CHAPTER 9

SIGNALLING AND TRAIN CONTROL

9.1 Introduction

The Signalling and Train Control system shall provide the means of an efficient Train Control, ensuring safety in train movements. It assists in optimization of rail infrastructure investment and running of efficient train services on the network.

On high speed lines in Europe and Asia, there are mainly two types of signaling systems presently in service. Europe is shifting towards ERTMS Level 2 on high speed lines and is becoming the standard in Europe. This is true for some Non-European countries also. Where as the countries which already have high speed lines in Asia like Japan, Taiwan etc are using the older proven signaling system having ATC based on track circuits.

Any of these systems can be deployed on a high speed line in order to have Centralized Train Control System.

9.1.1 Overview

High speed rail is expected to carry large number of passengers by maintaining shorter spacing between trains requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and Rolling stock necessitates optimization of its capacity to provide the best services to the people.

These requirements of the High Speed Rail are planned to be achieved by adopting ATC sub-systems. This will:

• Provide high level of safety with trains running at high speed at shorter headways ensuring continuous safe train separation.

• Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.

• Provides safety and enforces speed limit on section having permanent and temporary speed restrictions.

• Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed in his cab enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in bad weather.

• Increased productivity of rolling stock by increasing line capacity and train speeds, and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stock.
• Improve maintenance of Signalling and Telecommunication equipments by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

Signalling & Train Control system on the line shall be designed to meet the required headway during peak hours.

9.2 Train Control System

9.2.1 The trains are operated at such high speeds that wayside signals can hardly be recognized by the human eye, a cab signal system which indicates a permissible train speed on the driver's console is employed in place of the wayside-signal system. In addition, a device is employed which applies the brakes automatically (without intervention of the train crew) when it becomes necessary to lower the train speed. This is called Automatic Train Control (ATC), and it ensures the safe operation of trains.

9.2.2 The train control system ensures safety and reliability. In order to operate high-speed trains safely and efficiently, it is essential that all trains are controlled in a centralized manner. This is accomplished by implementing a traffic control system that permits confirmation of current train positions, train numbers, route open/close status and other information on an integrated display panel. The traffic controller can manipulate the points and signals at all stations from the display terminal. The integrated display panel and display terminal also permit continuous monitoring of the operating conditions of the entire line.

9.2.3 The Signalling and Train control system forms the basis of the security setup, and to ensure safety, stability and reliability, the system’s devices constitute a redundant fail-safe system. A fail-safe system means that it is designed to always work on the safe side, even in the event of failure. This concept supports the safety and reliability of railway.

9.3 Centralized Train Control Computer

9.3.1 It provides support to the traffic control personnel to implement sophisticated transportation management. They can constantly monitor the conditions of all trains in operation on the basis of the operating conditions (departure time, departure track number and train sequence at each station) of each individual train.

9.3.2 If any train is not operated as scheduled, this computer issues an alarm calling for suitable adjustments such as changing the sequence of departures/arrivals. In addition, central computer predicts train operating conditions according to conditions set by traffic control personnel.
9.3.3 This computer can also performs transport planning and traffic control, managements equipment, vehicles and maintenance, controls information and more in order to improve the reliability, economy, maintainability, operability and scalability of the System.

Description of two types of signaling systems prevalent on High speed rail networks:

9.4 ERTMS LEVEL 2 (based on Radio)

9.4.1 ERTMS Level 2 (also called ETCS Level 2) is a fix block continuous speed supervision and control system. This system works like a conventional Automatic Train Protection System but the vital information exchange between the train and track side equipments is through radio instead of track circuit. On the track side, centralized Radio Block Centers (RBC) and distributed EURO balises are provided. GSM-R radio basically transfers the vital information to and from onboard system and EURO balises are used for initialization and periodic calibration of onboard computer.

Eurobalise + Radio (GSM-R) + Radio Block Center

- No more Trackside Signals Required.
Movement Authorities through GSM-R.
Train Position via Eurobalise.

