सत्यमेव जयते

GOVERNMENT OF INDIA

MINISTRY OF URBAN DEVELOPMENT

REPORT OF THE SUB-COMMITTEE
ON

STANDARDIZATION OF SIGNALLING AND TRAIN CONTROL SYSTEMS FOR METRO RAILWAYS

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डॉ. सुधीर कृष्णा
Dr. Sudhir Krishna

सत्यमेव जयते
सचिव भारत सरकार
Secretary to the Government of India

शहरी विकास मंत्रालय
निर्माण भवन, नई दिल्ली-110108
MINISTRY OF URBAN DEVELOPMENT
NIRMAN BHAVAN, NEW DELHI-110108

Tel. : 23062377, Fax : 23061459
E-mail : secyurban@nic.in
URL : http://urbanindia.nic.in

MESSAGE

The growth story of India is to be written on the canvass of planned urbannisation and the success of planned urbanisation depends upon sustainable urban transport and transit oriented development (TOD). Efficiently designed, operationally sustainable and user friendly urban transport systems are instrumental in urban mobility.

India's urbanization process has now gained pace and as per the latest census, the growth of population in the urban areas has already exceeded that in the rural areas. As urbanization accelerates, we would need to tackle the issues of redevelopment of existing areas, creation of newly urbanised areas as well as provision of mass transit systems, modernisation and up gradation of existing urban transport systems in a manner that meets the aspirations of all classes of society. The concept would have to strategic densificastion of the urban areas, so as to optimise the land use through TOD approaches. That would invariably lead to comprehensive mobility planning for the urban areas, including the potentially urbanisable areas.

Metro railways are undoubtedly the preferred mode for mass transport on high demand corridors in big and medium cities and lead to making growing cities more liveable and sustainable. As a matter of policy, the Ministry of Urban Development (MOUD) envisages cities with 2 million plus population to plan for metro rail networks in next few years. As can be seen in Delhi, mass transport facilities such as the Metro, have been a game changer for urban transport and urban development. And that would hold good for any other large city too in the country.

With the creation of new metro facilities in several cities (tier 1 and 2), and in view of capital intensive nature of the metro rail projects, there is a need for cost optimization strategies, such as standardization and indigenization, of metro rail systems. The setting up of a committee for "Standardization and Indigenization" of metro railway systems by the MOUD an endeavour in that direction. The Committee produced a "Base Paper" wherein consensus items were indicated and also suggestions were incorporated for constitution of a number of sub-committees for in-depth study. To make rthe task more manageable, the following thematic sub-committees were constituted:

- Traction and power supply systems

- Rolling stock
- Metro railway Operation and Maintenance
- Signalling systems
- Fare collection systems
- Track structures

The initiative of MoUD to draw upon the expertise of professionals across various disciplines and also from industry has resulted in finalization of the reports of the various sub-committees. The Base Paper as well as the sub-committee reports have suggested multiple strategies for standardization and indigenization. Such evolving long term strategies for cost reduction are expected to yield significant results – in terms of both, cost optimization and high end knowledge accumulation in the country.

I encourage all cities, states, metro railway organizations and other organizations associated with metro rail systems to make full use of these reports for planning and implementation of metro rail systems in their cities as well as contribute to their further evolution in future.

I congratulate all the members of the Base Paper Committee and Sub-committees for successfully bringing out their respective reports.

(Sudhir Krishna)

New Delhi
19th November, 2013

Preface

1. Urban centers have been the dynamos of growth in India. This has placed severe stress on the cities and concomitant pressure on its transit systems. A meaningful and sustainable mass transit system is vital sinew of urbanization. With success of Delhi's Metro System, government is encouraging cities with population more than 2 million to have Metro systems. Bangalore, Chennai, Kolkata, Hyderabad are being joined by smaller cities like Jaipur, Kochi and Gurgaon. It is expected that by end of the Twelfth Five Year Plan India will have more than 400 km of operational metro rail (up from present 223 km).

   The National Manufacturing Competitiveness Council (NMCC) has been set up by the Government to provide a continuing forum for policy dialogue to energies and sustain the growth of manufacturing industries in India. A meeting was organized by NMCC on May 03, 2012 and one of the agenda items in that meeting was "Promotion of Manufacturing for Metro System in India as well as formation of Standards for the same". In view of the NMCC meeting and heavy investments planned in metro systems, thereafter, Ministry of Urban Development (MOUD) have taken the initiative to form a committee for "Standardization and Indigenization of Metro Rail Systems" in May 2012.

   The Committee had a series of meetings in June-August 2012 and prepared a Base Paper. With a view to promote domestic manufacturing for Metro System and formation of standards for such systems in India, as suggested in the base paper Ministry of Urban Development has constituted further Sub-Committees which are under:

   - Traction system
   - Rolling stock
   - Signalling system
   - Fare Collection System
   - Operation & Maintenance
   - Track structure
   - Simulation Tools

2. The Sub-Committee on Signalling System for Metros was constituted vide MoUD's order No. F.No.K-14011/26/2012-MRTS/Coord. dated 25th July 2012 as amended.

3. The Sub-Committee has since completed the assigned task, which effort has culminated into this Report.

4. Some areas of Sub-Committee work, such as detailed interface with sub-systems / systems need to be done. These interfaces can be finalized after inter action with industry so that more sourcing and manufacturing can be undertaken.

CONTENTS

EXECUTIVE SUMMARY

Following the decision of the Ministry of Urban Development (MoUD) to study the ways and means for standardization of Metro Rail systems primarily for standardization and reduce costs, a sub-committee for signalling and train control was appointed and this report details the deliberations and outcome as also the conclusions and recommendations.

Metro Signalling & Train control system technology focus means of reducing headway, ensuring safety and improving efficiency and reduction in cost of operation. The Signalling & Train Control system on Main Line Railways and Metros are different on account of very different traffic requirement besides civil and E&M infrastructure. Signalling & Train Control in metros not only ensures train safety, but it also integrate, interface and automates areas of operation, driving, passenger information, collection of information and analysis of the same. Signalling & Train Control systems have been dominated by use of Track Circuit based Signalling & Train Control for more then five decades. The use of transmission based (cable loop) system started in late 1980, but did not find many takers, further due to technology and environmental challenges. However, with the technology advances in telecommunication and IT, the CBTC have now become preferred technology for metros world over. The Sub-Committee has explored level of this technology and recommended this be perfect platform of all future metros and Mono Rail Signalling & Train Control systems.

Interoperable requirement and efforts under taken in this area world over have been studied by the Sub-Committee. These efforts have been mainly spearheaded by RATP, Paris and MTA, New York. Report brings out their status and notes that these efforts have met with very limited success besides years of efforts and use of huge resources both financial and manpower. These efforts have been taken in brown field projects i.e. for replacing earlier systems and therefore could afford a long time effort for attempting interoperable system including support from industry. The Sub-Committee has recommended that these efforts of RATP or elsewhere for evaluation /adoption in

Metros as and when these become successful and are adopted by more than one Metro Rail. The Sub-Committee notes that industry and operators also feel that such systems become isolated island of technology and change in such technology involve persuasion of stake holders to accept any change as it is more difficult because of limited market for such technology till industry and metro adopt this on large scale.

The Sub-Committee has identified systems and products, which include LED Signals, Depot Point Machine, Cables, UPS etc beside infrastructure, T&C activities, which are available indigenously and recommended these for local sourcing within the procurement guidelines of the funding agency i.e. JICA or any other guidelines. It has also been recommended to do data preparation, configuration of interlocking and ATS in India to begin with.

For an understanding of the issues involved in Metro Rail Signalling and Train Control systems, a brief summary of descriptions of the building blocks is provided in Section-3. Subsequent discussions on standardization, Section-4 provides a brief glimpse of the basics principles, features and benefits of the latest state-of –the-art CBTC system now increasingly adopted world over.

The Sub-Committee has suggested the serious efforts need to be made in developing ATS system locally as it is likely to succeed due to availability of software expertise in India beside the same product can be used on the Indian Railways with immense benefits. This will however, require further study to prepare detailed interfaces between sub-systems so as to be a workable solution. Sub-Committee also has received two different approaches from industry for increase in local sourcing / changeable sub-system. These two areas need to be studied by another Sub-Committee with participation of industry and IR.

The Sub-Committee has recommended in the area of software:

a) Sub-Committee has further recommended setting up of R&D centre for electronic in the field of Signalling & Train Control, Automatic Fare Collection and SCADA.

Recommendation is for immediate effort in ATS, which yield early fruitful results both in Metro and Indian Railways.

The same R&D centre will become a knowledge bank and spearhead for data preparation, verification, validation and safety certification process.

b) The Sub-Committee has recommended setting up of two or more joint ventures with private sector on the lines of RATP/Paris association with M/s Alstom and MTA/New York with M/s General Electric.

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ACKNOWLEDGEMENT

The Sub-Committee nominated by Ministry of Urban Development (MoUD) for 'Signalling & Train Control' to study the 'ways and means for standardization of Metro Rail Systems, primarily to control the total costs of the project and operations' has submitted this report after deliberations and discussions with suppliers and operators.

Background for appointment of the sub-committee along with its terms of reference and objectives has been briefly outlined in Section-1. Details about suppliers and operators who have been associated with the Sub-Committee have been listed in Section-2.

The Sub-Committee is thankful to DMRC, BMRCL, RMGL, CII, FICCI, ASSOCHAM, Thales (India), Ansaldo and Invensyes for allowing their representative to attend various meetings called for formalizing this report.

The sub-committee owes special thanks to Alstom, Autometers Alliance Ltd, Bombardier, Siemens and General Electric Transportation Inc who have extended their full co-operation for making presentations and contributing special inputs by way of detailed discussions.

The sub-committee is thankful to Shri B.Krishankumar, Chief Consultant (S&T)/ DMRC Chennai, who had extended full co-operation and shown sustained interest to provide valuable inputs in bringing out the Sub-Committee Report. A Goggle group was also created by him for inter-acting with all nominated Sub-Committee members, of which he was the administrator.

SECTION- 1

BACKGROUND ON FORMATION OF MoUD SUB-COMMITTEE ON METRO RAIL SIGNALLING & TRAIN CONTROL

1.1 Background

In the light of large number of Urban Guided Rail transport systems being planned for various cities in India and with a view to promote the domestic manufacturing for Metro Systems and formation of standards for such systems in India, the Ministry of Urban Development, GoI, had constituted a Group, with terms of reference mainly to prepare a base paper for developing guidelines on standardization and indigenization of Metro Rail Systems and sub-systems for improved safety, reliability and availability. The Order of MoUD and the terms of reference and details of members of the group are kept at Annexure-1 for ready reference.

It was felt that such attempts, as and when successful, would not only lessen the initial outlay, but also help in reducing the O&M costs, which will have a favorable impact on the total cost of operations of such systems. The Group so constituted had then identified certain issues which require detailed deliberations, cost benefit analysis and further technical study. The Group further suggested formation of sub-committees for the above purpose for different disciplines such as Train control, Rolling Stock, Traction, AFC etc with members drawn from the profession, from the government and industries associated with Metro rail systems.

1.2 **Terms of Reference**.

Accordingly, MoUD constituted the sub-committee on Metro Signalling & train Control systems vide their Order dated 25th July 12 and as amended vide letter dated 14th January 2013 indicating members and the terms of reference for the sub-Committee. (Copy kept at Annexure-2 and Annexure 2/1 for ready reference). The Terms of reference included identification of common platform for Train control system for standardization, study of feasibility of interoperability of sub-systems of different vendors, identifying the constraints in the process of indigenous development, providing recommendations for future course of action, etc. More details may be seen in the Annexure-2. The convener also decided to co-opt experts and professionals from the Metro administrations and the industry as also the prominent associations of Indian industry as necessary. Shri B.Krishankumar, Chief Consultant (S&T) Chennai was co-opted as Sub-Committee member and played very active role in formulation of this report.

Details of participants and course of action followed is further described in the following section.

SECTION-2

PARTICIPATION BY MEMBERS OF SUB-COMMITTEE & OTHER EXPERTS

The convener had constituted a Google Group for enabling discussions and also involved professional from signaling from DMRC as well as the major suppliers from the industry. The list of participants in the various meetings and deliberations is kept at Annexure-3.

The first meeting of the committee was held on 4th October 2012 and detailed discussions were held on the subjects connected with the terms of reference, which were suitably redrawn for easier study of the subjects. It was also decided to include study of train control for Monorail systems also. Though most of the members identified by MoUD or their nominees attended the meeting, the officers nominated by Railway Board and RDSO did not attend this meeting as well as sub-sequent meetings.

Director/MRTS/MoUD highlighted the need for developing standards in all areas of Metro Rail systems in the back drop of GoI's plans for introduction of Metro Rail systems in 15 more cities of more than 2 million populations, in addition to the seven cities where Metro rail exists or undergoing construction. He emphasized that the committee should focus not only on standardization but also on costs. He stressed that, as far as GoI is concerned, the bottom line is reduction of cost by standardization, but at the same time quality, reliability and keeping abreast of technological advances should be kept in sight by the committee. An exhaustive presentation was made by Director / Operations/DMRC convener of the sub-committee, on the present status of the technology in the field of Metro Signalling and Train control. The presentation covered the current status of the ATC systems in various Metro Rail Networks of India as well as the status in the international arena, particularly in Europe and Asia, the advantages in the latest CBTC system, the need for focusing the efforts around CBTC for the Metro rail in future, issues requiring deliberation in CBTC technology and past and ongoing international efforts to achieve standardization and interoperability in CBTC. A copy of this presentation is kept at Annexure-4.

After detailed discussions on the subjects related to the ToR, the committee identified the nature of common platform for standardization as also ways to go about for increasing the sourcing from within the country. Detailed minutes of the meeting which also indicate the deliberations of the committee is kept at Annexure-5.

It was also decided to hear the views of industry by way of presentations by them in the sub-sequent meetings. The following subjects were identified on which the established firms in Train control field were requested to make presentations:

1. Ideas & Specific views on sourcing from India
2. Experience and views on interoperability
3. Commonality between mainline and urban signaling
4. Simplification of testing and commissioning methods

5. Views on Automation of operations
6. Technical issues with CBTC
7. “Delinking” ATS

2.1 Meetings of the Sub-Committee.

Accordingly, presentations were made by the following manufacturers in the two subsequent meetings held at Metro Bhawan, DMRC, Delhi:

During the 2nd Meeting held on 7th November 2012:

1. M/s Alstom Transport

2. M/s Siemens Transportation Ltd

3. M/s Autometers Alliance Ltd (nominated by ASSOCHAM)

During the 3rd meeting on 15th November 2012:

1. M/s Bombardier Transportation

2. M/s General Electric transportation Inc

Though M/s Thales Ltd and M/s Invensys, who were present in the first meeting, had been requested to make presentations, they had declined the request.

Copies of the presentations made by the firms are kept vide Annexure 6 to 10.
During the course of these presentations, all the subjects covered under the Terms of reference were freely discussed to evolve commonality of views of the participants to arrive at the recommendations.

In order to appreciate the complexities of Train Control systems adopted by Metro rail systems world over, a brief introduction to the world of Metro Signalling and Train Control Systems follows in the next section.

2.2 Comments from Suppliers

During the course of finalization of Sub-Committee report, comments from M/s Alstom (2 mails) and M/s General Electric transportation have been received, which are placed at Annexure 6/1 and 6/2 from M/s Alstom and 10/1 from M/s General Electric.

No comments have been received from RDSO / Railway Board or any other Sub-Committee members. Therefore, it may be needful to study these views and deliberate further.

SECTION -3

BRIEF INTRODUCTION TO METRO SIGNALLING & TRAIN CONTROL

3.1 Introduction of Signalling & Train Control System:

The success of Metro rail systems lies in their ability to provide **frequent, fast, safe and comfortable journeys** in the urban conglomeration, not only to the regular commuters, but also to the occasional traveler or tourist alike**. Signalling and Train Control systems** play a major role in achieving these objectives. While enhancing operational efficiency by providing control systems to achieve the target headway, it also **ensures total safety of the train movements at all times beside adding value to other systems by on-line interface.**

To appreciate the need for complex signaling in Metro rail systems, it is necessary to distinguish its aims from the mainline railway systems. Aim of the Metro Rail is to move large number of people over relatively very short distances, at very frequent intervals within an urban conurbation. On the other hand , the main line railways moves passengers over long distances with limited number of services on any route and most of the main line Railway is with at-grade track with its implications of grade crossings with the road traffic. Hence, though the fundamental principles of failsafe signaling in Metro Rail are based on the evolution from main line signaling, due to the need for provision of absolute safety in the face of very close headway and stoppage every one km or so and due to the nature of train control coordination required, the Metro Rail signaling systems have evolved in a complex and unique way, with higher order of safety and train control provided to suit the needs of Metro rail as compared to main line networks.

The earliest Metro rail in London Underground (LUG) used the primitive signals common to main line in the beginning. But soon realizing the need for total prevention of Signal Passed At Danger (SPAD) incidents, LUG gradually introduced various forms of automatic train protection mainly by way of mechanical trips and stops, even as early as the early decades of 20th century. As developments in electronic systems progressed, use was made of the ability to transmit information between tracks to train, which enabled introduction of much more elaborate and intelligent train protection, train operation and control systems. The rapid developments in the computer and micro circuit technology as well as telecommunication have led to the development of Integrated Metro Control systems, in which computers (including failsafe forms of computers) fulfill many of the decision making roles traditionally performed by Train operators, station controllers, Traffic controllers etc, eventually leading to the introduction of highly automated Metro Rail with driverless trains.

The above developments have to be seen in a wider context than the fundamental passenger safety. In main line parlance, flexibility of operation is always somewhat affected by the needs of safety due to the nature and design of main line signaling. There is need to understand the interplay of many parameters in Metro rail which are not critical to Main line signaling. The need for very frequent trains with frequent stops demands a high level of train control by signalling system. With stations located underground, need for very accurate stops require automated control, which is not the case in main line trains. Tunnel environment restricts signal sighting distances, also requires provision of in-cab signaling. A centralized control is inescapable to monitor and handle any emergencies. With closed doors to ensure passenger safety, there is a need for opening the train doors on the correct side for the platform which has to be again failsafe to prevent wrong side opening leading to passenger injury. Thus the importance of signaling and train control systems to Metro rail operations has increased significantly in the recent decades with relentless urbanization leading to huge urban conglomerations having populations of close to or over 2 to 10 million.

3.2 Basic objectives and principles of Railway signaling:

As Railway systems evolved from mid-19th Century and signaling systems started developing from the initial primitive systems, the two main objectives of Railway Signalling were:
i) Provision of safety from collisions and derailments ii) Provide as maximum line capacity as possible for running many trains on same line within the safety constraints

A number of building blocks were involved in the science of Railway signaling, each of these themselves became further specialized and developments in communication and computing affected all these areas. (Thus the subject of signaling became a vast field which further categorized into two major branches, main Line signaling and Metro rail or rapid transit signaling. A few of the important sections of the field will be briefly covered in what follows and references are given for further study). The major concepts in signaling are explained below.

1. In order to achieve safety with a number of trains using the same line, it became essential to provide information to the driver by some sort of “signals” about where to stop or how fast the train can go etc. (The term “signal” was actually taken from the word used in Navy for exchanging information between ships on at a distance).
2. To derive the information required to convey to the driver through “signals”, some form of train detection was essential, to know where exactly the train in question is with reference to other trains or other hurdles.
3. To provide means for more than one train to use the same line, it became necessary to divide the line into “blocks” and ensure there is only one train in each “block”.
4. To control the trains and allow precedence between slow and fast trains, it became necessary to have stations with turnouts and loops.
5. To ensure the points and crossings of a turnout were set within safety limits for prevention of derailment, it was necessary to ‘detect’ the point by the signaling system before allowing train movement i.e it was necessary to “interlock” the signal with the points. This requirement led to the development of “interlocking”, which were initially achieved with so called vital relays and later solid state devices and micro processors entered the scene, resulting in introduction of Solid State Interlocking (SSI) and later Computer Based Interlocking (CBI)
6. The need for increasing the line capacity resulted in further advances such as block working, automatic Block signaling, Centralized Traffic control by a single operator controlling a line to avoid time delay for exchange of information between Station Masters.
7. The peculiar requirements of Metro rail systems further required complete safety by providing automatic train protection to eliminate driver errors.
8. The need for high frequency of train service in Metro rail resulted in automation of train supervision and route setting for quick turn round in terminal stations
9. The requirements of Metro rail for accurate stopping and energy efficiency etc resulted in development of Automatic Train Operation in LUG in mid sixties which has now reached its acme in Driverless and unattended trains.

The history of developments in all the above areas and detailed technical issues involving many of these systems can be found in many references. For example:

1. Section on signaling from web pages of "Railway-technical Web Pages" at the link www.railway-technical.com/sigtxt1.shtml (mainly for development of signalling in UK. A detailed index of signalling pages of this web site is at the link www.railway-technical.com/sigind.shtml)
2. For developments in Indian Railway signaling see "Art & Science of Railway Signalling" By Shri R.C.Sharma (Publisher Bahri Brothers Delhi)
3. Automatic Train Control In Rail Rapid Transit -A Report by Office of Technology Assessment, Congress of U.S.A submitted to Senate Committee on Appropriations.

3.3 Functions of Interlocking:

In any Rail network facility must be available for a faster or more important train to bypass a train travelling in front. Hence the latter train has to be moved from the main line to a siding for which purpose points & crossings are used which will divert the first train and then again set back to normal to allow the following train to go through. Points and crossings are also required to turn back the trains at terminal stations from one direction (UP) to the other (DOWN). Turnouts are also required in bigger yards for stabling more trains.

Whenever a train traverses a point in the facing direction if the point moves away from the setting under the wheels due to any reason there can be a derailment with the coach taking two routes. Hence it is necessary to lock the point and also detect it in correct setting by the signal before allowing movement over it. To avoid collisions (including side collisions) it is necessary to examine the position of the track circuits in the yard including the overlap (safety margin) at the end. All these functions are accomplished by "Interlocking" the signals with the points and other hazards such as level crossings in the yard on main line.

In the last three decades, the interlocking function has migrated to electronic / microprocessor based systems. Nowadays, in all Metro rail systems only Computer Based Interlocking (CBI) is used due to many advantages. The basic fail-safe principles of Interlocking can further be studied from Ref. 1 and Ref.2 given above.

3.4 Need for Train detection and methods used:

As seen above, to convey information to a train about where to stop and at what speed to run required all the trains on any line to be detected automatically by the system. This was achieved by the invention of the so called "track circuits". Track circuits were first invented in USA (DC Track circuits) in 1872 and later picked up and improved by British railways. London Underground was the first large scale user in a Metro rail network 1904-06.

The need to provide information to train resulted in the invention of "coded track circuits" with modulation of a basic AC carrier with codes. These required insulated joints between sections of rails similar to earlier track circuits for demarcating the individual track circuit blocks.

Later came the “joint less track circuits” which use audio frequencies and provide high impedance between adjacent track circuits by a tuning process thus avoiding the need for insulated joints. These are commonly called Audio frequency Track Circuits (AFTC) and these help in transmitting codes which modulate the basic AFTC carrier which in turn are picked up by an antenna suspended below the train.

In addition to track circuits, another system called “axle counter” is also used for train detection. In this method, axles are detected through a magnetic circuit linking a transmitter and a receiver across the rail and whenever a metallic axle interposes the received signal drops which is detected and counted as one pulse. In the manner all the axles coming into one block are counted at the entry and if all the axles are counted out at the exit of the block the block is declared as clear.

In the latest advancement in Metro signaling, a system called Communication based train control has been in use for more than a decade. In this system the primary train detection is purely based on failsafe communication link between the train and the control centre with the train communicating its position continuously and the control centre communicates the position to other trains for maintain the safety distance between two trains. Track circuits or axle counters if any are used only as a secondary detection in case the Metro operator desires a fall back system.

3.5 Train spacing and its impact on safety and line capacity (Headway):

Even from the beginning of rail transport, the need for running more than one train on a line was felt for more optimum utilization of a costly infrastructure. Initially a method based on a Time Interval system was adopted and a second train was allowed to follow after a set time interval. In case the first train had come to a halt due to any failure there was an unavoidable rear collision if the driver of the second train could not react in time and the braking distance was not adequate.

Hence a system of dividing the length of the line into fixed “Blocks” was adopted and Stations were created to demarcate the “Blocks. Signals were used at the stations to control the entry into these Blocks. In main line networks, such block lengths could extend anywhere from 5 KMs to even 30 or 40 KMs.

The block protection function to avoid collisions can also be achieved by continuous track circuiting of the entire section between two stations or by provision of axle counters.

In Metro Rail networks, considering the need for higher order of safety, as well due to the presence of halts at frequent intervals of even less than a KM length, continuous track circuits have been invariably used so far for detection of block clearance and to give permission to train to proceed further. The use of AFTC based track circuits in Metro Rail thus served the purpose of provision of fixed blocks of small length to enhance line capacity (Headway) while ensuring the basic safety by detecting the presence of a train in the block. The AFTC was also used to transmit the signals to the train about the limit of permission to proceed in terms of distance (Limit of Movement Authority LOMA), permitted speed etc.

In the recent CBTC systems, with train detection by communication, the concept of block has been further refined and what is known as a moving block is used, which include a safety envelope behind and in front of a train, always moving along with the train. This helped to improve the headway further by reducing the length of safety block and also with boundaries (moving block) required for each train.

3.6 Cab Signalling and need for track to train communication:

Colour light signals at the track side are used extensively by main line railways all over the world. Indian Railways uses mostly colour light signals which are now being provided with LED lamps instead of incandescent lamps.

Provision of fixed signals on the track side had its own draw backs, since action by driver depended on the visibility of the signal as well as his alertness to take prompt action on the aspect of the signal in time. In case of poor visibility due to curves or fog etc, there is a danger of the driver passing through a RED signal and colliding with another train. Such "Signals Passed At Danger (SPAD)" have been and continue to be the root cause of many fatal accidents in Railways.

To avoid the draw backs of track side signals, development of "Cab signaling" took place in which the signal aspects were made available right inside the driver's cab by way of displays. Information to be displayed had to be provided from track side to the equipment on-board the train. Initially this was done by fixing coils on the track as well as underneath the cab and transferring information by magnetic induction. This was further improved by way of fixed Beacons or Balizes mounted between rails transmitting the information electro magnetically through low frequency modulations to be picked up by antenna mounted below the engine of the trains. Later coded-track circuits and then coded AFTC have been introduced for this purpose.

For Metro rail, provision of cab-signalling is essential since visibility of track side signals cannot be guaranteed due to command constraint of space in tunnel. Also, maintenance of track side signals in other than station limits in a Metro rail environment has got its own problems. London Underground had many incidents and accidents for the first 40 years of its history due to non-availability of Cab signalling and train protection. Hence, as and when the technology was available Metro Rail Systems world over have switched to Cab-signalling displays to aid the driver when the train is driven manually, along with some form of protection against SPAD incidents. Provision of on-board electronic/computing equipment for cab signalling paid further dividends by way of development of electronic Automatic Train Protection (ATP) eliminating accidents due to SPAD. Concept of ATP and other sub- systems of the modern Metro Rail Signalling systems are discussed further below.

3.7 Automatic Train Control Systems (ATC) for Metro Rail networks:

At the present day the automation of signalling systems for Metro Rail have all been integrated into what is known as Automatic Train Control Systems (ATCS or ATC). Such combined ATC systems are in vogue in Metro rail since more than 30 years. The major components of the modern Automatic Train Control System (ATC) of a Metro Railway are:

1. Automatic Train Protection (ATP) comprises of the sub-systems which provide the basic safety by way of fail-safe detection of dangerous conditions and controlling and stopping the train when required independent of any action by the driver when the train is being driven manually. ATP also ensures similar fail safe protection even when train is being driven automatically.

2. Automatic Train Operation (ATO) which comprises of sub-systems which can enable automatic operation of the train without any intervention by the driver except for closing of the train doors. ATO obtains the safety instructions from ATP and other operational information from the ATS system automatically and runs the train as required.

3. Automatic Train Supervision (ATS) which comprises of various sub-systems which are used to regulate and control the operations of all the trains in the network by monitoring the positions of trains all over the network at every instant and implementing the pre defined operator commands for automatic route setting at interlocking and automatic turn backs at the terminal station etc. Thus ATS is the key system which enhances Headway by automating the operator actions and reducing the human delays involved. A sub component of ATS, namely Automatic Train regulation (ATR) is used to follow the given time table automatically to keep the trains moving at the intervals required controlling the given dwell times for each station in the route for each train. ATS works with the driver if the train is manually driven to keep him informed about when to leave a station. In case of ATO operation, the ATS will work with ATO and control the movements of all trains in the network. The Traffic Controller can manually intervene and take over the functions any time as required, due to any emergencies or disruptions in the network.

Brief details about the above major systems comprising the ATC are further given below. For more information on the integrated Metro signalling & ATC the following references may be seen further:

1. Book on “Metro Railway Signalling” by Institution of Railway Signal Engineers (London) and other information on their website www.irse.org
2. Railway technical Web pages at the links:
   i) Metro Signalling and ATP www.railway-technical.com/sigtxt2.shtml
   ii) ATC and its relationship with ATO, ATP and ATS. www.railway-technical.com/sigtxt6.shtml
   iii) ATO functions www.railway-technical.com/sigtxt4.shtml
   iv) ATP Transmission and Moving Block Systems www.railway-technical.com/sigtxt3.html

3.8 Development and Basic Principles of Automatic Train Protection (ATP):

The need for protection against SPAD was felt right from early days of London Underground**.** Even in the absence of cab signalling, LUG developed and introduced automatic mechanical tripping levers which tripped a brake cock or other device on the locomotive whenever signal ahead was indicating a STOP aspect and the train did not stop at the demarcated point. This was the earliest form of mechanical automatic train protection which continued for decades in the LUG as well as other places in USA. This type of primitive or early type of ATP can be called as 'Control at the signal location".

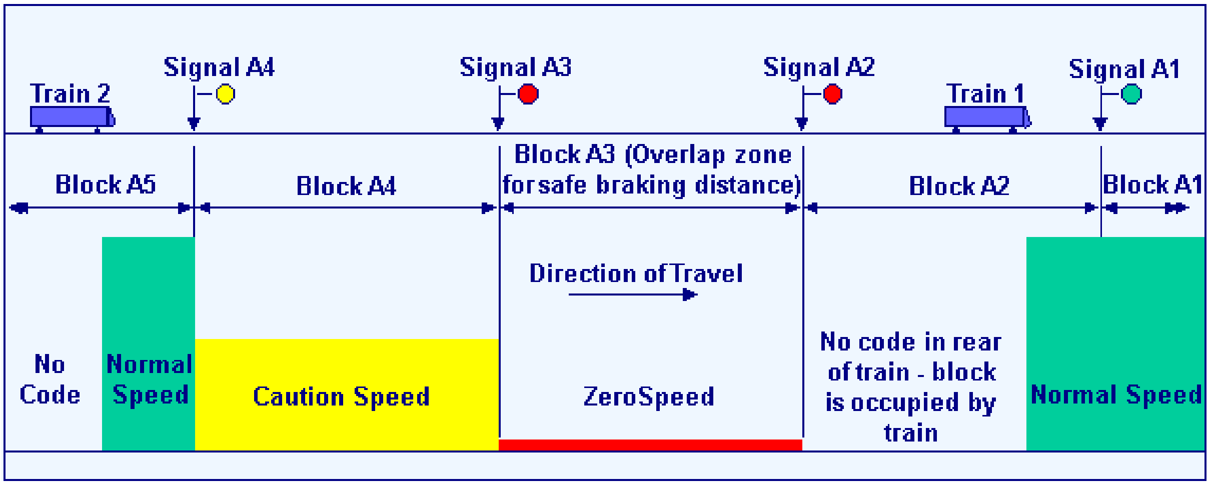
Beacons located at specific locations on the track coupling magnetically with coils on the engine, could convey the information even at a location in rear to take advance action. Such intermittent transmission of data resulted in the second type of ATP, sometimes called "intermittent ATP.

With the developments in track circuiting and other electrical and electronic devices, Automatic Train Protection equipment could get continuous as instant information on track changes ahead. The ability to extend the movement authority for a train almost as soon as it becomes available will help in reducing the Headway and increase the line capacity and as such this form of ATP, known also as "continuous ATP" or CATP is particularly appropriate for Metro rail which require the shortest headway possible to be achieved. Thus the intermittent type of ATP is common in main line network but by ETCS Level-I/II are now one of preferred option. On the other hand, CATP is the norm for Metro Rail and is simple referred as ATP. In Metro Rail environment ATP always means Continuous ATP. Thus ATP in Metro Rail has become quite sophisticated in due course and was integrated with the cab signalling display to keep the driver advised at all times about the conditions ahead. It was further integrated with ATO and ATS as part of the ATC system as Metro Signalling further advanced.

3.9 Speed Code systems of ATP:

Using the concept of splitting of the line into fixed blocks, automatic signalling had been introduced in main line network mainly for the suburban systems by providing a track side signal at the entry of each block. The block lengths varied from 6oo Meters to 1000 Meters. With the development of means of transmission of information from track side to train, this concept of fixed blocks was used to develop advanced ATP systems. The occupation of the specific block ahead by a train was advised to the following train through the coded / AFTC track circuit transmission, so that an on-board computer with all the data of the blocks already pre-loaded, could determine to allow the train to continue at the maximum speed possible taking into account the braking distance required by train. In case it is found the braking distance cannot be ensured, appropriate action can be taken by the ATP computer to apply the brake through its interface with the braking system of the rolling stock. Thus, in a full, fixed block ATP system, there will be an unoccupied, between trains to provide the full safe braking distance, as shown in the illustrative diagram below. Although signals are shown for the purpose of understanding the concept, most of the

ATP equipped systems do not have visible line side signals because the signal indications are transmitted directly to the driver's cab console (cab signalling).



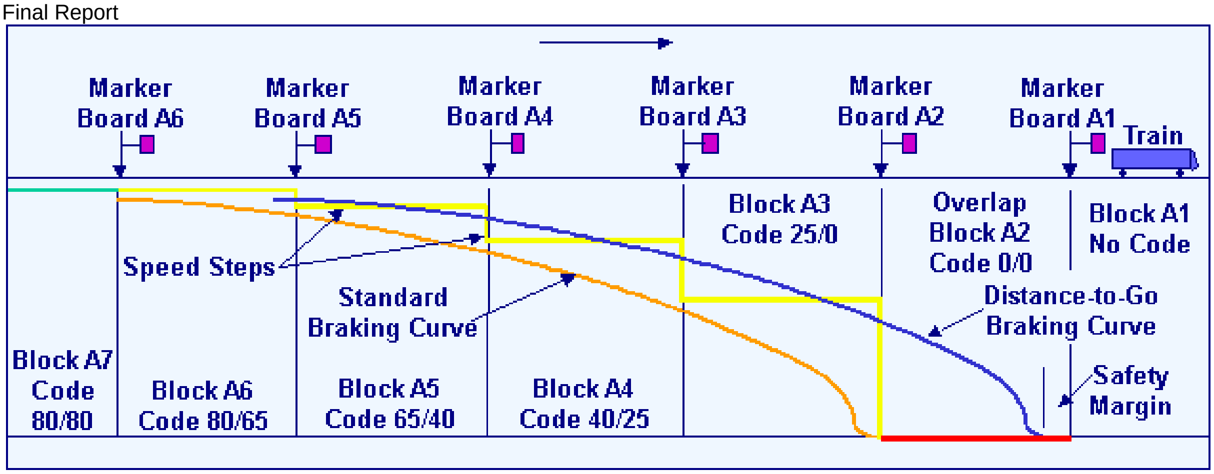
On a line equipped with ATP as shown above, each block carries an electronic speed code on top of its track circuit. If the train tries to enter a zero speed block or an occupied block, or if it enters a section at a speed higher than that authorized by the code, the on-board electronics will cause an brake application. This is a simple system with only three speed codes - normal, caution and stop. There were other improved systems where the number of speed codes could be increased and applied in the succeeding blocks appropriately to improve the Headway.

Thus a train on a line with speed code based version of ATP needs two pieces of information about the state of the line ahead - what speed it can do in this block and what speed must it be doing by the time it enters the next block. This speed data is picked up by antennae on the train. The data is coded by the electronic equipment controlling the track circuitry and transmitted from the rails. The code data consists of two parts, the authorized speed code for this block and the target speed code for the next block.

3.10 ATP based on Distance – To – Go principle:

The next stage of ATP development was an attempt to eliminate the space lost by the empty overlap block behind each train in the above system of ATP. If this could be eliminated, without in any way compromising the safety, line capacity could be increased by up to 20%, depending on block lengths and line speed. Thus the concept of "Distance To Go' ATP got evolved.

The Distance To Go (DTG) concept of the ATP system can be explained in a simple manner with the following illustration:



In this diagram (above), speeds have been associated with each block behind the first train only by way of illustration. In actual practice the maximum permitted speed at the entry of each block, and at every moment within the block is continuously calculated by the on-board computer with real time inputs of actual speed of train and distance being travelled. The train in Block A1 causes a series of speed reduction steps behind it so that, if a following train enters Block A6, it will get a reduced target speed. As it continues towards the zero speed block A2, it gets a further target speed reduction at each new block until it stops at the end of Block A3. It will stop before entering Block A2, the overlap block. The braking curve is shown here in brown as the "standard" braking curve. The explanation so far is same as for Speed code based system since one full block is still being counted as an overlap.

To remove the overlap section, it is simply a question of moving the braking curve forward by one block. The train will now be able to proceed a block closer (A5 instead of A6) to the occupied block, before it gets a target speed reduction. However, to get this close to the occupied block requires accurate and constant checking of the braking by the train, so an on-board computer calculates the braking curve required on a continuous basis, based on the distance to go to the stopping point and using a line map contained in the computer’s memory. The new curve is shown in blue in the diagram. A safety margin of about 30 Meters is allowed for error so that the train will always stop before it reaches the critical boundary between Blocks A2 and A1. (The braking curve "flares out" at the final stopping point in order to give the passengers a comfortable stop).

Both the older, speed code method of electronic ATP and "distance-to-go" ATP require the train speed to be monitored accurately, since the train’s ATP equipment only monitors the train’s speed against the permitted speed limit within that block. If the train goes above that speed, brake application will be invoked. For calculating the instantaneous maximum permitted speed, the distances have to be monitored by the computer continuously to know where the train is from the entry into a particular block.

For the distance-to-go system, the development of modern electronics has allowed the brake curve to be calculated accurately continuously so that the speed steps become unnecessary. When it enters the first block with a speed restriction in the code, the train is also told how far ahead the stopping point is. The on-board computer knows where the train is now, using the line "map" embedded in its memory, and it calculates the required braking curve accordingly. As the train brakes, the computer checks the progress down the curve to check the train never goes outside it. To ensure that the wheel revolutions used to count the train's progression along the line have not drifted due to wear, skidding or sliding, the on-board map of the line is updated dynamically regularly during the trip by fixed, track-mounted beacons laid between the rails with encoded chainages transmitted over the link by way of telegrams.

Distance-to-go ATP has a number of advantages over the speed step system. It can increase line capacity but also it can reduce the number of track circuits required, since you don't need frequent changes of steps to keep adjusting the braking distance. The blocks are now just the spaces to be occupied by trains and are not used as overlaps as well. Distance-to-go can be used for manual driving or automatic operation.

Thus the Automatic Train Protection started as mechanical device but matured as an excellent safety system with much improved line capacity by the use of Coded / AFTC track circuits transmitting information continuously from track side to train by "telegrams".

The concept of Distance-To-Go ATP developed during the track circuit era, has undergone further change in the new Communication based Train Control system (CBTC). Further details of this development are provided in the section dealing with CBTC.

3.11 Automatic Train operation (ATO):

The first step in automating any metro system is the automation of the primary safety functions through continuous, automatic train protection (ATP). With this foundation in place, the driving functions themselves can then be automated through the provision of automatic train operation (ATO). With the driving functions automated, real-time automation of the train management and train regulation functions becomes possible, through more sophisticated automatic train supervision (ATS) systems, providing operational benefits at the network level.

The term ATO is loosely used to cover a wide range of levels of automation, from the automation of the basic driving operation alone to the running of trains with no staff member on board. An IEC working group (TC9 Working Group 40) and the European MODURBAN project have therefore adopted the concept of levels of "Grade of Automation" (GOA), with GOA level 1 being ATP only with no ATO (ref. IEC 62290-1). At its most basic, ATO enables trains to run automatically from one station to the next, under the protection of an ATP system and under the supervision of a train driver. This mode of operation is also sometimes referred to as Semi-automatic Train Operation (STO) or GOA level 2.

An Automatic Train operation (ATO) system is a train borne system which controls the traction and service braking functions of a train, such that optimum movement of the train is obtained within the tolerances of the current movement and speed authorities made available by the ATP system of the train. A CATP system is a pre-requisite to have an ATO system as the ATO system is regarded as a non-vital system as it works within the safety boundaries defined by the ATP system. Thus any infringement of the safety boundaries while train is driven by ATO invokes an ATP reaction to guarantee the safety.

The prime advantage of the ATO system is the consistency of the train performance which can be achieved in terms of optimum acceleration and braking. An operating margin has to be always kept over and above the design Headway of the network to cater for operating efficiencies. ATO helps to reduce the operating margin as compared to manual driving. This helps to improve traffic regularity, minimizes bunching of trains and increases throughput. Thus ATO can facilitate meeting more stringent headway requirements.

A further benefit of ATO is that it enables regulation of train movement to be carried out automatically in the most optimum way such that the set requirements can be implemented in an efficient manner. ATO further helps in accurate stopping on the station platform than compared to human driver. This is particularly useful where platform screen doors are provided.

To provide information to each train regarding its next station-to-station run, it is necessary to provide information (through ATP or ATS) regarding the distance to next station stop, gradient data en-route, whether to implement coasting or not, etc. provision of data is normally possible only at stations, but in the case of CBTC it can be done instantly any time as the train is in touch with OCC on radio link.

In most cases, the train operator closes the train doors and selects the ATO from the console after which the train is completely controlled by the ATO till next station is reached and the train is accurately docked on the platform. ATO then opens the train doors automatically (the correct side opening is of course ensured by ATP in a failsafe manner). Normally ATO obtains the distances from the odometers and fixed beacons directly, calculates the speed continuously and estimates the braking effort and uses its own separate interface with the service brake to bring the train to halt at the platform. In order to aid in smooth braking to ensure passenger comfort, a number of synchronizing loops or beacons are provided on the platform track for ATO to obtain correct distance left to reach the docking point and adjust the braking smoothly. Thus in ATO, typically, the driver remains in the cab of the train, operates the doors, provides the start signal for the train to leave a station, and monitors the performance of the train and the track ahead without doing any driving as such. There are higher levels of automation as further explained below.

3.12 Driverless Train operation (DTO) and Unattended Train Operation (UTO):

More sophisticated systems free the driver from the need to be at the front of the train – referred to as Driverless Train Operation (DTO) or GOA level 3. In DTO the driver is able to move away from the front of the train, but remains available to provide customer facing duties and to drive the train in the event of a failure of the DTO/ATO system. As the driver is no longer able to see the route ahead this imposes a greater demand on guideway security and platform controls. Platform screen doors have to be provided, to allow ATO to handle door closing also on signal from ATP that all the Platform Screen Doors have closed fully. In DTO, train doors and train departure from a station platform may also be controlled automatically or manually from a location other than a drivers cab at the front of the train. ATO can be given the operating instructions by the ATS regarding dwell time and hold for regulating the train on platforms as required by the operational situation and in the normal course the driver wherever he happens to be on the train is relieved of all operational workload. The increased flexibility that derives from freeing the train service operation from having to provide a driver at the front of each train means, as a minimum, that the time that would be required for a driver to walk from one end of the train to the other when reversing control on actual dwell time can be saved, thereby increasing the throughput at terminal stations.

An example of a driverless train operation but with an onboard attendant (DTO) would be the London Docklands (DLR) system that first entered into service in 1987 with fixed block technology. In 1994 the line was re-signalled using CBTC technology to increase capacity in response to an order-of magnitude due to change in forecast demand. Such Driverless Train Operation (DTO) has been provided in many Metro rails in recent times successfully.

Further, if the CCTV information of the inside of coaches is transmitted live in new systems to OCC for controllers to observe for any untoward incidents inside the moving train and with other advancements in prevention and detection of unauthorized access to the viaduct or tunnel, even a separate train operator is no longer required on the cab in the train. The space required for the equipment could also be saved and passenger capacity increased at the end cabs. Thus it became possible to have Unattended Train Operation. Driverless ATO without an on-board attendant is referred to as Unattended Train Operation (UTO) or GOA level 4. UTO can range from empty train movements (only to a siding, or in an automated depot, for example) to the operation of trains in passenger service with no attendant on board. The latter requires that the reliability of the systems has to be of a higher level and the train can be operated remotely under failure conditions, or at the minimum can be reached by shore based personal in a short period of time. Passengers need to be reassured and hence good communication and CCTV links between the vehicle and an informed staff member at OCC or at specified location are essential.

Increased protection and monitoring of the guideway from intrusion or some form of obstacle detection is also required. Apart from the savings in staff costs the greatest benefit with unattended operation is that train service can be tailored directly to demand with trains being brought into service very quickly as and when the demand increases.

The first examples of unattended train operation on a metro line, with no person aboard (UTO), were in Kobe (Japan) in 1982, Lille (France) in 1983 and Vancouver (Canada) in 1985. The Kobe and Lille systems were based on fixed-block technology whereas the Vancouver system utilized CBTC technology. Other examples of UTO utilizing CBTC technology would include, for example, Lyon Line D (1992), Paris Meteor Line (1998), Kuala Lumpur (1998) and Singapore North-East Line (2003). Examples of UTO based on fixed block technology would include Osaka (1982) and Copenhagen Metro (2002) besides Dubai metro.

3.13 Automatic Train Supervision (ATS):

It is the sub-system which supervises the network operation of the train service in accordance with the scheduled Time table or train intervals. Functions of ATS include the following:

1. Despatch trains as per time table or as per command of controller
2. Issue coasting instructions as required for conserving power
3. Adjust dwell times on station platforms
4. Issue commands to station interlocking (CBI) including terminal for automatically setting Routes as required for train movements to maximize line capacity
5. Monitor train positions and progress and aid in display of the same
6. Devise and implement strategy to restore planned service if within its capability
7. Issue alerts to traffic controller and also suggest strategy if outside the capability of the automatic system for restoration of planned train services
8. Compute train schedules as per instructions of controller and revise them as per traffic flow.
9. Execute instructions received from traffic controller and provide status and feed back

10. Provide data to the Passenger Information systems and Train management systems for Displays and Announcements at stations as well as inside trains
11. Maintains logs with time stamps and compile all records as customized.

The ATS system is mainly software driven with redundant servers provided at suitable locations.

3.14 Centralized Control and Importance of Operations Control Centre (OCC):

Centralized control of points and crossings of all stations of the network from a single location by one operator helps in drastic reduction in the time required for setting the routes ahead of the train by eliminating human communication with local station controllers. This concept has been amply proven in the main line networks. In case of metro network due to higher demands of Headway and passenger information requirements etc ATS systems had been developed which could also take over the function of central controller for automatic route setting. Traffic controller can plan all the scheduling and can implement the same through ATS. Workload may be such that each line of the Metro may require a separate traffic controller. There are many other requirements for the smooth operation which requires a number of controllers handling different function of the network such rolling stock monitoring, traction control, security control, passenger interface controller etc. These operators are all located in one location called Operations Control Center (OCC). A number of automated systems similar to ATS for traffic control are provided in the OCC and most functions are automated. However the crucial role of OCC will be felt whenever there are failures or other perturbations to the system when the automated systems cannot make and implement decisions and human intervention becomes necessary. The operators can immediately swing into action for controlling the situation to ensure passenger safety, provide possible temporary services to move stranded passengers, evacuate passengers from danger zone and for quick restoration of normal service.

Normally the large hall in OCC, known as the theater is provided with large Screen Display Boards for describing the complete train information including all points, track circuits, signals, routes, alarms in the network. These LSD boards are located such that they can be easily seen by all operators from their desks and blinking lights on the LSD can attract quick attention to alarms and failures. Each operator is provided a desk top display which he can further use to diagnose the alarms / failures for quick action to restore the failure. A dedicated radio link with the moving driver and its alerts on the screen, can bring the attention of the controller quickly contacting driver.

An introduction to the latest state-of-art in Metro signalling, namely, Communication Based Train Control (CBTC), along with list of current Metro Rails of the world using CBTC and other details are briefly provided in the next section. For more details about the role of CBTC in automation and benefits of automation for Metro administration, some of the Papers submitted in CBTC seminar of IRSE Feb 2011 kept at Annexure-11 & Annexure-12 may please be seen. For complete details of current status of CBTC, strategy and business case for CBTC etc the proceedings of the Seminar on CBTC conducted by IRSE London on 15th February 2011 may be referred. These are available to members on the IRSE web site. (www.irse.org).

SECTION-4

CHARACTERISTICS & ADVANTAGES OF COMMUNICATION BASED TRAIN CONTROL SYSTEMS (CBTC)

Communications-Based Train Control (**CBTC**) is a railway signalling system that makes use of the telecommunications between the train and track equipment for the traffic management and train control. CBTC systems enables, exact position of a train is known more accurately than with the traditional signalling systems, which results in a more efficient and safe way to manage the railway traffic and improve headway.

As defined in the IEEE 1474 standard, a CBTC system is a "*continuous, automatic train control system utilizing high-resolution train location determination, independent of track circuits; continuous, high-capacity, bidirectional train-to-wayside data communications; and train borne and wayside processors capable of implementing Automatic Train Protection (ATP) functions, as well as optional Automatic Train Operation (ATO) and Automatic Train Supervision (ATS) functions.*"

4.1 Background CBTC

Unlike the traditional fixed block systems, in the modern moving block CBTC systems the protected section for each train is not statically defined by the infrastructure by operating appearance of a moving block but still constrained by physical blocks). Besides, the trains themselves are continuously communicating their exact position to the equipment in the track by means of a bi-directional link, either inductive loop or radio communication.

The advent of digital radio communication technology during the early 90s, encouraged the signalling industry on both sides of the Atlantic to explore using radio communication as a viable means of track to train communication, mainly due to its increased capacity and reduced costs compared to the existing transmission loop-based systems, and this is how CBTC systems started to evolve and grow.

SFO Air Train, in San Francisco Airport, was the first radio-based CBTC system deployment in the world. As a result, Bombardier opened the world's first radio-based

CBTC system at San Francisco airport´s Automated People Mover (APM) in February 2003. A few months later, in June 2003, Alstom introduced the railway application of its radio technology on the Singapore North East Line using wave guide. Previously, CBTC has its former origins in the loop based systems developed by Alcatel SEL (now Thales) for the Bombardier Automated Rapid Transit (ART) systems in Canada during the mid 1980s. These systems, which were also referred to as Transmission-Based Train Control (TBTC), made use of inductive loop transmission techniques for track to train communication, introducing an alternative to track circuit based communication. This technology, operating in the 30-60 KHz frequency range to communicate trains and wayside equipment, was widely adopted by the metro operators in spite of some electromagnetic compatibility (EMC) issues, as well as other installation and maintenance concerns.

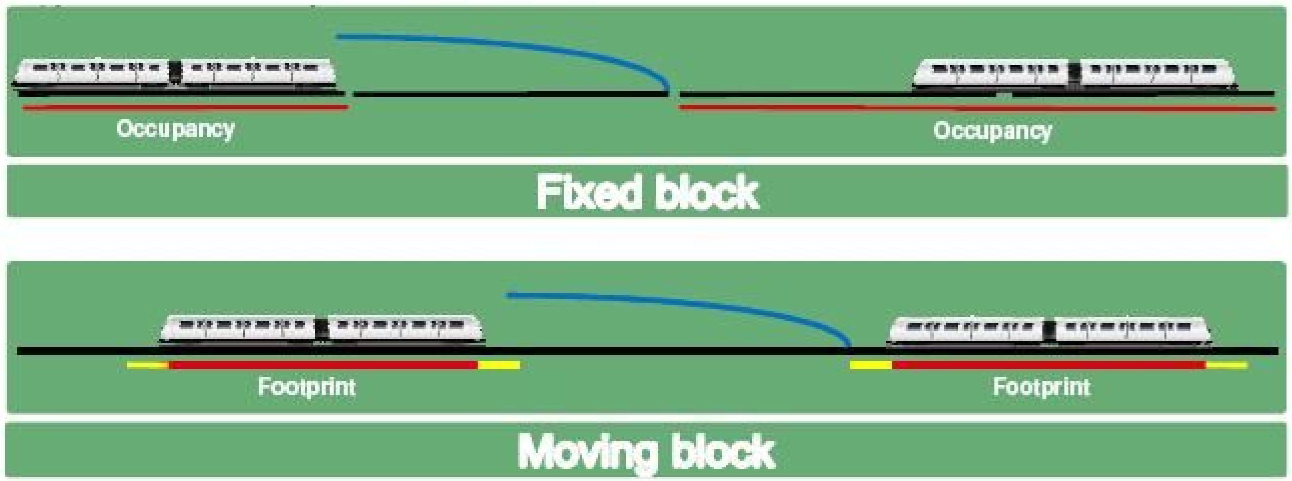
As every new application of any technology, some problems arose at the beginning mainly due to compatibility and interoperability aspects. However, there have been relevant improvements since then, and currently the reliability of the radio-based communication systems is accepted and preferred technology of operation.

Moreover, it is important to highlight that not all the systems using radio communication technology are considered to be CBTC systems. So, for clarity and to keep in line with the state-of-the-art solutions for operator's requirements, only CBTC solutions that make use of the radio communications and provide moving block solutions.

4.2 Main features

4.2.1 CBTC and moving block

CBTC systems are modern railway signalling systems that can mainly be used in urban railway lines (either light or heavy) and APMs, although it could also be deployed on commuter lines. For main lines, a similar system might be the European Railway Traffic Management System ERTMS Level 3 (not yet fully defined). In the modern CBTC systems the trains continuously calculate and communicate their status via radio to the wayside equipment distributed along the line. This status includes, among others parameters, the exact position, speed, travel direction and braking distance. This information allows calculation of the area potentially occupied by the train on the track. It also enables the wayside equipment to define the points on the line that must never be passed by the other trains on the same track. These points are communicated to make the trains automatically and continuously adjust their speed while maintaining the safety and comfort (jerk) requirements. So, the trains continuously receive information regarding the distance to the preceding train and are then able to adjust their safety distance accordingly.



