3. SYSTEM DESIGN

3.1 INTRODUCTION

MRVC vide their letter No. MRVC/W/184 (FC & VR-DW-PNVL) Dt. 28.02.2012 has appointed M/s RITES Ltd., as consultants for Consultancy services for carrying out Techno-Economic Survey and Preparation of Detailed Project Report for

i) New Sub-urban corridor on Virar – Vasai Road – Diva – Panvel section &
ii) Fast corridor on CSTM - PNVL Harbour line on Central Railway, Mumbai.

This Report covers the System Selection & System Design Criteria for the proposed new suburban corridor on Virar – Panvel section of Central Railway, Mumbai.

3.2 OBJECTIVE

The system Selection is a most important factor and the based on the certain parameters like:

- Operational philosophy
- Traffic demand on the corridor
- Designed headway & operating frequency
- Safety of the System & passengers
- Passenger amenities,
- Availability of power supply
- Ease of maintenance and
- Cost of the system.

Considering all the above factors the System for Proposed Virar-PNVL suburban corridor is so designed to meet the all operational& technical requirements. The proposed system for the said corridor is presented in this report.

3.3 TRACTION SYSTEM

Traditionally, electric traction is used in suburban systems as a prerequisite for requirement of high acceleration and pollution-free services in urban areas. There are three standard and proven systems of electric traction for use in suburban and metro lines, viz., 750V dc third rail, 1500V dc overhead catenary and 25kV ac overhead catenary system. Presently, all these three systems are in use in India (750 V dc third rail in Kolkata Metro, 1500V dc catenary in Mumbai suburban of Central &

Western Railways and 25kV ac catenary in Delhi Metro & Indian Railways). 1500 V dc system presently operational in few suburban sections of Central Railways will be converted to 25kV ac soon to meet increased traffic demand. Western Railways have already switched to 25 KV AC traction systems.

Proposed corridor is to run in parallel to the existing corridor used mainly for mail/express and freight train operations in addition to skeleton services of MEMO and DEMU to cater for the daily commuters of this area. As the proposed corridor will be integrated with existing corridor therefore; there is no choice for consideration of any alternate mode of traction. Proposed corridor will have 25 kV single-phase AC Traction similar to existing system. The overhead traction lines will be flexible copper overhead catenary system (OCS). Further details of the traction system are given in Power Supply Section of this report.

3.4 SIGNALLING AND TRAIN CONTROL SYSTEM

The signalling system will provide the means for an efficient train control, ensuring safety in train movements. It assists in optimization of rail infrastructure investment and running of an efficient train services on the network.

The adopted Train control & signalling system shall be for efficient, safe and quicker train movements. The proposed signalling system for Virar- Panvel suburban corridors hall be capable of supporting 12 car length trains and flexible enough to accommodate the up-gradation in phased manner to achieve optimum train operation.

The communication system shall be provided for monitoring train operation, and provides relevant train running information to passengers and meeting the operational and administrative requirements of railway network.

3.4.1 DESIGN CRITERIA

The signalling system designs are based with following criteria:

I. Signalling and Train Control systems shall be designed with fail-safe principles.
II. Safety critical systems shall be engineered for a Safety Integrity Level 4 (SIL 4)
III. The system is designed for the Train headway of 03 minutes in the year 2041.
IV. The Signalling shall be automatic signalling.
V. No trackside equipment (e.g. loop cables, beacons, etc) should affect passenger evacuation and maintenance activities. In addition, it shall not impose the tripping hazard to both passengers and maintenance staff.

VI. All Vehicle Position Detection devices (e.g. AFTC / HFTC /Digital axle counter) shall be AC-Immunized and shall not be interfered by other railway systems.

VII. All Signalling operations will be with a power backup of 4 hour and diesel generator/ solar power for operations during long power cuts.

VIII. The probability of a wrong side failure shall be equal to or less than 10-9 per train operating hour for the whole of the Signalling and Train Control system supplied.

IX. The design life of all the electronic equipment and associated wayside equipment shall be 20 years and 30 years respectively.

X. The Signalling systems shall be compatible with 25KV, 50 HZ AC traction.

XI. Power supply for signalling systems will be available continuously with back up of generators to ensure train running even during long power cuts.

XII. Remote operations of Signals/ points from control centre are possible for any station and especially crossing stations.

3.4.2 SELECTION OF SIGNALLING & TRAIN CONTROL SYSTEM

The Signalling system shall be designed to meet passenger traffic requirement and it can satisfactorily be managed by operating 12 cars EMU Train services at an interval of 3 minutes (headway) to meet the increased traffic demand in the course of time i.e. in year 2041.