9.4.2 Train detection and train integrity supervision are performed by the trackside equipment of the underlying signalling system (interlocking, track circuits etc.) and are outside the scope of ERTMS.

9.4.3 In the RBC, all static data such as static speed profiles, gradient profiles, track conditions and location of Balises are held in the form of a routemap. Through a direct connection between RBC and interlocking all the necessary dynamic information such as state of the points and signals are available in the RBC. Thus, in the RBC an image of the supervised area exists.

9.4.4 The fixed infrastructure information in RBC is combined with the variable information taken from the track side interlocking.

9.4.5 With this information, the RBC is constantly in a position to calculate a MA for every ETCS controlled train in the area, or to withdraw a previously issued MA.

9.4.6 This information is passed in the form of message to the GSM-R radio for assessment to the train.

9.4.7 The on board unit will process the information received via radio and the information available in the trainborne unit such as brake characteristics to determine the necessary speed profile and identify the necessary information for presentation to the driver via the DMI.

9.4.8 The on board unit also sends information to the RBC, for example MA request or position reports thus provide bi-directional data exchange on real time bases regarding train locations. Based on the position report, the train position on the RBC routemap can be updated. This information is processed by different systems for control and supervisory functions.

9.4.9 Recognised procedures are used to ensure the security of the radio communication.

9.4.10 Although in this arrangement, line side signals are not required but still it is proposed to keep line side signals on interlocked stations having point and crossings. Line side signal will also be required at the depot connections in both directions. These signals also provide backup in case of system failure.

9.4.11 This system provides continuous speed supervision and control and also protect against over run of movement authority. Train detection and train integrity supervision are performed by track side equipment (interlocking, track circuits etc.).
9.5 Components

9.5.1 List of trackside components

The various components of a trackside sub-systems can be:

- Balises (Eurobalise) mainly for location referencing
- A radio communication network (GSM-R) for bidirectional track train communication
- Radio Block Centres (RBC)

9.5.2 List of on board components

The various components of the on board sub-system can be:

- The ERTMS/ETCS onboard equipment
- The GSM-R on board equipment for ETCS

9.6 Main functions of ETCS trackside:

- Knowing each train equipped with and running under ETCS within and RBC area by its ETCS identity.
- Following each ETCS controlled train’s location within an RBC area.
- Determine movement authorities according to the underlying signaling system for each train individually.
- Transmit movement Authorities and track description to each train individually.
- Handing over of train control between different RBCs at the RBC-RBC borders.

9.7 Main functions of ETCS on board

- The train reads Eurobalises and sends its position relative to the detected Balises to the Radio Block Centre
- The train receives a movement authority and the track description via Euroradio relating to a Balise.
- Selection of the most restrictive value of the different speeds permitted at each location ahead.
- Calculation of a dynamic speed profile taking into account the train running/braking characteristics which are known on board and the track description data
- Comparison of the actual train speed with the permitted speed and command of the brake application if necessary.
- Cab signaling to the driver.

### 9.8 Generation of the movement authority

**9.8.1** The movement authority is generated by the Radio Block Centre, on the basis of communications with the ERTMS-equipped trains on one side and with interlocking on the other.

**9.8.2** The interlocking are responsible for

- Setting and releasing of routes, in relation to the orders from the Control Centre,
- Detection of track vacancy

**9.8.3** The main objective of the communication between interlocking and the Radio Block Centre’s then to provide information about:

- The routes that are set and locked
- The type of movement allowed on the route (“full supervision”, “on sight” or “shunting” movement)
- The emergency replacement of signals to red, due either to the intervention of the Controller or due to an emergency situation

### 9.9 Interface with the trackside operator (Local/Central)

**9.9.1** The Level 2 system will also provide an interface to the operator of the Control Centre.

**9.9.2** Typical facility offered by the Level 2 system is to allow the introduction and removal of temporary speed restrictions directly by the operator, or any portion of the area covered by the Radio Block Centre. Other commands can also be sent, as sending Unconditional Emergency stop to one or to all trains, sending text messages to a train, etc.

