PERFORMANCE OF NEW TECHNOLOGIES IN SIGNALLING SYSTEMS ON INDIAN RAILWAYS

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SUMMARY

This paper intends to analyse various aspects of processes and procedures followed on Indian Railways (IR) during the introduction of new technology based systems in signalling, and their comparison with the best practices of railways worldwide to find out the reason of dismal performance and inability to leverage new technology to improve reliability and availability of signalling systems.

Instead of bringing enhanced reliability, availability, safety and peace of mind to maintainers and maintenance managers, these new technology based equipments and systems have brought uncertainties, fear, helplessness and poor understanding. The reliability and improvement potential of the new systems compared to the old systems have been overshadowed by the poor performance often bringing 'sleepless nights' to the maintenance manager responsible for them. The volume of traffic carried by IR provides heavy demand for enhanced availability of signalling systems and there is no scope for compromise.

What has gone wrong is the question in the mind of all concerned? This paper attempts to answer this question after critical analysis of the entire process and its comparison with the best practices adopted across the industry.

1 INTRODUCTION

Indian Railways has remained adaptive to new technologies in the field of signalling and telecommunications since its inception in 1853. Introduction of multiple aspect colour light signalling, relay interlocking, various kinds of block working, points operation, and train detection and microwave radios etc has been done as soon as the technology was adopted by other railways across the globe. Indian railways have adopted these technologies mostly in a very smooth manner in the past. The operation and maintenance has never been an issue and most of the systems have been sustained without OEM support. Manufacturing of Block instruments, GRS point machines and B & Q type relays by various Signal Workshops owned by IR and full service support to the customers and continuation of Klystron based microwave radio equipments for the IR system for more than 35 years are positive example of successful technology induction.

However, during the last 10 – 15 years, the experience of the introduction of domestic or imported new technology based systems and equipments on IR have not been very encouraging. During this period, LED based Colour Light Signal lighting units, Integrated Power Supply System (IPS), Single and Multiple section Digital Axle Counters, Solid State Interlockings, ETCS level II based Train Protection & Warning System (TPWS), GPS based Anti Collision Device (ACD) and GSM (R) based train radio communication systems have been introduced. The trend of the deployment of these systems is displayed below.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Growth over Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2004</td>
</tr>
<tr>
<td>P I (No. of Stations)</td>
<td>2431</td>
</tr>
<tr>
<td>RRI (No. of Stations)</td>
<td>197</td>
</tr>
<tr>
<td>SSI (No. of Stations)</td>
<td>45</td>
</tr>
<tr>
<td>BPAC (No. of Block Sections)</td>
<td>296</td>
</tr>
<tr>
<td>LED Lit Signals (No. of Stations)</td>
<td>1308</td>
</tr>
<tr>
<td>Data Logger (No. of Stations)</td>
<td>2105</td>
</tr>
<tr>
<td>TPWS (Route Kms)</td>
<td>1686</td>
</tr>
</tbody>
</table>

Table – 1: Deployment Trend of New Technology Based Signalling Systems over IR

To date, none of the new systems introduced listed above have been able to deliver the consistent performance in terms of reliability, availability and maintainability. Even after completion of their large-scale deployment,
continued modifications in these systems point to poor system engineering. On average, the new technology equipment application contributing more than 55% signalling incidents on IR, not only affecting the train operation but lowering the standards of safety too. A specific example shows that that 70 – 80% of block and track circuit incidents are due to equipment failures pertaining to electronics based digital axle counters. A typical distribution of signalling incidents over a zone is as follows:

<table>
<thead>
<tr>
<th>Equipments</th>
<th>Nos.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block Systems</td>
<td>944</td>
<td>26.9</td>
</tr>
<tr>
<td>Train Detection</td>
<td>554</td>
<td>15.8</td>
</tr>
<tr>
<td>Relays</td>
<td>502</td>
<td>14.3</td>
</tr>
<tr>
<td>Cables</td>
<td>319</td>
<td>9.1</td>
</tr>
<tr>
<td>Signal Lamps</td>
<td>308</td>
<td>8.8</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>227</td>
<td>6.5</td>
</tr>
<tr>
<td>Fuse Blown</td>
<td>176</td>
<td>5.0</td>
</tr>
<tr>
<td>Lifting Barrier</td>
<td>144</td>
<td>4.1</td>
</tr>
<tr>
<td>Maintenance Issues</td>
<td>125</td>
<td>3.6</td>
</tr>
<tr>
<td>Power Equipments</td>
<td>89</td>
<td>2.5</td>
</tr>
<tr>
<td>Misc Equipment</td>
<td>77</td>
<td>2.2</td>
</tr>
<tr>
<td>Elect Point Machine</td>
<td>31</td>
<td>0.9</td>
</tr>
<tr>
<td>Interlocking</td>
<td>12</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>3508</td>
<td>100</td>
</tr>
</tbody>
</table>