I. The Signalling and Train Control system shall be of following types:

II. Interlocking: Electronic Interlocking

III. Point Operation: Electrical

IV. System of working – Automatic block Signalling

V. Signals: Multiple aspect colour light signals (MACLS)

VI. Signal lighting: LED

VII. Operation: Train Management System

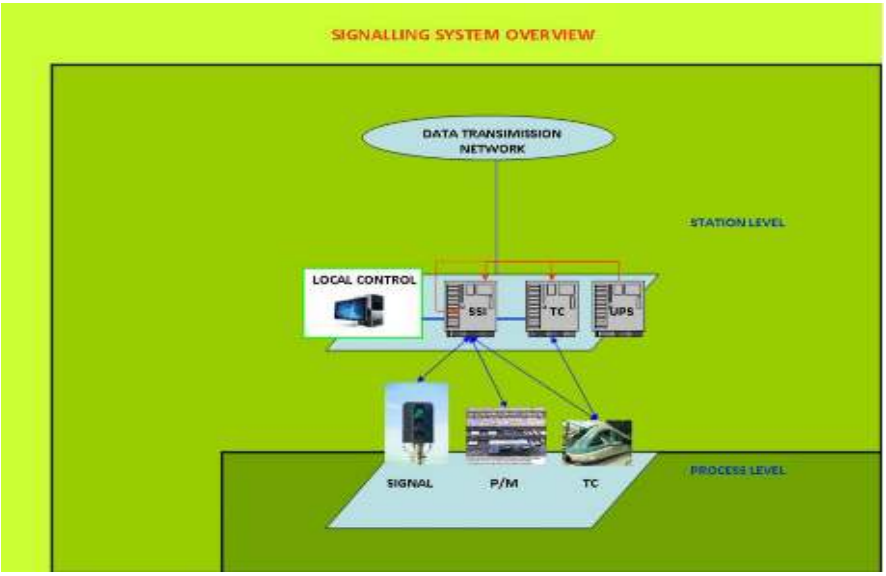
VIII. Track vacancy detection: AFTC / HFTC/ Digital Axle counter.

IX. Design Suitable for 25 KV AC traction systems

X. Isolation : Standard III isolation will be provided at all running yards,

XI. Safety Standard : Safety Integrity Level 4 CENELEC (SIL 4),

Fig : 1 Signalling System Overview



- Stations provided with points and crossings will have a Computer based Electronic (Solid State) Interlocking arrangement for operation of points / crossings & setting of routes.
- Facilities for setting of the route and clearing of the signals will be provided from SSI located at stations with points and crossings.
- Presence of Train on the track will be detected with the help of track Circuits (AFTC)/ Digital Axle Counters (DAC) with Double detection system.
- All Signals working in automatic mode will be equipped with Auxiliary Warning System.
- The Signalling and Train Control system and its Sub-system/Components will conform to international standards like CENELEC, IEC, BS, IS, ITU-T, IRS etc:
- The new Suburban corridor in junction with existing lines shall form an integrated system to provide smooth, uninterrupted traffic flow. It is presumed that by the time the proposed corridor becomes functional, this would have been equipped with Automatic Signalling.
- This will enable running of optimum train services, meeting traffic requirements in the most efficient and cost effective way.

3.4.3 SAFETY STANDARDS

Signalling and Train Control systems shall be designed with fail-safe principles. Safety critical systems shall be engineered for a Safety Integrity Level 4 CENELEC (SIL 4), as defined in IEC 61508 Standard. An alternative of other National or International Standard or equivalent standards will also be accepted but subject to the review and acceptance of Railway Board /MRVC.

3.4.4 ELECTRONIC INTERLOCKING SYSTEM

At all stations with points and crossings, Electronic Interlocking (EI) 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 .

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 based on fail-safe principle.

The equipment will withstand tough environmental conditions encountered in a Mass Transit System. Control functions in external circuits will be provided 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.

- The electronic interlocking proposed will be processor based interlocking with 2 out of 3 systems and with hot standby at all major yards, for other stations and crossing stations 2 out of 3 systems with warm standby will be provided.
- SIL4 level of CENELEC standards will be provided.
- EI shall have user-friendly graphic based design tool to generate station specific application software to carry out future yard modifications. For all vital inputs/ outputs, double cutting arrangement shall be provided. Both hardware & software of EI must meet SIL-4 as defined in CENELEC Standards.
- The EI system software as well as warm/hot standby changeover software should have been independently verified and validated including its offered configuration by third party. Railway shall verify application software pertaining to yard data.
- The audio-visual alarm shall be available for Approach locking, Button stacking etc. in EI.