Safety distance (safe-braking distance) between trains in fixed block and moving block signalling systems

From the signalling system perspective, the first figure shows the total occupancy of the leading train by including the whole blocks which the train is located on. This is due to the fact that it is impossible for the system to know exactly where the train actually is within these blocks. Therefore, the fixed block system only allows the following train to move up to the last unoccupied block's border.

In a moving block system as shown in the second figure, the train position and its braking curve is continuously calculated by the trains, and then communicated via radio to the wayside equipment. Thus, the wayside equipment is able to establish protected areas, each one called Limit of Movement Authority (LMA), up to the nearest obstacle (in the figure the tail of the train in front).

It is important to mention that the occupancy calculated in these systems must include a safety margin for location uncertainty (in yellow in the figure) added to the length of the train. Both of them form what is usually called 'Footprint'. This safety margin depends on the accuracy of the odometry system in the train.

CBTC systems based on moving block allow the reduction of the safety distance between two consecutive trains. This distance is varying according to the continuous updates of the train location and speed, maintaining the safety requirements. This results in a reduced headway between consecutive trains and an increased transport capacity.

4.2.2 Levels of automation

Modern CBTC systems allow different levels of automation or *Grades of Automation*, GoA, as defined and classified in the IEC 62290-1. In fact, CBTC is not a synonym for "driverless" or "automated trains" although it is considered as a basic technology for this purpose.

The grades of automation available, range from a manual protected operation, GoA 1 (usually applied as a fallback operation mode) to the fully automated operation, GoA 4 (Unattended Train Operation, UTO). Intermediate operation modes comprise semi-automated GoA 2 (Semi-automated Operation Mode, STO) or driverless GoA 3 (Driverless Train Operation, DTO). The latter operates without a driver in the cabin, but requires an attendant to face degraded modes of operation as well as guide the passengers in the case of emergencies. The higher the GoA, the higher the safety, functionality and performance levels must be.

4.3 Main applications

Dallas-Fort Worth Airport driverless APM vehicle equipped with radio-based CBTC true moving block system

CBTC systems allow optimal use of the railway infrastructure as well as achieving maximum capacity and minimum headway between operating trains, while maintaining the safety requirements. These systems are suitable for the new highly demanding urban lines, but also to be overlaid on existing lines in order to improve their performance.

Of course, in the case of upgrading existing lines the design, installation, test and commissioning stages are much more critical. This is mainly due to the challenge of deploying the overlying system without disrupting the revenue service.

4.4 Main benefits

The evolution of the technology and the experience gained in operation over the last 30 years means that modern CBTC systems are more reliable and less prone to failure than older train control systems. CBTC systems normally have less wayside equipment and their diagnostic and monitoring tools have been improved, which makes them easier to implement and, more importantly, easier to maintain.

CBTC technology is evolving, making use of the latest techniques and components to offer more compact systems and simpler architectures. For instance, with the advent of modern electronics it has been possible to build in redundancy so that single failures do not adversely impact operational availability.

Moreover, these systems offer complete flexibility in terms of operational schedules or timetables, enabling urban rail operators to respond to the specific traffic demand more swiftly and efficiently and to solve traffic congestion problems. In fact, automatic operation systems have the potential to significantly reduce the headway and improve the traffic capacity compared to manual driving systems.

Finally, it is important to mention that the CBTC systems have proven to be more energy efficient than traditional manually driven systems. The use of new functionalities, such as automatic driving strategies or a better adaptation of the transport offer to the actual demand, allows significant energy savings reducing the power consumption.

4.5 Risks

The primary risk of a CBTC system is that if the communications link between any of the trains is disrupted then all or part of the system might have to enter a failsafe state until the problem is remedied. Depending on the severity of the communication loss, this state can range from vehicles temporarily reducing speed, coming to a halt or operating in a degraded mode until communications are re-established. If communication outage is permanent some sort of contingency operation must be implemented which may consist of manual operation using absolute block or, in the worst case, the substitution of an alternative form of transportation. As a result, high availability of CBTC systems is crucial for proper operation, especially if we consider that such systems are used to increase transport capacity and reduce headway. System redundancy and recovery mechanisms must then be thoroughly checked to achieve a high robustness in operation. With the increased availability of the CBTC system, it must also be considered the need for an extensive training and periodical refresh of system operators on the recovery procedures. In fact, one of the major system hazards in CBTC systems is the probability of human error and improper application of recovery procedures if the system becomes unavailable.

Communications failures can result from equipment malfunction, electromagnetic interference, weak signal strength or saturation of the communications medium. In this case, an interruption can result in a service brake or emergency brake application as real time situational awareness is a critical safety requirement for CBTC and if these interruptions are frequent enough it could seriously impact service. This is the reason why, historically, CBTC systems first implemented radio communication systems in 2003, when the required technology was mature enough for critical applications.

In systems with poor line of sight or spectrum/bandwidth limitations a larger than anticipated number of transponders may be required to enhance the service. This is usually more of an issue with applying CBTC to existing transit systems in tunnels that were not designed from the outset to support it. An alternate method to improve system availability in tunnels is the use of leaky feeder cable that, while having higher initial costs (material + installation) achieves a more reliable radio link.

CBTC systems that make use of open standards for wireless digital communications link have a much larger attack surface and can be subject to various types of hacking including intrusion of the communications network and tampering with safety critical messages that, in the worst case, could result in a safety hazard. Defensive techniques for open networks as, for example, the ones prescribed by standard EN 50159-2 must be carefully analyzed. These attacks can however be mitigated using various security controls that must be implemented to effectively making use of the CBTC safety advantages.

With the emerging services over open ISM radio bands (i.e. 2.4 GHz and 5.8 GHz) and the potential disruption over critical CBTC services, there is an increasing pressure in the international community (ref. report 676 of UITP organization, Reservation of a Frequency Spectrum for Critical Safety Applications dedicated to Urban Rail Systems) to reserve a frequency band specifically for radio-based urban rail systems. Such decision would help standardize CBTC systems across the market (a growing demand from most operators) and ensure availability for those critical systems.

As a CBTC system is required to have high availability and particularly, allow for a graceful degradation, a secondary method of signaling might be provided to ensure some level of non-degraded service upon partial or complete CBTC unavailability. This is particularly relevant for brown field implementations (lines with an already existing signalling system) where the infrastructure design cannot be controlled and coexistence with legacy systems is required, at least, temporarily. For example the New York City Canarsie Line was outfitted with a backup automatic block signaling system capable of supporting 12tph, compared with the 26tph of the CBTC system. Although this is a rather common architecture for re-signalling projects, it can negate some of the cost savings of CBTC if applied to new lines. This is still a key point in the CBTC development (and is still being discussed), since some providers and operators argue that a fully redundant architecture of the CBTC system may however achieve high availability values by itself.

In principle, CBTC systems may be designed with centralized supervision systems in order to improve maintainability and reduce installation costs. If so, there is an increased risk of a single point of failure that could disrupt service over an entire system or line. Fixed block systems usually work with distributed logic that are normally more resistant to such outages. Therefore, a careful analysis of the benefits and risks of a given CBTC architecture (centralized vs. distributed) must be done during system design.

4.6 CBTC Architecture

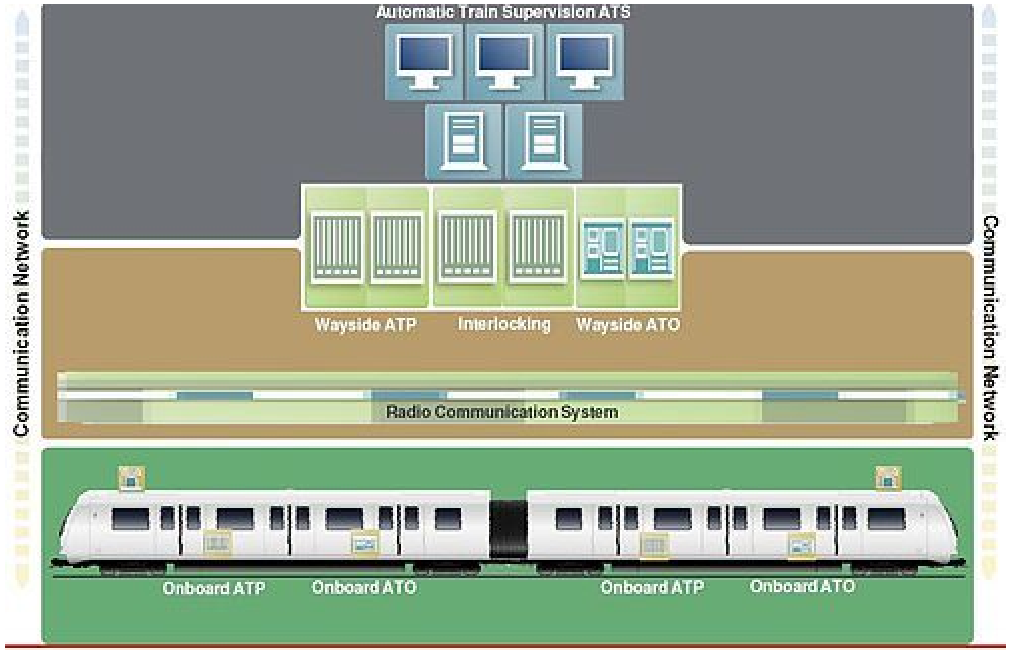


Illustration of a typical radio-based CBTC architecture. Technical solution may differ from one supplier to another.

Wayside equipment, which includes the interlocking and the subsystems controlling every zone in the line or network (typically containing the wayside ATP and ATO functionalities). Depending on the suppliers, the architectures may be centralized of distributed. The control of the system is performed from a central command ATS, though local control subsystems may be also included as a fallback.

1. **CBTC onboard equipment**, including ATP and ATO subsystems in the vehicles.
2. **Train to wayside communication subsystem**, currently based on radio links.

Thus, although a CBTC architecture is always depending on the supplier and its technical approach, the following logical components may be found generally in a typical CBTC architecture:

- **Onboard ATP system**. This subsystem is in charge of the continuous control of the train speed according to the safety profile, and applying the brake if it is necessary. It is also in charge of the communication with the wayside ATP subsystem in order to exchange the information needed for a safe operation (sending speed and braking distance, and receiving the limit of movement authority for a safe operation).

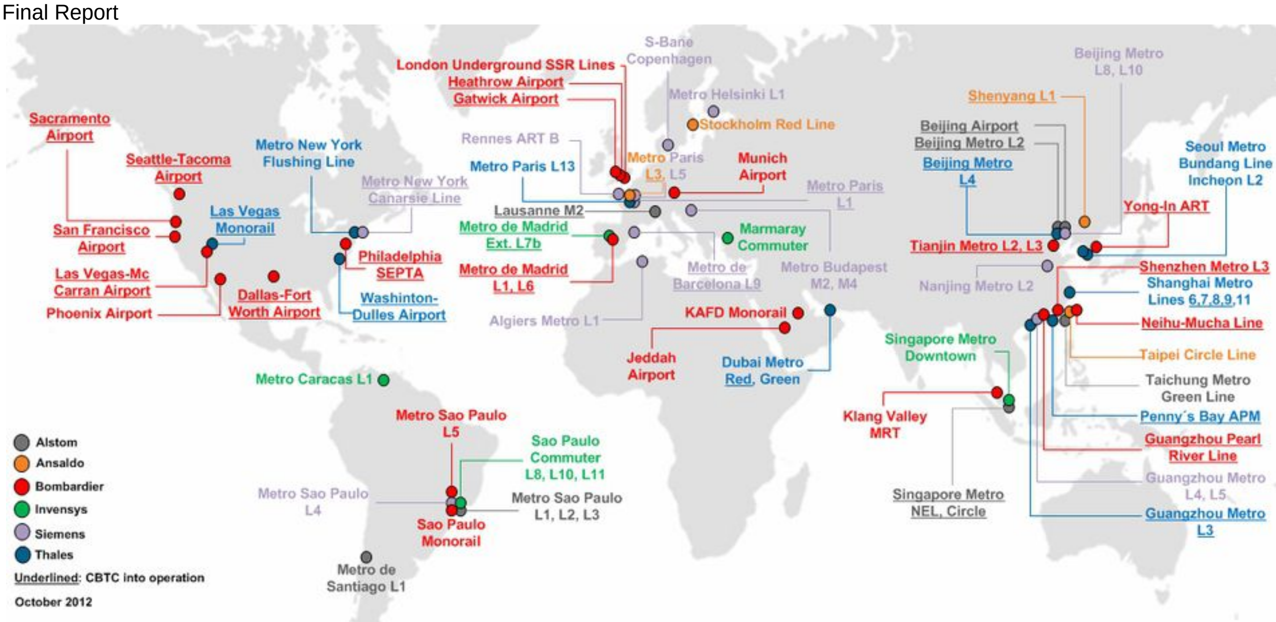
- **Onboard ATO system**. It is responsible for the automatic control of the traction and braking effort in order to keep the train under the threshold established by the ATP subsystem. Its main task is either to facilitate the driver or attendant functions, or even to operate the train in a fully automatic mode while maintaining the traffic regulation targets and passenger comfort. It also allows the selection of different automatic driving strategies to adapt the runtime or even reduce the power consumption.

- **Wayside ATP system**. This subsystem undertakes the management of all the communications with the trains in its area. Additionally, it calculates the limits of movement authority that every train must respect while operating in the mentioned area. This task is therefore critical for the operation safety.
- **Wayside ATO system**. It is in charge of controlling the destination and regulation targets of every train. The wayside ATO functionality provides all the trains in the system with their destination as well as with other data such as the dwell time in the stations. Additionally, it may also perform auxiliary and non-safety related tasks including for instance alarm/event communication and management, or handling skip/hold station commands.

- **Communication system**. The CBTC systems integrate a digital networked radio system by means of antennas or leaky feeder cable for the bi-directional communication between the track equipment and the trains. The 2,4GHz band is commonly used in these systems (same as Wi-Fi), though other alternative frequencies such as 900MHz (US), 5,8GHz or other licensed bands may be used as well.
- **ATS system**. The ATS system is commonly integrated within most of the CBTC solutions. Its main task is to act as the interface between the operator and the system, managing the traffic according to the specific regulation criteria. Other tasks may include the event and alarm management as well as acting as the interface with external systems.
- **Interlocking system**. When needed as an independent subsystem (for instance as a fallback system), it will be in charge of the vital control of the trackside objects such as switches or signals, as well as other related functionality. In the case of simpler networks or lines, the functionality of the interlocking may be integrated into the wayside ATP system.

4.7 Projects

CBTC technology has been (and is being) successfully implemented for a variety of applications as shown in the figure below (mid 2011). They range from some implementations with short track, limited numbers of vehicles and few operating modes (such as the airport APMs in San Francisco or Washington), to complex overlays on existing railway networks carrying more than a million passengers each day and with more than 100 trains (such as lines 1 and 6 in Metro de Madrid, line 3 in Shenzhen Metro, some lines in Paris Metro and Beijing Metro, or the Sub-Surface network SSR in London Underground). Some of these are tabulated in Annexure-19.



<u>Radio-based CBTC moving block projects around the world. Projects are classified with colours depending on the supplier; those underlined are already into CBTC operation</u>

Despite the difficulty, the table below tries to summarize and reference the main radio-based CBTC systems deployed around the world as well as those ongoing projects being developed. Besides, the table distinguishes between the implementations performed over existing and operative systems (Brownfield) and those undertaken on completely new lines (Greenfield).

We must take into account that the transmission technology based on inductive loops (referred to as TBTC in this article) is now being less and less used. That is why, for clarity, all the projects listed here are modern radio-based CBTC systems making use of the moving block concept as described above.

<u>Some of the top 30 World´s busiest metros in terms of annual passenger rides are utilizing a CBTC system. It can be easily concluded that CBTC has come of age and it will be the technology to go for current projects as well as foreseeable in future.</u>

The next section provides a comparison with main line signalling especially its train protection system as compared to Metro Rail Signalling & Train Control systems.

SECTION- 5

COMPARISON OF METRO SIGNALLING WITH MAIN LINE SIGNALLING & ERTMS

5.1 Development of signalling in main line and Metro Rail, a comparison:

As already seen in the section on Basics of Metro signalling, the principles underlying the Metro Rail safety philosophy are derived from the traditional main line signalling which have evolved over more than hundred years. The London Underground which ran with steam traction for 40 years before changing to electric traction used only the early signals available in common with the main line Railway. The basic track side signals such as 3-aspect or 4-aspect signalling are similar even today in both the systems, with evolution from mechanical semaphore signals taking place in parallel in both the systems all over the world. Developments of LED lamps have been adopted in both the systems. Similarly improvements in point machines for operation of turnouts were almost same in both the systems over the years. Many of the underlying building blocks of basic signalling are same or similar in both these networks. Basic components such as Point machines, vital relays, signalling cables, wiring arrangements etc are more or less same.

LUG also adopted the developments in interlocking, even the mechanical interlocking to begin with. Relay interlocking followed concurrently with developments in main line signalling. While electrical interlocking based on Relays are still widespread in all the main line systems all over the world including Europe, Metro Networks (except for older installations awaiting replacement) employ only processor based electronic interlocking (Computer Based Interlocking CBI), as these enable integration of the ATP system much easier than compared to relay Interlocking. Electronic Interlocking EI or CBI is also becoming the norm in main line networks due to its advantages.

British rail took the lead to advance the safety by invention of mechanical tripping to avoid SPAD incidents and started experimenting with solenoid based magnet systems for what was then called Automatic Warning System (AWS). These gave a warning indication to the driver inside the cab about 200 Meters in rear of a RED signal so that he can apply the brakes if he had already started braking. In the 1950s a large length of the main line was equipped with AWS in Britain and practically all the lines in BR have the AWS at the minimum as a protection against SPAD. Meanwhile track circuit based systems were also being experimented in many railways. All these trials were also adopted by LUG and other rapid transits in USA.

Track circuiting is the main stay for train detection in most of the main line Railways. Axle counters are also used in many networks for primary train detection. DC track circuits are slowly giving way to joint less AFTC in main line networks.

Experiments with ATP started in Metro / Transit railways first and developments took place in USA and in LUG even in 1930s and accelerated after the Second World War. Continuous ATP systems are in existence in Metro rail for over 50 years. LUG implemented ATP systems based on track circuits with CAB signalling in the 1960s. Coded track circuits are used and AFTC track circuits transmitting information to the train were employed by many railways to develop their own proprietary ATP systems, particularly when high speed trains had to be introduced on the main line. These systems were called TPWS (Train Protection and Warning Systems) in British Railways. The high speed TGV in France uses a system called TVM based on coded track circuits.

After formation of the European Union (EU), the need was felt for standardizing the ATP systems on the main line so that a long distance train traversing many countries in Europe need not change the Locomotives at every national border to continue to have Automatic train protection. Since the National systems were proprietary, the track side equipment of one country will not be compatible with the on-board system of the engine from a different country! This initiated development, around 1990, of what is known as the European Rail Traffic Management System (ERTMS), which was planned as a comprehensive railway management system spanning all the countries in EU. The signalling portion enforcing the automatic train protection within this system came to be designated European Train Control System (ETCS). Though both the terms are used synonymously, ETCS is the train protection part and the other components planned under ERTMS such as ATO and a common ATS are yet to see the light of day even after two decades. ETCS has made good progress in these twenty years and a number of lines in Europe including high speed lines have been fitted with ETCS. ETCS is a development for standardization of the proprietary ATP systems used till then by main line networks which were similar to those used in Metro Rail as for safety aspects are concerned. Considering the objective of the sub-committee, it will be worthwhile to look at the details and developments in ETCS which follows.

5.2 European Rail Traffic Management System (ERTMS) & European Train Control System (ETCS):

5.2.1 History of development and current status:

As mentioned above till 1990, the Rail transportation in Europe across countries was fraught with lot of complexities and difficulties. Together with other technical differences - for instance in terms of rail gauge, electricity voltage, rolling stock design, etc. - the existence of more than 20 train control systems in Europe had always been a major obstacle to the development of international rail transport. For this reason, the development of a common European system started to be discussed as early as the late 1980s. Trains were equipped with up to seven different train control systems. Each was extremely costly and took up space on-board. A train crossing from one European country to another had to switch the operating standards as it crossed the border. All this added to travel time and operational and maintenance costs. This situation was causing significant inefficiency in international rail traffic. In that environment either locomotive had to be changed at the national borders locomotives had to be equipped with the on board safety systems of the countries to cross. For example, the Amsterdam – Paris high speed train, had 7 different safety systems on board!

ETCS was thus an initiative taken up at the political level by the administration of EU. Following the decision taken by the European Transport ministers in December 1989, the UIC embarked upon a project to analyze the problems relating to signaling and train control. At the end of 1990, a group of railway experts (A200) were organized to develop

the requirements of ETCS. In June 1991, Industry, in the form of a group of firms which had till then developed the various national systems and various Railways through the umbrella of UIC, agreed on the principles of tight co-operation in order to consider the requirement specifications as the base for industrial development. Initial efforts were focused on bringing out a standard system requirements specification. This work went on for almost a decade before the first version of SRS (System Requirement Specifications) could be firmed up in April 1999 and the industry could go ahead to modify their systems in line with the ETCS specification. The specifications were subsequently reviewed continuously to include additional functionalities and better meet the needs from the railway companies and infrastructure managers. The specifications currently in force, are contained in the version SRS 2.3.0d, which was adopted by the European Commission in April 2008. This version has been cooperatively created by the group of manufacturer in their association called UNISIG. (It is important to note that the same vendors hold the market for the ATCS systems required by the Metro rail, but they provide individual proprietary systems to meet the need s of Metro rail for additional functions such as ATO and ATS which are not available in ERTMS.) To ensure that ERTMS is constantly adapted to the railway's needs, technical specifications are maintained under the lead of the European Railway Agency in cooperation with the signalling industry and railway stakeholders. Required funding is ensured by EU. Hence the standardization for ETCS was an international effort, with enough clout to persuade the major manufacturers to cooperate.

ETCS development also was made in an incremental manner, with an intermittent version of ATP standardized in the form of ETCS-Level 1 before tackling the Continuous ATP. This could enable commissioning of many lines gradually, helping in a continuous learning and consolidation process. With continuous and concerted efforts of EU and the individual member countries, ETCS is commissioned in many European countries on important lines in the last ten years. By April 2012, ETCS has covered 62000 RKM with more than 7500 Cabs / Vehicles equipped. (Details of current deployment of ETCS as in April 2012 are kept vide Annexure-13.)

However, there is also criticism about the complexity in making even small changes as the safety validation process is quite complex and costly. It is also felt that innovations will be very slow and latest developments in science and technology could not be incorporated with enough speed. Brief details of ETCS are given below**.** An excellent coverage of fundamentals of ETCS are given in the IRSE Australia Proceedings Paper on Application of ERTMS/ETCS October 2007. Copy is kept at Annexure 14 for more detailed reference.

5.2.2 ETCS Principles and Levels:

ERTMS' concept is based on standardization of data exchange in traffic management. This principle however does not imply automatically that all trains have exactly the same systems on board. Airplanes don't have that either by the way. The only things really standardized in aviation are communication procedures and specifications of communication equipment, with which any Plane is able to land in any airport.

Communication in Rail perspective means communication between the train and equipment alongside the track. Differences between certain interfaces showing information to the driver are still possible. In ETCS application ''Levels" define different uses of ETCS as a train control system ranging from track to train communications (Level 1) to continuous communications between the radio block centre and the train (Level 2). While Level 1 provides safety information to the train at designated locations on the track linked to the signals ahead (thus providing an “intermittent” automatic train protection), Level 2 can provide a continuous Automatic train protection as any change in the train location and status is immediately known to the Block centre which can alert and control the following train by radio.

5.2.3 ETCS level 1:

ETCS level 1 is designed as an add-on to or overlays a conventional line already equipped with line side signals and train detectors. Communication between the tracks and the train are ensured by dedicated beacons located usually on the trackside adjacent to the line side signals at required intervals.

ETCS Level 1 is a fixed block intermittent (or ‘spot’) speed supervision system. The trackside equipment consists of encoders or Line side Electronic Unit (LEU’s) and **Eurobalises**. (see photograph below). The LEU’s are programmed with fixed infrastructure information and combines this with the variable information taken from the aspects displayed by the signals to select and then pass a serial message to the Eurobalises for transmission to the train. The balise transmission takes the form of a telegram containing the ETCS Movement Authority (distance to go, speed restriction, gradient etc.) and other applicable control data.

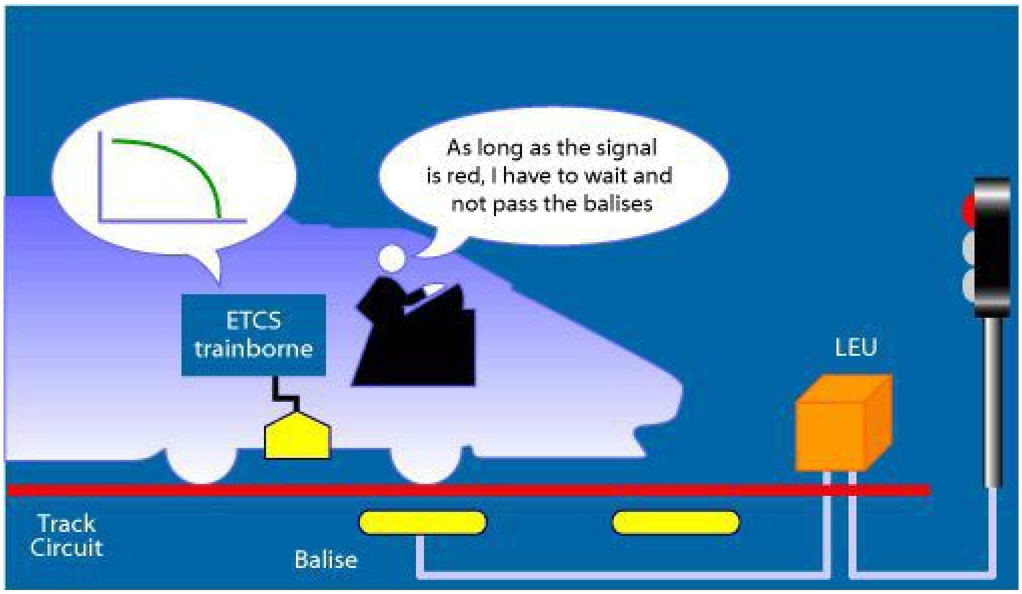
An antennae carried by the on-board ETCS equipment on the train cab receives the Eurobalise transmission. ATP modules within the train borne ETCS sub-system calculate a safe speed profile on the basis of the received ETCS data and known train braking parameters and pre-fed track description data. This information is displayed to the driver through a dedicated screen in the cabin (Driver Machine Interface DMI).

An onboard odometer system senses the movement of the train to provide the ATP functions with the means to check that the speed and distance limits defined by the Movement Authority are not exceeded. The odometer function uses two tacho generators and other sensors to determine speed and location. The outputs from these sensors are combined to form most advanced and most retarded locations to ensure that factors such as wheel slide/slip cannot lead to unsafe estimates of actual location. The odometer error band is reset to zero every time a Eurobalise is passed. Being an intermittent transmission system, a train is unable to take advantage of a signal aspect stepping up until it reaches the balise group at the signal. To mitigate against this “Infill” can be provided between the distant and main signal.
Both intermittent and semi-continuous infill options are available. Trackside signals are still required as the driver has to observe the status of the signal when approaching a balise group to know whether to stop the train in rear of the balise group (signal at “STOP” or to pass over the balise group (signal at “PROCEED”).

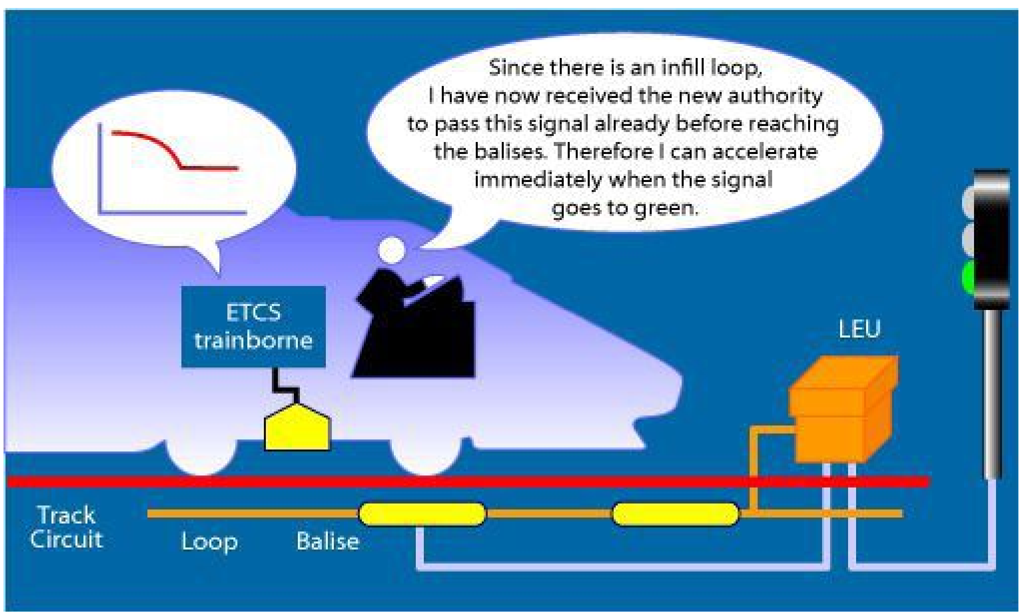
It is relatively very simple to equip existing traditionally signalled line with balizes and LEUs, without interfering with the existing system except to make use of some spare relay contacts and enhance the safety.

It will be possible for ETCS equipped as well as non-equipped trains to share the same track till all trains are equipped. It is also possible to have a track side system of one vendor and on-board equipment from different vendor making the system easily interoperable as long as they conform to ETCS-1 standard for the track to train communication. Because of these advantages, initially a number of lines were quickly provided with ETCS-1 systems.

Photographs of Euro balize and simple conceptual diagrams of ETCS-1 are appended below:



ETCS Level 1 with no infill

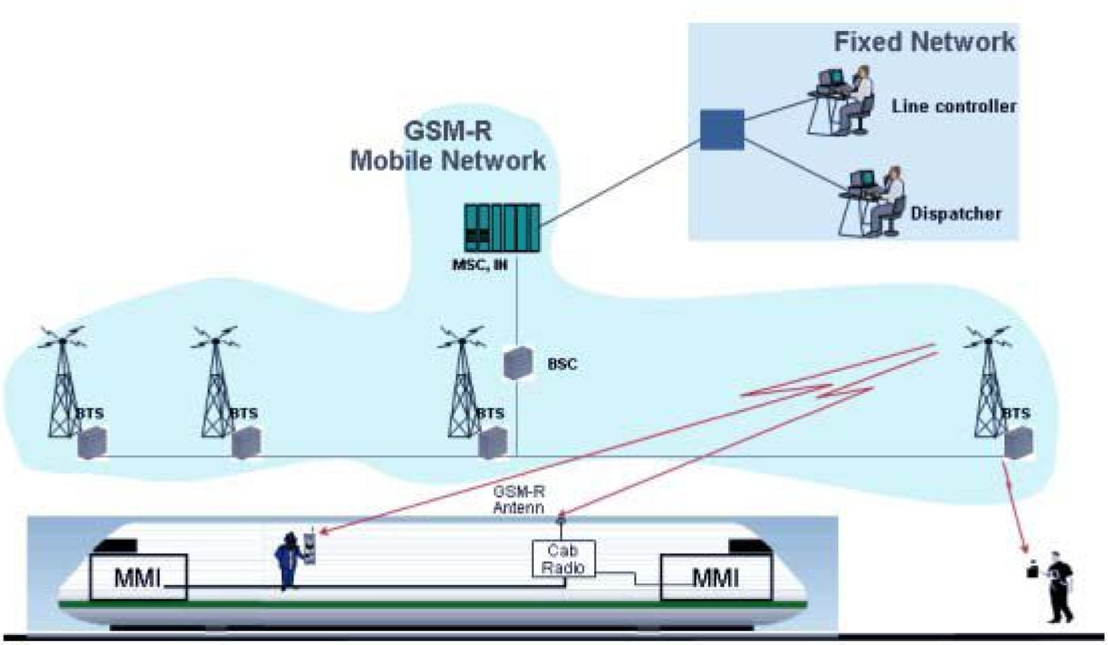


ETCS Level 1 with infill

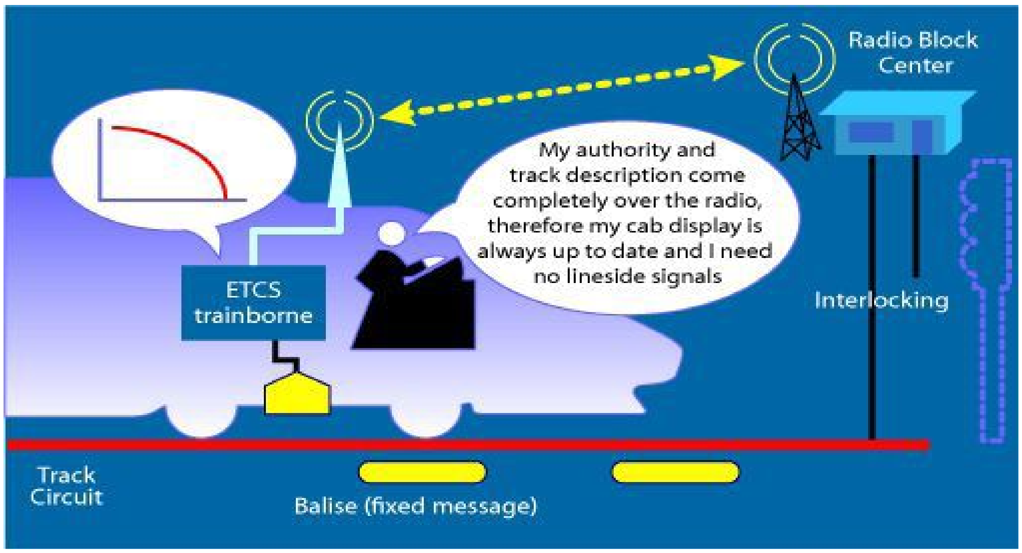

Eurobalise

5.2.4 ETCS Level-2

ETCS Level 2 is a fixed block continuous speed supervision system. The trackside equipment consists of centralized Radio Block Centers (RBC) and distributed Eurobalises. GSM R radio replaces the Eurobalise to transmit information to the train. Eurobalises are still used, but only as a means of initializing and periodically recalibrating the onboard odometer and to issue “fixed messages” such as location, gradient, speed limit, etc. The RBC takes information directly from the interlocking on the aspects displayed (and therefore the status of the line ahead) in place of the LEU. The RBC is programmed with fixed infrastructure information and combines this with the variable information taken from the interlocking to select and then pass a serial message to the GSM-R radio for transmission to the train. A continuous stream of data informs the driver of line-specific data and signals status on the route ahead, allowing the train to reach its maximum or optimal speed but still maintaining a safe braking distance factor. As GSM-R provides bi-directional (duplex) data transmission, real time data regarding train locations and speeds can be made available to the signalling control and train describer functions.

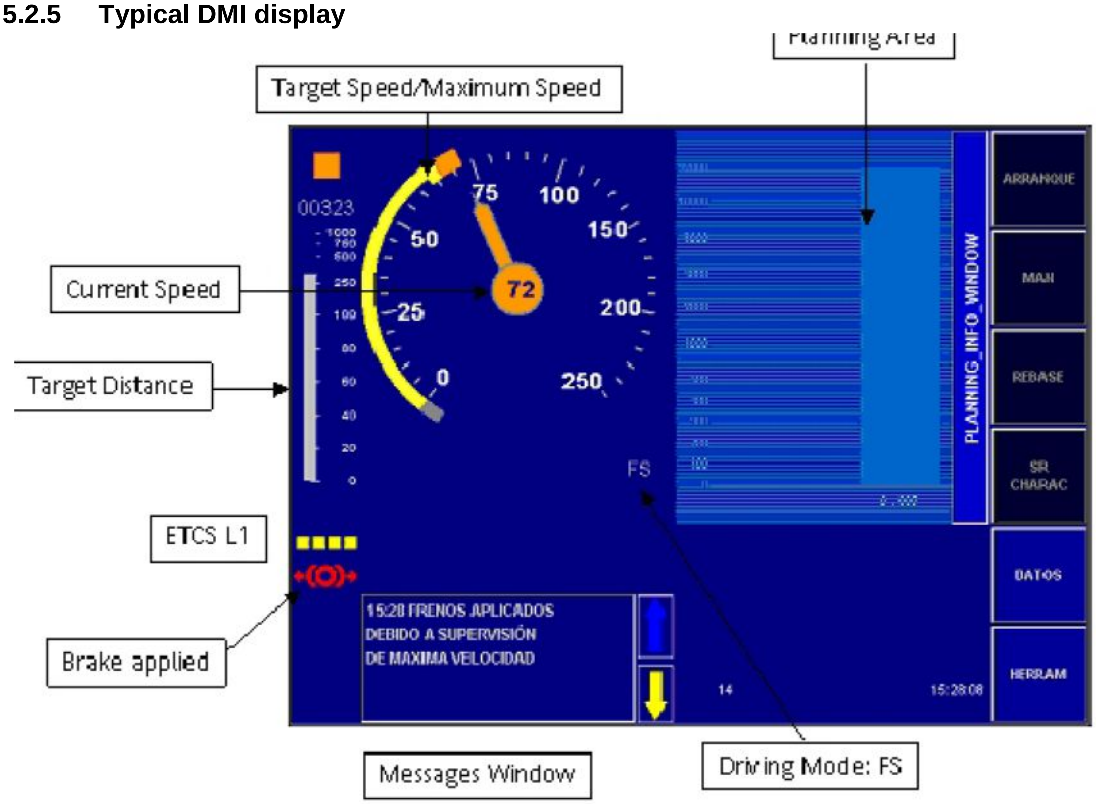


Though trackside signals are no longer required, some could be kept at key locations as a fall-back and also for use by non-ETCS trains. The RBC which provides the information to the trains knows each ETCS controlled train individually. It provides continuous speed supervision and also protects against overrun of movement authority. Train detection and train integrity supervision are performed by the trackside equipment of the underlying signalling system (interlocking, track circuits etc.). The system does not require trackside signals but they are often retained as a backup in case of system failure or in case not all trains operating on the line are ETCS equipped. A simple conceptual diagram of ETCS-2 is given below:



ETCS Level 2

5.2.5 Typical DMI display



5.2.6 ETCS – Level 0

A term Level 0 is also sometimes used. It is in effect non-availability of ETCS when an ETCS vehicle is used on a non-ETCS route. The train borne equipment monitors the train for maximum speed of that type of train. The train driver observes the trackside signals. Since signals can have different meanings on different railways, this level restricts drivers to one railway. If the train has left a higher level ETCS, it might be limited in speed globally by the last Balize encountered.

5.2.7 ETCS-Level 3

ETCS Level 3 is still in its conceptual phase. No manufacturer is yet to demonstrate a complete prototype incorporating a full Level-3 system. (A partial implementation is on a pilot trial of a version of ERTMS called ERTMS-Regional, on a low density line in Sweden with one or two trains equipped).

The concept allows for the introduction of a “moving block” technology. With Level 3, ETCS goes beyond the pure train protection functionality with the implementation of full radio-based train spacing. Fixed track-release signalling devices are no longer required. As with ETCS Level 2, trains find their position themselves by means of positioning beacons and via sensors (axle transducers, accelerometer etc and must also be capable of determining train integrity on board to the very highest degree of reliability. By transmitting the positioning signal to the radio block centre it is always possible to determine which point on the route the train has safely cleared. The following train can already be granted another movement authority up to this point. The route is thus no longer cleared in fixed track sections. In this respect ETCS Level 3 departs from classic operation with fixed intervals: given sufficiently short positioning intervals, continuous line-clear authorization is achieved and train headways come close to the principle of operation with absolute braking distance spacing, or moving block.

Level 3 is currently under development. Solutions for reliable train integrity supervision are highly complex and are hardly suitable for transfer to older models of freight rolling stock. The train length is manually entered and not automatically detected. All suppliers (UNISIG) have not agreed to provide any target to offer Level 3 at present in order to concentrate efforts on Levels 1 and 2. Some of these suppliers have made trial version of Level-3 but not formally validated as the standards for ETCS-Level 3 itself is yet to be agreed upon.

5.2.8 Process of verification and certification

The ETCS specifications lay down stringent conditions for ensuring the product of the vendor meets the fail safe requirements such as , Safety Integrity Level-4 as per EN-50126, EN-50128, EN-50129 standards. For this purpose a process of safety validation by preparation of a safety case has been laid down in the standards. Since the standards do not specify the details of the hardware or software systems (and they only specify the data exchange between interfaces), it is necessary to validate the system even if it is already proven. Since a lot of customization is involved to incorporate National Rules, every system installation has to undergo this tedious and costly process. Every time the common standards of ETCS undergoes version change, upgrade is required to avoid being out of date over a period of time. Even any small change of hardware or minor change in software requires safety validation.

5.2.9. Limited Interoperable Components / Sub-Systems.

Even with all the focus on inter-operability even ETCS could not be said to fully inter-operable. Only the track side to on-board interoperability has been achieved. Even this is by imposing lot of constraints on vendors in defining the solutions to use. Sometimes they may be forced to keep cost ineffective solutions and postpone innovations as the specifications have to be changed. Inside these two divisions of on-board and track side, no interoperability or inter-changeability is possible and all the sub-systems of one group has to be all from same vendor.

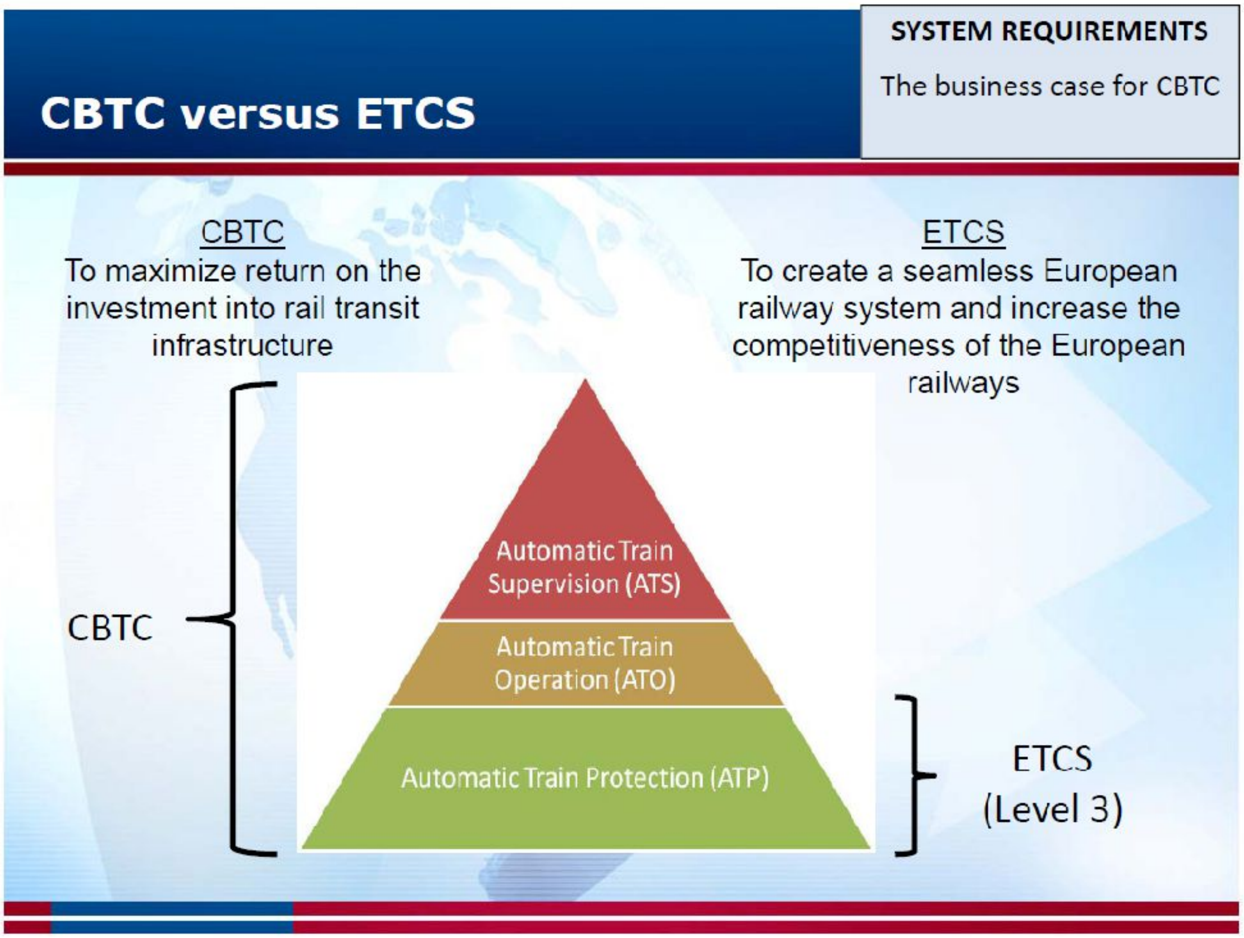
5.3 Comparison of ETCS with ATP systems of Metro rail network

As seen from the above, ETCS was mainly developed with the goal of allowing same train borne equipment to be able to communicate with track side systems of different countries as the long distance train crossed the national borders. This meant interoperability between on-board systems of one vendor with track side systems of several vendors was the only goal to start with. This has been achieved after great efforts to develop standard specifications for the main interfaces and for all the data exchanges between train and track side. ETCS does not attempt to lay down any equipment specifications. Thus the main ethos of ETCS is oriented to main line railway to mainly solve interoperability over national borders while taking care of the train safety problem.

On the other hand, Metro Rail goals and requirements are quite different. The Metro Rail has to handle high density of traffic within the urban limits unlike the main line Railway which encounters capacity problem only while nearing big cities and not in the long distances connecting the cities. Metro rail uses uniform and dedicated train sets which always stay as one unit, whereas the main line has to cater for all kinds of freight and passenger trains of different lengths and with locomotives of different characteristics. While the ATC product is fine tuned to answer all the operational requirements of a Metro rail administration, ETCS addresses only the train protection issue.

The major impediment in using ETCS for train protection in Metro Rail is the absence of ATO or interfaces to provide integrated ATS functionality. The latter is very vital for handling high volume of trains with required reliability and availability to avoid any disruptions in service. Thus ETCS at its current development stage cannot address the Metro Rail requirements. ETCS-Level 1 cannot meet the requirements of Metro Rail at all as it is only an envelope over the track side Signals which are a must, whereas Metro Rail dispenses with track side signals except where turnouts are involved. ETCS-Level 2 is based on radio block (fixed block) approach, working on GSM(R) network, Feasibility of making GSM(R) work inside tunnels is quite complicated. Though ETCS-Level 2 can dispense with track side signals its primary focus is for main line network and the process of software changes are also cumbersome, as technology changes keeping abreast will be quite a challenge. In addition, ETCS-2 also does not provide for ATO or an ATS without which no modern metro can meet the requirements of headway and reliability.

The current position of Level-3 compared to CBTC is amply illustrated in the following diagram:



ETCS Level-3 with its moving block approach tends towards CBTC in basic philosophy. However it is yet to be proven even on main line anywhere and is in development stage. Doubts are expressed by experts of main line signalling whether Level-3 can work successfully anywhere other than low density routes. It may take quite some time to develop and stabilize a successful Level-3 system which is also scalable to high density routes or eventually to Metro Rail. It may happen in the long term. However technical discussions go on in a number of ETCS as well as CBTC forums about the long term possibility of ETCS and CBTC convergence.

The following example illustrates the situation where CBTC is coming to the rescue of main line due to need for handling high density of trains in Main Lines passing through London:

To solve the train protection problem while ensuring high capacity to handle heavy main line traffic, the 'Cross Rail Ltd' has recently awarded a tender to a consortium of Siemens-Invensys for provision of a moving block CBTC system for the short stretches through London City which the main line trains have to cover while running through the city. For provision of CBTC, they have an exemption from Rail safety authorities from 2006 regulations making ETCS compulsory for main line, but with a condition that in the long run as and when ETCS-Level 3 is fully developed and successful, the CBTC equipment now being provided should be capable of being reused for ETCS-Level 3.

The authorization states " *The CBTC contractor will prepare an ERTMS Migration Plan (to enable ETCS Level 3 with minimal modifications) for the Infrastructure Manager to implement at earliest possible date; the plan shall refer to tests to verify that ETCS implementation meets Crossrail's requirements regarding performance, reliability and availability rates, in particular as regards; Automatic Train Operation, Platform Edge Door communications and Auto Reverse. The Migration Plan will need to be submitted to the Department for Transport and then agreed by the Commission before the authorization to place into service is granted*" (Ref: www.dft.gov.uk) (copy at Annexure-15.)

The second example is the provision of a CBTC layer on ETCS Level-1 system used in the suburban train network of Madrid, Spain. The administration was constrained to do so as they needed ATO and ATS for handling the high density of suburban traffic. They also hope to migrate to ERTMS Level-3 one day to have complete solutions to their operational problems.

The above examples bring out clearly that Metro Rail, which may have even denser traffic situations and complex operational problems to be handled will not be able to use ETCS Level-3 when developed for a long time to come.

Thus modern Metro Systems which require short headways and which have to have automation to keep their O&M costs down so as to be viable, cannot manage with ETCS for many years to come. The only option for eventual standardization for Metro rail ATC systems lies only in choosing the CBTC based ATC systems for the Metro Rail Projects as discussed further below.

(References for ERTMS may be seen at www.ertms.net, UIC, UNISIG websites as well as manufacturers' websites such as Siemens, Invensys, Bombardier, Alstom, Ansaldo, Thales)

SECTION- 6

COMMON PLATFORM FOR STANDARDIZATION OF METRO RAIL SIGNALLING & TRAIN CONTROL SYSTEMS

In the present scenario of Metro Railway signaling, it is seen from the foregoing sections that Automatic Train Control System (ATCS) with its associated train detection and data transmission between the track side systems to on-board signaling equipments forms the core of the whole Metro Signalling system world over, while Electronic Interlocking systems for yard operations has become an essential subsidiary system communicating with the main Automatic Train Control System (ATCS) to enable automation by use of ATS. It is now necessary to decide the issue of common platform for ATCS for Metro Signalling which can then help in standardizing the EI systems also. Hence the common platform for ATCS signaling system for Metro rail is discussed further below and deliberations of the committee regarding the common platform issue are provided.

In the ATCS domain, till recently train detection has been largely based on continuous provision of Audio Frequency Track Circuits (AFTC) throughout the line, which are also used for transmission of telegrams from the track side to On-board computer system for location of train and the functioning of Automatic Train Protection /ATO/ATS. These AFTC based systems are proprietary and there are mainly six-seven large vendors who have most of the market for these systems in the world. However, this method of train control on its way out and becoming costlier to maintain, in the light of advanced developments in Communication Based Train Control Systems (CBTC) which have many advantages including Headway Improvement and easy maintainability over the AFTC based systems as seen in the previous sections. In fact no Metro Administration in the world may go for AFTC based systems in future for new green field projects. For all re-signalling (so called brown field projects) most administrations choose CBTC to plan easy migration and less installation at ground.

On the other hand, since CBTC systems have evolved over more than 20 years and have become stabilized, a large number of Metro Administrations have adopted the same for both green field and brown field projects. Since an IEEE specification exists for CBTC systems working in the ISM band (IEEE1474), it may be easier to arrive at a solution for inter-operability on the basis of CBTC being the common platform at least in the long term future. In fact, two of the largest Metro Administrations, which have the necessary tactical advantage of large scale replacement plan or country based industry (New York & Paris), have already started trying to standardize the CBTC based systems so that there could be inter-operability between sub-systems. In fact their demands so far, are similar to one item of terms of reference specify with regard to common platform for inter-operability. It is seen that though MTA New York has made some progress in this direction, so far they have been able to bring only two suppliers to agree on the methodology of trials. It may take much more time before all the players to join this direction. Similar is the situation with the attempts of RATP, Paris. The history and current status of the CBTC inter-operability attempts are discussed in the next section in more detail.

Since many Metro Systems in India (other than Delhi Metro rail) have either just started the construction of their network or are yet to finalize their plans, it is necessary to agree on the signaling principles on which these Metro systems will be operated so that the efforts of this committee may prove fruitful in the long run. The following is a brief summary of the current position of signaling systems working or under construction in various Metro Systems in India:

1. Metro Rail in Kolkotta (Indian Railways) North-South Line:

   This 17 KM network has been working on traditional main line signaling with absolute block system of working of Indian railways with some changes. The minimum headway in operation is around 6 Minutes. A contract has also been awarded recently for installation of a TPWS kind of intermittent protection system based on ERTMS (ETCS) Level-1 signalling. **Even with automatic block working and ETCS-1 signalling it is understood design headway may be 4 to 5 Minutes which does not meet the modern metro rail standards for urban networks**. Some initial trials have been started to see the feasibility of managing the old rolling stock with the ETCS-1 on-board equipment. While extensions sanctioned on the same North-south line are also planned to be provided with ETCS Level-1 system, the separate new line sanctioned recently CBTC is in active consideration.

2. Delhi Metro Rail Network: AFTC based Train Control Systems are commissioned and working approx 190 KM in Line 1 to Line 6 (as also in Delhi Airport Metro Line). **For Phase-III (Line 7 & Line 8) DMRC has planned to go for CBTC based signaling system.**

3. Bangalore Metro Rail Network: In Phase-I of Bangalore Metro Rail 46 RKMS are planned on AFTC based system of which 7 RKMs have been commissioned for revenue service in Stage-I.

4. Chennai Metro Rail Network: In Phase-I, contract has been awarded for 45 RKMs for AFTC based Train Control System and work is in progress.

5. Kolkotta Metro Rail (E-W) Network: M/s KMRCL have awarded the contract for 14 RKMs for an AFTC based train Control System and work is in progress.
6. Hyderabad Metro Rail Network: Approx. 70 KM network will be provided with CBTC ATCS.

It is seen from the above, that all the new Metro Networks (other than the old Metro Kolkotta of IR) have gone for AFTC based or CBTC based Train Control systems which are proprietary systems.

Indian railways had commissioned a TPWS system on trial basis for the EMU service on mixed tracks on the S.Rly in 2009, providing ERTMS-Level 1 Balize based control linked to the aspects of each Automatic signal encountered by the EMU trains. Since this was a retro-fit on existing aged EMUs with 25 KV A.C traction, a number of problems due to EMC/EMI issues have cropped up which are yet to be fully solved and efforts for required level of reliability and availability as per ERTMS are continuing.

