# Joint Feasibility Study for Mumbai-Ahmedabad High Speed Railway Corridor

# Final Report
# Volume 1

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**Japan International Cooperation Agency(JICA)**
**Ministry of Railways, Republic of India(MOR)**

**Japan International Consultants for Transportation Co., Ltd.**
**Oriental Consultants Global Co., Ltd.**
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# Abbreviations

| Abbreviations | Formal Name |
|---|---|
| A | Articulated |
| AC | Alternative Current |
| ADB | Asian Development Bank |
| AGV | Automotrice à Grande Vitesse |
| AP | Affected Person |
| ASI | Archaeological Survey of India |
| AT | Auto Transformer Feeding |
| ATC | Automatic Train Control System |
| ATP | Auto Transformer Post |
| AUDA | Ahmedabad Urban Development Authority |
| AVE | Alta Velocidad Española |
| BIS | Bureau of Indian Standards |
| BLT | Build, Lease & Transfer |
| BOT | Build, Operate & Transfer |
| BT | Booster Transformer Feeding |
| BT | Build & Transfer |
| BTO | Build, Transfer & Operate |
| CAI | computer-aided instruction |
| CAM | Cement Asphalt Mortar |
| CAPEX | Capital Expenditure |
| CB | Circuit Breaker |
| CBA | Cost Benefit Analysis |
| CD | Compact Disc |
| CDM | Clean Development Mechanism |
| CDP | City Development Plan |
| CER | Certified Emission Reductions |
| CIDCO | City and Industrial Development Corporation of Maharashtra Limited |
| CMDA | Chennai Metropolitan Development Authority |
| CMP | Comprehensive Mobility Plans |
| CMS | Centralized Information Monitoring System |
| COMTRAC | Computer Aided Traffic Control |
| CPCB | Central Pollution Control Board, India, India |
| CRIC | China Rail Investment Corporation |
| CRT | Cathode-Ray Tube display |
| CRZ | Coastal Regulation Zone |
| CTC | Centralized Traffic Control |
| CVC | Classified Volume Count |
| CVCF | Constant Voltage Constant Frequency |
| DB | Deutsche Bahn |
| DC | Direct Current |
| DCF | Discounted Cash Flow |
| DEA | Department of Economic Affairs |
| DFC | Dedicated Freight Corridor |
| DMIC | Delhi Mumbai Industrial Corridor development |
| DMRC | Delhi Metro Rail Corporation Ltd. |
| DNA-CDM | Designated National Authority-Clean Development Mechanism |
| DPR | Detailed Project Report |
| DSCR | Debt Service Coverage Ratio |
| EAC | Environmental Appraisal Committee, India |
| EC | Environmental Clearance |
| ECBs | External Commercial Borrowings |
| EIA/ESIA | Environmental Impact Assessment/Environmental and Social Impact |

| Abbreviations | Formal Name |
|---|---|
| | Assessment |
| EM&MP | Environmental Management & Monitoring Plan |
| EMP | Environmental Management Plan |
| EMU | Electric Multiple Unit |
| EPA | Environmental Protection Act |
| EPCS | Electric Power Control System |
| ERP | Electronic Road Pricing |
| ES | Executive Summary |
| EVT | Earthed Voltage Transformer |
| FEM | Finite Element Method |
| FMS | Facility Management System |
| FSI | Forest Survey of India |
| FSI | Floor Space Index |
| FTr | Feeding Transformer |
| GC | General Consultant |
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gas |
| GIDC | Gujarat Industrial Development Corporation |
| GOI | Government of India |
| GRDP | Gross Regional Domestic Product |
| GUDC | Gujarat Urban Development Corporation |
| HDFC | Housing Development Finance Corporation Limited |
| HSR | High Speed Rail |
| HSRA | High Speed Rail Authority |
| HSRC | High Speed Rail Corporation of India Limited |
| HUDCO | Housing & Urban Development Corporation |
| ICC | Integrated Circuit Card |
| ICE | Inter City Express |
| ICT | Information & Communication Technology |
| IDC | Interest During Construction |
| IDFC | Infrastructure Development Finance Company |
| IEIA | Initial Environment Impact Assessment |
| IFCs | Infrastructure Finance Companies |
| IIFCL | India Infrastructure Finance Company Limited |
| IL&FS | Infrastructure Leasing & Financial Services Limited |
| IMF | International Monetary Fund |
| INR | Indian National Rupees |
| IOCC | Integrated Operations Control Center |
| IR | Indian Railway |
| IR | Involuntary Resettlement |
| IRFC | Indian Rail Finance Corporation Ltd. |
| IS | Indian Standard |
| JETRO | Japan External Trade Organization |
| JICA | Japan International Cooperation Agency |
| JNR | Japanese National Railways |
| JR | Japan Railways |
| JRTT | Japan Railway Construction, Transport and Technology Agency |
| LA | Land Acquisition |
| LA | Lightning Arrester |
| LAN | Local Area Network |
| LARAP | Land Acquisition and Resettlement Action Plans |
| LBS | Load-Break Switch |
| LCC | Life Cycle Cost |
| LCX | Leaky Coaxial Cable |

| Abbreviations | Formal Name |
|---|---|
| LGV | Ligne à Grande Vitesse |
| MAP | Million Annual Passengers |
| METI | Ministry of Economy, Trade and Industry, Japan |
| MEGA | Metro Link for Gandhinagar and Ahmedabad |
| MEXT | Ministry of Education, Culture, Sports, Science and Technology |
| MLIT | Ministry of Land, Infrastructure, Transport and Tourism |
| MMDA | Madras Metropolitan Development Authority |
| MMRDA | Mumbai Metropolitan Region Development Authority |
| MMTS | Multi Modal Transport System |
| MOEF | Ministry of Environment and Forest, India |
| MOR | Ministry of Railways, India |
| MOU | Memorandum of Understanding |
| MOUD | Ministry of Urban Development |
| MPSEZ | Mundra Port and Special Economic Zone Ltd |
| MSK | Minimum Shift Keying |
| MTC | Metropolitan Transport Corporation |
| MWCS | Maintenance Work Control System |
| MoEF | Ministry of Environment and Forest, India |
| NA | Not Articulated |
| NATM | New Austrian Tunneling Method |
| NBFIs | Non-Banking Finance Institutions |
| NEAA | National Environmental Appellate Authority, India |
| NH | National Highway |
| NHAI | National Highways Authority of India |
| NHSRA | National High Speed Rail Authority |
| NOC | None Objection Certificate |
| NRSC | National Remote Sensing Centre |
| NUDP | National Urban Development Policy |
| NW-4 | National Waterway |
| O&M | Operation & Maintenance |
| OCC | Operation Control Center |
| OCS | Overhead Catenary System |
| OD | Origin-Destination |
| ODA | Official Development Assistance |
| OFC | Optical Fiber Cable |
| OPEX | Operating Expenses |
| PAP | Project Affected Person |
| PAX | Passengers |
| PC | Power Concentration |
| PC | Pre-stressed Concrete |
| PCCP | Power Concentration Concentrated Power |
| PD | Power Distribution |
| PDDP | Power Distribution Distributed Power |
| PDL | Passenger Designated Lines |
| PE | Private Equity |
| PH | Public Hearing |
| PHC | Pre Hardened Copper |
| PIAs | Project Influenced Areas |
| PNB | Punjab National Bank |
| PPDPD | Person Per Day Per Direction |
| PPM | Post-Project Monitoring |
| PPP | Public Private Partnership |
| PPP | Purchasing Power Parity |
| PRC | Programmed Route Control |

| Abbreviations | Formal Name |
|---|---|
| PRIDe | Peninsular Region Industrial Development Corridor |
| PSU | Public Sector Unit |
| QC | Quality Control |
| RBI | Reserve Bank of India (Central Bank) |
| RC | Reinforced Concrete |
| RCC | Reinforced Cement Concrete |
| RDSO | Research Design & Standards Organization, India |
| RFF | Réseau Ferré de France |
| RFP | Request for Proposal |
| RLDA | Rail Land Development Authority |
| RO | Regional Office |
| ROB | Road Over Bridge |
| ROC | Republic of China |
| ROW | Right of Way |
| RP | Resettlement Plan |
| RPC | Railway static unbalanced Power Compensator |
| RS | Rolling Stock |
| RSCS | Rolling Stock Control System |
| RTRI | Railway Technical Research Institute |
| RVNL | Rail Vikas Nigam Limited |
| RUB | Road Under Bridge |
| RYWMS | Railway Yard Work Management System |
| SBI | State Bank of India |
| SCADA | Supervisory Control and Data Acquisition |
| SDH | Synchronous Digital Hierarchy |
| SEA | Strategic Environmental Assessment |
| SEAC | State Level Expert Appraisal Committee, India |
| SEIAA | State Environmental Impact Assessment Agency, India |
| SFC | Single phase Feeding unbalanced power Conditioner |
| SHM | Stake Holder Meeting |
| SNCF | Société Nationale des Chemins de Fer Français |
| SOD | Schedule of Dimensions |
| SP | Sectioning Post |
| SPC | Special Purpose Company |
| SPCB | State Pollution Control Board, India |
| SS | Substation |
| SSB | Single Side Band |
| SSO | Single Sign-on |
| SSP | Sub Sectioning Post |
| SUICA | Super Intelligent Card |
| TAZ | Traffic Analysis Zone |
| TBM | Tunnel Boring Machine |
| TEU | Twenty-foot Equivalent Unit |
| TGV | Train à Grande Vitesse |
| THSRC | Taiwan High Speed Rail Corporation |
| TIFS | Tax Increment Financing Schemes |
| TOD | Transport Oriented Development |
| TPS | Transportation Plan System |
| TSC | Taiwan Shinkansen Consortium |
| TSI | Technical Specification for Interoperability |
| TSS | Traction Substation |
| UN | United Nations |
| UNFCC | United Nations Framework Convention on Climate Change |
| UPS | Uninterruptible Power Supply |

| Abbreviations | Formal Name |
|---|---|
| USD | United States Dollar |
| UTI1 | Unit Trust of India |
| UTPCC | Union Territory Pollution Control Committee, India |
| VA | Volt Ampere |
| VCT | Voltage and Current Transformer |
| VFM | Value For Money |
| VGF | Viability Gap Funding |
| WACC | Weighted Average Cost of Capital |
| WPI | Whole Price Index |
| WTP | Willingness to Pay |

# Chapter 1 Overview of Study

## 1.1 Objectives of Study

### 1.1.1 Study Background

India has undergone rapid economic growth in recent years, and along with this growth has come a sharp rise in the volume of people and goods being transported in the country. To meet this rise, Dedicated Freight Corridors (DFC) are being constructed to haul freight from Delhi to Mumbai and Kolkata. As for passenger transport, the Ministry of Railways (MOR), the Republic of India, prepared the "Indian Railways Vision 2020" in December 2009, and pre-feasibility studies are now being started in sequential order on seven routes that are candidates for the construction of High Speed Railway (HSR).

A report issued by an expert committee on modernization of India's national railways that was established by MOR, the Republic of India, designates the line between Mumbai and Ahmedabad (approximately 500 km) as the first HSR section to be constructed. A pre-feasibility study was conducted for this line by RITES of India, Systra of France and others in FY2009.

Against this backdrop, India and Japan issued a joint statement on May 29, 2013, that included a decision to conduct a joint study on the construction of the HSR between Mumbai and Ahmedabad. In response, JICA and the Ministry of Railways, the Republic of India signed a Memorandum of Understanding (MOU) for the joint feasibility study on October 7, 2013.

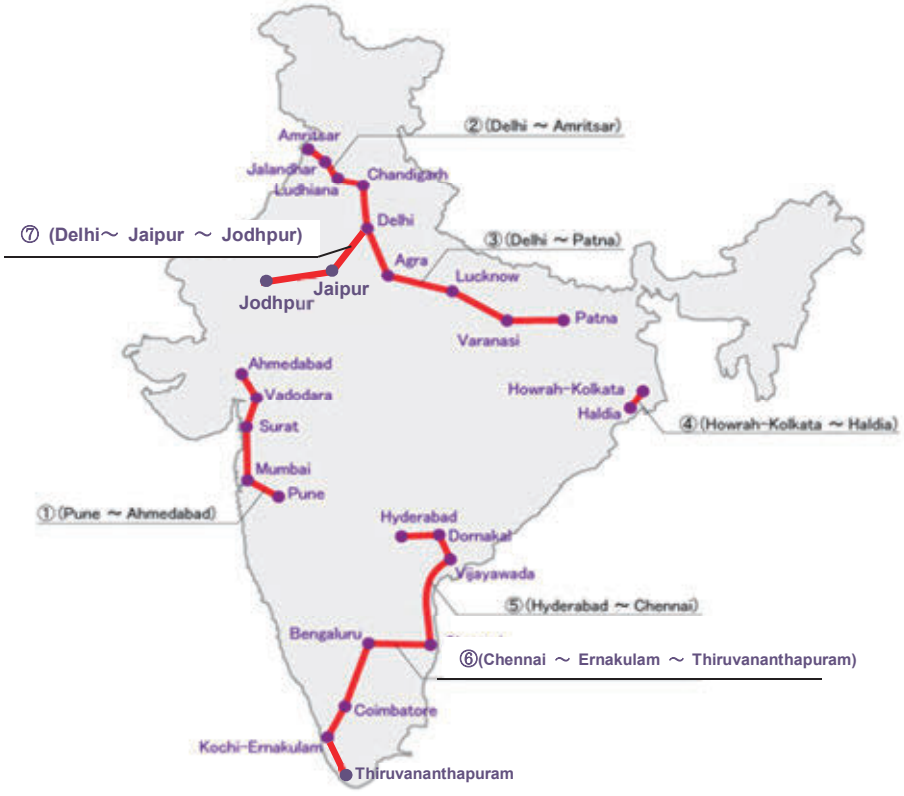



Figure 1.1-1 Planned HSR in India

### 1.1.2 Purpose of the Study

This study is a feasibility study concerning the plan to develop the HSR between Mumbai and Ahmedabad based on the above-mentioned MOU. Main items covered in the study are as follows:

(1) A review of related studies conducted in the past; including the feasibility study conducted by the Indian side.
(2) Preparation of a HSR basic plan (proposal) including comparative study of global HSR technologies and systems.
(3) Preparation of a HSR construction plan and operation/maintenance plan based on the best proposal.
(4) Preparation of a construction plan and calculation of estimated project cost.
(5) Study of project scheme and project implementation systems.
(6) Economic and financial analysis.
(7) Study of related legal systems/standards and human resources development.

### 1.1.3 Region Targeted by the Study

The region targeted by the study is a corridor having a length of approximately 500 km that links Mumbai which is located in the state of Maharashtra in western India and Ahmedabad which is the largest city of the state of Gujarat.
The areas, populations, and population densities of Maharashtra and Gujarat, which form the target region of the study, are provided in Table 1.1-1.


Figure 1.1-2 Mumbai-Ahmedabad Corridor

Table 1.1-1 Populations and Major Cities of Western India

| State | Area ($km^2$) | Population (people) | Population density (people/$km^2$) | Major cities |
|---|---|---|---|---|
| Maharashtra | 307,577 | 112.37 million | 365 | Mumbai |
| Gujarat | 196,024 | 60.38 million | 308 | Ahmedabad, Surat, Vadodara |

Source: Population (2011 Census of India)

## 1.2 Contents of Study

### 1.2.1 Overall Organization of Study Operations

The overall structure of the study is shown in Figure 1.2-1.

The study will be broadly divided in three stages.
During the initial stage, we reviewed the results of existing studies and compare and examine the HSR technologies and systems of each country. We formulated the best proposal for a HSR basic plan after considering the type of HSR system needed in the study section, environmental impact, and other matters and studying alternative proposals.

In the second stage, we prepared a project plan by devising a HSR construction plan and operation/maintenance plan based on the formulated best proposal, calculating estimated project costs, studying the project implementation system, conducting an economy and financial analysis, and studying the project scheme.

In the final stage, we will study legal systems and technical standards based on the study's results, study a human resources development plan, further deep understanding of the Project on the Indian side, engage in necessary coordination, and firm up the basis for consensus building.

We will also conduct assessments of environmental and social impacts and propose mitigation measures throughout the course of the study.

In addition to the above-mentioned activities, we had coordination and shared understanding between concerned persons in India and Japan and engage in consensus building at all stages of the study. We achieve these aims through explanations and discussions to take place in meetings of the joint monitoring committee, hearings Indian experts and other concerned persons, meetings of the environmental and social considerations review committee, and discussions with stakeholders.

| Year/month | Work Item | | | | Report |
|---|---|---|---|---|---|
| 2013/12 | **100: Gathering, arrangement, and analysis of related materials and information** | | | | IC/R |
| | **200: Briefing and discussion on the Inception Report** | | **1500: Committee preparations and video production** | | |
| | **100: Gathering, arrangement, and analysis of related materials and information** | | | | |
| 2014/01 | **300: Preparation of a HSR basic plan (draft)** | **400: Update of demand forecasts and setting of fare levels** | **500:Natural conditions studies** | **1400: Environmental and social considerations** | |
| 2014/02 | | | | | |
| 2014/03 | | | | | |
| 2014/04 | | | | | |
| 2014/05 | | | | | IT/R1 |
| 2014/06 | **600: Preparation, briefing, and discussion of Interim Report 1** | | **1500: Committee preparations and video production** | | |
| 2014/07 | **700: Preparation of HSR construction plan and operation and maintenance plan, and calculation of estimated project cost** | **800: Study of systems for project implementation and operation and maintenance** | **900: Economic and financial analysis** | **1000: Study of project scheme** | |
| 2014/08 | | | | | |
| 2014/09 | | | | | |
| 2014/10 | | | | | IT/R2 |
| 2014/11 | **1100: Preparation, briefing, and discussion of Interim Report 2** | | **1500: Committee preparations and video production** | | |
| 2014/12 | **1200: Study of legal systems and technical standards** | **1300: Study of human resources development plan** | **1400: Environmental and social considerations** | | |
| 2015/01 | | | | | |
| 2015/02 | **1400: Environmental and social considerations** | | **1500: Committee preparations and video production** | | |
| 2015/03 | | | | | IT/R3 |
| 2015/04 | **Preliminary Survey of Alignment (Additional)** | | | | |
| 2015/05 | | | | | |
| 2015/06 | **1600: Preparation of draft Final Report** | | | | DF/R |
| 2015/07 | **1700: Preparation of Final Report** | | | | F/R |

Figure 1.2-1 Overall Organization of the Study

### 1.2.2 Study Implementation Framework

The study is implemented by a consortium to be comprised of Japan International Consultants for Transportation Co., Ltd., Oriental Consultants Global Co., Ltd., and Nippon Koei Co., Ltd.

We work in cooperation with concerned personnel in India to execute the joint feasibility study. Additionally, we included Indian consultants as members of the study team. Moreover, we planned to actively gain Indian participation in the study by contracting some tasks to Indian organizations and consultants that possess abundant experience and knowledge pertinent to these tasks.

In general, the Ministry of Railways in India serve as the main counterpart organization in study activities. However, given the large size of the project and the fact that various ministries, agencies, and organizations are concerned with it, the joint monitoring committee is comprised of concerned ministries and agencies in India, The Embassy of Japan and others.

Consequently, the study team gave necessary explanations and reports at all study stages at meetings of the joint monitoring committee and other gatherings and make necessary responses, including revisions of draft reports, based on the opinions of the concerned parties.

