is almost impossible to live with. National or network wide roll out programs, even if not constrained by business cases, will typically require in the order of decades to complete, simply because of the limitations associated with engineering capacity and the availability of possessions. After all we do not help our end client to be successful in his market by closing down the railway to allow us to “do what engineers do”.

No cash cows either

My perception is that although prices are always too high, suppliers of railway signalling equipment are not the cash cows of the large global players in the electrical or electronics market of which they

are usually a subsidiary. At best they produce a decent return on sales, or write black zeroes in their balance sheets, but alas it seems a safe bet that the next Bill Gates is not in the audience today.

But with inherent instabilities

Perhaps as a side effect of the long product and system lifecycles, the signalling supply market seems to be going through cycles of growth and drought. Privatisation, restructuring or just plain and simple alteration of political priorities will see spending on renewal or expansion of the rail networks go through cycles. Because older generations of signalling systems are robust, it is tempting or even unavoidable to “sweat the assets” a bit longer. All of us have seen instances where investment in systems like ATP or level crossing protection have risen after an incident or accident, only to be reduced a number of years later when the budgetary realities become more pressing than (the publics) memory of past accidents. The risk based approaches to “everything” that we see today are perhaps very suited to demonstrate that investment in “A” will yield a much higher safety benefit than in “B”. So we do not spend on “A” any longer. But do we start spending on “B”?

In any case, the successive cycles of laying off and hiring staff in the signalling industry may now have become shorter than the time needed to train our specialists, even if the industry, post privatisation still has a training scheme in place. So, even in a market that does not grow, if mechanical interlockings or signalling relays suddenly developed the equivalent of rolling contact fatigue, and drastic measures needed to be taken, as an industry, could we cope, even if the possessions were available to carry out the work?

With successes like these

It is difficult to find reliable data on development costs, but from 1995 onwards at least 187 million euros from Europe’s TEN funds have helped fund approx. 367 million euros worth of ERTMS related development work. And I have the impression that a large proportion of our supplier’s R&D budgets must have been devoted to ETCS. Therefore an estimate of 500 million euros spent on ERTMS to date is a conservative estimate. Small wonder then, that suppliers and EU alike are urging the railways to stop dragging their feet and start investing in ERTMS projects. And small wonder as well our industry is in need of success stories and claims ERTMS is ready and available in stores, when in fact investing in ERTMS pre baseline 2.3.0 appears to me to be the modern day equivalent of buying Eurotunnel stock.

You don’t need a Harvard degree to work out that this is not sustainable and none of the players today would be able to develop the next generation of anything signalling related independently today. In fact it is my long held belief that if standardisation is to come about in railway signalling, it will be the result of further consolidation among our suppliers and the resulting rationalisation of their product lines. Can you imagine KLM approaching Boeing or Airbus with the message that yes, they might be interested in their 747 or A380, but only if they would agree to implement a further 54 change requests in addition to subset 108, some of which might be the equivalent of completely re-engineering the wing and tail-plane design because their technicians feel the need? They would be politely shown the door both in Seattle and Toulouse. Yet in our industry we appear to think nothing of it, even take it for granted.

Cost drivers

Lack of standardisation

Traditionally standardisation was never regarded as very important. In the cosy old world, where state owned railways co-operated closely with their national suppliers it was perhaps even seen as a risk. Just as different rail-gauges were used to prevent enemy armies from invading too easily using the railways, competition was kept at a distance and new entrants discouraged from entering the railway operations or supply market through the high cost of entry. To a degree that is still the case and our suppliers' reluctance to discuss standardised interfaces in such projects as Euro-interlocking is food for thought. But of course we lock ourselves into small markets that cannot support the ever increasing cost of development. ERTMS is a system that no single supplier or railway could have afforded to develop. We have only to observe the examples of the aircraft and telecomms industry to see examples of the unavoidable consolidation of the supply side and to observe what has happened to those suppliers that failed to recognise the trend.

System assurance

Earlier I stated that the signalling market does not grow. That is not true for the market of safety assurance services. When I started my career in the 1980's we used to require a "proof of safety" for new systems and equipment. These usually involved FMEA's of electronic equipment for which the principle of "inherent failsafe design" could no longer be applied, because the properties of the technology were no longer obvious and immediately understood and the consensus of specialists that "this was safe enough" was no longer taken at face value. I was impressed, if not awed, by the sheer volume of such proofs of safety, the time needed and the cost involved.