As already seen in the previous section, ERTMS Level-1 (ETCS-1) is mainly used for main line operations in Europe and being adopted for the main line in India, China and other countries essentially to provide for limited interoperability between vendors. **Since it is an intermittent train control system, it has severe limitations regarding Headway as already explained in the earlier section and hence is not suitable for Metro Networks which are expected to carry huge volumes of passengers, particularly in the peak hours, with mostly a design headway requirement of 120 Seconds.**

It is also to be noted that ERTMS Level II system based on Radio block working is not an optimum solution for Metro network of with very short distances between stations which in turn requires very short blocks between trains in order to meet the stringent Headway requirements. With regard to ERTMS / ETCS Level 3 which is being developed on the moving block principles used by CBTC, it was already brought out how it is not adequate for Metro Rail. **It is also to be noted that no Metro Network with high volumes of traffic and short headway requirements, have been commissioned in the world based on ERTMS, be it Level-1 or Level-2. ERTMS does not cater for ATO/ATS in a manner it required for Metros, is essential in Metro rail.**

We can only make attempts to make use of the specifications of any common components, as they exist. A list of CBTC (Annexure-17) metro lines, which are in progress or completed indicates that world over CBTC technology is preferred for Metro systems and costs have come down. **The issue was debated in the committee meetings and it was agreed by the committee that CBTC should be the common platform on which all attempts for standardization must be focused. Railway Board had issued system guidelines issued earlier under letter No. 98/Proj/DLI/30/1 dated 12.01.2000 (copy placed at Annexure-18). These have been updated in Technical Clearance Manual of January 2013 (Annexure E2) (Copy placed at Annexure-20). This may be considered for revision in view of preferred option of CBTC as at Annexure-21. Railway Board may consider issue of following guide lines in view of changing scenario:-**

A. For Signalling System.

S.No.	Description	Technical Requirement
1.	Type of Signalling	Cab Signalling CATC (ATP/ATO/ATS) Generally CBTC based ATC, ATO is optional.
2.	Back Up Signalling	Line Side Signals (CLS), as per operational requirement and at Point locations.
3.	Interlocking	Computer Based Interlocking.
4.	Train Control System	Redundant ATS with Operation Control Centre.
5.	Train Detection	• On Main Line: AFTC/Axle Counter. • (Depot AFTC/ Axle Counter RM mode) Driver/ Driverless Train Operation/ Un-attended Train Operation as per operational requirement of Metro).
6.	Point Machine i) For Main Line ii) For Depot	 Non Trailable High Trust with clamp lock Non Trailable / Trailable (Depending upon operational requirements) Indian Point Machine.
7.	Redundancy in Cab equipment for ATP (Cab Signalling)	1+1 as per prevalent and proven technology and meeting RAMS requirement.

B. For Telecommunication systems, Metro may plan as under:

1.	Telecommunication	Integrated system with OFC. Train Radio, CCTV, Centralized Clock and PA/PIDS systems.
2.	Positive Train Identification	To be provided as per Metro Operational requirement through suitable means.

Though Sub-Committee did not get direct inputs from RDSO/ Railway, it is seen from the reference of sub-committee of Railway Board for Technical approvals for Metro Signalling, CBTC has been indicated for Metro Rail systems. Hence it can be surmised that Railway Board also is of the view that attempts for standardization for Metro Control Systems should focus on CBTC based Train Control systems.

In the opinion of DMRC, it may be necessary in future to go for CBTC train control system for all the future Metro Systems of India.

It was agreed by the sub-committee that CBTC should be used normally for all future Metro or Mono Railway projects and attempt to standardize be focused on this platform.

SECTION- 7

CBTC INTEROPERABILITY PROJECTS OF THE WORLD & THEIR CURRENT STATUS

"Interoperability is the ability of systems to provide services to, and accept services from other systems, and to use the services exchanged to enable them to operate effectively together"

As we have seen earlier, in case of ERTMS/ETCS the very roots of the efforts for standardization from day one were to provide for inter-operability between train to track, to facilitate international travel within Europe and these efforts were guided right from the beginning by EU political administration by enactment of laws and mandates. **The efforts have paid off to some extent but it has taken 20 years with all the finances and powers of EU**.

There was and there is no effort of this magnitude from the top echelons of the government in USA or Europe towards interoperability in Metro. The challenging task was ultimately taken up out of necessity, separately by two large Metro Rail administrations of the world who were having deep packets/ financial support to spend the huge sums required for development and trials, when their old signalling systems had to be replaced on many of their lines. These were the RATP, Paris and the MTA New York. Realizing the benefits for easy and cheaper maintenance and reduced costs of expansion or re-signalling these two administrations started their efforts for inter operability more than 10 years ago. While MTA is yet to achieve their end goals for developing the specifications for replacement tenders for all their remaining lines, RATP has achieved some limited success in the sense, their re-signalling projects for 3 lines, contracts for which were awarded in 2004 are nearing completion, but delayed by more than 5 years!

These two attempts for CBTC inter operability are discussed in more detail below:

7.1 Interoperability Projects of Metropolitan Transport Authority (MTA) New York

The Rapid Transit system of New York is the largest in length and in number of stations in the world (335 RKM 1056 Track KM, 468 Stations) and its is the seventh busiest in the word carrying 5.3 Million passengers per weekday on an average. It offers revenue service on 24 Hrs X 365 days.

The first underground line started service in 1904 though an elevated line was serving as a suburban line even from 30 years earlier.(This line was later merged with the Rapid transit administration) . This system has reached the above gargantuan proportions by turn of the 20th century with 25 Lines working. As in the case of LUG, a number of lines were added at different times and by merger of two different private entities into the Metropolitan Administration in 1950s while forming MTA. This has resulted in systems of different vintage proliferating the network making the operations and maintenance the most difficult and gigantic task. After decades of working, signalling systems in many lines became over aged and due for replacement. MTA decided to go for a massive signalling modernization for higher performance and lower Life Cycle Cost (LCC)

MTA planned in 1997 itself that all future replacement should be with CBTC as that is the only system which can be implemented without prolonged suspension of traffic on the line and that is the only system on which interoperability could be attempted to ease the future maintenance and replacement problems on these lines. MTA decided to force the issue of interoperability on the vendors because of the huge business available for the vendors to make it attractive.

In 1997 NYCT released a RFQ for CBTC on the Canarsie (L) Line. This initial CBTC program was conducted in three phases. From the proposals received and evaluated NYCT selected three companies to participate in Phase-I, which was a demonstration of CBTC functionality on a test track of NYCT. Based on the results of the Phase-I evaluations on test track, NYCT selected Siemens Transportation Systems (Then Matra transport International) as the lead contractor. Alcatel Transport (later taken over by Thales) and Alstom signalling were selected as follower contractors. As the leader Siemens installed CBTC on Canarsie Line as Phase-II and produced Interoperability Interface Specifications (so called I^2S specs) which describe the interfaces of the subsystems of the CBTC. Follower contractors were required to modify their systems to be inter-operable with the Siemens CBTC and to demonstrate conformance to the Interoperability Interface specifications through simulation and field tests.

Alstom dropped out during the course and Alcatel Transport was taken over by Thales. The follower Thales modified its system so as to be compatible with Siemens' CBTC Interoperability was successfully demonstrated in Siemens lab in December 2005, witnessed by NYCT and Parsons, their interoperability consultant. Interoperability was demonstrated on a test track of the Culver line in June 2006, but without safety case, Future CBTCs on NYCT lines were supposed to be procured by lots between Leader and Follower(s). In Phase-III Siemens were testing and firming up the I^2S specifications in April 2004. In March 2004 an RFQ was issued along with I^2S specifications of NYCT inviting bids for CBTC systems which also have to be interoperable. In the 2004 RFQ, the goals of NYCT for inter operability were stated as below:

"The NYCT CBTC Program is designed to provide a state-of-the-art CBTC system that will provide reliable service with improved headway. Many operating lines on NYCT interconnect and operation of two or more lines on common tracks, service diversions, and other operating requirements lead to a requirement that CBTC systems are interoperable. NYCT desires to have multiple sources of CBTC systems to sustain competition, ensure favourable pricing, and ensure long-term supply of CBTC systems and subsystems. The CBTC Interoperability Interface Specifications provide the basis to achieve these goals and allow CBTC subsystems to be procured from different suppliers. For future lines to be equipped with CBTC, way side CBTC subsystems and car-borne subsystems may be procured from different suppliers"

The RFQ indicates the extensive efforts undertaken in the previous 6 years to make out the I^2S specifications. Even then the RFQ reserves the right to continuously upgrade these specs as changes occur due to innovations in technology. The firming up of the I^2S specs was further delayed for few more years, due to rapid changes in the radio and microprocessor technology. In view of the successful completion of all the three phases of the interoperability project, Siemens was finally awarded a contract for CBTC on Canarsie Line in 2008 which was eventually completed fully in November 2011 only.

Based on this I²S specification, through the 2004 RFQ at first 10 lines were supposed to be re-signalled using this standard (except for the Flushing line which was an immediate requirement and could not wait for identifying more vendors.) A tender was issued to only Siemens and Thales for the Flushing line which went to Thales in June 2010. The Flushing Line is likely to be commissioned with CBTC only by November 2016! An expression of interest to join the project has been positively responded by Alstom who may take part in the future tenders.

Meanwhile NYCT has issued a contract in March 2012 to Siemens and Thales to build a test track equipped with their systems on the Culver Line. The contract value is 111 Million US$ and the test line will be ready in July 2016 on which NYCT plans to test the products of all future vendors.

Hence with lot of efforts and expenditure and over a long period of 15 Years MTA / New York, with all their resources and experience have at last only two vendors with interoperable equipment! They are constrained to continue in this direction due to their operational problems which make interoperability essential as in the case of European National Railways.

Ref: 1. The current status of the interoperability project submitted to the appropriations committee is available as a public document and taken from this link:
http://www.mta.info/mta/news/books/pdf/120123_1400_CPOC.pdf
2. The 2004 RFQ of NYCT is available through this link:
www.tsd.org/**cbtc**/projects/nyct/04rfin10.pdf

7.2 The OURAGAN and OCTYS projects of RATP for CBTC Interchangeability

The **RATP Group**, also known as the **Régie Autonome des Transports Parisiens** (English: **Autonomous Operator of Parisian Transports**) is a state-owned public transport operator headquartered in Paris, France. Formed in 1948, the group has its origins as the public transport operator for the city of Paris. RATP is a huge Railway company operating not only the Metro Lines of Paris, but also the extensive suburban systems connecting the Greater Paris suburbs and the Regional Express Railway (RER). Like New York, Paris has one of the densest Metro Network with 300 Stations and 14 major Lines (Line 1 to Line 14) and two minor lines totaling a route length of 214 RKM, 197 KMs of which are underground. It carries 4.5 Million passengers per day. It has the world's largest and most complex underground station with five metro lines and three RER lines passing through it, namely, Chatelet – Les Halles.

The reasons, objectives and history of interoperability efforts of RATP are somewhat similar. However, RATP was more ambitious and called its project as not only interoperability but also "interchangeability" project. During the 90's RATP felt the need for modernization of its systems including the train control systems. It laid down a number of objectives to be achieved through modernization such as:

1. Obsolescence reduction, Replacement of older systems, tricky to maintain due to components & knowledge obsolescence

2. Safety improvement, Compliance with new safety standards (CENELEC)

3. Continuous speed control (incl. in manual driving mode)

4. Passengers capacity increase (reduction of headway)

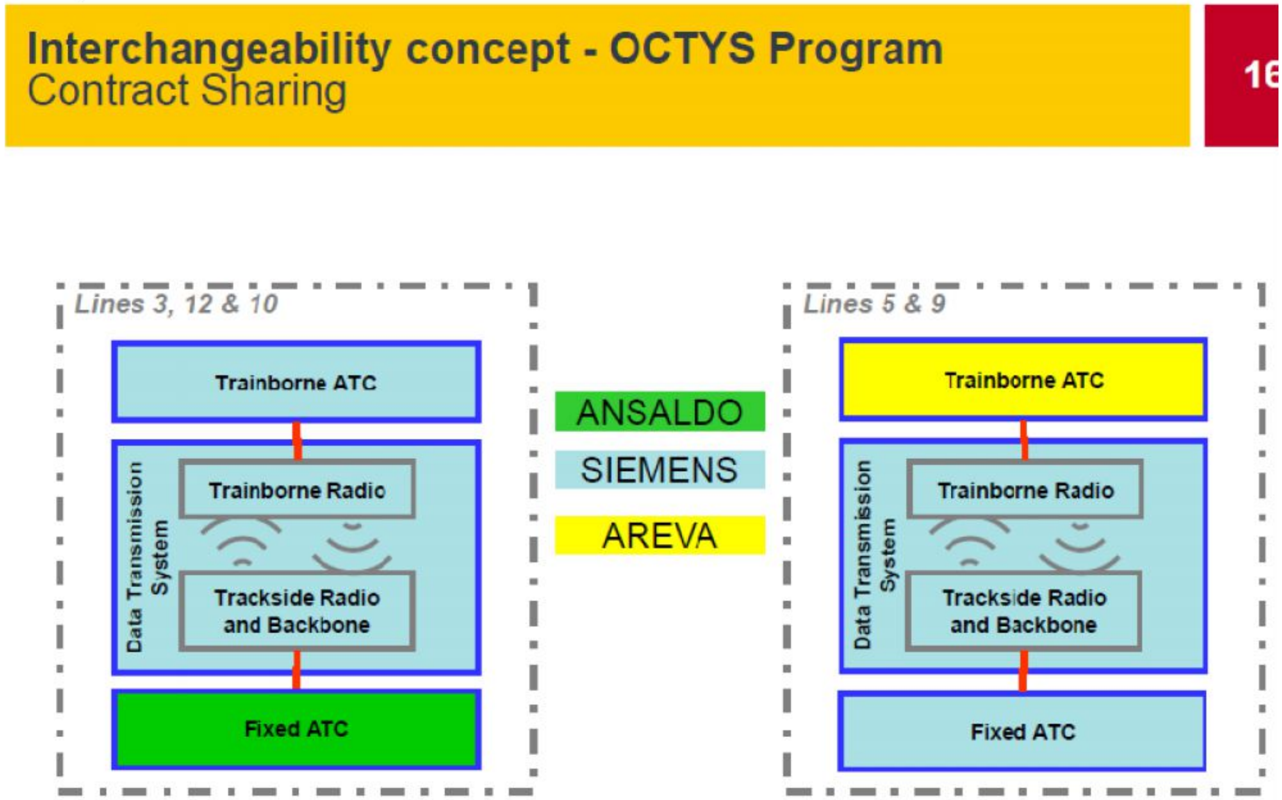
5. Quality of service increase through increased availability & maintainability of new systems, Performance of degraded modes management, Passenger exchange control (Platforms screen doors)

6. Operation Costs reduction

RATP had to replace signaling in Line1 and Line 13. It was decided to go for CBTC. Initially the I²S specifications of NYCT were used as a starting point to realize the advantages. The contracts for replacement on Line 1, as well as the new Line 14 (METEOR), were awarded to Siemens with a component to be newly tried in RATP, namely, Unattended Train Operation (UTO). The contract for Line 13 was awarded to Thales as part of the interoperability effort. This was called as the OURAGAN project to distinguish it from the other interoperability project for Line 3 and Line 5 which was called the OCTYS project (Open Control of Trains, Interchangeable and Integrated System). This was later to be extended to procurement for other lines.

OCTYS Contract signed in 2004 with 3 suppliers (ANSALDO, AREVA & SIEMENS), for 5 lines to be revamped (Lines 3, 5, 9,10 and 12), in parallel with, OCC modernization program, Rolling stock retrofit or renewal program, Signalling and Interlocking modernization program. RATP has defined their concept as the Interchangeability Concept as they believe interoperability between Track side and Train Borne system alone does not deliver all the benefits. In their view, technology will change one or several times during the 25 years of renovation/migration process and they are planning to devise a system design that is supportive and resilient to this constraint. In order to keep procurement of interchangeable modules competitive and reduce future procurement costs on the long term while allowing technological evolutions to take place on a competitive and level field. This is to be managed by ensuring Subsystems procured from any supplier at any period in time can interface with already existing equipment. This is to be achieved by standardization of functional and technical interfaces. For this purpose an Interchangeability Baseline Definition (RdDI) has been developed which includes i) System and Sub-systems functional specifications, ii) Interfaces functional and technical specifications, and iii) Generic system safety case. The objective is ultimately to devise a single solution for all lines for a generic system from which application data and external interfaces are configurable. They believe contract sharing between operators will force them to follow the interface standards and deliver the various sub-systems allotted to them.

The picture below indicates the position of contracts awarded indicating the different sub-systems with different vendors.:



Till date CBTC could be commissioned only in Line 3 and Line 5, though the contracts were awarded in 2004 and eight years have gone by. Replacements in other 3 Lines are still pending final commissioning.

Thus the experience of RATP also indicates that it is really an up hill task to bring about their desired Interchangeability. However, it is strongly felt by RATP that it is essential for their operations over next 25 years and the time taken is worth the trouble. Since all other lines are working with older systems the delay has not so badly affected their service unlike in the case of Green field projects for new line. They had wisely kept the new line 14 out of these attempts and completed it as a model CBTC line.

Conclusions: The detailed history given above regarding the CBTC interoperability attempts by two large Metro administrations, clearly indicate that these were taken up on operational need basis and they had to expend lot of time and funds for these efforts. It is very doubtful that India will be able to start from scratch and go along this path. Interoperability thus appears to be a distant and difficult goal at least as far as India is concerned.

SECTION- 8

FEASIBILITY OF DEVELOPMENT OF CBTC SYSTEM INDIGENOUSLY DE-NOVO WITHIN INDIA & FEASIBILITY OF DEVELOPMENT THROUGH JOINT VENTURE

Considering the long gestation period taken by CBTC to mature as a preferred technology, it can be easily seen massive R&D efforts have been spent by the established vendors. Most of them are also part of the UNISIG group and are major suppliers of ETCS equipment which has also helped them to go beyond ETCS and building on their earlier ATP experience they could integrate all the commonalities and successfully develop their proprietary CBTC systems. All these expenses could be justified by them by their global presence and by catering to the global market. A new entrant in this field may never be able to spend so much on development and nor gather a group of experienced persons in the field to start their R&D operations.

Signalling and Train control having become a highly specialized field, all the established players were unanimous in their view (Though this view may also be impacted by self interest) that it will be extremely difficult to start de-novo and develop an indigenous system by any Indian Company. **Most of the signalling experts participating in the discussions were also of the view that an Indian company de-novo development is remote possibility.** Unless there is an assured and sufficient market, no established vendor may like to consider a tie-up. The vendors explained that the experience in China was different due to many factors and even there only some measure of localization was achieved by the government due to the huge market which had opened up for Metro rail in China in the 80s.

As far as interoperability of CBTC is concerned, green field projects of India cannot wait for development of standardization. Efforts of MTA/New York and RATP indicate it will take decades. In the New York Project, so far only two out of the seven established CBTC vendors (Siemens & Thales) are involved and the same is the case as far as RATP is concerned Siemens & Ansaldo (AREVA are not regular suppliers of all sub-systems of train control). The views of General Electric (GE) by mail are at Annexure-10/1, which propose a global agreement between suppliers are summarized below:-

A generic interface to be laid down for:

a) Interlocking / ATC interface with ATS.
b) Generic interface between zonal controller / interlocking with Data Communication System (DCS).

GE proposal of such an interface has not yet been taken up by UIC/UITP/BU as far as is known.

Eventually for Interoperability / Interchangeability we may have to adopt either the NYTC or the RATP specifications provided it succeeds to avoid reinventing the wheel. But both these organizations are yet come to a conclusion of their efforts. Therefore, to come to possibility of better option between the efforts of RATP and MTA/New York metro and proposal of GE, detailed interaction and proposals from the suppliers will be necessary to include either way.

The Sub-Committee deliberated further what could be attempted for the long term.

In this context, it was noted that the Signalling & ATC systems for the Delhi Metro Rail Phase-I network may become due for replacement any time after the next 9-10 years. These systems were commissioned in 2001-02 and have completed more than 10 tears of their life. Action for replacement and planning for the same may have to be taken up and replacement requirement of DMRC, Bangalore, Chennai will start from 2022 onwards. Thus it is seen that after 10 years continuous replacement will start. Hence for the longer time frame some kind of self sufficiency for the country will need to be in place by another 10 to 12 years.

In this connection after deliberations it was noted that since de-novo indigenization is ruled out, feasibility of joint ventures with existing established vendors should be deliberated. Though the representatives of these firms had stressed that volumes do not justify any kind of technology transfer through joint venture (as the cost may not be economically borne by the consortium), it was felt that the picture may change and there will be some scope for the longer term when more projects may come up as also the re-signalling requirements. The joint venture(s) could be with private sector firms, especially software firms who may able to fund the venture.

OPTION – 1

It was noted that there has been a somewhat similar attempt of joint venture for R&D, including commercial exploitation, for which **RATP has signed an MOU** with M/s Alstom (Annexure-16). This is for **developing** complete **automated solutions for the urban Metro rail** systems covering infrastructures, rolling stock, signalling, passenger information, operations and maintenance. The solutions developed by **the joint venture called** Metro lab will be marketed by the RATP Group / Alstom Transport.

OPTION-II

It was further opined that attempts could be made by GoI to set up an R&D center for development of Train Control technology for the country for the longer term and in the medium time frame assist the joint ventures mentioned above by way of standardization, identification and development of local sources to supply sub systems to the joint venture who will integrate them with the software to provide the solutions. In this connection, efforts made by China in this direction, through a consistent and systematic action plan were noted. After persuading the established vendors to set up local manufacturing plants, China had gone for joint ventures with the established vendor. This had helped in ensuring manufacturing / assembly of hardware within China. Details of control on ventures are not known.

It may be feasible to come to an agreement with one or more established vendors for a National R&D laboratory to develop the systems for India in the next one decades. (These firms may be the same firms who come forward to take up joint venture for manufacture as mentioned earlier.) In this R&D venture the private sector in India (software firms and firms in the field of control systems etc) should be allowed to have a significant role. Similarly academic entities such as IITs may also roped in suitably. (In this connection, it was noted that Electronic Interlocking was developed indigenously by the joint efforts of IIT/Delhi and Indian Railways with funding from Dept of Electronics and IR. Though prototypes were developed these were not pursued later).

Major portion of funds for the prolonged R&D efforts may be from GoI. There could be more than one international association for the R&D centre. The subsidiary products such as beacons, balizes, industrial grade routers and access points etc which may be standardized by the lab in the intervening years could all be manufactured in India and start benefiting the urban transport systems as early as 2020.

OPTION-III

It is noted that ETCS-Level 3 is also based on moving block principle and since the convergence of CBTC and ETCS-3 is expected in future, it may be considered that Indian railways are associated with R&D effort as also the various Metro operators of the country.

After discussions as above, the committee came to the conclusion that de-novo development of an indigenous system was ruled out. Interoperability standardization is also ruled out for the short term span of 3-4 years. For the long term, the committee is of the view that

(i) Set up R&D centre for Metro electronic systems to work in the area of Signalling & Train Control, Automatic Fare Collection and SCADA. Work on ATS to be given priority as it can yield early fruits.

(ii) Encourage setting up of joint ventures by two or more established firms with local private sector for manufacture and supply of Metro rail ATC systems.

SECTION-9

FEASIBILITY AND OPTIONS FOR INCREASING THE SOURCING FROM WITHIN THE COUNTRY FOR ATC SYSTEMS BASED ON CBTC

As seen from the above sections, indigenous development as well as interoperability for CBTC implementation in Metro rail in India appears to have lot of impediments for the short term and can only be a long term goal through special R&D efforts in collaboration with established vendors and universities in India as discussed in previous section. The main purpose of this study by this Sub-Committee was for exploring standardization as a means to keep down the costs. Increase the sourcing from within the country where possible need to be encouraged, while keeping in view procurement guidelines of funding agency such as JICA.

Based on the presentation given by manufacturers and practices in the field of Signalling & Train Control for Metros, it is seen that manufacturing is controlled by few suppliers who have set up facilities, mostly in Europe on account of economy of the scale and demand. Therefore, local manufacturing on core components for Metros is not proposed as a first step for the short term. Hence feasibility and options for increasing the sourcing from India were discussed at length by the Sub-Committee and the participants of the meetings. Some of the deliberations in the meeting on 4th October are indicated in the Minutes of the meeting. During the next two meetings Presentations were my by the established vendors, during which the issues regarding increasing the sourcing from within India were further discussed.

It is necessary to find ways and means to incentivize system supplier to increase local sourcing. It was felt that significant portion of the hardware could be sourced from within the country and where, the hardware is closely linked with the safety software, such hardware could be locally manufactured by the vendor by setting up their own factory. RDSO has started to insist on local manufacturing of hardware for the Electronic Interlocking requirements of IR from the point of view of maintainability and quick response. Hence hardware for metro rail systems to be manufactured / assembled for interlocking / ATS can be considered within the country. This will require a policy decision and announcement in advance. Some of the industry representatives were of the opinion that cost of setting up of a local factory may be too high.

M/s Alstom further stated that each Metro Project has its own size, capacity requirements and other challenges and whether standardization can address all the issues and should there be different standards for large Metro Rail and smaller networks. M/s Bombardier stressed that unless the efforts of Indian Railways for the long distance network goes in the similar direction for Train Control solutions, costs cannot be expected to be reduced for the common components. He cautioned that the Metro rail market in India on its own may not be able to drive the efforts to achieve standardization or localization. M/s Invensys cautioned that localization can only mean manufacturing/assembling and not design, since the major vendors have centralized their design teams to suit global operations.

In order to understand the picture in Defense procurement, a presentation was given by M/s Autometers Alliance Ltd about the 'off set' policy followed by Ministry of Defence, which ensures local manufacturing by transfer of technology for sub-systems to a local Indian entity. Most of the members felt that defence contracts being high value and repeat orders are also expected suppliers are conforming to the policy. This being a policy issue for all imports, the subject has not been deliberated further.

Other feasible aspects of localization was discussed for procurement of all components external to the core ATC system, such as Point machines, LED signals, Cables, Optic fibre cables etc. BMRCL also suggested that even items such as AFTC, Computer servers can all be procured locally and installation and testing could also involve local staff. The tenders in future may stipulate suitable condition. There were suggestions for manufacture of entire system within the country. Siemens highlighted that if the main line railway i.e Indian Railways goes for ETCS in a large measure, this will give enough volumes for the signalling vendors to set up local factory which can easily take up the small volumes of similar Metro Rail products.

DMRC questioned vendors why it can't be delinked from the Interlocking / ATC system. If the interfaces are specified clearly software firms will be easily able to obtain the data from the signalling system for display and control by the traffic controllers. Later any modification or expansions will be easier and likely to be more cost effective. The vendors stressed that because of the need for ATO to be tightly controlled by ATS, it is not feasible to delink it though GE through their mail (Annexure-10/1) supported de-linking. Sub-Committee was generally of view that this could be done on the longer term, as complex data logging / display systems have been developed for Indian Railway.

Some of the members also opined that unless the common subsystems between main line and metro systems are increased substantially, volumes will not be available for improving the sourcing from within the country. If IR goes for ERTMS/ETCS, then components of ATP such as Odometers, Balizes / beacons, Antenna systems, AFTC etc could be eventually available within the country if there is commonality in these components between ATCS and ETCS systems.

SECTION-10

SUMMARY OF CONCLUSIONS OF THE COMMITTEE

Taking into account i) the increasing obsolescence of AFTC based Train Control System, ii) non-feasibility of using ETCS for Metro / Mono rail on account of headway requirements and due to absence of ATO and ATS and iii) considering the benefits of i.e. less field equipment, lesser impact of perturbation, better headway beside competitive investment costs, CBTC based Train Control systems, the committee felt that the efforts for standardization should proceed with CBTC platform for Train Control Systems and where ever possible CBTC systems should be planned for use in Metro / Mono Rail systems in future in India. These guide lines may be reviewed periodically with change in technology.

10.1 Interoperability and R&D

Considering the current mature status of Train Control Systems, and R&D structure in India, starting from scratch for developing a system on its own is not considered a feasible activity for any project. This is especially so, as even the international experience of attempts for interoperability have not been satisfactory. It was unanimously agreed by the sub-committee that de-novo R&D for this purpose should be done as parallel activity even as standardization is given priority. Any proposal for adopting specifications of MTA new York or RATP, Paris for inter operability or inter changeability for CBTC for the short term is also considered inadvisable in view of the current status of the Projects in these Metro Networks and taking into account the limitations of only two-three firms available with the experience of these specifications and thus creating a isolated island.

While indigenization may not be feasible for the core area for some time to come, efforts should be made to standardize the sub-systems to the maximum extent possible on a continuing basis with periodic review of the standards to keep up with technological advances. The ongoing efforts of MTA / New York and RATP / Paris could be kept under observation by a suitable technical committee on a continuous basis to decide in the long term whether adoption of these specifications with any customization or modifications is feasible from techno economic consideration.

10.2 Sourcing Locally

For the long term projects including re-signalling contracts, feasibility of setting up of two or more joint ventures of Indian private sector firms with established CBTC vendors should be explored, with all the hardware locally produced and only the core software supplied by the established player. This will require more detailed and in-depth study and interaction with all stake holders.

As another long terms option, feasibility should be examined for setting up of a nodal R&D establishment to support all the efforts for standardization, assist the joint venture firms, identify and encourage gradual local sourcing of sub-systems and finally produce fully owned solutions for implementation in the longer term. Involvement of Academic Institutions, software firms and firms manufacturing control systems, other R&D organization in DRDO or ISRO may help in this venture to provide a solid local base for future Train Control systems for India. This R&D effort may also be financed by Government of India through annual grants.

Representatives of the industry also acknowledged that efforts to standardize help the industry in their long term planning and provide clarity in the market. However, suppliers felt that the requirements of such systems should be sufficient large for the industry to get involved and make the process a success. Point machine for depot, including clamp lock, cables, LED signals, UPS and associated system, site accessories, computers and server, Direct Line Projectors. Entire wiring activity can be done in India. For software confirmation, data for Interlocking, ATS, Signal Plan and associated design beside testing and commissioning activity to be done by local resources.

It would be essential to increase the local sourcing in the Train Control systems in order to ensure availability of local expertise on a continuing basis for the life term of the equipment to have a control over total cost of operation and not the project costs alone.

10.3 Synergy with IR to increase local sourcing

Indian railways have taken a policy decision to adopt large portion of network, it was felt that common subsystems between main line and metro systems may be increased substantially, concern of low volume for TPWS / TCAS for improving the sourcing from within the country will remain. It was concluded that the requirements for Metro Rail systems in the Indian market alone for these components may not be sufficient to drive the local sourcing efforts in core sub-systems. If IR goes for ETCS in a big way, components of ATP such as Odometers, Balizes / beacons, Antenna systems, AFTC etc could be eventually available within the country. It was also concluded that the requirements for Metro Rail systems in the Indian market alone for these components may not be sufficient to drive the standardization or local sourcing efforts.

It was also concluded that equipment such as Point machines in depot and LED signals which are also common to Indian railway requirements may be stipulated for use in the Metro rail systems.

13.3.1 Data Preparation activity in India

It has been possible by DMRC efforts that the industry has started data preparation activity in India and there are two active examples (i) of Alstom who have st up a data centre in Bangalore and (ii) Infotech at Hyderabad. It is understood that M/s Siemens and Bombardier are also planning the same activities in India.

10.4 Automatic Train Supervision system

Suggestions were also made that the portions of ATS subsystem could be delinked from the Train control system and could be standardized separately such that even non-signalling firms in the Information technology sector can develop and provide the same locally as long as the protocols and the interface between signaling and ATS could be standardized. Hence delinking of ATS in the case of Metro systems should be considered, perhaps for the long term, for which a detailed study to define modules / sub-modules is recommended.

10.5 Software and configuration centre

Some members felt that mandating the setting up of design office within India with 80% of Indian staff with software skills with only 20% domain experts as one team, will help in reducing the costs for owner as well as the vendor as it is a form of software outsourcing to India which is already in vogue for application design with some of the signalling suppliers.

It may be desirable to stipulate that indigenous manufactured / supplied items should be used to the maximum extent possible within the stipulated guidelines of funding agency such as JICA , procurement process. If local suppliers of equivalent standards of quality are not available for a particular item, then only importing may be permitted. Contractual conditions could be included to this effect in the tender. In the long run such a condition will ensure gradual increase in local content as more and more firms within the country are able to produce similar products with the required quality.

Applying the “offset” policy of Ministry of Defense was considered to be out of the preview of Sub-Committee.

10.6 Proposed course of action

It is suggested that these systems may be implemented with CBTC based ATC systems. The standards will be generally as per IEEE 1474, the radio frequency and features to be employed may be decided by the respective Metro Administrations. Efforts to get frequency allocation for CBTC to continue (Annexure -21).

Local sourcing and framing of suitable tender conditions to this extent could be explored :

(a) Any component such as axle counters, switches, Point Machines, Track work, Racks, Cables etc.
(b) Interlocking design including lighting protection, cabling, racks, bungalows.
(c) Data preparation, customization, verification, validation beside detailed design for electronic interlocking may be done in India.
(d) Installation.
(e) Equipment staging, testing, commissioning.

(f) point machine for depot, LED signals (main and shunt), cables should be attempted for these systems to the maximum extent feasible and to this extent framing of suitable tender conditions could be explored.

It will be in the interest of Metro development in the country and also for development of industrial base, Sub-Committee is of the opinion that from a strategic view point , following action may be taken:

a) Set up a Research & Development centre, with experts of domain knowledge. For advice and guidance the R&D centre may have affiliations with software firms, Academic institutions, Govt. R&D labs under ISRO/DRDO etc. The R&D centre should be funded by GoI with a governing board with members from Ministry of Urban Development.

b) To develop a local base for these systems in India, Government may invite proposals and tie-up with well known suppliers in the field through a transparent process. This should be preferably in the form of Joint Venture and include participation of the private sector an example of RATP/Alstom and GE/MRTC is precursor.

c) Development of ATS software and use of commercially available industrial hardware, a dedicated team need to be setup in the field as early as possible, since this is a activity, which yield dividends not only for Metros, but also for the Main line of the Indian Railway.

SECTION-11

CONCLUSIONS AND RECOMMENDATIONS

Indigenization of ATCS systems as such may not be feasible in short run as efforts to produce an indigenous system from scratch by de-novo R&D need long term resources and commitment. Initially efforts should only focus on standardization.

11.1 Local Sourcing

Equipment such as Point machines for Depot, LED signals, Signalling cables for at grade and elevated sections, quad cables and OFC cables etc which are also common to Indian Railway requirements and for which sufficient manufacturers are already available can be used in the Metro rail systems instead of importing them. Data preparation, configuration for interlocking, ATS and interlocking design sourcing may be done locally.

Feasibility of using local hardware for displays, servers etc should be examined and even in the case of hardware closely linked with the safety system, possibility of weight-age or incentives should be examined to encourage the established vendors to set up local factory for manufacture of the same as has happened in the case of rolling stock.

11.2 Develop ATS

Feasibility of delinking the portions of ATS from the safety systems of ATC to be planned and implementation process started so that this portion can be sourced locally as enough Information technology vendors exist in India.

11.3 CBTC for Metro and Mono Rail

CBTC as a technology has become stable and mature and in view of the many fold advantages over the earlier AFTC based Train Control Systems, CBTC based Automatic Train Control Systems may be generally Train Control platform in all Metro rail and Monorail networks of India except extension of existing lines or requirement necessitate otherwise.

Radio based CBTC system may be proposed for the above purpose and unless better technology advances take place, CBTC may be implemented.

DOT to be requested to reserve a frequency Band without payment of spectrum. Earlier effort to be pursued further (DMRC request dated 16.07.2012 to DOT(WPC) and their reply of 16.01.2013 regarding allotment of additional frequency is attached at Annexure-22).

11.4 **Interoperability**

Inter-operability may be kept only as a long term goal in view of the massive efforts and funds required to achieve the same as seen from the progress made and experience of the international projects. If any useful immediately implementable inputs become available from the international inter-operability projects, these can be gainfully adopted for the benefit of the country as and when feasible. For development of Indian industry and also as a strategy for development of manufacturing and software capability in India, it is necessary that long term efforts should start for creating manufacturing and software base in India. Though it may not be possible to achieve inter-operability as has been seen from experience of New York Metro and RATP, for the time being, India could participate in appropriate international forums to promote CBTC inter-operability as a global need and objective.

For the long term, efforts should be made to encourage setting up of two or more joint ventures of private sector firms with an established CBTC vendor with the objective of manufacture and supply of the whole system locally.

11.5 **Design Centre**

It may be desirable to encourage vendors to set up design office within India with software skills and domain knowledge specially in the area of data preparation for Interlocking, ATS and Interfaces.

GoI should set up an R&D center for the purpose of centralizing, standardization efforts, to identify and encourage local sourcing of all hardware and sub-systems and gradually develop an indigenous version of CBTC which could be licensed for manufacture to the identified joint venture firms.

------------------------*****-----------------------------

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22. CENELEC standards
23. Joint Venture for R&D MoU signed between RATP and M/s Alstom.

ANNEXURE

Annexure –I	MoUD order No. F.No.K-14011/26/2012-MRTS/Coord dated 30 May 2012 for constitution of Group for preparing a base paper.
Annexure-2	MoUD order No. F.No.K-14011/26/2012-MRTS/Coord dated 25th July 2012 for constitution of Sub-Committee on Signalling & Train Control system.
	ASSOCHAM letter dated 13.08.2012 for nomination of associate members.
	CII letter dated 22.08.2012 for nomination of associate members.
	MoUD Office Memorandum No. F.No.K-14011/26/2012-MRTS/Coord dated 30.08.2012, 14.09.2012, 12.10.2012, 12.10.2012, and 30.11.2012, addendum of constitution of Sub-Committee.
Annexure-2/1	MoUD Office Memorandum No. F.No.K-14011/26/2012-MRTS/Coord dated 14th Jan 2013 addendum of constitution of Sub-Committee..
Annexure-3	List of Members of Signalling & Train Control Sub-Committee.
	List of Participants of meeting held on 04.10.2012
	List of Participants of meeting held on 07.11.2012
	List of Participants of meeting held on 15.11.2012.
Annexure-4	Copy of presentation given by convener on 04.10.2012.
Annexure-5	Copy of MoM of Sub-Committee meeting held on 04.10.2012.
Annexure-6	Copy of presentation given by M/s Alstom on 07.11.2012.
Annexure-6/1	Comments by Mail from M/s Alstom regarding redundancy
Annexure-6/2	Comments by Mail from M/s Alstom regarding SDD
Annexure-7	Copy of presentation given by Siemens on 07.11.2012
Annexure-8	Copy of presentation given by M/s AAL On 07.11.2012
Annexure-9	Copy of presentation given by M/s Bombardier on 15.11.201'2
Annexure-10	Copy of presentation given by GE & Train Control 15.11.2012
Annexure-10/1	Comments from M/s General Electric CBTC, Interoperability, local sourcing etc.
Annexure-11	Communication Based Train Control (CBTC)
Annexure-12	Paper of IRSE Seminar on Communication Based Train Control
Annexure-13	ERTMS/ETCS Development Statistics (April 2012)
Annexure-14	The Application on ERTMS/ETCS system IRSE Technical Convention (10/2007).
Annexure-15	Control command and Signalling TSI for the Cross Rail Core section (Feb 2012)
Annexure-16	RATP Paris Metro :Pioneering the Future in Metro Automation and Signalling (Sep 2011)
Annexure-17	List of Computer based Train Control (CBTC) Metro Lines in progress and completed.
Annexure-18	MoR letter No. 98/Proj/DLI/30/1 dated 12.01.2000 – Delhi MRTS project – Technical Clearance for Signalling and Telecommunication system
Annexure-19	List of CBTC projects world over (Radio based)
Annexure-20	Systems for Signalling & Telecommunications for Metro Rail (Annexure- E-2 of RDSO Manual Jan 2013)
Annexure-21	Recommended systems for Signalling & Train Control and Telecommunication for - Metro Rail System
Annexure-22	Copy of DMRC's letter dated 16.07.2012 to DOT(WPC) and their reply of 16.01.2013 regarding allotment of frequency.

F.No.K-14011/26/2012-MRTS/Coord
Government of India
Ministry of Urban Development
(MRTS CELL)

Room No.311, 'B' Wing, Nirman Bhawan,
New Delhi-110108, the 30th May, 2012

ORDER

Subject: Constitution of a Group for preparing a base paper on:-

(i) Standardization of Metro Railway Systems including certain important tender conditions.

(ii) Indigenization of Metro Railway Systems – Infrastructure, rolling stocks and their systems / sub-systems / equipments.

With a view to promote the domestic manufacturing for Metro Systems and formation of standards for such systems in India, it has been decided to set up a Group with the following Members to prepare a Base paper on the above stated issues:-

(i) Shri S.K. Lohia, Officer on Special Duty & ex-officio Joint Secretary, Ministry of Urban Development

(ii) Shri Gaurav Dave, Joint Secretary, National Manufacturing Competitiveness Council (NMCC)

(iii) Shri R.K. Bhatnagar, Adviser (Electrical Engineering-G), Ministry of Railways

(iv) Shri Rajiv Chaudhry, Executive Director (WP), Ministry of Railways

(v) Shri Satish Kumar, Director (Elec. Engg.), Delhi Metro Rail Corporation Ltd.

(vi) Shri B.S. Sudhir Chandra, Director (Project & Planning) Bangalore Metro Rail Corporation Ltd.

(vii) Representative of Hyderabad Metro Rail Ltd. (L&T)

(viii) Representative of Mumbai Metro Rail Corporation Ltd. (Reliance)

(ix) Shri I. C. Sharma, National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development — **Convener**

2. The Terms of Reference of the Group are as follows:-

To prepare Base paper covering guidelines for developing necessary guidance documents laying down uniform, parameters / specification / tender conditions for Standardization and Indigenization of metro rail systems and their sub-systems with the view to achieve economy, quality and availability of systems /sub-systems in the country, improved reliability, maintainability and safety of the existing Metro Railway Systems and those to come up in future.

3. The Group Members may co-opt or take inputs from the experts / professionals of other discipline associated with the Rail based Mass Transit Systems.

4. Institute of Urban Transport (India) (IUT) will provide the services of two / three experts / professionals for assisting the Group in preparing the Base paper and final report.

5. The expenditure for the services of 2 / 3 experts / professionals (to be arranged by IUT) for about 6 weeks, will be met from the GEF grant through the UNDP under Component 1A.

6. National Project Manager (Project Management Unit), Sustainable Urban Transport Project will be the Convener of the Group.

7. The Group shall summit the Base paper within a period of 4 weeks and the final report within 6 weeks to the Secretary (UD), Ministry of Urban Development from the date of issue of this Order.

30/5/12

(Deen Dayal)
Under Secretary to the Govt. of India
Tel. 23062935
Fax. 23062594
E-mail: deen.dayal69@nic.in

To

All the Members of the Group.

Copy for information and necessary action to:

1. The Managing Director, Hyderabad Metro Rail Ltd., Metro Rail Bhawan, Saifabad, Hyderabad-500004.

2. The Managing Director, Mumbai Metro Rail Corporation Ltd., Bandra Kurla Complex, Bandra (East), Mumbai-400051

3. Shri B. I. Singal, Director General, Institute of Urban Transport (India), Room No.217, 2nd Floor, G-Wing, Nirman Bhavan Annexe, New Delhi-1

4. National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development, Nirman Bhawan, New Delhi.

5. Smt. R. Dharini, Deputy Chief, Ministry of Commerce and Industry, Department of Industrial Policy & Promotion, National Manufacturing Competitiveness Council, Vigyan Bhawan Annexe, New Delhi w.r.t. letter No.3 (2) / 2012-NMCC dated 15.5.2012.

Copy also to for information:-

1. PS to UDM
2. Sr. PPS to Secretary (UD)
3. OSD(UT) & E.O. Joint Secretary
4. Director (UT)
5. Advisory to OSD (UT)
6. US (MRTS-I) / US (MRTS-II) / US (MRTS-III) / US (MRTS-IV)

30/5/12

(Deen Dayal)
Under Secretary to the Govt. of India

F.No.K-14011/26/2012-MRTS/Coord
Government of India
Ministry of Urban Development
(MRTS CELL)

Room No.311, 'B' Wing, Nirman Bhawan,
New Delhi-110108, the 5th June, 2012

CORRIGENDUM

Subject: Constitution of a Group for preparing a base paper on:-

(i) Standardization of Metro Railway Systems including certain important tender conditions.

(ii) Indigenization of Metro Railway Systems – Infrastructure, rolling stocks and their systems / sub-systems / equipments.

The undersigned is directed to refer to this Ministry's Order of even number dated 30th May, 2012 on the above stated subject and to say that para 2 relating to Terms of Reference of the said Order may be read as under:-

"2. The Terms of Reference of the Group are as follows:-

To prepare Base paper for developing necessary guidance documents laying down uniform, parameters / specification / tender conditions for Standardization and Indigenization of metro rail systems and their sub-systems with the view to achieve economy, quality and availability of systems /sub-systems in the country, improved reliability, maintainability and safety of the existing Metro Railway Systems and those to come up in future".

2. The other conditions of the order will remain the same.

5/6/12

(Deen Dayal)
Under Secretary to the Govt. of India
Tel. 23062935 / Fax. 23062594
E-mail: deen.dayal69@nic.in

To

All the Members of the Group:-

(i) Shri S.K. Lohia, Officer on Special Duty & ex-officio Joint Secretary, Ministry of Urban Development

(ii) Shri Gaurav Dave, Joint Secretary, National Manufacturing Competitiveness Council (NMCC)

(iii) Shri R.K. Bhatnagar, Adviser (Electrical Engineering-G), Ministry of Railways

(iv) Shri Rajiv Chaudhry, Executive Director (WP), Ministry of Railways

(v) Shri Satish Kumar, Director (Elec. Engg.), Delhi Metro Rail Corporation Ltd.

(vi) Shri B.S. Sudhir Chandra, Director (Project & Planning) Bangalore Metro Rail Corporation Ltd.

(vii) Representative of Hyderabad Metro Rail Ltd. (L&T)

(viii) Representative of Mumbai Metro Rail Corporation Ltd. (Reliance)

(ix) Shri I. C. Sharma, National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development — **Convener**

Copy for information and necessary action to:

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2. The Managing Director, Mumbai Metro Rail Corporation Ltd., Bandra Kurla Complex, Bandra (East), Mumbai-400051

3. Shri B. I. Singal, Director General, Institute of Urban Transport (India), Room No.217, 2nd Floor, G-Wing, Nirman Bhavan Annexe, New Delhi-1

4. National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development, Nirman Bhawan, New Delhi.

5. Smt. R. Dharini, Deputy Chief, Ministry of Commerce and Industry, Department of Industrial Policy & Promotion, National Manufacturing Competitiveness Council, Vigyan Bhawan Annexe, New Delhi

Annexure-2

F.No.K-14011/26/2012-MRTS/Coord
Government of India
Ministry of Urban Development
(MRTS CELL)

Room No.311, 'B' Wing, Nirman Bhawan,
New Delhi-110108, the 25th July, 2012

ORDER

Subject: Constitution of Sub-Committee on Signaling Systems.

The undersigned is directed to say that with a view to promote the domestic manufacturing for Metro Systems and formation of standards for such systems in India, this Ministry has constituted a Group for preparing a Base paper on Standardization and Indigenization of Metro Railway Systems vide Order of even number dated 30th May, 2012 (copy enclosed).

2. The Group has identified certain issues which require detailed deliberations / review, cost benefit analysis / study. The Group has suggested that to have examined / studied these issues, Sub-Committees may be constituted consisting of officers / professionals drawn from relevant field / profession from Ministry of Urban Development / Railways / Metros and industries associated with rail based systems / Metro Railway Systems.

3. Accordingly, it has been decided to constitute the Sub-Committee on Signaling Systems. The issues which are to be examined/studied under Signaling Systems by the Sub-Committee, Terms of Reference and Members of the Sub-Committee are given below:-

Issues	Terms of Reference	Members of Sub-Committee
Signaling Systems Including use of control/communication protocol based on common standard/standards for ensuring interoperability of systems/sub-systems of different makes	- Study of possibilities of having an Indian firm in the high end capability space of end-to-end train control technology - Development of common platform across vendors for inter-changeability / interoperability of	**Shri Rajkumar, Director (Operations), DMRC – Convener** Shri Prakash Singh, Director (MRTS), MoUD Ms. Rachna Kumar, US (MRTS-IV), MoUD

	components / equipment on any system - Study of possibility of signaling components procurement from different vendors. As an example, RATP Paris has developed interfaces in such a manner that they procure signaling components from four vendors and they are able to integrate the overall system to work as per RAMS requirements. - Study of life cycle cost concept at procurement stage - Identifying constraints in process of indigenous development and evolving strategy for placing development orders for assemblies / systems / subsystems - Study of possibilities of tender process based % indigenous components. - Recommendation for evolving procedure / guidelines for expeditious indigenization	Director (Signal) / Railway Board Director (Signal) /RDSO, Lucknow One officer to be nominated by MD/BMRC, Bangalore Mr. Anil Kumar, System head/ L&T/Hyderabad Metro Ltd. Representative from associated Industry to be nominated by FICCI/CII/ ASSOCHAM

4. FICCI / CII / ASSOCHAM will nominate representative only from those Industries who are having long association with Design / manufacture of Rail Based rolling stocks with three phase drive (propulsions), systems/ sub systems infrastructures i.e. IGBT based propulsions/signalling systems/Third rail/overhead electric traction/AFC-ticketing and Power supply system specially used in Metro Railways.

5. The Sub-Committee shall summit its Report within one month (by 21.8.2012) to Secretary (UD), Ministry of Urban Development from the date of issue of this Order.

25/7/12

(Deen Dayal)
Under Secretary to the Govt. of India
Tel. 23062935 / Fax. 23062594
E-mail: deen.dayal69@nic.in

To

All the Members of the Group.

Copy for information and necessary action to:-

1. Chairman, Railway Board, Ministry of Railways, Rail Bhavan, New Delhi.

2. Director General, Research Development & Standards Organization (RDSO), Manaknagar, Lucknow-226011.

3. Managing Director, Delhi Metro Rail Corporation Ltd., Metro Bhawan, Fire Bridage Lane, Barakhamba Road, New Delhi-.

4. Managing Director, Bangalore Metro Rail Corporation Ltd. 3rd Floor, BMTC Complex, K.H.Road, Shanthinagar, Bangalore- 560 027 **with the request to nominate one officer from BMRC.**

5. The Managing Director, Hyderabad Metro Rail Ltd., Metro Rail Bhawan, Saifabad, Hyderabad-500004.

6. Secretary, FICCI, Federation House, Tansen Marg, New Delhi 110001.

7. Secretary, Confederation of Indian Industry (CII), 23, Vardman Marg, Institutional Area, Lodi Colony, New Delhi, Delhi 110003

8. Secretary, Associated Chambers of Commerce and Industry of India (ASSOCHAM) Corporate Office, 1, Community Centre Zamrudpur, Kailash Colony, New Delhi – 110 048.

9. Shri I. C. Sharma, National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development, Nirman Bhawan, New Delhi.

10. Smt. R. Dharini, Deputy Chief, Ministry of Commerce and Industry, Department of Industrial Policy & Promotion, National Manufacturing Competitiveness Council, Vigyan Bhawan Annexe, New Delhi

Copy also to for information:-

1. PS to UDM
2. Sr. PPS to Secretary (UD)
3. OSD(UT) & E.O. Joint Secretary
4. Director (UT)
5. Director (MRTS-I)
6. Advisory to OSD (UT)
7. US (MRTS-I) / US (MRTS-II) / US (MRTS-III) / US (MRTS-IV)

25/7/12

(Deen Dayal)
Under Secretary to the Govt. of India

ASSOCHAM
INDIA
THE ASSOCIATED CHAMBERS OF COMMERCE AND INDUSTRY OF INDIA

D S RAWAT
Secretary General

Shri Deen Dayal
Under Secretary
Ministry of Urban Development
Room No. 311, 'B' Wing, Nirman Bhawan
New Delhi

August 13, 2012

Dear Sir,

Sub: Constitution of Sub-Committees on Traction Systems, Standardization, Rolling Stock and Signaling Systems.

Thank you for your letter no. F.No.K-14011/26/2012-MRTS/Coord dated 25th July, 2012 regarding the above mentioned subject. We are nominating following members to represent ASSOCHAM on the above mentioned sub-committees. We shall be grateful if all the future communications on the subject are sent to them at the following address:

1. Dr. A K Agarwal
   CEO, Autometers Alliance Limited, C-63, Sector 57, Noida - 201307
   Tel: 0120-2479200, 2583545 / 546 / 552 / 605, E-mail: busdev@autometers.com
2. Mr. Sajal Gupta
   General Manager, Autometers Alliance Ltd, C-63, Sector-57, Noida – 201307
   Cell: +91-98183 78735, Tel: +91-120-2479200, E-mail: busdev@autometers.com
3. Mr. Sanjeev Kumar
   Director, GE Transportation (GE India Industrial Pvt. Ltd.)
   Vipul Tech Square, Ist Floor, Block C, Sector 43, Golf Course Road, Gurgaon-122002
   Cell: +91 98180 22949, E-mail: sanjeev.kumar@ge.com
4. Mr. Manoj Kumar
   Business Head – Transport Solution, ANSALDO STS Transportation Systems India Pvt. Ltd.
   Cell: 9663364315, E-mail: manoj.krishnappa@ansaldo-sts.co.in
5. Mr. D S Rajora
   Senior Director, ASSOCHAM
   1, Community Centre, Zamrudpur, Kailash Colony, New Delhi – 110048
   Tel: 011 46550531, E-mail: d.s.rajora@assocham.com

You are requested to confirm the same.

Yours sincerely,

(D S Rawat)

R Sathish
Director

Confederation of Indian Industry
The Mantosh Sondhi Centre
23, Institutional Area, Lodi Road
New Delhi – 110003, India
Tel : +91-11-2462 5260/2462 9994-7
Fax : +91-11-2462 6149
Email : r.sathish@cii.in
Website : www.cii.in

22 August 2012

Dear Mr Dayal,

Constitution of Sub-Committees on Rolling Stock, Traction Systems, Signaling Systems and Standardization

This is with reference to your letter dated 14[th] August 2012 on above captioned subject. We have given the nominations from CII for the Sub-Committee on Rolling Stock in a letter dated 17 August 2012.