**9.9.3** The Level 2 system can also provide information about the trains it supervises, based on their position report and on the train data known by the Radio Block Centre. This includes train running number, train length, train category, train position, train mode and train speed.
9.10 Automatic Train Control (based on track to train communication)

9.10.1 The rails of train tracks are divided into sections (shorter than that in the vicinity of station), with each one electrically insulated from the adjacent sections to form a track circuit. When a train enters a section, its wheel sets drops a track circuit, indicating presence of a train, ATC telegrams are sent on the rails. The on board ATC system receives these telegrams from the rails with a receiver and displays it via the speedometer on the driving console. This enables the driver to acknowledge the signal aspect ahead even when forward visibility is insufficient due to rain, fog or other meteorological conditions. The ATC system automatically applies the brakes at the right time when required, regardless of the driver's intention.

9.10.2 This system is based on the principle of making the onboard devices take the initiative in controlling train speed. Under this setup, trains have a database that stores the information required for speed control such as data on track conditions and vehicle performance. Additionally, wayside devices transmit digital signals containing information on the position of the preceding train and the turnout open/close status. On receiving the information, the onboard devices retrieve an appropriate brake pattern from the database, perform the necessary calculations and implement optional brake control. The wayside devices send digital signals on the number of clear sections ahead and the route code to trains, based on which the onboard devices compute an appropriate brake pattern consecutively and perform optimal brake application.
9.11 Cab Signalling:

The information to drive the train are displayed in the cabin to the driver (cab signaling). Following information are displayed to the driver;

- Actual speed
- Maximum speed at which he is permitted to travel
- the target speed to achieve
- the target distance at which a target speed is to be achieved
- Mode of supervision

Cab Signalling enables the driver to acknowledge the signal aspect ahead even when forward visibility is insufficient due to rain, fog or other meteorological conditions. The ATC system automatically applies the brakes at the right time when required, regardless of the driver’s intention.

The diagram below shows a typical cab signal display.

![Diagram showing cab signal display](image)

9.12 Implementation with signals

ERTMS Level 2 system can be installed with or without signals. In the case this is implemented with signals, the implementation must take into account possible discord between the cab signaling and the signal indication.

Further, these redundant line side signals are useful for back up arrangement when trackside is defective.
9.13 Centralized Train Control and Supervision system

- A train supervision system will be installed to facilitate the monitoring of train operation and also remote control of the station. The train supervision will log each train movement and display it on the workstations with each Traffic Controller at the OCC and on one workstation placed in the Station Control room (SCR) with each Station Controller.

- The centralized system will be installed in the Operation Control Centre. The OCC will have a projection display panel showing a panoramic view showing the status of tracks, points, signals and the vehicles operating in the relevant section/whole system.

9.14 Interlocking System:

(i) Computer Based Interlocking (CBI)

At all stations with points and crossings, Computer Based Interlocking (CBI) will be provided for operation of points and crossings and setting of routes.

The setting of the route and clearing of the signals will be done by workstation, which can be either locally (at station) operated or operated remotely from the OCC.

This sub-system is used for controlling vehicle movements into or out of stations automatically from a workstation. All stations having points and crossings will be provided with workstations for local control. Track occupancy, point position, etc. will be clearly indicated on the workstation. It will be possible to operate the workstation locally, if the central control hands over the operation to the local station. The interlocking system design will be on the basis of fail-safe principle.

The equipment will withstand tough environmental conditions encountered in a Mass Transit System. Control functions in external circuits will be proved both in the positive and negative wires. Suitable IS, IRS, BS standards or equivalent international standards will be followed in case wiring, installation, earthing, cabling, power supply and for material used in track circuits, relays, point operating machines, power supply etc.

(ii) Track Circuits/Axle counter

Track Circuit/Axle counter will be used for vehicle detection and for transmission of data from track to train (if train control information is transmitted through track circuits).

(iii) Point Machines

Non-Trainable Electrical Point Machine capable of operating with either 110V DC or 3-phase 380V AC will be used on main line. The depot point machine will preferably be trailing type.
9.15 Depot Signalling

All depot lines except the one which is used for shunting and in the workshop shall be interlocked. A workstation shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard. Audio Frequency Track Circuits or DC track circuit will be used in the depot as well.