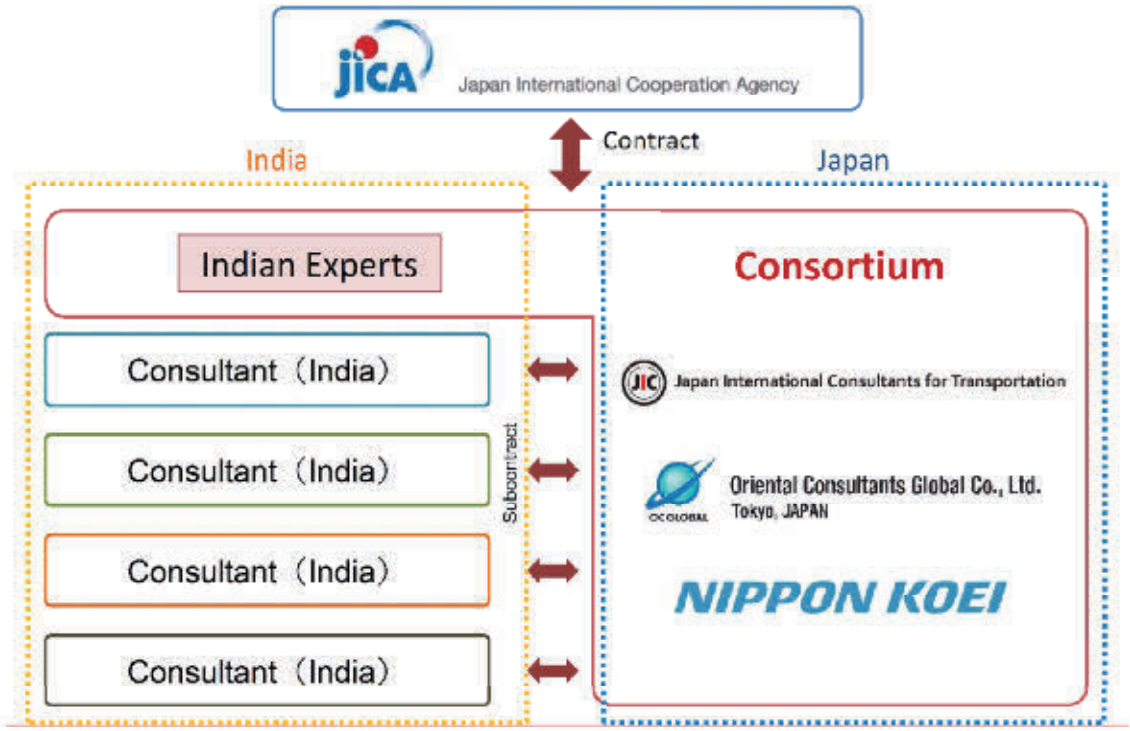



Figure 1.2-2 The Study Implementation Framework

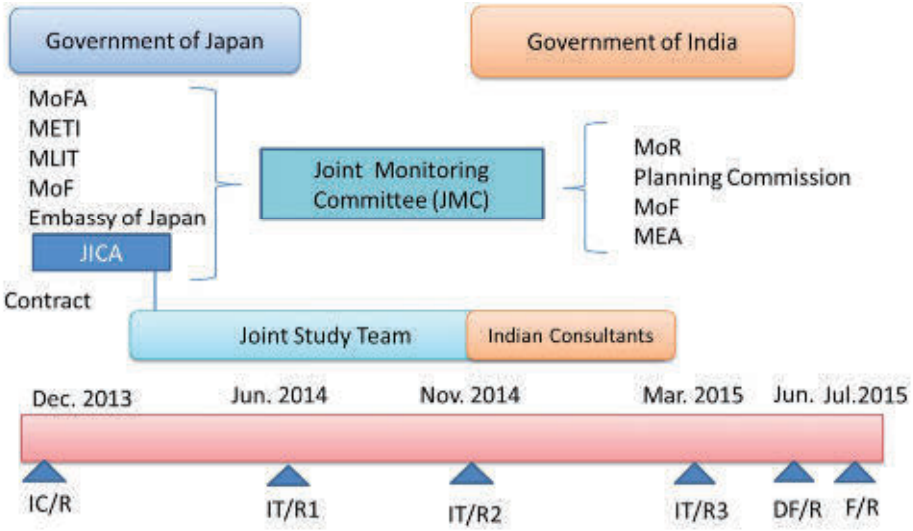



Figure 1.2-3 Response to the Joint Monitoring Committee

## 1.3 Schedule

Study schedule will be as shown in Figure 1.3-1.

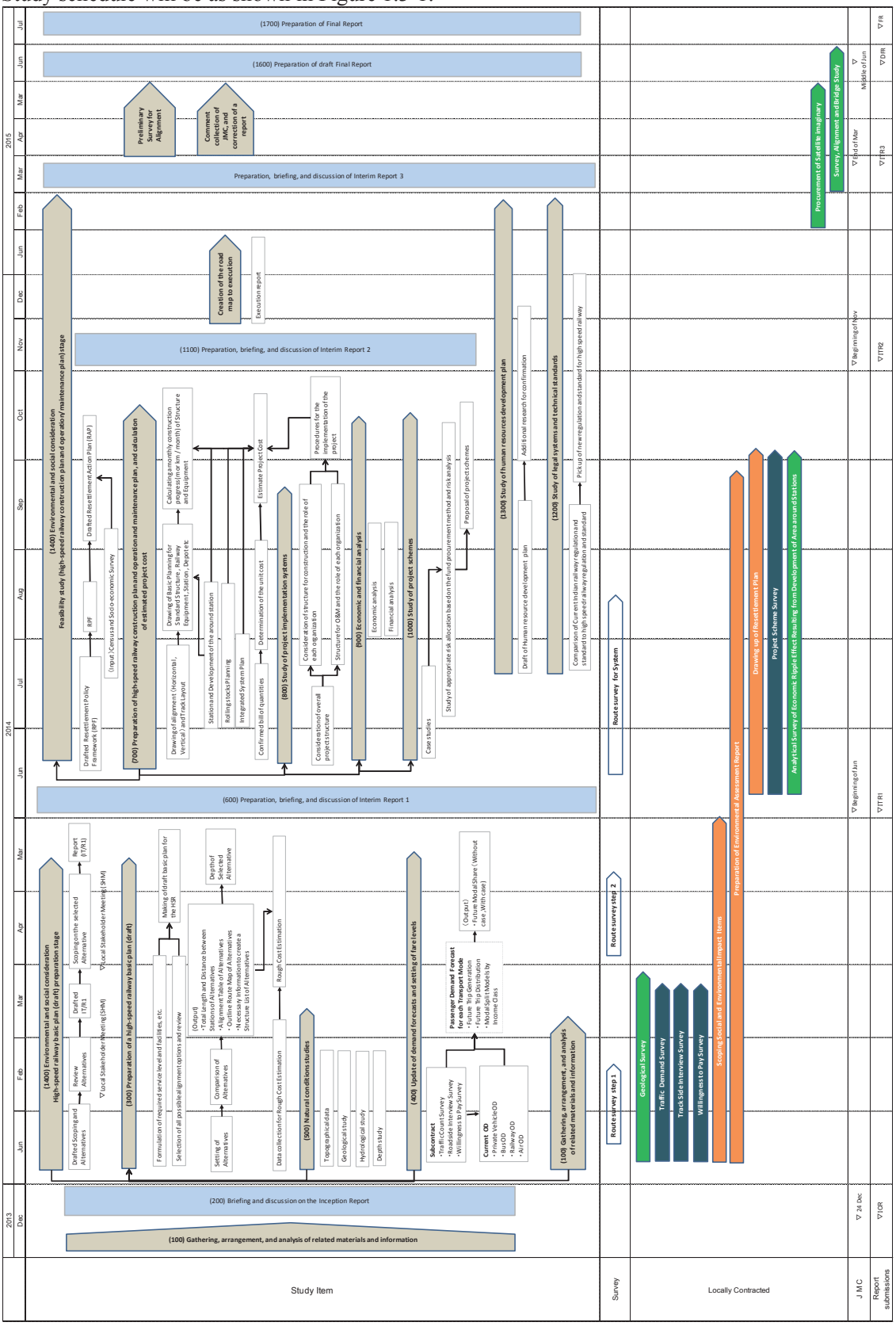



Figure 1.3-1 Study Schedule

# Chapter 2 Basic Route Information

## 2.1 The Study Area

The study area extends two states and two union territories in western India, namely Maharashtra state, Gujarat state, Dadra and Nagar Haveli and Daman and Diu.

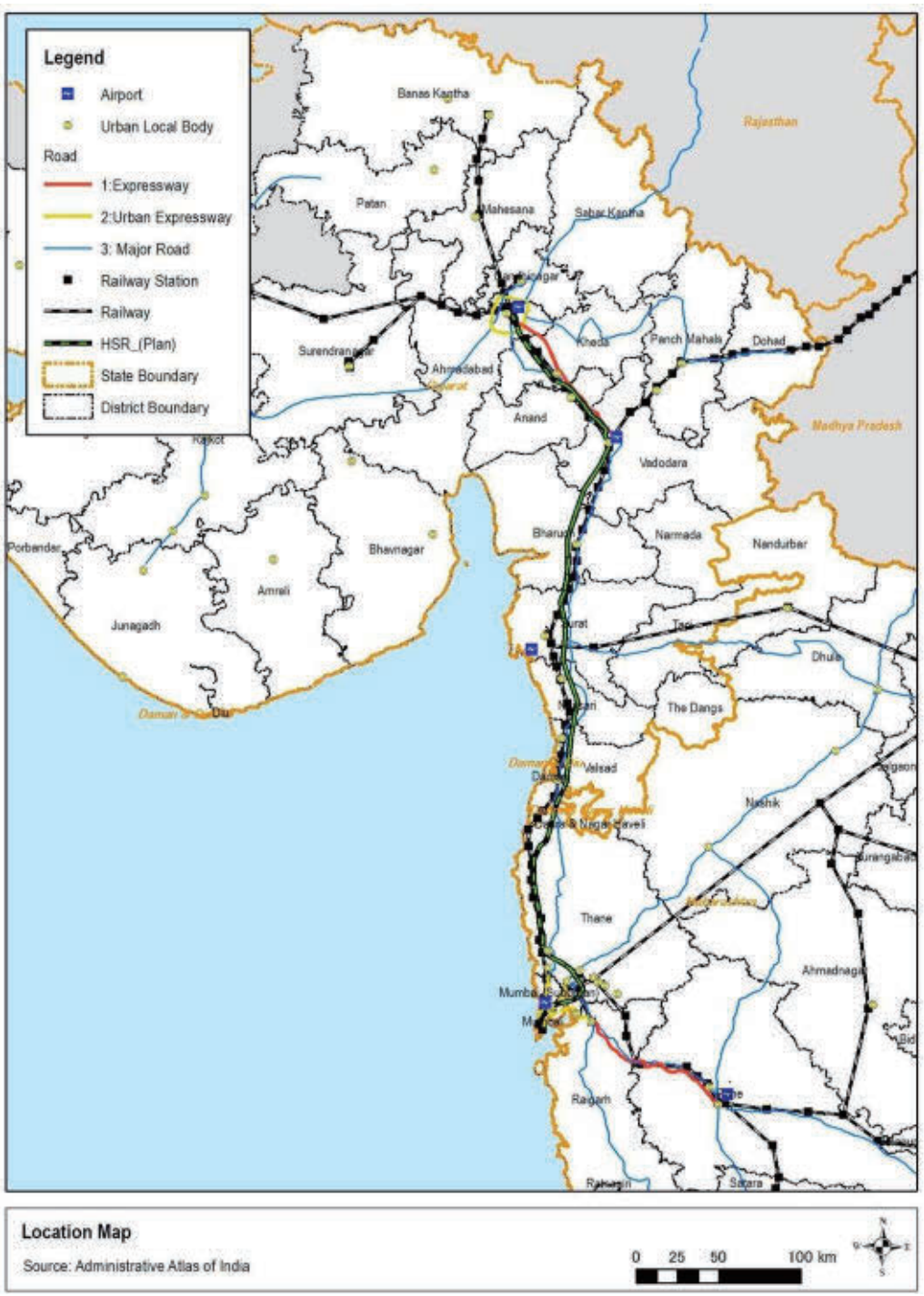



Figure 2.1-1 Location Map

## 2.2 Administrative Structure

Three administrative hierarchies are stipulated in the Constitution of India, namely, Union government, State government and Local government. State jurisdiction is composed of some districts, administrative divisions. Districts are further subdivided into sub-districts which are called Talukas or Tehsils. As of 2011, the year of population census, the number of district in Maharashtra, Gujarat and Dadra and Nagar Haveli and Daman and Diu was 35, 26, 1 and 2, respectively. In 2013, Gujarat state was divided into 33 districts.


Figure 2.2-1 Administration Boundary and Location of Urban Local Bodies as of 2011

## 2.3 Present Population

Table 2.3-1 shows the population by state along the along the HSR line from 1971 to 2011. The annual average population growth rate in the states of Maharashtra and Gujarat from 2001 to 2011 is 1.5 % and 1.8 %, respectively.

Figure 2.3-1 shows the population density by sub-district along HSR line. The population density per square kilometer of Mumbai city, Mumbai suburban, Thane, Surat, Ahmedabad city is approximately 42,000, 23,000, 10,000, 14,000 and 14,000, respectively. In the Mumbai Metropolitan Region (MMR), the Mumbai City and the Mumbai Suburban south area has high population density.

However, the population in the Mumbai city district (old town) has decreased in recent years. On the other hand, the population in Thane district next to the Mumbai and Pune districts has increased sharply.

Table 2.3-1 Population along the HSR Line

Unit: 1,000 persons

| State, Union Territory, and Country | 1971 | 1981 | 1991 | 2001 | 2011 |
|---|---|---|---|---|---|
| Gujarat | 26,697 | 34,086 | 41,310 | 50,597 | 60,340 |
| Daman and Diu | 63 | 79 | 102 | 158 | 243 |
| Dadra & Nagar Haveli | 74 | 104 | 138 | 220 | 344 |
| Maharashtra | 50,412 | 62,783 | 78,937 | 96,752 | 112,374 |
| All India | 548,160 | 683,329 | 846,388 | 1,028,737 | 1,210,193 |

Source: Provisional population totals (Registrar General & Census Commissioner, India 2011), Census of India 2011 (Updated in 2013)

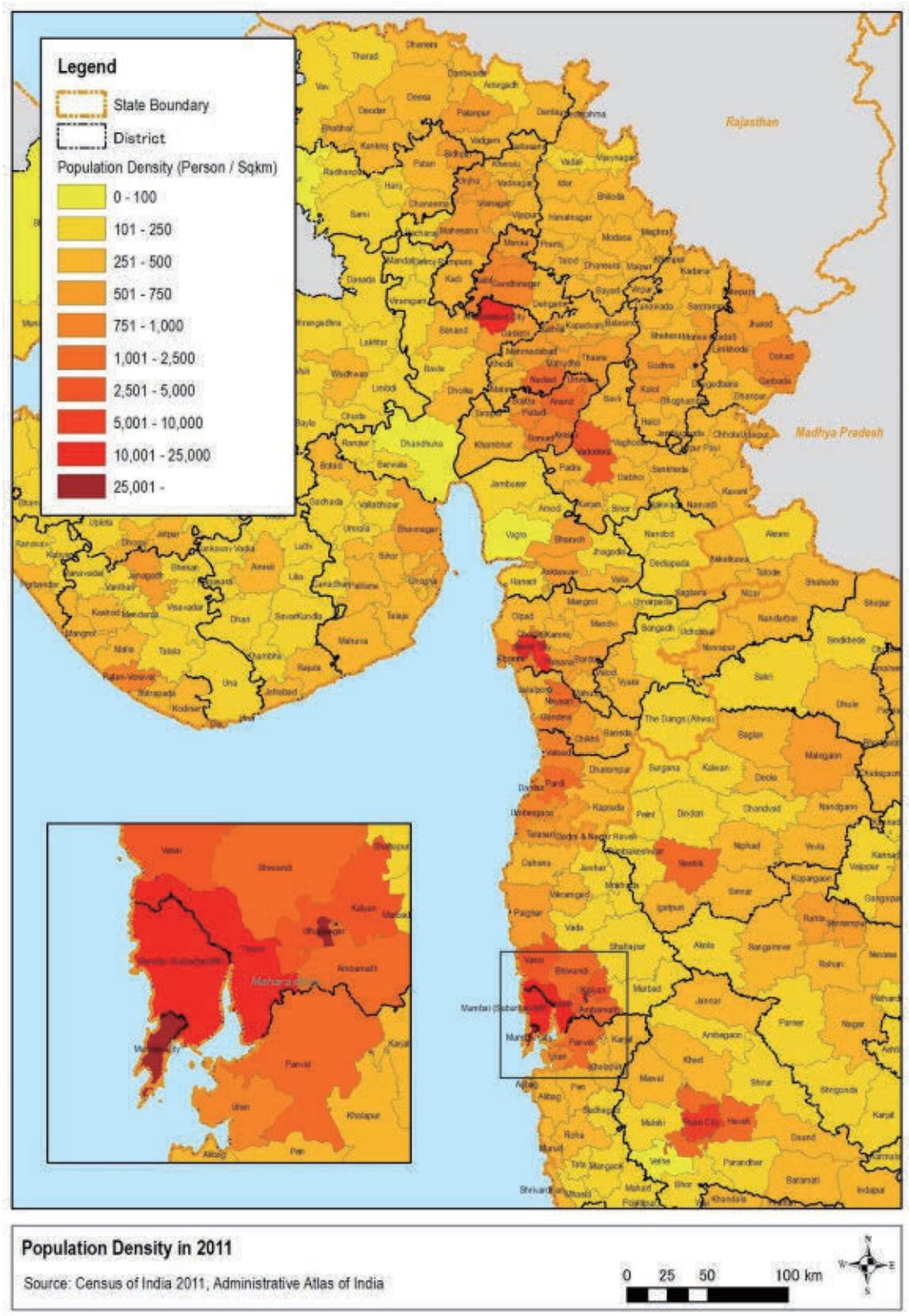



Figure 2.3-1 Population Density by Sub-district along the HSR Line

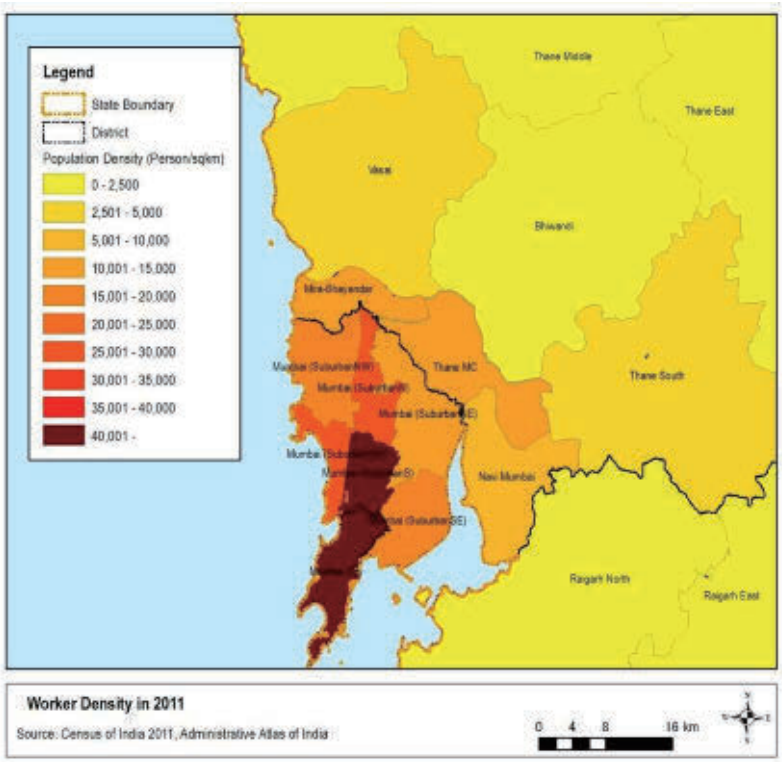



Figure 2.3-2 Population Density in MMR

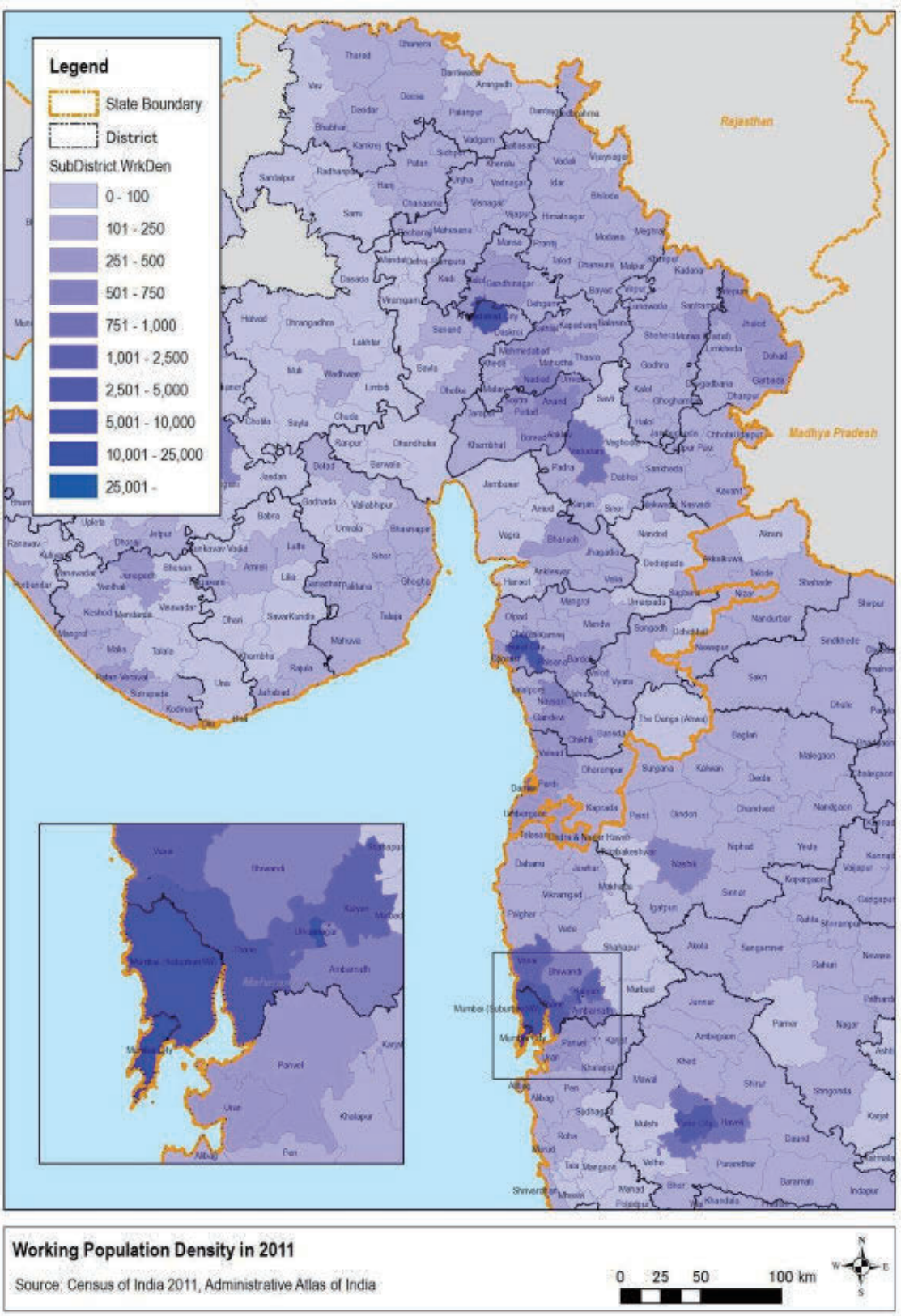



Figure 2.3-3 Working Population Density by Sub-district along the HSR Line

## 2.4 Economic Condition

### 2.4.1 GDP

Table 2.4-1 shows GSDP (Growth State Domestic Product) and growth ratio of the GSDP in Gujarat state, Maharashtra state and whole India. Except for Year 2008, the year of financial crisis, the GDP growth rate in India has been hit over 8% from 2005 to 2010. However, the growth rate as of 2012 was dropped to 5.0 % in 2012 reflecting recent ailing economy.