We would like to nominate the following representatives from CII for the Sub–Committees on Traction Systems, Signaling Systems and Standardization.

Sub – Committee on Traction Systems

1. **Mr Naresh Aggarwal**, Chairman, CII Railway Equipment Division, and Managing Director & Co-Chairman, VAE VKN Industries Pvt. Ltd.
2. **Mr Tilakraj Seth**, Vice Chairman, CII Railway Equipment Division, and Executive Vice President, Infrastructure & Cities, Siemens Limited
3. **Mr Samir Nirula**, General Manager, Medha Servo Drives Pvt. Ltd.
4. **Mr Mangal Dev**, Director, Alstom Projects India Ltd.
5. **Mr R Sathish**, Director, CII

Sub – Committee on Signaling Systems

1. **Mr Tilakraj Seth**, Vice Chairman, CII Railway Equipment Division, and Executive Vice President, Infrastructure & Cities, Siemens Limited
2. **Mr Sriram Raju**, Director, Bombardier Transportation India Ltd.
3. **Mr Mangal Dev**, Director, Alstom Projects India Ltd.
4. **Mr R Sathish**, Director, CII

Sub – Committee on Standardization

1. **Mr Naresh Aggarwal**, Chairman, CII Railway Equipment Division, and Managing Director & Co-Chairman, VAE VKN Industries Pvt. Ltd.
2. **Mr Tilakraj Seth**, Vice Chairman, CII Railway Equipment Division, and Executive Vice President, Infrastructure & Cities, Siemens Limited
3. **Mr Manjeet Narwan**, Resident Vice President, Texmaco Rail & Engineering
4. **Mr Ajay Sinha**, Regional Director, EMD Locomotive Technologies Pvt. Ltd.
5. **Mr R Sathish**, Director, CII

We look forward to working with you.

Regards

Yours sincerely,

R Sathish

R Sathish

Mr Deen Dayal
Under Secretary
Ministry of Urban Development
New Delhi

FROM :III [IHC]   FAX NO. :91 11 24682226   Aug. 22 2012 05:52PM P1

MOST IMMEDIATE

F.No.K-14011/26/2012-MRTS/Coord
Government of India
Ministry of Urban Development
(MRTS CELL)

Room No.311, 'B' Wing, Nirman Bhawan,
New Delhi-110108, the 30th August, 2012

OFFICE MEMORANDUM

Subject: Constitution of Sub-Committees on Rolling Stock, Traction Systems, Signaling Systems, Automatic Fare Collection System and Standardization.

The undersigned is directed to refer to this Ministry's Orders of even number dated 25.7.2012 on the above stated subject and to forward herewith the following nominations received from RDSO, DMRC and CII for information and necessary action as per details given below:-

(i) RDSO has nominated Shri Alok Katiyar, Director/Signal-III for the Sub-Committee on Standardization and Indigenization of Metro Rail Systems from Signal Directorate of RDSO/Lucknow (copy enclosed).

(ii) DMRC has nominated Shri Sanchit Pandey, CGM/Rolling Stock/P and Shri S.K. Sinha, GM/HR in the Sub-Committees on Rolling Stock and Standardization of Maintenance Practices etc. respectively (copy enclosed).

(iii) CII has nominated 5 Members in the Sub-Committee on Traction Systems, 4 Members in the Sub-Committee on Signalling Systems and 5 Members in the Sub-Committee on Standardization (copy enclosed).

(iv) BEML Limited has nominated Shri Amit Banerjee, General Manager (Technology Division) in the Sub-Committee on Rolling Stock (copy enclosed).

Encl. as above.

30/8/12

(Deen Dayal)
Under Secretary to the Govt. of India
Tel: 23062935 / Fax. 23062594
E-mail: deen.dayal69@nic.in

3/9/12
11

To

1. Shri R. K. Bhatnagar, Adviser (Electrical Engg), Railway Board and Convener of Sub-Committee on Rolling Stock, Rail Bhavan, New Delhi.

2. Shri Satish Kumar, Director (Elect), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Traction Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.

3. Shri Rajkumar Director (Operations), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Signalling Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.

4. Shri D. D. Pahuja, Director (Rolling Stock & Signaling), Bangalore Metro Rail Corporation Ltd. and Convener of Sub-Committee on Standardization, 3rd Floor, BMTC Complex, K. H. Road, Shanthinagar, Bangalore- 560 027.

Copy for information to:-

Shri I. C. Sharma, National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development, Nirman Bhawan, New Delhi.

30/8/12

(Deen Dayal)
Under Secretary to the Govt. of India

MOST IMMEDIATE

F.No.K-14011/26/2012-MRTS/Coord
Government of India
Ministry of Urban Development
(MRTS CELL)

Room No.311, 'B' Wing, Nirman Bhawan,
New Delhi-110108, the 14th September, 2012

OFFICE MEMORANDUM

Subject: Constitution of Sub-Committees on Rolling Stock, Traction Systems, Signaling Systems, Automatic Fare Collection System and Standardization.

The undersigned is directed to refer to this Ministry's Orders of even number dated 25.7.2012 on the above stated subject and to forward herewith the following nominations received from UTIITSL, BMRC, Ahmedabad Janmarg Limited and CII for information and necessary action as per details given below:-

(i) UTI Infrastructure Technology And Services Limited has nominated Shri Deepak Kumar, Chief Technology Officer (CTO) as Member of the Sub-Committee on Automatic Fare Collection System (copy enclosed).

(ii) BMRC has nominated following officers (copy enclosed):-

(a) Shri Jitender Jha, Dy. Chief RS Expert-GC in the Sub-Committee on Rolling Stock.

(b) Shri Brajendra Kumar, Dy. Chief Engineer (IT, Tel & AFC) in the Sub-Committee on Automatic Fare Collection System.

(c) Shri P. K. Krishnan, Dy. Chief Engineer (Sig) in the Sub-Committee on Signalling.

(d) Shri B. G. Mallya, Chief Electrical Engineer (Traction) in the Sub-Committee on Traction System.

(e) Shri D.D. Pahuja, Director (RSE, O&M) as **Convenor** in the Sub-Committee on Standardization.

(iii) Ahmedabad Janmarg Limited has nominated Shri Utpal C. Padia, Executive Director in the Sub-Committee on Automatic Fare Collection System (copy enclosed).

(iv) CII vide its letter dated 29.8.2012 has nominated Shri Jojo Alexander, Managing Director, Alstom Transport in India **in place of** Shri Mangal Dev, Director, Alstom Projects India Ltd in the Sub-Committees on Rolling Stock and Signalling Systems (copy enclosed).

Encl. as above.

14/9/12

(Deen Dayal)
Under Secretary to the Govt. of India
Tel. 23062935 / Fax. 23062594
E-mail: deen.dayal69@nic.in

To

1. Shri R. K. Bhatnagar, Adviser (Electrical Engg), Railway Board and Convener of Sub-Committee on Rolling Stock, Rail Bhavan, New Delhi.
2. Shri R. K. Singh, Director (UT), MoUD and Convener of Sub-Committee on Automatic Fare Collection System, Nirman Bhavan, New Delhi.
3. Shri Satish Kumar, Director (Elect), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Traction Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.
4. Shri Rajkumar Director (Operations), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Signalling Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.
5. Shri D. D. Pahuja, Director (Rolling Stock & Signaling), Bangalore Metro Rail Corporation Ltd. and Convener of Sub-Committee on Standardization, 3rd Floor, BMTC Complex, K. H. Road, Shanthinagar, Bangalore- 560 027.

Copy for information to:-

Shri I. C. Sharma, National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development, Nirman Bhawan, New Delhi.

14/9/12

(Deen Dayal)
Under Secretary to the Govt. of India

MOST IMMEDIATE

F.No.K-14011/26/2012-MRTS/Coord
Government of India
Ministry of Urban Development
(MRTS CELL)

Room No.311, 'B' Wing, Nirman Bhawan,
New Delhi-110108, the 12th October, 2012

OFFICE MEMORANDUM

Subject: Constitution of Sub-Committees on Rolling Stock, Traction Systems, Signaling Systems, Automatic Fare Collection System and Standardization.

The undersigned is directed to refer to this Ministry's Orders of even number dated 25.7.2012 on the above stated subject and to forward herewith the following nominations received from ILFS Rapid Metrorail Gurgaon Limited (RMGL), 2nd Floor, Ambience Corporate Towers, Ambience Island, NH 8, Gurgaon – 122001 for information and necessary action as per details given below:-

(i) Shri Parveen Kumar, Sr. Vice President (Signalling & Telecom Department), RMGL **(parveen.kumar@ilfsindia.com Tel. No.0124-4716300)** has been nominated in the following Sub-Committees:-

(a) Sub-Committee on Standardization and Maintenance
(b) Sub-Committee on Automatic Fare Collection
(c) Sub-Committee on Signalling Systems

(ii) Shri Keshav Saran Sharma, Sr. Adviser (Electrical Department), RMGL **(keshavsaran.sharma@ilfsindia.com Tel. No.0124-4716300)** has been nominated in the following Sub-Committees:-

(a) Sub-Committee on Rolling Stock
(b) Sub-Committee on Traction System

12/10/12
(Deen Dayal)
Under Secretary to the Govt. of India
Tel. 23062935 / Fax. 23062594
E-mail: deen.dayal69@nic.in

16/10/12

To

1. Shri R. K. Bhatnagar, Adviser (Electrical Engg), Railway Board and Convener of Sub-Committee on Rolling Stock, Rail Bhavan, New Delhi.

2. Shri R. K. Singh, Director (UT), MoUD and Convener of Sub-Committee on Automatic Fare Collection System, Nirman Bhavan, New Delhi.

3. Shri Satish Kumar, Director (Elect), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Traction Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.

4. Shri Rajkumar Director (Operations), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Signalling Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.

5. Shri D. D. Pahuja, Director (Rolling Stock & Signaling), Bangalore Metro Rail Corporation Ltd. and Convener of Sub-Committee on Standardization, 3rd Floor, BMTC Complex, K. H. Road, Shanthinagar, Bangalore- 560 027.

Copy for information to:-

(i) Shri I. C. Sharma, National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development, Nirman Bhawan, New Delhi.

(ii) Managing Director, Rapid Metrorail Gurgaon Ltd., 2nd Floor, Ambience Corporate Towers, Ambience Island, NH 8, Gurgaon – 122001

(iii) Shri Parveen Kumar, Sr. Vice President (Signalling & Telecom Department), Rapid Metrorail Gurgaon Ltd., 2nd Floor, Ambience Corporate Towers, Ambience Island, NH 8, Gurgaon – 122001

(iv) Shri Keshav Saran Sharma, Sr. Adviser (Electrical Department), Rapid Metrorail Gurgaon Ltd., 2nd Floor, Ambience Corporate Towers, Ambience Island, NH 8, Gurgaon – 122001

12/10/12

(Deen Dayal)
Under Secretary to the Govt. of India

MOST IMMEDIATE

F.No.K-14011/26/2012-MRTS/Coord
Government of India
Ministry of Urban Development
(MRTS CELL)

Room No.311, 'B' Wing, Nirman Bhawan,
New Delhi-110108, the 12th October, 2012

OFFICE MEMORANDUM

Subject: Constitution of Sub-Committees on Rolling Stock, Traction Systems, Signaling Systems, Automatic Fare Collection System and Standardization.

The undersigned is directed to refer to this Ministry's Orders of even number dated 25.7.2012 on the above stated subject and to forward herewith the following nominations received from Confederation of Indian Industry (CII), Mantosh Sondhi Centre, 23, Institutional Area, Lodi Road, New Delhi – 110003 for information and necessary action as per details given below:-

Shri Alok Sinha, Director Marketing, Invensys Rail Systems Private Limited, No.112 & 114 Raheja Chambers, 12 Museum Road, Bangalore, Karnataka-560001 **(alok.sinha@invensysrail.com)** and **Shri Samir Nirula,** General Manager (Marketing)-International, Medha Servo Drives Pvt. Ltd, P-4/5B, I.D.A, Nacharam, Hyderabad - 500 076 Andhra Pradesh **(samir@medhaindia.com)** Member of the CII Railway Equipment Division have been nominated in the **Sub-Committee on Signalling Systems.**

12/10/12
(Deen Dayal)
Under Secretary to the Govt. of India
Tel. 23062935 / Fax. 23062594
E-mail: deen.dayal69@nic.in

To

16/10/12

Shri Rajkumar Director (Operations), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Signalling Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.

Copy for information to:-

(i) Shri I. C. Sharma, National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development, Nirman Bhawan, New Delhi.

(ii) Shri R. Sathish, Director, Confederation of Indian Industry (CII), The Mantosh Sondhi Centre, 23, Institutional Area, Lodi Road, New Delhi – 110003 **(r.sathish@cii.in)**

(iii) Shri Alok Sinha (FIRSE), Director Marketing, Head- Business Development, Invensys Rail Systems India Private Ltd, No.112 & 114 Raheja Chambers, 12 Museum Road, Bangalore, Karnataka-560001 **(alok.sinha@invensysrail.com)**

(iv) Shri Samir Nirula, General Manager(Mktg)-International, Medha Servo Drives Pvt Ltd, P-4/5B, I.D.A, Nacharam, Hyderabad - 500 076, Andhra Pradesh **(samir@medhaindia.com)**

12/10/12

(Deen Dayal)
Under Secretary to the Govt. of India

MOST IMMEDIATE

F.No. K-14011/26/2012-MRTS/Coord
Government of India
Ministry of Urban Development
(MRTS Cell)

Room No. 311 'B' Wing, Nirman Bhawan,
New Delhi-110108, the 30th November, 2012

OFFICE MEMORANDUM

Subject: Constitution of Sub-Committees on Rolling Stock, Traction Systems, Signaling Systems, Automatic Fare Collection System and Standardization.

The undersigned is directed to refer to this Ministry's Orders of even number dated 25.07.2012 on the above subject and to forward herewith the following nominations received from FICCI for information and necessary action as per details given below:

(i) Mr. Manish Agarwal, General Manager, Rail Automation Siemens Ltd. (E-mail:manish.agarwal@siemens.com)
- Sub-committee on Signaling and Train Control System

(ii) Mr. Anupam Arora, Chief Manager – Marketing, Smart Grid – Rail Electrification, Siemens Ltd. **(E-mail: anupam.arora@siemens.com)**
- Sub-committee on Traction

(iii) Mr. S. Keshava Prasad, General Manager – Marketing – Rail Systems, Siemens Ltd. (E-mail: keshava.prasad@siemens.com)
– Sub-Committee on Standardization

(K.C. Meena)
Under Secretary to the Govt. of India
Tel: 23063480

To

1. Shri Raj Kumar, Director (Operations), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Signaling Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110 001.

2. Shri Satish Kumar, Director (Elect.), Delhi Metro Rail Corporation Ltd and Convener of Sub-Committee on Traction Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110 001.

3. Shri D.D. Pahuja, Director (Rolling Stock & Signaling), Bangalore Metro Rail Corporation Ltd. and Convener of Sub-Committee on Standardization, 3rd Floor, BMTC Complex, K.H. Road, Shanthinagar, Bangalore-560 027.

Copy for information to:

Shri I.C. Sharma, National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development, Nirman Bhawan, New Delhi.

(K.C. Meena)
Under Secretary to the Govt. of India
Tel: 23063480

MOST IMMEDIATE

F.No.K-14011/26/2012-MRTS/Coord
Government of India
Ministry of Urban Development
(MRTS CELL)

Room No.311, 'B' Wing, Nirman Bhawan,
New Delhi-110108, the 14th January, 2013

OFFICE MEMORANDUM

Subject: Constitution of Sub-Committees on Rolling Stock, Traction Systems, Signaling Systems, Automatic Fare Collection System and Standardization.

The undersigned is directed to refer to this Ministry's Orders of even number dated 25.7.2012 on the above stated subject and to forward herewith the following nominations received from Ministry of Railways, Metro Railway, Kolkata and Bureau of Indian Standards for information and necessary action as per details given below:-

Nominated by Ministry of Railways

Name of the Sub-Committee	Nominated officer as Members
Rolling Stock	Director (PE & Metro) / RDSO / LKO
Traction Systems	Director (TI) / RDSO / LKO
Signalling Systems	Director (Signalling) / RDSO / LKO
Standardization of Maintenance and Practices	Director (PE & Metro) / RDSO / LKO
	Director (TI) / RDSO / LKO
	Director (Signalling) / RDSO / LKO

Research Development & Standards Organization (RDSO) / Lucknow

Nominated by Metro Railway, Kolkata

Name of the Sub-Committee	Nominated officer as Member
Rolling Stock	Shri K. V. Rao, Chief Traffic Manager, o/o GM (Traffic) 33/1, J.L.N. Nehru Road, Metro Rail Bhavan, Kolkata-71. Telefax: 033-22175986, Mobile: 9007041902, Email: kvraoirts@gmail.com
Traction Systems	
Signalling Systems	
Automatic Fare Collection Systems	
Standardization of Maintenance and Practices	

Nominated by Bureau of Indian Standards

<table>
<tr><th>Name of the Sub-Committee</th><th>Nominated officer as Member</th></tr>
<tr><td>Rolling Stock</td><td rowspan="5">Shri M.M. Bansal, Scientist F (Transport Engg), Bureau of Indian Standards, 9, Bahadurshah Zafar Marg, New Delhi-2.
Telefax: 011-23236311,
Mobile: 9810821190,
Email: bansalmm@bis.org.in</td></tr>
<tr><td>Traction Systems</td></tr>
<tr><td>Signalling Systems</td></tr>
<tr><td>Automatic Fare Collection Systems</td></tr>
<tr><td>Standardization of Maintenance and Practices</td></tr>
</table>

14/1/13

(Deen Dayal)
Under Secretary to the Govt. of India
Telefax. 23062935
E-mail: deen.dayal69@nic.in

To

1. Shri R. K. Bhatnagar, Adviser (Electrical Engg), Railway Board and Convener of Sub-Committee on Rolling Stock, Rail Bhavan, New Delhi.

2. Shri R. K. Singh, Director (UT), MoUD and Convener of Sub-Committee on Automatic Fare Collection System, Nirman Bhavan, New Delhi.

3. Shri Satish Kumar, Director (Elect), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Traction Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.

4. Shri Rajkumar Director (Operations), Delhi Metro Rail Corporation Ltd. and Convener of Sub-Committee on Signalling Systems, Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.

5. Shri D. D. Pahuja, Director (Rolling Stock & Signaling), Bangalore Metro Rail Corporation Ltd. and Convener of Sub-Committee on Standardization, 3rd Floor, BMTC Complex, K. H. Road, Shanthinagar, Bangalore- 560 027.

Copy for information to:-

(i) Shri Jaideep, Director Elect. Engg (G), Ministry of Railways (Railway Board), Rail Bhavan, New Delhi-110001.

(ii) General Manager, Metro Railway, 33/1, J.L.N. Nehru Road, Metro Rail Bhavan, Kolkata-71.

(iii) Shri P. C. Joshi, Scientist F & Head (Transport Engg), Bureau of Indian Standards, Manak Bhavan, 9, Bahadurshah Zafar Marg, New Delhi-2.

(iv) Shri I. C. Sharma, National Project Manager, Project Management Unit, Sustainable Urban Transport Project (SUTP), Ministry of Urban Development, Nirman Bhawan, New Delhi.

Copy also for information to:-

1. Sr. PPS to Secretary (UD)
2. OSD(UT) & E.O. JS
3. Director (MRTS-I)

14/1/13

(Deen Dayal)
Under Secretary to the Govt. of India

Annexure-3

Sub-Committee (Signalling) nominated by MOUD

List of Members

S.No.	Name (Mr/Shri/Ms)	Designation	Remarks	
DMRC				
1.	Raj Kumar	Director (Operations)	Convener	Attended meetings on 04.10.12, 07.11.12 and 15.11.12
2.	Arvind Bhatnagar	ED/S&T	Associated	
3.	Prashant Rao	CSTE-I		
4.	Navneet Kaushik	CSTE-II		Attended meetings on 04.10.12 & 07.11.12
5.	D.K. Sinha	CSTE-III		Attended meetings on 04.10.12, 07.11.12 & 15.11.12
6.	B.Krishna Kumar	Chief Consultant (S&T)		Attended meetings on 04.10.12 & 07.11.12.
MoUD				
7.	Prakash Singh	Director (MRTS)	Member	Attended meetings on 04.10.12 & 07.11.12
8.	Rachna Kumar	US(MRTS-IV)	Member	Attended meeting on 04.10.12
Railway Board				
9.	Rajmal Khoiwal	Dir/Sig/RB	Member	**No meeting attended**
RDSO				
10.	Alok Katiyal	Dir/Sig-3/RDSO	Member	**No meeting attended**
11.	Kaushal Kishore	Dir-1 (QA)/RDSO	Member	**-**
L&T/HMRL/Hyderabad				
12.	Anil Kumar	Head/HML	Member	**No meeting attended**
B M R C L, Banglore				
13.	P.K.Krishnan	Dy.Chief Signal Engineer	**Member nominated at JAG level**	Attended meetings on 04.10.12 & 07.11.12
RMGL				
14.	Parveen Kumar	Sr. Vice President	Member	Attended meeting on 07.11.12
Kolkata Metro				
15.	K.V.Rao,	Chief Traffic Manager	Member	-
Bureau of Indian standards				
16.	M.M.Bansal,	Scientist F (Transport Engg)	Member	-
ASSOCHAM				
17.	Dr. A.K.Agarwal	CEO/AAL	Member	Attended meeting on 04.10.12

18.	Sajal Gupta	GM/AAL	Member	Attended meeting on 04.10.12
19.	Nirmal Datta	DGM/Mktg/AAL	Represented vice Dr.A.K.Agarwal & Sajal Gupta	Attended meeting on 04.10.12 & 07.11.12
20.	Neeraj Kaistha	AGM/AAL		Attended meeting on 07.11.12
21.	S.K.Jindal	Consultant/AAL		
22.	Sanjeev Kumar	Director/Sales/GE(I)	Member	Attended meeting on 04.10.12 & 15.11.12
23.	Manoj Kumar	Head of Business Development/Ansaldo	Member	Attending meeting on 04.10.12
24.	D.S.Rajora,	Sr.Dir/ASSOCHAM	Member	**No meeting attended**
25.	Kaushal Gupta	Executive/ASSOCHAM	Represented vice D.S.Rajora	Attended meeting on 04.10.12.
Confederation of Indian Industry (CII)				
26.	Tilakraj Seth	Vice Chairman/ Siemens	Member	**No meeting attended**
27.	Manish Agarwal	GM/Siemens	Member	Attending meeting on 04.10.12.
28.	J.P.Mura	GM/Siemens	Represented vice Manish Agarwal	Attended meeting on 07.11.12.
29.	Sriram Raju	Director/Bombardier	Member	**No meeting attended**
30.	Claudio Tiraferri	Head RCS(India)/ Bombardier	Represented vice Sriram Raju	Attended meeting on 04.10.12 & 15.11.12.
31.	Mangal Dev	Director/Alstom	Represented vice Jojo Alexander	Attended meeting on 15.11.12
32.	Jojo Alexander	MD/Alstom	Member	Attended meeting on 04.10.12 & 07.11.12
33.	Olivier Le Van Quyen	Customer Dir/Alstom	Represented vice Jojo Alexander	Attended meeting on 07.11.12.
34.	Alok SInha	Head Business Development/ Invensys	Member	Attended meeting on 04.10.12
35.	Anuj Sharma	Sr. Business Development / Invenses	Represented vice Alok Sinha	Attended meeting on 07.11.12
36.	R.Sathish	Director/CII	Member	**No meeting attended**
37.	Reeti Sujith	Executive/CII	Represented vice R.Sathish	Attended meeting on 04.10.11 & 07.11.12.
38.	V.G.Ramesh Kumar	KAM, Railways/ Thales (India)	Associated being supplier	Attended meeting on 04.10.12.
39.	Samir Nirula	GM/Mktg/Medha Servo	Member	**No meeting attended**
FICCI				
40.	Dr. Rajiv Kumar	Secretary General, FICCI	Member	**No meeting attended**
	Dr Akwyn Didar Singh			
41.	Binu Kwatra	Additional Director/FICCI	Represented vice Dr. Rajiv Kumar	Attended meeting on 04.10.12 & 07.11.12.

Sub-Committee (Signalling) nominated by MOUD
First Meeting held on 04.10.2012
At DMRC Metro Bhawan, New Delhi
List of Participants

S.No.	Name (Mr./Shri/Ms)	Designation	
DMRC			
1.	Raj Kumar	Director (Operations)	**Convener**
2.	Arvind Bhatnagar	ED/S&T	
3.	Prashant Rao	CSTE-I	
4.	Navneet Kaushik	CSTE-II	
5.	D.K. Sinha	CSTE-III	
6.	B.Krishna Kumar	Chief Consultant (S&T)	
MOUD			
7.	Prakash Singh	Director (MRTS)	
8.	Rachna Kumar	US(MRTS-IV)	
B M R C L , Bangalore			
9.	P.K.Krishnan	Dy.CE(Sig), BMRC	
ASSOCHAM			
10.	Dr. A.K. Agarwal,	C E O/ AAL	
11.	N. Datta	DGM/Mktg/ AAL	
12.	Sanjeev Kumar	Director/ Sales/ GE India	
13.	Manoj Kumar	Head of Business Development , Ansaldo	
14.	Kaushal Gupta	Executive/ ASSOCHAM	
15.	Sajal Gupta	Head , ASSOCHAM	
Confederation of Indian Industry (CII)			
16.	Manish Agarwal	General Manager, SIEMENS	
17.	Claudio Tiraferri	Head of RCS, India BOMBARDIER	
18.	Jojo Alexander	MD/ALSTOM	
19.	Alok Sinha	Head Business Development , Invensys	
20.	V.G.Ramesh Kumar,	Key Account Manager, Railways Thales (India)	
21.	Reeti Sujith	Executive (CII)	
FICCI			
22.	Binu Kwatra	Additional Director (FICCI)	

Sub-Committee (Signalling) nominated by MOUD
Second Meeting held on 07.11.2012
At DMRC Metro Bhawan, New Delhi
List of Participants

S.No.	Name (Mr./Shri/Ms)	Designation	
DMRC			
1.	Raj Kumar	Director (Operations)	**Convener**
2.	Arvind Bhatnagar	ED/S&T	
3.	Prashant Rao	CSTE-I	
4.	Navneet Kaushik	CSTE-II	
5.	D.K. Sinha	CSTE-III	
6.	B.Krishna Kumar	Chief Consultant (S&T)	
MOUD			
7.	Prakash Singh	Director (MRTS)	
B M R C L , Bangalore			
8.	P.K.Krishnan	Dy.CE(Sig), BMRC	
RMGL			
9.	Parveen Kumar	Sr. Vice President/ RMGL	
ASSOCHAM			
10.	Nirmal Datta	DGM/Mktg/ AAL	
11.	Neeraj Kaistha,	AGM/AAL	
12.	S.K.Jindal	Consultant/AAL	
Confederation of Indian Industry (CII)			
13.	Jojo Alexander	MD/ALSTOM	
14.	Olivier Le Van Quyen	Customer Director/ ALSTOM	
15.	J.P.Mura	General Manager, SIEMENS	
16.	Anuj Sharma	Senior Business Development , Invensys	
17.	Reeti Sujith	Executive (CII)	
FICCI			
18.	Binu Kwatra	Additional Director (FICCI)	

Sub-Committee (Signalling) nominated by MOUD
Third Meeting held on 15.11.2012
At DMRC Metro Bhawan, New Delhi
List of Participants

S.No.	Name (Mr./Shri/Ms)	Designation	
DMRC			
1.	Raj Kumar	Director (Operations)	**Convener**
2.	Arvind Bhatnagar	ED/S&T	
3.	Prashant Rao	CSTE-I	
4.	D.K. Sinha	CSTE-III	
ASSOCHAM			
5.	Sanjeev Kumar	Director/ Sales/ GE India	
Confederation of Indian Industry (CII)			
6.	Claudio Tiraferri	Head of RCS, India BOMBARDIER	
7.	Mangal Dev	Director/ALSTOM	

DMRC

MoUD Sub-committee for Train Control Systems for Guided Public Transportation

Presentation on Technology for S&T and Automatic Train Control Systems

Meeting on 4Th October 2012

REQUEST

- PHONES : Mute or Switch Off
- DISCUSSIONS/QUESTIONS PARTICIPATIVE

OPPORTUNITY FOR STANDARDISATION & SOURCING FROM INDIA

- **Metros Plan Across India**
- **In Progress**
  - **Delhi/NCR**
  - **Bangalore**
  - **Chennai**
  - **Mumbai**
  - **Hyderabad**
  - **Jaipur**
  - **Plans – For 15 more cities**
- **Mono Rails**
- **Similar Technology – For Main Line Railway**

Technology for Automatic Train control systems

PRESENT SCENERIO IN INDIAN METRO RAIL SYSTEMS:

1. Train detection: By Audio Frequency Track Circuits (AFTC)

2. Trackside to Train Communication: By transmission of telegrams through modulation of audio frequency used in AFTC

EXAMPLES: Delhi & Bangalore Metro Rail Networks

Chennai Metro rail (under execution) : AFTC based

Kolkata Metro rail

KMRCL (E-W) Line : Planned on AFTC

Metro Railway Kolkata (IR) : Absolute Block Working with no ATP in operation

<u>ATP</u>

Discrete - Beacon/Electromagnetic

AFTC –

(a) Speed Code

(b) Distance to go - MSS

Technology for Train control systems

PRESENT SCENERIO OF SIGNALLING SYSTEMS IN INDIAN METRO RAIL SYSTEMS:

1. **Electronic Interlocking is being used universally**
2. **LED Signals for trackside**
3. **Direct drive in comparison to conventional signalling relays / Relay driven.**
4. **High thrust point machines**
5. **Depot – .. Trailable**
   .. Non-trailable
   .. Interlocked area – Operational Need

Technology for Train control systems

INTERNATIONAL SCENERIO:

- **Train Control Systems evolved over decades. (Mechanical Stops still in use for train protection in some parts of London Under Ground.)**
- **Most of the Metro networks of the world use AFTC based ATC systems in the past. Use of AFTC based ATC systems on the decline and being phased out on completion of their life.**
- **Communication Based Train Control Systems (CBTC) are in use since more than a decade and have fully stabilized.**
- **In the last two decades many leading Metros have opted for CBTC systems for new lines or resignalling projects**

  -- Europe

  -- Asia

  -- America

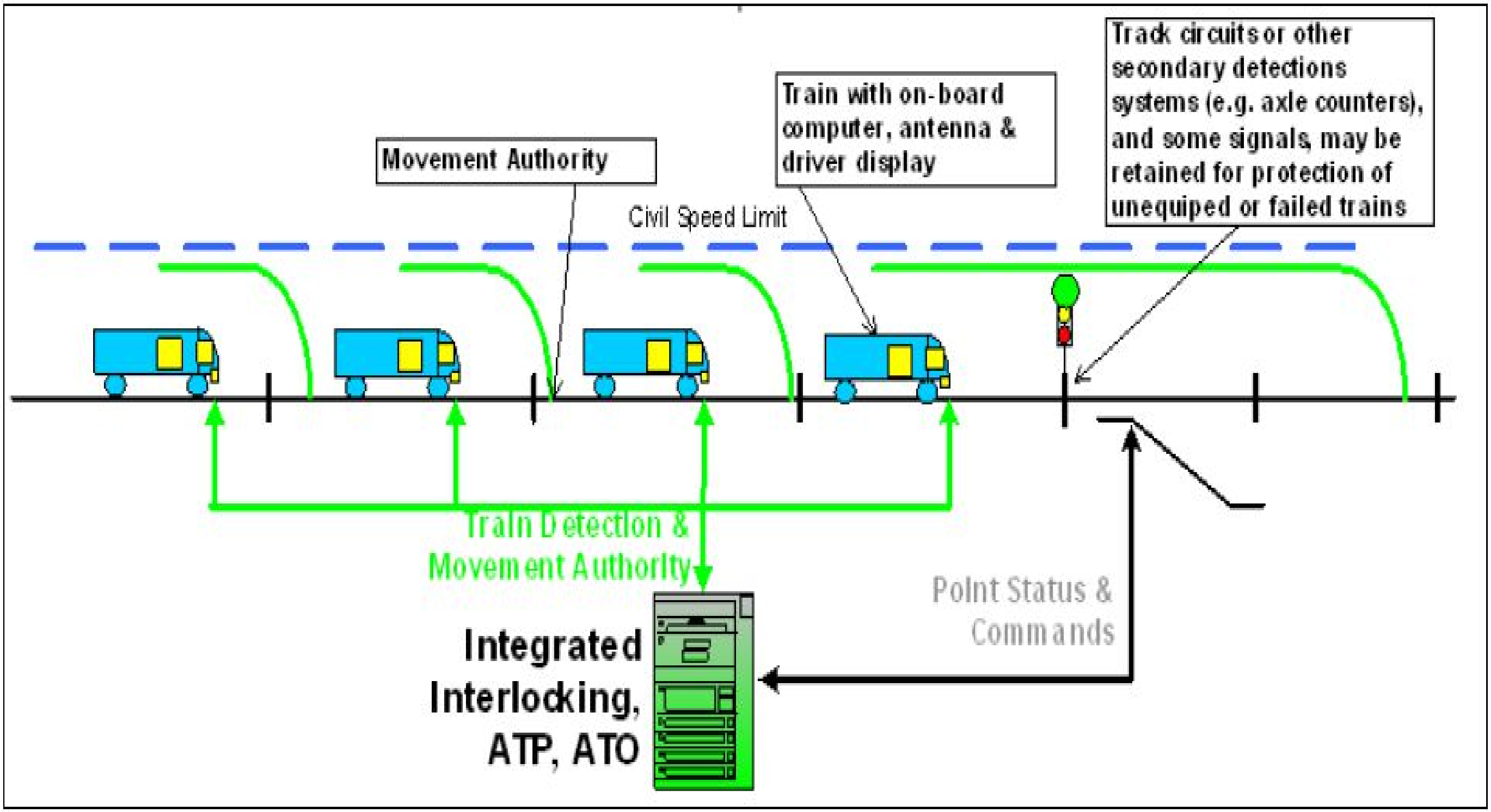
Technology for Train control systems

ADVANTAGES OF CBTC BASED ATC SYSTEMS

- **FEASIBILITY EXISTS FOR STANDARDIZATION & INTEROPERABILITY.**
- **REDUCED HEADWAYS (90 SECONDS) DUE TO USE OF MOVING BLOCK.**
- **RECOVERY FASTER DUE TO BETTER HEADWAY FROM STATION TO STATION (~20 SECS)**
- **REDUCED MAINTENANCE DUE TO LESS TRACK SIDE EQUIPMENT**
- **REDUCED LIFE CYCLE COST**
- **TECHNOLOGY MATURED FOR DRIVERLESS WORKING IN MAINTENANCE AND DEPOT.**
- **CIVIL COSTS**

Technology for Train control systems

MOVING BLOCK SIGNALLING



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ISSUES IN CBTC TECHNOLOGY:

1. **USE OF LEAKY CABLE VS RADIO BASED SYSTEMS**
2. **USE OF LICENSED FREQUENCY VS DELICENSED SPECTRUM (ISM BAND)**
3. **METHODS/NEED FOR FALL BACK DURING COMMUNICATION FAILURES**
4. **REDUNDANCY REQUIRED IN ON-BOARD & TRACKSIDE EQUIPMENT**
5. **INTEGRATION OF INTERLOCKING VS SEPARATE ELECTRONIC INTERLOCKINGS**
6. **RADIO DESIGN - CRITICAL**

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- **ISSUES IN PROVEN VS UNPROVEN SYSTEMS**
- **IS THERE NEED FOR DETECTION OF BROKEN RAIL BY SIGNALLING SYSTEMS OR NOT?**
- **NEED FOR SECONDARY TRAIN DETECTION USING AXLE COUNTERS OR TRACK CIRCUITS FOR PROTECTION AGAINST FAILED OR NON-EQUIPPED ROLLING STOCK**
- **INTEGRATION OF CBTC WITH OTHER SUPERVISORY & TELECOM SYSTEMS OF METRO RAIL – ISSUES OF MIXING VITAL AND NON-VITAL DATA ON SAME TELECOM CARRIER**
- **MEASURES NECESSARY AGAINST INTERFERENCE AND JAMMING**

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OTHER ISSUES IN CBTC BASED ATCS:

- **USE OF ATO, DTO AND UTO IN OPERATIONS**
- **USE OF HALF HEIGHT AND FULL HEIGHT PLATFORM SCREEN DOORS WITH CBTC**
- **AUTOMATION IN OCC AND DEPOT OPERATIONS**
- **PASSENGER VOICE COMMUNICATIONS TO/FROM OCC-TRAIN, TETRA/WI FI/PRIORITY ALLOCCATION.**
- **MODIFICATION OF RULES OF OPERATION**

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OVERVIEW OF STANDARDIZATION EFFORTS IN COMMUNICATION BASED TRAIN CONTROL SYSTEMS:

- PERFORMANCE AND FUNCTIONAL REQUIREMENTS ARE PROVIDED VIDE IEEE-1474
- IEEE-MODURBAN PROJECT OTHER WORKING AND EVOLVING.
- CBTC NOT A "PLUG & PLAY" TECHNOLOGY LIKE IN THE WORLD OF IT FIELDS
- STANDARDIZATION IS A NECESSARY STEP FOR INTEROPERABILITY AND INDUSTRY CO-OPERATION (LONG TERM PROFITABILITY) ESSENTIAL
- STANDARDIZATION OF ROLLING STOCK-ATCS INTERFACE IS A MUST IN ADDITION TO OTHER INTERFACES
- LONG TERM COMMITMENT OF ONE OR MORE GOVERNMENTS/METROS ESSENTIAL FOR ANY PROGRESS IN THIS AREA

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OVERVIEW OF STANDARDIZATION EFFORTS IN CBTC (CONTD):

- **MOST OPERATORS MUST COMMIT TO STANDARD COMMON FUNCTIONAL REQUIREMENTS AND OPEN STANDARDS FOR SUCCESS IN EFFORTS**
- **THERE MUST BE PROOF OF TOTAL SAFETY IN MULTI SUPPLIER ENVIRONMENT & CROSS ACCEPTANCE OF SUCH SAFETY CERTIFICATION PROOFS AMONG OPERATORS**
- **DELIVERY TIME FOR SUCH SYSTEMS SHOULD NOT IMPEDE THE ON-TIME COMMISSIONING OF THE MAIN PROJECT**
- **LONG TERM EFFORTS OF MTA NEWYORK & RATP PARIS TO ACHIEVE INTER-OPERABILITY SHOW ONLY LIMITED PROGRESS**

Technology for Train control systems

- EVOLUTION AND STABILIZATION OF CBTC ITSELF HAS TAKEN MORE THAN 15 YEARS FOR CBTC TO BECOME A MATURE AND PROVEN TECHNOLOGY

- EFFORTS FOR STANDARDIZATION AND INTEROPERABILITY MAY TAKE MUCH LONGER

- RAIL BASED PUBLIC TRANSPORTATION IN INDIA HAVE TO PLAY ACTIVE ROLE BY LEADING THIS

- FOR LEADERS OF SIGNALLING INDUSTRY – OPPORTUNITY NOT THREAT TO ASSOCIATE FROM INDIA AND GROW

RAILWAY BOARD SUB-COMMITTEE RECOMMENDATIONS FOR TECHNICAL CLEARANCE

S.No.	Description	Technical requirement
1.	Type of Signalling	Cab Signalling CATC(ATP/ATO/ATS)
2.	Back up Signalling	Line side (CLS) As per operational requirement and at Point locations
3.	Interlocking	SSI
4.	Train Control System	CTC (ATS with remote control)
5.	**Train detection**	**On Main line: AFTC/Axle counter** **In future – CBTC based ATP systems** **In Depot: Track circuit / axle counter**
6.	Point Machine i) For M/L ii) For Depot	 i) Non-Trailable high trust ii) Non trailable/Trailable (Depending upon operational requirements) preferably Indian point machine
7.	Redundancy in Cab equipment for ATP (Cab sig.)	1+1 as per prevalent and proven technology in the market and meeting RAMS requirement.

Technology for Automatic Train control systems

CONCLUSIONS & RECOMMENDATIONS:

- TECHNICAL CLEARANCE OF RAILWAY BOARD INCLUDES CBTC SYSTEMS
- DELHI METRO RAIL PHASE III (LINE 7 & LINE 8) PROPOSED TO BE BUILT ON CBTC
- DMRC L-7 L-8 (85 KMS +)
- HYDERABAD METRO RAIL (70 KMS +) CBTC
- RECENT MONORAIL SYSTEMS MOSTLY HAVE GONE FOR CBTC
- METRO RAIL KOLKATA (IR) NOW BEING PLANNED ON CBTC
- THIS SUB-COMMITTEE SHOULD RECOMMENDED THAT INDIA SHOULD FOCUS ON CBTC AS COMMON PLATFORM FOR FURTHER IMPLEMENTATIONS IN RAIL BASED PUBLIC TRANSPORT SYSTEMS

Technology for Automatic Train control systems

<u>CONCLUSIONS & RECOMMENDATIONS</u>:

- **CBTC BEING A RECENTLY MATURED TECHNOLOGY, STANDARDIZATION & INTEROPERABILITY WILL TAKE A LONG TIME TO EVOLVE**
- **EVEN METRO OPERATORS WITH MIGHTY FINANCIAL CLOUT SUCH AS MTA NEW YORK, RATP PARIS HAVE NOT MADE MUCH PROGRESS IN THIS DIRECTION EVEN AFTER MORE THAN TEN YEARS**
- **SUB-COMMITTEE MAY RECOMMEND THAT FOCUS SHOULD BE ON METHODOLOGY & SUGGESTIONS FOR STANDARDISATION AND SOURCING FROM INDIA.**
- **NEXT STEPS FOR SUB-COMMITTEE**
  - *** HEAR VIEW OF INDUSTRY**
  - *** PLAN FURTHER DETAILS.**

TOPICS FOR FIRMS' PRESENTATION

- **Ideas & Specific Views on Sourcing from India**
- **Any proposal for specifications**
- **Their Plans**
- **Experience/Views on Inter-operability**
- **Technical issues with CBTC**
- **Method of estimating life cycle costs**
- **ISA from within India**
- **Testing & commissioning Methods**
- **Views on automation of operations**
- **"Delinking" ATS**
- **Applicability of Off-setting similar to Defence systems**

THANKS

Minutes of Meeting Sub-Committee for Signalling and Train Control Systems for Guided Public Transportation nominated by MOUD - First Meeting Held on 4TH OCTOBER 2012

1.0 The first formal meeting of the sub-committee was held on 4-10-2012 at Metro Bhawan, DMRC , New Delhi. Nominees of Industries and S&T officers of DMRC attended the meeting in addition to the sub-committee members. List of attendees is enclosed at Annexure-A.

2.0 Mr. Raj Kumar Director / Operations, DMRC, the convener of the sub-committee welcomed the gathering and thanked them for attendance.

3.0 Mr. Prakash Singh, Director/MRTS/MoUD, in his introductory speech highlighted the need for developing standards in all areas of Metro Rail systems in the back drop of GoI's plans for introduction of Metro Rail systems in 15 more cities of more than 2 million population, in addition to the seven cities where Metro rail exists or undergoing construction. He mentioned that five sub-committees have been formed for this purpose such as Traction Systems, Standardization, Automatic Fare Collection and Rolling Stock etc in addition to the one for Signalling and Train Control systems. He emphasized that the committee should focus not only on standardization but also on costs. He stressed that, as far as GoI is concerned, the bottom line is reduction of cost by standardization, but at the same time quality, reliability and keeping abreast of technological advances should be kept in sight by the committee.

4.0 Mr. Raj Kumar then made a detailed technological presentation which threw light on subjects such as:

i) Current status of the ATC systems in various Metro Rail Networks of India
ii) The status in the international arena, particularly in Europe and Asia
iii) Advantages in the latest CBTC system
iv) The need for focusing the efforts around CBTC for the Metro rail in future
v) Issues requiring deliberation in CBTC technology
vi) Past and ongoing international efforts to achieve standardization and interoperability in CBTC such as those in MTA/New York, RATP/Paris, MODURBAN Project of European Commission and the limited success which has been achieved so far.

5.0 The convener then requested the views from the representatives of Industry and other attendees.

5.1 Mr. Jojo Alexander, MD/Alstom Transportation acknowledged that efforts to standardize helps the industry in their long term planning and clarity in the Indian Market for the long term will be quite useful for the industry. He mentioned the costs and duration of the projects are affected by the safety certification process as there appears to be no standard process and each manufacturer follows their own methods and standardization in this area will be helpful and also will reduce the cost. He further wondered how the issue of sourcing from India will appear to the major international players from a global perspective, as the vendors always try to reduce their cost globally and remain competitive. He cautioned that developing any such ATC system de novo in India will involve huge R&D costs and whether GoI will be prepared for the costs as has been incurred by China, even for customization and local production. The localization efforts of China succeeded due to very large number of Metro systems taken up by them and the number of fifteen projects in India will not be an incentive. He stressed that volumes are important to the vendor for incurring any costs.

He further stated that each Metro Project has its own size, capacity requirements and other challenges and whether standardization can address all the issues and should there be different standards for large Metro Rail and smaller networks. He also wanted to know the time frame over which such standardization is proposed to be implemented by MoUD as it will take significant time and efforts.

5.2 Mr Claude Tiraferri, Head-Rail Control Solutions , Bombardier pointed out that standardization and interoperability efforts may have their own costs which may be high, for the vendors to achieve the intended standards and make their products interoperable. He stressed that unless the efforts of Indian Railways for the long distance network goes in the similar direction for Train Control solutions, costs can not be expected to be reduced. He cautioned that the Metro rail market in India on its own may not be able to drive the efforts to achieve standardization.

5.3 Mr Alok Sinha , Director/Invensys pointed out that even RDSO in their efforts to reduce costs for signaling systems such as Electronic Interlocking, have laid down that localization would mean only manufacturing the systems in India and even they have not insisted on local designing of complex signaling systems. The market being such no vendor can afford to transfer or duplicate the design organization keeping the global perspective. Hence the standardization proposed should focus on local manufacture of hardware only.

5.4 Mr. Manish Agarwal, General Manager/Siemens wanted that while debating the costs of ATC system, there should be a focus on life cycle costs also and not the initial project costs alone. He stressed that high MTBF is very important and the Sub-Committee should also come out on an agreed formula for estimation of life cycle costs while taking up standardization.

6.0 Mr Raj Kumar stated that the response time for rectification is also important and affects the operators very much not only due to the disruptions but also the loss of image.

7.0 Mr Jojo Alexander felt that if maintenance contract is also given to the original vendor, then it may be possible to meet the response requirements , but not otherwise.

8.0 Mr.V.G.Rameshkumar, Key-Account Manager, Thales opined that the standardization should not get bogged down in micro-level details and can only on a broad level. The standards should also be open and flexible as it may take quite some time to evolve and changes in technology can be absorbed in the standardization efforts only if it is open. He pointed out that 100% indigenization is not at all possible considering the latest state-of-art. He felt that sourcing from India should also include the policy on taxation. He suggested adopting features used in main-line systems into Metro systems for increase of volumes and reduction of costs.

9.0 Dr. A.K.Agarwal CEO/AAL stressed that strong review mechanisms should be in place in any standardization effort to take care of technological advances taking place parallel so that the standards do not become obsolete too fast. He also felt that localization could first be focused on manufacturing in the country and include the design aspects over the longer term after gaining sufficient experience. He gave example of efforts by the department of Defence in this direction.

10.0 Aspects of increasing the sourcing from within the country were then debated. Mr Raj Kumar gave examples which can be immediately dictated such as point machine for depot and LED signals which should be sourced only from India as sufficient expertise is available. Mr Prashant Rao CSTE-I said that Alstom could share their experience in China as the sourcing from within China has been quite successful in which Alstom had a significant role. Mr Alexander replied that volumes played a major role in China and the number of projects with in India will not suffice for similar efforts. Mr Manish Agarwal pointed out that the cost of setting up an exclusive factory being significant, it would be impossible unless volumes are high. He also felt that if there are more common modules in main-line systems and Metro-systems it could help in reducing the cost. He also cautioned that standardization should not lead to stagnation in technology.

Mr. Raj Kumar then pointed out that if efforts are made to delink some of the portions of ATS from proprietary design, increased competition even from non-signalling firms may be possible and drive down the costs. Mr.Arvind Bhatnagar, ED/S&T pointed out the fast rate of obsolescence which makes it difficult to integrate the ATS of even same vendor with different versions of their own systems. Mr. D.K.Sinha, CSTE-III hoped that platform independent software can help in sourcing at least the hardware such as servers from India.

11.0 Mr Raj Kumar summarized the discussions and proposed that in the next meeting the major vendors could arrange to make individual presentations about their views and perceptions as also their suggestions to take the efforts forward. The major subjects to be focused by the manufacturer were then discussed and the following points emerged for the proposed presentations:

- Ideas & Specific Views on Sourcing from India
- Any proposal for specifications
- Their Plans in the direction of sourcing from India
- Experience/Views on Inter-operability
- Technical issues with CBTC
- Method of estimating life cycle costs
- ISA from within India
- Testing & commissioning Methods

- Views on automation of operations
- “Delinking” ATS

12.0 Mr.Prakash Singh in his concluding remarks again stressed on the need for the standardization process to focus on latest technology which is upgradable during its life of 25 to 30 years avoiding the need for scrapping the old system fully to make way for changes in the technical domain. He thanked the sub-committee and advised for early conclusion of their efforts within the stipulated period of three months.

13.0 Ms Rachna Kumar (US-MRTS) MoUD thanked all the participants and especially those from the industry for the interest shown and requested all the members to continue and conclude the efforts successfully.

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Annexure-A

Sub-Committee (Signalling) nominated by MOUD
First Meeting held on 04.10.2012
At DMRC Metro Bhawan, New Delhi
List of Attendees

S.No.	Name (Mr./Shri/Ms)	Designation	
DMRC			
1.	Raj Kumar	Director(Operations)	**Convener**
2.	Arvind Bhatnagar	ED/S&T	
3.	Prashant Rao	CSTE-I	
4.	Navneet Kaushik	CSTE-II	
5.	D.K. Sinha	CSTE-III	
6.	B.Krishna Kumar	Chief Consultant (S&T)	
MOUD			
7.	Prakash Singh	Director (MRTS)	
8.	Rachna Kumar	US(MRTS-IV)	
B M R C L , Bangalore			
9.	P.K.Krishnan	Dy.CE(Sig), BMRC	
ASSOCHAM			
10.	Dr. A.K. Agarwal,	C E O/ AAL	
11.	N. Datta	DGM/Mktg/ AAL	
12.	Sanjeev Kumar	Director/ Sales/ GE India	
13.	Manoj Kumar	Head of Business Development ,Ansaldo	
14.	Kaushal Gupta	Executive/ ASSOCHAM	
15.	Sajal Gupta	Head , ASSOCHAM	
Confederation of Indian Industry (CII)			
16.	Manish Agarwal	General Manager, SIEMENS	
17.	Claudio Tiraferri	Head of RCS, India BOMBARDIER	
18.	Jojo Alexander	MD/ALSTOM	
19.	Alok Sinha	Head Business Development , Invensys	
20.	V.G.Ramesh Kumar,	Key Account Manager, Railways Thales	
21.	Reeti Sujith	Executive (CII)	
FICCI			
22.	Binu Kwatra	Additional Director (FICCI)	

Information Note on Secondary Detection Devices for a CBTC system

Introduction

Since 2003, operators have chosen Radio Communications Based Train Control (CBTC) for close to 150 systems, including APM[1]'s, Light Rail Transit and Light to Heavy Metros. The great majority use Secondary Detection Devices such as track-circuits or axle counters.

The usefulness of Secondary Detection Devices (SDD's) in CBTC systems has been questioned recently in a number of forums and signalling events. This note looks at some benefits of SDD's for safety, for start-up reactivity of a CBTC system and in specific degraded modes.

Context and definitions

Primary Detection

For a CBTC system to operate, each trainborne ATC[2] controller must know its position and each wayside ATC controller must know the position of all trains in the controlled zone.

This is achieved by equipping trains so that they can safely determine and communicate to the wayside ATC controller their localisation on the track: the on-board ATC system detects trackside location references such as balises and measures train speed to compute the train position. This is often called the localisation function. The train position is then transmitted to the wayside ATC controller by redundant radios and data networks.

The process is called "Primary Detection".

Secondary Detection

Secondary Detection allows the trackside ATC to safely determine that a track section is free of any vehicle, without using information sent by the vehicles themselves. It safely (SIL4) enables detection of all the trains and in particular those without any Primary Detection equipment.

The track sections can typically extend from one station to the next.

The secondary detection system is not a signalling back-up or a signalling fall-back system. A signalling fall-back system would be an independent signalling system, such as a train-stop system or a speed-code system, for instance using a fixed block principle.

[1] Automated People Movers
[2] Automatic Train Control

Situations where SDD's bring high added value

Detailed analysis of the workings of a metro system using CBTC reveals a number of operating cases in which automatic functions supported by SDD's avoid fallible human procedures and otherwise improve availability while reducing down-time.

System initialisation

When the CBTC system is initialised (after a restart for example) the independant Secondary Detection Devices can prove immediately that track sections are free of any obstacles, which gives the possibility for trains to move immediately in protected modes.

Precautions and procedures if there is no SDD function:

- The whole line must be swept/cleared by a communicating train driven manually (at low speed),
- Or the Operator must <u>safely</u> and <u>manually</u> declare to the system that the track sections are clear.
- Or a separate system must be added on top of the CBTC to keep track of train positions.

Management of train stabling and wake up

While trains are put in "sleep mode" they stop communicating their position. SDD's are used to monitor the position of these sleeping trains, in order to protect other trains in the vicinity.

Precautions and procedures if there is no SDD function:

- The Operator must guarantee in <u>safety</u> that a sleeping train will not be moved (e.g. allowing for maintenance operations in the depot),
- Or a <u>safe</u> "cold movement" detection system must be deployed for non-communicating trains AND the operator must <u>safely</u> and <u>manually</u> communicate the new position of the train to the system.

Management of non-communicating vehicles

SDD's allow the system to detect and track trains which are not able to provide primary detection, either because they are not equipped or because they are in degraded modes or because of a communication failure due to external reasons. The impact of a failure would therefore have a much wider impact on the service.

Without SDD's, the system cannot detect a non-communicating vehicle entering the line, leading to a hazardous situation.