9.16 OTHER SAFETY SYSTEMS

The signals from these systems will be provided to Train Control system to ensure appropriate action to avoid a unsafe situation.

9.16.1 HOT BOX DETECTORS (HBD)

It is required to monitor the temperature of the axle boxes, in order to take appropriate decision in case of high temperature and avoid a derailment which could result from a broken axle.

9.16.2 DETECTION OF FLOODED TRACKS

Where there is a risk of flooding of the railway track, steps should be taken in order to slow down or stop the trains before the concerned area.

9.16.3 EARTHQUAKE DETECTION

A specific study should have to be realized in order to evaluate the risks and the possible consequences of an earthquake, taking into account the geotechnical characteristics of the site.

If there are risks with regards to the train operation, seismic captors shall have to be installed near the line and data shall be transmitted to the OCC/train control system.

9.16.4 DETECTION OF FALLING VEHICLES

All the Road Over Bridges (ROB) located on High Speed Line must be equipped with a protection system in order to avoid the fall of vehicles on the tracks. As a complement, the road bridges with heavy traffic and with such a configuration that fall of vehicles may be considered, a system for the detection of falling vehicles must be installed.

9.16.5 WIND DETECTORS

In windy areas, there is a risk of overturn of the train under the combination of crosswinds and induced winds provoked by the trains.

A meteorological study must be carried out in order to define the critical sites taking into account and protective steps ensured:
• the topographic environment,
• the records of wind speed,
• the dynamic characteristics of the train.

9.16.6 DETECTION OF FALLING ROCKS

To counter the risk of falling rocks on the tracks and/or landslides, special systems must be installed in order to prevent accidents.

9.17 Standards

System Description and Specifications

The Signalling and Train Control system shall be as below. Sub-system/ components will conform to international standards like CENELEC, IEC, BS, IS, ITU-T etc:

The following standards will be adopted with regard to the Signalling system.

<table>
<thead>
<tr>
<th>Description</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interlocking</td>
<td>Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for shunting, workshop/inspection shed areas.</td>
</tr>
<tr>
<td>• Operation of Points</td>
<td>With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.</td>
</tr>
<tr>
<td>• Track Circuit</td>
<td>Audio frequency Track circuits or DC track circuits on running section, test track and in depot.</td>
</tr>
<tr>
<td>• Signals at Stations with point &amp; crossings</td>
<td>Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.</td>
</tr>
<tr>
<td>• UPS (uninterrupted power at stations as well as for OCC)</td>
<td>For Signalling, Telecommunications and AFC</td>
</tr>
<tr>
<td>• Train protection system</td>
<td>ERTMS Level 2 or Train Control system based on Track circuit based transmission</td>
</tr>
<tr>
<td><strong>Signalling and Train Control</strong></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td></td>
</tr>
</tbody>
</table>

### Train Describer System

Automatic Train Supervision system. Movement of all trains to be logged on to a central computer and displayed on workstations in the Operational Control Centre and at the SCR. Remote control of stations from the OCC.

### Redundancy for TP/Train Describer

Redundant Train borne equipment and ATS equipment at OCC.

### Cables

Outdoor cables will be steel armoured as far as possible.

### Fail Safe Principles

SIL-4 safety levels as per CENELEC standard for signal application.

### Immunity to External Interface

All data transmission on telecom cables/OFC/Radio. All Signalling and telecom cables will be separated from power cables. CENELEC standards to be implemented for EMC.

### Train Working under emergency

Running on site with line side signal with speed automatically restricted to a predefined level.

### Environmental Conditions

Air-conditioners for all equipment rooms.

### Maintenance philosophy

Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling equipments shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/manufacturer’s premises.

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### 9.17.1 Power supply for Signalling

Reliable uninterrupted power supply is the most essential requirement for working of Signalling, Telecom and AFC installation. There will be a common 3 phase UPS catering to various loads to meet the requirement of voltage and frequency range of all the systems. UPS will also have generator backup.