The growth rate of Maharashtra state and Gujarat state have been larger than the growth rate of whole India.

Also, the GDP per capita of both states are larger than the number of whole India.

Table 2.4-1 GSDP[1] (Constant Price as 2004) and GSDP Growth Rate along the HSR Line

| | | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| GSDP (Billion Rupee) | Gujarat | 2,034 | 2,338 | 2,534 | 2,813 | 3,003 | 3,341 | 3,675 | 3,989 | |
| | Maharashtra | 4,155 | 4,709 | 5,347 | 5,948 | 6,102 | 6,669 | 7,352 | 7,874 | 8,436 |
| | India | 29,715 | 32,531 | 35,644 | 38,966 | 41,587 | 45,161 | 49,370 | 52,436 | 55,054 |
| Growth Rate (%) | Gujarat | | 14.9% | 8.4% | 11.0% | 6.8% | 11.3% | 10.0% | 8.5% | |
| | Maharashtra | | 13.3% | 13.5% | 11.2% | 2.6% | 9.3% | 10.2% | 7.1% | 7.1% |
| | India | | 9.5% | 9.6% | 9.3% | 6.7% | 8.6% | 9.3% | 6.2% | 5.0% |

Source: Planning Commission

Table 2.4-2 GDP per Capita and Growth Rate along the HSR Line

| | | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| GDP/ Capita (Rupee) | Gujarat | 38,107 | 43,032 | 45,822 | 49,967 | 52,415 | 57,283 | 61,902 | 65,997 |
| | Maharashtra | 41,057 | 45,845 | 51,275 | 56,199 | 56,794 | 61,153 | 66,412 | 70,072 |
| | India | 27,508 | 29,629 | 31,940 | 34,354 | 36,072 | 38,540 | 41,452 | 43,315 |
| Growth Rate (%) | Gujarat | | 12.9% | 6.5% | 9.0% | 4.9% | 9.3% | 8.1% | 6.6% |
| | Maharashtra | | 11.7% | 11.8% | 9.6% | 1.1% | 7.7% | 8.6% | 5.5% |
| | India | | 7.7% | 7.8% | 7.6% | 5.0% | 6.8% | 7.6% | 4.5% |

Source: Planning Commission, Population Census

### 2.4.2 Number of Worker

The working population density (Figure 2.3-3) of Mumbai city, Mumbai suburban, Thane, Surat, Ahmedabad city is relatively higher than other sub-districts likewise the population density.

[1] As of Mar. 2014, the GDP of Gujarat in 2012 isn't published. It also should be noted that the GDP by district in Gujarat has never been published.

# Chapter 3 Analysis of Relevant Data/Information

## 3.1 Review of HSR Plans

### 3.1.1 Indian Railways Vision 2020

MOR in India formulated the "Indian Railways Vision 2020" in December 2009 as a long-term vision up to the year 2020. The Vision was formulated to address four national goals: (1) Inclusive Development, both Geographically and Socially; (2) Strengthening National Integration; (3) Large-Scale Generation of Productive Employment; and (4) Environmental Sustainability. An investment as much as 14 trillion rupee (Rs) is planned for the next ten years. Specifically, the vision sets the objectives to drastically increase revenue, expand the network and transport capacity, enhance safety and environmental sustainability, and reform passenger services. It also sets targets for business development in various fields, including passenger services on the conventional railway, HSR and rail freight, luggage, advertisements, telecommunication, and so on.
For HSR that operates at the maximum speed of 250–350 km/h, the vision plans to implement projects for at least four corridors by 2020. Furthermore, it will also make plans for multiple routes to connect the commercial centers, tourist spots, pilgrimage destinations, and so on. Figure 3.1-1 and Table 3.1-1 shows the seven corridors of the planned HSR routes (Indian Railways Vision 2020 put forth six corridors but the Delhi - Jaipur - Jodhpur section was added later to total seven corridors). MOR is conducting pre-feasibility studies of these routes sequentially.
The following is an excerpt from the Report of the Indian Railways Vision 2020.

#### HIGH-SPEED RAIL TRAVEL

In the coming decade, Indian Railways (IR) must catch up with the developed railways of the world in the matter of speed of trains. The current effort to provide fast non-stop train services under the new brand of Duronto will continue. In addition, the vision aims at raising the speed of regular passenger trains to 160-200 km/h on segregated routes, which will bring about a major transformation in train travel. For example, train journey between Delhi-Mumbai and Delhi-Kolkata will become an overnight service.
The Vision 2020 also envisages the implementation of at least 4 HSR projects to provide bullet train services at 250-350 km/h, one in each of the regions of the nation and planning for at least 8 more corridors connecting commercial, tourist and pilgrimage hubs.
Six corridors have already been identified for technical studies on setting up of HSR Corridors. These are:

i. Delhi-Chandigarh-Amritsar;
ii. Pune-Mumbai-Ahmedabad;
iii. Hyderabad-Dornakal-Vijayawada-Chennai;
iv. Howrah-Haldia;
v. Chennai-Bangalore-Coimbatore-Ernakulam;
vi. Delhi-Agra-Lucknow-Varanasi-Patna

These could be built as elevated corridors in keeping with the pattern of habitation and the constraint of land in our country. The Railways will use the PPP mode for investment and execution, and draw on frontier technologies incorporating the highest standards of safety and service quality.
In the next 10 years, we would develop 50 World Class Stations which compare with the best, internationally. Once redeveloped, these stations would be well-integrated with other modes of transport in the cities and easy to access and use. There would be no congestion. Large, well-designed passenger concourses with adequate and high-quality waiting space easily accessible to platforms, conference halls, business centers, retail shops, restaurants, entertainment and cultural facilities, museums and art galleries, and a variety of other attractions would make the passengers stay pleasant and memorable.
In other words, these stations would go beyond being mere transport hubs. They would become vibrant centers of the life of the cities, for commerce, entertainment and social space. They would also become major tourist attractions, as is happening with redesigned railway stations in many parts of the

world. In addition, at least 200 large stations would be developed to provide multifarious facilities like offices, retail, entertainment, restaurants, theatres, hotels, and health and education services.
All this would be achieved using the PPP route, for which an attractive enabling policy and implementation structure will be presented shortly.
Our catering services must ensure availability of hygienically prepared and nutritionally balanced food to passengers and cater to the diversity of India's palate and pocket. To achieve these goals, railway catering services will soon undergo major reform.

#### Public Private Partnerships

To achieve the mammoth task Railways has set itself, it has to concentrate on its core activity of creation of railway infrastructure and operations and forge partnerships with private sector to do the rest. The challenge of project execution and efficient provision of service cannot be accomplished without involving private sector in a big way.
However, the activities and projects to be opened for private participation have to be carefully examined, selected and structured for their amenability to market-based incentives and smooth execution. Several areas currently identified for execution through PPP such as redevelopment/development of world-class stations, HSR corridors, setting up of Multi-Modal Logistics Parks, Kisan Vision projects, expansion and management of the extensive network of Optical Fibre Cables (OFCs) and big infrastructure projects like new lines and DFC, rolling-stock manufacturing units, Multi-functional Complexes at stations and port connectivity projects would be needed to develop and awarded on a mission mode. To be able to do so, Railways would have set up dedicated project organizations who would work with model documents and streamlined procedure within the framework determined by Government of India.

#### High Speed Corridors

India is unique and alone among the major countries of the world in not having a single HSR corridor capable of running trains at speeds of over 250 km/h. HSR corridors have played a major role in revitalization of Railways in Japan and Europe. Of late, HSR networks are also getting built in China, Taiwan and USA. IR would follow a two-pronged approach in this respect. The first approach would be to raise the speed of segregated passenger corridors on trunk routes using conventional technology to 160 to 200 km/h. The second approach would be to identify a number of intercity routes, depending on viability, and build state-of- the-art HSR corridors for speeds up to 350 km/h through on PPP mode in partnerships with the State Governments. Partnerships with the State Governments would be crucial as real-estate development would be a key element of viability of these high-cost projects. By 2020, at least four corridors of 2000 km would be developed and planning for 8 other corridors would be in different stages of progress.

### 3.1.2 High-speed Railway Vision

Figure3.1-1 and Table3.1-1 show the seven corridors planned for the high-speed railway. IR is conducting pre-feasibility studies sequentially.

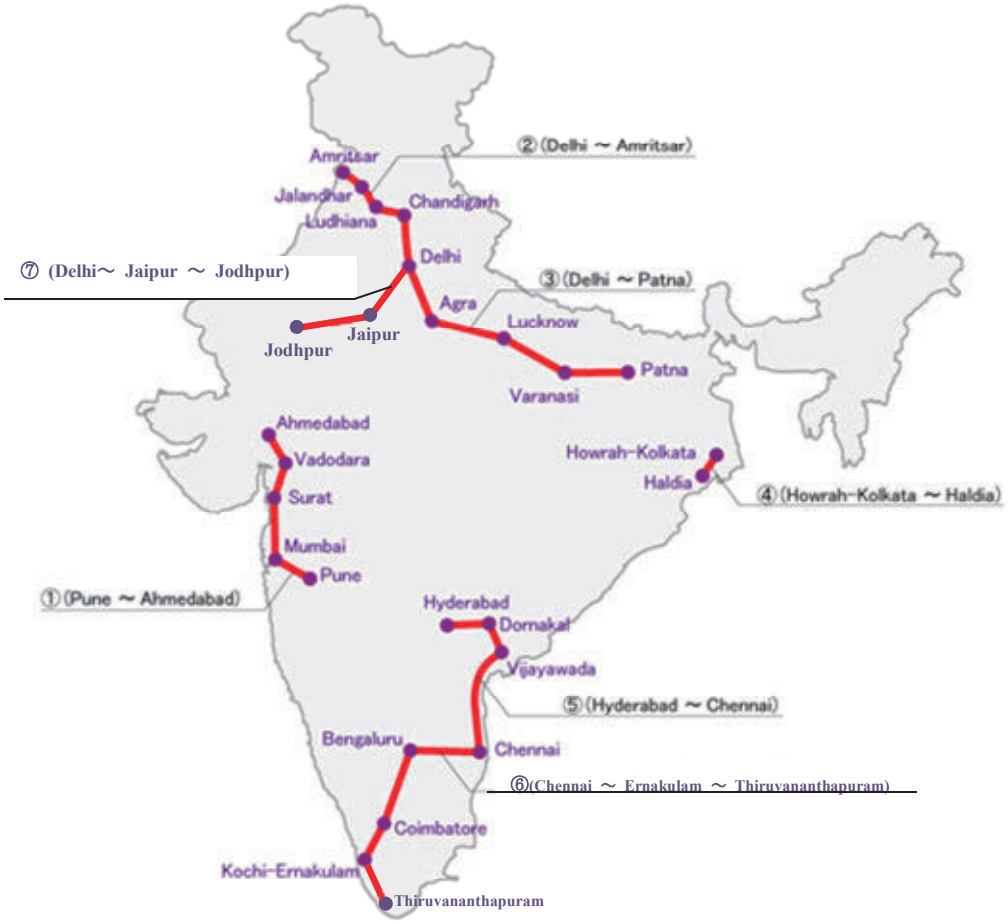



Figure 3.1-1 Seven Corridors for the Pre-feasibility Studies of HSR in India

Table 3.1-1 Seven Corridors Planned for HSR in India

| Corridor | Route | Length |
|---|---|---|
| ① | Pune–Mumbai–Ahmedabad | Approx. 680 km |
| ② | Delhi–Chandigarh–Amritsar | Approx. 480 km |
| ③ | Delhi–Agra–Lucknow–Varanasi–Patna | Approx. 1,000 km |
| ④ | Howrah–Haldia | Approx. 140 km |
| ⑤ | Hyderabad–Dornakal–Vijayawada–Chennai | Approx. 780 km |
| ⑥ | Chennai–Bengaluru–Ernakulam–Thiruvananthapuram | Approx. 1,020 km |
| ⑦ | Delhi–Jaipur–Jodhpur | Approx. 530 km |
| Total | | Approx. 4,630 km |

### 3.1.3 A Report by an Expert Committee on Modernization of Indian National Railway

A 2012 report by an expert committee on modernization of India's national railways that was established by the Indian Minister of Railways designates a route between Mumbai and Ahmedabad (approximately 500 km) as the first high-speed railway section to be constructed. The following is an excerpt from the Report of the Expert Group for Modernization of IR (New Delhi, date: 25 Feb. 2012).

High Speed Passenger Train Corridors
Construct a HSR line between Ahmedabad and Mumbai with speed of 350 km/h. Undertake detailed studies for 6 other HSR corridors already identified. These include:
(1) Delhi-Chandigarh-Amritsar (450 km);
(2) Hyderabad-Dornakal-Vijayawada-Chennai (664 km);
(3) Howrah-Haldia (135 km);
(4) Chennai-Bangalore-Coimbatore-Ernakulam (850 km);
(5) Delhi-Agra-Lucknow-Varanasi-Patna (991 km)
(6) Ernakulam-Trivandrum (194 km).
The likelihood of initiating projects in these corridors in next 5 years is low and so no attempt has been made to estimate the cost of these projects. This would lead to increased connectivity, traffic and faster intercity travel. The cost of HSR line between Ahmedabad & Mumbai is estimated as Rs. 60,000 crores. This cost has also been included under the PPP initiatives. The proposed timeframe is 10 years.

## 3.2 Review of HSR Study between Mumbai and Ahmedabad

### 3.2.1 Pre-feasibility Study Commissioned by the Indian Ministry of Railways in 2009

For this Study, we reviewed the contents of the pre-feasibility study on the development of HSR for the Mumbai - Ahmedabad route commissioned by the Indian government in 2009.
Table 3.2-1 gives an overview of the pre-feasibility study.

Table 3.2-1 Overview of Pre-feasibility Study (Mumbai - Ahmedabad Route)

| Item | | Overview of Study |
|---|---|---|
| Characteristics of section | Section | Pune – Mumbai - Ahmedabad |
| | Start of service | 2021 |
| | Demand forecast results | 26.6 million passengers/year (2021), 12 million passengers/year (Mumbai–Ahmedabad) |
| | Construction method | ・Construction of a new line for HSR. Construction can also be in phases by using some of the conventional lines.<br>・Double-track electrified lines |
| | Operation method | ・Parallel single tracks in both directions (operate on the left side)<br>・High-speed trains operate on some conventional lines. |
| Gauge | | 1676 mm |
| Civil engineering structures | | Length: approximately 640 km (earthwork: 550 km, bridges: 72 km, and tunnels: 18.3+1+2.6=21.9 km) |
| Track structure | | Fastened tracks (ballast less) |
| Signaling system | | ERTMS (European Rail Traffic Management System) Level 2<br>GSM-R (digital wireless network for railway use) |
| Overhead catenary line | | Simple catenary system, AT feeding system (2×25kV) |
| Telecommunications | | GSM-R (digital wireless network for railway use) |
| Traffic control system | | Distributed traffic control system<br>OCC (Operation Control Center) to be set up near Navi Mumbai |
| Fare collection | | Use conventional method because the card system is still in development |
| Infrastructure maintenance | | Proposed personnel, equipment, and methods, etc. |
| Train operation | | 80 trains/ day (one-direction) (2041) |
| Rolling stock | | To develop rolling stock 3,300 mm in width to match the 1,676-mm gauge<br>Multiple unit rolling stock. Train length approximately 200 m<br>No. of train sets needed: 38 (2021) |
| Car depot | | Not possible to set up car depot near Mumbai<br>Recommended to set up car depot at 10 km south of Ahmedabad |
| Alignment | | Construction standards for the design maximum speed of 350 km/h: (minimum curve radius 6,425m, maximum gradient 35‰)<br>Minimize the heights of earth structures, use mostly Rail over Bridge (RoB)<br>Intermediate stations that do not expect to have sufficient demand will be set up in the suburb, away from the city center. Use elevated structures in city centers. |
| Development of stations and real estate | | Rent from the development of railway sites in large cities is expected to account for 6–9% of the total revenue income |
| Project cost (as of 2021) | | Construction cost: Rs.490.75–546.15 billion (including Pune–Mumbai section)<br>Rolling stock cost: Rs.67.83 billion (both the construction cost and rolling stock cost are 2009 prices) |
| Financial and economic analyses | | Operating cost: Rs.2.05 billion (2009 price)<br>Maintenance cost: rolling stock Rs.1.45 billion, infrastructure Rs.2.54 |

| | |
|---|---|
| | billion (2009 price)<br>EIRR：13.60% (Pune–Ahmedabad)<br>10.61% (Mumbai–Ahmedabad) |
| Environmental impact assessment | Environmental impact assessment<br>Calculation of environmental cost |

### (1) Characteristics of this study

The construction method and operation method summarized in the "Characteristics of Section" in the above table are the important items in the selection of technical specifications/systems in the pre-feasibility study by the French consultants. The main characteristics are as follows:

- Because the high-speed trains will enter the conventional line stations, the track gauge and car width of the high-speed trains will be the same as the trains operate on the conventional lines.
- The signaling and telecommunication system ERTMS Level 2, which is the interoperability standard in Europe, is selected.
- The rolling stock will be the EMU, which is the mainstream of high-speed railway today.
- The feeding method will use the AC 2x25kV system, which is the standard for high-speed railway in the world.
- The track will be ballast-less to enable operation at 350 km/h in the future.