- The equipment will withstand tough environmental conditions encountered in railway system. Control functions in external circuits will be provided 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.
- Hardware and Software requirements
- Both hardware & software of EI must meet SIL-4 as defined in CENELEC Standards. The standards of interlocking are conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
- The EI system software as well as warm/hot standby changeover software should have been independently verified and validated including its offered configuration by third party.

3.4.5 ELECTRIC POINT OPERATION

The method of operating of points in electronic interlocking territory will be of electrical. For each & every point on the proposed Virar-Panvel suburban corridor an electrical point machine will be provided. In the designed signalling system, the point machines will be operated electrically either by individual operation or when a route is set/ Signal is cleared.

Fig: 2 Point Machine

3.4.6 TRAIN VACANCY DETECTION SYSTEM

Joint Less Coded Audio Frequency Track Circuit will be provided for train detection on main line on the proposed Virar-Panvel suburban corridor. Digital Axle counter will be used as Train Vacancy detection system in Yards/ Depot.

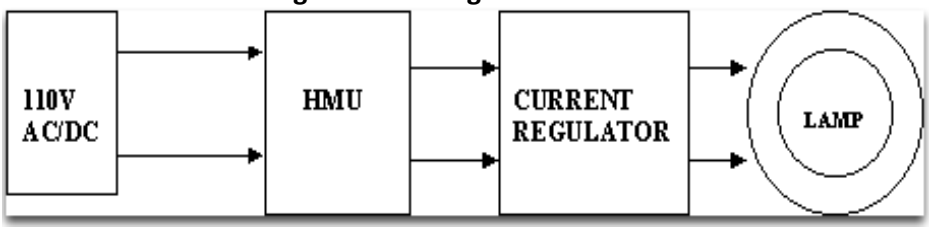
3.4.7 SIGNAL ASPECT

Multiple Aspect (3/4 Aspect) Colur Light LED Signals are proposed with automatic signalling.

The advantages of multiple aspect colour light signalling over semaphore signals are well known. In multiple aspect colour light signalling installations, each signal is pre-warned and its aspect is conveyed at signal in rear. This enhances safety and boosts confidence of the driver. Colour light signalling improves night visibility of signals and improves line capacity of a section.

Signal lighting arrangement shall be LED type high visibility and high performance lamps. The reliability of LED traffic lights is far superior to conventional lamp. In addition, the power usage is far lower than a conventional, thus resulting in reduction in electricity consumption. The bright LED light also improves the visibility of the signals. This technology virtually eliminates the dreaded phantom light (sunlight from a low sun reflected by the signal head). LED signal shall be as per CENEL SIL 4 standards and approved by RDSO or equivalent railway approving agency.

Fig : 3 Block Diagram of LED

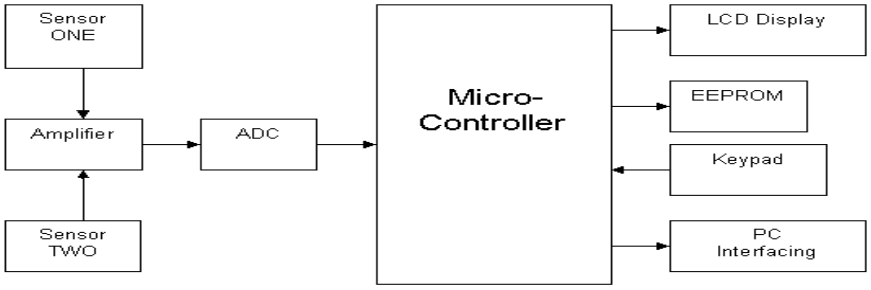


3.4.8 EVENT LOGGER /DATA LOGGER

An Event logger is an electronic device that records data over time or in relation to location either with a built in instrument or sensor or via external instrument and sensors. There would be data logging equipment for signal equipment, which will record information on the functioning of the signal and send it to a computer at a central point (Operation Control Centre)

where reports can be generated and alarms raised for various kinds of malfunctions (power failure, signal passed at danger, train entering without line clear, signal lamp failure, loose packing of points, etc.). The proposed data logger system will monitor all the signal equipments, track circuits and signal power supplies. Data Logger will have 128/256/512 digital and 16 analog inputs monitoring power supply

Fig : 4 Block Diagram of Event Logger System



3.4.9 POWER SUPPLY

Signalling systems will get primary power from Traction substations supply as that is the most reliable power supply available. There would be fallback arraignment from local power supply that will be switched over to in case of failure of Traction substation power supply. In the event both the power supplies fails, power would be sourced from the diesel generator input where diesel generator needs to be started. An uninterrupted power supply arrangement with battery backup (for power storage) up to 4 hrs will be provided at each station.