### 9.17.2 Space Requirement for Signalling Installations

Adequate space for proper installations of all Signalling and UPS equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for Signalling equipment shall be generally 60 sq.m for UPS Room (common for signalling and telecom) and for Signalling Equipment
9.17.3 Maintenance Philosophy for Signalling systems

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling and telecommunication equipments shall be followed. Card / module / sub-system level replacement shall be done in the field. Maintenance personnel shall be suitably placed at intervals and they shall be trained in multidisciplinary skills. Each team shall be equipped with a fully equipped transport vehicle for effectively carrying out the maintenance from station to station.

The defective card/ module / sub-system taken out from the section shall be sent for diagnostic and repair to a centralized S&T repair lab suitably located on the section. This lab will be equipped with appropriate diagnostic and test equipments to rectify the faults and undertake minor repairs. Cards / modules / equipments requiring major repairs as specified in suppliers documents shall be sent to manufacturer’s workshop.

9.17.4 Conclusion

Both train control technologies i.e. ERTMS Level 2 and Train Control based on track to train communication are suitable for high speed rail as both are proven and are working in Europe, Japan, Taiwan and China.

It is also suggested that line side signal will also be provided for back up signaling.

9.18 TELECOMMUNICATIONS

9.18.1 INTRODUCTION

The telecommunication system acts as the communication backbone for Signalling systems and other systems such as AFC etc and provides telecommunication services to meet operational and administrative requirements of metro network.

9.18.2 OVERVIEW

The telecommunication facilities proposed are helpful in meeting the requirements for

1. Supplementing the Signalling system for efficient train operation.
2. Exchange of managerial information
3. Crisis management during emergencies
4. Passenger information system
The proposed telecom system will cater to the following requirements:

- Train Traffic Control
- Assistance to Train Traffic Control
- Maintenance Control
- Emergency Control
- Station to station dedicated communication
- Telephone Exchange
- Integrated Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station.
- Centralised Clock System
- Train Destination Indicator
- Instant on line Radio Communication between Central Control and Moving Cars and maintenance personnel.
- Data Channels for Signalling, SCADA, Automatic Fare Collection etc.

### 9.18.3 TELECOMMUNICATION SYSTEM AND TRANSMISSION MEDIA

#### (a) Fibre Optic System (FOTS) - Main Telecommunication Bearer

The main bearer of the bulk of the telecommunication network is proposed with optical fibre cable system. A minimum 24 Fibre optical fiber cable with redundancy (cable on both side of track) is proposed to be laid.

SDH (minimum STM-4) based system will be adopted with SDH nodes at every station and OCC. Access 2MB multiplexing system will be adopted for the lower level at each node, equipped for channel cards depending on the requirement of channels in the network. Further small routers and switches shall be provided for LAN network at stations. Alternatively a totally IP Based High Capacity, highly reliable and fault tolerant, MPLS Ethernet Network can be provided in lieu of SDH/MUX.

#### (b) Telephone Exchange

For an optimized cost effective solution, small exchanges of 30 port each will be planned at each station and a 60 Port Exchange at the Terminal Stations will be provided. The exchanges at OCC/Depot can be of larger sizes as per the actual number of users. The Exchanges will serve the subscribers at all the stations and OCC. The exchanges will be interconnected at the channel level on optical backbone. The exchanges shall be software partitioned for EPABX and Direct Line Communication from which the phones shall be extended to the stations. Alternatively only for non-operational (other than Direct Line Communication) a separate IP Based Phone System can be implemented.
(c) **GSM-R network**

GSM – R system will cater to voice (in moving train as well as to maintenance mobile staff) and data communication for various purposes.

(d) **Passenger Announcement System**

The system shall be capable of announcements from the local station as well as from OCC. Announcements from Station level will have over-riding priority in case of emergency announcements. The System shall be linked to Signalling System for automatic train actuated announcements.

