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IRSTE

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CONTENTS **Page No.**

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Dear Members,

Indian Railway's Signaling & Telecommunication Department is now being faced with many challenges. The challenge is not only to implement the sanctioned projects but also to develop capacity in the corporate world to carry out these works. This issue carries a few international articles as well as thought provoking articles from Indian Railway officers.

I hope that the contents in the Journal will be useful to Signaling & Telecommunications professionals working on various Railways. I also request that Signaling & Telecommunications officers should come forward and write articles on the activities being done by them. With the opening of IRSE-Indian Section there is another dimensions added in the profession of Railway Signaling & Telecommunication.

(Kundan Choudhary)
DRM / Samastipur &
Gen. Secretary / IRSTE (India)

NEWS VIEW

Objectives of any institution like IRSTE is to provide an integrated platform to interact with fellow Railway Signalling and Telecommunication professionals and helps in improving the competence levels in the field of Railway Signalling & Telecom. It should provide a platform and opportunity to brush up and acquire new technical skills. Over the years, we have seen that IRSTE has tried with limited success to bring details of new technologies to help in the exchange of technical knowledge which otherwise would have remain concentrated at one place.
This Institution is not vendor specific or product specific forum but is a platform which critically analyzes any technology adopted at any place and brings out the positive features as well as areas to improve upon, thereby, identifying the need for the customization required for that Rail network. Thus it should provide an opportunity to the policy makers to identify the areas for skill development and competence enhancement of Railway Signalling and Telecom professionals not only of those associated with the railway operation but even of vendors and system integrators.

We have seen that Rail Transportation has seen renewed resurgence world over being the most green transportation system, which can reach difficult terrains, wherein and otherwise no other transportation mode may go there.
IRSTE is now to evolve and build a platform together with IRSE Indian Section thru interactions to open lot of opportunities to S&T professionals in India to interact with the technology provider, system integrators, study the adoption of such technologies abroad and then identify the type of systems we need to develop suitable processes specifications and quality standards to adopt the suitable available technology as per our requirement. However, the story does not end here as we need a competent working force in the form of a maintainer or a operator or a driver to not only use these new Signalling and Telecom systems which are available at the stations are now in the locomotive, efficiently in a user friendly manner. This needs that the desired competences have to be built into the people, who designing the system, who are building these systems or those who are operating or using these systems. And IRSE is the platform to do so. World over focus is shifting towards on board signaling systems from stations based signaling.

Institution of Railway Signal Engineers conducted a seminar on “Role of Modern Signalling, Telecom & ICT Systems in making Indian Railways a World Class Rail Network” at National Rail Museum, Chanakyapuri, New Delhi on 8th January, 2010. Mr. Sudesh Kumar, Member Electrical Railway Board, Mr. Ajay Bhattacharya, Administrator USO Fund, Mr. K. D. Sharma, Addl. Member (Telecom) Railway Board, Mr. S.K. Vasishta, Managing Director, RailTel Corporation of India Limited, Mr. K. K. Bajpeyee, Chairman IRSE and Mr. Anshul Gupta Secretary & Treasurer/IRSE were among the dignitaries, who graced the occasion. Delegates from Railway Board, all Zonal Railways and leading Corporate houses in the field of Railway Signalling attended the seminar.

On-board Signalling competency and competency in general

by

Buddhadev Dutta Chowdhury
MIRSE MIET

Railway Signalling and Telecommunications systems evolved over the years. It offers innovative and practical solution and encompasses growing need of capacity, performance and customer satisfaction.

Signal and Telecoms are no longer an individual entity and Signal Engineers also should have an adequate understanding of the infrastructure, the operations and rolling stocks to integrate the systems for optimum benefit.

The competency requirements also vary for the different stages of the system's lifecycle from conceptual stage to de-commissioning.

Scenario and performance regimes may be defined however will vary for the different types of operation. Commercial priority for the freight trains is higher than the passenger trains, but the social and the political obligations may not be the same. Mass transit systems have there own performance requirements.

On-board signalling systems and its complexity is increasing day by day, so requires lots of different skill-sets for design, integration, delivery and maintenance.

A working group was set up by the IRSE council after a demand from the industry to examine and establish a competency frame work for the train-borne control systems. The working committee produced and published a competency guidance document after wide consultations with the experts on this field and also considered the current working practices. The guidance provides high level competence management system on this issue.

A number of documents has been already published by several agencies is now available to the industry. Office of Rail Regulator's (ORR) document 'Developing and Maintaining Staff Competence' considered as a primary source for a structured approach to the competence management. Yellow book, published by the RSSB (Rail Safety Standard Board) is widely used by the UK rail industries as a guidance document for good practice on the competency and safety management.

On-Board Signalling System (Automatic Train Control) consists of ATO (Automatic Train Operation), ATP (Automatic Train Protection), MCU (Mobile Communication Unit), APR Reader, Doppler etc., interfaces with train functions such as, braking systems, traction package including motor demands, door systems, announcement systems, emergency alarm etc. Train Management systems consists of a range of software database which comprises code and data including geographical maps, which interfaces with on-board signalling systems for managing performance of efficient operation and aid to maintenance.

Competency depends on the activities undertaken and the phase of the system's life cycle. This may be sub-divided into design, integration, testing and maintenance. Maintenance task may further sub-divide into First Line and Second Line maintenance. Depending on the local procedure, the tasks may be further sub-divided into daily Train Preparation, Schedule Maintenance, Fault Diagnostics and Casualty Maintenance.

New technologies adapted for the on-board control systems have inputs from leading edge expertise in the fields of software, hardware and communications; however the experts involved may not have the adequate understanding on signalling and operation.

Safety validation experts validates this may not have the domain expertise on the systems. System engineers should have the knowledge of railway application and are able to translate customer's requirements into technical documents to integrate the company's products into a total system and the ability to produce safety case.

The engineers associated with basic train control have an understanding of the basic safety functions, material technology and EMC (Electro Magnetic Compatibility). This experts need to be supplemented by a general understanding of control centre technology and systems.

The engineers associated with process management with a greater understanding in automation, handling of process information and traffic optimisation. They may need a general understanding of railway safety systems and technology.

Training and Development takes a lead role for a successful delivery of railway signalling projects and we may need to review the existing training framework to ensure the supports provided as needed to the industry. If this is not sufficient, it may possible to adopts some good practices which are in used elsewhere.

As the working environments within Indian Railways are changing along with the introduction of new technologies, a strong workforce is needed with an enhance competencies and new skill- sets to enable the optimum solution for the whole life cycle of the project.

IRSE had a Continuous Professional Development policy aligned with the Engineering council UK to encourage its member to adopt the approach. This will allow broadening the skill with the updated knowledge by attending various training courses, seminars, conferences, building a network of contacts for an informed opinion on current trends, directions and good practices throughout the working life.

RSE is the only recognised International Professional Body for the signal engineers and its allied professionals, encourage for Continuous Professional Development to its members,which evolved over the years for the benefit to the industries. This can be supplement your needs or complements to the existing competency framework.

IRSE Exam: IRSE exam held once a year and the syllabus covered a wide range of topics associated with Railway signalling projects and its whole life cycle. Safety and Systems engineering are the modules apart from the core subjects on signalling and telecommunications principles and application, which always helps to gain a broader knowledge and understanding to delivery the modern signalling projects. IRSE training and development committee develop the technical contents and undertake periodical review to modify any latest trends or technologies.

IRSE Licence: This is a competence certification scheme for various categories which including Design, Testing, Commissioning, Project Engineering and Senior Engineering management. To obtain a licence, candidate should have appropriate training & knowledge and some evidences work experience, which he has done independently or under mentorship. Candidate has to qualify two stage assessment processes to achieve his licence. IRSE licence is one of the preferred competency certification in the Mainline and underground projects in UK. As the working environments of the Indian Railways are changing, it will be an opportunity to adopt IRSE licensing or similar approach to judge the level of competency of the supply chain for effective delivery of the projects.

IRSE Publication: There is a many different publications on signalling, communications principles and applications including safety management are on public domain for the benefit to the industry. A number of reports published by the IRSE International Technical Committee,may use as a information sources and as a good practice.
So let's use the domain resources & facilities available to the IRSE members as a complementary support to our competency development and to build up a strong signalling professionals to meet the forthcoming challenges.

TPWS OPERATIONS ON SOUTHERN RAILWAY – AN INTERIM REPORT CARD

by

N.KASHINATH,

CSTE/Projects/Southern Railway

SYNOPSIS:

The pilot project of Train Protection and Warning System (TPWS) on Southern Railway has been commissioned over a year back in the Chennai Central/Chennai Beach-Gummidipoondi section of 50 RKMs. The author as the in-charge of this project has in this paper presented the problems and challenges faced during this period and the efforts being made to improve upon the operational efficiency of the system. Details have been furnished of the problems identified and the modifications being carried out to overcome these problems. The author has expressed optimism that once these modifications are fully carried out the performance of the system will come up to the desired level.

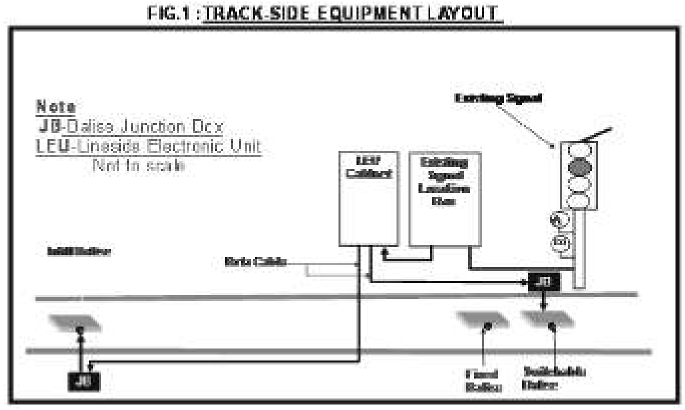
The TPWS project on Southern Railway installed in the Chennai Central/ Chennai Beach – Gummidipundi section of Chennai division was commissioned and services inaugurated by the then MOSR(V) on 2nd May 2008 on 4 EMU rakes to begin with. The works on the balance 37 rakes were progressively completed in the next few months. Presently all the 41 rakes proposed to be provided with TPWS on-board equipments are functional. The TPWS track side equipments in the section were fully provided, commissioned and made functional right from the date of commissioning.

This TPWS project based on the European Train Control System (ETCS) Level-I system faced many hurdles during the initial installation, proto-type testing, obtaining the required clearances from RDSO and CRS. Details of how there were overcome leading to the commissioning of the project in about 3 years of the issue of letter of acceptance was covered in my talk delivered during the last year's IRSTE Seminar held in November 2008.