Table – 2: Typical Distribution of Signalling Incidents over a Zone

These signal incidents are affecting the punctual running of trains and not only causing dislocation of services and discomfort to passengers but also introducing the human element in the train operation. The following diagram displays the seriousness of these incidents in terms of the number of trains loosing punctual running over different zones of IR during the year 2010 and 2011.

What Has Changed?

In keeping pace with the consistent growth in passenger and freight traffic, investment in the S&T infrastructure has also increased. As evident from the table - 3 and figure - 2, all the figures of Expenditure, Train Kilometres travelled (Km) and Signal Incidents are exhibiting an increasing trend. Increasing trends in Train Km signifies an increase of trains in the same route. To cope up with this increasing trend, a decrease in the Signal Incidents is
desirable to achieve the required line capacity. In order to manage this growing traffic demand and maintain operational safety, new signalling equipment technology has been introduced to achieve higher reliability and availability of signalling system. However, current statistics show that in fact there is no substantial decrease in the signalling incidents. This is evident from the trend shown in the Table – 3 and Figure - 2, the increase in signal incidents was been observed until 2008. A reversal in the trend has been observed in 2009 and onwards but until now, the status of the levels achieved during 2004 to 2006 has not been matched.

Figure 2: Trend of Signal Incidents vis a vis Expenditure on Signalling

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure (In 100 millions of INR)</td>
<td>688.53</td>
<td>817.7</td>
<td>1042.5</td>
<td>1179.2</td>
<td>1343</td>
<td>1380</td>
<td>1048</td>
<td>958.5</td>
</tr>
<tr>
<td>Train Km (Million)</td>
<td>776</td>
<td>799</td>
<td>825</td>
<td>856</td>
<td>892</td>
<td>933</td>
<td>981</td>
<td>1022</td>
</tr>
<tr>
<td>Signal Incidents (in 00)</td>
<td>117</td>
<td>124</td>
<td>115</td>
<td>148</td>
<td>168</td>
<td>141</td>
<td>123</td>
<td>119</td>
</tr>
<tr>
<td>% Change</td>
<td>10</td>
<td>6</td>
<td>7.3</td>
<td>28.7</td>
<td>13.5</td>
<td>(-16)</td>
<td>(-12.8)</td>
<td>(-3.3)</td>
</tr>
</tbody>
</table>

Table – 3: Trend of Expenditure in S&T Infrastructure vs. Signal Incidents and Train Km over the years

The only current recorded benefit of the increase in investment in new technology based signalling equipments is the reduction in train accidents attributed to the Human Factor, which is evident from the table – 4 below.

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Accidents Attributed to Human Factor</td>
<td>268</td>
<td>197</td>
<td>206</td>
<td>169</td>
<td>165</td>
<td>151</td>
<td>138</td>
<td>116</td>
</tr>
</tbody>
</table>

Table – 4: Trend of Accidents Attributed to Human Factor

2 NEW TECHNOLOGY BASED SIGNALLING EQUIPMENT

New technology based signalling equipments, proven all over the world has been inducted over IR. However, as described above the performance is not up to the mark. Since the issues pertaining to reliability and availability involved with most of the new technology based equipments are similar, the status of few systems/ equipments introduced to reduce the maintenance efforts and operational flexibility are discussed in following Paragraphs as follows:
Electronic Interlocking (EI)

After the first trial installations back in 1987 for the Southern Railway, large scale deployment of EI started in the 2002, when the first independent electronic interlocking of Union Switch and Signals, Micro Lock – II was installed as an independent system following the procedure of cross acceptance at Chakulia station on Howrah – Mumbai route in South Eastern Railway. Since then, more than 300 Microlock – II systems have been introduced over various zones of the IR during the last 10 years. The first major failure of the EI occurred at Chakulia due to Lightening within three months of installation, similar failures are taking place at other locations, the recent being at Basta station on Howrah – Chennai route of IR. These failures have occurred despite the implementation of a ‘full proof’ earthing and surge protection system evolved by M/s Ansaldo after 10 years of research. The MTBF figures display the dismal performance of EIs over IR with respect to specified figures of MTBF in RDSO specification for subsystem and availability of entire system, which is more than 1x10^5 hrs and 99.85 respectively.