Without SDD's, if a train stops communicating, the system can no longer safely localise it. This is hazardous, especially if trains are fitted with Restricted Manual, ROS and CUT-OUT driving modes, allowing train movement without trackside authorisation. To ensure safety, trains around this non-communicating train must then be driven manually (ROS/RM) and heavy constraints will be transferred to the Operator concerning movements in this area.

Precautions and procedures if there is no SDD function:

- The Operator must safely ensure that NO non-communicating vehicle can enter any area covered by CBTC (or all traffic shall be stopped and remain stopped when this occurs until this vehicle has completely left the area)
- Strong and safe rules must be laid out for the Operator and/or Drivers/Attendants to manage degraded cases.

Delocalised train

A number of events can cause a train to become "delocalised", meaning that the train position is no longer safely known by the trainborne computer, causing the train to stop. By combining SDD outputs with information in the CBTC Zone Controller, the system can automatically allow a delocalised UTO train to move quickly and safely to the next balise (norming point) with much less service delay than with manual intervention.

Optimisation of point area clearance performances

Up to several seconds can be saved in turn-backs thanks to judicious positioning of SDD boundaries: points may be released sooner after a train has passed a point as an SDD reacts faster that the primary detection.

Effect of SDD failures on CBTC availability

Because the CBTC uses the vital Primary Detection: SDD failures do not degrade the global system availability. Even better, the CBTC system detects the failure of an SDD and warns the Operator and Maintenance Manager so that the SDD is quickly repaired and available again if needed.

When Secondary Detection is implemented with axle counters, they occasionally need to be reset/restored. In a CBTC system, the counters are generally reset/restored automatically. This removes any Operator's concern about the need for staff intervention and associated risks.

SDD cost aspects

Axle counters and track-circuits are very widely produced Off-the-Shelf-Components. A high end estimate by a major Operator in India puts the CBTC cost increase for SDD's at 10%. Although this is still a pessimistic figure, it is already much lower than suggested by some rumours.

CONCLUSION

Because it enforces safety constraints that otherwise must be taken over by the Control Centre Operator (who then takes responsibility) Secondary Detection makes the CBTC system much more robust and safe whilst improving recovery time.

And the benefits are affordable as there is no need to deploy many Secondary Detection Devices.

From: LEVANQUYEN Olivier
Sent: lundi 8 avril 2013 15:21
To: dir.op.dmrc@gmail.com
Cc: 'dsig@rb.railnet.gov.in'; 'dsig3rdso@gmail.com'; 'sivasailam@bmrc.co.in'; 'bkkmas@gmail.com'; 'Sklohia65@gmail.com'; Jojo Alexander (jojo.alexander@transport.alstom.com)
Subject: {MoUD Signalling Sub-Committee} Constitution of Sub-Committee on Signalling and Train Control Systems – Agenda for 04.10.2012 Meeting at Metro Bhawan, New Delhi (7th Floor Conference Room).

Dear Mr. Raj Kumar,

I am referring to the draft report of Sub-Committee of Ministry of Urban Development on " Standardization of Signaling and Train Control System for Guided Rail Transport Network for Urban Transport in India".

Please find below one comment raised by Alstom on the draft report related to the following recommendation:

Section XII/ Recommendation IX : " *Requirements of redundancy, fall back modes of operation in case of communication failure, use of features of advanced operations such as DTO etc may be left to the individual Metro administration for decision based on size of metro, traffic volumes, costs and local operational needs."*

Our comment is to complete this recommendation by the following addition:

"It is recommended that a CBTC system shall have a provision for Secondary Train Detection Device (SDD) System in order to limit

-occurrence of human procedural errors

and

-exportation of operational safety constraints to the network operator.

(We are ready to elaborate our position in case you wish us to substantiate this assertion)

Best regards,

Olivier Le Van Quyen

Alstom Transport

Sub-Committee for Train Control Systems for Guided Public Transportation Ministry of Urban Development, Government of India

New Delhi, Nov. 7, 2012

TRANSPORT

We are shaping the future | ALSTOM

Agenda

1. Ideas & Specific Views on Sourcing from India
2. Experience/Views on Inter-operability
3. Commonality between mainline and urban
4. Testing & commissioning Methods
5. Views on automation of operations
6. Technical issues with CBTC
7. "Delinking" ATS

1.Ideas & Specific views on Sourcing from India

- Maximise procurement from India to develop local base of suppliers and proximity with final client.
- Standards can be of RDSO
- Localisation of production : a matter of quality !
- Localisation : Guarantee a volume of business is key to amortize ToT cost which are generally high (as per our experience)
- Objective and fair homologation /approval regime

2.Experience/Views on Interoperability (1/2)

- Interoperability: only RATP and NYCT have launched CBTC interoperability initiative
  - NYCT: started in 1999 with Siemens France as specification leader and Alstom and Thales as followers. Alstom withdrew in 2003. In 2012, still no line in operation with interoperability. A test track is being done with equipment from Siemens and Thales for operation in 2014. Also Alstom is expressing its interest to be the third supplier (reply to a RFI issued by NYCT). Too early to say anything about interoperability in NY.
  - RATP: 3 lines are in operation under OCTYS system (« Open Control of Trains, Interchangeable & Integrated System ») which is interoperable and to which Siemens, Areva and Ansaldo have participated . So nothing we can say about it as we did not participate.

- History: RATP is the first transport authority to have implemented a multi-sourcing strategy with SACEM system co-designed (in the 80's) by Alstom, Matra (Siemens), CSEE (Ansaldo). Successful experience for RATP, for Alstom and HK MTR.

- History: Key learning from ERTMS (mainline) : major industrial project implemented by Europe. ERTMS has required an intensive ten years phase of research and development under the statutory drive of EU. For urban, there is no such drive today.

- Any interoperability initiatives **are long to put in place / definition is key**

2.Experience/Views on Interoperability (2/2)

- Challenge is to ensure the interoperability between wayside and on-board equipment provided by 2 suppliers and to ensure global performance including safety issues. (Reactivity time is critical). Who takes the responsibility? RATP is taking the system integration and system management responsibility (RATP has large engineering team (1000-1500 persons)

- When interfaces are standardised, it is difficult to ensure evolution of the system or to easily upgrade it. Standardisation is a hindrance to innovation (RATP is presently defining the next generation of OCTYS system, not sure to see OCTYS systems in the coming tenders in Paris (Grand Paris)).

- As technology is evolving fast (obsolescence issue), some operators prefer to take advantage of recent innovations and buy the latest technology (that may be cheaper).

- Capabilities for interoperabilities are available: we have the technical skills and the knowledge to interface with subsystems (ATS, IXL, ATC) from other manufacturers.

3.Commonality between mainline and urban

Volume economies due to larger market

- Commonality between mainline and urban:
  - Eurobalise
  - Trackside security platform (2oo3 platform)
  - ATS ICONIS platform

- Unique on-board computer for all applications.

- There is a European initiative (JTI –Joint Technology Initiative) with the objective to create convergence between ERTMS and CBTC. **Work in progress.**

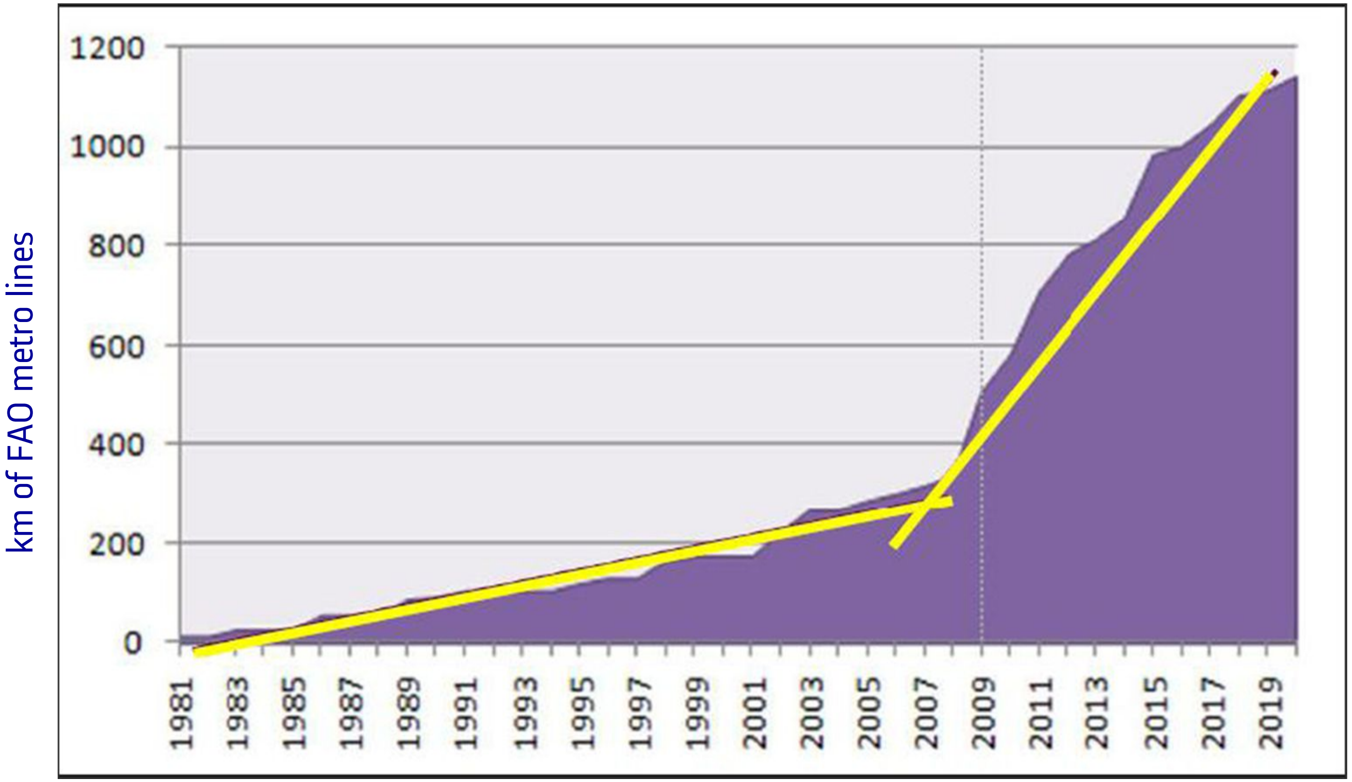
4.Testing & Commissioning Methods

Factory Integration & Validation Platform (FIVP) : a duplicate of the delivered system in a simulated environment.

- 70% of I&V process is performed with the FIVP – trouble shooting is done before delivery to the field
- Stable and mature software & data/parameters delivered to site.
- Shortens and masters the site test period
- Supports Customer training and maintenance activities.
- Should preferably be located close to the deployment site.

5.Views on automation of operations (1/3)

- Fully automated operation (UTO) is a global trend
- Slow but constant growth during the first 25 years. Trend acceleration after 2009 indicates that the technology is mature



5.Views on automation of operations (2/3)

➢ Fully Automated Operation (UTO) delivers Value for Money

Some operator priorities		FAO operation benifits
Increase line capacity		Shorter headways than with ATO. No space wasted for the driver's cab.
Satisfy passengers - for increased ridership and revenue		Reduced waiting time / less crowding, thanks to immediate and automatic increase of fleet in service (no stand-by drivers required, trains can easily be parked on sidings along the line).
Reduce operating costs		Energy savings thanks to immediate and automatic decrease of fleet in service. Overall less staff and less trains required.
Heighten staff image and motivation		Staff can assist passengers instead of driving.
Improve security and crowd control		Platform screen doors. Staff available for passenger control. FAO comes with Integrated Control Centre for better automatic train supervision and automated and/or remote incident management.

5.Views on automation of operations (3/3)

➢ A System Approach for Successful UTO deployment

- Enforce **high availability** on all the sub-systems to achieve overall system performance.
- **Management of interfaces** between Rolling Stock / Signalling system / Platform screen doors is key to attain the response time needed for the highest commercial speed.
- Expertise in train braking systems and train control to deliver the **robust stopping accuracy** that FAO needs – whilst preserving commercial speed and passenger comfort.
- Know-how to combine driving strategies, rolling stock performance and Hesop™ power sub-stations can save over 15% on propulsion energy cost

Automatic operation well established in Singapore,Shanghai, Beijing, Lausanne and under implementation on several lines

TRANSPORT ALSTOM

6. Technical issue with CBTC

- As worldwide leader in CBTC techno, we do not have particular technical issue.
- We have a robust and proven radio technology (10 years of revenue service, first radio CBTC in world : Singapore NEL project)

7.“Delinking” ATS

- Yes, “Delinking” ATS is possible …
- ATS is not critical in terms of safety **but is complex in terms of interface**
- Complex functions are often split between different subsystems (IXL, ATC) and **strong interface management** is required.
- **No real advantage to Operator**

Summary

A standardized solution will certainly yield advantages to both operator and industry in terms of economies, time for implementation. However, challenges are:

- **definition of common standards**
- **interface protocols**
- **harmonization of hardware**
- **reasonable period of time during which the standard must run**

Such initiatives must be driven by a centralised metro authority with a long term perspective, in which industry will also participate.

In this context we can highlight **Metrolab**, a research laboratory of RATP/Alstom dedicated to developing the automatic metro of the future. Primary mission of Metrolab being:

- Provide major conurbations with innovative and completely automated urban and suburban transport solutions for new networks or renovations to existing systems
- Develop complete systems covering infrastructures, rolling stock, signalling, passenger information, operations and maintenance.

www.alstom.com

ALSTOM

MoUD Signalling Sub-commitee meeting

Benefits of a standard platform for CBTC

Jean-Pol Mura

Rail Automation

Business Unit General Manager

Division Mobility and Logistics

Sector Intrastructure & Cities

Siemens Ltd

Standardisation objectives

- ☐ Foster competition ? ➔ India: already enjoys fierce competition
- ☐ Lower the CAPEX ? ➔ Indian market already among ww lowest prices
- ☑ Provide local VA ?
- ☑ Lower the OPEX / LCC ?
- ☑ Ensure future-proof solutions ?

SIEMENS

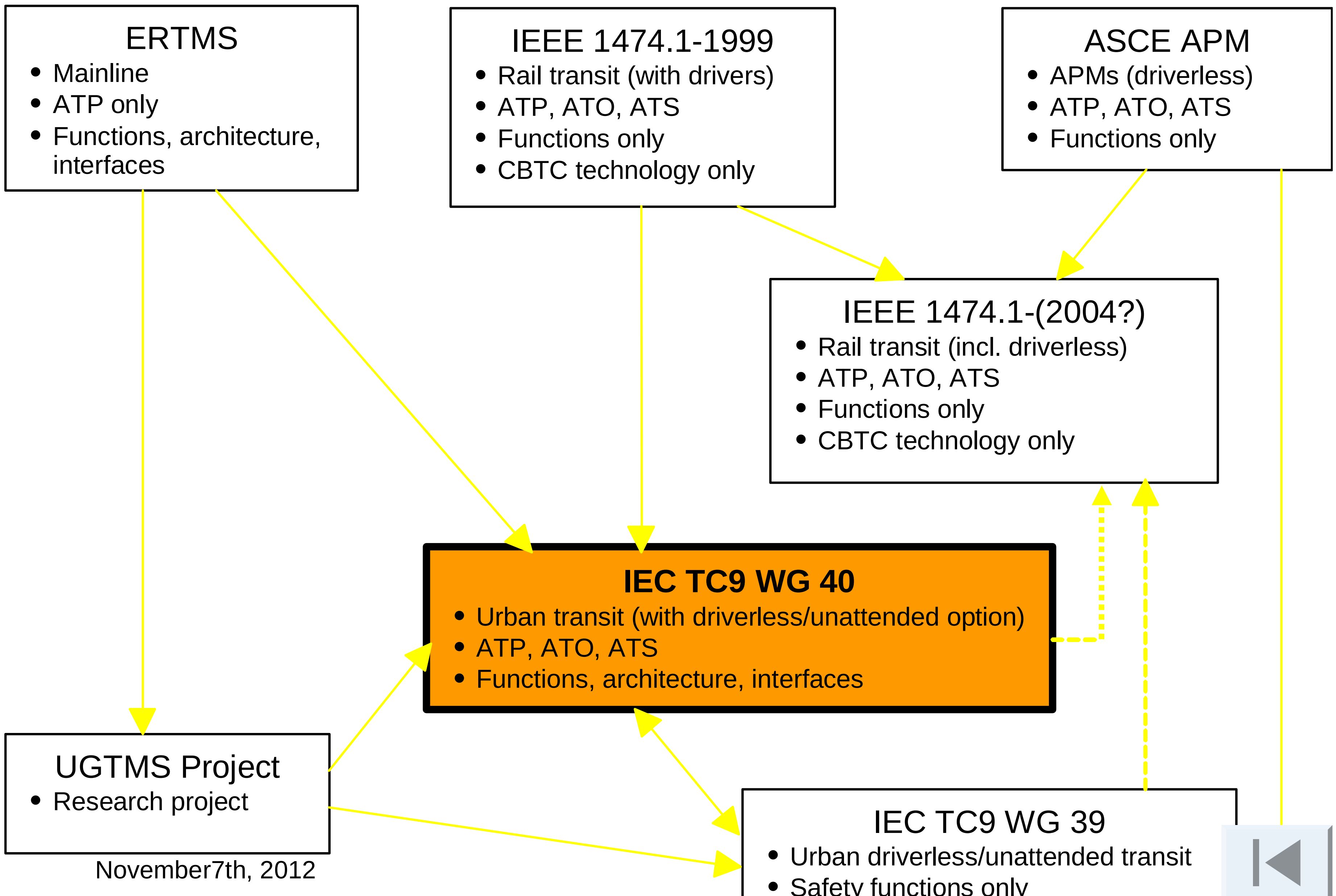
Standardisation

- 1 Siemens' pioneering role in standardisation
- 2 Interoperability is not the way to go
- 3 Focus on achievable results
  - Rely on available standards
  - Define a common component and safety platform to lower LCC

Mass Transit market is by definition not a 'standardising' / normative environment as each transportation network is isolated from the other.

SIEMENS

1 Siemens pioneer in CBTC standardisation

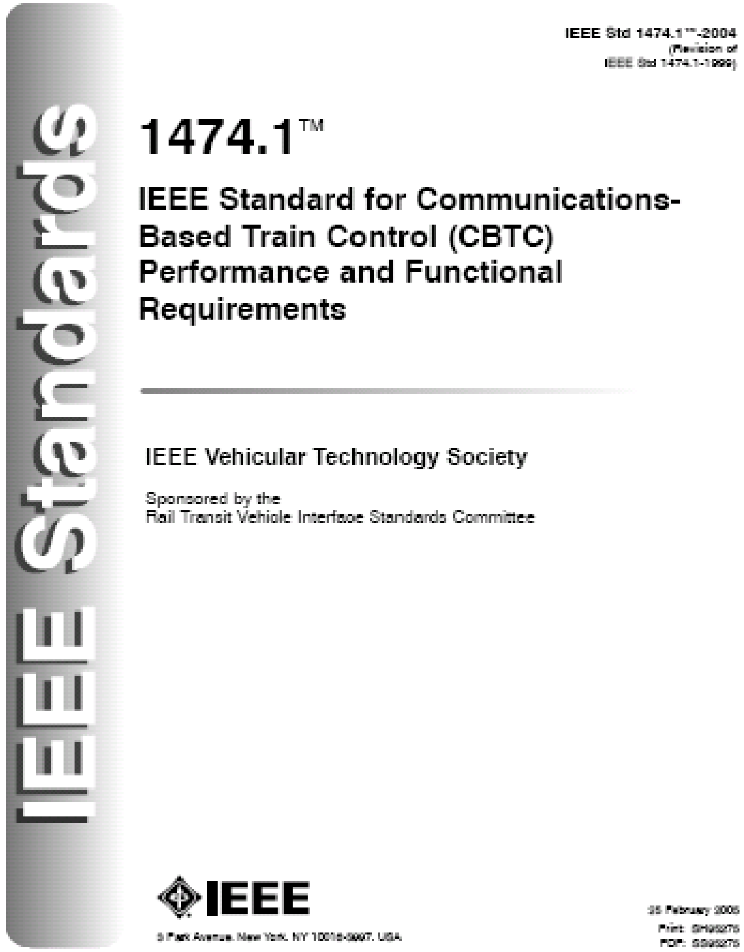


1 CBTC Standardisation efforts: 1st standard by the pioneers

- Train detection independent of track circuits
- Continuous train-to-wayside bi-directional data communications link
- Wayside and trainborne processors capable of performing safety critical functions
- IEEE 1474.1 standard defines CBTC

➔ Minimal standardization but took 10 years

➔ Not even a mention of Moving Blocks



SIEMENS

2 CBTC Standardisation efforts: Interoperability

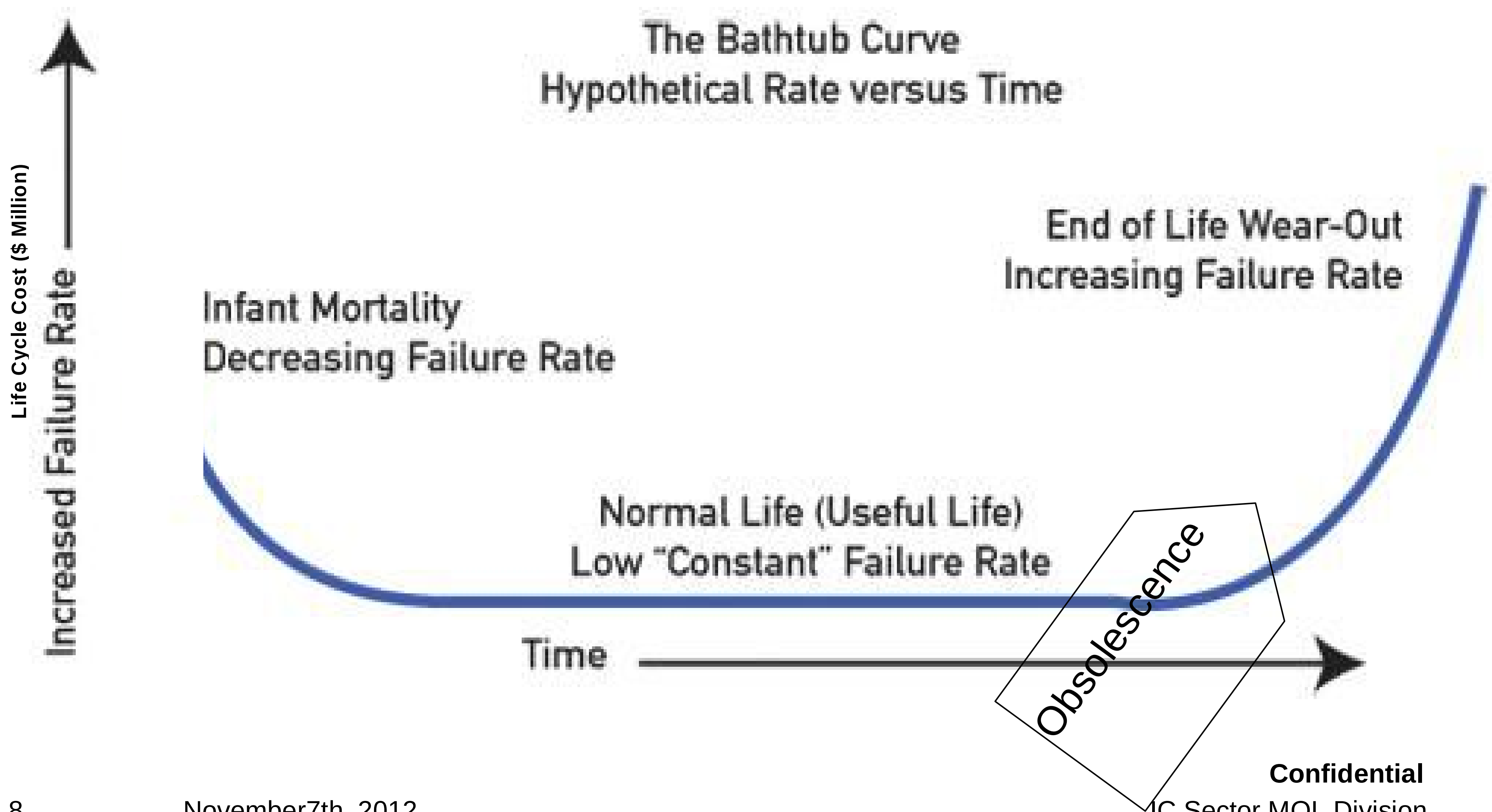
- The leader (Siemens) had to provide to the followers (Thales) a so called I²S interface document. Alstom dropped out of the contract
- The follower Thales modified its system so as to be compatible with Siemens' CBTC
- Interoperability was successfully demonstrated in Siemens lab in December 2005, witnessed by NYCT and Parsons
- Interoperability was demonstrated on a test track of the Culver line in June 2006, but without safety case
- Future CBTCs on NYCT lines were supposed to be procured by lots between Leader and Follower(s). Not for the Flushing line
- At first, interoperability interface was split Wayside-Carborne with a so-called air-gap interface. Since the only radio 'fit-for-the-job' was made by Siemens, a wire interface at the IP-level was defined.
- RATP defined its Ouragan/Octys system based on NYCT's

2 CBTC Interoperability: mixed results

- NYCT Interoperability Siemens leader with Thales follower
  - Alstom resigned
  - Successfully tested in Paris in 12/2005
  - Implemented on Culver Line 06/2006, without safety testing
- Based on NYCT's I²S specification, at first 10 lines were supposed to be resignaled using this standard
- To date only 3 are:
  - New York Canarsie Line
  - Paris (Ouragan/Octys Line 3 and 5)
- In the future, only Culver Line and Queens Bvd are planned

3 LCC Maintenance Costs increase over time

Figure 3-2: System Life Cycle Cost of Train Control Technologies



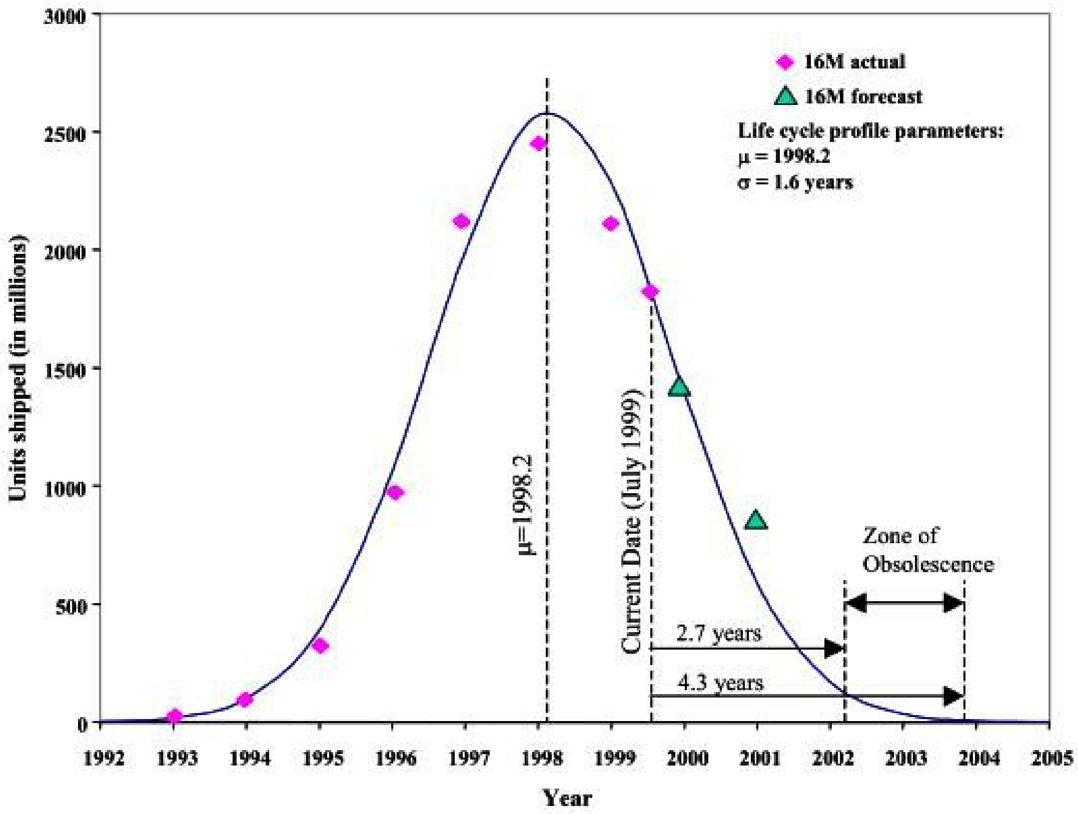
3 Obsolescence Management Program: issue for Mass Transit market

SIEMENS

Components PLC < 10 years

Vs.

Signalling PLC > 30 years



➔ Need for OMP

➔ COTS: not the solution

➔ Master the manufacturing of the safety platform « in house »

➔ Need « volume »

MT applications are low volume, specific applications.

Interoperability attempt: unsuccessful

➔ Merge platform with Main Line applications

3 OMP. Practical approach

➔ With indian metro market volume alone, quantities from 50 p.a.,

no business case, no localization concept possible

➔ With indian metro + TPWS mainline, volume of 500 p.a. reachable

➔ Sustainable / Future-proof solution as ETCS is becoming almost a ww standard (except USA)

➔ Standardization to go beyond the platform choice will take decades to accomplish (see I²S efforts). In the meantime, India has 500 km of metro lines to build

SIEMENS

3 Benefits of ETCS platform usage

➔ Sustainable / Future-proof solution as ETCS is becoming almost a ww standard (except USA)

➔ Minimize obsolescence-treatment costs

➔ Possible pooling of maintenance spare-parts

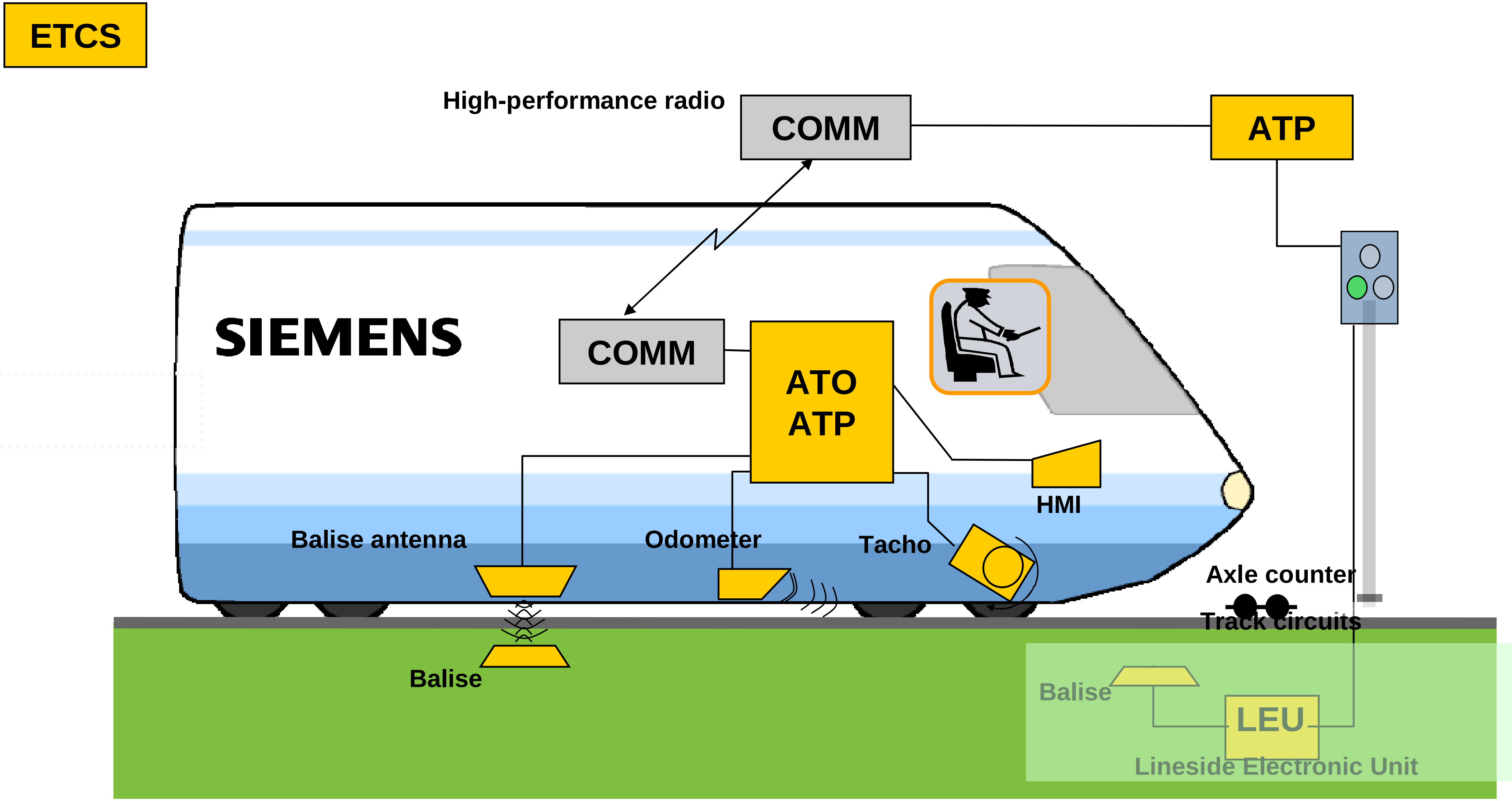
➔ Wayside Compatibility with TPWS-E suburban trains.

No dual equipment of balise, odometry etc…

➔ Siemens recommends to standardize the indian CBTC platform on ETCS components.

Example: Trainguard MT: ETCS components and subsystems

SIEMENS



"World class technology®
through power of Alliance"

Definition of OFFSET

Defense offset agreements are legal trade practices in the aerospace and military industries. These commercial practices do not need state regulations but, since the purchasers are mostly military departments of sovereign nation, many countries have offset laws, public regulations or, alternatively, formal internal offset policies.

An offset agreement is an agreement between two parties whereby a supplier agrees to buy products from the party to whom it is selling, in order to win the buyer as a customer and offset the buyer's outlay. Generally the seller is a foreign company and the buyer is a government that stipulates that the seller must then agree to buy products from companies within their country.

This is frequently an integral part of international defense contracts.

Reasons for OFFSET

Today, virtually all of the defense trading partners/ countries impose some type of offset requirement

Countries require offsets for a variety of reasons:

- to ease the burden of large defense purchases on their economy
- to increase or preserve domestic employment
- to obtain desired technology
- to promote targeted industrial sectors.

Ways of OFFSET

Offsets may be direct, indirect, or a combination of both. Direct offsets refer to compensation, such as co-production or subcontracting, directly related to the system being exported. Indirect offsets apply to compensation unrelated to the exported item, such as foreign investment or purchases of goods or services.

Direct offset	Direct or Indirect offset	Indirect offset
Co-Production	Technology Transfers	Export Assistance
Sub-Contracts	Training	Purchases
	Licensed Production	Offset Swapping (Compensation of Offsets obligation through reciprocal abatement)
	Foreign Direct Investment, Credit assistance and Financing	

OFFSET : Global Practices

The following 37 countries have some type of OFFSET policy

Australia, Austria, Bahrain, Belgium, Brazil, Bulgaria, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Japan, India, Israel, Italy, Kuwait, Lithuania, Netherlands, Norway, Poland, Portugal, Qatar, Romania, Saudi Arabia, Slovakia, South Korea, Spain, Sweden, Switzerland, Turkey, United Arab Emirates, United Kingdom, United States

http://en.wikipedia.org/wiki/Offset_agreement

which spells out

- Legal base for the OFFSET
- Purchase threshold above which the request is for OFFSET
- Quantity of OFFSET in terms of %
- Applied multipliers etc...

OFFSET : Global Practices

Country	Minimum Threshold	Level of Offset Obligation	Preference
Malaysia	Eur 10 M	50%	Direct & Indirect
Taiwan	5 M $	40%	Direct & Indirect
United Kingdom	No formal offset policy Eur 1.2 million	100%	Direct
Singapore	10 M$	25 ~30 %	Direct with Indirect in isolated cases
Brazil	1 M $	100 ~120%	Primary Direct, - focus on aeronautic industry
China	No formal offset policy		Seeks ToT, Licensed production, licences assembly and participation in R&D programmes
India	60 M $ (Rs 300 Crores)	30 ~50%	Direct & Indirect
Israel	5 M $	50%	Direct & Indirect

CII – defence offset challenges 17.Mar, 2012, Chennai

OFFSET CHALLENGES
Global Trend

- Success rate of offset in developed and industrial nations is almost 100%

- Success rate In the developing economies is about 30-40% of offset %age
  - Primary reason for shortfall
    – lack of sufficient industrial base.

India Defence OFFSET journey

- Offset as per DPP-2006
- Changes – DPP-2008
- Changes – DPP-2011
- Offset Guidelines - 2012

India OFFSET Policy
(OFFSET Guidelines 2012)

India's offset policy is focussed to serve the defence Industry and enhance its position in the manufacturing domain, leverage capital acquisitions to develop defence industry

Current offset guidelines are structured to promote India's National industrial objectives for the sustainment and creation of

- Defence jobs
- Acceleration in the maturity of the defence technology base
- Increase indigenous capability
- Enhance global competitiveness of public and private sector firms
- Cost reduction of the product / service

India OFFSET Guidelines Scope - 2012

- Applicable on all Capital Acquisitions categorised as “Buy (Global)” or “Buy & Make with ToT” with indicative cost of INR 300 Cr or more.
- Minimum Offset Value
  - 30% of indicative cost of “Buy (Global)’’.
  - 30% of foreign exchange component in “Buy & Make with ToT”
- DAC (Defence Acquisition Council) may prescribe varying Offset percentage.
- Offset under option clause would be as per guidelines prevailing at the time of signature of main contract.

Advantages of OFFSET

The offset programme serves as a vehicle for original equipment manufacture (OEM) to partner with their government customers to support and achieve the laid down objectives.

The OEMs can attain productivity gains such as

- Cost reduction
- Cycle time reduction

The offsets partners can expand their portfolio of

- Export orders
- Infuse needed technology
- Meet growth objectives
- Access to market-leading technologies

This creates a win-win-win scenario for all the three major stakeholders in the offsets programme - the Government, the OEM and Local industry

Advantages INDIA

The challenge for India in meeting its policy objectives will be expanding its indigenous production capabilities at the same time as meeting its acquisition objectives. Currently, 70 percent of India's Defence procurement needs are met by foreign sources with domestic companies supplying only around 30 percent of indigenous items to state-owned companies.

With each procurement that is made from foreign sources, Indian industry stands to benefit through offset requirements that plough some of those expenditures back into India - thus giving a boost to indigenous industry.

Thank you

AAL®

Autometers Alliance Ltd

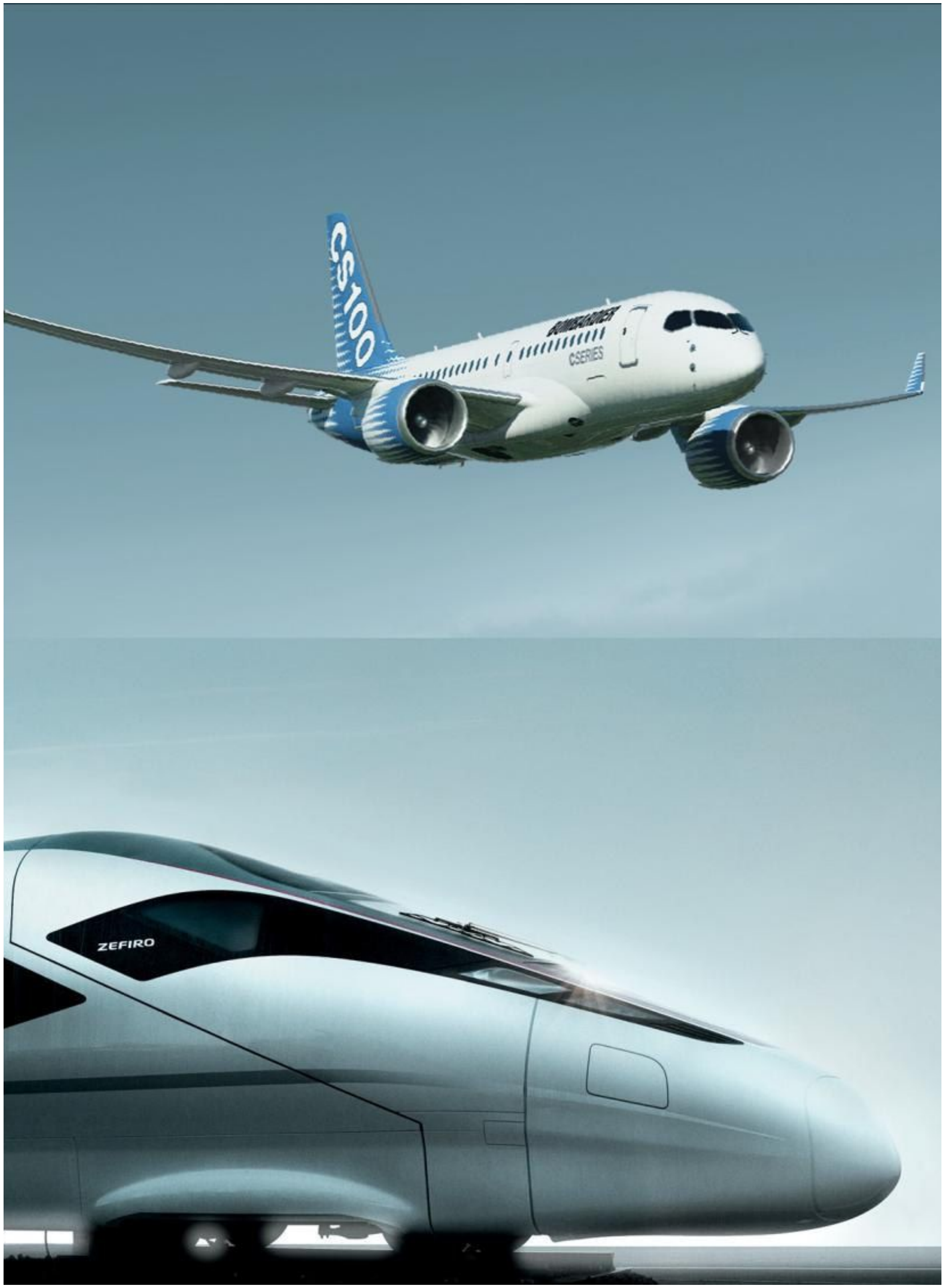
C-63, Sector-57, Noida - 201 307 (U.P) India.

Tel.: +91 (0) 120-2583545, 2583546

Fax : +91 (0) 120-2583542

E-mail : info@autometers.com

Website : www.autometers.com



Signalling and Train Control System Sub-Committee nominated by MOUD

Bombardier Presentation

Metro Bhawan - Delhi

15th November 2012

Claudio Tiraferri

BOMBARDIER
the evolution of mobility

These are the conclusions of the last meeting

CONCLUSIONS & RECOMMENDATIONS:

- CBTC BEING A RECENTLY MATURED TECHNOLOGY, STANDARDIZATION & INTEROPERABILITY WILL TAKE A LONG TIME TO EVOLVE
- EVEN METRO OPERATORS WITH MIGHTY FINANCIAL CLOUT SUCH AS MTA NEW YORK, RATP PARIS HAVE NOT MADE MUCH PROGRESS IN THIS DIRECTION EVEN AFTER MORE THAN TEN YEARS
- SUB-COMMITTEE MAY RECOMMEND THAT FOCUS SHOULD BE ON METHODOLOGY & SUGGESTIONS FOR STANDARDISATION AND SOURCING FROM INDIA.
- NEXT STEPS FOR SUB-COMMITTEE
  - HEAR VIEW OF INDUSTRY
  - PLAN FURTHER DETAILS.

Bombardier RCS View

- IDEAS & SPECIFIC VIEWS ON SOURCING FROM INDIA
- BOMBARDIER PLANS IN THE DIRECTION OF SOURCING FROM INDIA
- EXPERIENCE / VIEWS ON INTER-OPERABILITY
- ISA FROM WITHIN INDIA
- “DE-LINKING” ATS

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Ideas & Specific Views on Sourcing from India

Sourcing from India has become important for most significant players in the Signalling Market.

This has or will be achieved through the:

1. Localization of Engineering hours in India;
2. Localization of the production in India.

Some companies are already working on these options, implementing them integrally or partially.

Localization has got a non negligible cost, this cost can become acceptable when there is a tangible volume of contracts that can justify this cost.

Suppliers are considering the localization as part of their business model, but the level of localization is in line with market prospective, economies of scale become important.

Bombardier's main Interoperability experience is ETCS

Mission of ERTMS

Have a common signalling system for all EU administrations, allowing cross border operation for open operators competition.

Benefits

The main benefit come was the standardization and competition in sourcing, with a whole network interoperability.

Negatives

The system Interoperability is not fully effective, and imposing constraints in defining the solutions to use, have forced to go for non cost effective choices.

Standardization a way for interoperability 1/2

- Are the drivers for Mass Transit interoperability the same of the ETCS?
  - The scale of the Metro Networks are not the ones of Mainline
- Standardization will come with competition in sourcing?
  - Probably yes
- Is the cost for making this happen reasonable?
  - Maybe looking at the ETCS experience will give the right feeling, especially in terms of:
    - Skills/Competence
    - Effort
    - Stake holders
    - System proof/validation/safety

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Standardization a way for interoperability 2/2

Is the ETCS complexity comparable to CTBC?

- most likely not, the CBTC in terms of functionalities is more complex, and probably will need more effort in defining, standardizing, proving and validating the final system.

Is it enough to standardize the interfaces?

- Each major subsystem from each supplier, processes the data/information in a different way
- What needs to be done to guarantee the overall system safety?
  - It is not enough to demonstrate the safety of a subsystem, and every time subsystems from different supplier are put together extra safety activity needs to be performed.

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ISA from within India/Homologation

- Bombardier takes full safety responsibility of the signalling systems that are handover to the customer in order to put them in commercial operation.

- Bombardier ISA team is fully competent from a safety point of view and knows deeply the systems of our product/solution portfolio, this provides competent, objective and rapid assessment and support to the project, allowing the projects to respond to customers expectations.

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“Delinking” ATS

Delinking of ATS consists of using a different supplier for the ATS system.

Positives

- Considering that the ATS is mainly a SCADA system it will be available in the market at a competitive price.
- The possibility to change supplier based on the best offer.

Negatives

- Not having a defined interface between the ATS and the rest of the Signalling systems, means:
  - Using an ATS system from a supplier different from the one providing the signalling system will require time and effort because the two systems need to be integrated.
  - This effort will be required every time we change ATS supplier and/or Signalling supplier, more or less all the possible combinations.

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Key factors that can affect cost and performance

- **Fallback systems**
  - A number of reasons for including fallback system in the architecture
    - Mixed mode operation
    - Radio system availability (and reliability) – lack of confidence?
    - Speed of recovery in case of failure
  - Drives up whole life costs, but provides very little real benefit
  - Should the clients simply specify (realistic) availability and leave it to the suppliers to decide the best architecture?
- **Broken rail detection**
  - Only ~30% of the actual cases detected by track circuits
  - Is this a real problem in a well maintained closed loop metro system
    - Vancouver Rapid Transit has one case of broken rail in 20 years!
  - Effective rail condition monitoring coupled with pro-active maintenance delivers acceptable rail failure risk without track circuits
  - Elimination of track circuits can result in more efficient traction return

Conclusion

CBTC is the state of the art in terms of Metro Signalling systems

There are a number of suppliers that have demonstrated to have a proven in field CBTC solution

Localization requires considerable effort and costs that are justifiable with volume, in any case the suppliers are for sure doing their best in terms of localization to be more competitive

Interoperability:

- Mass Transit systems are usually "island" with no possibility of inter-running
  - Different gauge / different rolling stock / different tractions for example
- Commercial arguments are also not very strong
  - Several suppliers available: ensuring fierce competition
  - Non-recurring customisation accounts for most of the engineering costs
- Not enough volume to generate significant economies of scale
- Decoupling from technology mainstream

BOMBARDIER
the evolution of mobility

GE Transportation
Intelligent Control Systems

GE & Train Control

Next Gen Rail Signalling

Ministry of Urban Development (MoUD)
Signalling Sub-Committee Meet

imagination at work

GE
&
GE Transportation

imagination at work

GE today: things you need to know

GE Energy 30% / $43.7Bn

Healthcare 12% / $18.1Bn

Aviation 13% / $18.9Bn

Transportation 3% / $4.9Bn

GE Capital 31%/$45.7Bn

Home & Business Solutions, Media 11%/$16Bn

- √ GE power generation equipment creates **a quarter of the world's electricity**
- √ **Every 2 seconds**, a GE-powered aircraft takes off
- √ GE Healthcare technology helps doctors save **3,000 lives each day**
- √ **Over 50%** of GE's revenue comes from **outside of the US** (operating in 150+ global locations)
- √ $5.4Bn (**6% of revenue**) invested in **R&D** in 2011 (2,900+ patents filed in '10)
- √ **36,000 technologists and 10 global research centers** working across

- About 300,000 employees worldwide
- ~$147Bn revenue in 2011

imagination at work

GE Transportation today

Loco & Services $3Bn

- Locomotives
- Maintenance
- Services

Intelligent Control Systems $1Bn

- Fuel and cab electronics
- Signaling products
- Train control systems
- Office & Comms Systems
- Software & control systems
- Project Services
- AFC & PSD

GE Tempo™

Mining & P&SS $1Bn

- OHV wheels and parts
- O&G propulsion
- Battery
- Services
- Offshore vessels

- Established for more than 100 years
- 11,000+ people in more than 50 countries
- $5Bn+ of revenue in 2011

imagination at work

GE Transportation ICS?