The uninterrupted power supply (UPS) of suitable KVA, 415 V ± 1%, 3 phases with Battery bank of suitable AH capacity at each interlock station and suitable KVA with Battery bank of suitable AH capacity at each non interlock station will be provided for hour back up. UPS systems of proven technology shall be provided at all Stations, and the Depot to supply systems. This UPS may be modular and redundant, online type (i.e. output power shall be taken from the batteries at all times other than when a bypass is in operation.

3.4.10 STANDARDS

Subject	Organization	Standard
Electro-magnetic compatibility	EEC	89/336/EEC
Electro-magnetic compatibility	CENELEC	EN 50081-2, EN50121-1, EN50121-2, EN50121-3 EN 50121-4, EN50123 IEC 61000-1, IEC 61000-2 IEC 61000-3, IEC 61000-4 IEC 61000-5
Conducted immunity level	CENELEC	EN 50082-2
Electrostatic discharge (ESD)	IEC	IEC 61000-4-2
Fast transient burst	IEC	IEC 61000-4-4
Point machines	IR	IRS: S24
Electronic Interlocking	IR	IRS:S36
Electric Signalling & Interlocking Equipment	IR	IRS:S23
Lightening and Surge Protection	IEC	IEC 60364, 61643, 62305
Power surge	IEC	IEC 61000-4-5
Safety and Reliability Requirement of Electronic Signalling Equipment	IR CENELEC	RDSO/SPN/144 EN 50126 EN50128,EN50129
Software	CENELEC	EN 50128/EN50126 EN50129 EN50159-1 &2
Signalling / Train Control System	IEC	IEC 60529 Ed. 2.0 b
Functional Requirement Specification for ETCS(European Train Control System)	ETCS	A200 FRS
Environmental Requirement specification for ETCS(European Train Control System)	ETCS env	A200/FRSenv
Environmental standard for trackside equipment and external train borne equipment	IEC	IP code 67
Environmental standard for equipment in the	IEC	IP code 52

Signal equipment Room and internal train borne equipment		
Electronic equipment used on Railway Vehicles.	IEC CENELEC	IEC 571 EN50155
Prevention of inadvertent ignition of flammable atmospheres by radio frequency radiation	BS	BS 6656
Train borne equipment	IS	IS 9000
Trackside equipment	IS	IS 9000
Installation work and line side assets Network Rail (formerly Rail track) GS/IH0001 or equivalent Standard CD ROM format	ISO	ISO 9660
Network time protocol	Network Working Group	RFC 1305
Cable standard and cable installation standard	BS IEC	BS 6360 IEC 287 IEC 364-5-523
Cable standard	IRS	S-35/93 S63/89 Amendment-5; or latest TC30/05
Installation of Communication Networks in Industrial Premises	IEC	IEC-61918
Installation of Field	Buses IEC	IEC-61784-5-3
Terminal Blocks / Connectors and Testing of Terminal Blocks / Connectors	IEC	IEC 60947 & other Applicable IEC standards

3.5 TELECOMMUNICATION SYSTEM

The purpose of Telecommunication System is to serve the Operative and Administrative communication requirement of Railway Organization. Telecommunication System also acts as a backbone for Railway signalling System.

3.5.1 INTRODUCTION

The telecommunication facilities proposed are helpful in meeting the requirements for:

I. Supplementing the Signalling system for efficient train operation.

II. Exchange of managerial information

III. Crisis management during emergencies

IV. Passenger Information System

3.5.2 SELECTION OF 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
- Passenger Announcement System within the station and from Central Control to each station or station itself. .
- Centralized synchronous Clock System
- Passenger Display Information
- Data Channels for Signalling, SCADA for Traction & non Traction supply System etc

Telecommunication Requirements and the proposed solutions

Telecommunication Requirements	**Telecommunication System**
Traffic Control Communication	Optical Fiber Communication system / Quad copper cable System
Emergency Control Communication	Optical Fiber Communication system and Quad copper cable System
Administrative voice and data communication	Optical Fiber Communication system/Digital Microwave System
Operational voice and data communication	Optical Fiber Communication system / Quad copper cable System
Interactive Voice Response System- IVRS	Computer Network based System
Pre recorded Announcements	Computer Network based System
Coach Guidance system	Local / Centralized Computer based System
Public Announcement and Clocks	Local / Centralized Computer based Master-Slave GPRS Clock System
Telephone Exchange System	TDMA, PBX Exchange System / Centralized IP based New Generation Exchange System
Passenger Reservation System	TDMA Circuit switched / IP based Packet switching computer network
Surveillance of fixed and movable assets	Close circuit TV and SCADA
Yard communication in big Marshaling yards	Paging Talkback System / Voice Group call