<table>
<thead>
<tr>
<th>Railway</th>
<th>Population</th>
<th>Failures Per System Per Month</th>
<th>MTBF (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECR</td>
<td>3</td>
<td>0.0135</td>
<td>18136</td>
</tr>
<tr>
<td>SCR</td>
<td>40</td>
<td>0.0031</td>
<td>5951*</td>
</tr>
<tr>
<td>SER</td>
<td>52</td>
<td>0.0012</td>
<td>11457</td>
</tr>
</tbody>
</table>

* Major failures of EI of AzD Praha have contributed to the degraded value of MTBF over SCR

Table – 4: Performance of Electronic Interlocking Over Three Zones of IR

Major Issues:

i. Competency development in design, production, verification and validation of application logic is the key issue. As many as 14 issues found during the factory acceptance test (FAT) of application logic of Pabai station EI of Delhi – Chennai route exhibit the poor design production checking, verification and approval process. IR is dependent to the vendors for design, whereas verification and approval process is controlled in house. Such examples spread over all the zones in varying extent, present incompetent and unskilled resource availability not only limited to design but to the approval process too.

ii. Another serious issue is the damage occurred to the EIs from lightning and surges. In spite of all the trials and experiment in operation in this field during last 10 years, the solution offered by one of the major vendor of EI and vigorously pursued by the S&T branch of IR for implementation, has not withstood the first spell of lightening of the season at Basta station of South Eastern Railway during April 2012.

iii. Non-availability of user-friendly diagnostic tools, flow charts and event/ error logs make it extremely difficult to reduce the down time of failed EI system by IR own maintenance staff. The result is an Annual Maintenance Contract to the EI vendors, which is unable to ensure the minimum MTTR due to a lack competent resource available.

iv. Isolation of core EI equipments with outdoor equipments. The vendors attribute many transient natures of faults in EIs to the hard-wired interface. One of the major vendors has come out with the idea of doing away with SM control cum indication panel (CCIP) and go for VDU based operation terminals. However, non-availability of many features of CCIP and upkeep of VDUs are impediments.

Digital Axle Counters (DAC)

Axle counters on the IR were introduced during the 1970s and subsequently DACs were introduced in early 2000. DAC for block proving was introduced as part of the Corporate Safety Plan (2003-2013). The first technical specification for DAC was issued during 2003. The DACs are being used for train detection in the yards in place of conventional DC track circuits as well as block proving. In the beginning, Single Section Digital Axle Counters (SSDACs) were used for train detection in yards as well as block section. However, from 2005-06 and onwards, Multi Section Digital Axle Counters (MSDAC) are increasingly used in the yards for train detection purposes. As evident from the table - 2, more than 42% of signal incidents pertain to Block and Train Detection system. Out of these 42% incidents, 80% of block and 69% of train detection system incidents are attributed to the malfunctioning of DACs. These incidents are leading to the use of paper line clear and authority with human
element intervention to enter into block section or pass the signals at danger during the failure of Block Proving by Axle Counter (BPAC) and train detection devices respectively. These situations are potential hazards and prone to errors.

As far as diagnostics of these incidents are concerned, there are as many as 41 error codes displayed in the event of the malfunctioning of SSDAC and leaving a technician clue less. This is the example of poor human factors in the design of the equipment. In spite of these large number of error codes, multiple reasons for generation of one single error code are being observed. E.g. Error code 40 representing “Communication Error”, contributes 28% of the error codes displayed, however, more than seven different reasons has been established for generation of this error code. Even after its deployment in the field since last 8-9 years, one after the other modifications are being issued.