Supplying rail infrastructure assets is our core business

We are experts in supplying safety-critical systems

100,000+ microprocessor-based technology

We are a local player

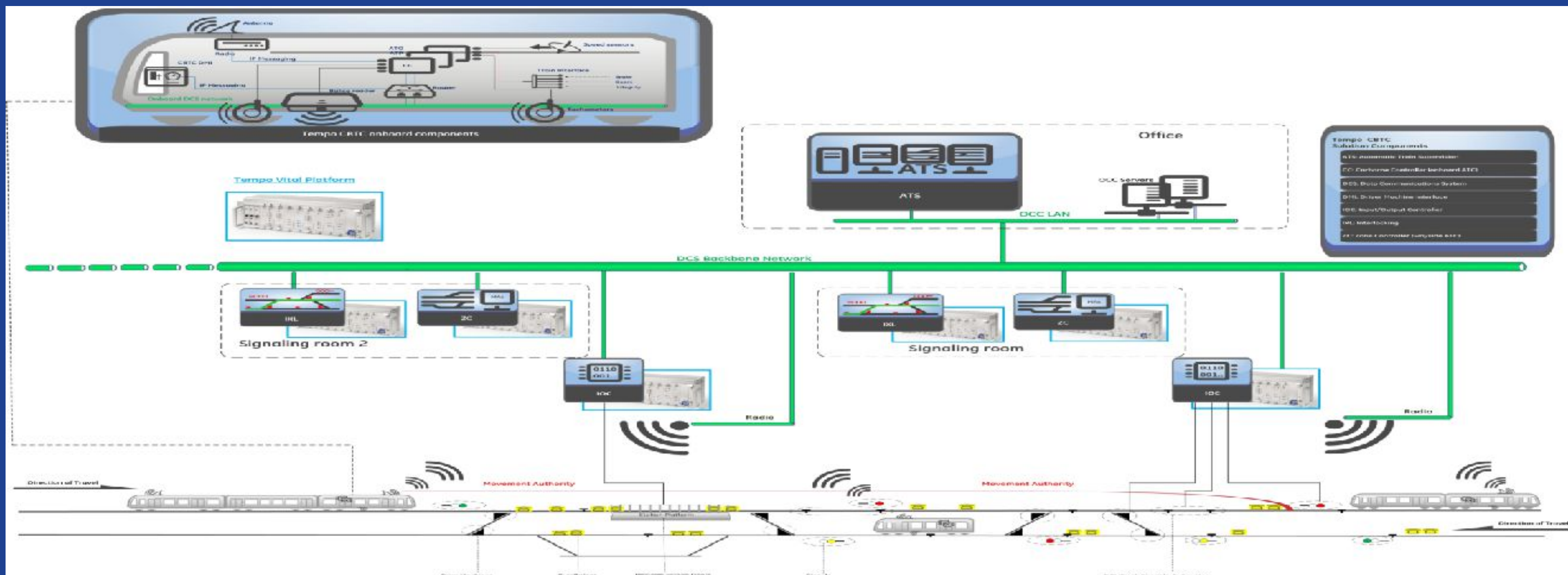
- 1,300 people globally (40% outside of the US), in 15 locations worldwide

Innovation fuels our growth

- Over $26MM R&D budget in 2011, focusing on Tempo ETCS/ CBTC and Computer Based Interlocking innovation
- GE's Trip Optimizer software can reduce one locomotive's fuel consumption by 5% to 12% per year

We design energy efficient products

Signalling Train Control Solution



GE's Suggestions / Inputs –

Optimize, Standardize and Localize to reduce cost & improve availability

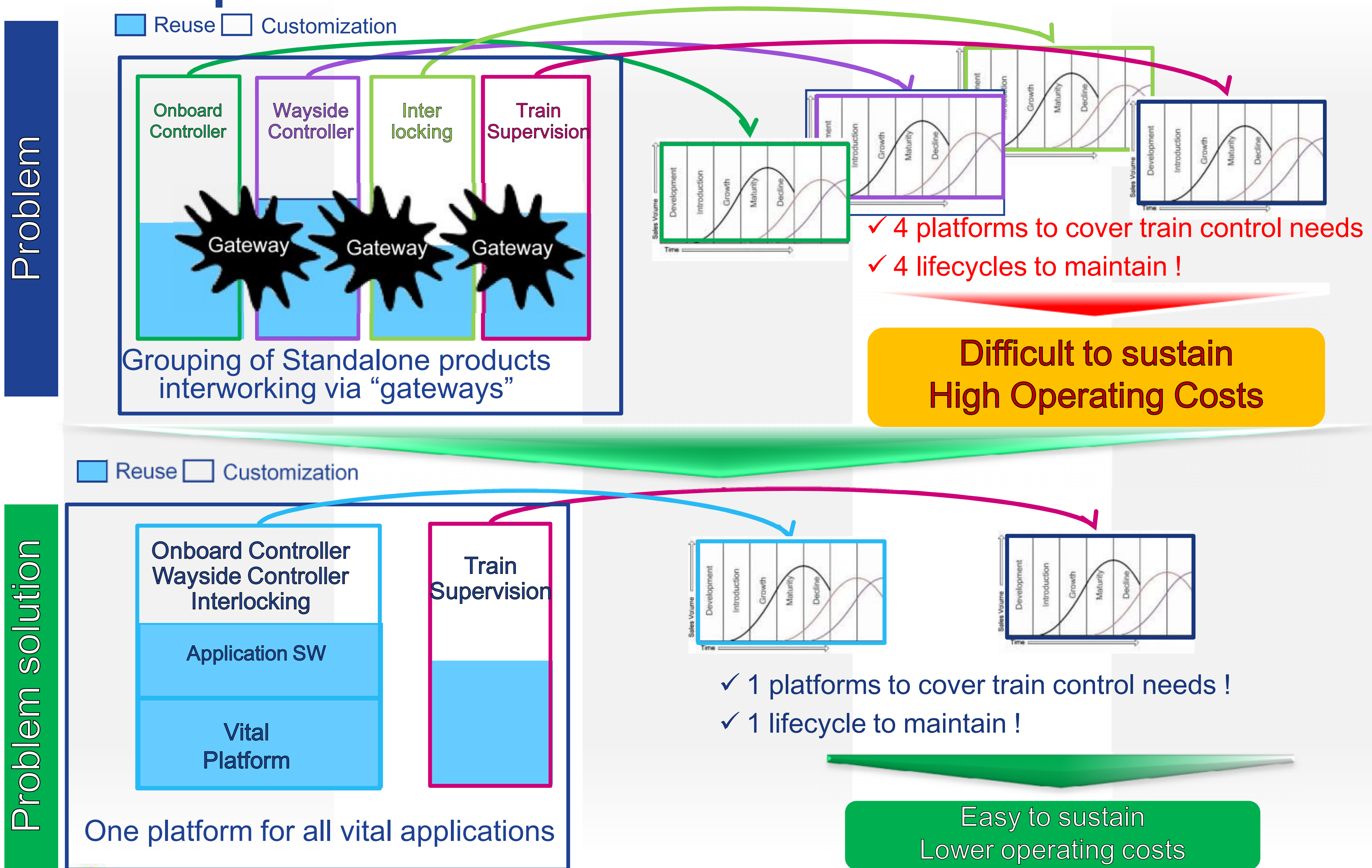
imagination at work

Design to optimize Total Cost of Ownership

- Optimize Hardware Platform Design
  - Common Vital Platform for controllers; OBC, LEU, IXL, RBC and Modular approach
  - Embedded Maintenance and Asset Management Capabilities
  - Energy Efficiency

- Innovate on Execution and optimize deployment time
  - Tool Suite for increased lab testing
  - Reduced Re-engineering efforts

Multiple Platforms to One Platform



imagination at work

Hardware platform: Innovative approach

A common, scalable and reliable platform for all Train control solutions

Optimization Strategies	Benefits
The Vital Platform should host: • Onboard Controller (**OBC**) • Lineside Equipment Unit (**LEU**) • Radio Block Center (**RBC**), Zone Controllers (**ZC**) • Interlocking (**IXL**) Controllers	• Controlled sw and hw **obsolescence** • Improved **implementation** and optimized **testing** • Reduced **inventory**, **spares**, **training** & **maintenance** costs
The Tempo Vital Platform: • Is CENELEC **SIL4** • Supports **2oo2/2x2oo2/2oo3** configuration • **Hot standby** , redundant architecture • All boards are **hot swappable & pluggable**	• Greater system **Availability**
• Embeds **advanced diagnostics** and **asset management** capabilities at board level	• **Smart energy** management • **Real-time system monitoring** (preventive maintenance, reduced repair time)
• Can be **networked** with other cabinets	• **Centralized or distributed** architectures
• Can be **extended** with up to 4 slave racks and 40 I/O Peripheral boards	• Enhanced **scalability** over the system operational life cycle

imagination at work

Innovate on Execution: reduce cost

Project Tool Suite – from tender to revenue service

	Tool type	Main tasks	Key benefits
Pre-Engineering	✓ Offer preparation ✓ Simulation and Validation	✓ Requirement analysis ✓ Documentation & Quotation ✓ Performance validation	✓ Meaningful dialogue with the Customer sooner in the process
System Design	✓ Model & Design ✓ Simulation ✓ Application Engineering	✓ Architecture and Functional definition ✓ Equipment Configuration	✓ Clear view on impact of requests / changes ✓ Quick re-engineering
Test & Comm.ing	✓ Supervision and maintenance	✓ Installation ✓ Diagnostic ✓ Configuration	✓ Upfront lab testing - automating as much as possible
Customer Operations	✓ On-site testing ✓ Maintenance ✓ Training	✓ Assist maintenance activities	✓ Optimization of maintenance & training

Tools should interact among them during the full cycle
design consistency   minimizing risk

Interlocking – Design for optimized TCO

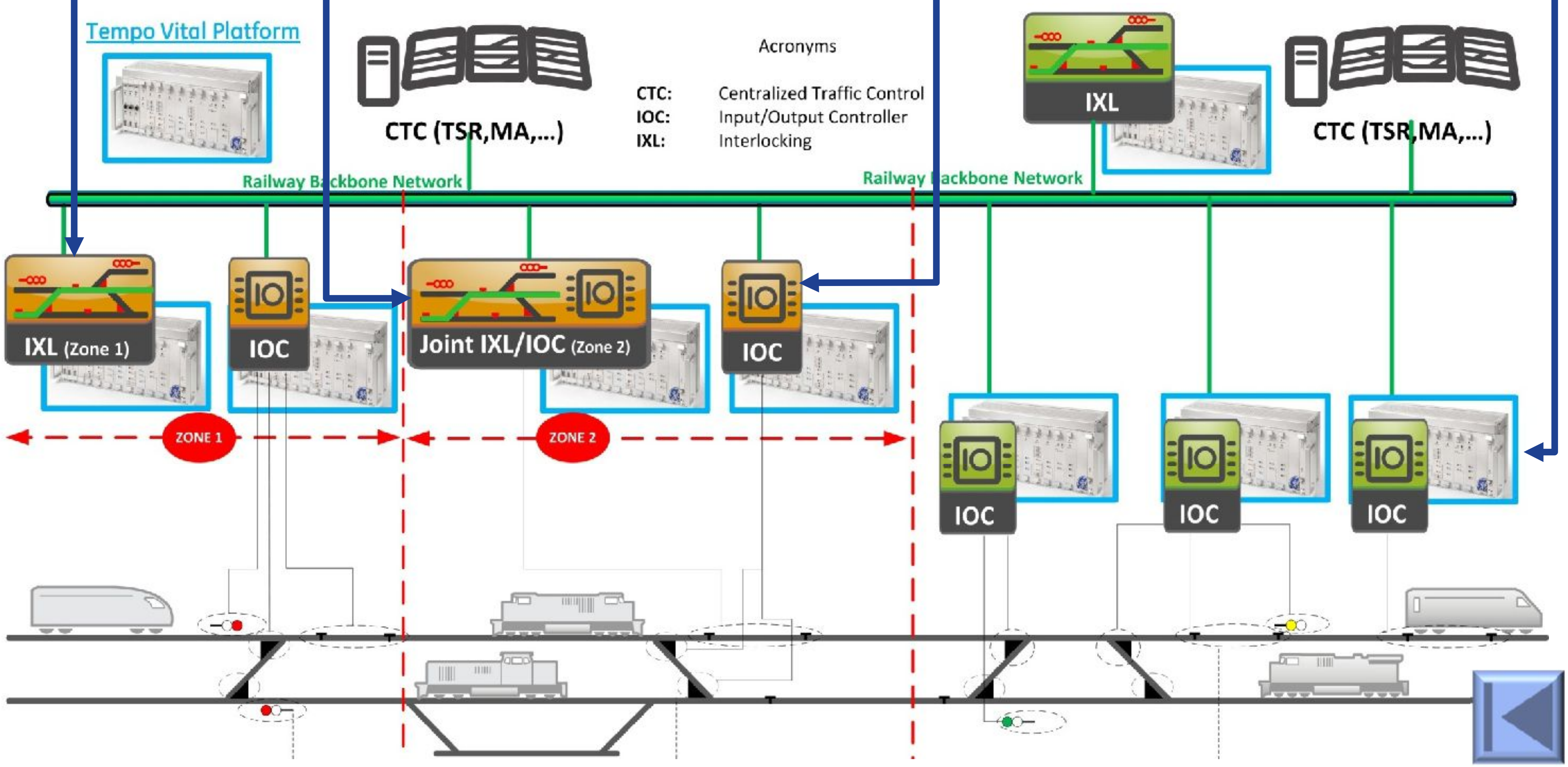
Centralized and distributed system architecture

The IXL Controller

- Can be concentrated or distributed
- Can be hosted in the same cabinet with the I/O Controllers (IOC)

The I/O Controllers

- Can be distributed, to reduce cabling
- Can directly control the field elements (no vital relays) for reduced cost and improved availabilty



Design to optimize Total Cost of Ownership

- Optimize Design and Opt for wireless IP technology for Onboard-Wayside comm.s for reduced cabling
- Optimize trains' driving styles reduce energy consumption while guaranteeing adequate level of service
- Optimize ATS with advanced timetable and regulation techniques for adaptation to real-time traffic conditions and increased energy savings.

Optimize Design for future changes

- Optimize Design to make it compatible with Greenfield or Brownfield projects and mixed operation for gradual introduction of CBTC equipped trains.
- Optimize design to ensure modular hardware architecture for new and retrofit rolling stock.
- Design to Manage Obsolescence better
- "Optimize" Grades Of Automation (GOA) - Design for Seamless up-gradation at reduced cost

		Train movement	Station Stop	Door Closing	Failure Recovery
Conventional with Driver	GOA0, A1	DRIVER	DRIVE R	DRIVER	DRIVER
Conventional with Driver	GOA2	Auto	Auto	DRIVER	DRIVER
Driverless	GOA3	Auto	Auto	Onboard attendant	Onboard attendant
Driverless Unattended	GOA4	Auto	Auto	Auto	Auto

Standardize…Standards and Protocols

Use standard and widely used telecom technologies

	Proposed
Radio network	Use of **Wi-Fi** (802,11n)
Backbone	IP over SDH over fiber or IP/MPLS, over fiber
On board network	IP over Ethernet over fiber or copper

Use proven, standard and open architecture

Wi-Fi	**Proven solution**	• Suppliers with large number of **references** in ruggedized **public transport environment** and fast handover mechanism
Protocols	**Euroradio**	• Proven **secured protocol** that meets **CENELEC 50159-2** req.ts • Widely **used in mainline** railways
	Standards	• use of IP, UDP, TCP, IPMPLS, SDH, Ethernet … **widely used in public transport systems**

Localize to reduce TCO and increased responsiveness

- In-country Service and Maintenance support
- Enhanced Engineering content from India
- In-country Testing and Validation skills and capabilities

Most companies including GE has their Global Engineering Centers of Excellence in Country

imagination at work

Focus on optimized life cycle cost, deployment flexibility and environmental friendliness

Reduce time and cost to deliver and deploy projects

- Platforming & integrated suite of tools
- Extensive use of lab optimization, simulation and automation

Reduce Cost to sustain systems over their life cycle

- Common platforming implementation across signaling subsystems
- Hardware and/or software modularity

Effective maintenance with reduced revenue service impact

- User friendly tools, embedded asset identification & diagnostic capabilities at board level
- Early system degradation detection capability

Energy efficiency

- Components designed for low energy consumption
- Energy optimization functionalities and embedded metering capabilities

GE imagination at work

www.getransportation.co
m

Inputs from GE

On

Draft_Report_of_MOUD_sub-committee_on_signalling-29-11-2012 (2)

Introduction

The following is information which should be considered based on many years of experience of people who worked on Train Control solutions including CBTC. The people were involved in the development of many CBTC solutions from different Train Control suppliers. The people giving inputs were also directly involved in the Modurban Group discussions, and the interoperability efforts both in New York and Paris.

CBTC architecture and interfaces

The architecture of a CBTC system is similar regardless of the supplier. The system is based on the continuous communication between the train and the wayside.

Although many discussions have taken place to establish that ideally the ultimate way to do CBTC would be to have all intelligence located on board the train (basically having intelligent train would mean having trains which know its position, the positions of all trains around it, and it will ultimately make all decision on its Movement authority Limit). The challenge is in reaching global agreement among suppliers mainly because no one supplier wish to re-design their solutions. Therefore the architecture is to have a train which sends its position to the way side (Zone Controller), then the Zone controllers collect all trains position and provide each train its movement authority Limit (MAL). Following this move, each train will then determine their performance curves to achieve this MAL.

The interface with the ZC and the IXL (Interlocking) is vital to establish a routing, and then the interface with the ATS will be critical for different aspect including the time table operation.

GE’s view is that below should be **promoted and encouraged** to achieve **some level of inter-operability**:

a) A form of interoperability which will help the end customer eventually, and an architecture that will promote **generic interface**
b) CBTC solution should be designed to be able to **interface with any ATS system** from any supplier; it should have the ability to integrate any interlocking into its design from any supplier.
c) CBTC Solution should be able to **interface with any DCS system** which can be provided by any supplier.

Interoperability

The document Draft_Report_of_MOUD_sub-committee_on_signalling-29-11-2012 (2) mention two efforts to reach interoperability. The two efforts done by NYCT and RATP were motivated by different reasons.

NYCT is motivated to have interoperability because they use all their trains on any lines which means that they need to have their trains equipped in such a way that they will be able to operate in any lines. Of course having interoperability is a good target to achieve, but is not necessarily achievable or realistic. NYCT has no in house signaling team or strong capability and this is why they chose to give to suppliers the task to identify the interfaces.

The suppliers being motivated by the desire to protect their market have invested efforts to protect the interfaces and design to ensure that no one could come into their market in an easy way. This is the main reason that the NYCT goal to achieve interoperability came with a very high price and has not met the objectives which were originally identified.

The RATP approached the interoperability in a different way. The RATP do not move trains from one line to the other under normal circumstances. It only moves train from certain lines to others when they move trains to a depot and have to route the train via another line. The RATP has a very strong signaling engineering team as part of their organization. This permitted them to design the interface themselves therefore avoiding the difficulties which were met in NY. The OURAGAN project was much more successful than NYCT because of the fact that RATP has internal Signaling capability to control the suppliers and their desire to protect the market.

Now the comment made at page 57 of the report to the effect that India should monitor what is happening in NY and Paris for interoperability, we would say that unless in India the operator wish to move trains from one line to the other, there is no need for such an approach in India. What should be considered is the **separation of the Interlocking, the ATS and DCS from the main body of CBTC**.

Sourcing in India

We believe that sourcing in India is a good target to aim for in the long-term and size of the market will drive that. The items which should be targeted to be sourced in India would be:

a) Any component such as **axle counters, switches, Point Machines, track work, racks, cables**, etc…
b) **Interlocking design** including **lighting protection**, **cabling**, **racks**, **bungalows**
c) Installation
d) **Equipment staging**, **testing**, **commissioning**,

We agree with the text in the document that eventually the size of the market will be a motivator for any supplier to move the technology in India. However we do not agree that the design cannot be made in India; we believe that some **design** can be made in India including **interlocking design**, **power interconnection, communication, SCADA, and more**.

By experience it may not be appropriate to expect an Indian based supplier to design a new CBTC de-novo system. Traditionally it takes a large investment and approx. 7 years on average to design a CBTC solution.

ETCS/CBTC common base

In South Africa, it has been discussed to use both solution CBTC and ETCS, onto the Gautrain. The main reason is the operation of the main line train system into a tunnel with more density train movement in this restricted space. The approach was to use **ETCS on the main line, and CBTC on the tunnel** or approach to the city.

Such approach in our view will be more and more viable because of the integration of the global transit system into a city operation. The same consideration is discussed in London for the Transport for London projects.

It is recommended to include in any **system which has the slightest possibility to use both**, in preparation for such operation. Train control systems should have the capability to have both onboard a train system which will be a significant advantage operators.

Data Communication System or DCS

The communication between the train and the wayside in the CBTC system saw its origin in the LZB system which was used in Germany in the late 70s.This was the origin of the loop based communication. The communication was probably 48KHz from loop to train and 54KHz from train to loop. The loop was formed of two copper cable located in between the tracks and which were crossing every 25 meters. This cross over resulted in a change in polarity of the signal which was the source of localization of the train.

In early 2000 other suppliers used leaky cable and specific radio for the communication train/wayside, and a few years later in Las Vegas, suppliers commissioned a system with a WiFi 208.11 ISM band system.

The **Wi-Fi system** using 208.11 is a very safe system to use for the CBTC communication and can/should be standardized. However futuristic solutions can be designed to use LTE DCS system which will provide a much wider bandwidth which will provide the capability to transport much more information or / and intelligence. The only drawback using LTE is the requirement to have a dedicated licensed frequency and if Metro authorities in India can work with Government of India for using **LTE** for public transportation; that should be standardized to take full advantage of the latest communication technology.

It is recommended to have an official LTE frequency devoted to train operation in India. In France, the RATP is applying pressure on the French Frequency management authority to have such dedicated frequency.

We would recommend usage of industry standards and protocols such as Euroradio and IP, UDP, TCP, SDH and Ethernet etc.

Focus on Life Cycle Cost

Since the objective of this effort is to eventually reduce cost of ownership of the system, we would also like to give few below suggestions beyond standardization and inter-operability to help Metro authorities reduce overall cost of ownership of CBTC systems and should be encouraged while evaluation to encourage suppliers to leverage latest technologies:

a) Hardware design methodology adopted by suppliers to reduce inventory
b) System should be designed in such a manner that it improves maintenance and asset management efforts, time and cost.
c) Energy efficiency
d) Re-Engineering efforts for any changes in the scope of change in infrastructure
e) Encourage architectures which lowers life cycle cost of the equipment
f) Encourage new but reliable suppliers to bring in innovation in this technology to India

We hope you will find these inputs useful for the purpose. Let us know if you need any more information.

Thanking you and assuring you of our best services.

Sincerely Yours
For GE India Industrial Private Limited
(Transportation Division)

Sanjeev Kumar
Sales Director - ITS

The Institution of Railway Signal Engineers Inc

Australasian Section Incorporated

Many Railways, One System – The Future with CBTC

Mircea P Georgescu
Product Strategy Manager
Thales Canada, Transportation Solutions

SUMMARY

Signalling is a conservative industry and has a cautious approach to adoption of new technology. Traditional signalling uses fixed blocks for train separation, leading to restrictions on train movements and line capacity. Communications Based Train Control (CBTC), developed in the 80's, introduced moving block technology, providing improvements in capacity and allowing a fully automated operation. Recent developments have provided further reductions in hardware costs, reducing energy consumption and increasing system reliability. With advancements in standardisation and demand for interoperability, driven by major operators in New York, Paris and Shanghai, the future of CBTC is now.

1 WHAT IS COMMUNICATION BASED TRAIN CONTROL (CBTC)

Rail signalling systems for transit use have evolved over the past 100 years, in response to ongoing advances in technology, and increasing user requirements as they realized that new levels of performance were available.

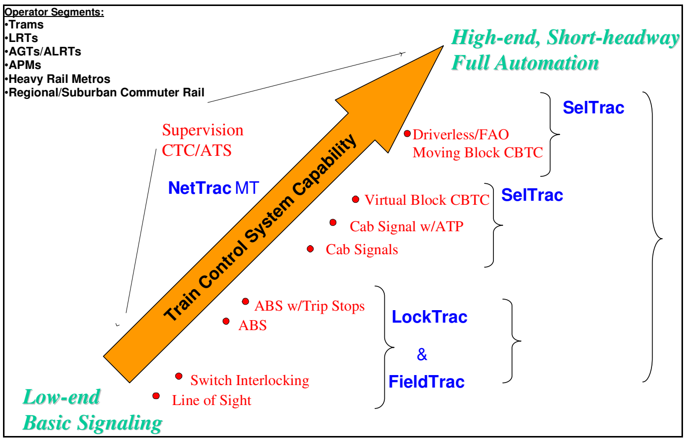


Figure 1 : Signalling Evolution

As well known, rail signalling, necessarily, a conservative industry, driven first and foremost by safety has led to a cautious approach in the adoption of new technology.

The traditional railway signalling is a fixed-block signalling technology using one-way communication from wayside to train and physical blocks define train detection resolution, as shown in Figure 2.

The separation of trains by fixed-blocks restrict train movement and line capacity Born in Toronto Canada, in the 80's, CBTC was a new, and disruptive, technology that has become the standard for more and more types of rail signalling applications. It introduces the moving block technology, as shown in Figure 3, providing a higher level of safety and operational flexibility with significant lower life cycle cost

1.1 CBTC the High End Automated Train Control

Industry members now unanimously recognize that the hierarchy for automated train control (ATC) systems is defined as Unmanned Train Operation (UTO), Driverless Train Operation (DTO), and Semi-automated Train Operation (STO) equivalent to the definitions in IEC 62290-1 (GAO2, GAO3, GAO4). Both UTO and DTO are also referred as Driverless operation.

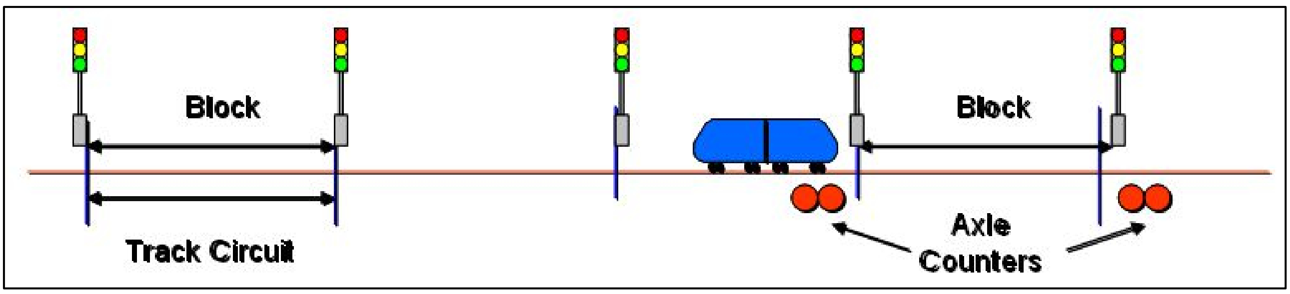


Figure 2 : Traditional Block Signalling

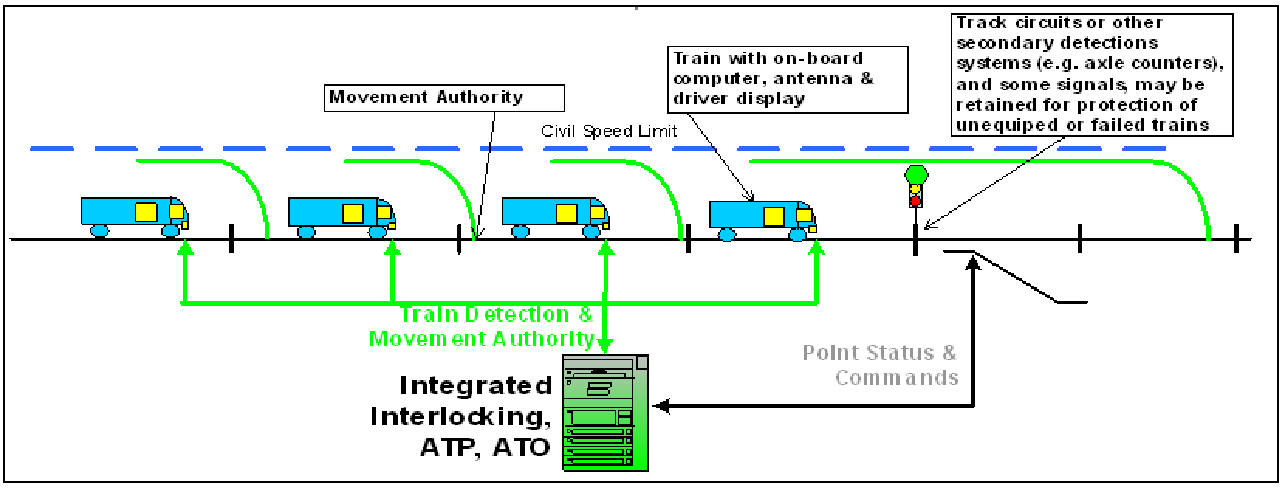


Figure 3 : Moving Block Signalling

IEEE 1474 defines CBTC as: Determination of train location, is to a high degree of precision, independent of Track Circuits; Continuous, bidirectional, train to wayside and wayside to train data communications, which can provide significantly more control and status information than is possible with a track circuit based system; Wayside and train-borne vital processors to process the train status and control data and provide continuous automatic train protection (ATP), Automatic Train Operation (ATO) and Automatic Train Supervision (ATS) functions.

Modern systems include sophisticated central control (i.e. ATS or System Management Centres) requiring few operators as many functions are automated.

STO has a driver in the cab who is responsible for safe departure of trains from stations, while the train drives automatically between stations, often with automatic turnback functionality. The driver observes the guideway for any hazardous condition, and will stop the train if a hazardous situation is observed. Train acceleration and braking is automated and the speed is supervised continuously by the system. The driver communicates with passengers and is part of the failure recovery strategy.

With DTO, a driver is not required in the front of the train to observe the guideway for hazards. There is, however, operations staff on board. Safe departure of the train from the station, which includes train door closing, can be the responsibility of the operations staff or may be done automatically.

With UTO, operation staff is not required on board the train. Safe departure of the train from the station, including door closing, is done automatically. As well, additional systems (such as Guideway Intrusion Detection, and platform and on-board CCTV) are usually installed to support the detection and management of hazardous conditions.

2 CBTC IMPLEMENTATION IMPACT ON SUBSYSTEMS

To implement CBTC, especially with driverless operation capability, design changes to several key traditional train control and auxiliary subsystems are required.

2.1 Rolling Stock

It is critical that fault indications, particularly with regards to safety, are communicated in real time to the central control operator. The typical faults that are supervised by central (mandatory condition), are: dragging brake, motion obstructed, fire/smoke, low air pressure, park brake, slip-slide, doors status and train integrity.

Train Management System (TMS)/Health Monitoring Unit (HMU) information may be transmitted to central control and/or the maintenance shop via a separate non-vital communications link, not necessarily in real time, but still in a timely manner to trigger required unscheduled maintenance activities. It is acceptable that such information is sent via intermittent communication, e.g. downloaded from the train at each station.

Automatic train control of propulsion and separate control for service, park and emergency brakes including revocable emergency braking are introduced. Variable brake rates are implemented by the vehicle at ATC request.

Automated Speed Control is no longer a driver attribute. Sophisticated algorithms ensure jerk limitation and ride quality together with adhesion (slip-slide) monitoring and compensation.

Door control with or without train operator involvement, door recycling, as well as reaction to ‘door status lost,’ will also change. This requires on-board equipment to vitally supervise indication of propulsion disabling and brake status to allow the doors to open.

Redundant on-board ATC equipment should be installed. This includes remote reset capability used to restore redundancy, in a timely manner.

2.2 Wayside and Trackside Equipment

Traditional ancillary equipment is not required for true CBTC systems. This has a direct impact on capital cost, reliability/availability and O&M cost. With true CBTC systems, ‘alternate train presence detection’ subsystems, based on track circuits or axle counters become an operator choice, not a requirement.

2.3 Infrastructure

If correlated with CBTC, the civil guideway design can be optimized to achieve significant cost savings in the capital investment. Running shorter trains at lower headway has a positive impact on platform length determination.

CBTC allows for shorter end-of-guideway safety distances, which again lowers capital investment. New sections of guideway can be designed to allow significant cost savings.

Rear station turnback in conjunction with guideway and vehicle dependent safety distances results in shorter tunnels at the end of guideway.

Front station turnback design will further decrease infrastructure costs. In conjunction with automatic operation and an efficient alternate platform routing algorithm, the headway will remain the same as achieved by the rear turnback.

3 SATISFYING OPERATOR DEMANDS

Major urban rail operators will tell you that their vision is to continually lower life-cycle costs of technology and operations while attracting more customers and serving them effectively. CBTC enables operators to achieve the benefits of fully automated, driverless operation in particular, provides an automated response to short-term service peaks or disruptions due to passenger surges from planned or unexpected events.

The pioneering Vancouver SkyTrain opened in January 1986. Operated by BC Rapid Transit Co, it is recognized for its high service frequency and availability, having carried more than 1 billion passengers in a quarter century of unattended train operating mode. It has an integrated architecture which includes a systems management centre, wayside vehicle control centers, switch machines and on-board controllers.

Communication is bi-directional via loop laid between the rails. Moving-block technology permits short distances between trains and safe stopping. Its automated depot functions include automatic coupling/un-coupling and train starting functions.

The routine storage of some trains in main line pocket and tail tracks, overnight as well as during daytime o -peak hours, provides a virtual extension of the depot, enhancing the response to delays or changes in demand, while reducing unproductive mileage.

More and more operators appreciate the integrated technology concept applied in 1986 to the signalling on the Vancouver SkyTrain installed on various new-build projects including Hong Kong's West Rail Line in 2003.

The next challenge was to apply CBTC to resignalling existing lines, which entailed altering long-held perceptions of signalling engineers. Thales' initial experience of retrofit projects was on the Docklands Light Railway in London in 1995 and the Market Street tunnel on San Francisco's Muni Metro in 1997. Both are attended ATO operations, using basically the same architecture as Vancouver's SkyTrain.

4 RECENT DEVELOPMENTS

Recent practical developments have addressed aspirations for a next-generation CBTC that provides further reductions in hardware costs and increases reliability. These include direct-drive technology; integration of functionality; the elimination of secondary train detection subsystems such as track circuits or axle counters; flexible location processors; and radio technology.

Direct-drive employs precision electronic components to manage current flow to signalling equipment in preference to conventional signalling relays, which are comparatively expensive to maintain. Thorough vital electronic designs ensure appropriate buffering and protection against voltage spikes.

Large numbers of expensive relay racks can now be rationalized into a couple of electronic racks. Thales has recently pioneered a number of direct-drive variants for both switches and signals, eliminating the need for vital interface control relays and reducing capital and operational expenditure.

Global disparity in field element control circuit designs is extensive, as many railway authorities have developed their own designs for signal or point control and detection. Thee equivalent custom built direct-drive product is able to provide significant savings.

The integration of functions in wayside zone controllers, as designed for the original CBTC in Vancouver, is attracting interest due to its robustness, reduced interface management requirements and life cycle cost effectiveness. Zone controllers are responsible for safe train separation. They provide interlocking functionalities for genuine moving-block operation, determining the limit of movement authority that is transmitted to the train via the data communication system. They also ensure ATP and ATO, receive location reports from trains in territory and interface with neighbouring zone controllers. The zone controllers also manage platform door interfaces and other station equipment.

5 REDUNDANCY

When applying CBTC, there is a growing trend for operators to forego secondary train detection equipment as unnecessary. Such equipment inherently presents fixed-block constraints which adversely limit CBTC performance because of the need to over-ride the fixed-block logic and provide algorithms to overcome track circuit failures.

CBTC installations have proved over the last 25 years that microprocessor redundancy - two out of three or hot standby configurations — eliminates the need for fall-back signalling based on track circuits. Redundant microprocessors perform comparisons of all vital outputs and inputs, and checked redundancy and diversity is built into all vital subsystems. Thee current levels of safety and reliability achieved by all of the top-tier CBTC suppliers make secondary systems justifiable only for applications with heavy mixed-mode operations where some of the trains are not equipped for CBTC.

Powerful modern processors enable location and relocation of functions on board or on the wayside. They provide an improved rate of real-time data processing versus off line calculated hard-coded parameters, resulting in optimised performance, better system response time, flexibility and effective software upgradeability. However, the life expectancy of modern electronics is far shorter than what is expected for signalling systems, and suppliers are challenged to present a clear maintenance and backwards-compatible upgradeability path that is seamless for the operator and manageable by the maintainer.

Communication between train and wayside has also evolved since ales implemented the first non-proprietary, free-space, wireless radio on the Las Vegas monorail in 2004. We have now successfully deployed similar open-architecture signalling on the Hong Kong Disneyland Resort Line, Washington's Dulles Airport APM, various lines in Shanghai, Beijing and Seoul Sin Bundang Line, with more to follow on the New York, Edmonton and in Incheon.

Although communication media is a commodity, operators are interested in further improvements to radio technology for wayside/train communication, maximizing the use of the available bandwidth by sharing it with non-ATC functions. Higher bandwidth, which allows more two-way data to pass between wayside and vehicle, offers the potential to introduce additional features such as on-board security surveillance, more health monitoring and proactive maintenance data, passenger information and audio/video transmission.

Operators dream of simplified systems to mitigate risks and implementation time, prompting the evolution of interface interoperability standards. However, there is still some resistance among signalling engineers to mixing vital and non-vital signals on the same carrier.

6 AUTOMATED CONTROL CENTRES

Improvements in efficiency and reduced life-cycle costs are also visible within the Operating Control Centre environment. Several operators have integrated CBTC and other supervision systems, including SCADA, onboard and platform passenger information, security and fire safety systems, which provides opportunities for integrated communications suppliers.

Failure management tools, common with CBTC operations, are now available to address equipment which lies outside the scope of ATC failures. The modern control centre provides 'global situation awareness' as well as all the advantages of automation and decision support. It has to be open to new applications without the need to upgrade or modify existing applications. Dealing with many suppliers normally raises concerns about interface issues, so the modern integrated control centre is built to comply with international standards for interfaces and incorporates architecture that enables integration of all types of applications, which can easily be upgraded or replaced.

Operators are now focusing on energy use. 'Greening' initiatives are in hand to optimise regenerative energy, which needs real-time balancing of deceleration of one train with acceleration of another, or a base load of station services, and to apply coasting techniques to reduce energy usage. Energy consumption on railways resides 60% rolling stock on braking and traction functions.

Due to its nature, low level train control dynamics, CBTC opens the door for multi objective optimization adding punctuality, regularity and travel time, which means that energy savings are provided without performance degradation.

7 STANDARDIZATION

Finally, we face the ongoing issue of standardization, which some believe will eventually happen. The impetus for this came from major operators in New York, Paris and Shanghai, who demanded signalling interoperability. The IEEE Working Group 2 has been examining this topic since 1999. In addition, suppliers and operators participating in the EU Modurban research project, which finished in 2008, focused on developing a jointly-agreed architecture.

If all CBTC systems and subsystems were the same, operators would be able to buy 'plug and run' technology from any supplier, as telecommunications operators can. From a supplier perspective, standardisation of requirements is necessary first step. Interoperability is not an inexpensive proposition and must be justified by a business case on an individual basis. An operator must make a long-term commitment to any interoperability programme, incorporating open standards and de-coupled radios, for such a strategy to be viable. Thales current product architecture is capable of interoperating with other CBTC systems, which is a positive step towards standardisation.

Will standardisation be achieved? In order to succeed, operators must agree on common functional requirements, there must be a proof of safety in a multi-supplier environment and cross-acceptance of safety proofs among operators.

CBTC is a highly competitive marketplace, and suppliers are under pressure to supply more and better. Those who demonstrate cumulative expertise in integrated communications and signalling innovation may have a certain edge over other suppliers. However, in addition to innovation and breadth of offering, delivering the project as contracted remains a critical factor.

7.1 Mainline Initiatives

In the 80's CBTC has evolved from the German mainline LZB, when ITT, now Thales, have developed the moving bloc technology based on bi-directional communication.

In Europe, the efforts for standardization and minimizing costs have developed ETCS which is in fact an automatic train protection system, based on cab signalling and spot and/or continuous track to train data transmission. It ensures trains operate safely at all times in providing safe movement authority directly to the driver through the cab display and in continuously monitoring the driver's actions. Now, at ETCS Level 2 the system is quite far of bringing all CBTC advantages, but on the roadmap, ETCS Level 3 will provide full CBTC capabilities.

In North America PTC initiative tries to provide similar train control, automated train protection and standardizations of all functions.

8 WHAT NEXT?

As demand has grown, qualified signalling suppliers have progressed over the past five years to provide their own versions of CBTC. But operators now want more. So where does CBTC technology go from here?

Although they perceive the benefits of improving CBTC design and upgrading its technology, major operators usually demand proven systems.

The solid-core CBTC design for unattended train operation, with its moving block technology that allows fully automated operation, has not changed drastically over the past 30 years. However, advances in subsystem technologies and faster processors continue to play a major role in meeting operators' growing demands for unattended (UTO), driverless (DTO) and semi-automated (STO) operations.

Maximizing performance can be challenging when CBTC is applied to an STO, as is the case in Shanghai, since it requires flexibility of design, while maintaining core functionality, to operate with external interlocking.

Since its adoption in the early 1980s, delivering increased safety and significant lower life cycle cost, CBTC has become the technology of choice signalling for transit operators the world over. It was first accepted for light rapid transit to medium-sized automated metros, but over the past 15 years all major operators have also started to upgrade their networks to CBTC from light rail to commuter lines. There is no doubt that the mainline modern signalling, call it European ETCS or North American PTC evolves to full CBTC either. The CBTC future is now.

AUTHOR

Mircea P. Georgescu

Mircea P. Georgescu obtained his Masters in Electrical Engineering, with a major in Automation and Computers, from Politechnica University in Bucharest, Romania.

He has spent over 30 years working on railway signaling projects, from conventional signaling to wireless Communications-Based Train Control (CBTC).

He started off as a project engineer for the first east European mainline control centre (dispatcher) to use a computer network.

Mr. Georgescu went on to become a major contributor of vital software development, and system field integration for many of Thales projects including San Francisco MUNI.

He was the design authority on the upgrade and extension projects of the Vancouver SkyTrain and JFK AirTrain.

Most recently he was the Product Solution Manager for Thales's flagship CBTC product, SelTrac, and he is presently the Product Strategy Manager for SelTrac Train Control Solutions.

His CBTC professional articles were published by Metro Rail International, IEEE and International Rail Journal. He was speaker and or panelist at several Metrorail, APTA, UITP, CompRail and APM conferences.

IRSE INTERNATIONAL TECHNICAL COMMITTEE

IRSE SEMINAR ON COMMUNICATIONS BASED TRAIN CONTROL

Written and edited by Alan RUMSEY, IRSE-ITC on behalf of the International Technical Committee of the IRSE

Summary

The mission of any metro transportation undertaking is to provide safe, reliable, efficient, high quality service to its passengers in a cost effective fashion. To meet this business need, our metro systems are increasingly being automated. Any new metro system constructed today would almost certainly incorporate some level of automation with many modern metro systems now providing driverless or unattended train operation. In addition, higher levels of automation are also being introduced into the older metro systems around the world in response to demands for increased capacity on the existing infrastructure, enhanced levels of safety, improved customer service, and reduced operating costs.

This article examines the benefits of automation, the various levels of automation that can be deployed, the maturity of the technology, and the challenges of selecting the appropriate level of automation for a specific application. The article focuses on automation of metro systems. Automation of our intercity main lines, high speed railways, and freight lines will be addressed in a separate article.

The Benefits of Automation

Metros are an expanding business with many existing metros operating at or near to their capacity limit. Given the often prohibitively high costs of constructing new metro lines or extending platform lengths, the benefits of automation are therefore invariable linked to maximizing the operational performance of the existing or planned transportation infrastructure. The characteristics of automation that support this goal include the following:

a) Automation of the train driving functions can provide for more regular and predictable run times between stations, eliminating the variations inherent with manual driving, and providing for a more uniform ride quality and reduced wear-and-tear on train propulsion and braking systems

b) Driverless/unattended train operation, with automatic passenger door opening and closing and automatic train departure from station platforms, can further reduce the variations in line operation

c) Unattended train operation also frees the metro operator of the constraints imposed by the need to provide for the rostering of train crews and provides the flexibility to operate shorter trains more frequently. Unattended train operation, when combined with fully automated maintenance yards and stabling tracks, also provides the flexibility to respond to unexpected increases in passenger demands by adding additional trains to the service, all without requiring additional train drivers or manual intervention

d) While automation can reduce operating staff costs, the reductions in cost associated with a reduction in train drivers have to be offset by any increase in staff costs for any additional passenger service and security personnel, as well as any additional maintenance costs associated with the automation system itself

e) Automation of turnbacks at terminal stations can reduce turnover times, reducing the number of train sets needed for operation

f) Automation of train regulation, train dispatching and train routing functions can more effectively regulate the performance of trains in relation to timetable (schedule) and/or headway adherence. Regulation can be achieved by automatically adjusting dwell times and/or by automatically controlling run times between stations (e.g., through adjustments to train acceleration and service brake rates, and speeds)

g) Automation of train regulation functions can also facilitate appropriate train meets, such as transfers between local and express tracks, and at the merge point between different lines in order to minimize overall system delays

h) The automatic, real-time control and coordination of train acceleration, train coasting, and train braking can also be utilized to implement energy optimization algorithms for example though coasting controls or by synchronizing the acceleration of one train with the braking of another train to maximize use of brake energy recovery

i) Automated failure detection and response can be more effective in responding to system disturbances and emergencies through the elimination of human error

While subjectively the benefits of automation may be self evident, quantifying these benefits in order to develop a specific business case is very application-specific and dependent upon the particular level of automation that is adopted.

Levels of Automation

The first step in automating any metro system is the automation of the primary safety functions through continuous, automatic train protection (ATP). With this foundation in place, the driving functions themselves can then be automated through the provision of automatic train operation (ATO). With the driving functions automated, real-time automation of the train management and train regulation functions becomes possible, through more sophisticated automatic train supervision (ATS) systems, providing operational benefits at the line/network level.

The term ATO is used to cover a wide range of levels of automation, from the automation of the basic driving operation alone to the running of trains with no staff member on board. An IEC working group (TC9 Working Group 40) and the European MODURBAN project have therefore adopted the concept of levels of “Grade of Automation” (GOA), with GOA level 1 being ATP only with no ATO (ref. IEC 62290-1).

At its most basic, ATO enables trains to run automatically from one station to the next, under the protection of an ATP system and under the supervision of a train driver. This mode of operation is referred to as Semi-automatic Train Operation (STO) or GOA level 2. With STO, the operation of the train's motors and brakes is automated providing a more consistent form of driving with fundamental benefits to the railway in terms of capacity and energy consumption. Typically, the driver remains in the cab of the train, operates the doors, provides the start signal for the train to leave a station, and monitors the performance of the train and the track ahead.

More sophisticated systems free the driver from the need to be at the front of the train – referred to as Driverless Train Operation (DTO) or GOA level 3. In DTO the driver is able to move away from the front of the train, but remains available to provide customer facing duties and to drive the train in the event of a failure of the ATO system. As the driver is no longer able to see the route ahead this imposes a greater demand on guideway security and platform controls. In DTO, train doors and train departure from a station platform may be controlled automatically or manually from a location other than a drivers cab at the front of the train. The increased flexibility that derives from freeing the train service operation from having to provide a driver at the front of each train means, as a minimum, that the time that would be required for a driver to walk from one end of the train to the other when reversing can be saved, thereby increasing the throughput at terminal stations and sidings.

Driverless ATO without an on-board attendant is referred to as Unattended Train Operation (UTO) or GOA level 4. UTO can range from empty train movements only (to a siding, or in an automated depot for example) to the operation of trains in passenger service with no attendant on board. The latter requires that the train can be operated remotely under failure conditions, or at the minimum can be reached by shore based personal in a short period of time. Passengers need to be reassured and hence good communication links between the vehicle and an informed staff member are essential. Automation of the door operation is now mandatory and requires means of detecting trapped articles of clothing or children. Increased protection of the guideway from intrusion or some form of obstacle detection is also required. Apart from the savings in staff costs the greatest benefit with unattended operation is that train service can be tailored directly to demand with trains being brought into service as and when the demand increases.

The benefits of the various levels of automation are summarized in the following table:

Benefit	STO	DTO	UTO
Automatic Train Protection (ATP)	√	√	√
More predictable run times between stations	√	√	√
More uniform ride quality	√	√	√
Reduced wear-and-tear of train propulsion/braking systems	√	√	√
Energy optimization	√	√	√
Reduction in variations in line operation / improved service regulation		√	√
Automation of turnbacks		√	√
Remove constraint of rostering train crews			√
Flexibility to operate shorter trains more frequently			√
Ability to respond to unexpected increases in passenger demands			√
Potential for reduction in operating costs			√
Automated failure detection / response			√

Whilst signalling and train control systems provide the foundation of an ATO railway, it is improvements in the security and communication systems that are the main difference between traditional manually driven trains and driverless or unattended operation. UTO for example typically requires the addition of passenger operated plungers on stations and trains to summon help in an emergency, extensive CCTV with links to a manned control centre, obstacle detection systems, and automatic platform area supervision to detect persons on the track. As an alternative to intrusion detection systems, platform edge doors may also be used to prevent access to the track in platform areas.

An IEC working group (TC9 Working Group 45) has recently completed a document addressing the safety requirements for fully automated (driverless/unattended) metro systems which should be released as an official IEC standard (IEC 62267) by late 2009. This document specifically addresses safety aspects applicable to driverless systems and does not include functions that would be the same whether or not there is a driver onboard the train (e.g. interlocking functions). In addition, the safeguards that are recommended in this standard to mitigate identified generic hazards may not apply in all situations and the metro authority and specific regulatory regime has the ultimate responsibility to determine, through hazards analysis, if a given safeguard is required.

ATO Technology Maturity

ATO can be superimposed on any form of continuous supervision-based ATP and as a consequence the introduction of ATO on urban mass transit railways was closely linked to the transition from wayside signalling technology to cab-signalling technology in the latter half of the last century.

London Underground's Victoria Line, which entered service in 1968, is generally regarded as the first ATO metro line. The Victoria Line signalling is based on fixed-block technology and the train driver closes the train doors and presses a pair of "start" buttons to depart a train from a station platform. If the way ahead is clear, the ATO system drives the train at a safe speed to the next station and stops there. The Victoria Line would therefore be classified as semi-automatic train operation (STO). The only other STO line on the London Underground currently is the Central Line which introduced ATO as part of a major upgrade of the line during the 1990's. The simultaneous renewal of trains and signalling - and the introduction of ATO – was introduced to make the best use of the Central Line's capacity and provide important benefits for passengers in terms of more frequent trains, greater comfort, shorter journeys and improved reliability. The implementation of ATO on other lines in the London Underground network is currently underway.

Similar STO systems appeared in the USA in the late 1960's with the PATCO (Port Authority Transit Corporation) Lindenwold line in Philadelphia in 1969, the San Francisco/Oakland BART system in 1972, the Washington Metro (WMATA) system in 1976, the Atlanta Metro (MARTA) system in 1979 and the Miami Metrorail in 1984, for example. The Hong Kong MTR system also adopted fixed-block STO technology when that system first entered service in 1979. Metro Madrid automated its first line, Line 7, in 1996 and has subsequently automated the majority of its other lines with STO.

In all ATO applications the basic principle is to provide a command to the train's propulsion and braking systems to cause the train to drive at a speed below the safe speed limit, with ATP enforcing the speed limit through the train's emergency brakes should the train attempt to exceed the safe speed. ATO functions may be implemented in equipment independent of the ATP equipment, or may be integrated with the ATP equipment.

The initial ATO applications used fixed block, coded track circuit technology with "speed codes" to indicate the maximum enforced speed. ATO functionality can also be provided with fixed block "digitally encoded", profile-based track circuit technology as well as Communications-Based Train Control (CBTC) technology which can support moving-block operations through continuous train-to-wayside and wayside-to-train data communications, and train location determination that is independent of track circuits.

The first example of semi-automated train operations (STO) using CBTC technology was the Scarborough RT line in Toronto which entered service in 1985. Other examples of STO utilizing CBTC technology would include, for example, San Francisco MUNI (1997), Ankara Metro (1997), Kong Kong KCRC West Rail (2003) and New York City Transit Canarsie Line (2006).

The first examples of unattended train operation on a metro line, with no person aboard (UTO), were in Kobe (Japan) in 1982, Lille (France) in 1983 and Vancouver (Canada) in 1985. The Kobe and Lille systems were based on fixed-block technology whereas the Vancouver system utilized CBTC technology. Other examples of UTO utilizing CBTC technology would include, for example, Lyon Line D (1992), Paris Meteor Line (1998), Kuala Lumpur (1998) and Singapore North-East Line (2003). Examples of UTO based on fixed block technology would include Osaka (1982) and Copenhagen Metro (2002).

An example of a driverless train operation but with an onboard attendant (DTO) would be the London Docklands system that first entered into service in 1987 with fixed block technology. In 1994 the line was re-signalled using CBTC technology to increase capacity in response to an order-of-magnitude change in forecast demand.

The examples above are not intended to be an exhaustive list of all ATO systems world-wide, but rather to demonstrate the widespread application of ATO technology over the past 40 years, and to provide an indication of the significant maturity of this technology.

Selecting the Appropriate Level of Automation

While ATO technology is certainly mature, and there are many suppliers capable of providing a wide range of ATO systems, there is however currently no universally accepted methodology to determine the appropriate level of automation that should be adopted for a specific metro application. When selecting the level of automation for a new metro line, or when upgrading an existing metro line, the desired operational performance and life-cycle costs should be two important starting points.

It is the operating authorities (and possibly local or national laws or regulations) that typically have the strongest influence on the selection of the appropriate level of automation. Operating authorities in turn often rely heavily on the experience of their own technical staff and/or on the advice of consultants contracted to assist in planning and development activities. Typically, the criteria for selecting a particular level of automation are more subjective in nature, rather than based on a systematic, top-down, business case analysis of the various alternatives.

The selection process is further complicated by a lack of unified standards to document and quantify the benefits of ATO drawn from world-wide experience. Selecting the appropriate level of automation is also often seen primarily as a “signalling” or “train control” decision, rather than considering the desired operating characteristics of the metro system as a whole.

Organized labour unions can also have a significant influence on the selection of the appropriate level of automation given concerns over potential job losses if train drivers cannot be retrained to take on the additional customer service or security functions that are typically required in driverless and unattended train operations.

There may be concerns that some passengers could be reluctant to ride on driverless or unattended trains and this can also influence a decision on the level of automation to be adopted. However this concern is seen to be more of a perception than a reality given the widespread acceptance of such systems by passengers around the world and the proven safety record of such system.

Conclusion

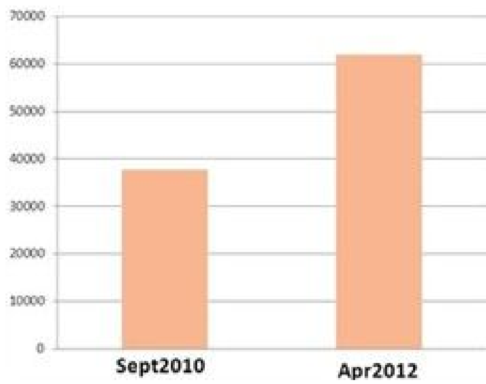
This article has highlighted the benefits and wide spread use of automation on metro systems around the world, and the trends towards increased levels of automation in the future. While this article has focused specifically on metro systems, surely it can only be a matter of time before the benefits of increased levels of automation on metro systems will similarly be realized on our main line and high speed railways.

ERTMS / ETCS Deployment statistics

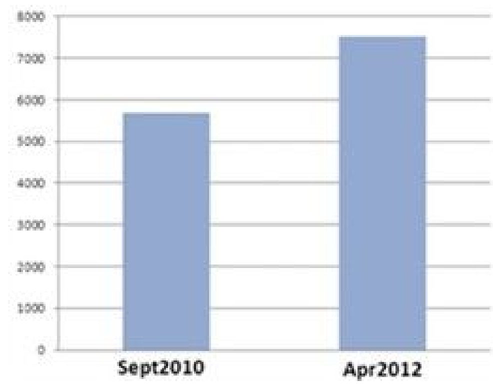
As on April 2012

The figures indicate the lines and rolling stock in operation as well as contract signed as per April 2012. Route and track length are expressed in kilometers, and include frame contracts whenever mentioned.