### (2) Review of Various Items

The important points of various items are reviewed as follows:

#### 1) Characteristics of Route Selection

Although it will mainly be a HSR line, the alignment is designed assuming entry into conventional line stations, thus the same 1,676-mm gauge as the conventional lines will be used.
The plan is to cross the Thane Creek by bridge. From a natural environment point of view, because the surrounding area of Thane Creek is designated as the Sanjay Gandhi National Park, it is subject to strict development regulations. As for crossing the Thane Creek, SU1 route which will cross it at the downstream was recommended. However, the construction will be affected because it will interfere with some of the Sanjay Gandhi National Park. The bridge of the SU2 route, which will cross the Thane Creek at the upstream, will also interfere with the Sanjay Gandhi National Park. Moreover, since it is planned that the route will pass through the eastern side of the Sanjay Gandhi Sanctuary north of Thane, it will interfere with part of the Sanctuary thus the development regulations are expected to remain a problem.
Because the plan is made for the Pune - Mumbai - Ahmedabad section, the alignment near Navi Mumbai is designed in a delta shape to split into the Mumbai, Ahmedabad, and Pune directions.
The route selected in the pre-feasibility study does not seem to have taken DFC (new freight line) into consideration. Supposedly, when the route intersects with DFC, the Rail Flyover (RFO) and approach will have to be a large structure because DFC will need large construction gauge. There is a possibility that the cost will increase significantly.

#### 2) Characteristics of Civil Structures

The breadth of the formation level is 13.6 m, which is wider than the plan which our study team recommends. As a result, the required dimensions of the land and structures are bigger.
The long tunnels comply with the tunnel safety standards of European specifications. The single-track tunnels will be constructed in parallel, with connection to each other at an interval of 500 m as an evacuation route. Since there is space for emergency vehicles to go through, the tunnel's cross-section is quite large.

#### 3) Operations

In the pre-feasibility study for the Pune - Mumbai - Ahmedabad section conducted by the French consultants, the operating section is divided into two: one for the Pune–Mumbai section and one for

the Mumbai–Ahmedabad section. The two sections overlap until the routes branch out into the Mumbai–Pune and Mumbai–Ahmedabad directions. In 2041, there will be 10 trains per hour operating in this overlapped section during peak hours. In the current plan, the possibility that this section will become a bottleneck in transportation is low. However, as the number of trains increases in the future, there is the possibility of a transport bottleneck.
When the Mumbai–Pune section also becomes operational in the future in addition to the Mumbai–Ahmedabad section, if the overlapped section needs more than 15 trains per hour (maximum 4-minute headway in Japan), this overlapped section may become a bottleneck and not be able to provide enough transport capacity. To resolve this, the overlapped section may need to have quadruple tracks or the position of the Mumbai station may need to be reconsidered so that there will not be any overlapped section.
The operation plan in the pre-feasibility study prepared by the French consultants assumes entry onto conventional lines. Because the high-speed trains will need to lower the speed when operating on a conventional line, the utility ratio of the rolling stock will be lower. As a result, the operation will require more train sets.
In the current plan, 18 train sets will be required to operate 19 trains one way in the Mumbai - Ahmedabad section (including trains operating in part of the Ahmedabad - Pune section and Ahmedabad - Vadodara section) when the service starts in 2021.
Through-operation with the conventional lines will require unifying the gauge (to broad gauge), vehicle gauge, and others. It is necessary to compare the convenience for through-operation with the efficiency for a dedicated HSR line

### 4) Rolling Stock

#### i) Basic Specifications

The major characteristics of the rolling stock proposed in the pre-feasibility study by the French consultants are explained below. The following specifications are proposed to meet the transport demand of the Pune – Mumbai - Ahmedabad and the characteristics of the ground facilities:

Table 3.2-2　aracteristics of Rolling Stock Proposed by French Consultants

| Item | Contents |
|---|---|
| Train set | Some countries use locomotives for their HSR including France. EMU, which is the mainstream of the latest HSR, was recommended. |
| Bogie | Not specified. Can be articulated or not articulated |
| Maximum speed | 350 km/h. It is the feasible speed stated in the rolling stock specification, rather than the actual operating speed. |
| Gauge | ・1,676 mm, taking into account through operation on India's conventional lines<br>・Claimed to have "no technical or cost issues" |
| No. of cars and capacity per train set | Reference drawing shows the car type adopted by the Chinese. It has 5 seats per row, car width of 3265 mm, 8 cars per train set, and capacity for 600 people. |

#### ii) Supplier/Rolling Stock Price, etc.

With regard to the development of broad-gauge rolling stock, the report states that Siemens and Alstom replied, "It can be done. The development cost can be absorbed with the delivery of 30–40 train sets."

### 5) Electric Power

The feeding system will be 2×25kV, the so-called AT (Auto Transformer). It is becoming the standard feeding system of high-speed railways in the world.
For the receiving system, the receiving of a single-phase from the power company's three-phase extra high voltage transmission lines (225kV) was proposed.

To reduce the effects of voltage variation and imbalance caused by the high speed and large capacitive loads of electric railway vehicles, the idea to find balance by cyclically receiving two-phase is adopted. However, if the time table is similar to that of the Tokaido Shinkansen with 16-car train sets in

operation, the impact on the power supply and induction problem of the nearby communication lines will cause concerns.
The pre-feasibility study proposed a dead section for the section where different power sources meet. The French TGV has in place a dead section of approximately 150 m and trains goes slowly when operating in that section. Once the train is detected before it enters the section, the notch on the train is automatically turned off.
On the other hand, the Japanese Shinkansen uses the automatic switching section. This method provides two sets of air sections at the location where different power sources meet to insulate the section electrically. The length between the two sets of air sections is approximately 1,000 m. The power switch to supply power to this section is turned on automatically to power the train in this section. The time for this section to have no pressure for the switching is less than 0.3 second.

### 6) Signaling and Telecommunication System

#### i) ERTMS (European Rail Traffic Management System) Level 2

The most significant characteristic of the signaling and telecommunication system proposed by the French consultants in the pre-feasibility study is the recommendation to use ERTMS Level 2.
ERTMS is known as the European Rail Traffic Management System. Currently more than 20 different operation safety systems are being used by different countries in Europe, posing a big barrier to interoperability within Europe. ERTMS is developed to standardize the train protection systems so that trains in Europe can operate interchangeably in all its countries. ERTMS is divided into levels by function. The ERTMS Level 2 proposed in this pre-feasibility study is for the on-board signaling system.

### 7) Earthquake Detection System

In high-speed railway, it is important to stop the train as soon as possible when there is a disaster or the danger of a disaster in order to prevent major accidents. For this reason, although making adjustment with the concerned members in India is necessary, it is essential to use an appropriate earthquake detection system. The pre-feasibility study states that the train will stop automatically when the earthquake exceeds 65 MG. Since there is no specific description, it is not clear which system will be introduced, what procedures will be used, and how soon the trains can be stopped.

### 8) Operation Control Center (OCC)

The pre-feasibility study recommends setting up the OCC at the Navi Mumbai area. It is desirable for the OCC to be located in a place where it is easy for the dispatchers to gather quickly in the case of an emergency and where it is convenient for commuting. In addition, although there is a description in the French case indicating that the Power Supply Centralized Control (PSCC) shall be separate from the operation control center; it is desirable, however, for them to be on the same floor for the sake of centralizing information so that they can share information immediately.

### 9) Environmental Impact Assessment

Comparison of alternative routes, understanding of the current state of environmental and social considerations, environmental impact assessment, and calculation of environmental costs are the main items described under environmental impact assessment.
In the comparison of alternate routes, multiple routes have been compared. However, the contents are mainly about the plan itself, such as the number of tunnels and viaducts, speed limits, and minimum curve radius. “Relocation” was the only item being compared under social and environmental considerations
The laws of India and existing literature were collected and organized to develop understanding of the current situation relating to environmental and social considerations. Local monitoring results of noise and vibration were shown. Land use in the project area, including length of the forests to be passed by the proposed project, was analyzed using the electronic data of land use.
IEE-level environmental impact assessment was performed. It included impact assessment with a focus on qualitative forecast, review of environmental and social management plans (environmental mitigation measures), and recommendations for environmental and social considerations based on the

findings. Although prediction of noise and vibration was made using prediction formula, only one case each was performed. The contents are quite schematic.
Besides the above, the environmental costs for soundproof walls, environmental monitoring, and the implementation of other such projects were calculated. However, there was no description of the rationale for the setting of unit prices or breakdown of details.

### 3.2.2 Study Commissioned by the Ministry of Land, Infrastructure, Transport and Tourism of Japan in 2012

#### (1) Characteristics of this study

The study decided to use standard-gauge new HSR lines (without the use of existing lines) for the following reasons:

- The majority of HSR of the world use standard gauge.
- The track capacity of the route's existing lines is limited.
- To the ensure operational safety of a railway of differing speeds

In addition, they studied carriages, signals, and other railway systems with focus on the Shinkansen, which has performed well in high-volume, high-speed operations for many years.

#### (2) Maximum speed

- Although the design maximum speed will be 350 km/h, they set the maximum speed in business operation at 320 km/h for the time being.

#### (3) Study preconditions

The study's preconditions are provided in Table 3.2-3.

Table 3.2-3 Preconditions (provisional)

| Item | Premise |
|---|---|
| Year of launch | 2020 |
| Section | Mumbai–Ahmedabad |
| Dedicated HSR line | Not intended for the operation of conventional trains or freight trains |

#### (4) Railway facility design standards

Table 3.2-4 shows the railway facility design standards used in the study. The construction gauge and vehicle gauge used in the study are provided in Figure 3.2-1, and a cross-section of an embankment, which is the main structure of the study, is provided in Figure 3.2-2.

Table 3.2-4 Standards for the Design of Railway Facilities for the Mumbai - Ahmedabad Line (provisional)

| Item | Standard value | |
|---|---|---|
| Gauge | 1435 mm | |
| No. of tracks on the main line between stations | 2 tracks (double track, one direction) | |
| Design maximum speed | 350 km/h | |
| Maximum operating speed | 320 km/h | |
| Minimum plane curve radius | Main line:<br>Passing track:<br>Car depot, etc: | R = 6,000 m<br>R = 1,000 m<br>R = 300 m |
| Vertical curve radius | 25,000 m | |
| Maximum grade | General areas excluding station：25‰<br>Inside station and side lines：3‰（In principle: Level）<br>Car depot, etc.：Level | |
| Track center distance | 4.3 m | |
| Width of formation level | 11.3 m | |
| Cross-section of tunnel | 63.4 $m^2$ (double-track tunnel) | |
| Maximum axle load | Less than 16 t | |
| Track structure | Tunnels and bridges: Slab track<br>Roadbed (embankment, cutting): Slab track or ballasted track | |
| Feeding voltage | AC 2x25kV | |
| Overhead catenary system | Simple catenary system | |
| Signaling system | Digital-ATC | |
| Train control | Automatic train control, traffic control | |
| Train radio | LCX (Leaky coaxial cable) | |
| Rolling stock | Maximum 16 cars (capacity 1,280 persons)/ (2 stories, capacity 1,600 persons）<br>Car width: 3.4 m | |

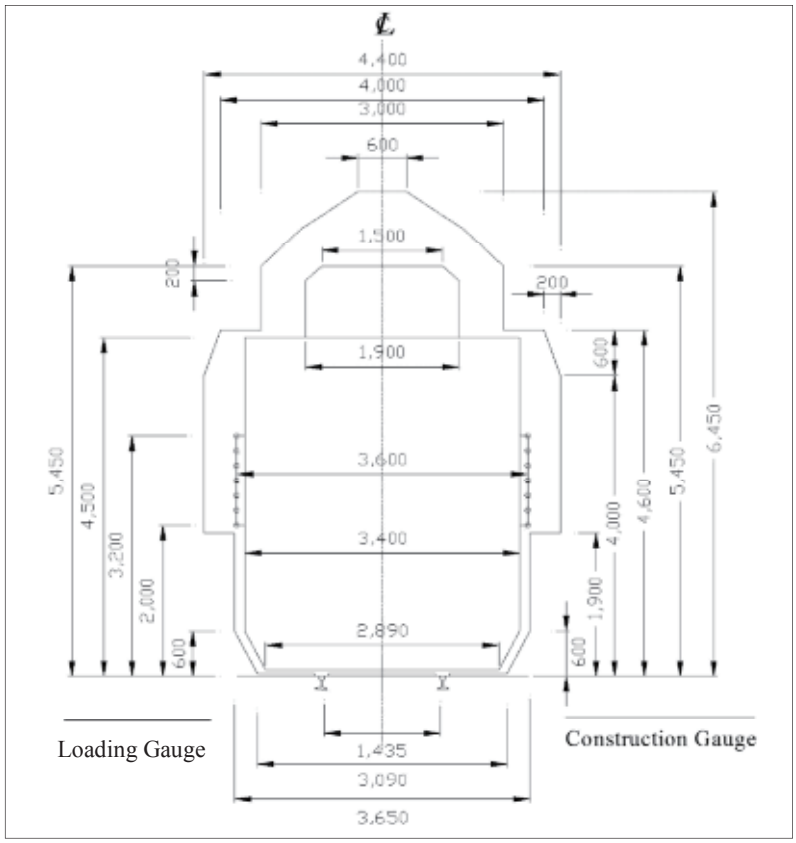



Figure 3.2-1 Construction Gauge and Loading Gauge

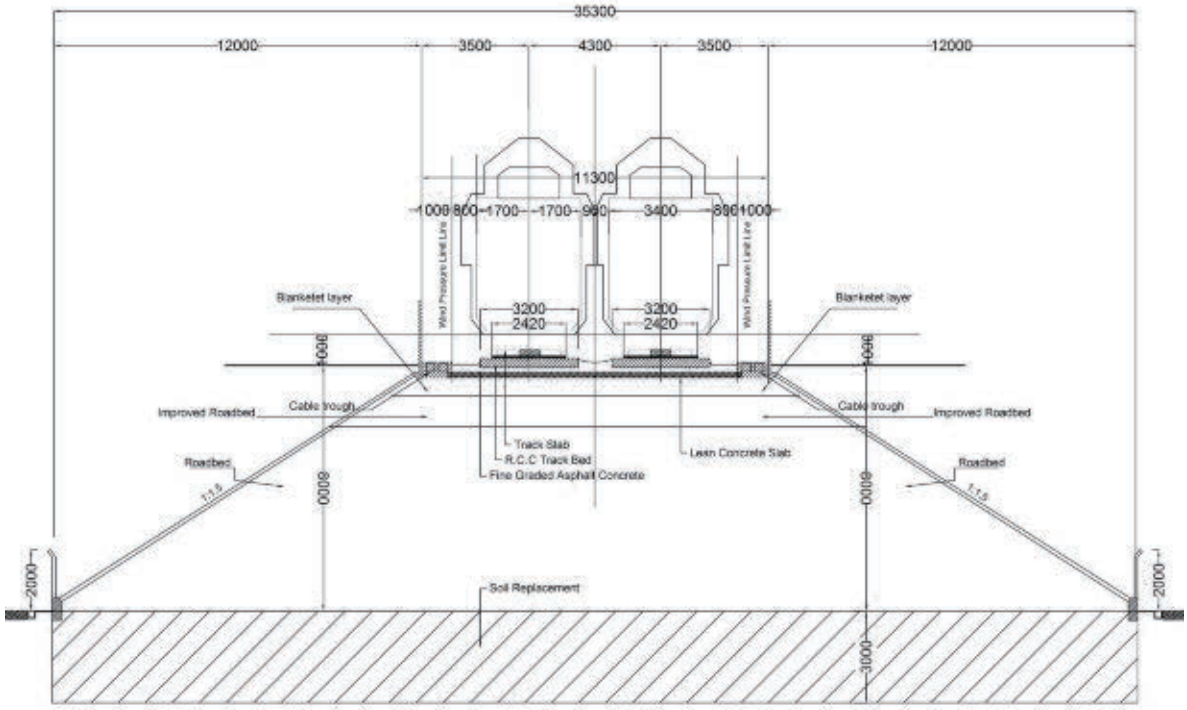



Figure 3.2-2 Cross-section of Embankment (slab section)

(5) Route plan

The Mumbai–Ahmedabad section is a long line with a total length of 500 km. In view of the distribution of cities on the line, we determined that the line would have 11 stations, with an average of 50-km interval between them. The study reviewed the original proposal on the assumption that the major stations in Mumbai, Ahmedabad, and Vadodara would be set up in the city centers or added to the existing conventional line stations. While avoiding the areas that would require environmental considerations, such as densely populated areas and national parks, we designed the route with alignment and gradient that would be suitable for high-speed operation.

Because the Mumbai station in the original proposal would be in the city center, the study planned to build a tunnel under the Thane Creek due to consideration for the existing urban areas and natural parks. If the original proposal is adopted, we will need to work on a detailed design and construction plan, including studies to verify the geology of the seabed under the Creek.

On the other hand, the study also put together a significant cost reduction proposal that would drastically reduce the project cost. In the significant cost reduction proposal, the Thane station in the original proposal will serve as the Mumbai station and no Mumbai station will be built. The Ahmedabad station will not connect to the existing station but it will be built in the suburbs to reduce the project cost.

As for the black cotton soil, which is a special soil, they mentioned the need to conduct detailed survey to find out its distribution, study soil characteristics, forecast consolidation settlement, and formulate counter measures.

Furthermore, due to the existence of many crossing points with big rivers, the relevant authorities shall be consulted on the bridge spans and types of structures, etc.


Figure 3.2-3 New HSR Line and Station Locations

### (6) Demand estimates

Looking at demand estimates for HSR being discussed here, estimates for the original proposal show that the maximum cross-sectional traffic volume for the section will be approximately 25,300 passengers/day (both directions, commencement of service in 2020) to approximately 199,000 passengers/day (both directions, 2050), while estimates for the vastly cheaper proposal show that the maximum cross-sectional traffic volume for the section will be approximately 21,300 passengers/day (both directions, commencement of service in 2020) to 178,000 passengers/day (both directions, 2050). It should be noted, however, that the access and egress time of high-speed railway stations from city centres of the vastly cheaper proposal do not take the effects of traffic congestion and other factors into account.

### (7) Fare-setting

When setting fares, the study conducted estimates based on an analysis of the fares that would generate the maximum amount of fare revenue from the fare-demand relationship using the results of a "stated preference" (SP) survey (survey of degree of preference by passengers of selected transport modes) that was conducted within another study (other route) in India.

### (8) Project cost

The project cost under this plan is Rs.754.5 billion (at the time of service commencement). The per-kilometer cost of the project is estimated to be Rs.754.5 billion / 498.52 km = Rs.1.513 billion per kilometers.

In the case of the vastly cheaper proposal*, the project cost Rs.542.9 billion (at the time of service commencement). The per-kilometer cost of the project is estimated to be Rs.542.9 billion / 448.2 km = Rs.1.21 billion per kilometer.

It should be noted that import duties and value-added tax, which were not include in the project cost of the 2009 pre-feasibility study (India), are similarly not calculated in the project costs of this study.

*The vastly cheaper proposal does not consider placing the Mumbai station in the city centre, but rather makes the Thane station of the current plan the terminus for the Mumbai metropolitan area. Moreover, for the Ahmedabad station, it does not envisage line extension to the existing Ahmedabad Station, but rather will establish a terminus for the Ahmedabad metropolitan area at a location outside the Ring Road. Consequently, it will be necessary to separately develop means of linking these high-speed railway stations with the city centers. The proposal makes no particularly noteworthy changes regarding the intermediate stations.

### (9) Economic Analysis

The EIRR, NPV, and CBR for this route are calculated as follows:

Table 3.2-5 Summary of Economic Cost and Benefit Cash Flow

| | EIRR | NPV | CBR |
|---|---|---|---|
| Route 1 | 18.7% | Rs. 360,250 million | 1.98 |

Because the EIRR of the surveyed route will exceed the 12% opportunity cost of capital in India, this project was confirmed to be beneficial to the economy and society.