(e) **Passenger Information Display System**

These shall be located at convenient locations at all stations to provide bilingual visual indication of the status of the running trains and will typically indicate information such as destination, arrival/departure time, and also special messages in emergencies. The boards shall be provided at all platforms and concourses of all stations. The System shall be integrated with the PA System and available from same MMI.

(f) **Centralized Clock System**

This will ensure an accurate display of time through a synchronization system of slave clocks driven from a Master Clock fed from a GPS equipment at the operation control center. The Master Clock signal shall also be required for synchronization of FOTS, Exchanges, Radio, Signaling, etc. The System will ensure identical display of time at all locations. Clocks are to be provided at platforms, concourse, Station Master's Room, Depots and other service establishments etc.

(g) **Closed Circuit Television (CCTV) System**

The CCTV system shall provide video surveillance and recording function for the operations to monitor each station. The monitoring shall be possible both locally at each station and remotely from the OCC.

The CCTV system backbone shall be based on IP technology and shall consist of a mix of Fixed Cameras and Pan/Tilt/Zoom (PTZ) Cameras. Cameras shall be located at areas where monitoring for security, safety and crowd control purpose is necessary.
(h) Network Monitoring and Management

For efficient and cost effective maintenance of the entire communication network, it is proposed to provide a network management system (NMS), which will help in diagnosing faults immediately from a central location and attending the same with least possible delay, thus increasing the operational efficiency and reduction in manpower requirement for maintenance. The proposed NMS system will be covering radio communication, Optical Fiber Transmission, Telephone Exchange and summary alarms of PA/PIDS, CCTV and Clock System.

(i) Technology

The Technologies proposed to be adopted for telecommunication systems are shown in Table 9.1:

<table>
<thead>
<tr>
<th>System</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Media</td>
<td>Optical Fibre system as the main bearer for bulk of the telecommunication network</td>
</tr>
<tr>
<td>Telephone Exchange</td>
<td>EPABX of minimum 30 ports is to be provided at all Stations, an Exchange of 60 Ports to be provided at Terminal Station</td>
</tr>
<tr>
<td>Train Radio System</td>
<td>Digital Train radio (GSM-R) communication between motorman of moving cars, stations, maintenance personnel and central control.</td>
</tr>
<tr>
<td>Train Destination Indicator System</td>
<td>LED/LCD based boards with adequate visibility to be provided at convenient location at all stations to provide bilingual visual indication of the status of the running trains, and also special messages in emergencies.</td>
</tr>
<tr>
<td>Centralized clock system</td>
<td>Accurate display of time through a synchronisation system of slave clocks driven from a master clock at the OCC and sub – master clock in station. This shall also be used for synchronisation other systems.</td>
</tr>
<tr>
<td>Passenger Announcement System</td>
<td>Passenger Announcement System covering all platform and concourse areas with local as well as Central Announcement.</td>
</tr>
<tr>
<td>System</td>
<td>Standards</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Redundancy (Major System)</td>
<td>Redundancy on Radio’s in the Base Stations,</td>
</tr>
<tr>
<td></td>
<td>Path Redundancy for Optical Fibre Cable by provisioning in ring configuration.</td>
</tr>
<tr>
<td>Environmental Conditions</td>
<td>All equipment rooms to be air-conditioned.</td>
</tr>
<tr>
<td>Maintenance Philosophy</td>
<td>System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure.</td>
</tr>
<tr>
<td></td>
<td>Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and co-ordination.</td>
</tr>
<tr>
<td></td>
<td>Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacture’s premises.</td>
</tr>
</tbody>
</table>

- **Requirement for Telecom Installations**

  Adequate space for proper installations of all Telecommunication equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for Telecom equipment shall be generally 25 sq.m for Telecom Room. UPS will be common for signal, telecom and AFC. These areas shall also cater to local storage and space for maintenance personnel to work. At the OCC, the areas required shall be as per the final configuration of the equipment and network configuration keeping space for further expansion.