<table>
<thead>
<tr>
<th>Railway</th>
<th>Population</th>
<th>Failures per system per month</th>
<th>MTBF (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECR</td>
<td>366</td>
<td>0.001</td>
<td>1975</td>
</tr>
<tr>
<td>SCR</td>
<td>447</td>
<td>0.36/0.001</td>
<td>1631</td>
</tr>
<tr>
<td>SER</td>
<td>292</td>
<td>0.0013</td>
<td>1815</td>
</tr>
</tbody>
</table>

Table – 5: Performance of Digital Axle Counters Over Three Zones of IR

Major Issues:

i. Software instability causing frequent hangs and no response to the actions

ii. Component reliability enhancement

iii. Robust design of track devices

iv. Standard Wiring discipline to minimise the effect of EMI and noise

v. Lightening and surge protection

vi. Fault diagnostic flow charts and robust error logger

Anti Collision Device (ACD)

In order to prevent 86% of train accidents taking place due to human failures, out of which railway staff was responsible for half of the cases; serious deliberations to adopt the accident prevention strategies started in IR around 1999 – 2000. Encouraged by the demonstration of the prototype of ACD developed by Konkan Railway Corporation Ltd (KRCL) in 1999, the ministry of railway sanctioned a pilot project of ACD for deployment in Katihar – Guwahati – Dibrugarh section (1736 Km) of Northeast Frontier (NF) zone of IR at a cost of Rs. 500 million in 2000 – 01.

After four years of sanctions of the work, a joint team of KRCL, Research, Development and Standards Organisation (RDSO) and NFR conducted the first site acceptance test of ACD system deployed in Katihar – New Jalpaiguri – Guwahati section in August 2005. During the trial, an un-warranted application of brakes due to sporadic detection of abnormal situations and miss-match of information installed in the locomotive, guard brake van, station and level crossings was found. Corrective action could not be decided by the Multi Disciplinary Team due to reluctance of KRCL to pass on the design and other documents. However, modifications were done by KRCL and the system was offered for a second site acceptance test in March 2007 i.e. again after 2 years. Although improvements in some of the parameters were observed, five serious items of abnormal track assignment, low battery event, spurious messages regarding head on collision and assurance of reliability and availability could not be fixed.

Before offering the system for second acceptance test, initial Functional Requirement Specification of ACD was modified to deviate from the initial concept. It was decided to take inputs from the signalling system for detection of obstruction. In this concept, interfaces were not deliberated and there was no provision of validation of the input from the signalling system. Reliability of the equipment was also a question as during the second site acceptance test, more than 20% of ACDs were found defective. The major concern was more than 40% defective ACDs deployed in repeaters and unmanned level crossing gates making the safety cover withdrawn in that area.
In this way, we find that a system, which was not comprehensive at the conceptual design stage itself, was planned for deployment over a large scale and failed miserably from the first acceptance stage itself. During the latest full board review meeting of IR over ACD, a decision was taken summarised as follows:

i. ACD is not a failsafe system and failure of system/ components resulting in an unsafe condition;

ii. Large number of accident scenario still uncovered;

iii. There are large number of safety, operational and maintainenece issues. Such as, failure of any onboard equipment in locomotive withdraw the safety cover for other trains also, failure of repeater withdraws the safety cover in the area, collision on main line is possible during station ACD failure; large number of unnecessary braking and booting of the system takes place; highly maintainenece intensive system with no redundancy.

iv. Every update of the system is bringing new problems and issues;

v. Dependence on GPS alone;

vi. SPAD protection is not available.

Major Issues

i. Defective conceptual modelling;

ii. Modification of the entire principle after un-successful trials;

iii. No consideration to the environmental conditions like power supply availability, law and order situation etc;

iv. No consideration for the cost of maintenance, whereas more than 200 personnel are required to look after the system;

v. No exchange of information with the stakeholders and interfaces.

Train Protection and Warning System (TPWS)

After satisfactory performance of Auxiliary Warning System (AWS) in the suburban sections of Central and Western Railway, The Ministry of Railways considered the trial offer for European Train Control System (ETCS) from International Union of Railways (UIC) {Union Internationale, DES, Chemins, Defer} in the year 1998. However, due to the delay in the decision by The Ministry of Railway and by start of formulation of the specification of ETCS level 2, the trial was deferred.

During 2003 and 2004, a modified system of TPWS, similar to ETCS level 1 was sanctioned for 52 Km of Chennai – Gummidipundi section of Southern Railway (SR) and Delhi – Mathura section of Northern Central Railway (NCR) respectively. Although the work for TPWS in 50 Km section of SR was commissioned on a trial basis during January 2008, many important issues coming in the way of its successful functioning are yet to be resolved even after a lapse of more than 4 years. The important ones are briefed as follows:

i. Even after the substantial modifications of the system during 2008 to 2011, analysis of the trial reports indicate the performance efficiency of the system ranging from 77% to 90% as opposed to the desired efficiency of 99.9 %. Few important impairments in the observed were:

   a. Blanking off of Simplified Driver Machine Interface (SDMI)

   b. Complete system failure during run

   c. System failure during booting and sleep mode

   d. Application of brakes during run without apparent reason

   e. Balise Transmission Module error

   f. Frequent Train Interface Unit failure

ii. Out of 5608 trials, there were as many as 868 incidents. Out of these incidents, 566 pertain to on board system failures, 255 trackside system failures and 47 miscellaneous such as data over flow and link error etc. There were as many as 958 cases of isolation of on board TPWS with trackside equipments. In addition, 1491 cases of isolation and defects were found during night examination of rakes also.

