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The Institution of Railway Signal & Telecommunication Engineers

Journal
October - December, 2006

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GENERAL SECRETARY'S LETTER

Dear Members,

The aim of the Institute is to disseminate and share technical knowledge relating to design, construction, maintenance and adoption of modern S & T systems amongst persons associated with it. To this end the technical journal plays a vital role facilitating interchange and sharing of ideas.

The present issue is the fourth issue of the year. Railways Signalling is on the threshold of major revolution for improving safety and efficiency in train operations.

6th & 7th October, 2006 was a very important day for IRSTE (India) when we held 2nd International Signalling and Telecommunication Equipment Exhibition cum Seminar attended by representatives of World Railways, Industry and Technical Experts at Pragati Maidan, New Delhi. I hope those who have attended the Seminar & Exhibition have benefitted a great deal. Press Brief released during the event & final recommendations of the Seminar are also included in this issue. I hope members will see the same and their esteemed views are welcome.

Distribution of this issue of the journal is directly done through CSTE's or Sr. DSTE's in the Railways as postal address in many cases gets out dated and not really available with IRSTE. It would be appreciated if members send their correct mailing address to undersigned to Shri Anshul Gupta. Of course, our esteemed retired members and sustaining members do get their copies by post. It is of course, essential that the retiring members do furnish their mailing address in advance to ensure prompt delivery and continued service. CSTE's / Sr. DSTE's are requested to ask all members on their Railway / Division to fill the feedback form so that IRSTE can update its records and next issue can be sent directly to the members.

Hope that you will find this issue an interesting one.

Wish you all Happy & Prosperous New Year, 2007

Sincerely yours



(Kundan Chaudhary)
General Secretary, IRSTE

New Delhi
Oct, 2006

**ELECTRONIC INTERLOCKING:
Proposed New Technological changes
for small input-fantastic outputs.**

by :
LOKESH VISHNOI
Dy. CSTE/CON-II/BSP

The Electronic Interlocking or Solid State Interlocking has established itself in the field of S&T gears operating system in Indian Railways. The ease of use and facilities available, along with the reduction in total number of relays to be fixed in station and resultant cost and maintenance problems reduction due to this has convinced both the S&T maintenance staff, as well as the station Operating staff for this method of working of stations gears, and we are progressing full steam in installing this methodology on more & more stations.

As the existing technology / methodology has proved itself, it is time we shall gear up and move towards further improvements on this technology. These improvements, though not containing much "technicality" in it, are very important to make the technology even more attractive and attention drawing. I will propose describe few simple changes and I believe, they will catch your attention like any thing and you will also become supportive of these small

I. Operating panel to be converted to an LCD screen with press sensitive operation: -

Presently, we found that panels like a very large number of ATMs, Station

based PNR enquiry systems etc., which are operated by the general population, even with math lower IQ than the persons operating our station panels. The LCD based operation panel will not only feel attractive, but with installation of LCD panel, we will not make the operational Panel look attractive; we can install simple co-axial cables between the LCD screen and the CTR panel having D/AC.

The LCD Panel will have touch sensitive screens, which makes incorporation of the alteration in yard very easy, and instead of going through the procedure of installing fresh dominos again / re-wiring the complex in-board wires, we can directly go for flashing the fresh image of the proposed yard, and software programming the dominos' output in the process of push-buttons.

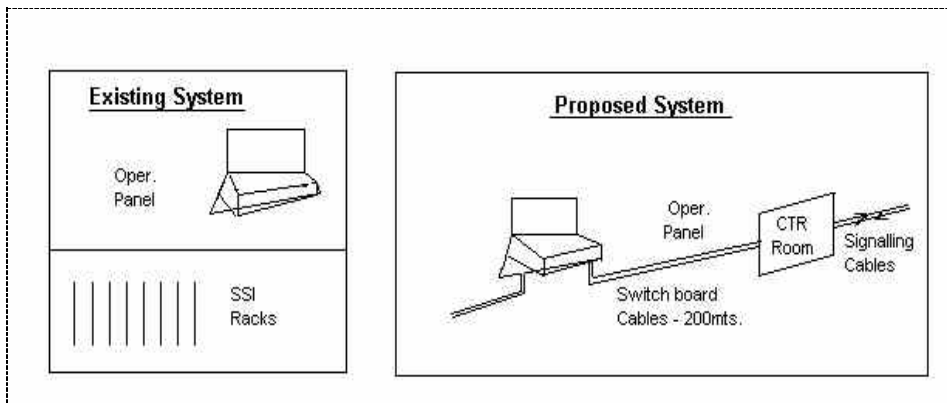
I am told that this is the adopted system for the prestigious KFW project. We shall adopt this technique in all future works, and go for changing of panels in existing stations, if needed.

II. We can install CTRs at both ends, approx 200 mts. at both ends through simple telecom cables connectors. This will save a lot of signalling cables cost of laying / termination.

As I had been discussing and discussed also in this issue that the equipment manufacturers of EI should conform to the use of simple coaxial cables for Distance upto 250 mts. thus, we can install the Relay room-cum-EI System Rooms approximately at least 200 mts. at both end of the Central Panel, so that we can save on procuring and laying of the underground Signalling Cable, which is already very costly and problems / incidents on the installation &

maintenance of the Signalling Cable for this short distance can be avoided by this simple method of carrying the cheap & easily layable switch board cables for a distance of 200 mts.

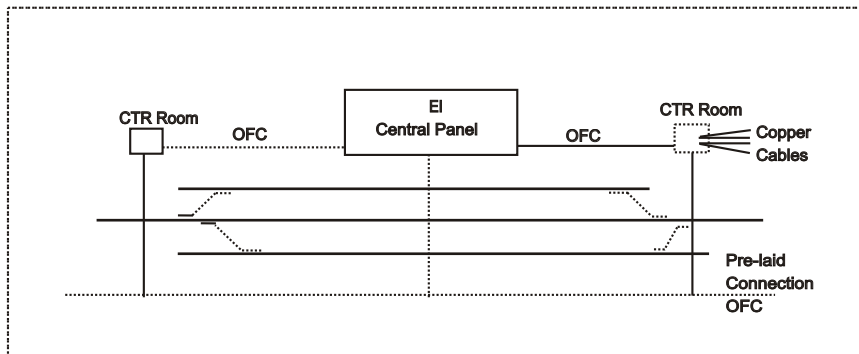
By this method, we may be able to save approximately $12 \text{Cables} * 200\text{mts.} * 80000 \text{Rs./Km} = \text{Rs. } 192000$ per station, and also avoid complexity / problems in related to Signal Cables laying / jointing at present.



III. We can install CTRs / Panel Interaction Rakes (PIRs) at cabins / approx. 700 mts. at both ends, near the furthest point, driven through DAC/ADC between Panel & CTR, and save as a very big lot of cable.

A further improvement on Point II above can be made if we decide to move a step further, and take the signals between the EI Central Panel and End Cabin CTR's, (or newly installed CTR Cabins very near to the top points on both sides of the yard in case existing End Cabins are not

available). The communication for the LCD Panels installed for operations will be digital, and in Serial mode, which we can take upto End Cabins / newly installed CTR rooms through OFC Cables (through a 2-Fibre OFC Cable, specially laid for this purpose, with the communication cable having a spare communication designed for this). Taking the communication between the EI's Central Panel and the End Cabin / CTR room on OFC will be very highly economical.



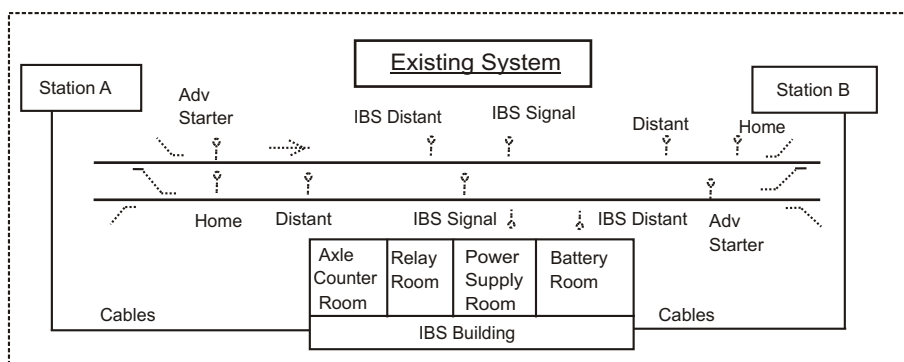
As can be seen from the diagram above, the most visible cost of the Signal Cables and its termination-cum-jointing will be saved when we adopt this method, as we will need to install only a ADC/DAC at the End Cabin / CTR room, and very high costs in procuring & laying of multiple Copper Cables and further headaches of jointing / terminating / periodically meggering it; can also be saved by this method.

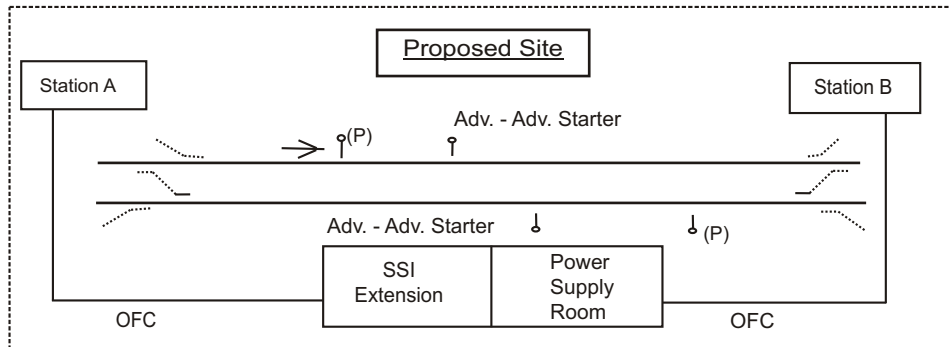
I am told that this is practice had already been started at many advanced tech Railways, especially in Europe. I will request the RDSO to start studies on this. I may be associated on this topic, as needed.

IV. IBS signals can be treated as Advanced Advanced starter for dispatch & Distant - Home before

home. This will save a lot of cables/ arrangements on IBS.

Presently also we treat IBS as a Signal of the base station, and the Block Section is counted between the IBS and the target station. If we include the logics of IBS also in the logic of Base Station SSI, we can avoid a lot of relay-logic making of wiring the same for providing an IBS. We can treat the IBS starter signal as the "Advanced-advanced Starter" of the Base Station and Reception Signal of the IBS as "Distanced Home Signal" of the Base Station. The savings in Logic Hardware, i.e. Relay Racks, Relays & their internal wiring and Power supplies will definitely be much more and also, the reduction of maintenance problems for remote installation like IBS will also be a welcome step by all.