In my talk today I will dwell on the challenges faced in the last one year or so during which this project is under operation. Before I go into the details, for the benefit of those who are not very familiar with the TPWS, briefly the system configuration and its working are given below.

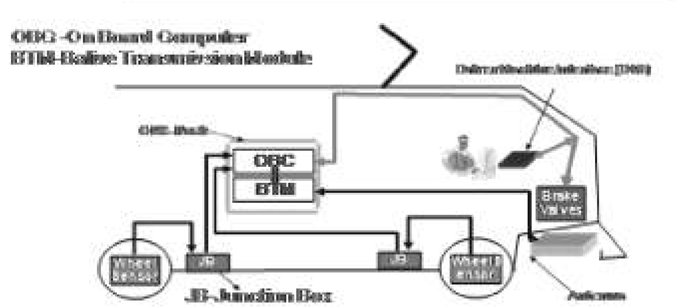
Train Protection and Warning System (TPWS) is an arrangement to ensure safe movement of trains under its supervision by ensuring that the speed of trains remain within the limits specified by the track and signals and in case of violations control its speed by the application of service or emergency brakes. To achieve these objectives, informations pertaining to signal and track conditions are communicated to the train through special devices fitted on the track close to signals called Balise & Line Side Electronic Units. The layout of these track-side equipments is shown in

FIG.1 : TRACK-SIDE EQUIPMENT LAYOUT



These informations are received and processed by the On-Board equipments fitted on the train cabs consisting of Antenna, Balise Transmission Module (BTM), Speed sensors and the On-Board computer (OBC). The results of the processing are displayed as permitted speed & movement authority to the driver on his front panel display called Driver Machine Interface (DMI) and when necessary brake activating commands are sent from the OBC. The layout of On-Board equipments is shown in Fig.2.

FIG.2 : ON BOARD EQUIPMENT LAYOUT



Once the TPWS system had been commissioned, close monitoring was started to evaluate the performance of the system. In order to make the Motormen more confident to handle the TPWS, a second round of training has been organised to refresh the original training given to them during the installation and testing phase, to clarify their doubts and to cover the new motormen who had joined in the intervening period. The pocket reference guide containing operating instructions of working TPWS for Motorman issued at the time of commissioning was expanded and reissued to make it comprehensive and cover most of the situations encountered while running. Now most of the motormen have become well versed with the operations & features of the TPWS leading to less intentional isolations refusals to work with TPWS in ON position.

Regarding monitoring the performance of TPWS fitted motor coaches, in the initial stages after the commissioning; M/s.Ansaldo provided man power to supervise switching ON and starting the train with TPWS. They monitored cases of isolations by observing the condition of the system at commencement and end of the journey. The motormen also started recording the failures encountered en-route in the EMU log book. Periodical downloading of the OBC logs and its scrutiny using sorting software specially developed also helped in studying the on run performance of the system.

Unfortunately once all the 41 EMU rakes were fitted with TPWS on- board equipments and ensuring that the system is kept continuously "ON" through-out the day, new problems on the on-board side started cropping up though the track-side equipments continued to work satisfactorily. The major problems noticed included

(i) On-Board system not booting.
(ii) On-Board system going into System failure (SF) during booting.
(iii) SDMI (Simplified Driver Machine Interface) going blank.
(iv) Speed display bouncing on the SDMI leading to braking.
(v) Brake application in the rear non-driving motor coach on run.

These problems resulted in the overall efficiency of the system achieve only about 70-75% thereby some motormen started treating TPWS as a nuisance and tended to isolate the system on sensing any trouble.

The Railways and representatives of Ansaldo India tried to investigate the causes for these problems but not much headway could be made, though Railways felt that the newer versions of the On-Board software could be a culprit as no such problems were noticed during the initial prototype trials conducted for more than a year. However, Ansaldo have maintained that the newer versions of the softwares are the ones which have been fully validated for meeting the SIL-4 requirements by a reputed third party.

Railways took up these issues at all levels with Ansaldo International which led to experts from Ansaldo France, Australia, Italy and Hong-Kong coming over to India and carrying out detailed study. The error logs of the OBC were also taken by them for further detailed analysis by their company subject specialists. Based on their analysis and study the following conclusions have been made about the above failures.

(I) Intermittent BaliseTransmission Module (BTM) failure.
(ii) Error in Train Interface Unit (TIU)
(iii) Error in the Odometric System
(iv) High back EMF from the coils of Emergency Brake (EB) relay and the Electro Pneumatic (EP) brake relay.

The following corrective actions have been proposed by M/s.Ansaldo to mitigate the above problems including the issue of application of brakes in the rear coach while running and blanking of the SDMI.

(i) Intermittent BTM failure: - Analysis revealed that there was antenna impedance mismatch. The standing wave ratio (SWR) was found more than the tolerance limit of 1.2 to 1.4. Interference from EMI was also suspected. There was problem in communication between the on-board computer (OBC) and BTM. The corrective actions for these problems included modifying the existing antenna protection cover and providing copper braided shields for the Tx-Rx cable between antenna and BTM and for the COTDL and PROFIBUS cable between OBC and BTM. The BTM configuration files were also modified based on some internal parameters.

(ii) Error in TIU: - Analysis revealed that there was problem in communication between some modules of the OBC and now screened twisted pair cables have been introduced to protect the signals from external noise and EMI.

(iii) Error in Odometric System: - To improve the performance of the Odometric system, the signal cables between OBC and speed sensors have been provided with copper braided shield firmly connected to the coach body. To suppress the noise in the 110V DC voltage derived from the motor coach battery, a filter has been provided at the input point of the OBC. The traction control relay has been shifted outside the OBC cubicle to reduce EMI. To improve earthing of the motor coach body, a 50 sq mm copper cable is to be connected between the EMU body and its bogie.

(iv) Back EMF from the EB & EP relay coils: - To cover come this problem, the relay coils and EB valve solenoid coils to be terminated with 180/200V MOVRs and the body of EB & SB relays to be firmly connected to the coach body.

(v) **EB application in rear coach:-**To overcome the problem of application of EB in the rear coach while running, the brake interface circuit has been modified to bypass the EB when the TPWS system in the sleeping mode (SM) i.e., when the cab is not the driving one.

(vi) SDMI Blanking:-To overcome the problem of SDMI blanking, its software has been upgraded. Apart from this, the OBC-SDMI communication cable connector cover which was earlier plastic has been changed to metallic. The OBC-SDMI communication cable and the SDMI power supply cable have been shielded with copper braids firmly connected to the coach body. A filter has been provided at the 110 VDC input point of the SDMI to suppress the ripples in the power supply.

The above modifications involve extensive re-work on the installation arrangements of the On-Board equipments in the EMU Motor coach. For this each motor coach has to be taken out of service for 3-4 days and thereby is a very time consuming job. Before carrying out these modifications on all the 82 motor coaches involved in the project, it was decided to test the actual effectiveness of these modifications by implementing them on 4 motor coaches to begin with and observe their performance for about 4 weeks. It was noticed that the performance of these 4 motor coaches modified as above, excluding the body to bogie connection showed significant improvements and it has now been decided to carryout these modifications on all the balance motor coaches also. Till now about 15 motor coaches have been modified and their performance is being closely monitored.

Out of all the modifications proposed by Ansaldo, they were immediately permitted to carry out all except the copper cable connection between the body & the bogie. This issue was examined in detail by the Electrical branch to study its implications. As body to bogie connections are already adopted on WR & CR and also existing on locos, CEE has recently permitted provision of this on the EMU motor coaches fitted with TPWS.

It may be a relevant question to ask as to why these modifications now being proposed were not carried out during the original installation process. Here it is pointed out that the above six problems were never encountered during the prototype trials on the one rake which extended for about 18 months. During the prototype trials and installation process Engineers from Ansaldo, France were continuously present and have cleared all the installation arrangements. All the components of the On-board subsystem are software controlled and these softwares have been supplied by Ansaldo France & Italy. Southern Railways do not have access to its details. M/s. Ansaldo point out that the original software used during the prototype trials has under gone refinements after it was got formally validated for meeting the SIL – 4 requirements as per the contract conditions. It is suspected that this refinement has reduced the tolerance levels of the systems to work in high EMI/EMC environment. Although Southern Railway has asked Ansaldo to provide the originally used software to check if the problems encountered now also come up with that software, they have not provided the same. Thus the only way out for the Railways now is to get all the installation arrangements in the Motor coaches modified as per the corrective actions proposed by M/s.Ansaldo at their cost.

The work to modify the installation arrangements in Motor coaches through in progress now by Ansaldo in the right earnest is not proceeding at the desire pace. Although it has been committed by Ansaldo to finish modifications for a coach in 2 days, presently it is taking 3-4 days. Ansaldo has been asked to introduce two shifts working to speed up the process. Close liaison is being maintained with Ansaldo and frequent meetings are being held to sort out any hitches. Meanwhile as the failures continue in the non-modified coaches, the division has also started complaining about the unsatisfactory performance of TPWS. However division is being requested to continue using the TPWS by motivating the motormen. Recently MOSR (A) has inspected the TPWS system and traveled in a TPWS fitted motor coach and was appraised about the benefits of the system.

Finally it is hoped that once the modifications are completed in most of the motor coaches by 31.03.2010, substantial improvements in performance would be noticed. We are keeping our fingers crossed and hope the top management will be patient and give us time for taking the project to its logical conclusion!

ERTMS Infrastructure The Spanish Experience

by

Antonio Domínguez Chala

Spain now has the highest number of lines fitted with ERTMS in Europe, and this had been driven by the objective of getting interoperable corridors with the rest of Europe. This had necessitated the adoption of the European standard track gauge for these lines.

Spain faced compatibility issues between the different software versions and the advantages/disadvantages of having single/multiple suppliers. Paper cover these aspects as well .

INTRODUCTION

When the Spanish Government took the decision in the mid-1980s to modernise, improve and enhance the railway, two lines of action were launched: firstly, improvement of the commuter lines in the major cities; and secondly, development of new high-speed lines linking these cities.

In the specification and design of the high-speed lines, interoperability with the rest of the European railways has been considered to be a key requirement.

For this reason it was decided to use the standard European track gauge of 1435 mm instead of the conventional Spanish 1668 mm gauge.Interoperability was also considered to be one of the key factors in regard to the signalling system for the high-speed lines. However in the late 1980s when the first of these routes, Madrid-Seville, was built, the development of a harmonised signalling system in Europe under ETCS was in its very early stages, and so the LZB (Linien Zug Beeinflussung) command and control system was chosen for this line.