A few years later, programmable electronics and electronic interlockings became the next innovation and everybody discussed how these should be proven to be safe enough. I became a member of the ORE A155 expert committee and met such distinguished IRSE members as Mr Goddard, Mr Stalder and others there. We learned from IEEE standards for software development that there were things as V-cycles, verification and validation activities, and these concepts can be traced from the UIC leaflets produced by A155, through the RIA standards into the Cenelec standards EN50126 – 50129 that are now so familiar to us today.

Safety cases

The development of the Cenelec standards was more or less something we wanted as a signalling industry, because we wished to profit from the benefits that electronic interlockings and more generally, ITBS systems, seemed to promise. We adopted those standards voluntarily, because we saw them as accepted best practice. But in the same period a many-headed monster called the safety case regime was born. This, in my perception, was largely an Anglo-American construct devised mostly to allow demonstrating, if the worst came to the worst, in an inquiry before a court of law, that we had discharged our duties of care, had sought an independent review and concurrence with that position etc. It is a consequence of a legal system that substitutes responsibility with liability and confuses claims with accountability. Basically it involves a process of decision making by committees and review panels. And committees and review panels cannot be sent to jail collectively, or, if they are, at least you'll have enough people in your cell to be able to play bridge.

Yet I firmly believe that the amount of bureaucracy and process cost this has introduced could have had a far better "return on safety". In fact I now believe that any two-word construct ending in "case"

(business case, safety case) is to be treated with the utmost suspicion. (Pillowcases and suitcases are fine though). A case has come to represent something that is so complicated that its logic and inherent truth is not immediately obvious to the naked eye or untrained reader. We therefore appear to need reams of paper to bring forward arguments, usually produced by expensive consultants, that no-one really believes or questions. Like a quantified “proof” of meeting SIL 4 criteria, or earning back our investment in 30 years time. Because no-one really believes or understands this, we need assessors or auditors that study these cases carefully and then tell us that with a number of restrictions and caveats, if certain conditions can be met, which unfortunately had to be exported to a third party, it appears the emperor is wearing some form of clothing after all. The concept of Harry Potter’s invisibility cloak comes to mind!

Independent Safety Assessors

Along with the safety cases came Independent Safety Assessors that assess them. We ask them to concur with our claim that *“the design authority and the validator have achieved a product that meets the specified requirements and to form a judgement as to whether the product is fit for its intended purpose”*

In only a few years time, an entire industry has emerged. One that has developed its own language that I like to call “New Jesuit”, in which nothing is ever said in simple straightforward sentences, but in which lots of caveats and conditions are used. If you were an alien circling earth and the first thing your sensors picked up was a discussion in a hazards transfer meeting, where “evidence of successful mitigation of an exported constraint would be a condition for an assessment report without blocking findings”, what would you do? Land your spaceship or go to warp speed and find another galaxy?

It is difficult to measure the effectiveness of this work in terms of potential hazards avoided, or do a cost benefit analysis of ISAs and safety cases, but I believe that we have overshot the mark. (Please keep in mind that until very recently I was an Independent Safety Assessor and the certification manager for a Notified Body). As anecdotal evidence, I estimate that the total development cost spent on the Dutch New generation of ATP (ATB NG) in the period between 1988 and 1994 (approx. 4 M€ without compensation for inflation) is roughly equivalent to the cost of producing and assessing the safety case for HSL-Zuid’s signalling system. And of the cost of 30 M€ of upgrading that high speed line to ERTMS baseline 2.3.0, just under 50% is spent on re-test, re-certification and keeping the project organisation alive a bit longer.

Notified Bodies

In the wake of the safety case regime came European standardisation and interoperability, all codified now in European law through such documents as the Interoperability Directives and the TSIs. Of course compliance with these standards cannot be taken for granted, so it needs to be demonstrated and assessed by an entity called a notified body (NoBo). In theory the NoBo checks compliance with a well defined set of interoperability requirements, among which is safety, using the TSIs. Each TSI also defines the processes for conformity assessment in detail. In all fairness, this is probably a good thing because to a degree, it prevents the NoBos from transgressing the scope of their assessments as ISAs are sometimes accused of doing. So, we should never say that Brussels does not learn from experience. In a further effort to prevent the market for consultants that produce the technical files and for NoBos that assess them from spinning out of control, the concept of cross-acceptance of NoBo certificates was mandated. There is an obvious overlap between the work of a NoBo and that of an ISA.