- **Maintenance Philosophy for Telecom systems**

  The philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling and telecommunication equipments shall be followed. Card / module / sub-system level replacement shall be done in the field. Maintenance personnel shall be suitably placed at intervals and they shall be trained in multidisciplinary skills. Each team shall be equipped with a fully equipped transport vehicle for effectively carrying out the maintenance from station to station.
The defective card/ module / sub-system taken out from the section shall be sent for diagnostic and repair to a centralized S&T repair lab suitably located on the section. This lab will be equipped with appropriate diagnostic and test equipments to rectify the faults and undertake minor repairs. Cards / modules / equipment requiring major repairs as specified in suppliers documents shall be sent to manufacturer's workshop.

9.19 AUTOMATIC FARE COLLECTION

9.19.1 INTRODUCTION

High Speed Rail Systems is expected to handle large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate and maintain, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. In view of above, computer based automatic fare collection system is proposed.

For Multiple Journey, the Store Value Contactless Smart Card can be utilized and for the Single Journey, Smart Contactless Token can be utilised.

AFC system proves to be cheaper than semi-automatic (manual system) in long run due to reduced manpower cost for ticketing staff, reduced maintenance in comparison to paper ticket machines, overall less cost of recyclable tickets (Smart Card/Token) in comparison to paper tickets and prevention of leakage of revenue. Relative advantages of automatic fare collection system over manual system are as follows:

A) Manual fare collection systems have the following inherent disadvantages:
1. Large number of staff is required for issue and checking of tickets.
2. Change of fare structure is time consuming as has to be done at each station.
3. Manipulation possible by jamming of mechanical parts.
4. Staff and passenger interaction leading to more chances of confrontation.
5. Almost 100% ticket checking at entry / exit impossible.

B) Automatic fare collection systems have the following advantages:
1. Less number of staff required.
2. Less possibility of leakage of revenue due to automatic ticket check by control gates.
3. Recycling of ticket fraudulently by staff avoided.
4. Efficient and easy to operate, faster evacuation both in normal and emergency.
5. System is amenable for quick fare changes.
6. Management information reports generation easy.
7. System has multi-operator capabilities. Same Smart Card can be used for other applications also, including in other lines of the Metro.

A. AFC systems are the worldwide accepted systems for LRT/Metro environment.

The proposed ticketing system shall be same as that to be of Contactless Smart Card type for multiple journey and Contactless Token for Single Journey. The equipment for the same shall be provided at each station Counter/Booking office and at convenient locations and will be connected to a local area network with a computer in the Station Master's room.

C) **Choice of Control Gates**
Retractable Flap Type/Paddle Type Control Gates are proposed which offer high throughput, require less maintenance and are latest in modern metros internationally. Tripod turnstile type gates offer less throughput and require more maintenance.

D) **Passenger Operated Machine**
At all stations, two Passenger Operated Machines (Automatic Ticket Vending Machines) each are proposed. The POM’s will provide convenience to passengers to avoid standing in queues at ticket booths and provide them international standard service.

Technology

The technology proposed for AFC systems are given in Table 9.2:

**TABLE 9.2**

<table>
<thead>
<tr>
<th>Standards</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fare media</td>
<td>a) Contactless smart card – For multiple journeys.</td>
</tr>
<tr>
<td></td>
<td>b) Single Journey : Same as being adopted for other Metro Line (East – West Corridor).</td>
</tr>
<tr>
<td>Standards</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Gates</strong></td>
<td>Computer controlled retractable flap type automatic gates at entry and exit. There will be following types of gates:</td>
</tr>
<tr>
<td></td>
<td>• Entry</td>
</tr>
<tr>
<td></td>
<td>• Exit</td>
</tr>
<tr>
<td></td>
<td>• Reversible (if required as per final station layout) – can be set to entry or exit</td>
</tr>
<tr>
<td></td>
<td>• Reversible Handicapped Gate - gate for disabled people.</td>
</tr>
<tr>
<td><strong>Station computer, Central computer and AFC Network</strong></td>
<td>All the fare collection equipment shall be connected in a local area network with a station server controlling the activities of all the machines. These station servers will be linked to the central computer situated in the operational control centre through the optic fibre communication channels. The centralised control of the system shall provide real time data of earnings, passenger flow analysis, blacklisting of specified cards etc.</td>
</tr>
<tr>
<td><strong>Ticket office machine (TOM/EFO)</strong></td>
<td>Manned Ticket office machine shall be installed in the stations for selling tickets to the passengers. Also POM’s shall be provided for Automatic Ticket Vending.</td>
</tr>
<tr>
<td><strong>Ticket reader and portable ticket decoder.</strong></td>
<td>Ticket reader shall be installed near EFO for passengers to check information stored in the ticket.</td>
</tr>
<tr>
<td><strong>UPS (uninterrupted power at stations as well as for OCC)</strong></td>
<td>Common UPS of S&amp;T system will be utilized.</td>
</tr>
</tbody>
</table>
Entry/Exit Gates
9.20 **The Technology for Ticket sale for High Speed Rail in Other countries**