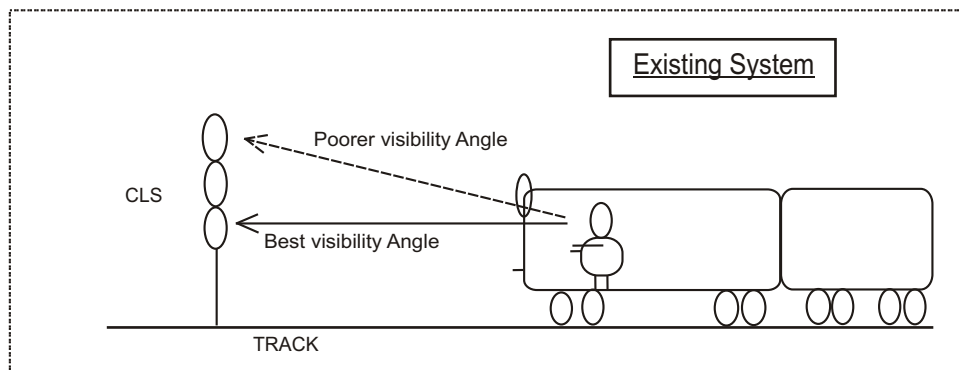


V. Employing LCD in CLS to improve visibility to Loco Pilots & reduce maintenance gears:

As we all know, we do the settings and testing and testing to give "Red" the most visibility and fix it at the supposed Eye-level of the Loco Pilot. In this methodology, other Signal Aspects that is YRY are put in disadvantage - however minor it may be. With the continuously increasing velocity of our Powers and trains, the increased visibility will be very

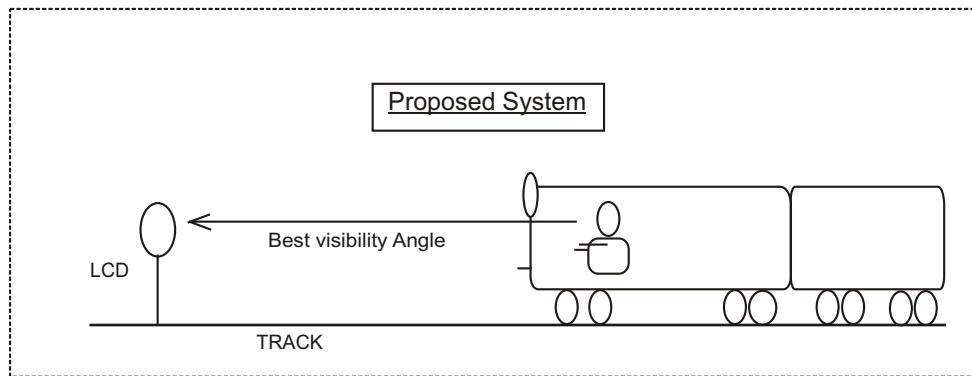
helpful towards proper operations and safety as well. Regarding the visibility properties of LCD display, we know that it is as visible as other devices if viewed in proper direction. Here, the focusing of Signals will be more stressed on, but when focused properly, the visibility will be go excellent in intended direction.

By employing the LCD, we will ensure that all the aspects are at Loco Pilots Eye-level, or the best visibility level, as all



Moreover, by this methodology, we may reduce the total Hardware in use as well as total spares needed to be kept, as we will be using only one Aspect Unit, which will be changing its displayed colours depending upon the commands sent from Control Panel. With the LCD

technology already proven in Computer Screens, newer TV Screens, our PNR Status display boards, all Bank's ATM Panels etc. I believe we can depend upon this fully reliable technology, reducing our problems in multiple ways.



VI. Logging of all station data / activities to application, either that our own net or internet, and give advice to station and inputs to test room.

To reap the advantages of the Infotech boom, we shall use the easy resources available to us. Instead of fighting over the failure details & timings, we can direct that the data loggers at all the stations shall be connected to a specific application of Railways developed for this and also, an entry form can be opened in the FOIS entry terminals to enter the failure records from the concerned station itself. This will save a lot of infights over the details and time of occurrence / rectification times over various failures. Moreover, these will be no chances of modification over the data's and the actual fields raw data will be available to all to take any action over that.

VII. Signal cable of increased Cross Section for reduction in the number of

cable co-rage unnecessary employed.

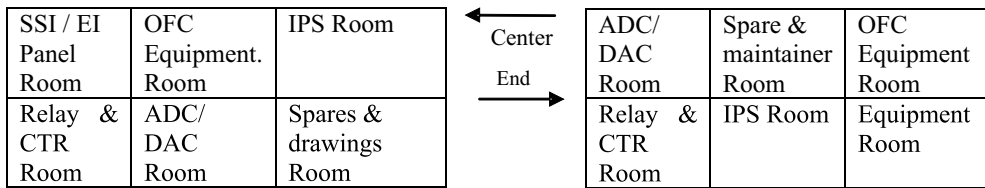
On disturbing trend that is seen in that we are procuring Signalling Cables of only one diameter, and for Signals erected far off from the Panel, we are using multiple cores of the Cable. This, though technically all right, but consumes a lot of cost towards addition of Cable (in terms of Core PVC Sheath, armouring, Cable sheath etc.), laying cost of additional number of cables, etc.

All this can be avoided if we start procuring under our contracts Signalling Cable of heighten cross-section. As such, Signalling Cables of different cross-section can be procured, and to avoid the chance of inter-mixing, cables for distant and inner-distant signals, or as decided, may be differently marked for identification higher cross-section cables.

VIII. Standard design for SSI buildings:

Presently we prepare the drawings for the Buildings of SSI depending upon the local conditions and concerned Division's inclinations. It will be a lot better if we

standardize the design of the SSI buildings, so that it's utilities and fittings are same every where and not changed at the whims & fantasies of persons everywhere.



The above points are based on the experience of both construction & maintenance side. I am sure they must have appealed you a lot. I also propose that an experts' team may be constituted

to study these, as well as many other recommendations by persons in both construction & maintenance side in a wide spectrum and give their experts advices as final on these.

**Performance review and benefits accrued from automatic signaling
in sections with mixed traffic - a case study of
Rajkharsawan-Tatanagar section of S. E. Railway**

by :

SATYAKI NATH

Dy. Chief Operation Manger/P&P, South Eastern Railway

MANAS KUMAR BOSE

Chief Signal & Telecom Engineer/Project, South Eastern Railway

Introduction

Rajkharsawan-Tatanagar section, a 42 Km stretch on Howrah-Mumbai route is a double line section provided with automatic signaling. The section comes under Chakradharpur Division of south Eastern Railway and is strategical located in the sense that iron ore extracted adjacent to Dongaposi area feeds four steel plants viz. Bokaro Steel City, Durgapur, Burnpur and TISCO and two ports viz. Haldia and Paradeep. Besides iron ore, limestone and dolomite loaded from Raganpur, Sonakhan and Birmitrapur for TISCO, Durgapur and

Burnpur steel plants are transported over this route. Washed coal loaded from BCCL and TISCO washeries for Rourkela, Bhilai and TISCO steel plants also move on this route. Finished steel products from these steel plants are transported over the east-west corridor via this route as well. The section is, therefore, of utmost importance to S. E. Railway in terms of revenue earning.

Traffic Pattern

The diagrammatic representation of the train service dealt on this section is depicted in Fig-1.

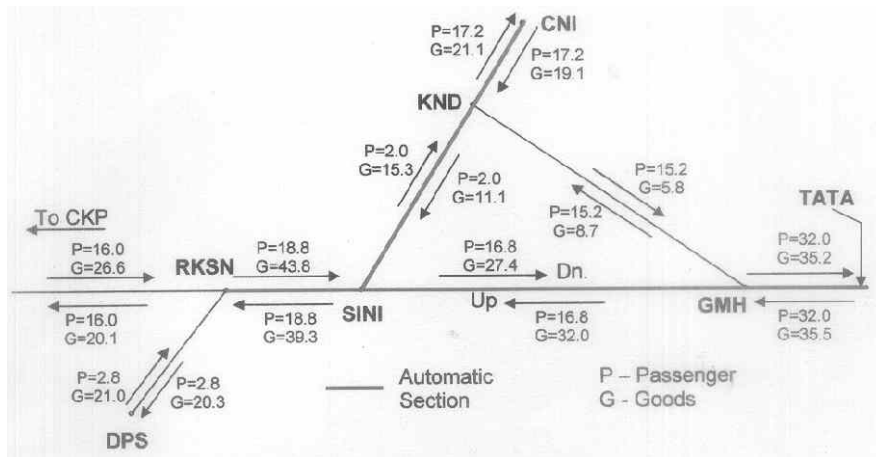


Figure 1 : Train Services in TATA - Rajkharsawan Section

The figure show a substantial mix of passenger trains and the various goods rolling stocks running in the section are given in the table below :

Maximum Sectional Speed of Passenger Trains in KMPH	Maximum Sectional Speed of different Goods Rolling Stock (Wagons Empty / Loaded) in KMPH				
	BOXN	BCN	BRN	BOBS	BOY
105	80/75	80/75	80/75	75/70	65

It can be seen from the figure that the Rajkharsawan-Sini section dealt with 18.8 passenger services each way, 43.8 goods rakes in Down direction and 39.3 goods rakes in Up direction each day during 2004-05. This totals to 58.1 train service in Up direction and 62.6 train services in Down direction as per Annual Report 2004-05 of South East Railway.

Similarly, Tatanagar-Gamharia section dealt with 32.0 pairs of passenger traffic each way, 35.2 goods trains in down direction and 35.5 goods trains in Up direction each day during 2004-05 which totals to 67.5 train services in Up direction and 67.2 train service in down direction.

On the east of Tatanagar is the Tatanagar-Kharagpur section and on the west of Rajkharsawan is Rajkharsawan-Chakradharpur section. Both the section are each doubl line sections with absolute block working. The charted line capacity of kharagpur-Tatanagar section is 54 and that of Rajkharsawan-Chakardharpur is 64 without maintenance block. With maintenance block the line capacity of these section are 53 respectively.

Setion	Length in Km.	Line capacity without maintenance block	Line capacity without maintenance block
TATA-GMH	10.6 Km	113	94
GMH-SINI	16.2 Km	138	115
SINI-RKSN	15.3 Km	138	115

The Scott's formula indicates line capacity of 56 for Tatanagar-Rajkharsawan section with Gamharia-Sini as the longest block section with average running time of 13 minutes with absolute block working. The actual line capacity for this section assuming absolute block working is, thus, expected to be in the vicinity of this figure. Evidently the existing double line section between Tatanagar-Rajkharsawan would have saturated long back without the use of automatic signaling.

Line Capacity Increase Through Automatic Signalling

The provision of auto signaling between Sini-Rajkharsawan section was sanctioned in 1958-59 at a cost of Rs.25 lakhs allocated to CAP. Similarly the provision of auto signalinf between Tatanager-Sini was sanctioned in 1963-64 at a cost of Rs.26.40 lakhs allocated to CAP. These works were completed in 1962 and 1967 respectively with sharp increase in line capacity. The charted line capacity of Tatanagar-Sini and Sini-Rajkharsawan section with the provision of automatic signaling are given below :

It can be seen that the provision of automatic signaling increased the line capacity more than twice arrived from Scott's formula as well as double that of actual charted line capacity of adjacent

sections. Thus the advantage accrued from providing automatic signals competes with that of what have been achieved using quadruple line sections.

Effect of Mixed Traffic:

Section	Trains running			Passenger to Goods Ratio	Section capacity without/ with maintenance block
	Passenger trains each way	Goods trains in UP direction	Goods trains in Dn direction		
TATA-GMH	32.0	35.5	35.2	≅ 1:1	113/94
GMH-SINI	16.8	32.0	27.4	≅ 1:2	138/115
SINI-RKSN	18.8	39.3	43.8	≅ 1:2	138/115

From the above table, it can be seen that the TATA-GMH section where the number of passenger trains are nearly equal to the goods trains, i.e. Perfectly Mixed traffic, the section capacity is less than the section capacity for GMH-SINI and SINI-RKSN section where the goods to passenger ratio is approximately 2:1. Thus in a mixed traffic area, the section capacity is expected to decrease compared to the ideal situation

where all trains are running at equal speed. This is attributed to the fact that while a mail/express train is pushed into the automatic section; it is normally ensured that the automatic section ahead is free of goods trains. Thus, all the goods trains with low speed are controlled in the nearby station section and accordingly, the advantage of automatic section during the movement of high-speed trains is not utilized fully.