Similar is the status of TPWS work in Delhi – Mathura section of Northern (NR) and North Central Railway (NCR). The tender for which was awarded in June 2005. Delay of more than 6 years to start the trials is
attributed to the poor interface management among various disciplines within Indian Railways, i.e. Locomotive, P. Way and Signalling and frequent changes in the design of the equipments to suit the conditions over IR.

The above-mentioned facts display the highly unsatisfactory implementation and performance of the ambitious project of Train Protection and Warning System that Indian Railways wants to strongly pursue. Despite deterring status of trials, Work for provision of TPWS at around 900 Km sections spread over five (5) zonal railways has been sanctioned by The Ministry of Railways during the year 2010 – 11.

LED Signals

The technology for LED based signals has been available worldwide since the 1990’s. However, an effort to introduce the same on IR was made during 1999-2000. RDSO issued the draft specification in the year 1999 along with an approved list of manufacturers. Sporadic efforts were made over various zones to introduce the same. However, replacement of conventional signalling lamps with LED lit signals received thrust during the execution of an overdue infrastructure replacement works, financed by the Special Railway Safety Fund (SRSF) since 2002. By the year 2007, more than 1300 stations i.e. around 22% stations were provided with LED signals.

The use of LED signals provided great respite to the signalling maintenance management from the pre-mature fusing of conventional lamps and frequent replacing of signal lamps. Yet similar to other new technology equipments, this system was also brought in with flexibility to use conventional cast iron Colour light signal units and Lamp Checking Relays (ECR) instead of ECRs suitable for LED signals.

Large numbers of incidents started emerging due to non-picking up of conventional ECRs used with LED signals causing failures. It is only during the beginning of 2012 that RDSO mandated to stop the use of conventional ECRs through revision 4.1 of the specification. As per pre-revised specification of LED signals, both ECRs were permitted to use. Apart from the above mentioned problem of ECRs, large scale failures of current regulators of LED lit signals due to penetration of water through improperly sealed colour light signal units put another dimension to the problem. Although, several temporary measures like putting sealing tapes and sealing of the units by improved gaskets etc were tried, the poorly designed current regulators could provide little succour as adequate heat dissipation is still a serious cause of worry. We can see that here too the issues have cropped up leading to another problems overshadowing the advantage provided by the new and improved technology. The performance of LED signals over three zones of IR is shown in table – 6 as follows:

<table>
<thead>
<tr>
<th>Railway</th>
<th>Population</th>
<th>Failure Per System Per Month</th>
<th>MTBF (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECR</td>
<td>5028</td>
<td>0.0002</td>
<td>60876</td>
</tr>
<tr>
<td>SCR</td>
<td>25939</td>
<td>0.0001</td>
<td>431318</td>
</tr>
<tr>
<td>SER</td>
<td>10794</td>
<td>0.0003</td>
<td>606730</td>
</tr>
</tbody>
</table>

Table – 6: Performance of LED Signals Over Three Zones of IR

Major Issues:

i. Non-involvement of the maintenance teams and interfaces;

ii. Poor design and non-compatibility of the equipments with their environmental conditions;

iii. Re-drafting of the specifications to suit the equipments to the environmental conditions prevailing over different zones of IR

Mobile Train Radio Communication:

Mobile Train Radio Communication (MTRC) over IR was introduced during 1980’s in Nagpur – Durg, Nagpur – Itarsi and Nagpur – Bhusawal sections of SER and CR zones of IR. Although the system met, the requirements of MTRC, yet bulky handsets provided to drivers and guards and logistic for it’s charging made this system very un-popular. In addition, the system could not sustain due to lack of support from OEM and development of in house expertise as done earlier with microwave radio equipments, which were successfully used beyond their
codal life. GSM(R) based MTRC works were sanctioned during 2005 and deployed over NFR, ER, NCR and NR zones purely for train control communication purpose.