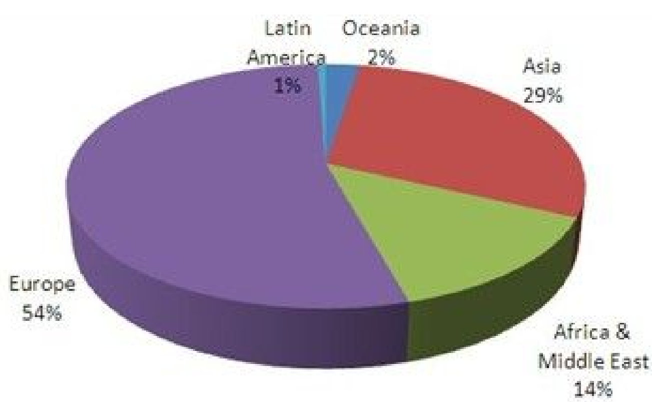
ERTMS DEPLOYMENT STATISTICS - OVERVIEW



ERTMS trackside contracts, in tracks km (excluding frame contracts),comparison September 2010 -April 2012

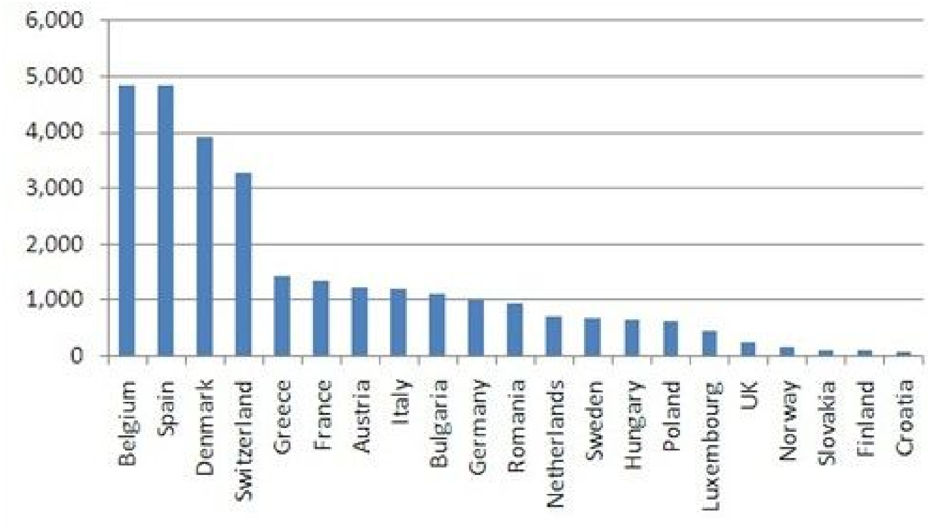


ERTMS onboard units contracted, comparison September 2010-April 2012

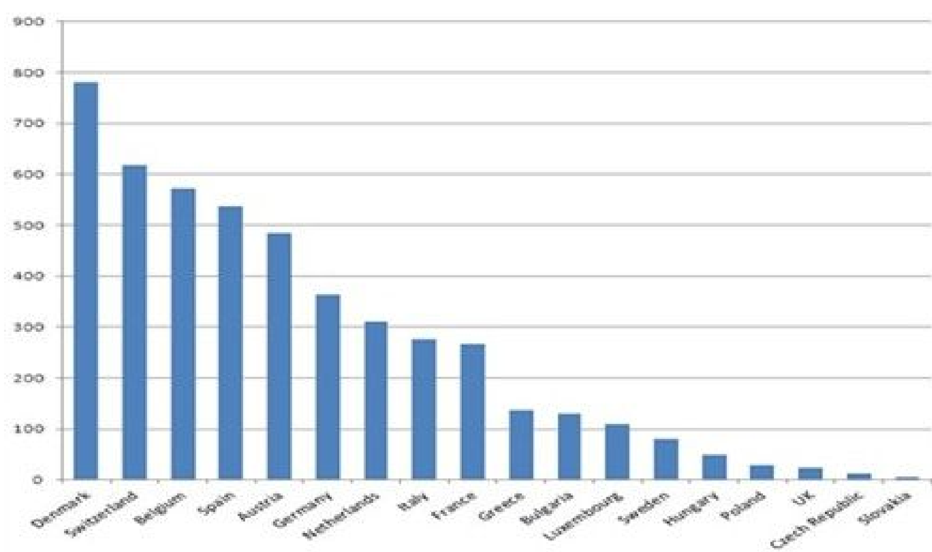


ERTMS trackside contracts, in percentage, by region

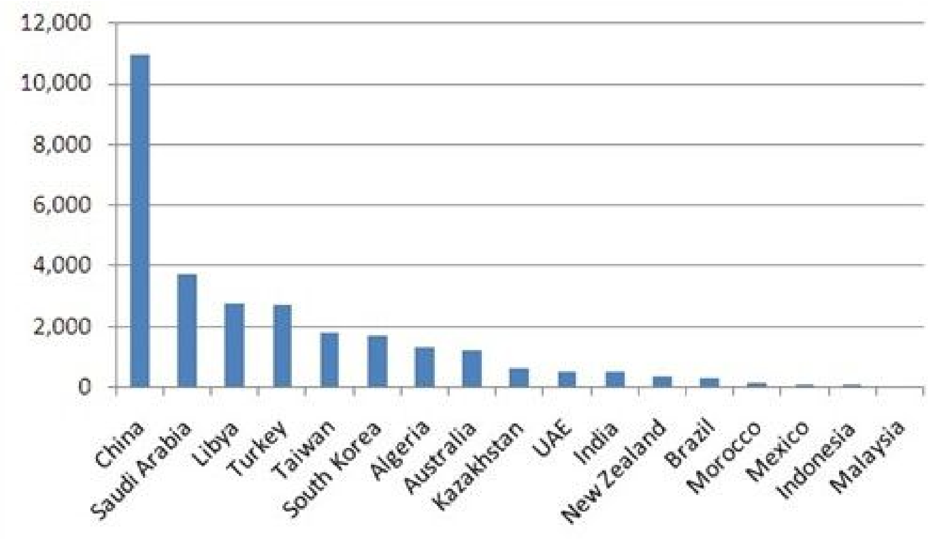
ERTMS DEPLOYMENT STATISTICS - BY COUNTRY



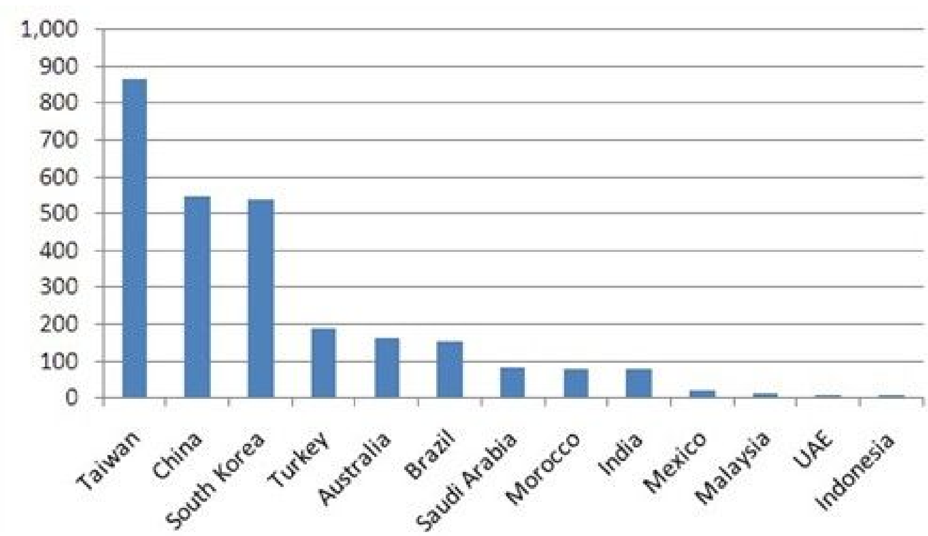
ERTMS trackside contracts, Europe, in tracks km (excluding frame contracts)



ERTMS onboard contracts, Europe, in number of vehicles



ERTMS trackside contracts, Rest of the World, in tracks km (excludingframe contracts)



ERTMS onboard contracts, Rest of the world, in number of vehicles

Statistics show that EU countries are gradually installing ERTMS on some of their train lines, countries outside Europe are also starting to embrace ERTMS as their train control system of choice. This is explained by the numerous benefits brought by ERTMS on top of interoperability. You can access the full list of ERTMS projects worldwide by visiting the projects part of the website.

The Application of ERTMS/ETCS Systems

Eddie Murphy

HND Engineering, MIRSE

Westinghouse Rail Systems Australia

SUMMARY

It is timely to provide an update about ERTMS/ETCS given that there is a trial application currently in progress with RailCorp in NSW and other states have also shown considerable interest. Though the ERTMS/ETCS system is well defined and enables interoperability of trackside and onboard technologies from different suppliers, there are some critical high level and many detailed application decisions that will impact on the railway network once the system is in service. Some of the main factors to be considered when applying ERTMS/ETCS into a railway network are:

- Network rules and procedures including safeworking
- Train operations
- Signalling principles
- Drivers and human factors
- Rolling stock
- Maintenance
- Capacity
- Migration

Many of the rail networks in Australia currently employ simple Train Protection technology e.g. trainstops, AWS and TPWS or in some cases have no train protection at all. It is a big step to go from this to a full cab signalling system that will fundamentally alter the way the system is operated. Railway organisations will therefore need to involve all stakeholders in the decision making process including Corporate Safety, Safeworking, Train Operations, Train Crewing, Drivers, Train Control, Engineering Standards, Rolling Stock and Signalling Maintenance and future capacity planning.

1. INTRODUCTION

ERTMS/ETCS (hereafter called "ETCS") is a train control system designed to replace all existing national systems on the Trans European Rail Network. It enables trains equipped with onboard units from different suppliers to operate freely over track equipped by the same/different suppliers. It consists of both onboard and trackside sub-systems, with a choice of transmission system for the communication between the two.

The functional and system requirements for ETCS are contained in two documents, the Functional Requirements Specification (FRS) and the System Requirements Specification (SRS). The FRS is produced by the operators (EEIG) and in theory is the base document for the creation of the SRS by the suppliers (UNISIG) but in some cases the relationship has been the other way round.

Different levels (STM, 0, 1, 2 and 3) have been defined to allow each individual railway administration to select the appropriate ETCS application trackside, according to their strategies, to their trackside infrastructure and to the required performance. These levels mainly differ in the trackside and communication systems that are used, and in which functions are processed in the trackside and in the on-board equipment respectively. The functionality from a user point of view is however very similar in all application levels. A line is always equipped to a specific ETCS level, with double equipping being possible.

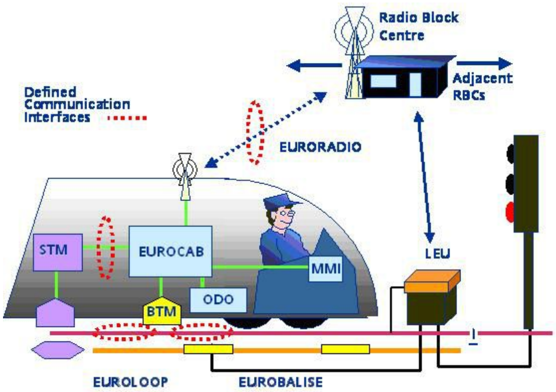


Figure 1 The ETCS system

ETCS is an advanced form of distance-to-go Automatic Train Protection (ATP) based on predictive speed profiles that reduces the likelihood and severity of a signal passed at danger (SPAD) as well as providing overspeed protection by ensuring that the train stays within the Static Speed Profile (SSP), but it can also supervise against other risks, such as track characteristics, power supply changes etc. It also provides a varying level of supervision under a number of degraded operating situations, as well as when shunting trains, running with multiple traction units etc.

For that purpose ETCS has defined a number of operating Modes. These modes define the exchange of information between ETCS and the train driver as well as how the responsibility of supervising train operation is shared between the two. An ETCS onboard unit always operates in a single mode, with transitions between modes taking place under well defined circumstances.

2. TERMINOLOGY

ATP	Automatic Train Protection
BTM	Balise Transmission Module
CBI	Computer Based Interlocking
DMI	Driver Machine Interface
EEIG	European Economic Interest Grouping
EOA	End Of Authority
ERTMS	European Rail Traffic Management System, composed of ETCS + GSM-R
ETCS	European Train Control System
EVC	European Vital Computer
FFFIS	Form Fit Functional Interface Specification
FIS	Functional Interface Specification
FRS	Functional Requirements Specifications
FS	Full Supervision driving mode
GSM-R	Global System for Mobile communications for the railway
JRU	Juridical Recorder Unit
LEU	Lineside Electronic Unit
Level	The different ETCS application levels (in short: levels) are a way to express the possible operating relationships between track and train, principally related to the trackside equipment used, to the way trackside information reaches the on-board units and to which functions are processed in the trackside and in the on-board equipment respectively
LS	Limited Supervision driving mode
LTM	Loop Transmission Module
Mode	Modes are operating states within the application levels that have a different split of operational responsibility between the driver and the ETCS system.
NL	Non Leading driving mode
OS	On Sight driving mode
PT	Post Trip mode
RBC	Radio Block Centre
RIU	Radio Infill Unit
RV	Reverse driving mode
SH	Shunting driving mode
SPAD	Signal Passed At Danger
SR	Staff Responsible driving mode
SRS	System Requirements Specifications
SSP	Static Speed Profile
STM	Specific Transmission Module
TIU	Train Interface Unit
TR	Trip mode (emergency brake)
TSR	Temporary Speed Restriction
UNISIG	The six ERTMS suppliers Alcatel, Alstom, Ansaldo, Bombardier, Invensys and Siemens

3. ETCS APPLICATION LEVELS

There are four application levels to be considered; levels 0, STM, 1 and 2. Level 3 is not currently being offered by the suppliers by mutual agreement in order to focus on the other levels.

3.1 ETCS Level 0

Level 0 covers operation of ETCS equipped trains running on lines or sections of a line not equipped with ETCS. For example an unfitted line being upgraded in stages will have already upgraded sections of Level 1 track with the yet to be upgraded sections as Level 0.

Only a few basic functions are implemented, e.g. level transition and supervision of maximum train speed. No ERTMS/ETCS trackside equipment is used except for Eurobalises to announce level transitions and other specific commands.

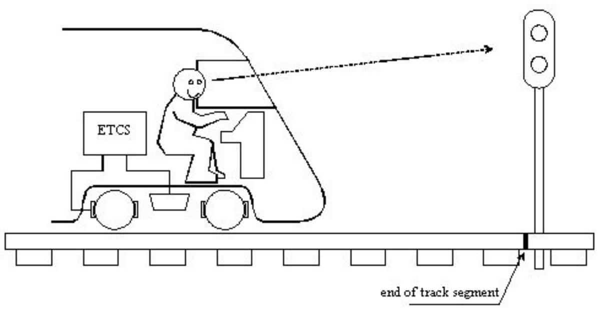


Figure 2 ETCS Level 0

3.2 ETCS Level STM

Level STM is used to run ETCS equipped trains on lines equipped with other national train control and speed supervision systems. Train control information generated trackside by the national train control system is transmitted to the train via the communication channels of the underlying national system and transformed onboard into information interpretable by ETCS.

The achievable level of supervision is similar to the one provided by the underlying national systems. In Australia this includes AWS plus variants, ATSS, Ebicab 700/900, GETS in-cab, mechanical train stops, TPWS and WESTECT.

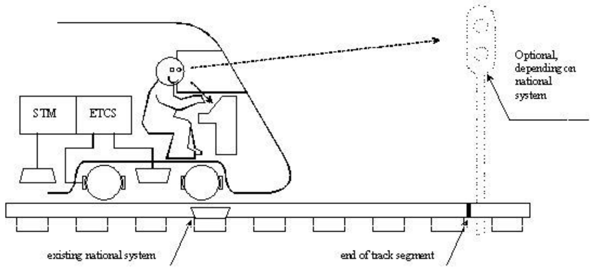


Figure 3 ETCS Level STM

3.3 ETCS Level 1

ETCS Level 1 is a fixed block intermittent (or 'spot') speed supervision system. The trackside equipment consists of encoders (LEU's) and Eurobalises. The LEU's are programmed with fixed infrastructure information and combines this with the variable information taken from the aspects displayed by the signals to select and then pass a serial message to the Eurobalises for transmission to the train. The balise transmission take the form of a telegram containing the ETCS Movement Authority (distance to go, speed restriction, gradient etc.) and other applicable control data.

An antennae carried by the ETCS train receives the Eurobalise transmission. ATP functions within the trainborne ETCS sub-system calculate a safe speed profile on the basis of the received ETCS data and known train braking parameters.

An onboard odometry system senses the movement of the train to provide the ATP functions with the means to check that the speed and distance limits defined by the Movement Authority are not exceeded. The odometry function uses two tacho generators and two radar sensors to determine speed and location. The outputs from these sensors are combined to form most advanced and most retarded locations to ensure that factors such as wheel slide/slip cannot lead to unsafe estimates of actual location. The odometer error band is reset to zero every time a Eurobalise is passed.

The Level 1 trackside sub-system does not know which train it is sending the information to.

ETCS Level 1 can be readily overlaid onto an existing conventional signalling system without the need for signalling renewals, interlocking modifications, signal boxes/control centres.

Being an intermittent transmission system, a train is unable to take advantage of a signal aspect stepping up until it reaches the balise group at the signal. To mitigate against this "Infill" can be provided between the distant and main signal. Both intermittent and semi-continuous infill options are available.

Trackside signals are still required as the driver has to observe the status of the signal when approaching a balise group to know whether to stop the train in rear of the balise group (signal at "STOP" or to pass over the balise group (signal at "PROCEED"). To summarise ETCS Level 1:

- Eurobalise tells train where it is, current signal aspect, permitted speed, target speed and distance data etc. Intermittent updates by in-fill Eurobalises, possibly semi-continuous updates by in-fill cable loops or GSM-R radio.
- Onboard computer calculates maximum safe speed, braking curve speed, advises and warns driver by display in cab.
- Driver obeys trackside signals and signs, as well as cab indications.
- Onboard computer takes over control of vehicle if required.
- Control Centre controls and monitors trains via Interlocking.
- Interlocking processes Control Centre commands, controls and monitors Movement Authority (signals), train position (tracks), points etc. and sends indications to Control Centre.

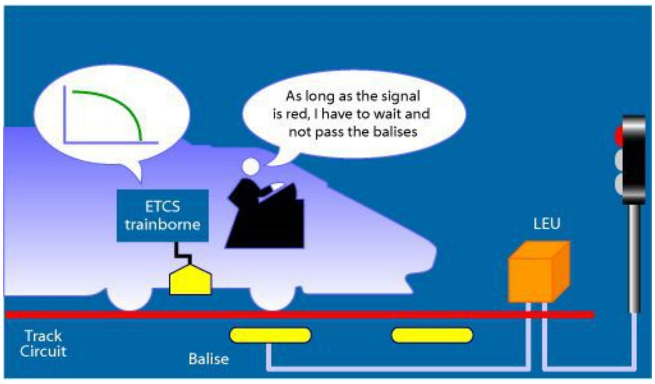


Figure 4 ETCS Level 1 with no infill

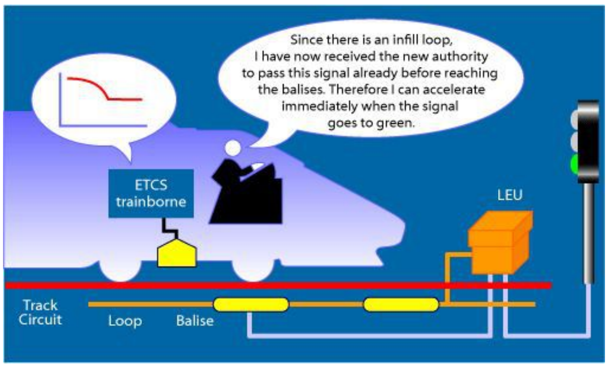


Figure 5 ETCS Level 1 with infill

3.4 ETCS Level 2

ETCS Level 2 is a fixed block continuous speed supervision system. The trackside equipment consists of centralised Radio Block Centres (RBC's) and distributed Eurobalises. GSM-R radio replaces the Eurobalise to transmit information to the train. Eurobalises are still used, but only as a means of initialising and periodically recalibrating the onboard odometer.

The RBC takes information directly from the interlocking on the aspects displayed (and therefore the status of the line ahead) in place of the LEU. The RBC is programmed with fixed infrastructure information and combines this with the variable information taken from the interlocking to select and then pass a serial message to the GSM-R radio for transmission to the train.

As GSM-R provides bi-directional (duplex) data transmission, real time data regarding train locations and speeds can be made available to the signalling control and train describer functions.

Though trackside signals are no longer required, some could be kept at key locations as a fall-back and also for use by non-ETCS trains.

The RBC which provides the information to the trains knows each ETCS controlled train individually.

It provides continuous speed supervision and also protects against overrun of movement authority. Train detection and train integrity supervision are performed by the trackside equipment of the underlying signalling system (interlocking, track circuits etc.).

The system does not require trackside signals but they are often retained as a backup in case of system failure or in case not all trains operating on the line are ETCS equipped.

To summarise ETCS Level 2:

- Eurobalise tells train where it is.
- RBC tells train via GSM-R (Movement Authority) how far to go (fixed block marker board), permitted speed, target speed and distance data etc. Continuous updates by radio as train is detected moving.
- Onboard computer calculates maximum safe speed, braking curve speed, advises and warns driver by display in cab.
- Driver obeys cab indications.
- Onboard computer takes over control of vehicle if required.
- Control Centre controls and monitors trains via Interlocking.
- Interlocking processes Control Centre commands, controls and monitors "Aspects" to RBC, train position (tracks), points etc. and sends indications to Control Centre.

4. LEVEL 1 AND 2 SYSTEM ARCHITECTURES

The environments in which the trackside and onboard sub-systems operate consist of:

- the train, which interfaces with the ETCS onboard equipment through the train interface
- the driver, which interfaces with the ETCS through the driver machine interface
- external trackside systems (interlocking, control centres, etc)

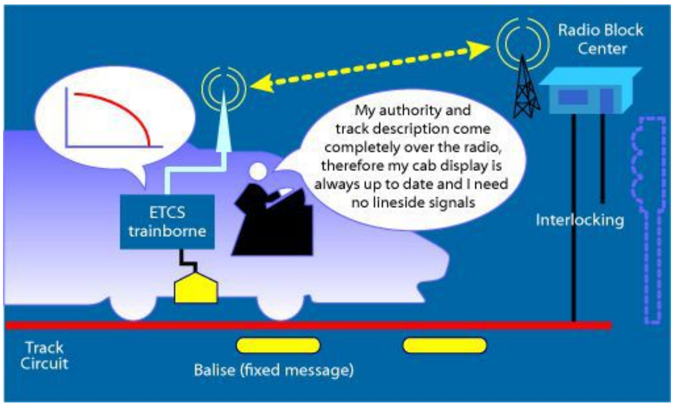


Figure 6 ETCS Level 2

The ETCS standards only specify those interfaces as mandatory which are relevant for the operation of a train equipped by one supplier to operate on a line equipped by somebody else. Exchangeability of components etc. is not ensured by the standard.

Figure 7 below shows the ETCS reference architecture as it is currently specified with the standardised interfaces, either FIS or FFFIS.

FIS (Functional Interface Specification) interfaces are only defined on a functional level, meaning that the logical dataflow is specified, but not the physical interface. A FIS does not therefore ensure exchangeability, as the physical interface might be different from application to application. Example: The Train Interface (TIU FIS) specifies the dataflow between ETCS and the train (brake commands, pantograph control etc.), whether this is implemented through a serial bus as on most modern rolling stock or by discrete relays is left open.

FFFIS (Form-Fit Functional Interface Specification) interfaces are defined on a functional and technical level, meaning that the detailed physical characteristic of the interface is also specified. A FFFIS ensures exchangeability on that interface (not necessarily of a component). Example: The Eurobalise Airgap FFFIS specifies physical characteristic of the air gap, including frequencies, signal levels, start-up timings etc. to the point where the antenna of one supplier can read Eurobalises of other suppliers.

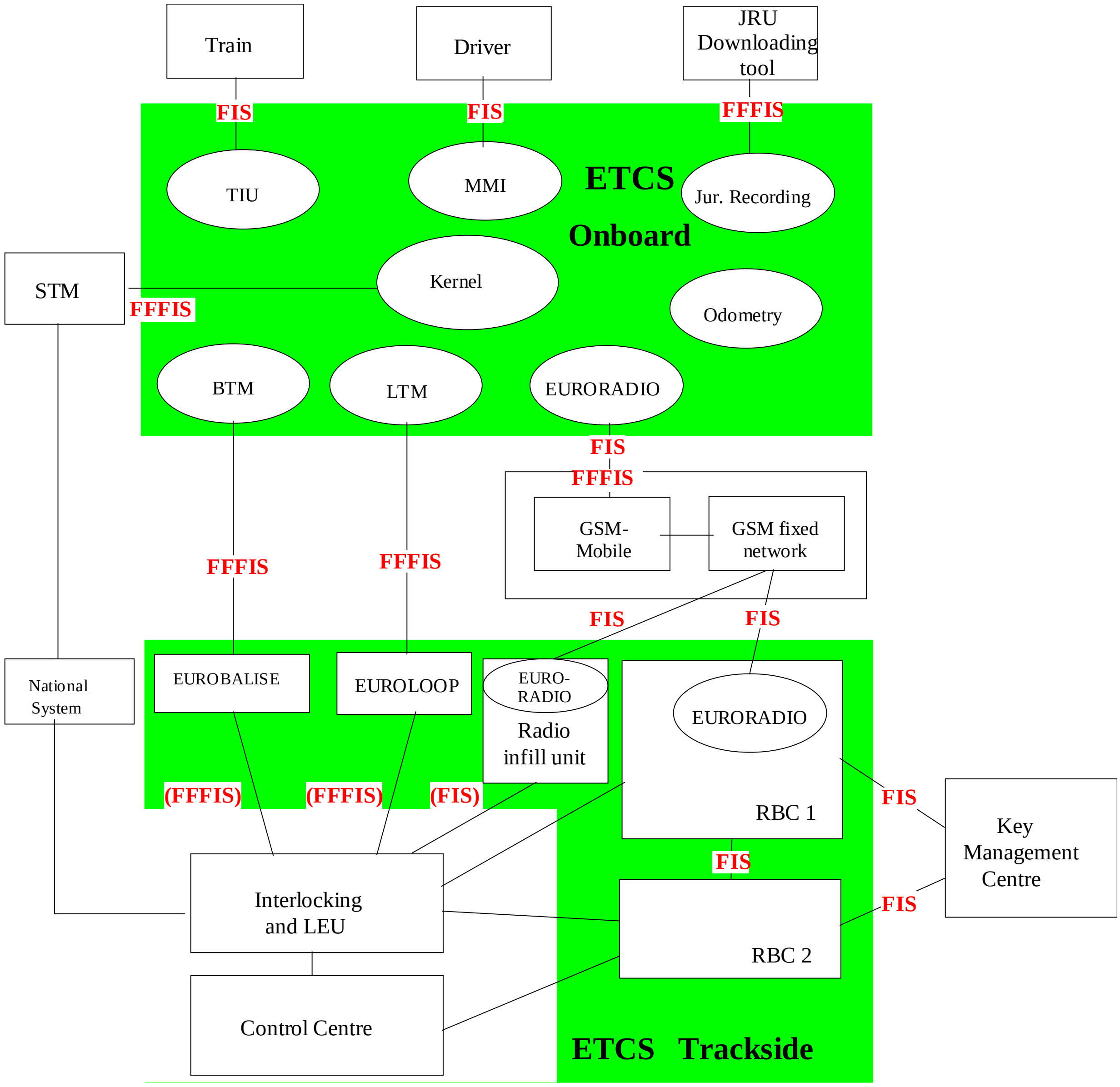


Figure 7 ERTMS/ETCS System Architecture

4.1 Trackside

4.1 1 Level 1 Trackside

The Level 1 trackside consists of the following equipment:

Trackside Electronic Unit (LEU) - selects the appropriate telegram to be sent to each controlled Eurobalise in accordance with the information received from the interlocking. The information can be taken from the interlocking by either current sensing signal lamp feeds and/or voltage free contacts from control relays. Information sent to the onboard system in the telegram includes linking information, movement authority (speed and distance), gradients, static speed profile, TSR, driving mode and other miscellaneous information.

The LEU's are typically located in the signal feed location huts to provide a distributed architecture but some suppliers also offer networked LEU's, that enable a centralised solution.

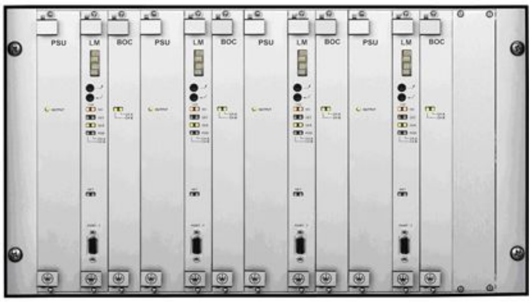


Figure 8 Lineside Electronic Unit (LEU)

Controlled and Fixed Eurobalises – passive devices that transmit controlled and fixed data respectively to the onboard subsystem. The fixed balise does not require a tail cable, the controlled balise requires a specialised low current transmission tail cable.

Eurobalises can also be used to provide intermittent infill.

Figure 9 Eurobalise

Euroloop – active device that transmits controlled and fixed infill data to the onboard subsystem. It provides a semi-continuous transmission using a cable as the antenna.

Telegrams are supplied to the loop by the LEU via a loop modem.

Figure 10 Euroloop

Euroradio – transmits controlled and fixed infill data to the onboard subsystem. It provides a semi-continuous transmission using GSM-R via a Radio Infill Unit (RIU).

Other equipment – depending on the supplier, ETCS maintenance workstations and TSR workstations may also be available, with local and in some cases remote control.

4.1 1 Level 2 Trackside

The Level 2 trackside consists of the following equipment:

Radio Block Centre (RBC) - The RBC in Level 2 performs the same tasks as the LEU in Level 1 in that its main function is to provide movement authorities to trains which have established communications with it. However, the RBC also supports additional functionality including:

- Setting-up, termination and maintenance of train communications
- Perform handover of a train from one RBC Processor to another
- Management and transmission of Temporary Speed Restrictions
- Management of Emergency Stop Areas and transmission of Emergency Stops
- Handling of Level Transitions for trains entering and leaving the Level 2 area
- Transmission of Plain and Fixed Text Messages
- Management and transmission of Areas of Reduced Adhesion

- Management of Temporary Shunting Areas
- Sending the train running number to the train

The RBC interfaces with the interlocking (typically a serial connection to a computer-based interlocking) and the Traffic Control Centre. Note that this may require upgrade to either or both systems. For example, if trackside signals are retained and advanced features like configurable TSR's are not required the Traffic Control Centre may not need to be updated.

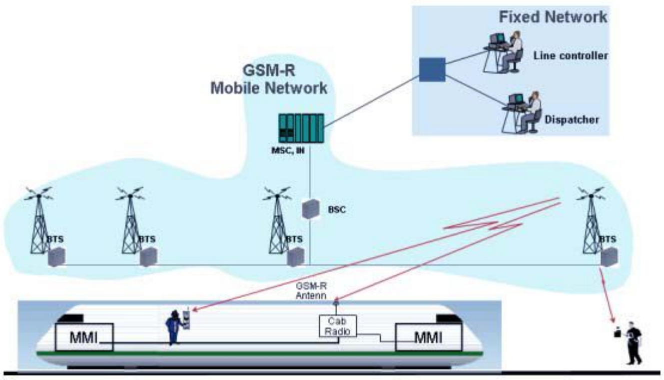


Figure 11 GSM-R network

Fixed Eurobalises – only fixed Eurobalises are required to transmit fixed track data and to update the position accuracy.

GSM-R ground network – Many railways currently employ or plan to install GSM-R to provide digital radio communication between drivers, signallers, trackside maintenance staff etc. It is also the transmission medium for ETCS Level 2.

A GSM-R ground network currently providing radio communication only can be upgraded to support ETCS data transmission.

4.2 Onboard

In contrast to the trackside sub-system, there is very little difference between the onboard sub-system in Levels 1 and 2. The only difference is that Level 2 adds the GSM-R digital train radio equipment.

'Eurocab' is the generic name given to the complete ETCS system when fitted to a vehicle. The Class 1 specifications define the system functional requirements and the track to train transmission interface but do not include the Eurocab internal architecture. There is therefore no inter-changeability between different supplier's onboard systems.

European Vital Computer (EVC) - The European Vital Computer (EVC) is the central processing unit of the Eurocab system. The EVC receives information from the peripheral systems and the trackside infrastructure and if applicable generates a safe profile in which the train can proceed under the control of the driver.

Figure 12 European Vital Computer (EVC)

Euroradio - The GSM-R data radio interfaces to the ETCS system via a Radio Transmission Module (RTM) normally located within the EVC cubicle.

Speed & Location Devices (Odometry) - For ETCS to work effectively it is vital that the EVC is able to accurately monitor the speed of the train at all times. This is not easy to achieve, reliance cannot be placed on a single tachometer connected to a motored or braked axle. ETCS has therefore been designed to use multiple speed and location systems, each of which overcomes the shortfalls of the others. In this way the EVC can accurately and consistently establish the vehicle's position relative to the last Eurobalise and provide the necessary velocity data for the EVC to calculate the vehicle speed at any time.

The odometry architecture is not standardised, however most suppliers achieve the requirements by the inclusion of some if not all of the following:

- Tachometers, mounted on the axle ends to provide wheel rotation information. If these are mounted on braked and/or motored axles then problems due to wheel slip and slide can occur.
- Doppler radar, radar speed detection although this can be affected by track conditions.
- Inertia monitoring, by using accelerometers to establish the rate of change in velocity.

In addition, the Eurobalises are used to regularly update actual position to ensure that any accumulative error within the EVC is kept to a minimum.

The velocity peripheral sensors interfaces to the ETCS system via a proprietary interface normally located within the EVC cubicle.

Figure 13 Doppler Radar unit

Train Interface Unit (TIU) - The EVC must provide input and output information and control to e.g. the drive system, brakes, traction cut-off and other train services. This is achieved via a Train Interface Unit (TIU). The TIU facilitates a common ETCS interface to any vehicle by providing the physical connection point.

ETCS controls both Service Brake and Emergency Brake. If the system applies the emergency brakes (Trip mode) the driver is unable to release them until the train has come to a stand (Post Trip mode). If the system applies the service brakes they are released automatically once the train speed has been reduced to the correct value.

Juridical Recording Unit (JRU) – this accident resistant "black box" unit permanently records the main variables involved in the operation of the train's safety systems. It is employed in case of an accident to establish events leading up to an accident.

Figure 14 Juridical Recorder Unit

Driver Machine Interface (DMI) - provides the communication interface between the ETCS system and the driver. Due to space limitations and human factor issues associated with multiple DMI's (i.e. each national system + ETCS), the ETCS development included an integrated DMI.

The DMI Specification defines those parameters that must be displayed such as current speed, target speed, distance to go etc. The DMI is normally a "ruggedised" sensitive LCD. The ETCS screen provides computer generated graphical information to the driver and is broken down into six main areas, corresponding to the tasks required by the driver:

- Brake Details (braking to a target).
- Speed Control (curve and target supervision).
- Maintain Speed (actual vehicle speed and advisory information).
- Planning (advance information of future events).
- System Monitoring (alarm and system status information).
- Driver Input (the DMI facilitates data input to the system via the touch sensitive computer generated key pad).

Figure 15 Typical DMI in a RENFE cab

The computer generated analogue speedometer is colour coded to provide easy recognition by the driver.

- White – Normal non-restrictive driving.
- Yellow – First Warning, reduce speed.
- Orange – Second Warning, reduce speed immediately (a warning horn will also sound).
- Red – System intervention, full service brake (or in extreme cases the emergency brake) will be automatically applied.

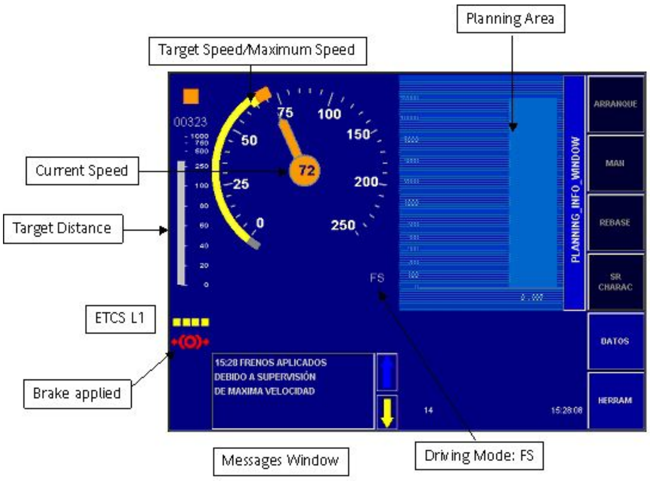


Figure 16 Typical DMI display

Balise Transmission Module (BTM) – receives information from the trackside sub-system via an antenna fitted underneath the train. It is responsible for translating the antenna signals into digital data that can be handled by the EVC.

If Euroloop is installed, a Loop Transmission Module (LTM) is also required; depending on the supplier the same antenna as used for the BTM can be used.

If the train is required to operate over existing national Train Protection systems, and Specific Transmission Module (STM) is required; one for each national system.

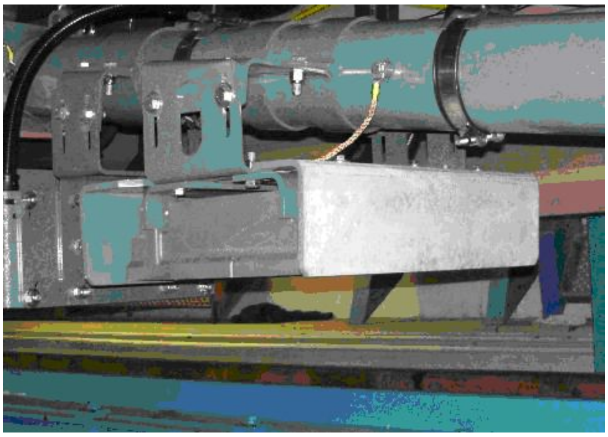


Figure 17 Antenna

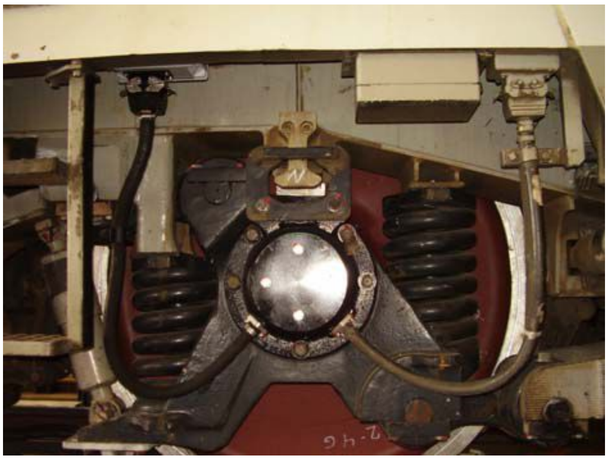


Figure 18 Tacho mounted on axle

5. DESCRIPTION OF ERTMS/ETCS MODES

In addition to the basic supervision functions of a train control system such as supervision against speed and distance limitations during normal train running, ETCS also provides a varying level of supervision under a number of degraded operating situations, as well as when shunting trains, running with multiple traction units etc.

For that purpose ETCS has defined a number of operating Modes. These modes define the exchange of information between ETCS and the train driver as well as how the responsibility of supervising train operation is shared between the two. An ETCS onboard unit always operates in a single mode, with transitions between modes taking place under well defined circumstances. The modes can be entered either automatically or manually, depending on the mode.

Many, but not all, modes are available in each level. For example, a train can be in Level 1 On Sight (OS) mode or Level 2 OS mode. There are two basic modes, Full Supervision (FS) and partial supervision. Partial supervision is then further divided into 15 different modes. Depending on the particular railway organisation, not all modes will be used.

The modes to be used, and their relationship with the signalling aspect system, will have to be agreed between the railway organisation and all potential suppliers though some modes are compulsory. For example, Non Leading (NL) and Reversing (RV) modes may or may not be required depending on the operating rules of the railway organisation but Trip (TR) mode is compulsory.

It is possible in some cases to change modes part way through a move, e.g. a move with a long approach to a station platform where only the platform track is occupied could start in Full Supervision (FS) then change to On Sight (OS).

Examples of some of the most common modes are:

Full Supervision (FS) - The ETCS on-board system shall be in FS mode when all train and track data, which is required for a complete supervision of the train, is available onboard.

The ETCS on-board equipment is fully responsible for the train protection except that the driver is responsible for respecting the end of authority (EOA) when approaching an EOA with a release speed (by observing the trackside signal).

Full supervision cannot be selected by the driver, but shall be entered automatically when all necessary conditions are fulfilled.

Shunting (SH) – is the mode that enables the driver to make forward and reverse shunting movements.

The ETCS on-board equipment only supervises the train movements against:

- ceiling speed: the shunting mode permitted speed limit speed
- a list of expected Eurobalises (if such list was sent by the trackside equipment). The train shall be tripped if a balise group, not contained in the list, is passed
- "stop if in shunting mode" information. The train is tripped if such information is received from a balise group

Shunting can be entered either manually by the driver (if the train is stationary) or automatically if ordered from the trackside.

On Sight (OS) - enables the train to enter into a track section that could already be occupied by another train, or obstructed by any kind of obstacle.

The ETCS on-board equipment shall only supervise train movements against a dynamic speed profile.

The authority to use this mode shall come from trackside only (this mode cannot be selected by the driver).

Staff Responsible (SR) - allows the driver to move the train under his own responsibility in an ETCS equipped area. This mode is used when the system does not know the route. For example:

- After the ERTMS/ETCS on-board equipment starts-up (awakening of the train).
- To pass a signal at danger / override an EOA.
- After a trackside failure (for example: loss of radio contact).

Trip (TR) – is automatically entered if a train tries to pass an EOA and results in an emergency brake application. Once the train is at a standstill the driver is allowed to enter Post Trip (PT) mode.

Post Trip (PT) - shall be entered immediately after the driver acknowledges the trip.

Once in post trip mode, the onboard equipment shall release the Command of the emergency brake. The driver is then able to select from a list of available modes and restart the journey.

6. FUNCTIONAL REQUIREMENTS

In order for a railway organisation to achieve interoperability between different suppliers, a number of ETCS specifications and functions need to be agreed. Whilst many functions are an inherent part of the system; others are optional and can be selected or not by the railway organisation. This selection of functions is not a simple process and requires the railway organisation to work closely with all potential suppliers. It is also imperative that the railway organisation involve all internal stakeholders in the process to avoid problems later on.

It is worth noting that the ETCS specifications are not cast in stone and that they are, and will continue to be, developing.

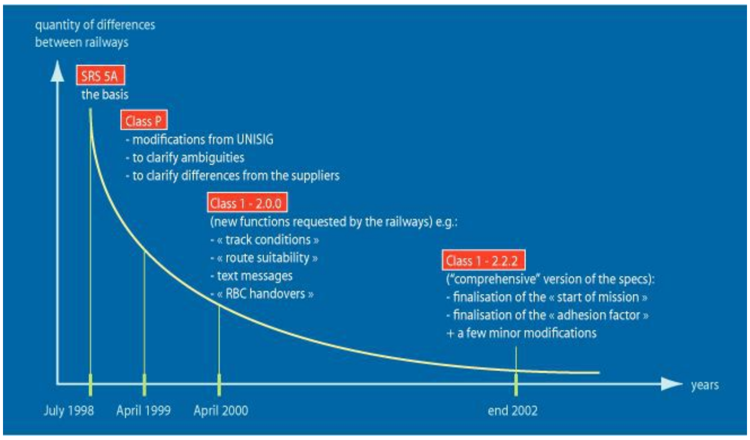


Figure 19 Development of ETCS Specifications

6.1 FRS and SRS - the Functional Requirements Specification (FRS) produced by the operators (EEIG) is generally the first document to be agreed as it lists the high level requirements. The current officially released version is 4.29 and the latest draft is version 4.56.

The System Requirements Specification (SRS) is produced by the suppliers (UNISIG) to detail the technical specifications. The first pilot lines in Europe were deployed to Subset 026 SRS version 2.0.0 starting in 2000, with experience gained from these leading to version 2.2.2 being released in 2002 and then again in 2004. A change process was added to these versions that were documented in Subset 108. The change requests (CR's) in subset 108 were marked as 'In', 'Out', 'NA' or 'Rejected'. The 'In' CR's have now been consolidated and the SRS updated; version 2.3.0 was officially released earlier this year. The next planned released version of the SRS is version 3.0.0 in 2010-11.

The question may then be asked "what happens when a train runs over a trackside of a different version?" A train of a 'higher' version e.g. 2.3.0 should be able to run over the track of a 'lower' version e.g.2.2.2 but if a 2.2.2 train has to run over a 2.3.0 track investigation will be required as the 2.3.0 track may send the 2.2.2 train information it does not recognise.

6.2 Data Packets – The SRS contains a list of all possible data packets from track to train and vice versa. A railway organisation will need to agree with the suppliers which packets will be used.

6.3 National and Default Values – are a set of variables configurable by the users. A railway organisation will need to agree with the suppliers the values of all of these. The National Values are used by the various system components and exchanged between them via balise, loop or radio. Once a National Value is received by the onboard sub-system it remains valid until new values are received (e.g. at a new national border). If the system detects that they are no longer valid then the default values that are harmonised for all countries are used. As an example, NSW, Victoria and Queensland may all have different National Values but the Default Values would be harmonised for all of Australia (assuming there was some cross-border traffic).

Typical examples of National/Default Values are shunting mode permitted speed limit, distance for rollaway protection and permitted speed limit when the "override EOA" function is selected.

6.4 System Values – have values assigned by different parties on different levels. Some examples are the variable "loading gauge profiles" used for route suitability supervision and balise group identifiers specified by a railway organisation in accordance with their numbering scheme for trackside equipment.

6.5 Other functions – the use of some miscellaneous optional functions also need to be agreed, e.g. "reporting of geographical position" (from track to train) and "text messages" (like station announcements, asset protection systems etc.).

7. MATCHING THE DIFFERENT APPLICATION LEVELS TO DIFFERENT TYPES OF RAILWAY

One of the most fundamental decisions to be made is what application level to install. Application levels currently available to be installed in Australia are Level 1 and Level 2. Level STM is unavailable as STM's for Train Protection equipment installed in Australia do not exist. All suppliers (UNISIG) have agreed not to offer Level 3 at present in order to concentrate efforts on Levels 1 and 2.

When considering the most suitable application levels for networks in Australia, it is useful to consider the applications selected by the European railway networks.

Where the main driver in upgrading to ETCS is increased safety, a L1 solution is often sufficient. It can be added as an overlay to the existing system. Examples in Europe are Austria, Bulgaria, Czech Republic, Greece, Luxembourg, Slovakia and Slovenia.

Generally speaking, L2 is only required on high-speed and/or high-capacity lines. In the UK the decision is to only fit Level 2 as the current national system TPWS/AWS already provides warning and supervision functions.

A common split is to fit L1 to existing main lines and L2 to new high-speed lines. Examples in Europe are Italy and Spain.

A requirement to replace obsolete Train Protection systems is driving ETCS in Norway, Finland and Sweden.

Many countries will retain some of the existing infrastructure as a backup e.g. some trackside signals.

SBB have realised a saving by only upgrading to ETCS at critical points (stations and junctions).

When considering the railway networks in Australia, it can be seen that there are various categories of railway existing in each network, e.g.

- Inner City – 20+ trains per hour, passenger EMU's only, signal spacing 500m
- Suburban – 10 – 20 trains per hour, mixed traffic, signal spacing 500m – 1,000m
- Country – 2 trains per hour or less, mixed traffic, signal spacing 1,000m to 10,000m

These different categories may well require different solutions, for example a mix of Level 1 and Level 2. Having a mix of Level 1 and Level 2 is not a problem as the onboard system is the same.

It should be remembered that each level has its own advantages and disadvantages. Level 2 is not an 'upgraded' or 'better' system than Level 1 and Level 3 is not an 'upgraded' or 'better' system than Level 1 and 2. Whilst true that Level 3 offers moving block, seen as 'the ultimate signalling system' by some; a fixed block system with lots of very short blocks offers virtually the same capacity benefit.

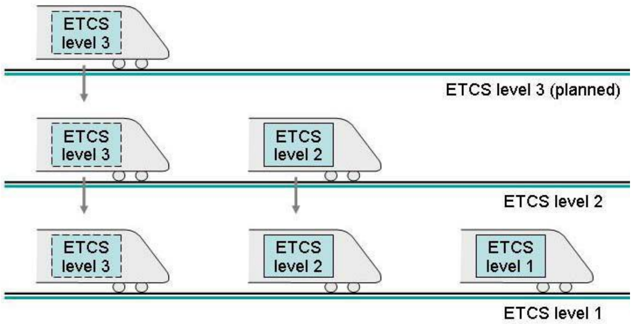


Figure 20 ETCS Trains running over tracks of different levels

8. BENEFITS OF ETCS AND COMPARISON OF DIFFERENT LEVELS

The benefits of introducing an ETCS system largely depend on:

- what the railway organisation wants to get out of it.
- The way that the railway network is currently run

Increased safety, capacity, availability and reduced infrastructure are all possible, but there are many trade-offs to be made between them. The following is a simplified example of a table that railway organisations can use to decide what is important for them.

Issue	L 1	L 1 + infill	L 2 + fallback	L 2 no fallback	Relevant for train operator	Relevant for Infrastructure
Capacity						
Cost						
Availability						
Safety						
Maintenance						

FACTORS TO CONSIDER WHEN IMPLEMENTING ETCS

8.1 Network Rules and Procedures – is the methods of safeworking that covers movements of rail traffic, unusual circumstances and events and the interaction of people with the equipment and systems in use, managing track work, managing train working, systems of safeworking and special working. The following are a few examples of rules and procedures impacted by the introduction of an ETCS system:

- Imposition of network-wide speed restrictions for impact of extreme weather
- Work trains and track vehicles
- Passing signals at STOP
- Pilot Staff Working

ETCS could allow a quicker and more selective imposition of a network-wide speed restriction for impact of extreme weather by e.g.

- Applying pre-programmed TSR's from a centralised location
- Applying the TSR's to specific track sections / only to certain rolling stock.

ETCS enables the provision of a temporary balise to impose a speed restriction on any work trains entering a work site as additional protection to the usual speed warning and caution boards. "Dynamic TSR's"

The rules for passing a signal at STOP will change as the driver will need to apply the ETCS override function in addition to the current procedures.

The safety level of Pilot Staff Working (e.g. wrong road unsignalled movements) can be improved by using an appropriate ETCS mode (Staff Responsible or On Sight) to enforce speed limits.

Other possibilities include providing overspeed protection in unsignalled areas e.g. stabling yards and maintenance depots.

8.2 Train Operations – typically cover the responsibilities of train crews and other operations staff. The following are a few examples of rules and procedures impacted by the introduction of an ETCS system:

- Reporting faults
- Failures of the drivers safety systems
- Setting back at a platform

In terms of driver's safety systems, a decision will have to be made about what to do in the event of an onboard ETCS failure. If the system fails its start-up tests in the depot at the beginning of its shift the service may be cancelled or, if some method of fallback is provided, continue with some restrictions.

The rules for setting back at a platform in the case of a train overrunning will need to be modified as the ETCS system will not allow the train to reverse in normal running. In addition the train may also have been tripped if a platform starter signal was provided and was at STOP.

8.3 Signalling Principles - some of the changes that impact on the signalling principles are:

- Approach control
- Overlaps
- Elimination of speed steps
- Improvement to speed boards
- Simplification of signal aspects/route information
- Lamp degradation

Many of the potential improvements would however require a major change to the interlocking so would probably only be done if the interlocking was renewed or for a new line.

Approach control - is used to prove train speed at or below a calculated value, e.g. to take a turnout safely or to allow a reduced overlap to be used. Conditional clearance has been shown to be a root cause of many where a signal is regularly approached at red and steps up when the train is close to the signal. The drivers become to rely on the signal clearing and approach at a higher than desired speed which, in the odd case that the signal does not clear, results in the train running past the signal.

Lines fully fitted with ETCS where all rolling stock are ETCS fitted have no need of conditional clearance as the ETCS system intrinsically contains this function. The inherent ATP speed control also allows trains to approach a signal at the correct speed rather than being based on the “worst case”.

Overlaps - ETCS does not require the traditional overlap that can be a significant factor in the signalled headway, e.g. train stop areas with fully braked overlaps. Reducing an overlap to a nominal distance (trip distance from ETCS release speed), would reduce headway time, increase operational flexibility and more significantly reduce the complexity of the interlocking (with a resultant saving in design and testing for new or altered works).

As an example, reducing an overlap at a station from 500m to 100m might enable points in advance of the Station Starter signal that are currently locked with a train approaching the signal to be free. This would then allow other train movements to take place that are currently prevented.

Simplification of signal aspects/route information – ETCS only requires two signal aspects, STOP and GO. Current signals could be replaced with two-aspect dwarf signals.

Lamp degradation – ETCS gives the possibility of train movements being independent from signal lamp failures as the ETCS can take its inputs directly from the interlocking (either control relays or CBI data). The current drive to upgrade to LED signals will however make the need for this less critical.

8.4 Drivers, DMI and Human Factors – Though ETCS offers advanced cab signalling, the driver remains in control. The ETCS is there to assist with the driving task and provide backup in case of human error.

The ETCS Driver Machine Interface (DMI) went through an exhaustive human factors process and a ‘standard’ DMI has been defined. Some railway organisations prefer to customise the physical and graphical layout whilst others have stayed with the standard to enable changing of crews or rolling stock with minimal retraining required.

The introduction of ETCS requires a consultative process to be followed with drivers, not only for the DMI but also with respect to changes in workload and the interaction with existing cab systems like dead mans and vigilance devices. In theory the existing dead mans and vigilance devices could be removed once ETCS is fitted however they are often retained as a fallback.

A human factors study will be required as part of the consultative process.

Figure 21 ETCS Testing Simulator

8.5 Rolling Stock – the choice of braking parameters to be used by the ETCS onboard system is a critical issue. The braking curves/tables supplied by rolling stock engineers, that are an inherent component of signal spacing, are a summation of many different factors including:

- brake application delay
- deceleration rate
- wear and tear
- loading (tare or crush load)
- adhesion factor
- contingency

A detailed investigation needs to be made in order to choose the most suitable braking curves. A balance needs to be struck between making the system too conservative resulting in being difficult to drive/poor performance and too aggressive resulting in frequent SPADs.

8.7 Maintenance – the ETCS trackside equipment requires little preventive maintenance, but an investigation needs to be made of potential damage to Eurobalises, loops and tail cables from track vehicles.

The ETCS onboard equipment requires little preventive maintenance apart from visual inspection for damage to equipment installed on the underside of the train that is part of the normal daily pre-start inspection.

The ETCS trackside sub-system should not cause any concerns for signalling maintenance staff already familiar with e.g. computer-based interlockings. The ETCS onboard sub-system may be more of an issue where it is retrofitted to old rolling stock as it involves putting complicated electronic/computerised equipment on board trains that were previously relatively low-technology. This may require the up-skilling of rolling stock maintainers.

8.8 Capacity – some of the factors that impact on capacity are:

- Level 1 or Level 2 system
- For Level 1, type of infill i.e. none, intermittent or semi-continuous
- Braking curve values, conservative or aggressive or somewhere in between
- Modification of interlocking to take advantage of ETCS e.g. minimal overlaps and removal of approach control
- Removal of speed steps when braking to a target
- More accurate (less restrictive) speedboard placement, i.e. closer to the actual permitted values
- Increased linespeeds by adding additional aspects “electrical sight” to look ahead
- The way trains are currently driven, e.g. defensive driving techniques or ‘formula 1’
- Gaining independence from signal lamp failures

As an example of the above, if defensive driving techniques are in use on a network a driver will immediately reduce train speed when passing the first caution aspect. ETCS enables a driver to continue at linespeed until the required braking point is reached. This gives a positive impact on capacity. On the other hand, if drivers on a network are currently required to overspeed to keep to the timetable (e.g. making up time when falling behind schedule due to a previous delay) then ETCS can negatively impact on capacity unless other capacity-enhancing measures are also introduced.

9. ITEMS TO BE CONSIDERED FOR MIGRATING TO ERTMS/ETCS

The fundamental question is “what are the respective priorities of a railway organisation’s objectives in installing ETCS?”

The situation is different in every country/state, considering factors like track km, number of vehicles, age of infrastructure, percentage of cross-border traffic etc. For this reason there is no common strategy and each country is developing its own path. Each country will give a different rating to the following factors:

- Interoperability
- Cab signalling to increase linespeeds
- Increased capacity
- Increased safety
- Renewal of life-expired infrastructure
- Renewal/refurbishment of life-expired rolling stock
- Recovery of existing Train Protection systems

A popular strategy is to tie in ETCS upgrades with normal planned upgrades due to life expiry of infrastructure and rolling stock.