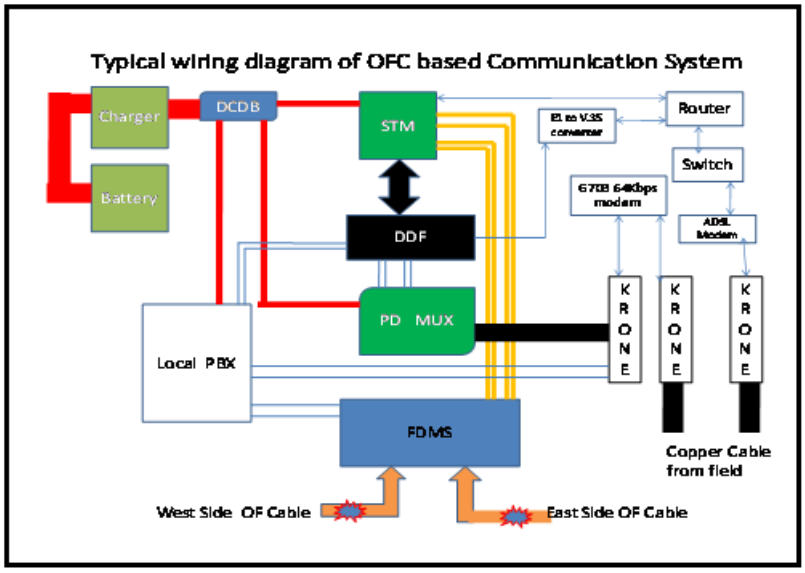
3.5.3 OPTICAL FIBER CABLE- MAIN TELECOMMUNICATION BEARER

The main bearer of the bulk of the telecommunication network is proposed with optical fiber cable system. Considering the channel requirement and keeping in view the future expansion requirements 24 fibre, Optical Fiber Cable is proposed to be laid in ring configuration with path diversity. This medium shall be utilized to carry video/audio signals and SCADA related information.

Apart from meeting required optical characteristics, it will be low smoke/ low halogen type optical fibre cable for underground applications. OFC shall be laid on either side of the tracks to ensure path diversity for improved reliability.

SDH STM-4 based system will be adopted with SDH nodes at every station and depot. Access at 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 will be provided for LAN network at station for system/subsystems.

Fig : 5 Optical Fibre System



3.5.4 TELEPHONE EXCHANGE SYSTEM

A cost effective solution a small EPABX of at least 40 ports upgrade able up to 96 ports will be provided at each station and at the major stations including Virar, Vasai, Diva & panvel and depot 256 port exchanges upgrade able up to 512 will be provided. The Exchanges will serve the subscribers at all the stations, and depot. The exchanges will be interconnected at multiple 2 MB levels through redundant optical fiber cable paths. The Exchanges will be software partitioned for EPABX and Direct Line Communication from which the phones will be extended to the stations.

3.5.5 PUBLIC ADDRESS SYSTEM

The public Address System shall be capable of digitized voice announcements and will generally operate in automatic mode providing information of time and destination of the next schedule train, special upcoming event, safety and security announcement at pre determined intervals and general information to enhance the travel experience for all users. There will be over ridding facility for manual announcement in case of an emergency.

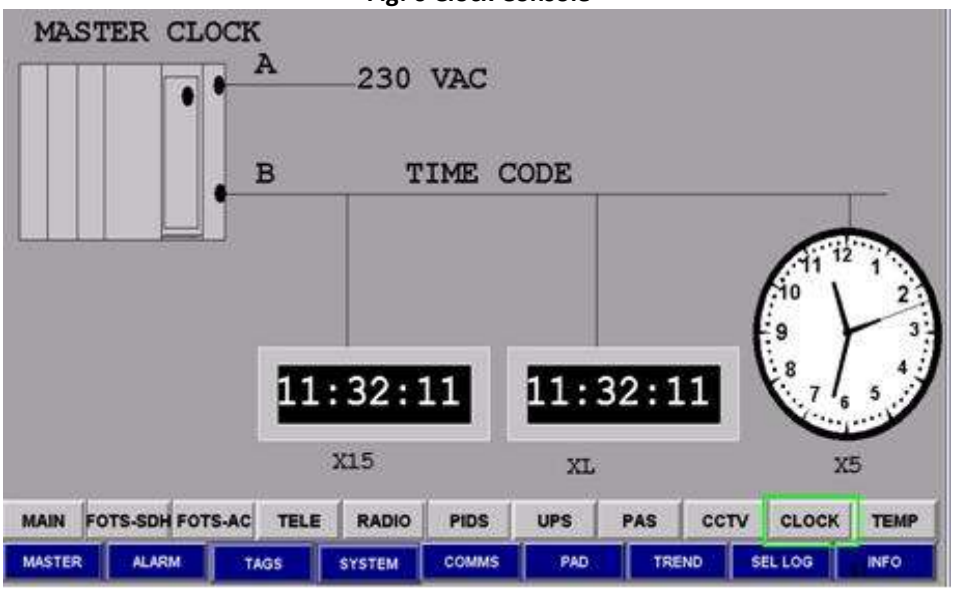
3.5.6 CLOCK SYSTEM

The Clock System shall provide synchronized time for the whole Rail system. The time source shall be the Global Positioning System (GPS).