Due to the high initial cost of GSM(R), which could be justified only after its use in signalling applications like cab signalling etc; GSM(R) based MTRC was deployed with compromised system engineering with large inter BTS distances leading to poor signal strength and call drops. In addition, vast differences in the environmental conditions of locomotive cabs for which the handsets were designed by the OEMs, the sets provided to the loco drivers were not able to provide the adequate comfortable level of volume and clarity in voice communication leading to complete dissatisfaction amongst users. The investment of around 975 million INR remains gainfully unutilised. Again, due to poor system engineering and no consideration for the interfaces and environmental conditions, a proven technology in the world has been discredited over IR; which has much more potential than its use over IR.

Major Issues:

i. Design of suitable handsets for use in locomotives with high ambient noise and adverse environment conditions;

ii. A plain talk over the usefulness of the GSM(R) based communication over IR in the present system of train working rules overloading the drivers with activities;

iii. Relook at the system engineering

3 ROAD AHEAD

Sub optimal performance of these new technology based signalling systems will add problems to the users, maintainers and customers alike. Therefore, a serious thought to improve the reliability and availability of these systems is required.

Adopting Correct Approach of Induction

Having seen a glimpse of the performance of a few of the new technology based signalling systems installed on IR during last decade, we find that the real benefit has not come to the users and maintainers of the new technology. The question arises, where have we slipped up? To find the answer to this question, we have to compare the two systems with fundamental approach of System Life Cycle starting with planning, design, installation, testing and maintainence. During this comparison, we find a fundamental difference between the two different genres of the system. Whereas, the Feel and See Through the various stages is the fundamental factor in the design, installation, testing, commissioning and maintenance of old technology based signalling system; This Feel and See Through factors are replaced with the Conceive, Measure and See. In addition, documentation of every stage for understanding by interfaces is must.

To manage the old technology based systems, technicians and engineers with conventional engineering backgrounds are of sufficient requirement whereas the same is not true with the new generation of equipments where we require an altogether different approach, knowledge and skill sets with the planning, implementation, operation and maintainence regime. This new regime must have the understanding and implementation techniques of logical handling of sensitive equipments, fully conversant and equipped with the diagnostics tools, aids and documentation. In brief, the requirements in both the systems are compared as follows:

<table>
<thead>
<tr>
<th>Phases of Life Cycle</th>
<th>Old Technology based Systems</th>
<th>New Technology based Systems</th>
</tr>
</thead>
</table>
| Design               | • Overlapping Design, Installations and Testing functions  
                       • Full understanding of implementations | Designer has neither knowledge nor skill set for other phases |
| Installations        | • Done by technicians & supervisors; not by qualified engineers  
                       • Skill set requirements: Soldering, Wire testing, Knowledge of relays, Point Machines, Battery charges & batteries | • To be done by qualified technicians and engineers  
                       • Skill set requirements: handling of sensitive electronic components and software based system |
<p>| Testing &amp; Commissioning | Limited to continuity, wire counts, simulation and correspondence | • Application and interface logic validation in addition to those required in old technology system |</p>
<table>
<thead>
<tr>
<th>Phases of Life Cycle</th>
<th>Old Technology based Systems</th>
<th>New Technology based Systems</th>
</tr>
</thead>
</table>
| Maintenance          | • Preventive: by qualified technicians and Directed maintainance under the guidance of engineers  
                         • Corrective: Except for major faults, diagnosis and rectifications at the level of technicians and supervisors | • Preventive: Only directed maintainance under the guidance of especially trained engineers  
                         • Corrective: Except for minor faults, diagnosis and rectifications at the level of supervisors and especially trained engineers  
                         • Systems are scattered hence one group of Executives and Supervisors is not feasible due to insufficient strength |
| Training Requirements | Simple with availability of expert trainers in abundance | • Complex with availability of few expert trainers  
                         • Only system knowledge is not adequate. Must cover the special fault diagnostic techniques, understanding to decode the alarms, events and errors and correlate with the subsystems |

For successful implementation and use of these new generation equipment, a System Life Cycle approach is required for adoption of the new technology based signalling systems over IR in contrast to the overlapping design, installation and testing regime of old technology based systems.