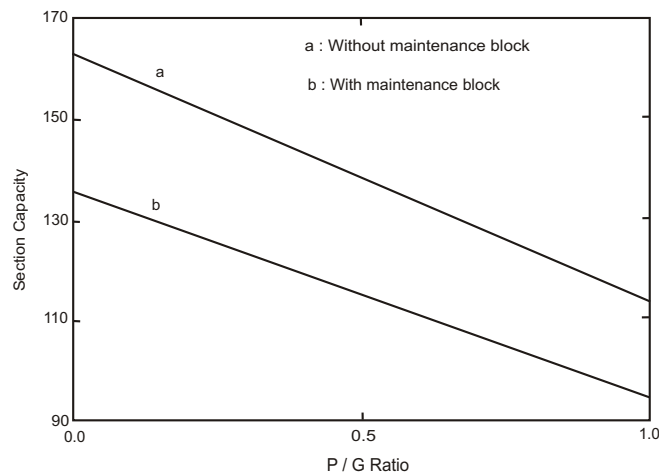


Fig.2: Dependence of Traffic Mix on Section Capacity

The functional dependence of section capacity on the ratio of passenger to goods traffic is shown in figure 3 based on the charted section capacity of TATA-Rajkharsawan section. A linear interpolation to Zero passenger to goods ratio i.e. The case where all the trains are running with same speed gives a figure of 163 for the section capacity without the maintenance block and capacity all the trains are running at equal speed.

Effect of Automatic signaling on speed:

It is normally believed that in automatic sections the average speed of trains is much less compared to the sections with absolute block working. The preception is based on the surmise that in an automatic section, the trains are

pumped on after another due to which the trains continuously confront signals with yellow aspect and the trains can never pick up speed. An analysis of a typical control chart, on the contrary, reveals that the trains move in the automatic section nearly at the sectional speed. However, at the exit of the automatic section, the trains get controlled due to substantial difference in section capacity between the automatic territory and the absolute block territory. For example, during peak hours, 7 trains an hour arrive at Rajkharsawan-Barabamboo section can handle only 4 trains an hour at the maximum. The differential, thus causes train detentions of long durations not only at Rajkharsawan but also at stations in rear where are controlled to get ride of the saturation at Rajkharsawan. The situation is depicted pictorially in Fig. 3.

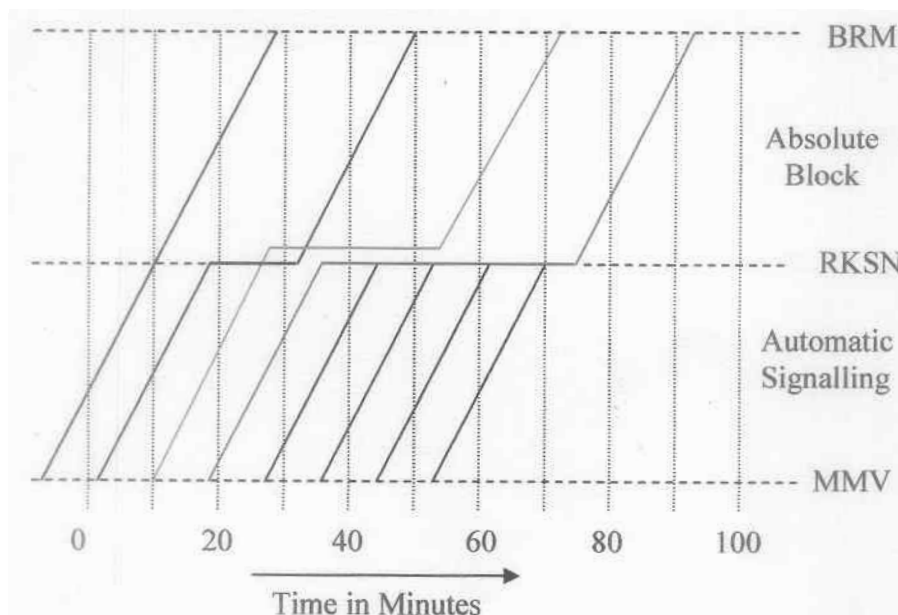


Fig.3: Detentions due to transition between automatic signalling and Absolute Block Working

Similar argument holds good at the exit end of TATA as well. The low average speed of trains in an automatic section is therefore not an attribute of the automatic signaling itself but results due to the bottleneck at the boundary between the automatic section and the absolute block section.

Effect of Gradient:

The section capacity in an automatic signaling section is directly related to the signal spacing distance. Ideally, the signal spacing distance should be equal to the braking distance in 3-aspect signalling while; in 4-aspect signalling the signal spacing distance should be equal

to half the braking distance. The gradient of a section, however, decides the braking distance and accordingly affect the signal spacing and the section capacity in automatic signalling sections. Moreover, the signals cannot be positioned at sharp gradients because of which the location of the signals needs some adjustment. This results either in a larger signal distance or imposition of aspect control on signals. Both these factors tend to reduce the section capacity. The TATA-RKSN section has an undulatory terrain and has sharp gradients with ruling gradient of 1 in 100. The gradients in section steeper than 1 in 125 are shown below:

Gradient	Total No.	Total Stretch in Km.
1 in 100	1	0.3
1 in 114.4	1	0.7
1 in 125	15	9.5

The inter signal distance in the section are accordingly in the range of 1.5 to 2 Kms whereas in a flat terrain the inter signal distance are around 1 Km. Thus, the sharp gradient in the section has some derogatory effect on the section capacity with respect to the ideal situation in flat terrains.

Serious concerns are often expressed regarding the use of automatic signalling in sections with sharp gradients. Since the trains may stop and then start at the foot of the automatic signals in the mid section with sharp gradients, possibility of stalling, parting, rollback and consequential accidents cannot be ruled out. In other

words, it is argued that the automatic signalling in sections with steep gradients are prone to accident. TATA-Rajkharsawan stretch with steep gradients in the section handles large number of heavy hauls each day and is an ideal example for case study in this section in September 2001 when a goods train waiting at the foot of the home signal at Mahalimarup was hit in the rear by another goods train. No casualties were reported in the accident.

Effect of failure:

The failure in the auto section for the last 3 years are tabulated below:

Year	No. of failures	Average number of signals affected in each failure	Total duration (Mins.)
2003-04	142	2	21300
2004-05	136	2	20400
2005-06	241	2	36150
Total in 3 Years	519	2	77850

This works out to 14.4 (say 15) failure on an average in the auto section with total duration of interruption in train services being 2160 minutes in a calendar month. There are total 48 automatic signals in the above section of which 2 signals on an average are affected in a failure. The failure effecting train operation in terms of percentage is, therefore, only 0.2% and can be considered negligibl for all practical purposes.

Cost Benefit Analysis:

At present the cost of laying new track is around Rs.4 crores per Km. Thus to lay double line track would cost Rs.8 cores per Km. To convert the double line section into a quadruple line section to achieve section capacity approximately that achieved using automatic signaling on double line section would cost around Rs.320 crores for a section of 40 Kms. However, in terms of the present day cost, the provision of automatic signaling on double line section costs somewhere in the range of 30 to 40 lakhs a Km. This would mean an investment of only Rs.16 crores to achieve nearly equal gain of a quadruple line section.

The present maintenance cost of the Tatanagar-Rajkharsawan automatic

section is approximately Rs.50 lakhs per annum. This work out to Rs. 1.2 lakhs per Km per annum towards maintenance cost of automatic signaling at the present market rates. At the same time the maintenance cost of tracks is around Rs.1.65 lakhs per track Km per annum and that of maintenance cost of electrical traction is in the range of Rs. 1 lakh per track Km per annum. Thus, provision of automatic signalling is a cheaper option with respect to laying new track even in terms of maintenance.

Conclusion:

The introduction of automatic signalling in TATA-Rajkharsawan section improved the section capacity tremendously. Even after considering the degradation due to mixed traffic and the sharp gradients in the section, the chartered section capacity competes with that of what could have been achieved using quadruple line sections even though the provision of automatic signalling is much cheaper. The automatic signalling is inherently safe and does not in any way reduce the average sectional speed.

This paper was presented in the 2nd International Signal & Telecom Seminar held at Pragati Maidan on 6th & 7th October, 2006.

CASE ON SAFETY OF RUNNING TRAINS

by :
ANSHUL GUPTA

In 1998 a serious Train collision took place at Khanna station in Punjab resulting in more than 250 deaths. This was followed by another worst train accident in August 1999 due to collision at Gaisal station claiming many lives.. With collisions resulting in more than 40% of fatalities on Indian Railways, Railway Board during 1999-2000 decided to develop and provide Collision Prevention system on identified sections of Indian Railways.

Background:

Signalling systems provided at station and between stations govern the safe running of trains on Indian Railways. Though, adequate Safety systems are available to take care of the mistakes and uncertainties involved in train operations by the human interface by the provision of systems like Electrical or Electronic Interlocking Systems, Track Occupancy verification devices, Complete Train Arrival Systems at a station, more advanced systems as used on leading rail networks of the world to centralize Train Control on a complete section so as to take care of human mistakes completely. Further to take care of human mistakes and errors committed by the loco driver, no technically advanced Train Control System is in operation. In all the zonal railways the train control systems are manual. In all the developed railway systems, some or the other form of Automatic /Auxiliary Warning System (AWS) is used as a basic safety system for preventing drivers passing a signal at danger (SPAD). And also to improve efficiency, effectiveness, and reliability in train operations.

As per Railway Safety Review committee Report¹ (RSRC) 1998 headed by Justice Khanna, about 75 % of the total train accidents on Indian Railways are caused due to human error. Collisions on IR constitute 7% of total accidents but account for 40% of total fatalities. About 60% of collisions on IR are due to disregard of the signals by train drivers. RSRC, headed by Justice H.R.Khanna, also suggested among other things that Train Protection and Warning System (TPWS) should be developed and introduced on I.R. , vide its recommendations in para 6.2 & 6.3 of RSRC Part I report. The density of train traffic is increasing day by day and with more emphasis on higher speed, the train drivers are likely to be subjected to increasing stress.

In the meantime, expert Committee set up by Railway Board to conduct a detailed techno-economic study on various railway systems world over and suggest a suitable system of Automatic Train Protection for adoption on IR recommended that:

“A radio- GPS based failsafe Auxiliary Warning System super imposed on existing signalling system is considered to be most suitable for Indian Railways. It is pilfer free, damage free and also provides the integrated solution to the various requirements of Indian Railways”.

Accordingly a pilot project of providing Train Protection system, based on European Train Control System was sanctioned. However the pilot project got delayed due to ongoing trials of the system in Europe. In the meantime a number of serious train accidents due to collisions took place as detailed below:

S.N	Causes Of Train Collisions	% Of The Total Accident On IR	Typical Train Accident
1	Drivers disregarding signals.	58.93	On 27.7.97, 2627 Karnataka Express dashed in the rear of 6317 Himsagar Express at Faridabad station on Central Railway due to driver of Karnataka Express passing Home signal at danger.
2	Reception of a train on a blocked line or dispatching into a blocked section	18.45	On 2.8.1999, 5610 Awadh Assam Express collided head on with 4055 Brahmaputra mail on Kishanganj- New Jalpaiguri section at Gaisal station of Northeast Frontier Railway due to train sent on wrong line.
3	Reception on line obstructed by vehicles from adjacent line	2.98	On 25.3.1999 at Panskura station of Kharagpur Division of South Eastern Railway, 2021 Shatabdi Express while passing line no. 2, side collided with a diesel engine which was standing without clearing the fouling mark.
4	Derailed vehicles obstructing the adjacent line in mid-section	2.98	On 26.11.1998, 2903 Golden Temple mail derailed between Khanna and Chawapail stations on Northern Railway infringing the adjacent track. Meanwhile 3152 Sealdah Express come on the other line and collided with derailed coaches of 2903. There was not sufficient time gap between the derailment of Golden Temple mail and Sealdah Express coming from other side.
5	Trolleys or Lorries not being protected.	3.57	Yard Collisions on various Railways
6	Other causes	12.50	Yard Collisions on various Railways

This was the time when, Railway Board took a decision to develop and adopt Collision Prevention System called **Anti Collision Device** on Indian railways to prevent all types of collisions. Konkan Railway Corporation Limited (KRCL) was entrusted with the work of developing this state of the art system in association with Research, Design and Standards Organization (RDSO) of Indian Railways to prevent various types of collisions, e.g.

head-on collisions, side and rear-end collisions and those caused due to infringement by derailed vehicles on adjoining tracks.