1 The author is Director of Planning and Network Development with ADIF, the Railway Infrastructure Authority in Spain

Later when the Madrid-Barcelona line was designed, although ETCS was not fully developed the technical specifications were substantially complete. Application to this and future high-speed lines was considered appropriate at that stage, to reap the benefits of new technology and European standardisation.

ADVANTAGES OF THE ERTMS SYSTEM

From a functional point of view ERTMS provides three important advantages.

INTEROPERABILITY

The European Commission considers railway interoperability to be a key factor in enhancing the railways and giving them an advantage over other transport modes Amongst the various factors required to ensure interoperability, there is no doubt that a harmonised system of signalling and train control is fundamental from both the technical

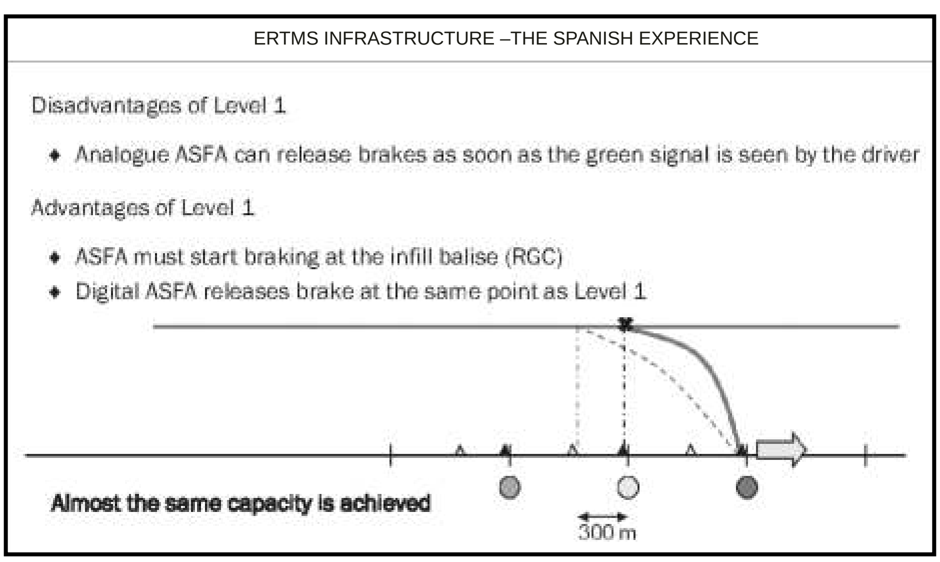


Figure 1 Comparison of line capacity for ASFA and ERTMS Level 1

and operational points of view, eliminating barriers by permitting free movement of trains across frontiers without change of engine or of driver.

In this connection the EC has encouraged the development of freight corridors, and Spain participates in the "D corridor" linking Budapest with Valencia through Barcelona (Spain), Lyon (France), Turin (Italy) and Ljubljana (Slovenia).

SAFETY

The ETCS system provides a substantial increase in safety relative to some of the national protection systems, providing cab signalling and continuous speed control.

INCREASE IN LINE CAPACITY

Because ETCS Level 3 does not require track-based train detection, it increases the capacity of the line for train movements compared with conventional signalling systems by making it possible for a train to run at braking distance behind the one in front (i.e., moving block). However with Levels 1 and 2, which do need train detection systems on the track to determine the presence of trains, the key characteristic is the length of blocks or train detection sections on the track, that is of track circuits. Bearing in mind that Level 1 uses spot transmission, information being transmitted only when the train passes over a balise, whereas in Level 2 transmission of information over the GSM-R radio channel is continuous, there are in fact differences in the increase in traffic capacity that the two systems can provide.

Firstly, comparing the capacity provided by ETCS Level 1 with that provided by a conventional signalling system such as the Spanish system ASFA (Anuncio de Señal y Frenado Automático) which also uses balise transmission (ASFA transponders), we observe that the capacity is almost the same (see Figure 1). There are slight differences, due to application of ADIF's (Administrador de Infraestructuras Ferroviarias -the Spanish Infrastructure Authority) regulations established for ETCS cab signalling with continuous train supervision and monitoring as opposed to ASFA that provides speed control only when the train passes over a transponder. Today the Spanish railway has a new digital version of the ASFA system which incorporates almost continuous speed control and will improve its functionality slightly.

Before comparing the line capacity provided by Levels 1 and 2 we have to recall the concept of theoretical capacity, that is the maximum number of trains that can move in a specific time period, running at the maximum permitted line speed and stopping only where a station stop is scheduled in the timetable. This means that for the capacity calculation the train must pass all signals at Clear except on approach to a station where it has a scheduled stop.

Figure 2 shows two different cases to allow analysis of the parameters influencing the increase in capacity in Level 2 as compared with Level 1.

The first is a theoretical case in which the length of the block section coincides with the braking distance of the train after it passes the red signal. In this case the capacity is the same for both Levels. If the first train had not overrun the red signal, the following train should begin to slow at the same point with either Level 1 or Level 2, and therefore the minimum time between consecutive trains is the same for both.

In the second case we have assumed a block section with a length greater than the stopping distance and possibly with several train detection zones. In this case a train equipped with Level 2 could run longer without needing to start braking than a train with Level 1, up to the point where the preceding train passes the next signal, the one showing red. Figure 2 shows a mathematical expression for the comparative value between the time sequence of trains with Level 1 and the train with Level 2, and therefore the increased capacity with Level 2 compared with Level 1.

Applying these criteria to different cases of block section lengths, a maximum increase in capacity for Level 2 compared with Level 1 of about 5 to 15% can be estimated. Of course this approach only takes into account the times of physical occupation of the block sections and times of passing balises or points to the start of braking, without considering switching times, reaction times, etc. because

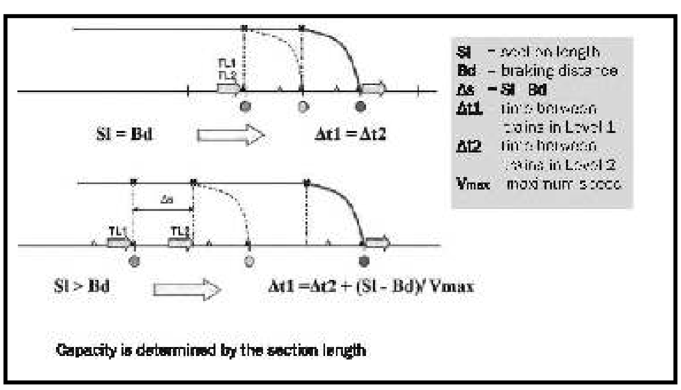


Figure 2 Comparison of line capacity for ERTMS Levels 1 and 2

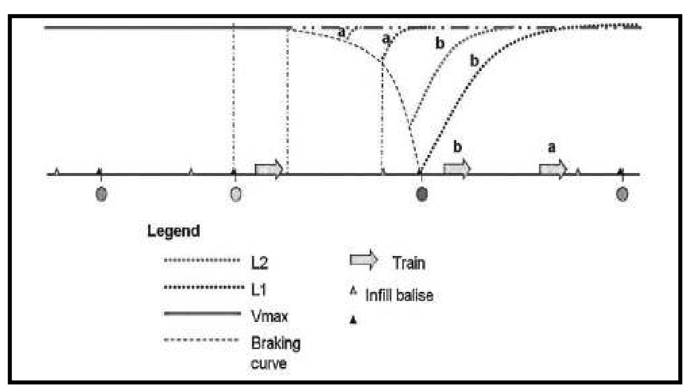


Figure 3 Comparison of Headway for ERTMS Levels 1 and 2

these reaction times can be taken to be the same for both Levels and because relative rather than absolute values have been used in this approach, the results and data can be considered valid.

As we can see, although there is an increase in capacity for Level 2 compared with Level 1, it does not represent a determining value. However Level 2 provides significant advantages over Level 1 on lines with high traffic density where the level of occupancy of the line is at the limit or could even exceed the theoretical capacity at individual locations.

Figure 3 shows how a train equipped with Level 2, once it is braking, can return to maximum speed if the next section becomes free sooner than a Level 1 train can. The Level 1 train must pass over an infill balise or a signal balise before it receives the new less-restrictive information, whereas the train equipped with Level 2 can receive the new information as soon as it changes state.

ERTMS INFRASTRUCTURE STATUS IN SPAIN

The tables opposite show respectively the high-speed lines and conventional lines which are in commercial service or under construction, indicating the supplier, the ERTMS version implemented, the ERTMS level and the length of track fitted. Note that almost all the UNISIG companies have participated in the development of the infrastructure.

It is worth pointing out that at the present time Spain is the country with the largest deployment of ERTMS, with nearly 2000 route-kilometres of lines fitted.

Figure 4 opposite shows the lines where the system is installed, or in the process of installation.

EXPERIENCE AND ISSUES FOUND IN THE FIRST PROJECTS

During the implementation of ERTMS on the first projects, quite a significant number of issues have appeared arising

HIGH SPEED LINES

Line	Supplier	Version	Level	Route-km
In service				
Madrid – Lleida	Ansaldo (CSEE)	2.2.2	2+1	460
Lleida – Barcelona	Thales	2.2.2	2+1	190
Madrid – Valladolid	Thales	2.2.2	2+1	180
Córdoba – Málaga	Dimetronic (Invensys)	2.2.2	2+1	155
Under construction				
Zaragoza – Huesca	ALSTOM	2.2.2	1	80
La Sagra – Toledo	Thales	2.2.2	2+1	21
Madrid – Valencia	Dimetronic (Invensys)	2.3.0d	2+1	470
Barcelona – Figueras	Thales	2.3.0d	2+1	130
Total				1686

CONVENTIONAL LINES

Line	Supplier	Version	Level	Route-km
In service				
Albacete – La Encina	Bombardier	2.2.2	1	93
Under construction				
Madrid commuter lines	Thales / Dimetronic	2.3.0	2+1	160
Total				253
Total (High-Speed and Conventional)				1939

from the fact that ERTMS was a completely new system and from the added difficulty that it is a system composed of two distinct parts, equipment on the track and equipment on board trains, which have to operate together. The main concerns fall into three broad groups.

COMPATIBILITY ISSUES BETWEEN DIFFERENT SUPPLIERS

Most of these problems were due to different interpretations of the technical specifications between the different suppliers because of gaps in the specifications themselves.