### (10) Financing Plan and Project Model

Table 3.2-6 shows the two basic cases for review in this Study:

Table 3.2-6 Basic Cases for Review

| Project scheme | | Superstructures | Substructures |
|---|---|---|---|
| 1. Two-tiered (public project) | Entity | Public | Public |
| | Funding source | Yen loan | STEP |
| 2. Two-tiered (superstructures: PPP, substructures: public project) | Entity | Public | Private (+ Public) |
| | Funding source | Yen loan | Project finance |

Source: Compiled by Study Team

The following are main results of the study:
i) Separation of Superstructures and Substructures (Public Project)
The Project FIRR became 1.6%, which exceeded the interest rate shown in the Japanese ODA loan conditions table for low-income countries. In addition to yen loan, this approach can also use STEP. This will make the financing cost the lowest among the two cases, making it easy to implement the project. It is the ideal case but the concerned parties must share the risks.

ii) Separation of Superstructures and Substructures (Superstructures: PPP, Substructures: Public Project)
For the superstructures, the Project FIRR (8.0%) is lower than the WACC (8.7%), making the approach not viable as a PPP project. To obtain project finance, the concerned parties must share the risks appropriately. The availability payment method shall be considered but the SPV must not bear any demand risk. The use of project finance will make the financing cost the highest among the two cases mentioned above.

## 3.3 Review on Transport Related Sector

### 3.3.1 Present Situation of Existing Traffic Mode and Future Plans

All the main three main modes of transport (Railways, Highways and Airways) are widely used for travel in the study corridor. They are discussed as below.

#### (1) Railways

IR is organized into 17 railway zones. Refer to Figure 3.3-1. Most of the HSR study corridor comes under Western Railway Zone (Zone No. 9) and the Mumbai to Thane stretch comes under Central Railway Zone (Zone No. 8).

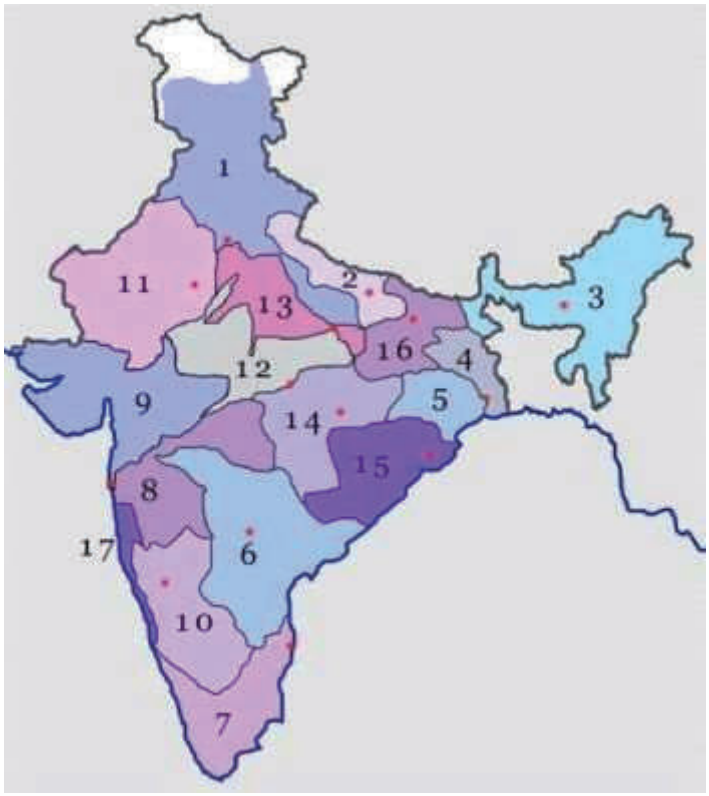



Figure 3.3-1 Zones of IR

#### 1) Western Railways

The Western Railway zone, with its headquarters at Mumbai Church gate, stretches from Mumbai Church gate station and goes up to Ahmedabad and beyond. The railway zone is further divided into six operating divisions: Vadodara, Ahmedabad, Rajkot, Bhavnagar, Ratlam and Mumbai.

Main stations in this zone are Vadodara railway station, Ahmedabad station, Surat station and Mumbai Church Gate station. Vadodara railway station being the junction point for the Ahmedabad - Mumbai route and the Mumbai - Delhi route is the busiest junction station in Western Railways. Surat railway station is also one of the main railway station in Western Railway where more than 160 trains passes per day.

Out of the 11 proposed HSR stations, except for Thane Station, all the other 10 stations fall in Western Railways.

## 2) Central Railway

The Central Railway is one of the largest of the 17 zones of IR. Its headquarters is in Mumbai at Chhatrapati Shivaji Terminus (formerly Victoria Terminus). The Central Railway covers a large part of the state of Maharashtra and small part of Southern Madhya Pradesh and North-Eastern Karnataka. Mumbai CST to Nagpur, and Mumbai CST to Pune are the main lines. Kalyan is a main Junction of Central Railway where trains split for Nagpur or Pune.

The Proposed HSR Thane station comes under Central railway.

Table 3.3-1Total No. of Railway seats (AC class) in the study corridor

| S.No. | Section | Class | | | | Total |
|---|---|---|---|---|---|---|
| | | 1 AC | 2 AC | CC | EC | |
| 1 | Mumbai Central - Ahmedabad Jn | 60 | 400 | 1668 | 30 | 2158 |
| 2 | Mumbai Central - Vadodara | 92 | 497 | 1192 | 10 | 1791 |
| 3 | Mumbai Central – Surat | 51 | 415 | 1307 | 7 | 1780 |
| | **Total** | | | | | **5729** |
| 1 | Ahmedabad Jn - Mumbai Central | 89 | 520 | 1603 | 25 | 2237 |
| 2 | Ahmedabad Jn - Vadodara | 40 | 289 | 790 | 27 | 1146 |
| 3 | Ahmedabad Jn - Surat | 49 | 396 | 1033 | 21 | 1499 |
| | **Total** | | | | | **4882** |
| 1 | Surat - Mumbai Central | 64 | 360 | 899 | 17 | 1340 |
| 2 | Surat - Vadodara | 49 | 303 | 1021 | 14 | 1387 |
| 3 | Surat - Ahmedabad Jn | 38 | 306 | 921 | 20 | 1285 |
| | **Total** | | | | | **4012** |
| 1 | Vadodara - Mumbai Central | 57 | 437 | 1223 | 13 | 1730 |
| 2 | Vadodara - Surat | 60 | 522 | 752 | 0 | 1334 |
| 3 | Vadodara - Ahmedabad Jn | 30 | 199 | 513 | 4 | 746 |
| | **Total** | | | | | **3810** |

1AC : 1st AC, 2AC: 2nd AC, CC: Chair car, EC: Executive Chair

Table 3.3-2 Fares (in Rs.) between Major Railway Stations

| S.No. | Section | 1 AC | 2 AC | CC | EC |
|---|---|---|---|---|---|
| 1 | Mumbai Central - Ahmedabad Jn | 1685 | 1000 | 665 | 1680 |
| 2 | Mumbai Central - Vadodara | 1470 | 880 | 500 | 1330 |
| 3 | Mumbai Central - Surat | 1275 | 785 | 400 | 1055 |
| | | | | | |
| 1 | Ahmedabad Jn - Mumbai Central | 1710 | 1020 | 660 | 1635 |
| 2 | Ahmedabad Jn - Vadodara | 1145 | 685 | 290 | 670 |
| 3 | Ahmedabad Jn – Surat | 1145 | 690 | 385 | 965 |
| | | | | | |
| 1 | Surat - Mumbai Central | 1140 | 755 | 430 | 1095 |
| 2 | Surat – Vadodara | 1145 | 690 | 285 | 660 |
| 3 | Surat - Ahmedabad Jn | 1150 | 685 | 410 | 1020 |
| | | | | | |
| 1 | Vadodara - Mumbai Central | 1460 | 875 | 520 | 1415 |
| 2 | Vadodara – Surat | 1210 | 725 | 260 | 0 |
| 3 | Vadodara - Ahmedabad Jn | 1145 | 690 | 325 | 725 |

1AC : 1st AC, 2AC: 2nd AC, CC: Chair car, EC: Executive Chair

### (2) Highways

#### 1) National Highway No. 8 (NH8)

NH8 connects the Indian capital city of New Delhi with the Indian financial capital city of Mumbai. It is considered to be one of the busiest Highway in India and is part of Golden Quadrilateral project undertaken by NHAI. It passes through important cities like Delhi, Gurgaon, Jaipur, Ajmer, Udaipur, Ahmedabad, Vadodara and Surat and Mumbai.

NH8 is the main National Highway that runs in this corridor and will also be studied while preparing forecasts for HSR.

#### 2) Ahmedabad Vadodara Expressway (AVE)

The Ahmedabad Vadodara Expressway, (also known as National Expressway 1, or the Mahatma Gandhi Expressway) is an toll expressway connecting the cities of Ahmedabad and Vadodara. It is a 96 km long expressway, fullyfenced on both sides and having two exits, one at Nadiad and second at Anand. Two-wheelers are not allowed on this expressway. It is a 4-lane expressway and is presently being upgraded to 6-lane expressway. It is the main highway for road users for travel between Ahmedabad and Vadodara.

#### 3) Proposed Vadodara-Mumbai Expressway (VME)

VME is planned as an access-controlled 6/8 lane Expressway from Vadodara to Mumbai (JNPT port), is 474 km long. On the Mumbai side, it is planned to end very close to the upcoming International Airport in Navi Mumbai. It is also planned to connect with Mumbai- Pune expressway which will have 12 interchanges.


Figure 3.3-2 Route Alignment of Vadodara-Mumbai Expressway

Table 3.3-3 Salient Features of Vadodara-Mumbai Expressway

| S. No. | Features | No./ Particulars |
|---|---|---|
| 1. | Length | Total 473 Km<br>Divided into 3 phases (Phase-I 274 Km, Phase II 173Km, Phase-III 26Km. |
| | Phase-I | 274.02 Km<br>(260.41 Km in Gujarat + 5.46 Km in Dadra & Nagar Haveli + 8.15 Km in Maharashtra) |
| 2. | Lane | 6/8 lane |
| 3. | Civil Construction Cost | Rs. 10,253.82 Cr. |
| 4. | Total Project Cost(TPC) | Rs. 14703.00Cr.(Rs.53.66 Cr. Per Km) |
| 5. | Concession Period | 30 Years |
| 6. | Construction Period | 4 Years |
| 7. | Traffic Range | 52,425-72,648 PCUs (2013) and 20646 only in 4 Km |
| 8. | Premium / VGF with 15% IRR | Premium Rs. 300.00 cr. Per year |
| 9. | Land Acquisition | Total Land required :3450.04 Hectare<br>Land in possession : Nil<br>Balance land to be acquired : 3450.04 Hectare<br>3(a) : Published |

| | | |
|---|---|---|
| | | 3 (A) : 2025.6 Hectare (58.71%)<br>1276.16 Hectare (in advance stage)(34.10%) |
| 10. | Forest Clearance | case submitted and in process. |
| 11. | MOEF Clearance | TOR for environment clearance approved on 30.10.2013. Environment Impact Assessment (EIA) under study. Thereafter 2nd stage clearance shall be sought. |
| 12. | GAD | Drawing of Road Over Bridge for all 7 ROBs are in advance stage of approval by Railways. |
| 13. | Wildlife clearance | NOC from National Wild Life Board required in Dadra & Nagar Haveli (on account of being within 10 Km of notified wild life boundary). Request for NOC made on 07.02.2013. |
| 14. | CRZ Clearance | Required for 1.925 Km length in Gujarat State for which State recommendation has been forwarded to MOEF for approval. |

### 4) Study on Multi-modal corridor

MMRDA is conducting a study on a 100km stretch from Vasai-Virar to Alibag. They call this stretch as multi-modal corridor because it has both rail and road. Louis Berger is conducting this study.

### (3) Airways

There are four major airports in the study area, Mumbai, Ahmedabad, Vadodara and Surat airport. The table below shows the present number of seats for each route from these main airports.

Table 3.3-4 Daily no of Airways Seats for Each Route in the Study Corridor

| S.No. | Air Route | First Class | Executive | Economy | Classic | Total |
|---|---|---|---|---|---|---|
| 1 | Mumbai - Ahmedabad | 4 | 159 | 2771 | 200 | 3134 |
| 2 | Ahmedabad - Mumbai | 0 | 164 | 2636 | 0 | 2800 |
| | **Sub-Total** | **4** | **323** | **5407** | **200** | **5934** |
| 3 | Mumbai – Vadodara | 0 | 96 | 792 | 0 | 888 |
| 4 | Vadodara - Mumbai | 0 | 64 | 856 | 0 | 920 |
| | **Sub-Total** | **0** | **160** | **1648** | **0** | **1808** |
| 5 | Mumbai – Surat | 0 | 0 | 189 | 0 | 189 |
| 6 | Surat – Mumbai | 0 | 0 | 189 | 0 | 189 |
| | **Sub-Total** | **0** | **0** | **378** | **0** | **378** |

### (4) Bus Transport

Buses are also used widely for long-distance travel in the study corridor. The availability of AC class buses between main routes is given below in the Table.

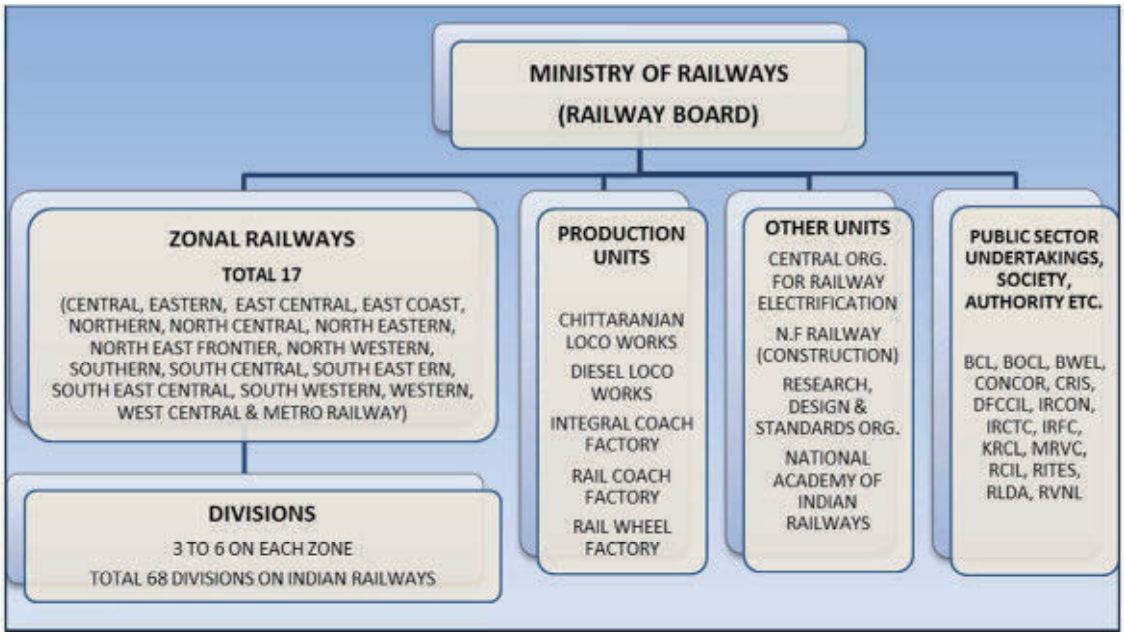
Table 3.3-5 Daily no of Bus Seats (AC Class) between Major Cities in the Study Corridor

| S.No | Bus Route | Bus Class | | | Total |
|---|---|---|---|---|---|
| | | AC | VOLVO | MERECEDES | |
| 1 | AHMEDABAD - SURAT | 497 | 531 | 48 | 1076 |
| 2 | AHMEDABAD - MUMBAI | 564 | 627 | 96 | 1287 |
| 3 | AHMEDABAD - VADODARA | 465 | 1134 | 90 | 1689 |
| | **Total** | **1526** | **2292** | **234** | **4052** |
| | | | | | |
| 1 | VADODARA - SURAT | 165 | 133 | 72 | 370 |
| 2 | VADODARA - MUMBAI | 520 | 489 | 96 | 1105 |
| 3 | VADODARA - AHEMDABAD | 276 | 941 | 48 | 1265 |
| | **Total** | **961** | **1563** | **216** | **2740** |
| | | | | | |
| 1 | SURAT - VADODARA | 140 | 229 | 48 | 417 |
| 2 | SURAT - MUMBAI | 300 | 364 | 48 | 712 |
| 3 | SURAT - AHEMDABAD | 197 | 449 | 96 | 742 |
| | **Total** | **637** | **1042** | **192** | **1871** |
| | | | | | |
| 1 | MUMBAI - SURAT | 205 | 580 | 46 | 831 |
| 2 | MUMBAI - VADODARA | 392 | 657 | 46 | 1095 |
| 3 | MUMBAI - AHEMDABAD | 307 | 773 | 48 | 1128 |
| | **Total** | **904** | **2010** | **140** | **3054** |

### 3.3.2 Organization of Ministry of Railways, Republic of India (MOR)

#### (1) Structure

IR has a three tier structure. At the apex level is MOR and the Railway Board which is the main policy and long range decision making body on IR. The Ministry is headed by a Cabinet Minister who is assisted normally by two Ministers of State. The Railway Board consists of a Chairman and six members, each of whom is in charge of a functional discipline. At the next tier, the 64,600 Km rail network is divided into seventeen Railway Zones each of which is headed by a General Manager with Principal Heads of Departments for each functional area under him. At the third tier Operations & Maintenance at the field level of the network are managed by the 'Divisions' each of which is headed by a Divisional Railway Manager who is assisted by Branch officers belonging to each discipline. There are a total of sixty eight Divisions on IR. The Railway Board also controls Production Units, the Research, Designs & Standards Organization, a Central Organization for Railway Electrification, and a Construction Organization for projects on North East Frontier Railway apart from a few others. The Ministry also has under its charge Public Sector Undertakings which operate in a wide range of activities e.g. consultancy, construction, container transportation, catering & tourism, wagon manufacture etc. The broad structure is indicated in the Figure 3.3-3.




Source: Compiled by Study Team

Figure 3.3-3 IR Organization Structure Showing Main Units

#### (2) Railway Board

##### 1) Railway Board

The Board was constituted under a resolution of the Government of India in 1905. Under the provisions of the Indian Railway Board Act 1905, the Railway Board has been vested with certain powers of the Central Government under the then Indian Railway's Act, 1890 (now Railway's Act 1989). Apart from its functions as the top Railway executive body for the administration, technical supervision and direction of the Railways, the Railway Board also functions as a Ministry of the Government of India and exercises all the powers of the Central Government in relation to railways. The Railway Board itself is a structure along functional lines. The broad distribution of responsibilities amongst the Chairman and Members of the Board are as indicated in the Table 3.3-6. Although individual members have full powers to take

routine decisions within their areas of responsibility all important policy decisions are taken jointly by the Board. In order to support the functioning of each member there are directorates in each specialist area and a hierarchy of Additional Members, Advisers, Executive Directors, and Directors in the various functional areas.

Table 3.3-6 Railway Board Members and their Areas of Responsibility*

| | BOARD MEMBER | MAIN AREAS OF RESPONSIBILITY |
|---|---|---|
| 1 | **Chairman Railway Board** | Corporate Coordination, Planning, Efficiency & Research, Public Relations, Consultancy Services and Export Promotion, Safety, Vigilance & Information Technology |
| 2 | **Financial Commissioner** | Accounts, Finance, Statistics and Economics, MIS |
| 3 | **Member Traffic** | Transportation, Commercial, Catering & Tourism, Coaching, Computer & Information services |
| 4 | **Member Engineering** | Civil Engineering including Track & Works, Projects, Land Management |
| 5 | **Member Mechanical** | Mechanical Engineering, Mechanical Engineering Workshops, Mechanical Engineering Production Units, Railway Stores |
| 6 | **Member Electrical** | Electrical Engineering, Electrical Engineering Production Unit, Railway Electrification, Signalling & Telecommunication |
| 7 | **Member Staff** | Labour Policy, Industrial Relations, Establishment, Legal Affairs, Management Services, Health, Security & Intelligence |

*Based on Office Order No 11 of 1998 of MOR & further modifications to it.
Source: Compiled by Study Team

### 2) The Zonal Railways

The Railway network is divided into 17 geographical based zones spread throughout the country. Each Zonal Railway is further divided in to 3 to 6 Divisions for efficient management of the physical infrastructure, rolling stock and manpower resources. The seventeen Zonal Railways, the route kilometers under each, the Zonal headquarter and number of Divisions is mentioned in the Table3.3-7.