Safety Systems on other World Railways:

On all the developed Railway networks in Europe and USA, Train Protection and Warning systems have been accepted

as a mandatory requirement for higher speeds and heavy density traffic routes. Most of these Railways have provided these systems in suburban sections as well as on sections having speeds in excess of 120 Kmph. These countries had Automatic Train Protection system which can prevent collisions at stations due to driver passing a RED signal or signal at danger. These systems also had features to automatically control the speed of the train as well as automatic brake control. However these systems were not having features to prevent head on, rear on and side collisions in

between two stations. In these systems whenever driver exceeded the allowed speed, a warning is given to driver to enable him to react and avoid intervention from Train Protection and Warning System (TPWS) the intervention of brake. TPWS will apply emergency brake in case train passes stop signal at red or danger irrespective of the speed of train.

As per Jane's Book on World Railways 2002-03, the details of such systems as available on these Railway networks are given below:

SN	Railway System	Total Length (Route Km)	ABS (R Km)	CTC (R Km)	AWS/TPWS (R Km)
1	Algeria (ER 283)	2888	100	0	0
2	Australia (QR)	6800	3200	3200	0
3	Australia (ER)	5500	3000	1000	3000
4	Belgium (ER 2600)@	3500	3200	1500	1500
5	Brazil (EFC)@	892	892	892	892
6	Bulgaria (2700)	4000	2000	700	500
7	China (ER 14000)	58000	40000	10000	10000
8	Costa Rica	950	950	950	0
9	Cuba	3500	350	300	0
10	Czech Republic (ER 1800)	9400	2500	6000	2500
11	Denmark (ER 200)	2300	1300	1300	800
12	Finland (ER 2400)	5800	2500	2200	3000
13	France (RFF – ER 6000)@	32000	24000	24000	24000
14	Germany (EBA – ER 18600)@	38000	17000	17000	17000
15	Hungary (ER 2600)	7500	2500	1000	850
16	Ireland (EB 50)	1947	1000	600	400
17	Israel	640	640	640	0
18	Italy RF 1 (ER 10000)	All lines above 150 Kmph			
19	Japan (JR East)@	6500	6500	6200	2500
20	Japan (Central)@	1425	1425	1400	1425
21	Japan (JR West)@	4400	3200	2500	2500
22	Kyushu – Japan@	2100	1600	1600	1600
23	South Korea	3215	2000	1200	3200
24	Latvia	2300	2000	1400	700
25	Luxemburg	274	274	274	274
26	Macedonia	700	220	0	0

27	Malaysia	2200	2200	50	50
28	Mongolia	1800	1577	0	0
29	Myanmar	4000	Under Progress		
30	New Zealand	3900	3900	3900	3900
31	Norway	4200	2600	2600	2400
32	Pakistan	7700	200	200	200
33	Russia	87200	63000	30000	10000
34	Slovakia	3600	720	0	500
35	South Africa	19000	6500	6500	0
36	Australia	37000	n/a	n/a	n/a
37	Vietnam	3000	1100	0	0

ABS : Automatic Block Signalling
CTC: Centralised Traffic Control System
AWS: Auxiliary Warning System
@ :Mandatory at higher speeds

This clearly shows that most of the World's leading Railway networks had made it mandatory to have provision of AWS/TPWS at speeds in excess of 70 mph or 120 Km/h. Similarly most of these Railway networks have opted for ABS as a cost effective solution for enhancing line capacity and increasing throughputs.

Developments on Indian Railways:

Though Indian railways had its experience of AWS in Mumbai suburban area, but no worthwhile system is in operation on any other section of its network. After the decision of IR to develop and provide Anti Collision Device for collision prevention, KRCL took up this challenging task. First conceptual prototype of ACD was demonstrated in December 1999. The first commercial prototype was developed by 22nd January 2000. ACD was put on extended field trials on Jalandhar - Amritsar section of Northern Railway, which was completed in January 2003. Although, the primary features could be demonstrated during the trials, but the reliability level was found to be very low

90.5% due to various design flaws. Necessary modifications in software and hardware of ACD were thereafter incorporated by KRCL. Being an electronic system to be deployed for the operational safety of the trains, it was considered necessary to work for the finalization of Functional Requirement Specifications(FRS), which was still not frozen. However due to repeated design changes and modifications in software and hardware, and despite the passage of about 3 years, the design could not be frozen. The work of finalizing the FRS was targeted for completion in Jan 2004. However the development team could not achieve the same and the design was again to be amended 3 times in next one year i.e. upto Oct 2004, when finally the FRS was frozen. Based on the frozen FRS, Systems Requirement Specification (SRS) & Quality Assurance Plan (QAP) was finalized by KRCL and handed over to RDSO and Railway Board in Dec.04. As per requirement of ISO 9001:2000, third Party certification of Anti Collision Device for Conformity to Specifications (FRS & SRS) and Quality assurance (QA) was essential, this took some time. In the meantime as the project on NFR was getting delayed it was decided to undertake the work on NFR without 3rd party validation and certification.

Design and Validation issues in ACD:

As per international safety standards while developing such safety systems which are used directly in the carriage of passengers certain safety processes need to be followed so as to attain a desired safety integrity level, which will define the approach towards its designing. Further when design issues and all design processes are frozen, the system need to be verified and safety validated by an independent assessor. This is a long process and takes considerable time for a system to finally be available for adoption on a passenger carrying transport system. However when the ACD project was taken up for implementation on North East Frontier Railway. It was found that KRCL has so far not undertaken the development as per International standards of CENELEC or ISO. This was pointed out to KRCL by RDSO in the year March 2003. Accordingly KRCL applied for the safety validation in consultation with RDSO to DnV, France during the year 2004 . However the independent assessor while assessing the design process validated the ACD as Safety Integrity Level 0 system. Thereby indicating that system is not 'failsafe' and can not be termed as a signaling safety system. It was also deduced that system does not support the feature to prevent collisions due to 'Signal Passed at Danger' (SPAD). This was a serious shortfall as 60% of the collision on IR are due to SPAD only and as per principle ' Safety Systems' should be ' FAILSAFE'. However a conscious decision was taken by Railway Board to go ahead with the work of implementation of ACD on NFR, pending improving the ACD design to include the features not available in the present design.

Installation of ACD was undertaken on North East Frontier Railway (NFR) in the

year Feb 2005. The installation on NFR was targeted for completion by June 2005. However the work could not be completed as Automatic Breaking Unit (ABU) was initially activated only in passenger trains and the ABU provided in passenger trains started giving a lot of problems. The system was provided on a part section on Katihar - New Jalpaiguri Guwahati section of the project by July 2005. Railway carried out the Site Acceptance Test of Anti-collision Device (ACD) system deployed on this section during the period 31-07-2005 to 17-08-2005, and found that system was having important deficiencies, like generation of false messages, unnecessary brake applications and speed restrictions, and was not in conformity to the specifications. KRCL was advised to eliminate the deficiencies. After some time even the software started giving problems because of which further deployment of ACD on the balance sections of Tinsukhia and Lumding divisions could not be taken in hand in by Dec 2005. It took some time to modify the software and as soon as the bugs in the software were rectified the work of deploying ACDs on Guwahati Tinsukhia Dibrugarh section was taken in hand and completed by April 2006. Final Fine tuning and testing (incubation with ABU isolation) has also started in the GHY-TSK-DBRT section.

Conclusion:

Though conceptually a good system for prevention of collisions on Indian railways, but serious delays in its development which is still in progress, there are serious doubts as to when, the sanctioned works can be completed and perfected. As already indicated, on NFR (Guwahati Dibrugarh), installation work is still being perfected. Konkan Railway Corporation Ltd. (KRCL) has even developed a new version of software to overcome the

deficiencies noticed in the Initial Site Acceptance Test (SAT) conducted by RDSO on Northeast Frontier Railway (NFR). However even after introducing the new software, working is not without failures, though It was reported by KRCL in July 2006 that all the major deficiencies identified by KRCL on Konkan Railway in the SAT report have since been rectified. As such there is no firm commitment by KRCL as to what date they will make the ACD network on the entire North East Frontier Railway FAILUREFREE and offer the same for final Site Acceptance Test.

In Dec 2005, Ministry of Railways had also indicated that it would have been better if there were 2 or 3 vendors. A decision was taken to develop 3 sources so that even for development and problem solving their capabilities can be synergized. During the period this implementation was taking place a few train accident took place which could have been prevented had ACD was working as per designed FRS on these sections. During June 2006 while reviewing the progress of the ACD project on NFR, Railway Board have decided following with regard to ACD :-

“ACD is a commitment of IR to Parliament to cover the entire BG network by 2013-2014. ACD work should progress in line with this commitment. ACD needs to be further improved to bring in a feature to take care of collision situation fully in station areas by taking feedback from the existing signaling system i.e. to prevent collision in case signal passing at danger would have resulted in collision on main line or loop line”.

Recently IRSTE(India) organized an International Signalling and Telecommunication equipment exhibition

and seminar at Pragati Maidan in the month of Oct, 2006. During the seminar, world's leading Railway networks like AMTRAK of USA and Russian Railways from Russia showcased the satellite based Train Protection and warning system as deployed on their network. European Railway networks of Switzerland, France, Germany, Spain etc put forward the merits of adoption of advanced safety systems like European Train Control Systems being provided on their networks from users perspective, it was indicated by all of them that these systems are capable of providing higher safety levels at higher speeds. All these systems are not only FAILSAFE but also leads to generation of additional line capacity at least cost. Hence IR has an alternative to identify a suitable technology out of these proven systems and customize them as per IR's requirement and adopt on IR. The Railway Administration has now to decide as to whether to adopt one of these technologies as already in use on leading world railways customized as per IR's requirements or continue its investment in ACD. A decision has also to be made to make provision of AWS/TPWS, CTC and Automatic Block Signalling systems mandatory for all trains at higher speeds and on suburban sections. We have already seen in table 2 that many world's leading railway networks have made it mandatory to provide AWS / TPWS mandatory for higher speeds

These are the excerpts from the Case Study presented by the author as a part of the course at MDI during 2006-07. Author was earlier working as CSTE/Project/NCR and currently on training at Management Development Institute, Gurgaon

OPERATIONAL EFFICIENCY AND SAFETY THROUGH MOBILE TRAIN RADIO COMMUNICATION

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GSM-R project has just been completed in Howrah-Dhanbad Rajdhani Route of Eastern Railway. OPH and GPH sets have been deployed to the Drivers and Guards of few trains, ASMs and Controllers. These GSM-R sets are expected to change the way communication is done today in the railways and enhance operational efficiency and safety. Action to be taken for usage of OPH instead of Cab radio meant to be Driver's communication tool as per EIRENE has also been suggested.