The synchronized time information shall be displayed on slave clock units and provided to other interfacing systems via the Data Transmission System.

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

Fig: 6 Clock Console



The free run accuracy of the master clock units shall never be more than 30 milliseconds different from the GPS reference. Network time synchronization over the data network shall be using NTP, with an accuracy of ±0.1s per 24 hours to the reference. The system shall have a minimum accuracy of 1 second a day when they do not receive signals from the master clock.

3.5.7 PASSANGER INFORMATION DISPLAY

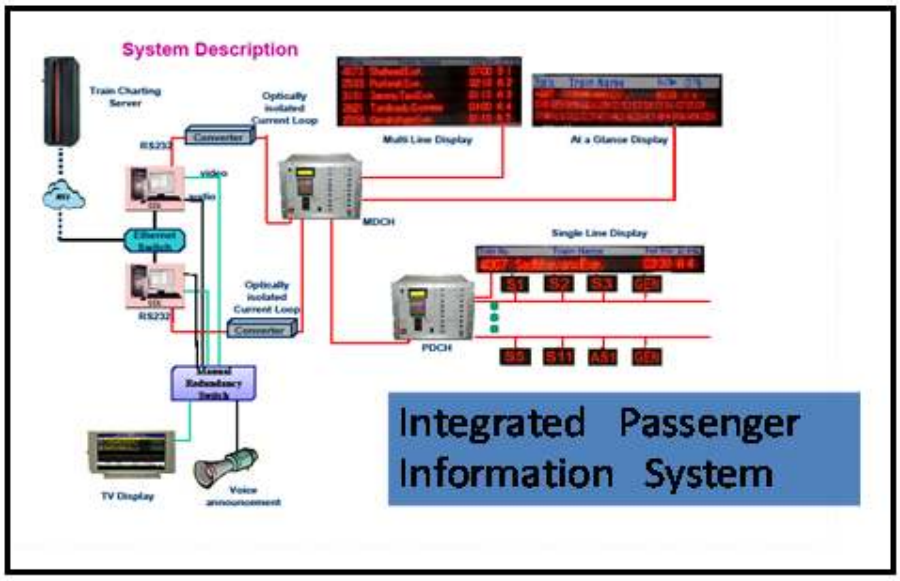
On board Passenger Information Display screens (Flat Panel Displays) shall be fitted to provide passenger information on train movements and next train indication. They shall be full colour display capable of showing graphics and video. The display shall show information to match automated audio announcements. A link to the fire safety system to provide evacuation information shall be provided.

3.5.8 PASSANGER INFORMATION SYSTEM

At all stations, suitable Electronic Passenger Information Display Boards (Flat Panel) will be provided. The PIS will be of train actuated along with facility for manual inputs from the local station.

Passenger Information display boards will be provided at convenient locations at all stations to provide trilingual visual indication of the status of the running trains and will typically indicate information such as destination, platform numbers, arrival/departure time, and also special messages in emergencies. The boards will be provided at all platforms and concourses of terminal & junction stations.

Fig:7 Passenger Information Display System



It is envisaged that Public Address and Passenger Information Display System is provided in the car so that passengers are continuously advised of the next stoppage station, final destination station, interchange station, emergency situations if any, and other messages. The rolling stock is provided with Talk Back Units inside the cars, which permit conversation between passengers and the drivers in case of any emergency.

3.5.9 SPACE REQUIREMENT FOR S&T INSTALLATIONS

Adequate space for proper installation of all Signalling and Telecommunication equipment at each of the stations should be provided keeping in view the maintenance and use of instrumentation set up for regular testing. The areas without infringement by air conditioner required at each of the stations for S & T equipment will be generally 60 sq.m each for Telecomm Room, 60 sq.m for UPS Room and 55-60 sq.m for Signalling equipment room at interlock stations & 30 sq.m at non interlock stations. This area will also cater to local storage and space for maintenance personnel to work.

At the Depot, the areas required will be as per the final configuration of the equipments and network configuration keeping space for further expansion. For laying the S&T cable along with track a viaduct size 500X250 mm to be provided at opposite side of power cable and 200X250 mm each side along the track for optic fiber cable and connectivity from viaduct to equipment room to be provided.