Table 3.3-7 Zones, Headquarter Station, No. of Divisions and Route Kilometres

| Zonal Railway, Headquarter | No. of Div. | Route Kms. | Zonal Railway, Headquarter | No. of Div. | Route Kms. |
|---|---|---|---|---|---|
| Central Railway, Mumbai | 5 | 3,905 | North Western Railway, Jaipur | 4 | 5,502 |
| Eastern Railway, Kolkata | 4 | 2,447 | Southern Railway, Chennai | 6 | 4,994 |
| East Central Railway, Hajipur | 5 | 3,656 | South Central Rly., Secunderabad | 6 | 5,810 |
| East Coast Railway, Bhubaneshwar | 3 | 2,676 | South Eastern Railway, Kolkata | 3 | 2,661 |
| Northern Railway, New Delhi | 5 | 6,990 | South East Central Rly, Bilaspur | 3 | 2,455 |
| North Central Railway, Allahabad | 3 | 3151 | South Western Railway, Hubli | 3 | 3,191 |
| North Eastern Railway, Gorakhpur | 3 | 3,767 | Western Railway, Mumbai | 6 | 6,440 |
| North East Frontier Railway, Maligaon | 5 | 3,965 | West Central Railway, Jabalpur | 3 | 2,965 |
| | | | Metro Railway, Kolkata | 1 | 25 |

Source: Indian Railways Year Book 2011-12

Whereas policy decisions, major investment decisions, fund allocation and co-ordination functions are undertaken by the Railway Board the day to day management of the Railway is done by the Zonal Railways. The operations and maintenance functions rest wholly with the Zonal Railway as does basic planning, execution of works, the customer interface and achieving physical and financial targets. The General Manager exercises significant administrative and financial powers. Some of these are delegated to the Principal heads of Departments and

Divisional Railway Managers. Harmonious industrial relations are yet another important objective of the Zonal management. The General Manager is assisted by an Additional General Manager and a team of Principal Heads of Departments who have various Heads of Department under them as shown the Figure3.3-4. There are 3 more tiers in the hierarchy at the Zonal Headquarters below what is shown in this chart. Each Principal Head of Department and other Heads of Department under them bring expertise in the areas under their control. Each Department is allocated a budget which relates to routine working expenses such as salaries and allowances, procurement of stores, fuel and sanctioned new works to be carried out during the year. Each functional area is also set targets by the General Manager at the beginning of the year. Targets for example in operations are in terms of originating freight tonnage to be loaded and rolling stock utilization in case of freight and punctuality performance in passenger train operations, in commercial area it is financial revenue targets for passenger and freight, for Rolling stock maintenance it is in terms of locomotive, coach and wagon availability with a target for ineffective stock, similarly targets are set for performance of workshops and maintenance depots (i.e. No. of wagons/locomotives/coaches to be overhauled or repaired in each period), in case of civil engineering, signal & telecom and electrical assets it is in terms of reliability of assets with the objective of minimising failure of various assets. Decision making at various levels is with the objective of achieving the targets that have been set whether they be productivity related or for ensuring asset reliability.

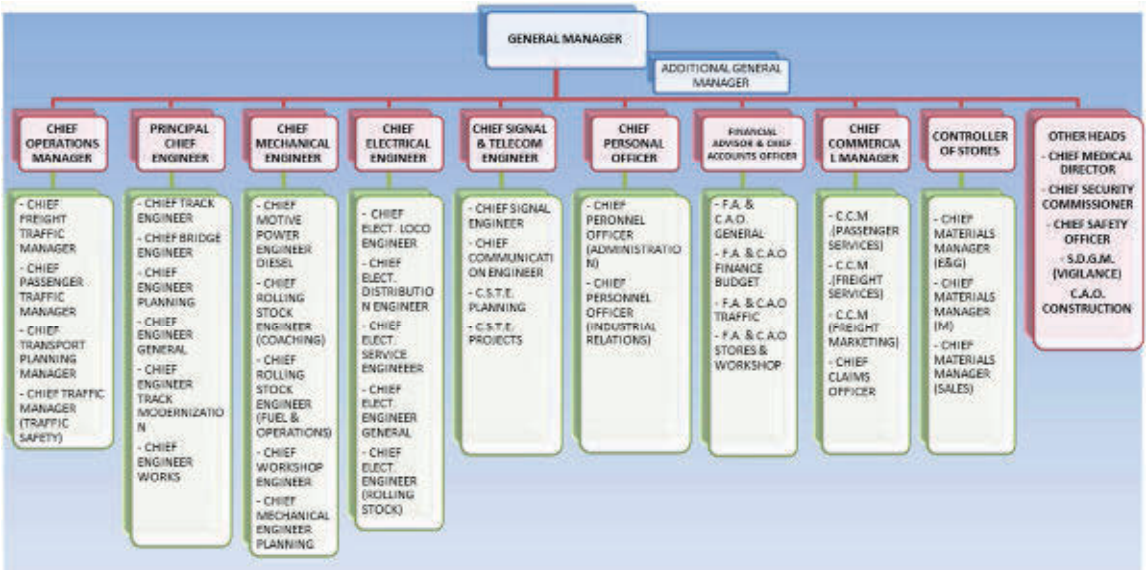
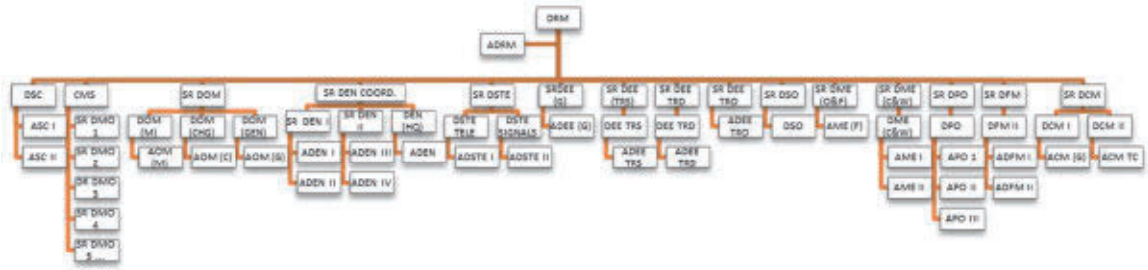



Figure 3.3-4 Senior Management at the Zonal Headquarters

### 3) The Divisional Level

This is the level in Railway management which directly controls firstly all the field assets viz., locomotives, wagons, track, signals, telecommunication assets, overhead electrical equipment etc. and they also control all the field staff involved in operations and maintenance such as station masters, locomotive drivers, trackmen, signal maintainers, ticket collectors etc. The managerial cadre at the divisional level is shown in Figure 3.3-5 and reflects the various specialized functional disciplines required in the effective management of a railway system. Number of officers may vary from Division to Division depending upon workload. The various 'Branch officers' on a Division viz. Sr. Divisional Operations Manager, Sr. Divisional Engineer, Sr. Divisional Signal & Telecom Engineer, Sr. Divisional Electrical Engineer, Sr. Divisional Financial Manager etc. work under the direct administrative control of the Divisional Railway Manager and are responsible to him for delivering results, however for professional guidance in their respective functional area they depend on the Principal Head of Department at the Zonal

Headquarter. Therefore, in the direct chain of command the come under the Divisional Railway Manager, however, they have a 'dotted line' relationship with their Principal Head of Department at the Headquarter office with respect to the professional area they are in charge of. Below the 'Branch officer' there are two more levels in the Divisional hierarchy for example in Civil Engineering under the Senior Divisional Engineer there are Divisional Engineers and below them are Assistant Engineers. Below the Assistant Engineers, Assistant Operations Manager etc. is a very important category described as Senior Supervisors who have designations like Senior Section Engineer (Permanent Way), Section Engineer (Signals), Traffic Inspectors, Commercial Inspectors, Electrical Foremen, Chief Train Examiner etc. These supervisors actually inspect and supervise the work of field workers and provide an interface between managerial cadres and the field employee.



SR – SENIOR, DSC – DIVISIONAL SECURITY COMMISSIONER, CMS – CHIEF MEDICAL SUPERINTENDENT, DOM – DIVSIONAL OPERATIONS MANAGER, DEN – DIVISIONAL ENGINEER, DSTE – DIVISIONAL SIGNAL & TELECOM ENGINEER, DEE – DIVISIONAL ELECTRICAL ENGINEER, DSO – DIVISIONAL SAFETY OFFICER, DME – DIVISIONAL MECHANICAL ENGINEER, DPO – DIVISIONAL PERSONNEL OFFICER, DFM – DIVISIONAL FINANCE MANAGER, DCM – DIVISIONAL COMMERCIAL MANAGER, DMO – DIVISIONAL MEDICAL OFFICER, PREFIX 'A'-ASSISTANT, G – GENERAL, TRD TRACTION DISTRIBUTION, TRS TRACTION ROLLING STOCK, TRO TRACTION OPERATION, C&W – CARRIAGE & WAGON, O&F – OPERATIONS & FUEL

Figure 3.3-5 Organization of the Managerial Cadre at the Divisional Level

### (3) Production Units & Public Sector Under Takings

#### 1) Production Units

These are large manufacturing units where Rolling Stock or their components are manufactured. The units are directly controlled by the Railway Board and the main units are under the charge of a General Manager. The units are: (i) Chittaranjan Locomotive Works (CLW), set up initially to make Steam locomotives later began production of Electric Locomotives and produced 246 Electric Locos in 2011-12 including 76 state of the art 3 phase 6000 H.P. Locomotive, (ii) Diesel Locomotive Works (DLW), Varanasi which manufactured 259 locomotives in 2011-12 including 190 High Horse Power Locomotives, (iii) Integral Coach Factory (ICF), Chennai manufactures Coaches and produced 1511 coaches in 2011-12 including Electric Multiple Units and Diesel Electric Multiple units, (iv) Rail Coach Factory (RCF), Kapurthala which manufactured 1421 coaches of various types in 2011-12, (v) Rail Wheel Factory (RWF), Bengaluru produces wheel and axles and manufactured in 2011-12 over 70,000 wheel sets, 2,00,000 wheels and 1,00,000 axles. (vi) Diesel Loco Modernisation Works, Patiala is involved in remanufacturing traction motors and engine blocks for upgrading Diesel locomotives. New Production Units are also being set up which include a Rail Coach factory at Raebareli, a Rail Wheel Plant at Bela (Bihar), Rail Coach Factory at Palakkad (Kerela), a Diesel Component factory at Dankuni and two new Locomotive Manufacturing Units are planned at Marhowrah (Diesel) and Madhepura (Electric) in Bihar. In most countries such Manufacturing units are in the private sector, however, in India the Ministry has decided to continue these plants in the Public Sector under their direct control. For the new Loco plants proposed, however, Private sector J.V. partners are being sought.

#### 2) Public Sector Undertakings PSUs

MOR has over a dozen Public Sector undertakings under it. These Companies are run under Company's Act like any other corporation however the entire equity in these companies had

been subscribed by MOR. The Companies are run by a Board of Directors with a Chairman cum Managing Director at the helm. There are some official Directors nominated by MOR, however, the Government has also appointed independent Directors on their Boards. The Companies are independent in their decision making and pay dividend to the Government of India. The Companies are professionally managed and in most cases have grown manifold since their formation and are very successful business ventures. Among the more important PSUs are (i) RITES, a total transport engineering & management consultancy organization with a Turnover of Rs.934 Crores and net Profit of Rs164 Crores in 2011-12, (ii) IRCON a construction company that has diversified into several infrastructure sectors both in India and abroad. The Company had a Turnover of Rs.3782 Crores and Profit after Tax of Rs.470 Crores in 2011-12. (iii) Indian Railway Finance Corporation (IRFC) raises money for procuring Rolling Stock which is leased to IR. Till 2011-12 it had leased Rolling Stock Assets worth Rs.82,409 Crores to IR and that year had a Net Profit of Rs.481 Crores, (iv) Container Corporation of India (CONCOR) was set up to promote multi-modal transport and logistics for container operations and is today a carrier, terminal operator and warehouse/ CFS operator. It transported 2.6 million TEU in 2011-12 and had a Turnover of Rs.4061 Crores and paid dividend of Rs.214.7 Crores on its paid up Capital in that year. Other PSUs include Railtel Corporation of India Ltd. (RCIL) in the Telecom sector, Indian Railway Catering and Tourism (IRCTC) involved in Catering and Tourism, Rail Vikas Nigam Ltd. (RVNL) for augmenting Rail Capacity by taking up Infrastructure building works and DFC Corporation of India Ltd. (DFCCIL) for constructing and operating DFR. Government is also keen on disinvesting in many PSUs to firstly raise funds for itself and secondly to improve professionalism and accountability. In case of CONCOR 37% of the shareholding has already been disinvested.

### (4) IR Personnel

#### 1) Manpower strength & Categories

IR is one of the largest organizations in India and the largest amongst world railways in terms of staff employed. On 31st March 2012 the total manpower on IR was 1.3 million. IR has been consciously and progressively reducing staff strength through a process of natural attrition as a result of which the strength has come down from a level of about 1.7 million in the mid nineteen eighties. Employees are categorized into four Groups viz. Group 'A', 'B', 'C' and 'D'. At the apex level is Group 'A' officers who are recruited by the Union Public Service Commission through a competitive examination at a young age after they have completed their graduation/ post-graduation from University / Engineering Colleges. After joining they are trained at specialized training institutions and are under probation for two years. They join one of the several specialist 'Cadres' of the Central Services e.g. Indian Railway Service of Engineers (IRSE), Indian Railway Service of Mechanical Engineers (IRSME), Indian Railway Traffic Service (IRTS), Indian Railway Service of Electrical Engineers (IRSEE), Indian Railway Accounts Service (IRAS) etc. Group 'B' officers are those who after working at the supervisory level through a selection process are promoted to the managerial cadres. Supervisors, artisan staff, Station Managers, Booking office personnel, Locomotive Drivers etc. constitute the Group 'C' categories. All other staff working as helpers, cleaning staff and other categories fall in Group 'D'. The total number of staff in various categories is shown in Table 3.3-8. Rising Staff costs including Pension Payments have been a cause for concern in recent years. In 2011-12 over Rs 586.80 billion was spent on staff wages which was about 54% of the ordinary working expenses and with every Central Government Pay Commission Award and increase in Dearness Allowance instalment for Government employees the staff costs increase over which IR has little control.

Table 3.3-8 Category Wise Staff Strength on IR as on 31.03.2012

| CATEGORY | NUMBER | %AGE OF TOTAL |
|---|---|---|
| **GROUP 'A'** | **9,116** | **0.7%** |
| **GROUP 'B'** | **8,197** | **0.6%** |
| **GROUP 'C'** | | **89.0%** |
| (i) Workshop & Artisan | 3,39,018 | 26.0% |
| (ii)Running (Drivers, Guards etc.) | 1,01,591 | 7.8% |
| (iii)Others | 7,21,189 | 55.2% |
| **GROUP 'D'** | | **9.7%** |
| (i) Workshop & Artisan | 33,323 | 2.6% |
| (ii) Others | 93,267 | 7.1% |
| **TOTAL** | **13,05,701** | **100.0%** |

Source: Indian Railways Annual Report & Accounts 2012-13

### 2) Human Resource Management

Considerable emphasis is given to Human Resource Development within the organization. An important aspect is staff training, particularly in safety categories. The Railway devotes a significant effort towards HR Development. In addition to in-house training, railway men are also nominated for acquiring specialized training in other institutions in India and abroad. Employees are encouraged to acquire higher educational qualifications in the specified areas relevant to their work. Training infrastructure and methods are being progressively upgraded. For training of managerial cadres there are a number of Central Training Institutions. These include the National Academy of IR at Vadodara, Indian Railways Institute of Civil Engineering at Pune, Indian Railways Institute of Signal Engineering and Telecommunications at Secunderabad, Indian Railway Institute of Mechanical & Electrical Engineering at Jamalpur, Indian Railway Institute of Electrical Engineering at Nasik and Indian Railway Institute of Transport Management at Lucknow. There are in addition 270 other Training Institutions for Group C&D staff. Training programmes are conducted for new recruits, induction training, refresher courses, specialized theme based programmes etc. Staff welfare is yet another important activity, particularly as employees often are posted at far flung corners of the country with difficult working conditions. I.R. therefore provides residential accommodation to several (44%) of its staff, provides extensive medical facilities to employees through its chain of 125 Hospitals and 586 Health Units, a large number of schools for children of employees, excellent sports and recreation facilities and a network of Holiday Homes and Rest Houses which may be availed by employees. The Personnel Department is involved in manpower planning, organizing training & development programmes, managing establishment records and Industrial Relations.

### 3) Industrial Relations

The Railways have a Permanent Negotiation Mechanism which ensures regular Meetings with recognized unions at all three levels, Divisional, Zonal and National to ensure harmonious relations. The last major Labor Strike took place forty years ago in 1974. Recognition of Unions is through a democratic process where employees periodically vote to decide which Union they owe allegiance to. Only those Unions which secure a third of the total employee votes are then recognized. Normally two Unions are recognized on each Zonal Railway. The Unions have over time adopted a very positive and progressive approach to ensure improved productivity and performance.

## (5) Financial Management

### 1) Parliamentary Control on Railway Finances

IR functions as a Department of the Government of India therefore Parliament exercises a direct control over its Finances. Prior to the year 1924-25 the receipts and payments of the Railways used to be a part of the General Budget of the Government of India. However, based on the recommendations of High level Committee it was decided to separate the Railway Finances from the General Finances of the country and since that year as a result of a 'Separation Convention 1924' the Railway Budget is presented to Parliament a few days prior to the General Budget. This historical legacy continues to this day and is the only country in the world where Railway Budget is presented to Parliament. The funding requirements for the financial year are presented to Parliament in the form of 'Demands for Grants'. These demands are shown in Table 3.3-9 which reflect the various broad categories of activities and expenditure heads involved in running a Railway. The demands are based on a detailed analysis of various components such as wages, materials etc.

Table 3.3-9 'Demands for Grants' under which Funds are Sought from Parliament in the Railway Budget*

| GROUP | DEMAND NO | DEMAND NAME |
|---|---|---|
| POLICY FORMULATION & COMMON SERVICES TO RLYS. | 1 | RAILWAY BOARD |
| | 2 | MISC. EXPENSES (GENERAL) |
| GENERAL SUPERINTENDENCE & SERVICES ON RAILWAYS | 3 | GENERAL SUPERINTENDENCE & SERVICE ON RAILWAYS |
| REPAIRS & MAINTENANCE | 4 | REPAIRS & MAINTENANCE OF WAY & WORKS |
| | 5 | REPAIRS & MAINTENANCE OF MOTIVE POWER |
| | 6 | REPAIRS & MAINTENANCE OF CARRIAGE & WAGONS |
| | 7 | REPAIRS & MAINTENANCE OF PLANT & MACHINERY |
| OPERATIONS | 8 | OPERATING EXPENSES - ROLLING STOCK & EQUIPMENT |
| | 9 | OPERATING EXPENSES – TRAFFIC |
| | 10 | OPERATING EXPENSES – FUEL |
| STAFF WELFARE & RETIREMENT BENIFITS | 11 | STAFF WELFARE & AMENITIES |
| | 12 | MISC. WORKING EXPENSES |
| | 13 | PROVIDENT FUND / PENSION & OTHER RETIREMENT BENIFITS |
| RAILWAY FUNDS & PAYMENT TO GENERAL REVENUES | 14 | APPROPRIATION TO FUNDS |
| | 15 | DIVIDEND TO GEN. REVENUES, REPAYMENT OF LOANS & AMORTIZATION OF OVER CAPITALIZATION |
| WORKS EXPENDITURE | 16 | ACQUISITION, CONSTRUCTION & RELACEMENT OF ASSETS |

*Based on Course Notes of National Academy of Indian Railways

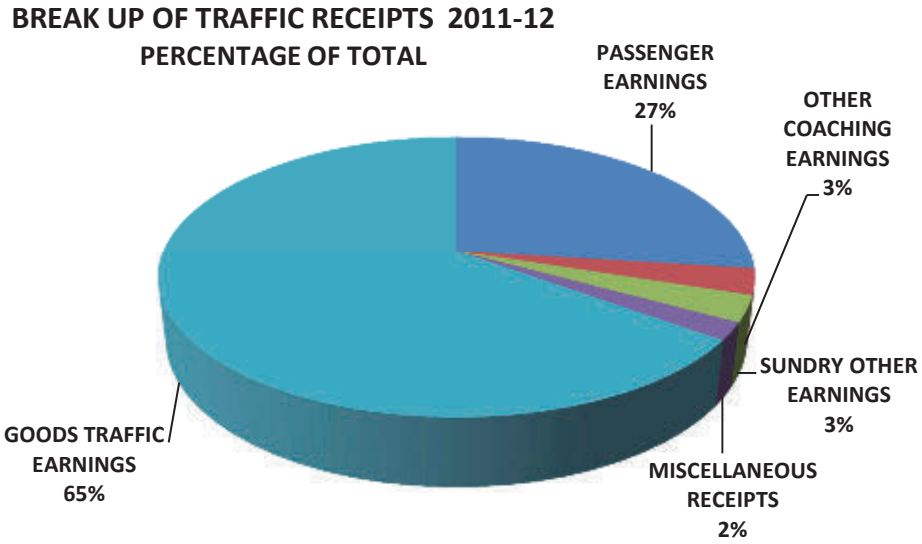
### 2) Traffic Earnings

Traffic Earnings of the Railways are broadly divided into three categories. These include (i) Earnings from Coaching Services which is revenue from Passenger and Parcel traffic, (ii) Earnings from Goods Services i.e. revenue accruing from Freight traffic booked on the railways and (iii) Sundry Earnings from other items & services such as sale of grass and trees along the line, rent for land and buildings, commercial advertisements etc. In addition there are certain Miscellaneous Receipts that include receipts from Railway recruitment Boards, some elements of subsidy from general revenues etc. An interesting point to note is that the receipts from traffic

booked and sundry earnings that railways collect are not directly available for expenditure and are credited to the Consolidated Fund of India. For the purpose of expenditure, money is drawn from the Consolidated Fund of India after the passage of the Railway Budget in Parliament. The proportion of traffic revenue in different categories is shown in Figure 3.3-6.