1. Introduction:

This paper deals with the operational efficiency and safety using Mobile Train Radio Communication. The modalities of survey of the Mobile Train Radio Communication system are also elaborated upon. The frequency allotment and the numbering plan of the present system implemented is also explained. The basic features of the system and the technical description of the existing system in Eastern Railway are also discussed.

2. Origin of Mobile Train Radio Communication :

Mobile Train Radio Communication had its origination in the European railways where there had been a drive to generate a common European Infrastructure to enhance the usage of the Railways. This resulted in the development of the European Rail Train Management

system (ERTMS). It was also decided that ERTMS would be based on a Train Radio Communication Platform, preferably GSM system that would support Train radio, Shunting radio, Maintenance Crew radio and European Train Control system (ETCS).

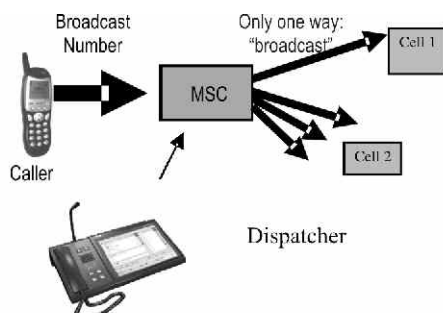
In accordance to this, in 1996, European Union passed the directive 96/48/EG describing the interoperability of high-speed traffic. In 1997, 32 railway companies commit to observe the EIRENE specifications to achieve full interoperability. At present, Germany, Sweden, Italy, France, Netherlands, Switzerland, Austria and Denmark have either implemented MTRC or in the process of implementation of the technology in their Railways.

3. Basic Features

It is a digital wireless network based on GSM-R (Global System for Mobile

Communication-Railways) technology specification (FRS) and System designed on EIRENE (European Requirement specification (SRS). The Integrated Railway Radio Enhanced Network) Functional requirement basic features are:

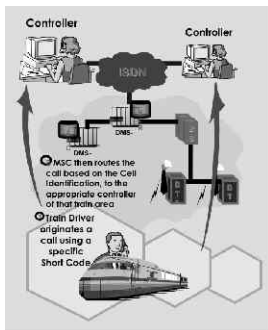
Point to Point call	Allows user to make a distinct call.
Voice Broad cast call	Allows groups of user to receive common information generated by a single user or broadcaster
Voice Group call	Allows groups of user to make calls within /among the groups having different Group IDs.
Emergency call	It is a Group call with Group ID 299.It allows user to notif y a predetermined group of users along with controller by pressing a button during emergency. Any emergency call is programmed to reach its subscribers by freeing all busy resources. It is of the highest priority.
Functional addressing	Allows a user or an application to be reached by means of a number, which identifies the relevant function and not the physical terminal. For example, the driver and guard can be accessed by their functional number.
Location dependent addressing	Provides the routing of mobile originated calls to the correct controller e.g. relative to the geographic area.
eMLPP (enhanced Multi -Level Precedence and Preemption)	Allows resource preemption for priority calls i.e. a high priority call can release resources occupied by lower priority calls.
Call set up time	GSM-R supports reduced call set up time , as low as 2 sec for emergency calls.
Access matrix	This feature allows restriction of calls among users, calls are screened before making the connection.



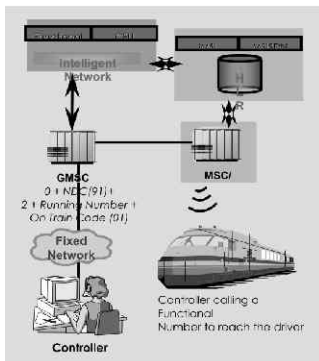
Voice Broadcast Call: Service subscriber can generate one way broadcast calls only in the Group call area the subscriber is currently available. The dispatcher can also generate a Broad cast call towards a set a subscribers by dialing a group ID i.e. Broadcast call to all ASM



Voice Group Call: Service subscriber can generate a voice group call using a group ID within the GCA. It is a both way communication, with only one service subscriber getting uplink at a time in a cell and dispatcher having both way communication. Emergency call is group call of Priority 0 with Group ID 299.



Location Dependent Addressing: Service subscriber can reach predefined controller by dialing a single short code which will be routed as per his location i.e. in different divisions, it will be routed to different divisional controllers.



Functional addressing: The driver has to register in his functional identity as per EIRENE defined numbering plan on boarding the train. The driver will then be accessible by the functional addressing by the train number and function code instead of MSISDN which is not required to be known for any on train functions.

4. Radio interface and frequency in GSM-R

The Radio link uses both FDMA (Frequency Division Multiple Access) and TDMA (Time Division multiple Access) technique. The 900 MHz frequency bands for down link and up link signal are 935-960 MHz and 890-915

MHz respectively. Though internationally downlink and uplink are available from 921-960 MHz and 876-915 MHz (R-GSM Band), Wireless Planning and Coordination (WPC) under Ministry of Telecommunications have allotted the eight spot frequencies in 952.8-954.4/907.8 909.4 MHz band for GSM-R network of Indian Railways.

5. Method of Survey:

• Site Survey

Detailed site survey is required for the design of Radio Network to provide a highly reliable shadow free Mobile Train Radio Communication on the route. The main objective of the site survey is

- i) To update the clutter (i.e. nature of terrain, vegetation)) along the Railway track.
- ii) To verify the latitude and longitude of all the sites.
- iii) To identify the required antenna mounting heights, antenna orientation and tilt keeping in mind the obstructions in direction of radiating antennae including cuttings and tunnels as well as to minimize the adjacent channel and co channel interference keeping in mind the interference threshold given in EIRENE specification i.e. $C/I > 15$ dB.

The obtained data is loaded in a planning tool which is also updated with the exact land usage prevalent on date. This enables the tool to predict the coverage more accurately as given in EIRENE specifications.

- i) coverage probability of 95% based on a coverage level of 38.5 dBuV/m (-98 dBm) for voice and non-safety critical data.
- (ii) coverage probability of 95% based on a coverage level of 41.5 dBuV/m (-95 dBm) on lines with ETCS levels 2/3 for speeds lower than or equal to 220 km/h.

• Radio planning

The base station sites are situated close

to the track using directional antennae with distances of typically 5 to 10 Km. Thus, the highest power efficiency can be reached with antenna beams directed along the track. Depending on the topology, applications and reliability the above mentioned distances could be longer and shorter as well. Examples for different needs in coverage / capacity are:

- a) In areas with low capacity requirements, cell splitters can be used to extend a cell to both side of the site along the track.
- b) To cater the need in station area, ideally omni directional antenna and in tunnels leaky feeder cable/repeater solutions are to be adopted.
- c) For mitigation of the multi path propagation effect, diversity reception is to be established with two receiving antennas per direction.

In Eastern Railway, cell splitter with diversity reception has been used.

• Capacity of the system

Capacity of the system is decided based on traffic originated. Traffic is quantified by ERLANG which is the traffic generated when a subscriber speaks for 1 hr continuous in the busy hour. ERLANG calculation of a proposed system defines the dimensioning of the system and in turn the capacities and number of the equipments of the system.

In Eastern Railway, system has been designed with a traffic of 30 m erlang per subscriber with a planned load of 4000 subscriber.

6. Numbering Scheme:

The uniform numbering scheme for the Indian Railway network has been circulated by RDSO.

- **International Mobile subscriber identity (IMSI)** It is used to identify the called Mobile station. It is not known to

the user and is used by network only. IMSI is stored in SIM, the Home Location Register(HLR) and the serving Visiting Location Register(VLR). The IMSI consists of three parts: A three digit Mobile country Code (MCC), a two digit Mobile Network Code (MNC) and a 10 digit Mobile Station Identification Number (MSIN).

International Mobile Subscriber Identity (IMSI) for Indian Railway Network.

Railway	MCC	MNC	MSIN	
			HLR Identification Code	
Eastern Railway	405	48	250	0000000-9999999

Where the last 7 digits are reserved for the railways. The HLR Identification code is different for different Railways.

- **Mobile Subscriber ISDN (MSISDN) number :**

The directory number dialed to reach a Mobile subscriber is called the Mobile subscriber ISDN number (MSISDN) which is defined by the Numbering Plan. It is stored in the HLR and programmed via OMC-S, which is a part of the Operating Sub System (OSS).

Mobile Subscriber ISDN Number (MSISDN) for Indian Railway Network.

CC (Country Code) (2D)	AC (Access Code) (2D)	MSC Code (3D)		Divn.(1D)	Dept.(1D)	Subscriber Number (4D)
		Zone(2D) (Eastern Railway)	CT(1D)			
91	99	25	8	0-9	0-9	XXXX

Where D=digit. The total length of MSISDN is 13 digit but individual subscribers can be dialed by the last 11 digits i.e. 99258XXXXXX.

Where CT=Call type, different values are assigned to the Call types (eg CT=2 means train functional number) in EIRENE specification depending on the type of calls. CT=8 for MSISDN calls and has to be a part of the numbering scheme.

Where the zone code is different for different Railway zones.

- **National EIRENE Numbers :**

National EIRENE Numbers are used specifically for Railway purposes and consist of three parts.

i) Call Type (CT): The call type prefix identifies the nature of call. It distinguishes between the different types

of user numbers that are allowed within the National EIRENE numbering plan. The call type prefix tells the network how to interpret the number dialed. It is one digit long.

- Coach Number for CFN (Coach Functional Number)
- Shunting team location number
- Maintenance team location number
- Train controller location number

ii) User ID: The user identification Number can be one of the following:

- Train Running Number for TFN (Train Functional Number)
- Engine Number for EFN (Engine Functional Number)

iii) Function code (FC): Each function of the train like Driver, Guard, Catering staff is allotted one code which has to be registered in the following format. After registration, the driver, guard can be accessed by the functional number irrespective of MSISDN

Dialed digits	Description
2+TRN+FC	Train Functional Number
3+EN+FC	Engine Functional Number
4+CN+FC	Coach Functional Number
6+LN+TT+Y+XX	Shunting & Maintenance Functional Number

Where:

TRN:	Train Running Number	(5-8 digits)
EN:	Engine Number	(8 digits)
CN:	Coach Number	(9 digits)
FC:	Function Code	(2 digits)
LN:	Location Number	(5 digits)
TT:	Team Type	(1 digit)
Y:	Team Member	(1 digit)
XX:	Team Number	(2 digits)

Train Functional Number is used for calling the driver by its train number. The following numbering scheme is used in the Railway.

Functional Number of driver in Rajdhani Express for Thursday is as follows.

<u>2</u>	<u>4</u>	<u>2301</u>	<u>0</u>	<u>01</u>
↓	↓	↓	↓	↓
Call Type	Thursday	Train Number	Schedule Train	Driver

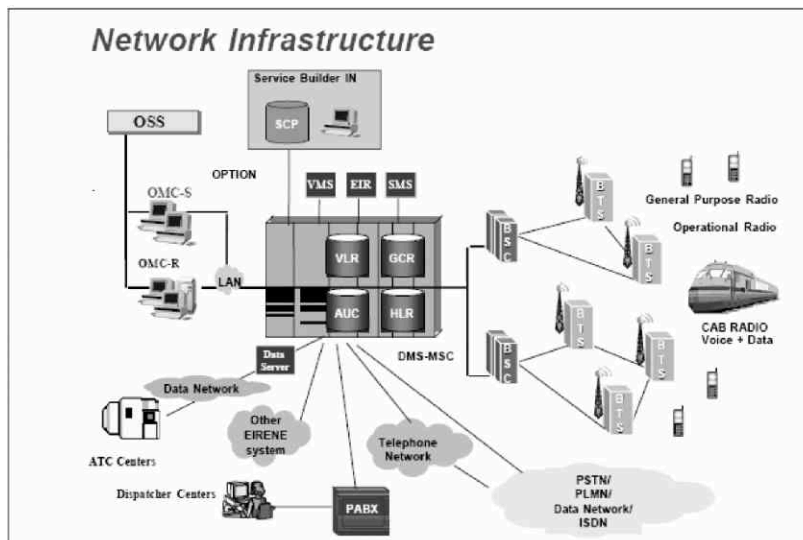
for link train - 1 for Guard - 80
for special train - 2

User can register itself as a driver / guard of any train from their handset by dialing 091 i.e. Railway access code following the above digits for a specific train.