In other situations, the compatibility problems were due to the implementation of added functions to the current version used by each supplier, according to the stage of equipment development they had reached.

RELIABILITY

Reliability problems are normal at the beginning of the installation of new systems and components. The problems were mainly due to failures in certain components and in external interferences to the system. Examples of these problems include flaws in trainborne odometry equipment under weather situations with snow and ice, and disconnection of some balises due to external electrical interference.

CHANGES IN THE TECHNICAL SPECIFICATIONS

It is quite normal for the specifications of a new system such as ERTMS to require modification, either to correct errors or to include new features or functionality. When this happens though, it is essential that the new versions are backwards-

compatible with the previous ones. Otherwise significant problems could arise, from an economic point of view because of the need to modify existing equipment and installations, and from an operational point of view because such changes must be carried out on lines and on trains in service. It is therefore necessary to achieve a principle of backwards compatibility of specifications which ensures that:

“Trains equipped with the latest version of ETCS should be able to run on lines implemented with earlier ETCS versions.”

Version management in Spain

The first ERTMS contracts, for trackside and trainborne ETCS equipment for the Madrid-Zaragoza-Lleida line, were based upon version 2.0.0. During the construction phase a change was made to version 2.2.2, and this has since been applied to the other high-speed lines in public service.

Later, in the ERTMS bid for the commuter lines network around Madrid, the recently approved version 2.3.0 was specified.

On 4 July 2008 the European Commission and the Railway User Group signed a Memorandum of Understanding to speed up development of ERTMS. This included two very important decisions for the future deployment of ERTMS: **version 2.3.0d is to be the basis for technical interoperability in Europe; and any future version must be backwards compatible with version 2.3.0d**. For this reason, version 2.3.0d was specified in the calls for the ERTMS system tender for the High Speed Lines from Madrid to Valencia and from Barcelona to the French border at the end of 2008.

A number of problems with compatibility between infrastructure and train-borne equipment can arise from the variety of versions of each. For that reason an analysis has been carried out to verify the changes needed in order to upgrade the lines of the system where the earlier versions are already installed to permit movement of trains with the new version 2.3.0d. This analysis concludes that there is only one new feature incompatible (CR 458) between the installed 2.2.2 version and the 2.3.0 version installed in Spain, and that between the version 2.3.0 and 2.3.0d there are only three new functions that are incompatible (CR 257, 20 and 792) for the required functionality in Spain. All incompatibilities occur at Level 2, while for Level 1 it is only necessary to apply certain engineering rules to ensure compatibility between versions.

The migration process from the existing installations to the compatible version 2.3.0d is very complex on those lines in which the system is already operating in commercial service, since it is not possible to make the necessary changes to all the equipment installed on the lines and on the trains simultaneously. However, in the Spanish case this migration can be done in a reasonable way because Level 1 and Level 2 are installed on all the lines. Taking into consideration that there are no significant problems of compatibility at Level 1, the migration can be done easily. The table in Figure 5 shows the compatibility between the trainborne equipment and the infrastructure for the various versions and the two Levels.

CONSIDERATIONS IN IMPLEMENTING ERTMS

For the installation of a system such as ERTMS signalling it is necessary to take into account different factors. Among the most important of these to note are the number of suppliers, and the functionality associated with the different possible options to implement the ETCS levels.

SELECTION OF THE NUMBER OF SUPPLIERS

Regarding the selection of the number of suppliers, there are certain advantages in choosing a sole supplier, including a reduction in the number of interoperability issues between equipment on board and infrastructure and a closer relationship with the supplier for solving technical problems.

The selection of multiple suppliers brings a number of advantages such as a reduction in prices because of the possibility of carrying out open tenders between suppliers. At the same time, once the initial problems of interoperability have been solved, real interoperability between the equipment from the different suppliers that can run on the line is guaranteed.

LEVEL 1 & LEVEL 2 FUNCTIONALITY

In relation to the functionality provided for each of the ETCS Levels, it is important to study the differences between the Level 1 installation and the Level 2, considering in the first place the functionality and in the second the cost.

As regards the functionality, it is possible to mention three aspects in which there are significant differences between the Levels

Train \ Track	2.2.2 +(456)	2.3.0 +(257, 20, 792. IR)	2.3.0d +(IR 2.2.2)
Level 1	2.2.2	2.2.2 (without Level 2)	2.2.2 (without Level 2)
	2.3.0d	2.3.0d	2.3.0d
Level 2	2.2.2 +(456)	2.3.0d	2.3.0d

Figure 5 ERTMS – Migration between versions

Line Capacity

This has already been considered in depth above, where the increase in the capacity provided by Level 2, with the added advantage of allowing to improve the regularity in case of any incident on the line, was demonstrated.

Temporary speed restrictions

The method of implementing temporary speed restrictions (TSRs) is much more flexible in Level 2 than Level 1, because it is possible to set up the speed limit at the conflict points on the track without affecting operation of the line too significantly, so reducing the effect of having speed limitations longer than necessary. However the new centralised dynamic TSRs of Level 1 provide similar flexibility to the current Level 2 TSRs, because they provide the generation of Level 1 telegrams adapted to the real restrictions on the track without requiring presetting of the section's length on the track with the limited speed previously defined.

Release speed

The operational and system requirement for the release speed in Level 1 can cause problems in some stations where the track layout is too complicated and the release speed required to maintain safety is too low. It is however possible to mitigate this issue and to reduce the risk, for example by positioning the infill balise at the appropriate point in relation to the stopping point and at an adequate distance from the main signal. It is especially important to take this into account at exit signals at stations. Another alterative to mitigate this effect is the use of Euroloop or radio infill equipment.

LEVEL 1 & LEVEL 2 COSTS

Once the differences in terms of functionality between the two levels have been taken into account, it is also important to assess the differences in cost, throughout the entire lifecycle of the installations.

Regarding installation costs, the actual experience of deployment of the system indicates that the costs of installation of the two Levels are comparable. However some steps can be taken to reduce the cost of Level 1. The main one is reducing the cost of cabling, which can be achieved in two ways. Lineside Encoder Units (LEUs) can be connected directly to the signals in the field, without the need to connect directly to the interlocking. Temporary speed restrictions (limitaciones temporales de velocidad, LTV) can be centralised and sent to exit signals at the stations, there being no need to implement this feature at block signals.

Maintenance costs are clearly lower for Level 2 on for Level 2 on account of the reduced amount of trackside equipment.

One very important aspect that should not be forgotten is the impact on the existing interlocking of the decision to implement ERTMS. To implement all its functionality Level 2 requires to interface with an electronic interlocking, whereas Level 1 can interface with relay (or geographic

Figure 6 ERTM deployment strategy in Spain

relay) interlockings without undue complication. When ERTMS is to be implemented on a new line on which all the interlockings are electronic, there is very little difference between Levels 1 and 2. However when implemention of ERTMS is under consideration on an existing line, where it is quite usual to find different type of interlockings, it is important to keep in mind the need to renew the old interlockings for Level 2 when costs in relation to those of Level 1 are being considered.

STRATEGY FOR ERTMS IMPLEMENTATION IN SPAIN

Once the ERTMS system has been consolidated and stabilised, the Spanish strategy will be to implement only one ERTMS level for the conventional lines and one for high speed lines, taking into account the specific characteristic of each.

In the case of high speed lines, Level 2 will be the only system to be implemented because of the increase in capacity and flexibility that it provides for operation, as well as the reduction in costs on account of lineside signalling not being required between stations.

On conventional lines several cases need to be considered. In areas with high traffic density, such as commuter areas and main rail corridors, Level 2 will be implemented because of the increased capacity that it is able to provide and the improvement in regularity as described above.

In the rest of the network, the installation of Level 1 and Level 2 has to be evaluated in each case on the basis of a cost-benefit analysis. This analysis should take into account the differences in cost described above. In either case, it is a requirement that the installation of Level 1 provides functionality equivalent to Level 2.

The key guidelines for the development of the Spanish railway system are defined in the Strategic Plan for Transport Infrastructure (PEIT) of the Ministry of Civil Works, as shown in Figure 6. This plan defines the rail network for the year 2020, and ERTMS is an essential part of it, much of it being already implemented or under development.

A life cycle assessment proves that LED lamps are the most environment friendly lighting products. There is a tremendous potential of the LED technology, to save energy. In fact, the time is not far when 400 lumen will be obtained with just 4 watt of power consumption. Also, they are competitive with today's energy saver compact fluorescent lamps (CFLs).

Worldwide, almost 20 per cent of the electricity consumption is used by lighting applications, which corresponds to 2651 TWh/year. 70 per cent of this energy is consumed by inefficient lamps.

Solid state light sources, e.g. light emitting diodes (LEDs), are based on inorganic semiconductors that emit light by electroluminescence. LEDs will revolutionize modern lighting due to their unique properties – such as long lifetime, colour tune ability, and instantaneous switching. Moreover, they are mercury free. But most important: LEDs will be amongst the most efficient light sources in the near future. Today LEDs are already five times more efficient than incandescent lamps. In the future, however, it is expected that LEDs will become more than ten times more efficient compared to incandescent bulbs. No doubt, tremendous amounts of energy could be saved which will not only reduce CO2 emissions but also lower the energy bill of consumers.

Life Cycle Assessment (LCA)

On Railway's effort has already been made to convert signal Lamp with LED Lamps. However due to circuit limitation, energy savings are not much, hence, need of the hour is to redesign signal lightning circuit specification for LED signals to achieve energy conservation. LCA analyse the environmental impact of an LED lamp over its entire life, and to compare it with a compact fluorescent and an incandescent lamp. The complete life cycle of all three light sources was carefully modeled and analyzed from start to finish. The relevant material and energy supplies were determined in detail for all components and production processes of the lamps. The impact inventories are broken down into the five life cycle stages, which are namely raw material production, manufacturing and assembly, transport, use and end of life.

Three types of lamps were analyzed: a 40W incandescent lamp (GLS), an 8W Superstar compact fluorescent lamp (CFL) and an 8 W Parathom LED lamp with 6 Golden Dragon LEDs. Common basis for the comparison was a luminous flux of all lamps in a range between 345 and 420 lumen (a 40 W equivalent requires 345 lumen minimum according to IEC Norm 60064). a correlated colour temperature between 2700 to 3000K (warm white). A colour rendering index of > 80 and a Classic A shape with E27 socket. All lamps provide comparable luminous flux and all are warm white lamps, but the fact of a 'cold' perception of the light from different emission spectra of the lamp types is not considered.