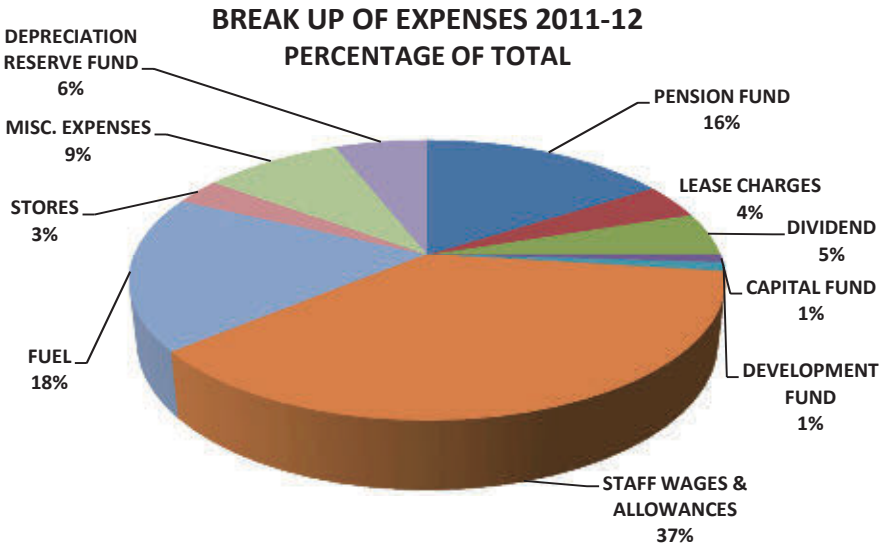
### 3) Revenue Expenditure

Revenue Expenditure comprises of a few categories reflected in the 'Demands for Grants'. These categories are (i) Ordinary Working Expenses incurred in the day to day working of the Railways such as General Superintendence and services, Repairs and Maintenance of Assets, Operating Expenses, Staff Welfare etc. and includes expenditure under Demands 3 to 13, (ii) Other Miscellaneous Expenditure includes expenditure on the Railway Board, Audit, Centralized Training Institutes, Research, Designs & Standard Organization, Surveys etc. i.e. expenditure under Demands No 1 & 2, (iii) Appropriation to various Railway Funds such as the Development Fund, Depreciation Reserve Fund, Pension fund and Capital Fund are also made from Revenue under Demand No 14 and (iv) Dividend Paid by Railways to General Revenues as shown under Demand No 15. The proportion of expenses in different categories is shown in Figure3.3-7.




Source: 2013-14 Explanatory Memorandums: Railway Budget

Figure 3.3-6 Proportion of Traffic Revenue from Different Sources




Source: 2013-14 Explanatory Memorandums: Railway Budget

Figure 3.3-7 Proportion of Expenditure under Different Categories

4) Works Expenditure

This is an important category, for which funds are sought under Demand No. 16, as it deals with expenditure on acquisition, construction, replacement and renewal of assets under various 'Plan Heads' that cover the entire gamut of Railway Working. It represents in the budget the Annual Investment Plan for expanding and upgrading the network, inducting new technology, modernization of assets, acquiring rolling stock, carrying out safety enhancement works etc. The Plan Heads under which various works are sanctioned and funds allocated is shown in Table 3.3-4.

Table 3.3-10 The Annual Investment Plan of the Railways Funds Various Works in the Different Plan Heads or Categories. Individual Works are Listed in the Annual Works Programme*.

| P.H. NO. | PLAN HEAD | P.H. NO. | PLAN HEAD |
|---|---|---|---|
| 11 | NEW LINES | 33 | SIGNALLING & TELECOM |
| 12 | RESTORATION OF DISMANTLED LINES | 35 | ELECTRIFICATION PROJECTS |
| 13 | GAUGE CONVERSION | 36 | OTHER ELECTRICAL WORKS |
| 14 | DOUBLING | 37 | TRACTION DISTRIBUTION WORKS |
| 15 | TRAFFIC FACILITIES | 41 | MACHINERY & PLANT |
| 16 | COMPUTERIZATION | 42 | WORKSHOPS / PRODUCTION UNITS |
| 17 | RAILWAY RESEARCH | 51 | STAFF QUARTERS |
| 21 | ROLLING STOCK | 52 | AMENITIES FOR STAFF |
| 22 | LEASED ASSETS - PAYMENT OF CAPITAL | 53 | PASSENGER AMENITIES |
| 29 | ROAD SAFETY WORKS - LEVEL CROSSINGS | 62 | INVESTMENT IN GOVT.COMM. UNDERTAKINGS |
| 30 | ROAD SAFETY WORKS-ROAD OVER BRIDGES | 63 | INVESTMENT IN NON-GOVT UNDERTAKINGS |
| 31 | TRACK RENEWALS | 64 | OTHER SPECIFIED WORKS |
| 32 | BRIDGE WORKS | 81 | METROPOLITAN TRANSPORT PROJECTS |

*Based on Foundation Course Notes of National Academy of Indian Railways

5) Sources of funds for the Annual Investment Plan

Sources of funds for the Annual Investment Plan are mainly three. Firstly Gross Budgetary Support from the Central Government, secondly, internal generation of resources from within the organization and thirdly extra budgetary sources which include market borrowing by IRFC which is used for acquisition of Rolling Stock which is then leased to IR. Other extra budgetary sources include Private sector funding through Joint Ventures or SPV structures in a PPP arrangement. In 2012-13 for example the budgeted Plan Outlay was Rs.60,100 Crores. This comprised of Rs.24,000 Crores from Gross Budgetary Support, Rs.18,050 Crores from internal resources Rs.16,050 from extra budgetary resources. In addition the Railway received Rs.1,102 from Diesel Cess for Road Safety Works at level crossings and Rs.898 Crores from the Safety Fund,

### 6) Procedure for Sanction of Works

Financial powers have been delegated by the Board to the General Manager who in turn has delegated powers to Principal Heads of Departments and Divisional Railway Managers. Every proposal must be justified in terms of benefits and financial return and must be concurred by the Finance Department. Relatively small works get sanctioned and executed at the Zonal and Divisional level. Larger Works have to be submitted to the Railway Board. Proposals for Works are prepared at the Divisional or Zonal Railway and each proposal must be accompanied by a detailed justification, financial analysis and IRR calculated through a discounted cash flow methodology over the life of the Project. The projects are screened at the Railway Board level and a short list of Projects based on Priority is discussed a Meeting of the Railway Board where it is decided to include or drop projects for the Annual Works Programme. Major Projects such as New Lines, Gauge Conversion Works, Doubling or Railway Electrification costing above Rs. 300 Crores have to get 'in principle' approval & concurrence of the planning Commission and then be approved by an 'extended' Railway Board which apart from all Railway Board Members includes representatives of Secretary, Ministry of Finance, Planning Commission and Secretary, Ministry of Statistics & Programme Implementation. If the 'extended' Railway Board approves a proposal it is submitted to the Cabinet Committee on Infrastructure for final clearance. Works sanctioned by the Railway Board, Cabinet Committee on Infrastructure are included in the Works Programme.

### 7) Financing the 12th Five Year Plan

Planning in India is based on Five Year Plans prepared by India's Planning Commission. Currently the country is in the middle of the 12th Five Year Plan (2012-13 to 2016-17). The Plan for the Rail Sector is ambitious. It highlights the need for investment in DFC, High capacity Rolling Stock, last mile rail linkages and Port Connectivity. On Passenger business it proposes enhancing accommodation in trains, enhancing speed of trains, introduction of tailored services and decongesting major passenger terminals. It has set a target of 1405 million Tonnes of originating freight loading for 2016-17 (2012-13 – 1008 million tonnes) and originating passengers at 11,710 million in 2016-17 (2012-13 – 8640 million passengers). It targets New Line construction at 4,000 Kms, Dedicated Freight Corridors at 3,338 Kms, Gauge Conversion at 5,500 Kms, Doubling at 7,653 Kms and Railway Electrification at 6,500 Kms. This is apart from acquisition of Rolling Stock modernisation of Signalling, developing HSR Corridors and safety enhancement works. The estimated resources required for financing the plan are Rs. 5,19,221 Crores. This is envisaged to be funded by Gross Budgetary Support of Rs. 1,94,221 Crores and Internal and Extra Budgetary Resources of Rs. 2,25,000 Crores including Private Sector investment of Rs. 1,00,000 Crores. This is a challenging task as Private Sector Investment in Railways so far has been small. The Figure 3.3-8 gives the Planning Commission proposal for Funding IR's 12th Five Year Plan.

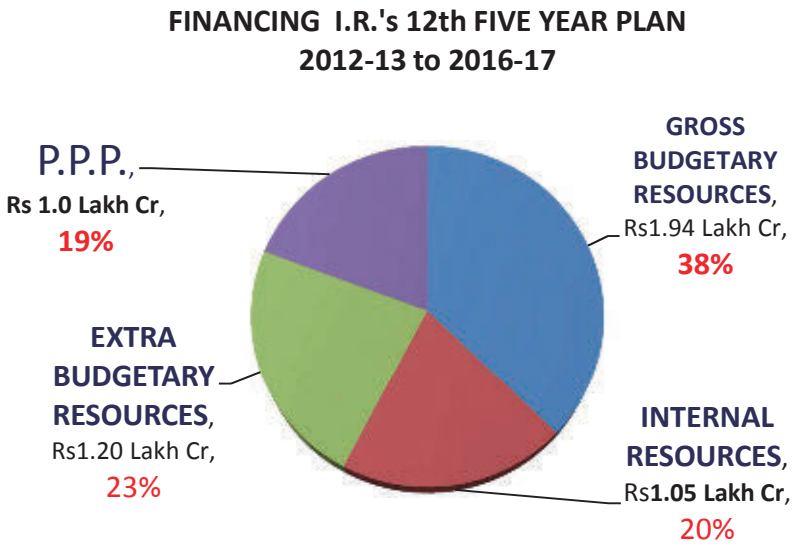



Figure 3.3-8 The 12th Five Year Plan proposes Large Scale Private Investment

### (6) Financial Performance

#### 1) Revenue and Expenditure

Net Revenue and Dividend paid to General Revenues. Dividend is paid on the Capital invested by the Central Government in the Railways. Dividend is paid in perpetuity and the rate of interest is decided periodically by the Parliamentary Convention Committee.

Table 3.3-11 Revenue & Expenditure of Indian Railways 2003-04 to 2012-13

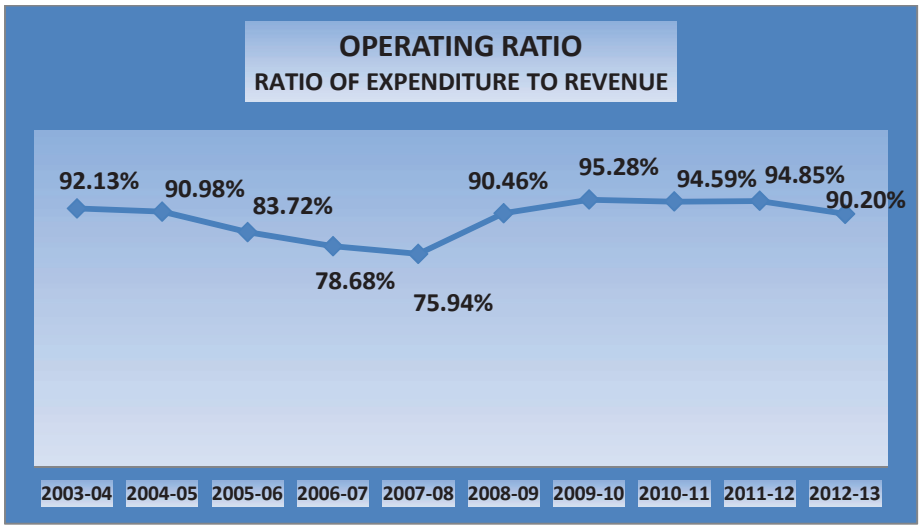
| YEAR | TOTAL RECEIPTS (Rs Crores) | TOTAL EXPENDITURE (Rs Crores) | NET REV. RECEIPTS (Rs Crores) | DIVIDEND TO GEN. REVENUE | EXCESS/ SHORTFALL (Rs. Crores) |
|---|---|---|---|---|---|
| **2003-04** | 44,910.62 | 40,432.13 | 4,478.49 | 3,387.08 | 1,091.41 |
| **2004-05** | 49,046.58 | 43,773.03 | 5,273.55 | 3,199.32 | 2,074.23 |
| **2005-06** | 56,315.51 | 48,309.63 | 8,005.88 | 3,667.92 | 4,337.96 |
| **2006-07** | 64,784.84 | 50,332.71 | 14,452.13 | 4,246.81 | 10,205.32 |
| **2007-08** | 73,276.57 | 54,942.55 | 18,334.02 | 4,902.93 | 13,431.09 |
| **2008-09** | 81,658.98 | 72,484.53 | 9,174.45 | 4,717.67 | 4,456.78 |
| **2009-10** | 89,229.29 | 83,685.20 | 5,544.09 | 5,543.34 | 0.75 |
| **2010-11** | 96,681.02 | 90,334.88 | 6,346.14 | 4,941.25 | 1,404.89 |
| **2011-12** | 1,06,245.28 | 99,463.68 | 6,781.60 | 5,656.03 | 1,125.57 |
| **2012-13** | 1,26,180.43 | 1,12,565.24 | 13,615.19 | 5,348.94 | 8,266.25 |

Source: Indian Railways Report & Accounts 2011-12 and Interim Budget Papers 2014-15

#### 2) Operating Ratio

One of the indices that IR measures its performance by is the 'Operating Ratio' which is the ratio of Working Expenses to Traffic Receipts as a percentage. The lower the figure the better is the financial performance of the organization. The operating ratio of I.R. over the 10 year period since 2003-04 is shown in chart 3-7. During the period 2005-06 to 2007-08 there had been significant improvement owing to economic growth in the country and certain operating strategies. Since then the operating ratio deteriorated owing to large salary increases as a result

of a Government Pay Commission Recommendation.




Source: Indian Railways Report & Accounts 2011-12 and Interim Budget Papers 2014-15

Figure 3.3-9 Operating Ratio of Indian Railways 2003-04 to 2012-13

### (7) I.R. Organization and the High Speed Railway Corridors

1) As mentioned in the previous paragraphs IR is an extremely large organization in terms of its size, scale of operations, assets and manpower. Its structure and systems have evolved over time. Whereas most Railway systems in the developed world have reorganized, reformed and changed over to a business segment oriented structure and in some cases segregated fixed infrastructure from operations Indian Railways continues to be a traditional functional organization. IR organization has a number of strengths. The most important is that it has the strength of the Central Government behind it which means issues like land acquisition, coordination with State Governments, Central Government funding of Projects, Sovereign Guarantee on Multilateral and Bilateral Loans, grant of various permissions and access to various Governmental services is relatively much easier. The Railways are also a very professional organization with a great degree of in house expertise in railway technology and management. It does, however, have few constraints with its traditional structure and several tiers in the hierarchy which impose their own limitations. Moreover rapidly growing demand for Passenger and Freight traffic and major capacity constraints on the existing system make it difficult for management to focus on new areas.

2) The key question that arises is whether the HSR should be an integral part of the Indian Railway System, totally separate or associated with it in some way. The Government has already recognized the need for introducing HSR in India. The Twelfth Five Year Plan document clearly states that of the several HSR Corridors identified it plans to “undertake at least two Detailed Project Reports and develop one corridor of about 500 Km for construction”. It also mentions the proposal for setting up a National High Speed Rail Authority (NHSRA) as an Autonomous body through a Bill in Parliament for implementation HSR projects of IR as well as planning, standard setting, implementing and monitoring these projects. MOR has, however, created a High Speed Railway Corporation (HSRC) as a subsidiary company of RVNL. HSRC has started initiating studies in HSR and Semi high speed rail projects. Therefore, clearly with the direction given by Government and the inherent advantages such a project will derive from Government, participation of IR is essential. However, HSR will need to be market oriented, dynamic & responsive and will need to look at an entirely new Business Model if it is to be viable and competitive.

3) The Twelfth Five Year Plan document also highlights the example of JR East where 30% of its revenue comes from non-transportation business e.g. station space utilization, shopping centres & office buildings etc. Similarly it mentions the German Railway (DB) where 48% of its revenue comes from non-rail business and 41% of its revenue comes from international operations. The challenge for Indian Railways is for it to help create an entity that though different from its own structures and systems encourages it to look at new Business Models, new revenue streams, new organizational structures, systems and procedures so that HSR become a competitive and viable mode of transport that contributes to economic growth and nation building.

4) An organization that has already been created is that for the construction and Management of DFC. The DFCCIL is a SPV formed specifically for this purpose and functions as a Public Sector Undertaking (PSU) under MOR. A similar model could be considered for the HSR Corridors. However, there is a difference, whereas DFCCIL constructs and maintains Fixed Infrastructure the rolling stock and crew that will run on the system will be that of IR and a Track Access Charge shall be paid to by IR to DFCCIL. For HSR, Rolling Stock will be different and therefore the entity that is created for constructing and maintaining the HSR could also own, maintain and operate the rolling stock or a separate operating company may have to be created for the purpose. Several options will need to be explored. What is important that IR will need to play a key role in planning, funding, arrange multilateral and/or bilateral funds and create an appropriate entity or entities for the construction, operation and maintenance of the HSR Corridors.

References

Indian Railways Year Book 2011-12
Indian Railways Annual Report & Accounts 2011-12
Ministry of Railway Budget Papers 2013-14 and 2014-15
Twelfth Five Year Plan (2016-17) Volume II, Planning Commission of India
Foundation Course Notes, National Academy of Indian Railways, Vadodara

### 3.3.3 Operation/Maintenance of MOR including Safety Management

#### (1) Background

Operations & Maintenance practices on IR are based on policies, procedures and rules that have been established over time. Each department has its Codes and Manuals which lay down the procedures and rules that govern the operating and maintenance practices followed by employees in the field. These Manuals lay down, for example, the frequency of inspections to be carried out by officials at different levels, items to be inspected, permissible tolerances, precautionary measures that should be taken in different seasons etc. The underlying objective in all the provisions of policy, procedures and rules is firstly to ensure productivity and reliability of the assets and secondly, to ensure safe train operation. It should also be noted that operating and maintenance practices are constantly undergoing change, more so in recent years, based on new technology, experience gained over time, the need to cope with tremendous growth in traffic volume and attempting to adopt global best practices. The following paragraphs describe the main aspects of Operations and Maintenance Practices on IR.

#### (2) Growth in Traffic

Practices being followed need to be viewed with the perspective of the challenge of transporting steadily growing volumes of traffic without a matching growth in fixed infrastructure and rolling stock. These assets are therefore being, progressively, more intensively utilized. The growth in freight and passenger transport is indicated below graphically in Figure 3.3-10 to Figure 3.3-13 which depict the Originating Freight Tonnes, Net Tonnes Kilometres, Originating Passenger Numbers and Passenger Kilometers.