7. System Architecture:

The figure below illustrates the system architecture. In this architecture a Mobile Station (MS) communicate with a Base Station Subsystem (BSS) through the Radio interface (Um). The BSS is

connected to the Network Switching Subsystem (NSS) using the A interface. The BTS are connected to the BSC via the Abis interface which are basically 2 Mbps streams with some slots allotted to different BTS.



8. Brief description of sub systems :

The system consists of following sub systems :

- Mobile Station (MS)(OPH,GPH, OPS)
- Base Station Sub system (BSS)
- Network and switching sub system (NSS)
- Operating sub system (OSS)
- Dispatcher
- Cab Radio

Mobile Station (MS) :

The MS consists of two parts

- Subscriber Identity Module (SIM)
- Mobile Equipment (ME)

Subscriber Identity Module (SIM):

The SIM is a personalized memory chip which contains the IMSI and other specific software program and data required for providing the various facilities to the subscriber. The SIM card for GSM-R is a customized one and is different in software programming from the GSM SIM cards normally available in the market.

Mobile Equipment (ME):

The mobile handsets for GSM-R are different in features from the handsets available for GSM network. There are two types of handset

(a) Operational purpose handheld(OPH)- As per EIRENE, these sets are to be provided to operational staff i.e. shunting and trackside maintenance staff. These sets are more rugged and have single button "Emergency Call" facility.



(b) General purpose handheld(GPH)- As per EIRENE, these sets are to be provided to other Railway personnel not involved with train operations.



Base Station Sub system (BSS):

The BSS connects the MS and the NSS. The BSS contains of three parts.

- i) Base Transceiver Station (BTS).
- ii) Base Station Controller (BSC)
- iii) Trans Coder Unit (TCU)

The primary function of the BSS is to receive and transmit the radio signals to the MS and process the information including data, voice and signaling from the BTS through BSC and rate adoption in TCU for reduction of E1 Ater interface to the MSC.

The BTS comprises the Base Transceiver Unit, Antenna and Cable assembly. It works on 48 Volt DC supply, with a receive sensitivity of 110 dBm and EIRP 20W(43 dBm).

Network and Switching Subsystem(NSS):

The NSS consist of the following units:

- **Mobile Switching Center (MSC):**

The MSC as a whole is responsible for:

- a. Call Processing, switching & routing of traffic
- b. Supplementary services like call waiting, forwarding, data capability.
- c. Connections to PSTN.
- d. Visitor Location Register (VLR) for subscriber location management.
- e. Service Switching Point (SSP) functionality for the IN network.
- f. Switching and Network Management activities.

- **Intelligent Network (IN):**

It supports the following functions

- a. Creation of functional numbers against Train numbers and dynamic mapping against MSISDN
- b. Allows registration and deregistration of functional numbers by drivers and guards
- c. Allows location dependant addressing i.e. dialing 1200 in HWH division will place the call onto the dispatcher at HWH division and from ASN division will land it onto Dispatcher/Deputy Coaching at ASN division automatically.
- d. Creation of subscriber groups and allow/disallow calls between the groups using VPN
- e. Forced deregistration: The operator can force deregister any functional number if the MSISDN is known.
- f. Interrogation: The operator can interrogate the MSISDN against any functional number.

An integrated **Home Location register (HLR)** and **Visitor location Register (VLR)** to hold the temporary subscriber data while the subscriber is in the MSC's area. An integrated **Authentication center (AuC)** for authentication and ciphering provided by the AuC.

Operating Sub system (OSS) :

Operating sub system consists of

a) Operation and Maintenance Center for Radio (OMC-R). Functions :

- Security Management
- Configuration management
- Performance management
- Fault management
- Server administration
- File transfer management

b) Operation & Maintenance Center for Switch (OMC-S). Functions:

- NSS hardware and software configuration management.
- Fault detection and presentation of faults.
- Performance management:
- Security management:

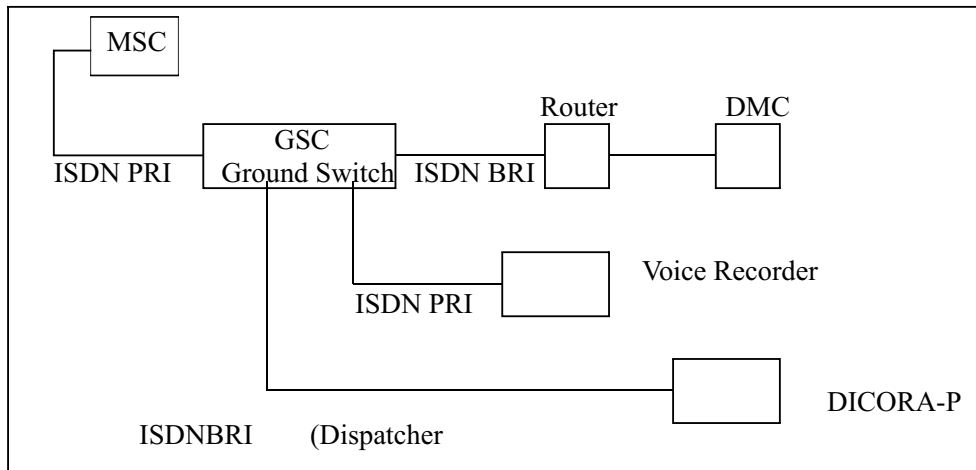
- User Profile management.
- Session monitoring and logging.
- OMC-S operation:

Dispatcher :

Eastern Railway has provided one dispatcher terminal of M/s Frequentis make at Howrah Control office which can support all GSM-R specific features. It consists of a touch pad terminal, audio module, voice recorder system and maintenance terminal.



As can be seen from the drawing below, dispatcher is connected with MSC through the ground switch (GSC) equipment.



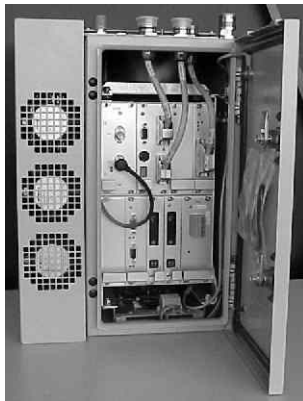
Voice Recorder stores voice that is established through dispatcher. At present 120 voice channels can be directly connected. These voice files can

be recorded as .wav files and replayed later. Additional dispatcher terminals can be connected using ISDN BRI links.

- **Cab Radio :**

As per EIRENE, cab radio to be provided to the drivers and other on train functions. It is suitable for voice and data communication inside the locos and can be used with ETCS for train control. It consists of three units.

- (i) Radio
- (ii) Man Machine Interface(MMI)
- (iii) Shark Fin Antenna.



Key features of Cab Radio

- (i) Operation in the R-GSM,E-GSM and P-GSM bands.
- (ii) Mobile Station Class 2 (8 watt transmission output) and receive sensitivity of -104 dBm
- (iii) Voice Group and Broadcast calls.
- (iv) All GSM supplementary services.
- (v) Robust design .
- (vi) Full duplex data communication.
- (vii) SIM commands for editing and using EIRENE and ASCI specific fields of the SIM card.
- (viii) Testing and diagnosis are possible both on line during operation and off line.

Operating voltages of 13V and 5V are required for internal supply of power to the components of the Cab Radio. The

DC on board supply of locomotive with nominal voltage between 24V and 110V DC serves as the Power source. The average power consumption is 18W.

9. Status in Indian Railways:

The Railway Safety Review Committee (RSRC) 1998 recommended in Para 2.11.1 to provide reliable communication facility between driver, guard, ASM, Level crossing gate and approaching trains as a first step within 3 Years on 'C' and 'A' routes and in another 3 years in 'B' route. In accordance with these recommendations, Mobile Train Radio Communication based on Global system for Mobile Communication-Railways (GSM-R) technology was sanctioned in works programme, 2000-2001 on a total of 2225 route kms. This includes Jammu Tawi/Amritsar-Delhi-HWH section and Katihar-Guwahati section on NF Railway.

10. Status in Eastern Railway:

Eastern Railway awarded contract for the work in the section Howrah to Pradhankunta along the chord line (A Route) in 2004 to M/s TCIL who have offered technology of M/s Nortel Networks. The system has been put into service of the users i.e. the drivers, guards and ASMs from 22.09.2006 onwards. The Driver of 2339 up Coalfield Express has made the first call to the Dispatcher at Howrah Control.

11. Benefit of Mobile Train Radio Communication over existing mode of emergency and mobile communication:

The earlier mode of Emergency communications using PCP sets in Non RE and RE area is prone to the following disadvantages.

-
-
- The driver /Guard have to carry cumbersome PCP sets and poles.
 - Hooking onto overhead alignment or RE sockets are difficult procedures.
 - The driver/guard may have to travel maximum 500 m in case of RE area.
 - The emergency sockets and overhead posts are prone to external interference.
 - There is no way the driver/guard can speak with the nearest station master, they can only speak with the controller.
 - The section control is not able to contact the driver/guards in the moving condition.
 - Emergency communication can only be initiated by the driver/guard from the site.
 - SOS facility is not available.
 - S&T staff have to load/unload the PCP sets and poles. This entails maintenance of a separate unit only for loading and unloading.

Due to such limitations in Emergency communication, the above mode of communication do not satisfy the emergent needs of situations like Accidents, unusual situations like land slide, floods, obstructions on the track, Robbery/theft on train, carriage and wagon problems, loco failures, overhead problems and chain pulling.

In Indian Railways ,the mobile communication, where available, is based on 5 W handheld set and 25 W VHF base set . This arrangement is prone to the following disadvantages.

- The major limitation is of range of operation
- Works satisfactorily only in stationary/low speed mode, with antenna of the set placed outside.

- Redundant hardware is not used and reliability is less.
- Operates on a common Radio channel and can be listened by anybody tuning to that frequency.
- Mostly simplex communication with duplex only at selected frequencies. However, limitation of range of operation exists.
- Interconnection to exchange telephones is cumbersome.

To get around such situations, a mobile radio system is required which will provide the following communications.

- Voice telephony services in full duplex mode.
- Private and Secure communication.
- Reliable communication with hardware redundancy will be available.
- Fast call set up times specially for emergency calls.
- General data applications- minimum rate of 2.4 kbps.
- Train control applications.
- Automatic fax and data services.
- Multi party voice calls.
- Additional services like CLIP, CLIR, eMLPP, CUG, Call forwarding, call holding, waiting and barring.
- Railway emergency calls.
- Functional addressing.
- Location dependant addressing.
- Shunting communication.
- GPRS and EDGE support.