3.5.10 STANDARDS FOR TELECOMMUNICATION

Description	Standards
Transmission System	SDH/GE (Giga Ethernet) based for the entire telecom network. OFC backbone network shall be formed by laying two outdoor single mode optical fiber cables (to be laid on either side of tracks). The normal and protected routes shall arrange in two different cables for path diversity.
Optical Fiber cable	OFC for underground environment shall be steel armoured and manufactured from Fire Retardant/resistance, Low Smoke and zero halogen materials. For elevated portion of corridor, it shall be steel armoured and conforming to IRS specifications.
Telephone Exchange	IP based Electronic Exchange
UPS	415 V ± 1%, 3- phase Conforming to international standards. Rated for continuous operation System availability > 99.9% Reliability shall be > 99.9%.
Passenger Display Information System	It shall be interfaced with signalling system for online update of train information. IEC as applicable or any equivalent international/National standard.
Synchronised Clock system	GPS based, master – slave system IEC 61588 or equivalent standard
Public Address System	Passenger Announcement System shall be interfaced with signalling system for online update of train information. IEC 60268 as applicable or any equivalent international/National standard. The characteristics to be specified and the methods of measurement for the equipment shall be in accordance with IEC 268 Part 1 to 17 – Sound

	System Equipment. Fire resistant Low Smoke Zero Halogen cables shall be used to maintain the circuit integrity in case of fire.
CCTV/ Camera	¼" CCD Camera progressive Scan of International Standards like EN/FCC/UL/CE CCTV network shall be as per IEEE standards. Approval: EN/FCC/UL/CE
Compression techniques	H.264, MPEG4 or similar
Minimum illumination	For Colour 0.5 LUX For B/W 0.008 LUX
Redundancy (Major System)	Redundancy on Radio base station equipment.
Environmental Conditions	All equipment rooms to be air-conditioned
Maintenance Philosophy	System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and coordination. Card/module level replacement will be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

3.6 ROLLING STOCK

Rolling Stock proposed for Panvel-VIRAR suburban corridor shall be Broad Gauge, 100 Kmph maximum speed, Stainless steel body, Automatic Voice Announcement System, well ventilated etc. The broad features of Rolling Stock, which may be followed for this corridor, are presented in Table below; the basis of which is given in the following paragraphs.

Table 3.1: Broad Features of Rolling Stock

S. No.	Parameter	Details
1	Basic Unit	One Motor coach (MC) and one Trailer coach (TC) and one driving coach (DC).
	12-Car Train	DC-MC-TC-TC-MC-TC-TC-MC-TC-TC-MC-DC

	Composition	
2	Coach construction	Light weight stainless steel body
3	Tare Weight	DC (32.0 T), TC (32.0 T), MC (52.0 T)
4	Axle load	20.5 T
5	Propulsion system	3 phase drive system with VVVF control
6	Type of traction supply	25KV AC Overhead collection
7	Passenger Loading (SDCL)	DC (28.0 T), TC (34.0 T), MC (27.0 T) Loading Equivalent to 16 standing passenger /m2

3.6.1 OPTIMIZATION OF COACH SIZE

Considering the clearances and also the space required for service and cables etc., the coach with following principal dimensions has been prescribed.

Table 3.2: Size of the Coach

Car	Length	Width at Door	Height
Driving Trailer Coach (DC)	21.0 m	3.66 m	4.2 m*
Trailer/Motor Coach (TC/MC)	21.0 m	3.66 m	4.0 m

* Height over panto in down condition

3.6.2 COACH DESIGN AND BASIC PARAMETERS

The important criteria for selection of rolling stock are as under:

i. Proven equipment with high reliability
ii. Passenger safety feature
iii. Energy efficiency
iv. Light weight equipment and coach body
v. Optimized scheduled speed
vi. Aesthetically pleasing Interior and Exterior
vii. Low Life cycle cost
viii. Flexibility to meet increase in traffic demand

3.6.3 SPEED /ACCELERATION / DECELERATION

The equipment shall be designed for following operational parameters at maximum gross weight (SDCL).

i. Max. operating speed : 100 kmph

ii. Max Test Speed: 110 kmph

iii. Starting Acceleration (zero to 40 kmph) : 0.54 m/s2

iv. Deceleration Average from booked to 50 kmph : 0.76 m/s2

v. Average from 50 kmph to standstill : 0.86 m/s2

3.6.4 SELECTION OF TECHNOLOGY

i) Low life cycle cost

The low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems. It is possible to achieve these objectives by adopting suitable proven technologies. The selection of following Technologies has been adopted to ensure low life cycle cost.

ii) Car body

In the past carbon high tensile steel was invariably used for car bodies. In-fact almost all the coaches built by Indian Railways are of this type. These steel bodied coaches need frequent painting and corrosion repairs, which may have to be carried out up to 4-5 times during the service life of these coaches. It is now standard practice to adopt stainless steel or aluminum. The car body with aluminum requires long and complex extruded sections, which are still not manufactured in India. Therefore aluminum car body has not been considered for use. Stainless steel sections are available in India and therefore Stainless steel car bodies have been specified. No corrosion repair is necessary on stainless steel cars during the service life of the cars.