Towards Sustainable Signalling

Of course we must ask ourselves “how can we afford this” and “how much longer will we be able to survive” if we keep this up? The question we have to address therefore must be “how do we achieve sustainable signalling?” Why? We are part of a supply chain. A very simple lesson, which I learned from a Siemens marketing specialist a very long time ago, says that a supplier of a half-product can only be successful if he helps his client to be successful in his own market. Passengers pay real cash to get something I will loosely define here as “mobility”. In most cases society is willing to subsidise, or pay for the transportation system called the railway, that provides those end users with this service. Railway operators provide and sell this service and a supply chain which involves infrastructure operators and managers, rolling stock operating companies, suppliers of rolling stock and signalling and telecoms and therefore everyone in this audience depends on their success. To put things in perspective, for a newly built line like the Betuweroute signalling accounts for less than 3% of the total cost to build it.

What is sustainable signalling?

Sustainable signalling stands for a paradigm in which our industry has found ways to operate in a healthy way, one that respects the simple criterion that all of us are part of a supply chain and rely on each other’s successes to thrive and survive.

If I knew how sustainable signalling can be achieved, you’d probably have a different President addressing you today. I would then be the President of AlMensAlBardierSys, the hugely successful supplier of signalling systems creating shareholder value every day, including my own shares and stock options of course. It is doubtful that I would be sharing the secrets of my success with my competitors today. But after summing up the issues we have today, as I have done just now, we know which issues to address. Care to join me on a trip to neverland?

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How do we achieve it?

To achieve that we in Almensbardiersys have to respect a few simple criteria:

- My products are based on platforms I buy in webshops, that is a measure of how off the shelf they are. Customisation is through the architecture of grouping my boxes and through the application software. Of course I have a redundancy strategy which is implemented throughout, both in hardware and software platforms, up to the application level.
- Time to market, i.e. the time between start of a product development and commercial availability, for my systems is between three and five years.
- The size of the potential market is at least as large as the European Union plus its associated partner states
- Roll out of a new system, e.g. ERTMS in the UK, can be achieved in 5-10 years
- System generations are backward compatible and offer an upward migration path
- System interfaces are chosen with care, but should at least include train-track, peripheral equipment and inter-supplier interfaces. Those interfaces are in the public domain and are true form fit function specifications. They use standardised interfaces as much as possible. That opens me up to competition but I don’t care. My competitors are too expensive anyway.

In fact my competitors are ..Catel, ..Stom, Sie…, Bom……. And IN…… Rail Systems (they lost half their businesses to me you see!). They still supply the peripheral equipment railways still need, such as point machines and eurobalises, that simply do not fit my business model. They fight over their small internal national markets and the legacy systems and by clinging to their proprietary incompatible interface standards, they have locked themselves and unfortunately their clients, into small market segments that hardly support innovation at all.

- I manage my ISAs and NoBos very strictly in terms of the scope I allow them to address. Furthermore I have chosen an incremental assessment and audit strategy that makes them work for my benefit. And of course my black boxes and redundant system architecture strategy allows me to confine their involvement to the application functionality and the interface engineering anyway.

Some of the stumbling blocks are evident. COTS solutions do not always fit well in the railway environment, especially for on-board equipment. Most equipment must “live” in non-air conditioned enclosures in a harsh environment. But not all of it! Secondly to protect the investment in software, the platforms, or at least functionally equivalent ones, must be available for periods that exceed the usual commercial product life-cycle times. If we cannot achieve some degree of standardisation of interfaces and harmonisation of functions and operating rules, the market volume required to sustain our developments will not be realised. In that respect, the examples of ERTMS/ETCS operating rules and Euro-interlocking offer little hope, even today. And perhaps this points us in the direction of another property of sustainable signalling that has escaped us until now.

Simplicity.

The fact that technology is complicated in itself does not seem to be the real problem, at least not if we adhere to industrial standards and open systems interfaces. But the fact that we need a new layer of European bureaucracy to act as the systems authority for ERTMS, just to manage specifications and system versions, cannot be a good thing for our industry. ERTMS is after all the addition of (almost) everything the European railways ever wanted or needed in an ATP/ATC system. Its inherent complexity shows in the fact that it has taken until version 2.3.0 of its baseline to become useable and interoperable (more or less), with a baseline 3.0.0 already on the horizon. And even now, backwards compatibility between versions is an issue that suppliers do not want to commit to. If that is the state of affairs after 17 years of continued effort, do we really need to embark on a Euro-interlocking, or should we just aim for a Euro-interlocking platform instead?