The communication can be established between

- Driver to Control
- Guard to Control
- Driver to Station Master
- Driver to Guard
- Guard to Train Crew
- Maintenance staff to Control

-
-
- Maintenance staff to Station Master
 - SOS signal to all in vicinity

12. Safety in Train operation using MTRC

Mobile train Radio communication, therefore, provides an instant and seamless connectivity between train crew, stationmaster of the adjoining station and the section controller even at high speeds i.e. up to 220 Kmph. Not only it will help in establishing instant communication by the driver for arranging quick relief and saving precious lives in case of accidents, the restoration time can also be reduced due to prompt communication.

The system can also be used in avoiding accidents in situations where one of the tracks is blocked due to accident infringing the adjoining track. In such cases, the driver of the effected train can pass on the message to the driver of the incoming train on the adjoining track , thus avoiding another accident. The accident can also be avoided in case of any hanging part of the loco by giving timely information to the driver.

MTRC system provide broadcast and emergency group call facility, enabling Railway management to convey the message instantly to all the concerned. Since the secured and reliable communication for the accident site can be established through control circuits/railway exchange/PSTN network, it can be of great help during disaster management. It can also be ensured that any SOS call will reach the concerned group of persons in a predefined area so that the drivers of the train can be cautious while approaching the site of derailment.

13. Improvement in asset Utilization using MTRC

MTRC has the potential for being used, apart from emergency situation, to minimize the impact of loco and signal failures, train parting, spring breakage, TRD and civil engineering block and in improving train running conditions.

- **Loco failure:-**The impact of the loco failure in train traffic is most prominent as it blocks the line for substantial time. With availability of MTRC, in case of loco failure, the driver can immediately inform the TLC, Loco foreman, DME/DEE for guidance in rectification of the failure. TLC can give instruction to the driver of the relief loco directly on MTRC thus saving valuable time and subsequent detention of trains.

- **Signal failure:-** This system can be utilized for exchange of private number required for authority to proceed on faulty signals as there is a facility of recording voice and subscriber identity in this system. Alternatively, the memo for piloting the train can also be faxed to the driver through cab radio.

- **Civil Engineering block:-** MTRC can be utilized for coordination in case of blocks.

- **TRD Block:-** Similar to civil engineering block, TRD can also use MTRC for power block.

- **Spring breakage and hot axles:-** In case of spring breakage or hot axles, the driver of a moving train can be informed by the station master on MTRC. The driver can take corrective action to avoid accidents. In case of spring breakage en route, noticed by the driver, he can inform

the next station to arrange spring clamps in advance so that time in arranging the same is not wasted.

• **Health monitoring system for locos:-** One channel on MTRC can be used for monitoring the vital parameter of the locomotives from the Control Office and therefore, continuous watch on the health of the locomotive can be kept..

• **Shunting operations:-** MTRC is helpful in shunting operations. The chief Yard master can talk to the shunting staff for shunting operations. This communication is limited within shunting group.

• **Maintenance:-** MTRC is helpful for maintenance of assets. It provides:

a) Communication within the trackside maintenance team and between maintenance team at the adjacent station.

b) Local mobile communication at the stations and the maintenance depots.

• **Passenger amenities:-**

1. MTRC system provides speech and data channel from the moving trains to the master switching center.

2. The MSC can be connected to the public network and therefore, the speech and data channel from the moving train can be extended through out country. This facility can be used for providing mobile communication to the passengers through out their journey through PSTN.

3. Internet café , e-mail and fax can also be provided in the trains for the use of passengers.

4. The system can also be used by the commercial staff for conveying information to the stations ahead regarding availability of the berths.

5. In case of any passenger needing medical help, the message can be instantly transmitted to the station ahead for immediate relief.

6. The on-line location dependent information can also be displayed in the train with the use of MTRC system.

Thus, the MTRC system can be used for generating additional revenue in addition to meeting the communication requirements of the Railways. The facility of above communication between the various functionalities involved in train running results in continuous monitoring of train running with the possibility of taking corrective action at any time even on run, thus increasing operational efficiency and safety.

14. Issues related to utilization of Cab Radio :

Provision of Cab Radio requires fixing of shark fin antenna, power supply unit, Radio unit, MMI and cabling on permanent basis in the locos. Indian Railway locos being both ended, two MMI are required to be fixed at either cab of the loco along with one cab radio, which requires additional cabling. The shark fin antenna has to be fixed on the roof of the loco and the cable is to be drawn through a hole on the loco roof.

The present plan of low scale usage of Cab radios on experimental basis has the following problems.

1. Only a few locos can be provided with

cab radios as only limited number have been procured.

2. Locomotives are not earmarked for trains in a particular route resulting in locomotives fixed with cab radio being used in non-MTRC route.

3. Locomotives of one railway may go out of that railway and may come back after long time resulting in non-utilization of the cab radio.

4. Mostly locomotives are placed in the yards unmanned and unguarded creating problem of security of the equipments.

5. There are different types of locomotives in the Railways and all are not having enough space for cab Radio installation.

15. Use of OPH in place of Cab Radio

Due to the inadequacy of the number of Cab Radio and above problems, OPH is being used as driver's communication tool in the Railways. It has been tried with external antenna with magnetic base. This arrangement needs a hole to be drilled on the side wall of the loco for passage of the antenna cable. This total

system with antenna, car kit and OPH needs loading and unloading at various points. Use of antenna can be obviated by increasing the number of BTS and thereby improving Radio coverage which will improve the acceptability of this set.

16. CONCLUSION:

1. To implement GSM-R with OPH and GPH without external antenna for driver and guard instead of Cab radio, the spacing of BTS will have to be adjusted to achieve better radio coverage in shielded environment after thorough survey.

2. In future separate arrangement for accommodation and power supply of cab radio should be kept in the new locomotives and in the old locomotives, when these locomotives go for POH. This should be done in a programmed manner keeping in view implementing cab radio solution in course of time. This equipment would be a part of locomotive.

3. The OPH and GPH, now being used by drivers and guards to be extended to train crew who needs mobility in a shielded environment for better quality of passenger services.

ETCS Level 1 :

Practical Experiences on the Line

Vienna - Budapest

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1 SUMMARY

The Austrian Federal Railways (ÖBB) decided to implement ETCS Level 1 in the upcoming years on the entire main network. The implementation on the line Vienna - Budapest that is part of the important TEN corridor IV has been finished and now the benefits of the chosen design can be investigated under real operational conditions. Various test scenarios with different focuses have been performed on the line in order to gather experiences.

2 INTRODUCTION

The primary purpose of the ETCS train protection system is to ensure safe train movement based on the specific train characteristics and on information provided by infrastructure signalling facilities. The European countries committed themselves to replace existing national and mutually incompatible train protection systems by this technology in order to make cross border rail traffic more efficient, cost effective and in many cases safer than with today's systems. As the intended global application implies a wide diversity of requirements which have to be fulfilled by ETCS currently three upward-compatible levels are defined.

ETCS Level 1 as being the simplest level derives the necessary information about the secured routes either directly from

available light signals or from dedicated interfaces to interlocking systems and transmits this information at fixed places along the track towards a standardized interface via Eurobalises to the ETCS equipped train. ETCS Level 2 and 3 are using a radio based (GSM-R) communication channel to pass interlocking derived information to the trains. Whereas ETCS Level 1 and 2 are based on fixed block topology schemes ETCS Level 3 introduces the moving block concept which is known from many mass transit applications throughout the world. Refer to *Table 1: ETCS Modes of Operation* for a brief overview of some characteristics distinguishing the different modes of ETCS operation.

Within the past few years a few pilot projects and then more and more commercial projects have been awarded to the signalling industry to start the Europe-wide rollout of this new signalling technology. Now it is the time to evaluate the first experiences on equipped lines not only from the technical and functional perspective but also from the operational view of an infrastructure provider and railway operator.

The ETCS specification defines a comprehensive language (see [1]) which allows to express very accurately the current state of the wayside signalling systems (signal aspects, routes, etc.), static track properties (gradients, speed profiles, etc.) and many other vital aspects

for safe train operation. Compared to conventional light signals operation this enables benefits as for example significant performance gain potential as the train supervision can be precisely adjusted to the present signalling situation. As shown in [2] the approach times in complex stations can be significantly reduced without changes of the existing infrastructure by overlaying ETCS level 1 onto the signalling system in place.

The ETCS on-board system performs a permanent supervision of the current train speed. Various track side parameters as for example the speed profiles, gradients and the distance to target are input to the current permitted speed to be calculated. In addition specific train characteristics like brake capabilities and train length complete this dynamic calculation. Therefore ETCS enabled trains adjust the brake intervention points automatically to the specific situation which opens the opportunity in many cases to drive faster for a longer distance by still maintaining the highest safety standards applicable to railway operation today.

3 ETCS application in Austria and Hungary

Austrian Federal Railways (ÖBB) decided to apply ETCS Level 1 on the main network within Austria (about 2500km). The pilot project on line Vienna - Budapest has been recently officially inaugurated by high ranking officials of the European Community, the Austrian and Hungarian Ministries of Transport and of ÖBB and MÁV ([7]). At the time of writing this article

the first EC Declaration of Conformity according to the TSI for the overall track-side system accordingly based on the Conformity Declarations of the products (constituents) installed on the line is close to being issued by the Notified Body Arsenal Research Vienna. The next major implementation step has already been done as the main line from Vienna to Salzburg and Passau has been awarded to Alcatel and Siemens end of 2005. This line comprises about 380km of double track line where ETCS Level 1 featuring a comprehensive infill solution is to be applied.

The Hungarian state railways (MÁV) started ETCS activities with a pilot line on the Hungarian - Slovenian border back in 2000. The project has been awarded to Alcatel and covers about 85km ETCS level 1 track-side and 5 on-board systems mounted in the M41 locomotive. In 2003 the first large commercial project in Hungary has been again awarded to Alcatel. This project connects Budapest with the Austrian border in Hegyeshalom and forms the Hungarian part of the important Vienna - Budapest line connecting two capital cities in Europe. In addition 17 locomotives of type V63 are retrofitted with state-of-the-art ETCS on-board equipment provided by Alcatel. With ETCS Level 1 operation featuring full supervision cab-signalling MÁV decided to increase the current maximum speed of 120km/h to 160km/h increasing the network performance on that line significantly.



Experiences now show that the introduction of ETCS and especially ETCS L1 cannot be done without impact on the national signalling and train operation rules. In order to achieve performance benefits for approaching trains cab signalling now gets priority over light signals in the Austrian operational rules. In addition the train driver now has to follow the standardised procedures for safe ETCS train operation.

As shown in [4] not only the "normal operation" case has to be addressed but also degraded situations must be investigated as individual system failures of signals, Eurobalises or ETCS onboard equipment shall not lead to high negative impacts on daily railway operation.

3.1 Field Experience

With the completion of the track side installation on the line between Vienna and Nickelsdorf (Hungarian Border) in 2004 a series of evaluation tests with different focuses were done to get more familiar with the aspects of future ETCS operation. The following chapter shortly describes the environment and focus of the test trips and discusses some results derived from certain test cases.

3.2 Interoperability Tests

One of the most advertised aspects of the ERTM/ETCS signalling and train protection system is the interoperability of different ETCS track side system realisations and ETCS on-board system solutions provided by different suppliers. In order to evaluate operational scenarios interoperability tests on the line between Vienna and Nickelsdorf have been organised and performed. The tests

were performed in cooperation with MÁV, ÖBB Traction, ÖBB "Signal and Systemtechnik", DB Systemtechnik, Alcatel Austria AG and Siemens.

3.2.1 Track-side system characteristics

As part of TEN network and section of the Danube passage, the track is equipped with ETCS Level 1 according to [1]. The "infill – functionality" is realised by Eurobalises and Euroloops to guarantee operational safety and to increase operational performance. Route information is ascertained at the respective signals by detection of the signal aspects via the interface "SC" (lamp current measurement).