Rail transportation requires Automatic Fare Collection (AFC) system to charge passengers for the transport service. Between all the systems around the world, there are principally two systems. The two most popular ticketing systems are:

- Paper tickets and open area in the rail station
- Mixed tickets (magnetic ticket and contactless card) and close area in the rail station

We can find the first one principally in Europe and the second one in Asia.

That is the two parts of the world where high speed lines are the most experienced.

This document is intended to provide a view of AFC systems dedicated to high speed lines. It will present:

- Two different ticketing systems existing in the world.
- The functionalities expected from the ticketing.
- What is important in ticketing today?

**Existing Systems.**

Here the AFC systems existing around the world is described. The examples highlighted herein present the ticketing systems in France and Japan by functionalities:

- Tickets media
- Sale
- Validation
- Control

**France**

**Tickets media**

France uses actually one ticket media for the high speed train, the paper ticket. The dimension is: 20.3 cm x 8.2 cm. This ticket contains the travel information

**Sale**

In France the train ticket can be bought:

- At a ticket counter in the rail station
- At a ticket distributor in the rail station.
- In a rail company shop
- On Internet.

The ticket counters and the company shop are equipped with Post Of Sale (POS)
All the sale systems need a connection with the booking system to attribute and book the place.

For the Internet system the customer chooses how to get this ticket. He can get it by mail or in a ticket distributor in a rail station. Recently the rail operator offers at the customer to print his ticket himself but not for every train at the moment.

Validation
The French rail stations are all open area. The customer must validate his ticket before boarding. There are many validators principally close to the platforms.

The validators print on the ticket the station’s name, the date and the time plus mark a triangle shape in relief and it is not possible to validate a second time.

Control
The control is done on board the train. The controllers do a visual check of the ticket and use a Personal Digital Assistant (PDA) with a dedicated application to register the potential violation.

Japan

Ticket Media.
Japan uses two tickets media for the high speed train, the magnetic ticket and the contactless card.

The dimensions of the magnetic ticket are: 8.5 cm x 5.75 cm. This ticket contains the travel informations:

The cards incorporate contactless Radio Frequency Identification (RFID) technology developed by Sony, called FeliCa. These cards are available at card vending machines at the train stations that allow these ones.

These cards are prepared, the user recharge with a value.

This card is interoperable with other transit systems (metro, bus) in Japan.

Sale
In Japan the train ticket can be bought:

- At a ticket counters in the rail station.
- At a ticket distributor in the rail station.
- On Internet.

The ticket counters are equipped with Post of Sale (POS).

All the sale systems need a connection with the booking system to attribute and book the place.

The contactless card can be recharged:
● At a counter in the rail station.
● In a distributor in the rail station.

**Validation**

The rail stations are closed areas, the customer uses the ticket or the smart card to pass the entrance gates to go in and out.

For the magnetic ticket, the validator checks if it is the right station.

For the smart card, the validator records the departure station in the card and the minimum fare is collected. At the destination station, the validator calculates the amount and collects the complement if necessary.

**Control**

The control is done on board the train. The controllers do a visual check of the ticket and use a Personal Digital Assistant (PDA) with a dedicated application to register the potential violation.

The PDA includes a card reader to check the smart card.