Could it be that in our railways, research organisations, user groups and supply industry we have too many chefs meddling with the soup? Aren’t we over-engineering ERTMS into the next Eurofighter?

A role for the IRSE

You may laugh, or you may have recognised parts of your own strategies or worries tonight. My strategy is not complete, and as a true consultant I recommend further study and analysis of course. The Institution has a role to play in developing the concept of sustainable signalling further.

It is evident that fresh ideas need to be generated, possibly by our younger members and the International Technical Committee. Meanwhile we must all hope that our traditional suppliers and our infrastructure managers find ways of ensuring our legacy and bespoke systems remain operable and manage the transition to our new paradigm.

I believe our industry will not be able to survive if they don't. The example of ERTMS/ETCS has already shown us that without the massive subsidies from Europe's framework programs, the development of a system of this complexity and scale would not have been possible. Standardisation might only come about "naturally" by the fact that only one or two large suppliers will remain in the market. The Boeing – Airbus model applied to railway signalling. We have already got a European Railway Agency to assume the role of the FAA after all.

Acknowledgements

It is traditional and fitting for incoming Presidents to take this opportunity to thank the people who have helped us and brought us here. And as always, there are too many to name them all. So I'll start off with the IRSE and its members. The IRSE has given me the opportunity to meet with and learn from countless colleagues, many of whom became friends. The International Technical Committee in particular has provided me with ample opportunities for networking, brainstorming and "going places". I owe much of my professional development to the IRSE and am happy to do something in return by serving on Council and as your President this year.

The chief executives, both Ken Burrage and Colin Porter, and some of the Past-Presidents, especially Clive Kessell and Anthony Howker, have encouraged me to take the plunge and assured me I would be fine and have to be commended for their wisdom and vision. They must have recognised things in me that I did not.

I owe much to my mentor in the early years of my employment at Nederlandse Spoorwegen (NS), Peter Middelraad, a Fellow of the Institution, now retired. He has probably forgotten more about railway signalling than I'll ever know. And to my employers and bosses at NS, Henk Kok and Gert Koppenberg in particular, who had the vision and the trust to allow me, as a very young engineer, the freedom to find my way around the UIC, ERRI and subsequently the IRSE. And of course to Movares today, for still allowing me the freedom to participate in all those countless activities without ever questioning its usefulness to their business and for sponsoring me this year.

And last, but certainly not least, to Conny, who, in the context of the IRSE is above all a loyal and patient wife, for her support and for helping discharge formal duties once in a while.

Glossary

ATB	Automatische Trein Beïnvloeding, Dutch ATP system
ATC	Automatic Train Control
ATP	Automatic Train Protection
CCS	Command Control and Signalling
COTS	Customised Off The Shelf, as in customised off the shelf equipment
Ebicab	Scandinavian balise based ATP system, the Ebicab balise is the technological pre-cursor of the Eurobalise
EEIG	European Economic Interest Group, form of incorporation and acronym for the group of six European fairways acting as the EU's contract

	partner in the development of ERTMS/ETCS
ERRI	The former European Rail Research Institute, which formed part of UIC
ERRI A200	ERRI expert committee formed in 1989 to specify and develop ETCS
ERTMS/ETCS	European Rail Traffic Management System / European Train Control System
FMEA	Failure Modes and Effects Analysis
IRSE	Institution of Railway Signal Engineers
ISA	Independent Safety Assessor
ITBS	Information Technology Based Signalling
ITC	International Technical Committee (of the IRSE)
KVB	Kontrole de Vitesse a Balise, French balise based ATP system, based on Ebicab technology
LZB	Linien Zug Beeinflussung. German cab signalling system, based on UIC standard pre-dating ERTMS/ETCS
NoBo	Notified Body, an agency that certifies conformity of products and system to European standards
SIL	Safety Integrity Level
STM	Specific Transmission Module, additional equipment on board to ensure backward compatibility of ERTMS trainborne equipment with existing ATP systems listed in the TSI
TEN	Trans European Network
TGV	Train a Grand Vitesse, French high-speed train
TSI	Technical Specification for Interoperability, a mandatory form of standard in European legislation
TVM 300	Transmission Voie Machine, version 300, first generation of French high-speed cab-signalling system
TVM 430	Later generation of TVM 300
UIC	Union Internationale des Chemins de Fer (International Railway Union)
UNISIG	Group of signalling suppliers participating in the development and standardisation work for ERTMS/ETCS