To ensure comparability of the three lamp types, a lifetime of 25000 hours was taken a reference parameter, which was evened out by the number of lamps used. This way, the lifetime of 25 incandescent bulbs (25000 hours) equals the lifetime of 2.5 compact fluorescent lamps, which equals the lifetime of one Parathom LED lamp. For comparability reasons in the study, it was assumed that all three lamps would have a light output between 345 to 420 Im during their whole lifetime, and then burn out.

An extra analysis was done, which took the gradual reduction of brightness into account. The difference was too small to impact results, though. Turn-on and off cycles were excluded from the study.

LCA of the Three Lamp Types

The Incandescent Bulb Classic A: A classical incandescent bulb in use ever since Thomas Edison turned it into a product for the masses in the early 1900s was used for the comparison.

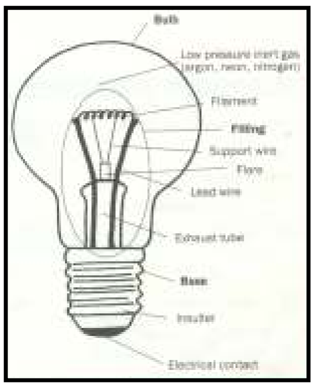
The Compact Fluorescent Lamp Dulux Superstar: A compact fluorescent lamp (CFL),

The LED Lamp: An LED lamp, the 8 W Parathom Classic A55, with six Golden Dragon Plus LEDs from OSRAM was used in the study for comparison to the other two lamps.

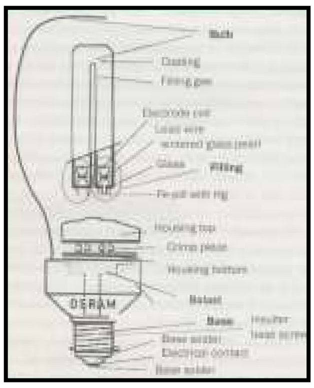
A 40W incandescent lamp, an 8W compact fluorescent lamp and an 8W LED lamp with six LEDs were used in the LCA.

The whole life cycle includes –
Manufacturing. Use and End of Life. The phases are explained in the following paragraphs.

Manufacturing Phase: All lamps are divided into parts for the base, bulb, filling, including packaging and transportation.



Various parts of an incandescent bulb.



A compact fluorescent lamp (CFL) is also known as an energy-saving-lamp.

The packaging consists of a cardboard box, and transportation includes all transportation processes within the manufacturing phase, including transport of the final product to the customer in Europe.

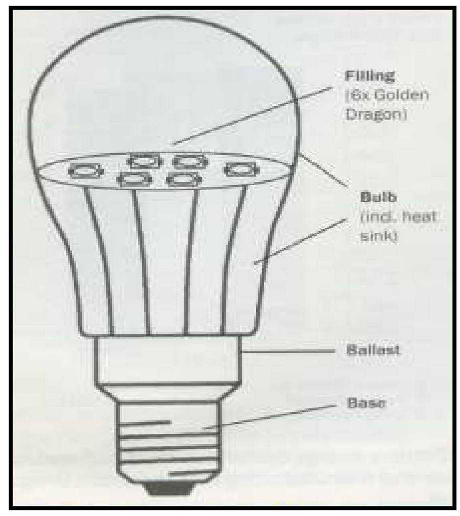
	GLS	CFL	LED Lamp
Base	- Solder - Screw Shell - Insulter - Basing Cement - Electrical Contact	- Basing Cement - Housing (top + bottom) - Glue - Screw Shell - Insulator - Solder - Electronic Ballast	- Insulator - Contact Plate - Plastic Sleeve - Aluminum Board - Electronic Ballast
Bulb	- Glass	- Glass	- Bulb material - Heat Sink
Filling	- Getter - Filament - Wire (Support + Lead) - Exhaust Tube - Flare	- Filling Gas - Coating - Frame (Electrode Coil, Emission Material, Sintered Glass Pearl, Wire, Tube (Stem +Exhaust) Fe pellet with Hg)	- 6 x Golden Dragon Plus

Comparison of the materials of construction of the three types of lamps.

In this study, special emphasis was given to the investigation of the manufacturing of the LED itself, here the productions is split up into two main process stages: front end, where the 1 square mm semiconductor chip is fabricated, and back end, where the chip is contacted and packaged.

Further the back end processes are carried out that include the deposition of the LED chip into a lead frame, wire-bonding as well as phosphor and lens deposition. All processes are accompanied by optical and electrical inspection.

Other components needed to manufacture the LED lamps are enclosure bulb and ballast.



Construction details of an LED lamp.

Use Phase: The use phase was modeled by average processes without heating value or direct emissions. The emissions, as outcome from the use phase, are resulting only from power supply. For the use phase in Europe, the power mix of the European Union was taken into consideration. For the European average power mix, 1 kWh electricity has a CO2 output of 0.55 kg.

End of Life Phase: For all systems as end of life scenario incineration of household waste is modeled.Although CFL, and LED lamps are obliged to be recycled professionally according to the EU Directive 2002/96/EC-WEEE, many lamps are cast away by the consumer, which is the reason why disposal in domestic waste was assumed. For the CFL and LED lamp this is not the required method of disposal as valuable raw materials can be recycled, but all lamps were treated in the same way for comparative reasons. A professional disposal is handled in the sensitivity analyses.

Results of the Life Cycle Assessment

The total primary energy demand during manufacturing for the LED lamp is 9.9 kWh. The LEDs themselves have a share of 30 per cent of the primary energy demand of the LED lamp out of which the metals included have a dominant share. The CED of the lamp is dominated by the common power consumption for production, the large amount of aluminum required for the heat sink and the ballast.
Primary energy demand of all three lamp types has been depicted in the graph, multiplied by the number of lamps needed for a lifetime of 25000 hours. With about 0.61 kWh the GLS consumes the lowest amount of energy during manufacturing. However, 25 bulbs are needed to compensate a life time of 25000 hours, and thus the GLS solution has the highest CED. CFL and LED are consuming about the same amount of primary energy over 25000 hours.

Over the entire life cycle of the lamps, including manufacturing, use and end of life, it was found that the use phase dominates the manufacturing phase in terms of energy consumption by far. The primary energy consumption over the entire life cycle of the LED lamp and CFL is about 667 kWh, while that of the GLS is about 3302 kWh, almost five times more. Since the use phase of the CFL and LED lamp is dominant, and they run on equal wattage, they had the same total primary energy consumption as well as electricity consumption. For electricity consumption that means: over their life of 25000 hours, the GLS consume 1000 kWh, while the CFL and the LED lamp merely consume 200 kWh of electricity, thus provide 80 per cent saving potential.

The energy demand of the manufacturing has been zoomed out by a factor of 10, as otherwise it cannot be seen in graphical presentation. Less than two per cent of the primary energy demand over the complete life cycle is required for manufacturing. End of Life is not depicted in the diagram, as it is not visible due to the extremely small role in plays with about 0.1 per cent of the primary energy demand over the entire life cycle. For the GLS a credit of 3 kWh is obtained, for the CFL and LED lamp less than 1 kWh is gained. Thus, the above values for the entire life cycle are achieved.

Environmental impact categories: The domination of the use phase over the manufacturing phase observed for the CED was found for all environmental impact categories. Extremely high results for the GLS are caused by the high number needed for 25000 hours, and the comparatively high wattage needed to run them. The required energy dominates the environmental impact.

Photochemical Ozone Creation Potential (POCP)

The LED lamp shows higher values for the POCP of the manufacturing phase than the other two lamps due to chemicals in common waste of the LED front-end process. However, that minor difference is negligible with respect to the use phase. Less than 2.5 per cent accounts for the manufacturing phase compared to the POCP of the entire life cycle.

Future Outlook

Since, the LED has incredible development potential in comparison to the relatively mature CFL and GLS technologies, a future scenario was calculated. In the future, LEDs are predicted to achieve 150 lm/W for warm white and even 180 lm/W for cold white light emission. Taking into account losses in the electronic ballast and optics as well as thermal losses, an LED lamp could reach an efficacy of 100 lm/W. And that is even a more conservative assumption.

In that case a light output of 400 lm can be achieved with just 4 W of power consumption. That would cut down all values for the use phase by half. In the use phase the LED lamp would only need about 335 kWh of primary energy over its lifetime of 25000 hours, or 100 kWh of electricity.

In the manufacturing phase, improvements are also expected: less aluminum will be needed in the heat sink in the future. Thus, the LED lamp will also be the favoured solution with respect to all environmental impact categories.

Conclusions

Less than two per cent of the total energy demand is needed for production of the LED lamp: The manufacturing phase is insignificant in comparison to the use phase for all three lamps as it uses less than two per cent of the total energy demand. This study has dismissed any concern that production of LEDs particularly might be very energy-intensive.

Merely about 0.4 kWh are needed for production of an LED

LED lamps are competitive to CFL today: In contrast to the primary energy consumption of incandescent lamps of around 3,302 kWh, CFL and LED lamps use less than 670 kWh of primary energy during their entire life. Thus, 80 per cent of energy can be saved by using CFL or LED lamps. The bottom line is that LED lamps are more efficient than conventional incandescent lamps and also ahead in terms of environmental friendliness. Even today, LED lamps show nearly identical impact on the environment compared to CFL.

Future improvements of LED lamps will further cut down energy demand: As the efficiency of LEDs continues to increase, LED lamps will be capable of saving more energy and achieving even better LCA results in future.

This life cycle assessment proves that LED lamps are amongst the most environmentally friendly lighting products.