The stainless steel car body leads to energy saving due to light weight. It also results in cost saving due to easy maintenance and reduction of repair cost from excellent anti corrosive properties as well as an improvement of riding comfort and safety in case of crash or fire. A design life of 30 years for coach has been recommended.

iii) Bogies

Bolster less lightweight bogies with rubber springs are now universally adopted in metro cars. These bogies require less maintenance and overhaul interval is also of the order of 4,20,000 km. The use of air spring at secondary stage is considered with a view to keeps the floor level of the cars constant irrespective of passenger loading unlike those with coil spring. The perturbations from the track are also dampened inside the car body on account of the secondary air spring along with suitable Vertical Hydraulic Damper. The primary suspension system improve the curve running performance by reducing lateral forces through application of conical rubber

spring. A smooth curving performance with better ride index is being ensured by provision of above type of bogies.

iv) Braking System

The brake system shall consist of –

- An electro-pneumatic (EP) service friction brake
- A fail safe, pneumatic friction emergency brake
- A spring applied air-release parking brake
- An electric regenerative service brake
- Provision of smooth and continuous blending of EP and regenerative braking

The regenerative braking will be the main brake power of the train and will regain the maximum possible energy and pump it back to the system and thus fully utilize the advantage of three phase technology. The regenerative braking should have air supplement control to bear the load of trailer car. In addition, speed sensors mounted on each axle control the braking force of the axles with anti skid valves, prompting re-adhesion in case of a skid. The brake actuator shall operate either a tread brake or a wheel disc brake.

v) Propulsion System Technology

The brush less 3 phase induction motors has now replaced the d.c series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based Mass Rapid Transit applications. The motor tractive effort and speed is regulated by 'Variable Voltage and Variable frequency' control and can be programmed to suit the track profile and operating requirements. Another advantage of 3 phase a.c. drive and VVVF control is that regenerative braking can be introduced by lowering the frequency and the voltage to reverse the power flow and to allow braking to very low speed.

Converter and Inverter should be IGBT based. The advanced IGBT contains an Insulated Gate Bipolar Transistor (IGBT) and gate drive circuit and protection. The advanced IGBT incorporates its own over current protection, short circuit protection; over temperature protection and low power supply detection. The inverter unit uses optical fiber cable to connect the control unit to the gate interface. The optical fiber cable provides electrical isolation between the advanced IGBT and the control unit and is impervious to electrical interference. These features are recommended for adoption in Trains of Mumbai MRTS.

vi) Cab Layout

The modern stylish driver panel shall be FRP moulded which give maximum comfort and easy accessibility of different monitoring equipments to the driver along with clear visibility. The driver seat has been provided at the left side of the cabin.

3.6.5 COMMUNICATION

The driving cab of the cars are provided with continuous communication with base Operational Control Centre and station control for easy monitoring of the individual train in all sections at all the time. Public Address and Passenger Information Display System is provided in the car so that passengers are continuously advised of the next stoppage station, final destination station, interchange station, emergency situations if any, and other messages.

3.6.6 NOISE AND VIBRATION

The train passes through heavily populated urban area. The noise and vibration for a metro railway become important criteria from public acceptance view point. The sources of noise are:

i. Rail-wheel interaction

ii. Noise generated from equipment like Blower, Compressor, air conditioner, door, Inverter etc.

iii. Traction motor in running train. For elimination and reduction of noise following feature are incorporated: -

- Provision of anti drumming floor and noise absorption material
- Low speed compressor, blower and air conditioner
- Mounting of under frame equipments on anti-vibration pad
- Smooth and gradual control of door
- Provision of GRP baffle on the via-duct for elimination of noise transmission
- Provision of sound absorbing material in the supply duct and return grill of air conditioner
- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes
- Provision of bolster less type bogies having secondary air spring.

3.6.7 PASSANGER SAFETY FEATURES

- **AWS** The complete system shall be compatible with the Auxiliary Warning System already working in Mumbai area.

- **Fire** The rolling stock is provided with fire retarding materials having low fire load, low heat release rate, low smoke and toxicity inside the cars. The electric cables used are also normally low smoking zero halogen type which ensures passenger safety in case of fire.

- **Crash worthiness features**

  The rolling stock is provided with inter car couplers having crashworthiness feature which reduces the severity of injury to the passengers in case of accidents**.**