Overall there are 88 LEUs, 27 Euroloops and 240 balises installed on the test section which is a part of the line between Vienna and Nickelsdorf.

3.2.2 On-board system characteristics

Test sets with different locomotives and ETCS on-board solutions have been performed: The Hungarian state railways (MÁV) provided the vehicle BR M41 2206 which is equipped with the Alcatel ETCS on-board system of the type Alcatel 6413 AITrac featuring a full ETCS compliant driver machine interface. In addition to the ETCS solution the system is fitted with a specific transmission module (STM) providing the EVM track circuit function for non-ETCS operation in Hungary.

DB-AG provided its test locomotive BR 707.001 which is equipped with an ETCS solution provided by Siemens. The driver display is a standard MFA ("Multifunktionsanzeige").

3.2.3 Test cases

To evaluate the interoperability between the subsystem track and the subsystem vehicle a representative series of operational scenarios were performed during the tests. The operational scenarios comprise ordinary events as well as special cases. The following list gives an overview about the performed test cases:

- general movements with standard- and special (Ersatzsignal) signalling
- routes by using of real track speeds
- system entry/exit
- takeover of national values
- speed increase by infill balises
- driving without Euroloop information
- continuing after EOA
- driving with "override EOA"
- mode transitions
- driving in specific ETCS modes
- approaching "Stop" signals
- overrun "Stop" signals

The detailed description of the test trips and results would exceed the limits of this article. Refer to [5] and [6].

3.2.4 Conclusion – Summary of the test results

The aim of these interoperability tests was to provide evidence that a foreign ETCS equipped locomotives are able to run on a ÖBB line which is equipped with ETCS. A multiplicity of test cases were performed. Both regular operational events with different routes, signal aspects and special cases were tested. All tests could be successfully finalised and the system behaviour met the operational expectations. None of the test cases resulted in a safety critical situation.

Performance restrictions occurred in some test cases with specific signal aspects due to the ÖBB track equipment and the use of Euroloops (which cannot be evaluated by the tested locomotives). On the other hand it was demonstrated that the operation on Euroloop equipped lines is in general

possible even if the locomotive is not capable of receiving loop telegrams.

In a nutshell, the tests could be successfully finalised and the proof of interoperability of the tested ETCS Systems was performed.

3.2.5 Operational Rules

When starting the implementation of ETCS in Austria, the operation with the new system was not covered by existing operational standards and rules. So it was a requirement to create operational standards for using this new system before setting the system into operation. During the implementation period of the system, a working group consisting of specialists for trackside and driver operational rules, with technical experts for the ETCS system elaborated operational standards and rules based on existing ÖBB standards and rules.

3.2.6 Lessons learned

ÖBB, as an early implementer of ETCS technology, started the new system as a pilot without having the possibility to look for some help or advice from other real commercial projects. The learning experience in this pilot project is now valuable for the implementation on the entire Austrian railway network. Important experiences were collected by performing operational tests during the implementation phase of the pilot project - refer to chapter 3.1. Based on theoretical reflections the design of infill-information and trackside transmitted release speed configuration has been implemented on the pilot. The results of the tests showed that the configuration of infill by Euroloop and Eurobalises and the implemented release speed - particular in stations - did not fully fit the required high operational performance of the system.

As a consequence it was necessary to adopt the engineering rules for the layout of the system.

The knowledge on layout design collected within the pilot project offers ÖBB the

possibility to elaborate a basic planning for further projects. This basic planning is a considerable important part of call for offers to industry to make the offers of different suppliers comparable and supports/simplifies the evaluation of offers.

3.3 Validation & Certification

The supply, installation and finally the

commissioning of an ETCS Level 1 line is a process where many interactions between supplier, customer and authorities have to be managed and close cooperation between all parties is required. The output of each phase triggers the next and depending on the project size interleaved situations are not unusual. Figure 2 sketches the major steps of a track side project.

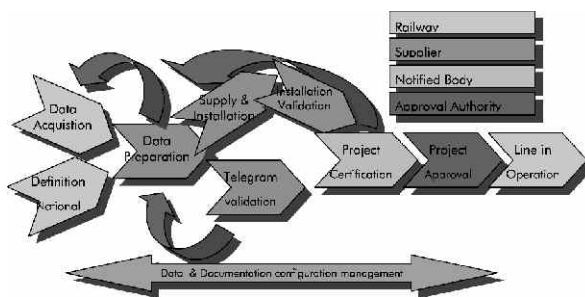


Figure 2: ETCS Level 1 Track Side Project

The project on the Vienna - Budapest line in Austria is not only a pilot project for the new technology and evaluation of ETCS operation but also the first project for the validation, certification and approval processes. New methodical approaches are required to minimise unnecessary repetition of certain steps due to wrong or incomplete input data. From the project experience we can list the following aspects:

- Track data/plans are not always accurate and up-to-date.
- National rules have to be a flexible framework and shall be extendible if required
- The amount of ETCS telegrams exceeds manual manageability. A comprehensive tool support is required to manage the data consistently and caretaking of the data and documentation configurations
- ETCS Installation validation typically has to be done during normal train operation

- Telegram validation has to be supported by intelligent tool support automating all possible data consistency checks. It is impossible to validate all telegrams itself and necessary telegram combinations within the living installation by exhaustive trial runs with ETCS trains. Only exemplary scenario tests can be performed.
- Approval documentation (Telegram reports, etc.) has to be generated out of the same database as the technical telegrams are calculated.
- Difference reports showing changed data elements (telegrams, documents, etc.) are a must for efficient project progress as iterations in the process will occur.

For the pilot project and potential follow-up projects the interfaces between the supplier (Alcatel), the railway (ÖBB), the notified body (Arsenal research) were elaborated in a joint effort in order to make the project communication and realisation as smooth as possible.

4 Conclusion

ETCS Level 1 is getting more and more acceptance as the properties of this solution allow a feasible migration path towards ETCS for railway operators. Not only the flexibility with respect to overlay existing signalling systems (from simple signal aspect detection to sophisticated route control/interlocking derived telegram selection) but also the potential for optimised track design to meet various operational needs at reasonable cost are convincing for many railways.

After the finalisation of the track side installation on the line Vienna - Budapest evaluation activities have been performed in order to verify various aspects of ETCS operation. From an infrastructure point of view it has been identified that the full performance and safety potential of ETCS Level 1 on the basis of optimised track layouts can only be achieved with careful design of the different ETCS parameters, adaptation of operational rules (priority of the cab signal, etc.) and careful tuning of various parameters influencing the standardised brake models.

The current operational experience on the Vienna – Budapest line therefore shows that it is possible to introduce an ETCS Level 1 train control system as an overlay to the existing trackside signalling system (interlockings, light signals, underlying fixed block scheme) in a way to meet the operational necessities of infrastructure and rolling stock operators, given the close

cooperation of the latter including notified bodies involved, approval authorities and the relevant supply industry.

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Table: Table 1: *ETCS Modes of Operation (See [3])*

Application Level	Level 1	Level 1 + Infill Loop	Level 2	Level 3
Transmission media	Eurobalises	Eurobalises + Loop	Eurobalises GSM-R	Eurobalises + GSM-R
Transmission characteristics	Spot / discrete track → train	Semi-continuous, track → train	Continuous, bi-directional	Continuous, bi-directional
Supervision characteristics	Continuous (with the exception release-speed)	Continuous	Continuous	Continuous
Track occupancy facilities needed	Yes	Yes	Yes	No
Line side signals mandatory (precondition: fully equipped trains)	Yes	No	No	No
Fixed block scheme	Yes	Yes	Yes	No ("moving" block)
Train integrity check required	No	No	No	Yes
Provision of route control information	LEU (interface to signal or interlocking)	LEU (interface to signal or interlocking)	RBC (interface to interlocking)	RBC (time face to interlocking)

RESOLUTION

2nd International Seminar on Railway Signaling and Telecom Systems for “Cost effective solution for Line Capacity enhancement” held on 6/7 October 2006.

With the growth of the Indian economy, IR has been witnessing an unprecedented growth in traffic volumes over the last few years. NTKMs per wagon per day have gone up from a figure of 2042 in 2001-02 to more than 3000 in the last financial year. Though IR has been successfully handling the enhanced traffic volumes, the high density routes of IR have been operating at above saturation levels. Keeping in view the projected growth of the economy, a steep increase in the traffic demands is forecast in the coming years. To meet the projected traffic demands, capacity augmentation of the high density routes and feeder networks has become inescapable.

Although, IR has decided to go ahead with the dedicated freight corridor project on the golden quadrilateral, which would equip it not only to meet the higher traffic demands but also enable an increase in the IR's market share of the total freight traffic in the long term, there is an extremely urgent need to adopt cost effective and highly reliable S&T solutions to generate additional capacity in the interim phase so as to continue to sustain the growth in the short to medium term.

It is in this background that “Cost effective solution for Line Capacity enhancement” has been identified as the theme of the 2nd International Seminar on

Railway Signaling and Telecom Systems.

Experiences and user perspective of major world railway networks were presented during the seminar. The deliberations brought out that the advanced signaling and telecommunication solutions have emerged as cost effective options for line capacity enhancement.

- o Automatic signaling has emerged as the most effective techno economic solution for enhancing line capacity and improving safety in a short span of time. Moreover investment made in automatic signaling will continue to be useful even after other solutions like provision of additional track and improved freight stock are adopted later on. From the experiences shared it can be inferred that even in mixed traffic conditions the charted section capacities for automatic signaling sections increases by 30 -50% depending on mix of traffic and the other local conditions like terrain, brake power etc. These systems should be considered for introduction on identified HDN sections and feeder routes. To adopt an incremental approach, intermediate block signal/ hut should be provided to meet the immediate demand of enhanced traffic.

- o With growing traffic density, improved speeds and the need to sustain

higher standards of safety, additional signaling systems have been provided in the block section IBS, gate interlocking etc. This has led to increased level of stress on the driver during train operation. This enhanced level of risk can be mitigated by providing a proven on board train protection system as an aid to the driver to eliminate human errors. World over, on board systems are synonymous with high density operations. Keeping in view the availability of large no. of such systems for various functions, it is essential to identify the suitable technology which would be compatible with other existing systems and fulfill all the required functions in order to avoid multiplicity of cab equipments and resultant compatibility problems. Proven technology with open standards and multiple vendor support OR indigenous adoption of the technology on TOT basis are options available to Indian Railways for adoption.

o On new corridors like the DFC where new independent systems are to be provided we need to consider advanced signaling and telecommunication solutions which meet the requirement of safety, line capacity, reliability and low operational cost. Integration of signal, telecomm. and train control systems is essential to provide seamless operations and provide an efficient customer information system.

o The need for Mobile train Radio communication system has already been accepted and need not be stressed any further. With the experience gained from projects world wide and in India, we should plan to cover all major routes with this system which provides a secure communication between train crew and field staff. This also is a key enabler for adoption of integrate signaling and train control system. Further this also provides a communication back bone for various passenger and commercial applications such as on board train information system, on board ticketing and on board signaling.

o Introduction of advanced S&T solutions with properly designed levels of reliability and safety will still need trained and skillful organization to operate, maintain and support the system. This is absolutely necessary to improve the availability of the system and to minimize the impact of a failure. Therefore, adequate measures need to be taken to improve training systems on IR.

o The concept of development of intelligent Railway Networks which will be a complex system of systems for the purpose managing the day to day traffic but also to manage the unknown, needs to be examined and considered for future direction to be given to Indian Railways. The concept heavily depends on information capture, transfer and processing which will require a very robust no break optical network.

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