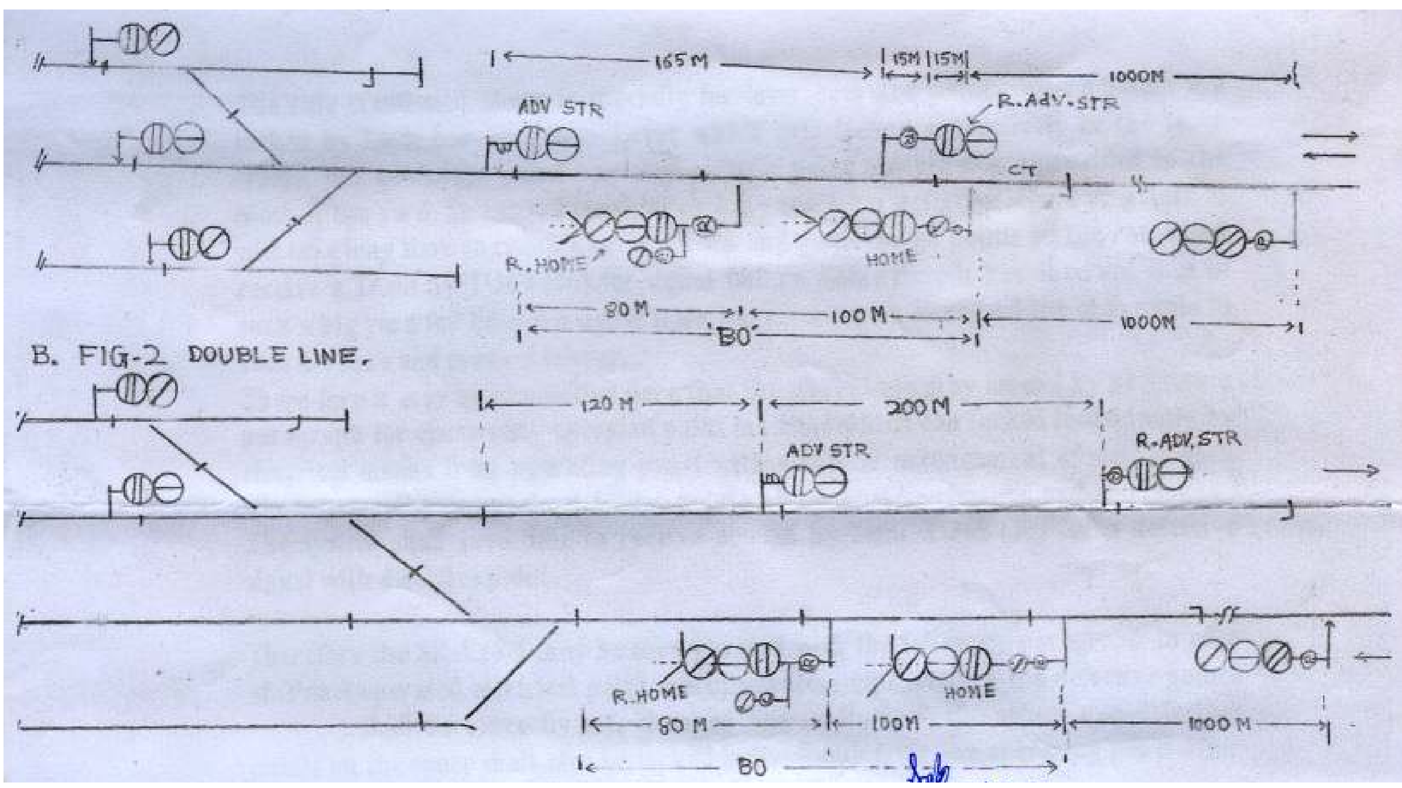
A PROPOSAL MODIFIED SIGNALLING PLAN

by
S. K. Mitra
SSTE\CON\PL\MLG
N.F Rly

There has been so many accidents/collision occurred in station section or block section due to overshooting of signal due to human mistake of drivers of the train. If we provide a reminder Home Signal and a reminder Advance Starter (according to the sketch signalling plan) which will work as a Repeater Signal of Home and advance starter in advance of the signals. These reminder signals shall confirm the train driver about the conditions of main Home or Adv. Starter Signals which he passed before entering the station section or block section. In such a way many accident can be prevented from human mistake. Moreover there are so many case of no light of signal which is most unsafe at night in such case the reminder signal can help the driver also.

To implement these signals, incremental cost is involved and fly back of the signal is by the same track circuit as original TC.

A.Fig 1, Signal Line



GR & SR of 2004 Addition.
H. Defective of fixed signal and points.

GR.3.68-Duties of Station Master generally when a signal is defective:-
SR.3.68\1-(a)..............

(b) Before issuing the form T/369-(3b) for a defective signal at his station or before granting Line Clear for a train for which T/369-(1) has been issued by the nominated station/rear station, the station master shall ensure by his personal inspection that the relevant points over which the train will pass, are correctly set, clamped and padlocked and the key of the padlock is in his position and also that the lock bars(s) where provided is in its proper position. However, at non-interlocked stations where the points are not detected by signal, the station Master, if he has personally ensured that relevant points have been properly set and locked by the relevant key (shall keep such key(s) in his custody before issuing T/369-(3b).

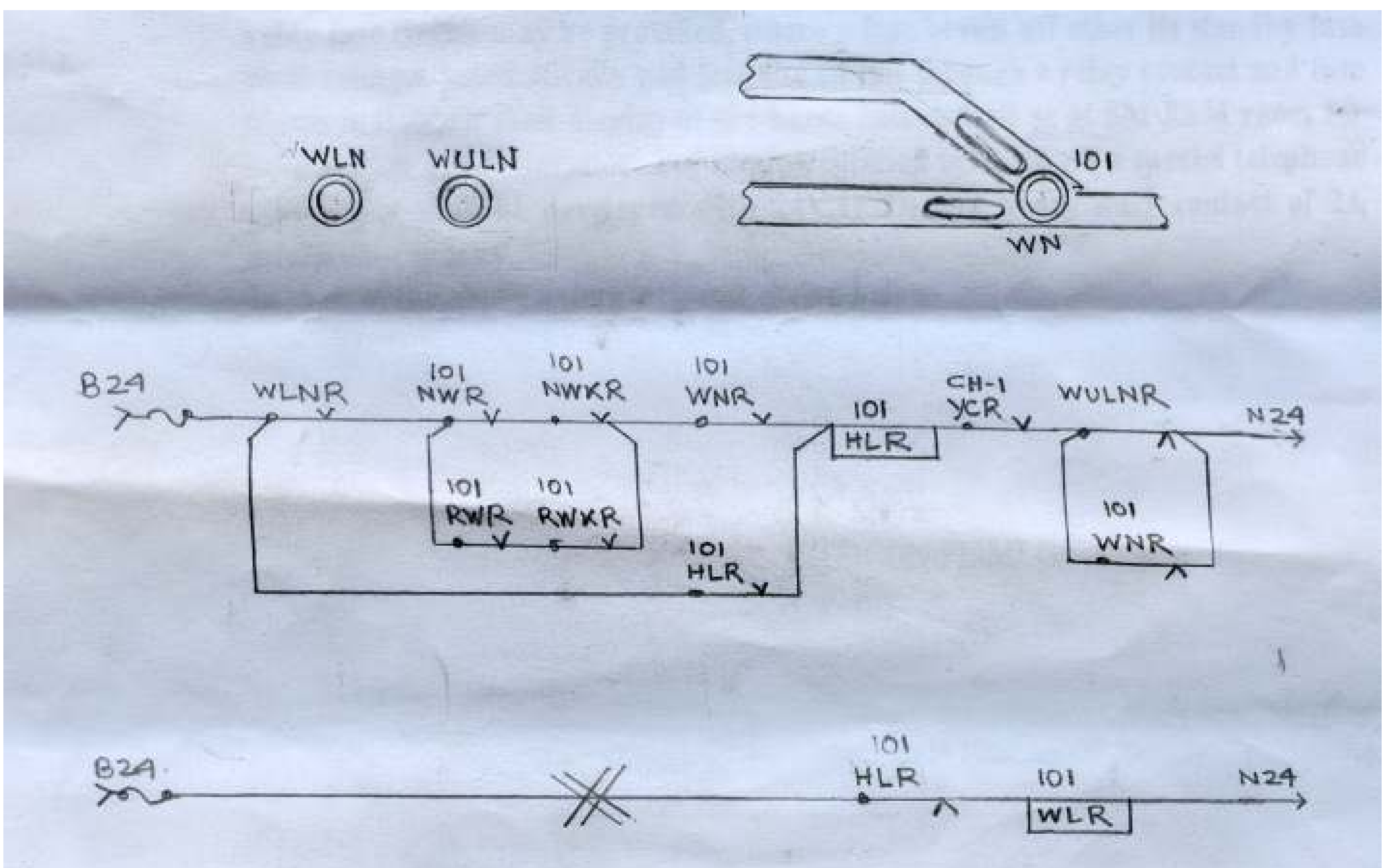
Details instructions in all such cases as applicable to individual station interlocked or not, shall be incorporated in the station working rules in amplification of the principles enunciated in this rule.

The rule mentioned above is specially for lever operated points, where points are locked by Lock bar or points lever which gets locked successively in the lever frame. But nowadays panel operated electric point machines are provided in the most of the yard. In case of medium or big yard for a defective signal or points, it will take long time to crank handle, clamp and padlocks all points on the route and receive a Train by T/369-(3b) for signal failure. Some time it is observed that in such a big yard due to failure of a signal, train is received by disregard, the above rule to save time and manual labor.

Therefore it may be mentioned here that the above rule may amend by addition a paragraph for electrically operated point machine which can lock individually by electrical means from operating panel with a special arrangement of similar interlocking except the defective points which must be clamped and pad locked. The system shall save time to receive a train on form T/369-(3b) for a defective signal with defective point.

Therefore the SR 3.68/1 may be incorporated with the following paragraph-"In case of panel operated electrical point machine becoming defective, the defective points shall be correctly set, clamped and padlocked, the others non- defective points on the route shall also be locked individually from the operating panel after correct setting with indication the points for the nominated line."

A Simple circuit shown below for individual locking of the electrical operated point from a Operating Panel.



C. Failsafe Relay Fuse.

Fuse blown is the common fault in the internal signaling circuit, for which so many train detention occur. To arrest such fuse blown incident, a simple relay fuse circuit may be provided, where a fuse blown off other its standby fuse shall connect automatically and feed the circuit through a relay contact and fuse blown indication shall display at the burnt fuse as well as at SM/ESM room for information and restoration. For implementation such circuit a special telephone type Relay shall be developed with 24V,, 1F/2B and heavy duty contact of 2A minimum capacity.
In view of the above a simple circuit shown below will be there.