A comprehensive system of testing, installation and maintenance is required to be evolved and nurtured, which positively requires a set up of a core group having the specialization in the above-mentioned areas to help the system establishing its credibility. Simply writing about the requirements of compliance to various standards in the specification will not help. A comprehensive methodology for testing to demonstrate the compliances must be specified and the people involved has to be trained.

**Training**

An entire novel approach to training staff for this new technology based equipments from the earlier system of training is required to be adopted. Training of the decision makers in assessment and validation techniques is missing leading to decision being made in ignorance. Simply posting an engineer in RDSO and expecting him to be an expert in the various assessment techniques to evaluate the performance of the new system is a dishonest approach. People involved in these processes are to be especially trained and equipped.

In addition to the knowledge about the system, fault diagnosis techniques, knowledge to decipher and decode the event & error logs and alarms to correlate with the faulty system, subsystems or cards and components are missing in the staff involved in the upkeep of the system after commissioning. To keep these system-trained people in continuous touch with the system, their placement is also important to ensure that they continue to work on the system and further their knowledge and skill in the chosen field. The fear of attrition and conventional style of management for placement of trained staff must be given up.

**Documentation**

At present documentation made during the validation and cross acceptance process is very sketchy. In the absence of clearly drafted Functional Requirements Specifications of the system and parameter & method to demonstrate the compliance of EN50126, 50128, 50129 and 50121, no safety case of the system is produced and verified by independent assessor. The documentation demonstrating the satisfactory performance with lowest MTTR and highest MTBF are not being produced and independently verified by a competent verifier or independent assessor.

Most of the documentation provided by the manufacturers and vendors of these new technology equipments provide the information related to system schematic knowledge, sketchy installation and testing techniques and poor drafted non-comprehensible fault diagnostics, flow charts and manuals to decode and decipher the alarms, events and error. These manuals are even not understood by the staff of these vendors involved in the various aspects of handling of these equipments. The requirement is to bring out the documents not from the designer or manufacture perspective but for the maintainence technicians and engineers.

The vendors and manufactures are compromising in sharing this knowledge with IR customers due to the fear of grim business prospects or after-deployment services. However, it is to be clearly understood that any business
with a knowledgeable customer technician or engineer available at site capable of handling the minor or major events, errors and alarms is a win-win situation for both the vendors and their customers. The satisfactory figures of MTTR and MTBF can be ensured within the limit for the railway working on 24x7 basis through a trained and capable staff at site only. His allegiance hardly matters in the hours of crisis.

Issues for IR Signalling

The issues of major significance and requiring attention to avoid the discredit to proven technologies and improve the experience of customers and working environment of maintenance management are:

- Mandate the process of making independent system and functional requirement specification avoiding the cross references to the similar systems;
- System Engineering and life cycle approach before induction of a new technology based signalling system;
- Documentation of EMI signatures of the existing systems like locomotive, EMUs, track maintenance machines, power cars, charging and AC equipments;
- Independent assessment and validation of the systems before type approval;
- Robust Cross Acceptance process including Safety cases;
- Change in working rules and procedures to supplement the system rather than designing the system as per procedures;
- A documented quality procedure to ensure the foolproof testing of these equipments before coming out of the manufacturing line;
- Specifications providing for method of verification of compliances to the provisions of standards like EN 50126, 50128, 50129 by the quality check streams;
- Training and skill building of people behind these systems in design, installation, testing, maintainence and operation;
- Sanction of trial works on a limited scale;
- Mandate to large scale deployment only after documented and verified reliability and availability figures after field trials;

4 CONCLUSION

In the future that is emerging with growing Indian economy requiring fastest possible clean transport system, an efficient and performing IR comparable to the acceptable standards worldwide is the need of the hour. An efficient and safe Indian Railways in absence of a top performing new and emerging technology based signalling infrastructure is a mirage. This is feasible only, when a life cycle approach is followed before induction of a new technology based signalling system, Safety cases are build up, robust cross acceptance process is put in place. After induction of these systems competent pre-acceptance quality check group, and trained, skilled, motivated and confident in service maintenance team is readily available to look after the incidents taking place during system service life. In order to achieve the designed reliability and availability parameters of the new systems, involvement of all stakeholders and interfaces, i.e. designers, manufacturers, users, maintainers and neighbours and their understanding of the system is of paramount importance. IR has to take immediate steps to put in place the above-mentioned processes for successful induction of the new signalling systems. However, the global railway signalling fraternity must share the responsibility en masse which will benefit not only IR but the signalling industry and IR customers in delivering safe and efficient services in a cost effective manner.