9.1 Level 1 Applications - trackside signals are retained and there are two possible strategies:

- Level 1 as an overlay
- Level 1 plus signalling modification

Level 1 as an overlay can be implemented without major modifications to the interlockings and underlying signalling principles. The existing Train Protection system(s) can also be retained in parallel to ETCS during the migration period.

Level 1 plus signalling modifications allows capacity benefits of ETCS to be realised e.g. shortened overlaps, removal of approach control, simplification of aspects, enables creation of multiple short block sections etc. This needs an assessment of the interlocking suitability for change to meet the capacity requirements.

If a move to Level 2 or Level 3 is required in the future the onboard changes need to include a suitable GSM-R data radio, though the trackside will need to be re-engineered.

9.2 Level 2 Applications - The RBC needs to be linked to the interlockings and traffic control centre in a centralised way, which is easier to achieve with Computer Based Interlockings. As with Level 1 there are two possible strategies:

- Level 2 as an overlay
- Level 2 plus resignalling

Level 2 as an overlay where the trackside signals and underlying signalling principles are retained is a viable option if the existing interlockings can be interfaced to easily and benefits from reduced trackside infrastructure. It is also quite attractive if the railway organisation already has/proposed to employ GSM-R as the digital train radio backbone. The disadvantages currently are that not all the additional benefits of ETCS can be realised and the system may not be suitable for high capacity areas due to time delays in GSM-R communication set up times. This limitation may change in the future.

Level 2 plus resignalling with no trackside signals offers benefits of capacity and additionally a reduction in signalling assets. Trackside infrastructure is minimal and system performance can come close to the moving block concept if lots of short block sections are provided. The disadvantages are the cost of upgrading/renewing interlockings and the provision of GSM-R and the lack of a fallback (if operational requirements necessitate a fallback). It also requires all rolling stock to be fitted. None the less, installing an ETCS Level 2 system to provide additional capacity in capacity-constrained areas is probably more cost effective than double/triple/quadruple tracking.

9.3 Level 1 Limited Supervision (LS) Mode – ETCS Full Supervision (FS) mode offers cab signalling where the driver no longer has to rely on the information from the trackside signals and is a pre-requisite to run trains at over 160 km/hr. For many lines in service today however, full cab signalling and/or high speed is not an immediate requirement and a lower level of Train Protection supervision is sufficient. This has led to the proposal for a new mode ‘Limited Supervision’ (LS).

LS Mode allows a railway organisation to only upgrade to full Train Protection at selected critical locations and to retain the existing more basic level of protection offered by the existing national systems i.e. warning, train stop or speed trap at the other locations.

This enables ETCS to be introduced in a shorter time and with lower costs compared to Full Supervision (FS). A railway organisation can then upgrade to FS in stages as time/costs permit. It can therefore be considered as a trackside migration strategy.

ETCS LS mode is not included in the current version of SRS 2.3.0 but is included in the next major version SRS 3.0.0, currently planned for release in 2010-11.

9.4 Other Considerations – some other benefits of introducing ETCS are:

- Better recovery from disruption
- Better management of mixed traffic lines
- Reduced trackside maintenance, especially for ‘24/7’ Metro lines or remote lines
- Reduced trackside equipment enables reduced trackside cabling and power supplies
- Improved real time information for drivers, railway management and passengers
- Cab signalling eliminates signal sighting problems
- Enforced static speed profile reduces track wear and tear

10. RAILCORP TRAIN PROTECTION TRIAL

A trial ETCS project is currently in progress for RailCorp on the Blue Mountains Line in New South Wales. Four of the six UNISIG suppliers will be installing and trialling their ETCS systems on three trial sites and three 4 car V-Set multiple unit trains. The track sites will all be fitted with Level 1 and include transitions to Level 0 as well as seamless Level 1 transitions between suppliers.

Progress to date is that all three trackside systems are installed and in the testing and commissioning phase. Test running with the first onboard system is planned to commence in November 2007.

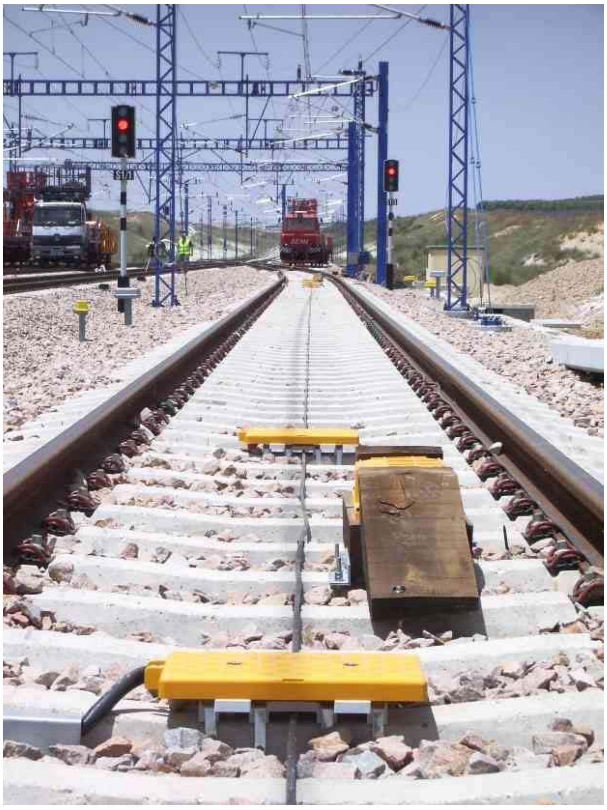


Figure 22 Eurobalise installed in Spain alongside LZB loop and ASFA transponder

11. CONCLUSION

This paper has given a brief overview of the ETCS system and highlighted some of the considerations that should be made.

There are a number of application levels available that should be selected according to the needs of the individual railway organisation.

An understanding of the architecture(s) to be implemented in accordance with the application level is also required.

There are numerous driving Modes available; not all of them may be required; their selection based on the status of the trackside and interaction with the driver in terms of responsibility between human and system are critical.

The selection of the appropriate application level(s) and the benefits from them will be particular to each railway organisation. There is no 'one size fits all' solution.

The factors to be considered when implementing ETCS are many and each factor cannot be considered in isolation. It is often the interaction between factors that determines how the system will ultimately perform. The selection process is not therefore something that should be rushed. Though the initial work will be office-based, the system must then be installed, tested and trialled in real operating conditions. The outcomes of the testing and trial running will highlight many issues and require rework of the initial office-based selection process.

Defining the optimal strategy for migration is a demanding task, for example is it better to double fit the trackside, onboard or both? For lines with a low number of dedicated traction units (e.g. a new high speed line) double fitting the onboard may be best, for lines with a large number of different trains double fitting the trackside may be best.

To conclude:

- ERTMS/ETCS is a viable solution that is available now
- Railway organisations considering a migration to ERTMS/ETCS will need to involve all disciplines in the decision making process
- Infrastructure owners will initially have a big learning curve to overcome and the selection of the best migration strategy/technical solution will require a collaborative approach with the suppliers

12. SUGGESTED FURTHER READING

The following websites give an overview on ERTMS/ETCS and you should be able to find a copy of the SRS 2.3.0 that is also a good place to start.

http://www.ertms.com/

http://gsm-r.uic.asso.fr/

http://etcs.uic.asso.fr/

http://www.era.europa.eu/public/Pages/default.aspx

13. ACKNOWLEDGEMENTS

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Chris Carr
Deputy Director
Rail Standards and Safety
Department for Transport
3/19 Great Minster House
33 Horseferry Road
London
SW1P 4DR

Direct Line: 0207 944 2423

Web Site: www.dft.gov.uk

Our Ref:

17 February 2012

David Hughes
Director Crossrail Joint Sponsor Team
Transport for London
Crossrail
2nd Floor, West Wing
55 Broadway
London
SW1H 0BD

Dear David

DEROGATION FROM THE CONTROL COMMAND AND SIGNALLING TSI FOR THE CROSSRAIL CORE SECTION

Following your request for a derogation for the core section of the Crossrail project I am writing to determine on behalf of the Secretary of State that this request has been successful.

The Commission Implementing Decision of 26 January (see attached) enables the derogation subject to conditions. This derogation is being given, subject to the conditions being met as set out below, under regulation 14 (2) (d) of the Railways (Interoperability) Regulations 2011 (RIR 2011). This derogation means that the Control Command and Signalling (CCS) TSI for conventional rail (Commission Decision 2006/679/EC) need not apply to the Crossrail core section, because application would compromise the economic viability of the project.

The core section is the central operating section of Crossrail running from Westbourne Park-Paddington to Whitechapel-Stratford/Abbey Wood.

The effect of this derogation letter is that it enables a CBTC system to be installed and operated as an interim measure on the core section as long as a number of conditions are met. As soon as ERTMS is used as the primary signalling system on the core this derogation expires. The conditions are consistent with those agreed by Crossrail, Transport for London and Rail for London last November and are as follows:

1. The CBTC Contractor will prepare an ERTMS Migration Plan (to enable ETCS Level 3 with minimal modification) for the Infrastructure Manager to implement at the earliest possible date; the plan shall refer to tests to verify that ETCS implementation meets Crossrail’s requirements regarding performance, reliability

and availability rates, in particular as regards; Automatic Train Operation, Platform Edge Door communications and Auto Reverse.The Migration Plan will need to be submitted to the Department for Transport and then agreed by the Commission before the authorisation to place into service is granted by the ORR;

2. A communications bearer capable of supporting ETCS level 3 should be installed as part of the initial installation;
3. The Migration Plan must be implemented.
4. As soon as final tests confirm that the switch to ERTMS, as the primary signalling system is possible, the Infrastructure Manager shall notify the Department for Transport in order that the Commission may be informed;
5. The Infrastructure Manager shall make the switch to ERTMS as soon as tests confirm this is possible.

The ORR will therefore, before granting an authorisation for placing into service of a signalling subsystem that relies on this derogation, need to be satisfied that conditions 1 and 2 of this derogation have been met. In addition under regulation 7 of the RIR 2011 the ORR can include conditions and restrictions in an authorisation, which will continue to apply to the operator of the subsystem under regulation 20 (ie the infrastructure manager or railway undertaking). I am asking the ORR to consider how to cross refer to the derogation conditions above in any conditions and restrictions they include in an authorisation.

I would ask you to also note that under regulation 15 of the RIR 2011 notified national technical rules (NNTRs) are used as a means of proving the essential requirements are met in cases where a derogation from a TSI has been granted and to make transparent the technical rules that apply to demonstrate compatibility with the system. Such rules are checked by third party assessors known as designated bodies. This means the project entity that applies for the authorisation for the signalling subsystem should consider what NNTRs will be used as the applicable standard.

If Crossrail wish to apply any new NNTRs you should be aware that there is a requirement under the Technical Standards Directive (98/34/EC) that new standards are first submitted by the Department as draft for consideration by other Member States. These rules could be subject to a standstill period of up to six months before they can be formally notified and applied as a standard. It would be helpful if the Crossrail team and the contractor contacted the Department to discuss how they intend to develop new NNTRs to deal with this derogation.

I have copied this letter to the ORR for their information.

Yours sincerely,

Chris Carr
signed by the authority of the Secretary of State

RATP Paris Metro: Pioneering the Future in Metro Automation and Signalling

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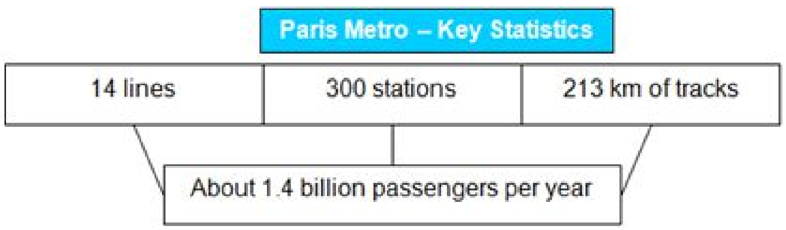
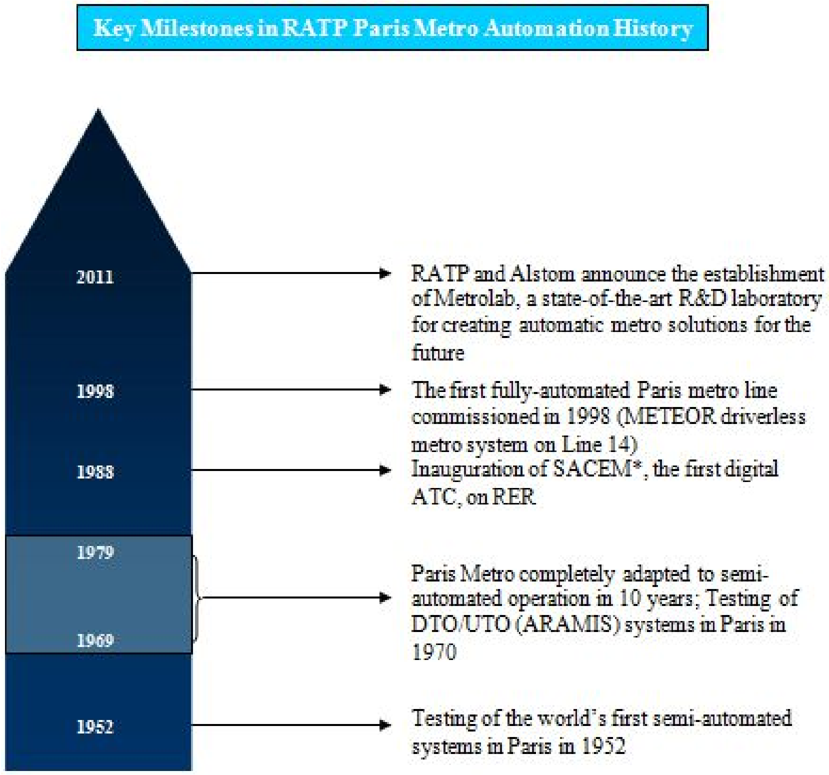
By Sudhakaran Jampala, Sr. Research Analyst, Automotive & Transportation
Email: sudhakaranj@frost.com

The Métro de Paris (Paris Metro) is a symbolic icon of the capital of France. The Paris Metro network ranks among the densest in the world, for which the following statistics stand as a testament.



Source: RATP

The Régie Autonome des Transports Parisiens (RATP) Group, which manages the Paris Metro, also manages an extensive suburban regional express network (Réseau Express Régional or RER), which carries more than 1.8 million passengers a day on two lines - A (1.2million) & B (0.6 million). RATP operates 4,500 buses and three lines of tramways as well, with four additional tramway lines to be introduced into operations within the next five years. All in all, passengers carried by the company reach 8.5 million a day. Experience gained between the RER and Metro with the first generations of Automatic Train Operation/Automatic Train Control (ATO/ATC) and SACEM RER ATC has neatly fit into the group's continuous programme for modernizing train control systems. Innovations in train control in one mode have fuelled technological modernizations in another.

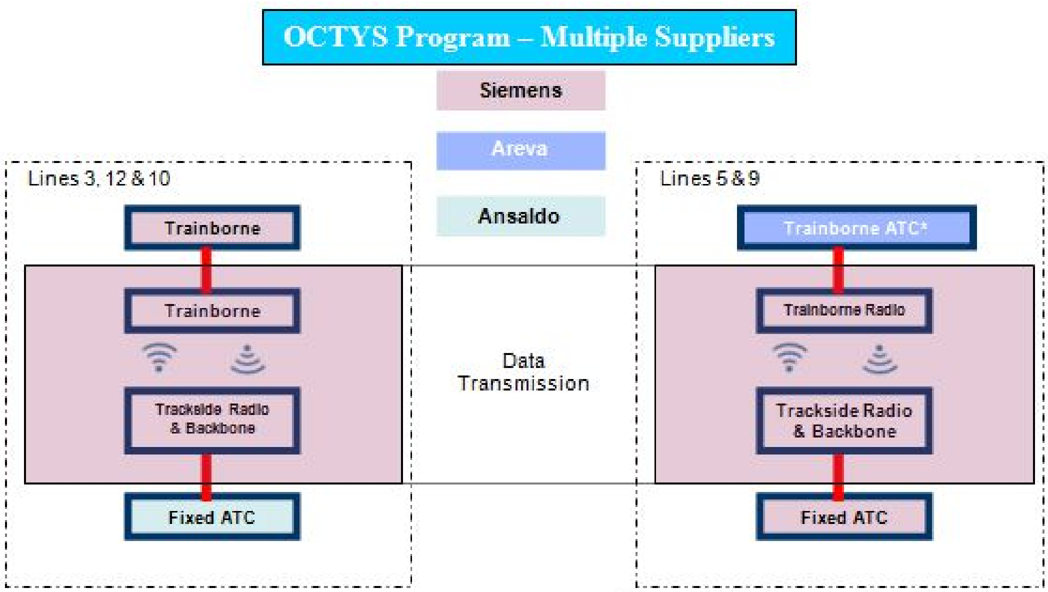


**Designed by a consortium, including ALSTOM, CS Transport (now ANSALDO), and MATRA (now Siemens Transportation Systems)*
Notes: DTO - Driverless Train Operation; UTO - Unattended Train Operation.
Source: RATP; Siemens; and Frost & Sullivan analysis

One among leading metros in the world, RATP has displayed the most nimbleness in addressing the imperative to shift from driver-operated lines to completely automatic ones. In 1998, Paris Metro's Line 14, the world's first completely automated wide gauge metro line, was inaugurated. Two line extensions were carried out in 2003 and 2007, with daily passenger ridership, on the 9 km line, currently at 450,000. The ridership figure implies an average annual growth rate of 12.3 per cent from 230,000 per day in 1998. Operations run at a reliability of 99 per cent, with operating costs estimated at approximately half of that of the other lines. Headways stand at 85 seconds, while typical headways on other lines stand at an average of 105 seconds. The line also enjoys an average speed of 40 kph, in comparison with 20-27 kph range of the non-automated ones. These statistics stand as a testament to Line 14's punctuality, comfort and easy accessibility.

Though there are multiple cities worldwide that have commissioned driverless systems on Greenfield projects, RATP launched an ambitious programme for automation of the Brownfield Line 1, which is the busiest and the oldest line in the network. The line was commissioned in 1900 and currently carries close to 220 million passengers per annum. Thus, with the launch of the Line 1 automation project in 2004, the line has become the first Brownfield metro line in the world being converted to a Driverless Train Operation (DTO) mode. Line 1 is expected to be fully unattended by 2012, with a new series of completely automated Alstom MP05 rolling stock coming on stream after a brief period of coexistence with the driver-operated MP89 trains. The total cost of the project is approximately €550 million, with approximately 70 per cent of it channelled into acquisition of new rolling stock. RATP also has an expansive Semi-automatic Train Operation (STO) programme, either progressing or planned, across six lines, including L3 and L5 as a testimony and first step of application for a generic Communication Based Train Control (CBTC) programme currently planned to be ultimately deployed across the lines that do not fall under the potential UTO programmes (OCTYS).

RATP has rolled out, since 2003, a vast resignalling programme initially called Offre Urbaine Renouvelée et Améliorée Gérée par un Automatisme Nouveau (OURAGAN) - which means renewed, improved, automatically controlled urban offer - and was later renamed OCTYS in order to support the drive toward enhanced metro automation. The generic OCTYS system today entering service on lines 3 and 5 is based on a concept that RATP calls 'Interchangeability,' according to which the CBTC system is segmented into a number of subsystems, so that dependence on any one supplier in averted.



*Notes: *ATC – Automatic Train Control;*
Source: RATP and Frost & Sullivan Analysis

RATP has proved itself as a strong systems integrator, as evidenced by its integration of CBTC units through purchase of individual components from multiple suppliers. Thus, suppliers are compelled to vie for better performance levels in relation to one another, as they understand that RATP is not interested in off-the-shelf unitary products. The strategy also displays RATP's intent to address line extensions, new rolling stock procurement and general maintenance spares procurement on a fully competitive basis. The operator's bold metro automation procedures and innovative market strategies have widely benefited multiple projects managed by Transport Authorities around the world, with respect to strategic procurement from suppliers, whose earlier generation of automatic products had been proven and referenced in RATP networks.

The benefits to passengers are many in the process, including heavily reduced headways, enhanced punctuality, increased communication and coordination of diverse train timetables and better mobility.

Annexure-17

LIST OF COMMUNICATION BASED TRAIN CONTROL (CBTC) METRO LINES IN PROGRESS AND COMPLETED.

Alstom (Commissioned)							
Place	**Lines**	**Commissioning date**	**Headway Design**	**DTO/ UTO**	**Length KM**	**Stations**	**Depot**
Beijng	L-2	June 2008	120s		23	18	2
Beijng	Airport Line	July 2008	180/120s	DTO	28	4	1
Beijing	Fanshan	2010	90s		24.7	11	1
Milan	L-1	2007/2011	90s		27	38	2
Lausanne	M-2	June 2008		UTO/ DTO	6	14	
Singapore	NE	2003	90s	DTO	20	16	1
Singapore	Circle	2009		DTO	40	29	1
Sao Paulo	L-1, 2 & L-3	2008/2010	75s	DTO	58	55	3
Sanghai	L-10	2008/2010	90s	DTO	36	31	1
Shenzhen	L-2	2008/2010	90s		36	29	1
Mexico	L-12(P- 1 & 2)	2011/2012	90s		17/9	12/8	1+1
Lausanne M2		2000/2008			06	14	
Singapur circle line		2000/2009			40	29	1
Singapur north east line		1997/2003	90s		20	16	1
Shenzhen	L5	2011	90s		40	27	1
Alstom (To be commissioned)							
Sanghai	L-21	2011/2013	90s		59	13	1
Mexico	L-12(P- 2)	2012	90s		9	8	1
Santiago	L-1	2010/2012	67s	DTO	20	27	1
Toronto	YUS Line	2006/2012	120s		31+16 Extn	32	-
Malanga	L-1 & L-2	2006/2011	120s		13	18	-
Panama	L-1 (P-1)	2010/2014	75s		13.7	13	1
Shanghai	L-12	2010/2013	90s		41	31	1
Shanghai	L-13	2010/2012	90s		16.4	14	1
Shenzhen	L-5	2009/2011	90s		40	27	1
Gaungzhou	L-6	2009/2011	90s		24.4	22	1
Kunming	L-1	2010/2013	90s		42	31	1
Ningbo	L-1	2010/2013	90s		20.8	20	1
Wuhan	L-2	2011/2013	90s		27	21	1

Wuhan	L-4	2011/2014	90s		33.4	28	1
Beijng	L-9	2009/2012	90s		16.5	13	1
Dubai Al Safoon	LRT (P-1)	2013	180s		10	13	1
Dubai Al Safoon	LRT (P-2)	2013	180s		4	6	-
Siemens (Commissioned)							
Paris	L-14	2003/2007	85s	DTO	8	9	
Paris Ouragan	L-3,5,9,10,12	2008	90s	UTO	35		
Bankok	MRTA	2004			22	18	
Bankok	Airport Link	2007			28	24	
Newyork	-	2006			17	24	
Newyork	NYCT	2008			175	172	
Beijing	L-10/ L-8	July 2008	90s		30.5	26	
Sao paulo	L-4	2010	75 sec	DTO	12.8	11	
Gaungzhou	L-4	2007 ITC 2008 CTC	90s		37.8	10	
Gaungzhou	L-5	2009	90s		31.3	21	
Nanjing	L-2	2010	90s		24	20	
Gaungzhou	Foshan	2010	90s				
Istanbul	L-1	2010 (ITC & CTC)	90s		21	16	
Canarsie/NY		2006					
Sao Paolo	L-1	2010					
Barcelona	L-9	2010			44	49	
Paris Ouragon		2009					
Budapest	M-2	2009			11		
Budapest	M-4	2010	90 sec	DTO	8	10	
Paris	L-1	2010		DTO			
Siemens (To be commissioned)							
Chongqing	L-1	Under Construction					
Suzhou	L-1	Under Construction					
Beijing	L-10 (P-2)	Under Construction					
Beijing	L-8 (Extn.)	Under Construction					
Helsinki		Under Construction					
Metro Algier		Under					

		Construction					
Thales (Commissioned)							
New York	JFK Air Train	2003					
Beijing	L -4/L-15	2009/2010					
Hong Kong	Ma On Shan	2004					
Vancouver	Sky Train	1985					
London	DLR						
San Francisco Muni		1992					
London ***(Tubes Line)***	Jubilee Line	2009			35		
Paris	L-11	2006	***I/L replacement***				
Santiago	L-1 & L-5	2009	***I/L replacement***				
Seoul	Line 9	Oct 2011			19	6	NIL
Thales (To be commissioned)							
London (Tubes Line)	Northern Line	2011			57		
London (Tubes Line)	Piccadilly Line	2014			71		
Paris	Line-13	2011					
New York	JFK Line	2003		DTO			
Hong Kong	Ma On Shan	2004					
Vancouver	Sky Train	1985		DTO			
Ansaldo(Commissioning dates not known)							
Paris	L-3				12	25	
Stockholm					41.2	36	
Copenhagen City Ringen	Driverless			DTO	17	17	
Alifana	Railway				90	13	
Ankara	L-1				32	23	
Ankara	L-2				18	16	
Ankara	L-3				8	6	
Ankara	L-4				5	5	
Shenyang	L-1				29	18	
Shenyang	L-2				25	18	
Chengdu	L-1	2012			15	15	
Taipei	Circular Line			DTO	15.5	14	
BOMBARDIER (Commissioned)							
China,	L-3, Shenzhen	Dec 2010			42	31	
USA	Dallas/Fort	May 2005	120s		10	12	

	Worth Airport						
Guangzhou ZJXC APM		2010	100 sec		4 k.m (dual)		
Tianjin	L-2	2011			22.65	19	
Tianjin	L-3	2012			29.65	23	
BOMBARDIER (Commissioning dates not known)							
USA	San Francisco Airport	Feb 2003	120 sec		10		
UK	Heathrow Airport				7	3	
Taiwan	Taipei Neihu Line				39,8	24	
China	Gaungzhou Pearl River				4	9	
South Korea	Yongln Everline		90 sec		18,5	15	
USA	McCarran Airport				1,7		
UK	London Gatwick				1,2		
USA	Sacramento Airport				0,3		
USA	Seattale Tacoma Airport				2,7	8	
Spain, Madrid	L-1				16.7	27	
Spain, Madrid	L-6				23.5	27	
USA	San fransisco APM				4.8	9	

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GOVERNMENT OF INDIA (BHARAT SARKAR)
MINISTRY OF RAILWAYS (RAIL MANTRALAYA)
(RAILWAY BOARD)

No.98/Proj./DLI/30/1.

New Delhi, dated 12-1-2000

The Managing Director,
Delhi Metro Rail Corporation Ltd.,
NBCC Place, Bhishma Pitamah Marg,
Pragati Vihar,
New Delhi.

Dear Sir,

Sub:- Delhi MRTS project – Technical Clearance for Signalling and Telecommunication systems

Ref:- Director (P&P)/DMRC's letters. No. DMRC/102/98 dated 28-1-99, 16-4-99, and 18-5-99.

Broad details of the Signalling and Telecommunication systems, proposed to be adopted for Delhi MRTS (Phase-I) project, were forwarded to the Ministry of Railways vide your letters under reference. These details have been examined in consultation with the concerned Directorates.

Technical clearance of the Ministry of Railways is, hereby, accorded for the adoption of Signalling systems, as per details enclosed with the DMRC's letter dated 28-1-99 subject to the following proviso:

S.No	Description	Metro Corridor	Rail Corridor	Remarks
1)	Type of Signalling	Cab Signalling CATC(ATP/ATO/ATS)	Cab Signalling ATP/ATS	Approved
2)	Back up Signalling	Line side (CLS) at entry and exit.	Line side (CLS) at entry and exit	Approved with Line side (CLS) at entry and exit at all interlocked stations.
3)	Interlocking	SSI	SSI	Approved with built in Block working facilities
4)	Train Control System	CTC (ATS with remote control)	CTC (ATS with remote control)	Approved
5)	Type of Track Circuits.	Coded Audio Frequency Track Circuits (AFTC)	Coded Audio Frequency Track Circuits (AFTC)	Approved

/–

	Point Machine i) For M/L ii) For Depot	i) Non-trailable high thrust ii) Trailable high thrust	i) Non-trailable high thrust ii) Trailable high thrust	i) Approved as non-trailable high performance Point Machine. ii) Approved as trailable high performance Point Machine.
	Redundancy in Cab equipment for ATP (Cab Sig.)	1+1 (hot stand by)	1+1 (hot stand by)	Approved.

Technical clearance is also, hereby, accorded for the **Telecommunication systems** as under:

S.No.	Description	Metro Corridor	Rail Corridor	Remarks
1)	Tele-communication	Integrated system with OFC, Train Radio, CCTV, Centralised Clock, PA System.	Integrated system with OFC, Train Radio, Centralised Clock, PA System.	Approved with the additional provision that Train Display Boards at stations should also be integrated in the system. Regarding Train Radio System, it should be fully digital and duplex system. The standards may be chosen based on techno-economic considerations.
2)	**Positive Train Identification**	Provided with inter-face between ATS and Train Radio.	Provided with inter-face between ATS and Train Radio.	Approved.

Yours sincerely,

(S.K. JAIN) .1.2000
Executive Director (Delhi Metro),
Railway Board

Copy, for information, to Shri Ashok Pahwa, Secretary, Ministry of Urban Development and Chairman/ DMRC, Nirman Bhavan, New Delhi.

Copy to AM(Sig.) and AM(Tele.), Railway Board

Annexure- 19

	CBTC project list around the world (radio-based and moving block principle)							
S.No.	**Location**	**Line/System**	**Supplier**	**Solution**	**Commission Date**	**Km**	**No. of trains**	**Comments**
1.	San Francisco Airport	AirTrain APM	BOMBARDIER	*CITYFLO*	2003	5	38	Greenfield, UTO
2.	Singapore Metro	North-East Line	ALSTOM	Urbalis	2003	20	40	Greenfield, UTO
3.	Seattle-Tacoma Airport	Satellite Transit System APM	BOMBARDIER	*CITYFLO*	2003	3	22	Brownfield, UTO
4.	Las Vegas	Monorail	THALES	SelTrac RF	2004	6	36	Greenfield, UTO
5.	Wuhan Metro	1	THALES	SelTrac	2004	27	32	
6.	Dallas-Fortworth Airport	DFW Skylink APM	BOMBARDIER	*CITYFLO*	2005	10	64	Greenfield, UTO
7.	Hong Kong Disneyland	Penny´s Bay Line	THALES	SelTrac RF	2005	3	2	Greenfield, UTO
8.	Lausanne Metro	M2	ALSTOM	Urbalis	2008	6	17	Greenfield, UTO
9.	Beijing	Airport Express	ALSTOM	Urbalis	2008	28	10	Greenfield, DTO
11.	Beijing Metro	2	ALSTOM	Urbalis	2008	23	48	Brownfield, STO
12.	Metro de Madrid	1, 6	BOMBARDIER	*CITYFLO*	2008	48	143	Brownfield, STO
13.	Las Vegas-McCarran Airport	McCarran Airport APM	BOMBARDIER	*CITYFLO*	2008	2	10	Brownfield, UTO
14.	London Heathrow Airport	Heathrow APM	BOMBARDIER	*CITYFLO*	2008	1	9	Greenfield, UTO
15.	Metro de Barcelona	9	SIEMENS	TG MT CBTC	2009	46	50	Greenfield, UTO
16.	New York City Subway	BMT Canarsie Line	SIEMENS	TG MT CBTC	2009	17	53	Brownfield, STO
17.	Washington-Dulles Airport	Dulles APM	THALES	SelTrac RF	2009	8	29	Greenfield, UTO
18.	Shanghai Metro	6, 7, 8, 9	THALES	SelTrac	2009	135	111	Greenfield and Brownfield
19.	Taipei Metro	Neihu-Mucha	BOMBARDIER	*CITYFLO*	2009	26	76	Greenfield and Brownfield, UTO
20.	Philadelphia	SEPTA Light Rail Green Line	BOMBARDIER	*CITYFLO*	2010	8	115	STO
21	Beijing Metro	4	THALES	SelTrac	2010	28	33	DTO
22.	Guangzhou Metro	Pearl River Line APM	BOMBARDIER	*CITYFLO*	2010	4	19	Greenfield, DTO
23.	Guangzhou Metro	3	THALES	SelTrac RF	2010	67	40	DTO
24.	London Gatwick Airport	Terminal Transfer APM	BOMBARDIER	*CITYFLO*	2010	1	6	Brownfield, UTO
25.	Paris Metro	3, 5	ANSALDO STS / SIEMENS	Inside RATP´s Ouragan project	2010, 2013	26	40	Brownfield, STO
26.	Yongin	EverLine ART	BOMBARDIER	*CITYFLO*	2011	19	30	UTO
27.	Shenzhen Metro	3	BOMBARDIER	*CITYFLO*	2011	42	43	STO
28.	Metro de Madrid	7 Extension MetroEste	INVENSYS	SIRIUS	2011	9	?	Brownfield, STO
29.	Dubai Metro	Red, Green	THALES	SelTrac	2011	70	85	Greenfield, UTO
30.	Seoul Metro	Bundang Line	THALES	SelTrac	2011	17	12	Greenfield, DTO

	CBTC project list around the world (radio-based and moving block principle)							
S.No.	**Location**	**Line/System**	**Supplier**	**Solution**	**Commission Date**	**Km**	**No. of trains**	**Comments**
31.	Shenyang Metro	1	ANSALDO STS	CBTC	2011	27	23	Greenfield, STO
32.	Sacramento International Airport	Sacramento APM	BOMBARDIER	*CITYFLO*	2011	1	2	Greenfield, UTO
33.	Paris Metro	1	SIEMENS	TG MT CBTC	2011	16	53	Brownfield, DTO
34.	Tianjin Metro	2, 3	BOMBARDIER	*CITYFLO*	2012	52	40	STO
35.	Singapore Metro	Circle	ALSTOM	Urbalis	2009	35	40	Greenfield, UTO
36.	Metro Santiago	1	ALSTOM	Urbalis	2012	20	42	Greenfield and Brownfield, DTO
37.	São Paulo Metro	1, 2, 3	ALSTOM	Urbalis	2012	62	142	Greenfield and Brownfield, DTO
38.	Algiers Metro	1	SIEMENS	TG MT CBTC	2012	9	14	Greenfield, STO
39.	Phoenix Sky Harbor Airport	PHX Sky Train	BOMBARDIER	*CITYFLO*	2012	3	18	Greenfield, UTO
40.	Riyadh	KAFD Monorail	BOMBARDIER	*CITYFLO*	2012	4	12	Greenfield, UTO
41.	Shanghai Metro	11	THALES	SelTrac RF	2012	50	58	Brownfield and Greenfield
42.	São Paulo Commuter Lines	8, 10, 11	INVENSYS	SIRIUS	2012	107	136	Brownfield, STO
43.	Helsinki Metro	1	SIEMENS	TG MT CBTC	2014	35	?	Greenfield and Brownfield, STO[19]
44.	Paris Metro	13	THALES	SelTrac RF	2013	23	?	STO
45.	Beijing Metro	8, 10	SIEMENS	TG MT CBTC	2013	49	82	STO
46.	Nanjing Metro	2, 10	SIEMENS	TG MT CBTC	2013	38	35	Greenfield
47.	Caracas Metro	1	INVENSYS	SIRIUS	2013	21	?	Brownfield
48.	São Paulo Metro	Tiradentes Monorail Extension Line 2	BOMBARDIER	*CITYFLO*	2014	25	54	Greenfield, UTO
49.	Stockholm Metro	Red	ANSALDO STS	CBTC	2014	41	30	Brownfield, STO
50.	Jeddah Airport	King Abdulaziz APM	BOMBARDIER	*CITYFLO*	2014	2	6	Greenfield, UTO
51.	Incheon Metro	2	THALES	SelTrac RF	2014	29	37	UTO
52.	Munich Airport	Munich Airport T2 APM	BOMBARDIER	*CITYFLO*	2014	1	12	Greenfield, UTO
53.	São Paulo Metro	5	BOMBARDIER	*CITYFLO*	2015	20	34	Brownfield & Greenfield, UTO
54.	Taipei Metro	Circular	ANSALDO STS	CBTC	2015	15	17	Greenfield, UTO
55.	Singapore Metro	Downtown	INVENSYS	SIRIUS	2016	40	73	Greenfield, UTO
56.	Taichung Metro	Green	ALSTOM	Urbalis	2017	18	29	Greenfield, UTO
57.	Kuala Lumpur MRT	Klang Valley MRT	BOMBARDIER	*CITYFLO*	2017	51	74	Greenfield, UTO
58.	New York City Subway	IRT Flushing Line	THALES	SelTrac RF	2017	25	46	Brownfield, STO

	CBTC project list around the world (radio-based and moving block principle)							
S.No.	Location	Line/System	Supplier	Solution	Commission Date	Km	No. of trains	Comments
59.	London Underground	SSR Lines: Metropolitan, District, Circle, Hammersmith & City	BOMBARDIER	*CITYFLO*	2018	190	334	Brownfield, STO
60.	Rennes ART	B	SIEMENS	TG MT CBTC	2018	12	19	Greenfield, UTO
61.	Copenhagen S-Train	All lines	SIEMENS	TG MT CBTC	2018	170	136	Brownfield, STO
62.	Budapest Metro	M2, M4	SIEMENS	TG MT CBTC	?	17	41	
63.	Guangzhou Metro	4, 5	SIEMENS	TG MT CBTC	?	70	?	
64.	São Paulo Metro	4	SIEMENS	TG MT CBTC	?	13	14	Greenfield, UTO

Annexure-20

Annexure-E2

SYSTEMS FOR SIGNALLING & TELECOMMUNICATION FOR METRO RAIL

It may be noted that the given criteria is based upon systems already adopted by the existing Indian Metros. However, in case Metro Authorities are adopting a new technology, then the same shall be advised and in principle concurrence of RDSO should be obtained in principle.

Signalling systems

SN	Description	Minimum requirement
1.	Type of Signalling	Cab Signalling, CATC (ATP, ATO, ATS). ATP and ATS are essential, ATO is optional.
2.	Back up Signalling	Line Side Signals (CLS) at entry and exit at all interlocked stations
3.	Interlocking	E1 with built-in block working facilities.
4.	Train Control system	CATC(ATP, ATS, ATO optional)
5.	Type of Track Circuits	Coded Audio Frequency Track Circuits (AFTC)
6.	Point Machine	
	i) For Main Line	i) Non-Trailable high thrust, high performance point machine
	ii) For Depot	ii) Trailable high thrust, high performance point machine
7.	Redundancy in cab equipment for ATP (Cab Sig.)	1+1(hot standby)

Telecommunication systems

SN	Description	Minimum requirement
1.	Telecommunication	Integrated system with OFC, Train Radio, CCTV, Centralised clocks, PA system, with the additional provision that Train Display Boards at stations should also be integrated in the system. Regarding Train Radio system, it should be fully digital and duplex system, the standards may be chosen based on techno-economic considerations
2.	Positive Train	Provided with interface between ATS and Train Radio

Annexure – 21

Recommended Systems for Signalling & Train Control and Telecommunication for Metro Rail System

A. For Signalling System

S.No.	Description	Technical Requirement
1.	Type of Signalling	Cab Signalling CATC (ATP/ATO/ATS) Generally CBTC based ATC, ATO is optional
2.	Back Up Signalling	Line Side Signals (CLS), as per operational requirement and at Point locations.
3.	Interlocking	Computer Based Interlocking.
4.	Train Control System	Redundant ATS with Operation Control Centre.
5.	Train Detection	• On Main Line: AFTC/Axle Counter. • (Depot AFTC/ Axle Counter RM mode) Driver/ Driverless Train Operation/ Un-attended Train Operation as per operational requirement of Metro).
6.	Point Machine i) For Main Line ii) For Depot	Non Trailable High Trust with clamp lock Non Trailable / Trailable (Depending upon operational requirements) Indian Point Machine.
7.	Redundancy in Cab equipment for ATP (Cab Signalling)	1+1 as per prevalent and proven technology and meeting RAMS requirement.

B. For Telecommunication systems, Metro may plan as under:

1.	Telecommunication	Integrated system with OFC. Train Radio, CCTV, Centralized Clock and PA/PIDS systems.
2.	Positive Train Identification	To be provided as per Metro Operational requirement through suitable means.

Annexure-22

Telefax : +91-11-23418304

दिल्ली मेट्रो रेल कॉर्पोरेशन लि०
DELHI METRO RAIL CORPORATION LIMITED

(A JOINT VENTURE OF GOVT. OF INDIA & GOVT. OF DELHI)
Metro Bhawan, 13 Fire Brigade Lane, Barakhambha Road, New Delhi - 110 001

RAJ KUMAR
DIRECTOR (OPERATIONS)

No.DMRC/S&T/Tele/WPC/4843 Dated: 16.07.2012

The Wireless Advisor,
Ministry of Communication and IT,
Department of Telecommunications,
WPC Wing, 6th Floor, Sanchar Bhawan,
New Delhi – 110 001

(Kind Attn: Dr. Ashok Chandra, Wireless Advisor)

Sub : Policy Guidelines for allocation and price TETRA Frequencies and Reserving bandwidth for Train Control for Metro Operation

Ref: (i) Your office letter No. L-14021/75/2006-LR/1003 dated 26.06.2009.
(ii) DMRC letter No. DMRC/S&T/Tele/WPC/2658 dated 27.10.2009.

Sir,

1.1 VOICE COMMUNICATION

Metro Railways use dedicated voice network, as it is essential for Operational and Safety requirement for train operations. For this purpose all Metros in India and elsewhere in the world are generally using TETRA Radio system for voice communication. To meet Operational, Safety and Security requirement, there is a need of more than 10 simultaneous Talk Groups.

TETRA Radio system supports 4 time slots for each frequency pairs (Trans and Receive), which in turn can support maximum 4 Talk Groups. In Metro operations, there is a requirement of more (>10) Talk Groups. Therefore, each base station requirement comes to 3-4 pairs of frequency. In Metros network, which only starts with 1-2 lines, minimum 10 frequency pairs are essential for adequate design, considering frequency re-use and preventing over-reach communication. As the Metro network grows, frequency re-use leads to interference. Unlike a Public Mobile system, interference has to be avoided by design, as TETRA Radio system for Metro plays important role in Safety and Train operation, being the only means of communication from train (Train Operator) to ground (OCC/Station). In case of DMRC, the same network is used by security agency i.e. CISF for Delhi Metro and Delhi Metro Police.

Based on the experience of Delhi Metro, Wireless Planning and Coordination (WPC) wing of Ministry of Communication may agree to adopt following guidelines:-

1) Minimum 10 frequency pairs to be allocated to a new Metro, to start with.

2) In addition to the minimum ten frequency pairs, minimum ten more frequency pairs to be allocated for every 100 km of the Metro network.

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3) For a requirement beyond the minimum as stipulated in item 1 and 2 above, the respective Metros to take up the additional requirement, if any, with the WPC for further allotment.

1.2 DATA COMMUNICATION FOR TRAIN CONTROL AND OPERATION

With increasing flexibility of need of train running with 100 seconds headway, world over, Metros are using Communication Based Train Control (CBTC) technology. A safe spacing / distance is ensured between trains with the help of this technology. This function is vital function. This technology also required for monitoring health of train's equipment and interface with passengers from Control Centre and this activity is a non vital function. needs two types of data network from train to ground:-

1) **Train Control:** These functions relate directly to Train control and dedicated Wifi network is used by most of the train control suppliers. Normally Wifi network of 5.7 GHz (unlicensed) bands are used. In order to eliminate noise from other user, WPC may consider limiting the use of these unlicensed bands about 50 meters of Metro alignment.
2) **Monitoring functions**: For the purpose of real time CCTV streams from train to Control Centre and for transfer of alarm and event functions from train to ground in real time 2.4GHz Wifi is planned to be used.

DMRC will need additional 10 pair frequency in addition to what already being used for TETRA system and requests reserve frequencies in 5.7 GHz and 2.4 GHz Wifi bands.

Thanking you,

Yours sincerely,

(Raj Kumar) 18/7/12
Director (Operations)

Not on Original

OSD to MD – For kind information of MD please.

DE – For information with reference to Advisory Board.

Annexure-22

Government of India
Ministry of Communications & IT
WPC Wing, Sanchar Bhavan, 20 Ashoka Road, New Delhi-110 001

No.: L-14022/01/2012-NT

Date: 16.01.2013

To,
The Director (Operations),
Delhi Metro Rail Corporation Limited,
Metro Bhawan, 13, Fire Brigade Lane, Barakhambha Road,
New Delhi-110 001

Subject: Policy Guidelines for allocation and price TETRA frequencies and reserving bandwidth for Train Control for Metro Operation.

Sir,

I am directed to refer to your letter No. DMRC/S&T/Tele/WPC/4843 dated 16.07.2012 on the above mentioned subject and to state that the 2.4 GHz and 5.7/5.8 GHz bands have been de-licenced; as such there is no provision of reservation of frequency in these de-licenced bands.

As regards the allotment of additional frequencies for TETRA system, DMRC may send their requirement with full justification.

Yours Faithfully
रामलगन राम
(Ram Lagan Ram) 16.1.2013
Assistant Wireless Advisor
to the Govt. of India

24/01/13
1903

ED/S&T
CSTE-1

Dy. CSTE/TM-1

Adv/S&T may also like to see

Annexure-23

Views , comments from RDSO on final report as came to my mind while going through report are as follows:

1. CBTC being most advance technology, a critical safety system like ATP must ensure safety in the worst possible case. In order to ensure this, a ***Hot Stand-by ATP*** system as real-time backup train protection system, when the train is operated in Coded manual Mode or ATO mode, is essential. Warm or cold standby cannot be taken as the ideal for setting standards for safety systems; that too for a Metro in a mega-polis city like NCR, Mumbai, where once Metro operations start, it will be really catastrophic to run a Metro with restricted speeds***.(item 7 of table A:signalling system page 49).***
2. Train side back bone network is available to achieve this as OFC is in use for the data connectivity.(http://www.railway-technology.com/downloads/whitepapers/cables/filecbtc-connectivity-solutions)
3. Indigenization in **"Independent Safety Assessment"** of such advance system. Few lines may also deliberate upon.

4. **PSD** necessity, though not directly linked with the signalling standards, but as our traffic crowd/ daily commuters are not as disciplined as the country discussed in the report, may also be deliberated upon as we are going to UTO like operations**.(Para 3.12 of final report).**

5. **Capacity & integrity of data network (maintenance point of view):**The technology under discussion ie. CBTC rely on equipment modules, both on and off trains, which need to communicate with each other in real time in a sophisticated manner. CBTC is a sophisticated software-driven system, with many on-train units interfacing with each other, with off-train CBTC elements, and with other systems on the train.

   Systems and components on the railways do not work perfectly all the time. It is common for faults to develop on them, and these faults generate costs to the industry in a number of ways: They may cause delays to services. The systems or components in question may need to be inspected and possibly repaired or replaced. In an attempt to minimize faults, preventative maintenance is carried out on systems and components.

However, faults are often not purely random events, for example:

- Faults/Defects may be associated with the introduction of new technologies to the railways, and in particular with the combination of new technology, new methods of installation and new maintenance requirements.
- Faults which persistently recur on specific part of equipment, often when the fault has been reported before, and the equipment has been examined and apparently repaired, or where no fault has been found on previous examination.
- Faults which occur more on particular types of trains than others.
- Faults which occur more in particular places than others.

These patterns of faults/defects may be difficult for the S&T engineers to identify unless a record is kept of them. However, if a detailed record is kept, it becomes more likely that the root cause behind particular fault patterns will be identified, and dealt with.

Many times in signalling &telecom engineers report their frustration with so-called ‘no fault found’ (NFF)/auto-right events/NINA failures (Neither informed nor attended). An NFF/Auto right occurs when a particular part of equipment is reported as being faulty, but on examination (either in situ or after it has been removed from service), the fault cannot be reproduced.

Such defects may arise because:

- The wrong item is investigated.
- The correct item is identified but not properly investigated; due to inadequate competence or application of competence (e.g. the investigation fixes a fault but not the underlying cause).
- The correct item is investigated and corrective action is taken to return it to service but it is not a permanent repair.

- The correct item is investigated but the fault is at the interface not with the component itself (e.g. interference, incompatibility, operating tolerances).
- The correct item is investigated and repaired but the problem is caused by the operating environment. The replacement component is also defective. The item is not fit for purpose.

Control Command &Signaling (CCS) systems have little in common with the technologies that inspired the current maintenance regime on the railways. The sub-units of these technologies are electronic, and for the most they part have no moving parts, so their performance does not gradually degrade over time. Failure of these types of technologies cannot generally be predicted by prior inspection.

Fault recording and corrective action system for handling IT based technologies is required for such system to arrest failures and make smooth operations.

Such system shall require suitably trained people, supported by an IT system, which gather accurate information about the performance of systems and components, and take intelligent action to maximise the performance of the system as a whole and its component parts. Although IT is important, it is the trained people and processes which comprise such system that are most crucial to its success.

To achieve this data network reliability, availability, radio as well as OFC should be also provided with ***suitable redundancy****.* ***(item1.B: telecommunication :page 49of report).***

6. ***Regarding open standards: The radio system is using open standards &transmitter power is limited by Nation's radio Law, EU is 100mW & Japan 10mW, Since open band is also used in ISM like (WLAN, Wi fi) so electromagnetic interference, weak signal strength or saturation of***

communication medium are easy to be caused &lead to disrupt the communications.

To ensure a stable & reliable communication location of base stations shall be a major concern. Another solution paper on this aspect I found Going through net regarding security/reliability of Open standard for CBTC titled "HiNet: Radio Frequency Communication Based Train Control (RF-CBTC) System Jointly Using Hierarchical Modulation and Network Coding" whose abstract is "As Information and Communication Technology (ICT) evolves, unmanned train operation has become norm by using wireless communication technology such as IEEE 802.11. Such a train control system based on wireless technology is called Radio Frequency Communication Based Train Control (RF-CBTC) system. IEEE 802.11 is widely used for RF-CBTC system since IEEE 802.11 is able to operate in license exempt Industrial Scientific and Medical (ISM) band. With the emergence of smartphone, devices using IEEE 802.11 have increased dramatically leading to severe interference to IEEE 802.11 based RF-CBTC system. Since safety of train depends on the reliability of RF-CBTC system, RF-CBTC system must provide reliable communication schemes. This paper proposes HiNet, which is a novel solution to providing a reliablity and efficiency in RF-CBTC system. HiNet takes advantage of network coding and hierarchical modulation in IEEE 802.11 architecture. By jointly using *network coding and hierarchical modulation*, we show that HiNet is able to provide both reliability through the rateless property of network coding and efficiently through the flexibility of hierarchical modulation. Our simulation results using MATLAB corroborate our intuition that joint use of network coding and hierarchical modulation is able to provide communication reliability and efficiency in RF-CBTC system." (Para 4.5 of finalreport)

7. Similarly on Hitachi network I found they are also developing the CBTC for world users consider reliability enhancement on open standards. http://www.hitachi.com/rev/field/industriasystems/__icsFiles/afieldfile/2012/12/26/r2012_07_110.pdf, ***This aspect should be included in ongoing/future work execution of CBTC, & can also be made a part of standardisation. (Para 4.5 of final report)***
8. **Few lines may also be deliberated on "Provision of Software and its**

Source Code License Agreement between Metros/users, the "LICENSEE", and from whom LICENSEE acquired the software product(s) as its indigenisation may not be feasible in near future for these modern systems running / planned. (e.g. http://www.appinf.com/legal/SCLA.pdf) (para 10.5).

KAUSHAL KUMAR

Dated: 2013-04-14

18

N. SIVASAILAM, IAS
Managing Director

Bangalore Metro Rail Corporation Ltd.
(A Joint Venture of Govt. of India & Govt. of Karnataka)
3rd Floor, BMTC Complex, K.H. Road
Shanthinagar, Bangalore - 560 027, INDIA.
Phone : 080-2296 9202, 2296 9203, Fax : 080-2296 9204
Web : www.bmrc.co.in

No. BMRCL/07/CST/S&T/2012/Signalling sub-committee/ 1119 — 4th June 2013

To
Shri. Deen Dayal,
Under Secretary to the Govt. of India,
Ministry of Urban Development,
MRTS Cell, Nirman Bhavan,
New Delhi – 110011.

Dear sir,

Sub:- Final report on Standardization of Signalling and Train Control system for guided rail transport network for urban transport in India for Metro Railways.
Ref:- MoUD letter No. K-14011/26/2012-MRTS-Coord(Pt.III) dt.15th May 2013.

MoUD have circulated the final report of sub-committee on Singalling and Train control vide above reference. This has been examined and following remarks are offered for needful action in the matter.

1. The sub-committee has recommended CBTC signalling for new metro railways in India. This is in line with the technical solution implemented contemporarily elsewhere. The standards for CBTC system have also been indicated in page 48 of the report. However, it may be noted that in CBTC system the trains can be operated in UTO / DTO / STO. The basic requirement of UTO/DTO are different from that of STO based operations viz. in UTO/DTO, live on-board monitoring of coaches from the OCC is essential. Therefore, minimum requirement of CBTC system depends on how the trains are operated. This requires further deliberation.

2. For the operation of CBTC systems in UTO/DTO/STO, there is a need for bringing out operational manual to address management of train operations during normal and de-graded conditions. A para on this issue may be added.

3. The train detection is indicated in the proposed guideline vide sl. no. 5 as "on main line – AFTC /Axle counter". This is not so in case of CBTC based system. The AFTC/Axle counters act as secondary detection devices only. Primarily train position is detected by accurate location determination by appropriate odometer calculations and its calibration. This para i.e. sl. no. 5 of guidelines for signalling systems may require suitable modification. A stipulation with regard to the train detection made as AFTC/Axle counter may be suitably modified to be included "as optional" item for secondary detection methods.

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4. There are a number of cable connectors in rolling Stock and signalling. Reliability of these connectors is very important considering dynamics of the train. However, it may be possible to indigenize these items apart from other items indicated in the report.

5. The sub-committee vide page no. 61 have indicated that, UPS can be sourced locally in India. However, concerns exist for obtaining required reliability levels with optimum maintenance inputs for such equipment. Though UPS is available in India it is to be noted that, their maintenance requirements are high / have redundancies adding to additional energy cost. Therefore, prescribing local sourcing can have an effect on performance since the health of UPS is the main requirement for various sub-systems viz. Signalling/train control, Communication & AFC.

6. The spelling 'Trust' vide sl. no. 6 of proposed signalling system guideline in page no. 48 may be corrected as 'Thrust'.

The above remarks are offered on the captioned subject for consideration.

Yours faithfully,

N. Sivasailam,
Managing Director


Airport
EXPRESS