S. K. Mitra
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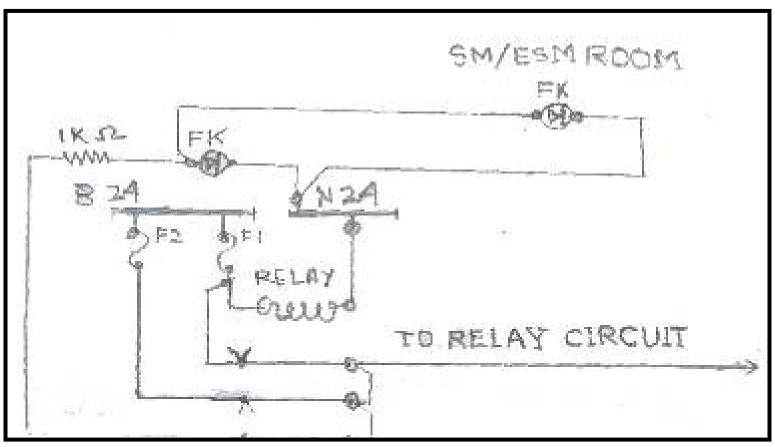

Formalization cuts costs and increases safety

by
Jesper Carlström
Prover Technology

Railway signalling systems are surprisingly expensive to produce. Formal methods have emerged as a way to cut costs and increase safety at the same time. Why did this happen, and what have been achieved so far?

In the early days of railway history there were no interlocking systems. It was enough to have personnel at the stations manually observing trains and operating signals. The need for automatic signalling eventually became evident: human beings tend to make mistakes, which can lead to serious accidents, and the capacity of railroads was reduced by all manual procedures.

The drawbacks of automatic signalling were however obvious: huge investments were needed, and although automatic systems were not as error-prone as manual processes, reliance on automatic systems led to potentially even more dangerous errors. Therefore, the construction of automatic signalling systems had to be extremely safety-conscious. An obvious dream was to try to be able to prove, by mathematical methods, that the systems were correct. Although pleasant, this dream could not be realized except in toy examples, as there were no reasonable technical solutions that allowed proving that a complex signalling system was correct.

Instead, a tradition of strict developments processes with thorough reviewing was introduced, requiring even reviews of the reviewing processes, thus resulting in the production of an enormous amount of documents. Needless to say, this made automatic signalling even more expensive and hard to maintain. But there seemed to be no alternative. As late as in year 2000, the CENELEC (European Committee for Electrotechnical Standardization) EN-50128 document stated that "*There is no known way to prove the absence of faults in reasonably complex safety-related software*" and concluded that well-documented production processes was the only available method to guarantee safety. It is fascinating to see that the situation has become quite different only ten years later.

State-of-the-art of formal verification

Today, there are proof engines that can formally verify the safety requirements for a railway interlocking system in a few minutes using an average laptop computer. Time-consuming and incomplete safety testing can be replaced by mathematical proofs that, for a fraction of the previous cost, can provide 100 percent coverage. This approach requires good quality of the specifications. They must be formalized in a mathematically precise formal language, so that proof engines understand exactly what they are supposed to prove. This formalization step has been a main obstacle that made people hesitate adopting the new techniques:

1 Can our safety principles really be expressed in such a precise way?
2 What formal language is suitable for railway signalling systems?
3 How can we guarantee that the formalization is correct?

An example can be used to indicate the answers. Let us formalize the requirement "a signal may only show 'proceed' if the route is clear" in the language PiSPEC, which builds on predicate logic but adds types and object orientation. First, we spell out that it is not about "a" signal, but actually about all signals. Then, let's observe that "the route" is not an arbitrary route, but the one that starts at the signal. Moreover, there may be several routes starting at the signal, so we need to say that we mean the one that is currently signalled for. The notion of "route locking" can be used for that. We thus need to say something like:

ALL si:SIGNAL ALL rt:si.routes (rt.locked & si.proceed -> t.clear)

In plain English: "For all si (that are signals) and all rt (that belong to the routes that start at signal si), if rt is locked and si displays proceed, then rt must be clear". One must also define what "si.routes", "rt.locked", "si.proceed", and "rt.clear" means.

It is a straight-forward task to formalize safety principles in this way. Any formal language that can express simple concepts like the ones above can be used for the formalization.

By choosing a formal language that is at the same time highly readable and mathematically precise, it becomes easier to review that the informal requirements have been faithfully represented by their formal counterparts. Because safety principles are seldom altered, their formalizations need not change either, thus the review need not be repeated for every station.

Formal verification is now strongly recommended by safety standards organizations such as CENELEC, and several leading railway infrastructure managers, such as Paris Metro, Swedish National Rail, Norwegian National Rail and New York City Transit require formal verification as part of their safety assessments. The reason: formal verification increases safety and quality, and provides more efficient processes for otherwise costly and time-consuming safety testing.

Formalized specifications

Consider a situation in which a signalling system shall be purchased. It is not possible to simply order something that "works", because it is important that it works in accordance with the operational rules and signalling principles applied in the area where the system is going to be installed. Moreover, the engineers of the trains will expect the signalling principles to be similar at all stations, so purchased systems must behave in more or less the same way, even if they are provided by different suppliers. Thus there is a need for a precise specification.

Most system specifications are written in natural language (English, Hindi, French, et cetera). Natural language may seem easy to understand at first glance, but experience shows that it tends to be interpreted differently by different people. In particular this is true if the author of the specification leaves out "obvious" parts, as these parts may not at all be obvious to the system provider engineer, in particular if he lives on the other side of the planet, and is used to completely different signalling principles. Even worse: if the purchaser receives a system which fulfils every requirement spelled out in the specification but not the "obvious" implicit ones, it can be hard to argue that the system was not the ordered one. The project gets delayed, runs over budget, and the business relations become frosty.

Formal logic has gained importance as a way to overcome the problem of natural language not being precise enough. Using formal logic, one can state in a mathematically precise way exactly what is required. As in the example provided above, the mere process of formalization can make you discover that some things are not spelled out with enough detail. By communicating formal requirements, you are perfectly clear about what you require. As for any mathematical text, the formal requirements need to be explained in natural language too. These explanations are what you read to get familiar with the ideas, while the formal requirements provide the precise interpretation, covering every corner case.

Formal requirements for system evaluation

When a system has been delivered and is in its "acceptance phase" (when it is supposed to be inspected, tested and in other ways evaluated), the formal specification can be used by the V & V engineers to understand precisely what is supposed to be tested or verified. It is not a matter of interpretation whether the system fulfils the requirements.

Safety verification usually amounts to a significant portion of the overall system development cost, and is often carried out by experienced key staff using testing and manual reviews. While testing and review are important techniques, they cannot guarantee an exhaustive analysis; judging with certainty whether a system is safe with respect to its safety requirements cannot be done using these techniques, even if they are applied during a very lengthy process.

There are many cases in point to testify to the limitations in testing and review as the only safety verification methods. A recent example is the safety-related problem that was discovered in a relay-based interlocking system that had been in operation for some 20 years in Stockholm, Sweden: in rare occasions, a signal could display a too permissive aspect. This error was found by formal verification and could be reproduced in field. It was corrected in the spring of 2010.

Apply formal verification early

If the system provider knows that the purchaser will evaluate the system using formal verification against the requirements given in the specification, he is of course tempted to try to do it himself first. There is no point in handing over a system that will immediately be returned because of errors discovered by formal verification.

By performing formal verification early in the development process, errors can in fact be removed almost immediately after their introduction, giving shorter iteration cycles and saving significant development resources. Rather than discovering errors when the system development has been completed, one can discover them during the software design, which is much cheaper.

Formalized requirements for system design

When a safety specification has been formalized, it sometimes becomes so clear that it is more or less evident how a system should be designed to meet the requirements. Not only does this mean that the development costs are lowered, it also raises the question if it would be possible to automatically generate an interlocking system from the requirements alone. The answer is partly yes, but with some modifications. First, the requirements are generic, that is, they are stated in a way which makes them always apply. Therefore, configuration data of a specific application has to be added before software code for it can be generated. Secondly, a proper set of safety requirements still leaves some freedom in the design of the system. For example, a safety requirement may state that a signal may not display proceed in certain circumstances, without giving much information about when it shall in fact display proceed. So safety requirements alone need not be sufficient for system generation, but the method of formalization also applies for design principles.

This demands something of the signalling engineer. He has to abstract, because he is not supposed now to construct an interlocking system for a specific location, but he is supposed to pin down the underlying generic principles. If he manages to do this in a formal logic, which can require some effort indeed, the reward comes immediately. By simply providing configuration data, a computer tool can use the generic principles to automatically construct an interlocking system that can also be formally verified against the safety requirements. The complete implementation process for a medium size station (50 to 100 routes) can be performed in a few days. When it gets altered, an updated version can be produced in a few hours. This way of working is especially efficient for new lines that will contain many stations. As the same signalling principles will be used throughout the line, they need only be formalized once. When this has been done, the only thing that has to be performed for every location is:

1 draw the new track layout,
2 configure all objects.

Then, by a push of a button, a new interlocking system is produced. All the tedious repetitive work is done by a computer, leaving more interesting tasks to the signalling engineer.
A second pay-off of formalization comes the day the senior signalling engineer leaves or retires and takes his knowledge with him. The formalized signalling principles then remain, to be used as a knowledge base by engineers.

Diversification and safety bags
The safe operation of railway interlocking systems can be ensured by other methods than formalized requirements and formal verification.

One method is diverse programming. One assumes that, although everyone makes mistakes, it is unlikely that two independent persons or teams make the same mistake. By hiring two teams, constructing two different versions of the same interlocking system, it is very likely that at least one of them does the right thing. By running both systems in parallel and comparing their results (in run-time), one can immediately stop the traffic if the systems are not in agreement. Besides being an expensive development process, this solution yields poor functional capacity, as errors still occur and lead to traffic interruptions.

A somewhat cheaper solution is to construct only one system but add a safety bag. A safety bag is a computer program that checks that the system fulfils its requirements in every moment. As soon as it does not, the traffic is stopped. This solution requires only one system to be constructed, but it also needs formalization of requirements in some computer programming language, and it has the same capacity problems as the diversification solution. It reminds of the formal verification method because requirements have to be formalized, but it defers the discovery of the errors to the revenue service of the system.

The conclusion is that formal verification is superior to the above-mentioned techniques mainly because it offers full coverage and early discovery of errors. Diversification techniques are fruitfully applied on a higher level: to ensure that formal verification results can be trusted, they can be implemented diversified by independent programmers. If one implementation turns out to be faulty, traffic needs not be stopped, because the system has not even been taken into operation yet.

Combining all benefits of formalization
It has become evident over the years that formal methods become even more profitable when combined with each other because of synergy effects. If a language like PiSPEC (of which an example was provided above) is used, which is suitable both for human reading and for computer processing, formalization becomes a valuable resource that can be used for several different purposes.
Prover Technology has 20 years of experience in formal verification and proof engine construction. Prover Technology offers Prover iLock, a complete Windows-based software for the production, verification, and simulation of interlocking systems and onboard systems. Based on a generic design specification given in PiSPEC and on configuration data (layout drawn by the user with a mouse and other data entered in various ways), Prover iLock generates a complete interlocking system in a computer language of the user's choice. If safety requirements are provided in PiSPEC, formal verification can be carried out by a push of a button. A powerful built-in proof engine then proves the requirements, or, if faulty, displays to the user why they fail. Also a simulator is provided, so that it can be checked not only that the system is safe, but also that it operates as expected. Prover Technology also has a solutions team that help clients with the formalization of their specifications, and to get up and running with Prover iLock.

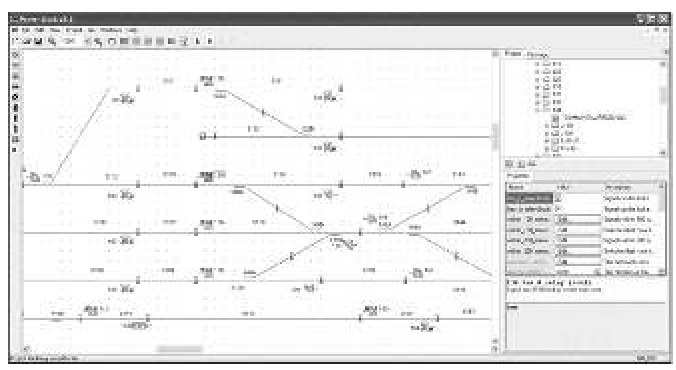

Figure : A specific application is drawn and configured in Prover iLock

The Prover iLock process is carried out as follows:
1 Gather signalling principles, safety principles, wayside object types used, and so on.
2 Formalize safety, test and design requirements into a PiSPEC library.
3 Use Prover iLock to check syntactic and semantic correctness of the specifications.
4 Use Prover iLock to draw a track layout and configure objects.
5 Use Prover iLock Verifier to verify the safety of the specific application.
6 Use Prover iLock Simulator for functional testing of the specific application.
7 Use Prover iLock Coder to automatically generate application code for the specific application,

together with documentation about statistics and quality assurance activities carried out.

Notice that only the last four bullets have to be repeated for new locations with the same signalling principles.

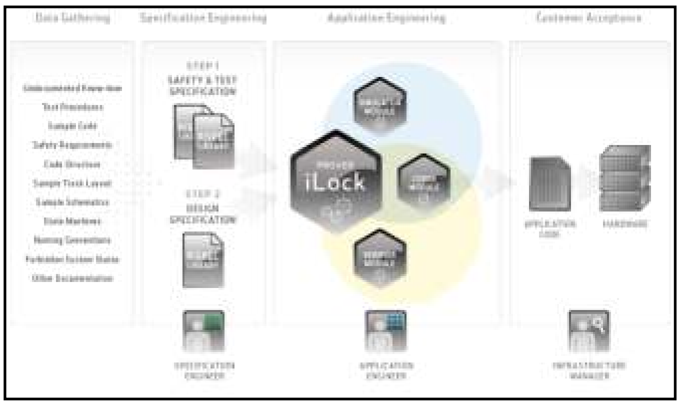

Figure Prover iLock process

Reliability

The question naturally arises: how can you trust software that constructs interlocking systems? You should not. No software is perfect; there is always a risk of errors. By choosing software that has been heavily used again and again, one can be more confident in its correctness.

In some situations, like when formal verification is supposed to replace other safety checking procedures, it is however important that the software can be fully trusted. Prover Technology offers a CENELEC SIL-4 certifiable solution for this purpose. It has been used by RATP to base a safety case entirely upon formal verification. Prover iLock's verification abilities are then viewed as nothing but a development tool, while the independent CENELEC SIL-4 certifiable formal verification solution is used to finally seal the safety case.

Summary

Specifications written in natural language (English, Hindu, French, et cetera) may turn out to be harder to interpret than formal specifications because they to large extents refer to “tribal knowledge” that may not be shared by all engineers involved. This is one reason to formalize the requirements. Other important reasons include to enable use of efficient tool support to replace the tedious, repetitive “grunt work” by automated functional testing, formal verification and code generation. Efficient tool support means railway signalling engineers can focus on the more productive and interesting tasks involved in creating high-capacity and safe railway signalling systems.

About the author

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CORPORATE MEMBERSHIP FORM

Name of the Representative ______________________________

Working Organization ______________________________

Present Address of the Organization ______________________________
____
____

Designation ______________________________

No. of People in the Organization ______________________________

Cheque No. for Corporate Membership (Amt. Rs. 10,000/-) ______________________________

Note : Kindly send the same on the following email or address

gautamarora22@gmail.com
anshulgupta@railtelindia.com

Institution of Railway Signal & Telecommunication Engineers (India)
Room No. 16, IRCOT Office, Shivaji Bridge,
(Behind Shankar Market),
New Delhi-110001

Institution of Railway Signal Engineers

Non-UK ONLY: Fellow, Member, Associate Member – Application Form

Section A - PERSONAL INFORMATION:

For Office Use Only:

Application No:

Please write clearly using BLOCK CAPITAL LETTERS or download the form from the web-site: www.irse.org

NOTE: Before completing this form the applicant should read the 'Guidance for Applicants' (may be downloaded from the IRSE Web -Site)

Class of Membership you are applying for:		
Current Class of IRSE Membership: (if applicable)		Membership No.:
IRSE Licence Holder:	Yes/No	Licence No:

Please indicate preferred Mailing Address with an X below: ?

Title (Mr/Mrs/Ms/etc):	Address:
Surname (family name):	Postcode: Telephone: Email:
First name(s):	Employer and Address:
Date of Birth (dd/mm/yy):	Postcode: Telephone: Email:

Section B – DECLARATION OF APPLICANT:

Declaration by Applicant: I, the undersigned, certify that the details given by me on this form are correct and in the event of my election, I will be governed by the Articles of Association, Bye-Laws & Code of Conduct of the Institution of Railway Signal Engineers. *(See note 4 below)*

Signature: Date:

Section C – DECLARATION OF PROPOSERS:

Declarations of Proposers. We the undersigned, having read the particulars on this form, and from personal knowledge of the applicant, recommend election/transfer to the class of membership shown. *(See notes 1, 2 and 3 below)*

Name:	Class:	Mbr No.	Signature:	Initials:
Name:	Class:	Mbr No.	Signature:	Initials:

Notes:

1. Minimum requirements for Proposers are:
   For the class of FELLOW: Two Fellows.
   For the class of MEMBER or ASSOCIATE MEMBER: One Fellow and one Member, or two Fellows.
2. The attention of Proposers is particularly drawn to the IRSE Bye-Laws, which define the qualifications & requirements for each class of membership on which your above recommendation is based.
3. Proposers are asked to initial those details of the applicant's qualifications and experience of which they have personal knowledge.
4. The applicant must obtain the signatures of the two Proposers.

Section D – OFFICE USE ONLY

Recommended for election/transfer as:		Date:	

Section E – ACADEMIC QUALIFICATIONS

Academic Qualifications (relevant to your application)

NOTE: Copies of the highest academic qualification(s) should be verified by one of your proposers and attached to this application.

College/University:	Academic Qualification (inc. subjects taken) :	Date: From –To (mm/yy)	Full or Part time:

Have you passed the IRSE Examination? (or equivalent – give details separately)		YES / NO (delete as appropriate)

Section F – TRAINING

Training

Please give details of your training in engineering subjects since completing your academic education or early professional education

Date: From –To (mm/yy)	Training Details:	Verifying Proposers Initials
	Continue on a separate sheet if necessary	

Section H – KEEPING UP TO DATE WITH ENGINEERING DEVELOPMENTS

Keeping Up To Date With Engineering Developments

The IRSE requires all members to keep up to date with developments in technology and engineering practice and to take all reasonable steps to maintain, develop and record their professional competence.

Full details of the requirements are shown in the Institution's Continuing Professional Development Policy Statement on the IRSE web-site.

Record of Activities

Please complete the following section with brief details of what you have done to keep up to date over the last two years.

Date:	Skill/Knowledge:	What Learned/How Applied:	Any Follow-Up Actions:	Verifying Proposers Initials

Section J – EXPERIENCE

Details of Responsibility and Experience

1. You should give below, and if necessary on continuation sheets, brief details of your 'responsible' experience and personal responsibilities to the present date. (You should include descriptions of the type of work on which you have been engaged and if applicable number of members of staff for whom you are responsible).

2. Applicants for MEMBER must show details of their 'senior responsibility'.

3. Applicants for FELLOW must show details of their 'senior' and superior responsibility'.

4. Note: Guidance on the requirements for 'responsible', senior responsible' and 'superior responsible' experience may be downloaded from the web-site www.irse.org

5. Note attached CV's, job descriptions and log book entries are NOT ACCEPTABLE

Date: From –To (mm/yy)	Position in Company, Description of Duties and Responsibilities:	Verifying Proposers Initials
	Continue on a separate sheet if necessary	

Section K – ORGANISATION STRUCTURE

Organisation Structure Please draw or attach a tree indicating your present position inyour company organisation. The number of persons under your control should be stated where this is not clear from the tree. In large organisations, details of the immediate group or section will be sufficient. An additional tree showing details of former positions may be included.	
	Verifying Proposers Initials
Continue on a separate sheet if necessary	

Section L – CHECKLIST

Have you completed all the relevant sections for your application as listed below?

Section:		Completed: *(please tick)*	Comments:
A	All applicants for membership/transfer		
B	All applicants for membership/transfer		
C	All applicants for membership/transfer		*Have you obtained the 'Proposer's' signatures?*
D	*Office use only*	-	*Official use only*
E	All applicants for membership/transfer		*Have you included a verified copy of your qualification certificate*
F	All applicants for membership/transfer		
H	All applicants for membership/transfer		
J	All applicants for membership/transfer		
K	All applicants for membership/transfer		

The completed application form & attachments should be returned to:

All (except those from Australia or New Zealand):
THE MEMBERSHIP MANAGER, INSTITUTION OF RAILWAY SIGNAL ENGINEERS, 4th FLOOR,
1 BIRDCAGE WALK, WESTMINSTER, LONDON, SW1H 9JJ, UNITED KINGDOM.

Applications from Australasia or New Zealand:
IRSE AUSTRALASIA, SECRETARY/TREASURER, 31 BARNETT AVENUE, ST MARY'S, SA 5042, AUSTRALIA.

Please DO NOT SEND ANY PAYMENT with the application. You will be issued with a payment invoice when you are granted a class of membership.

xxxxxx