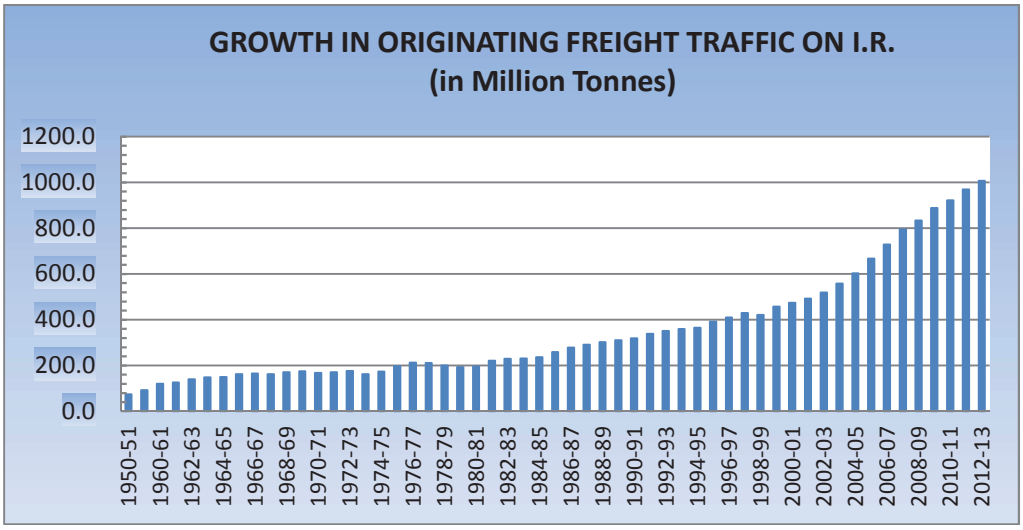



Figure 3.3-10 Originating Freight Traffic (1950-51 to 2012-13)

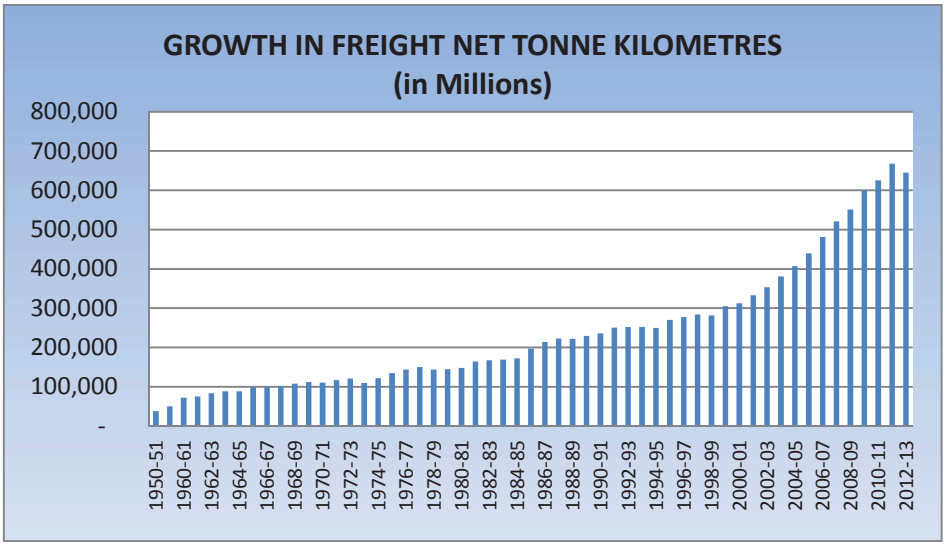



Figure 3.3-11 Net Tonne Kilometers- Freight Traffic (1950-51 to 2012-13)

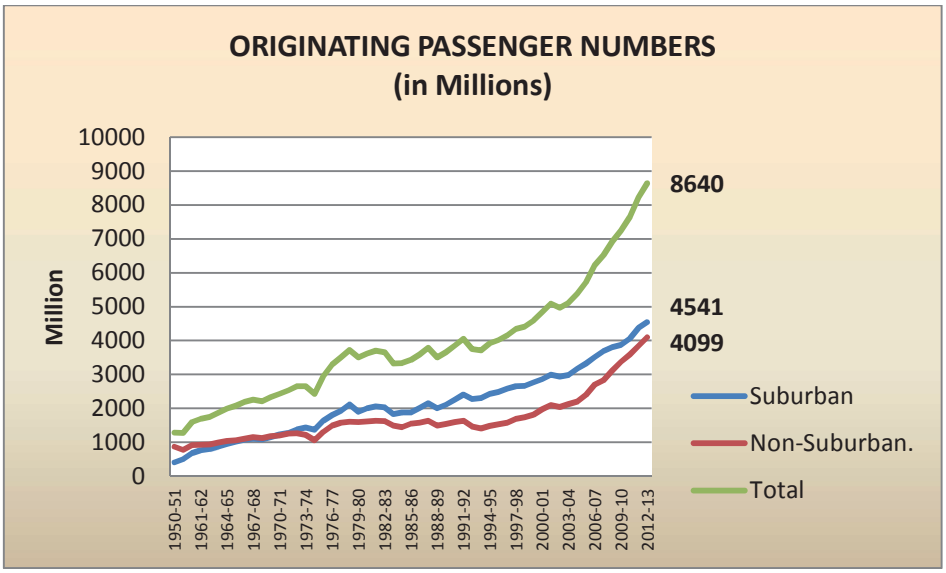



Figure 3.3-12 Originating Passenger Journeys (1950-51 to 2012-13)

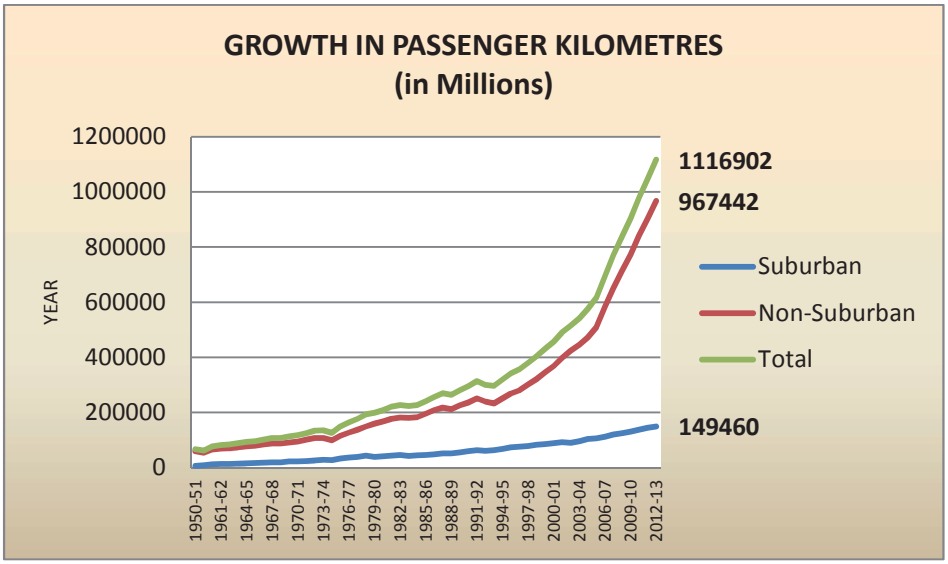



Figure 3.3-13 Passenger Kilometers(1950-51 to 2012-13)

## (3) Operations

### 1) Freight Operations – Commodities Transported

The Freight traffic carried over IR consists primarily of bulk traffic. This is because IR in the mid-eighties took a conscious decision to only transport trainload traffic and discontinued the booking of wagon load commodities. Less than trainload traffic is encouraged to move in containers. The commodity wise traffic carried in Table3.3-12 below.

Table 3.3-12 Commodity wise Freight Traffic Transported on IR on 2011-12

| COMMODITY | ORIGINATING TONNES* | PERCENT | NET TONNE KILOMETRES* | PER CENT |
|---|---|---|---|---|
| COAL | 455.81 | 47.04% | 291455 | 43.66% |
| IRON ORE | 104.70 | 10.80% | 40300 | 6.04% |
| IRON & STEEL | 35.15 | 3.63% | 33919 | 5.08% |
| CEMENT | 107.66 | 11.11% | 62036 | 9.29% |
| FOODGRAIN | 46.40 | 4.79% | 57927 | 8.68% |
| FERTILIZER | 52.69 | 5.44% | 43810 | 6.56% |
| MINERAL OIL | 39.77 | 4.10% | 26096 | 3.91% |
| LIMESTONE / DOLOMITE | 17.66 | 1.82% | 11764 | 1.76% |
| STONES | 12.96 | 1.34% | 6369 | 0.95% |
| SALT | 5.14 | 0.53% | 6877 | 1.03% |
| SUGAR | 4.56 | 0.47% | 7344 | 1.10% |
| OTHERS | 86.55 | 8.93% | 79710 | 11.94% |
| TOTAL | 969.05 | 100.00% | 667607 | 100.00% |

*ALL FIGURES IN MILLIONS

### 2) Freight Operations – Rake Allotment

The loading of freight traffic is done in Train Loads (a train load is a set of 58 or 59 Bogie Wagons which is called a Rake). The demand for loading is placed at Station Goods Sheds, Industrial Sidings etc. by the consignor submitting a Forwarding Note accompanied by a Wagon Registration Fee. These 'Indents' for rake allotment are Registered based on a priority specified in Preferential Traffic Schedule issued by MOR wherein instructions exist regarding priorities to be followed for allotment of wagons. Under these top priority is given to Priority 'A' which are Military Movements sponsored by the Ministry of Defence, next is Priority 'B' which include movement of Goods in natural Calamities and Government sponsored movement of Food Grains and levy Sugar for Public Distribution System and other welfare Schemes, Priority 'C' includes movement of other commodities sponsored by nominated authorities which have been approved by the Railways e.g. edible salt by Salt Commissioner, Coal by specific Coal Companies based on approval by a Govt. Linkage Committee, Raw Material to Steel plants based on specified criteria, Fertilizer and Petroleum Products from Oil Companies and all balance commodities come under Priority 'D'. The total demand registered on a Division every day is consolidated by the Divisional Operations Control and Empty rake allotment is decided on a daily basis in consultation with Chief Freight Traffic Manager of the Zonal Railway and empty rakes are moved to locations where demand exists accordingly.

### 3) Freight Operation – Train Movement

The Divisional Control office also monitors availability of Locomotives and once a train is loaded it assigns a locomotive and crew for hauling the train. Once the train is ready train examination staff checks the air brake system and issue a Brake Power Certificate to both the driver and guard and the train starts on its journey. Movement is controlled by a Section Controller who decides on crossings and precedence of trains on a section. The Section Controller is in continuous contact with all stations and issues instructions to Station Masters regarding precedence and crossings. A well-defined system of priority is followed with respect to train running. Top priority is given to Rajdhani Express Trains, then other Mail / Express trains, thereafter stopping Passenger Services and lastly Freight Trains. Charting of trains which was earlier done manually on a time – distance graph is done electronically through a computerized control office application. Trains are run through to destinations, stopping en-route for crew change, locomotive change if necessary, fuelling in case of diesel and for crossing and precedence. There has been a constant endeavour to improve productivity of rolling stock through introduction of technology, operating strategies and innovation. Significant results have been achieved over time in terms of wagon utilization for example in terms of Net Tonnes kilometers per wagon day, Average Train Load of Goods Train and Wagon Turn Round (the time in days between successive loading) as may be seen from these indices in the Figure3-14 to -16 below. Wagon Turn Round indicates the time interval in days between successive loadings of wagons. The improvement reflects better utilization of wagons.

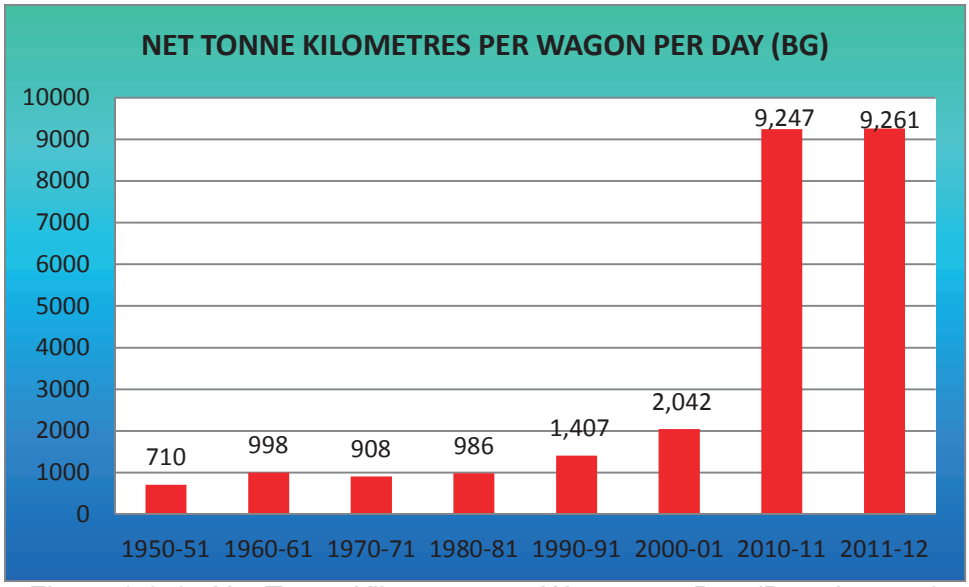



Figure 3.3-14 Net Tonne Kilometersper Wagon per Day (Broad gauge)

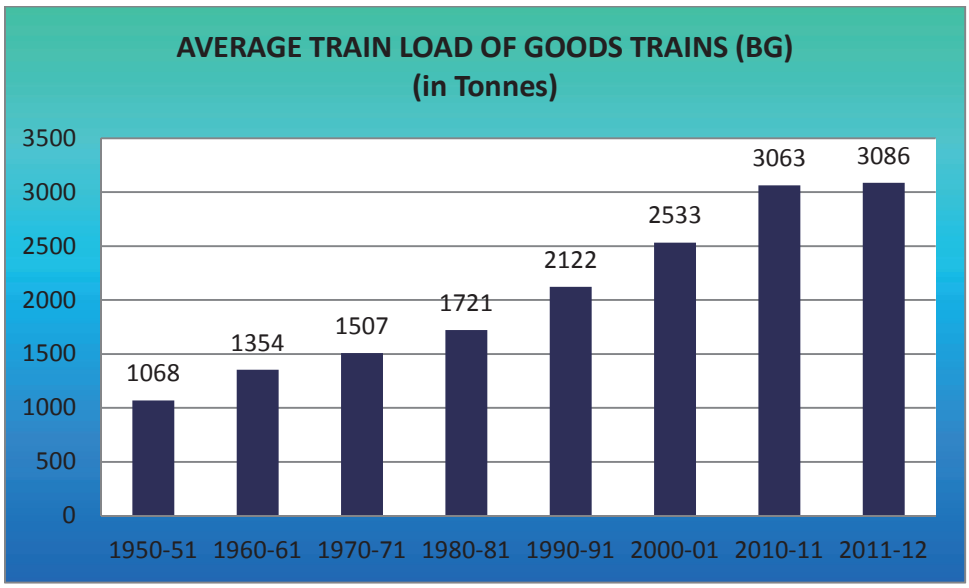



Figure 3.3-15 Growth in Average Train Load (BG) in tonnes including weight of engine
The Graph displays the increase in load of freight trains

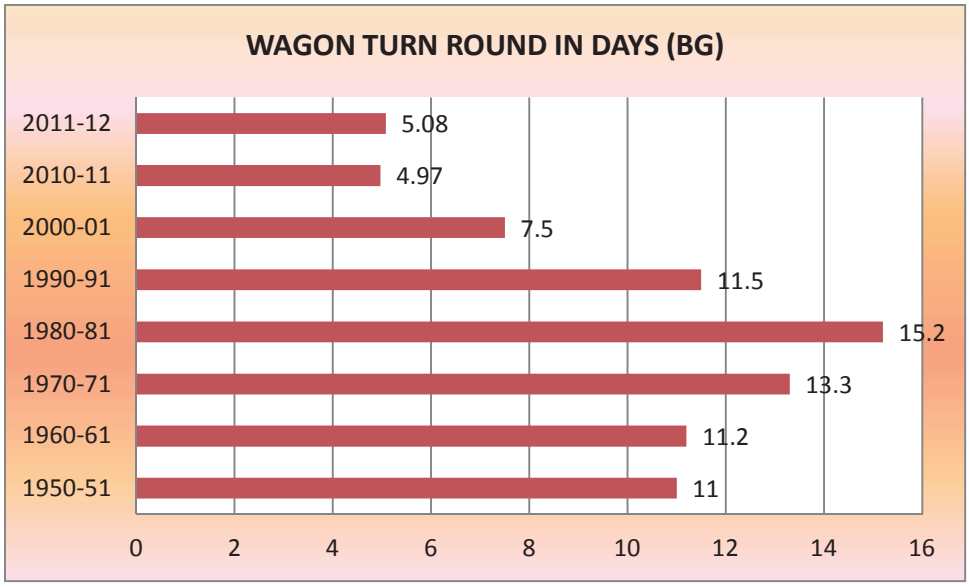



Figure 3.3-16 Improvement in Wagon Turn Round

### 4) Passenger Train Operation – Train Composition & Time Tabling

Passenger Trains are broadly divided into three categories viz. the Fast Air Conditioned Services such as the Rajdhani, Shatabadi and Duronto Express Trains, other Mail Express Trains with limited stoppages and Passenger Trains that stop at most stations. Each Train has a fixed composition of coaches with various class of accommodation such as AC I, AC 2 Tier, AC 3 Tier, II Sleeper Class and unreserved coaches. Each Train Service is operated by a fixed number of Rake Formations that operate in a link. Each Zonal Railway publishes a document known as the Composition and Marshalling Order of Passenger Trains that gives firstly the Composition and exact marshalling order of each service operated by the Railway as well as the Rake Link. It is possible that one rake link may operate two or more pairs of different services with a view to optimize passenger train utilization. In addition all passenger services are run to fixed timings based on a Time Table. Each Zonal Railway Publishes a Public Time Table as well as a Working Time Table for the use of Staff. The Working Time Table (WTT) contains a large number of details which include for each train the 'Maximum Permissible Speed', the 'Booked Speed', the 'Engineering Allowance' provided for Speed Restrictions imposed for maintenance on track, 'Traffic Recovery' Time for making up time if the train is running late. The stoppage at stopping stations and train passing time for stations where the train runs through is also indicated in the WTT. The Time Tabling exercise is very elaborate is undertaken once a year in order to speed up trains, introduce new services or increase the frequency of existing services. A Time Table Committee Meeting is convened by the Railway Board to enable coordination between Zonal Railways and decide on inter-zone interchange timings.

### 5) Passenger Trains – Scale of Operation

The Passenger Train Operations are managed through operating a fleet (as on 31 March 2012) of 46,688 conventional coaches and 8617 Electrical Multiple Units (EMUs)/ Diesel Multiple Units (DEMUs)/ Diesel Hydraulic Multiple Units (DHMUs). The EMUs etc. are used in Suburban systems of some Metropolitan areas and for providing short distance commuter services in various parts of the country. IR run a total of about 12,335 Passenger Trains every day including 4,644 EMU Services, 3071 Mail / Express Services and 4,620 Passenger & Mixed Trains. The overall average speed of trains (including stoppages) on Broad Gauge in 2011-12 was 40.5 km/h for EMU services, 50.3 km/h for Mail/ Express Trains and 36.2 for passenger & Mixed trains. There has been a steady growth in Passenger Train Kilometers in order to cater to

the needs of the rising passenger demand. The growth in passenger Train Kilometers is shown in Figure3.3-17. The Passenger Train Kilometerson IR are much higher than the Goods Train Kilometres. The Passenger Train Kilometers in 2011-12 were approximately 681 Million Train Kilometres. This is significantly higher than Freight Train Kilometers which in the same year were 391 Million Train Kilometres. There has also been a tremendous growth in Coaching Vehicle Kilometers which has been much greater than in case of Passenger Train Kilometers as the number of coaches per train have increased very significantly over the years. The growth in vehicle Kilometers is shown in Figure3.3-18. The Vehicle Kilometers on IR have grown much more than Passenger Train Kilometers as the number of vehicles per train have increased very significantly. Today computerization has facilitated the close monitoring of Passenger Train Operation, its punctuality, as well as coach maintenance.

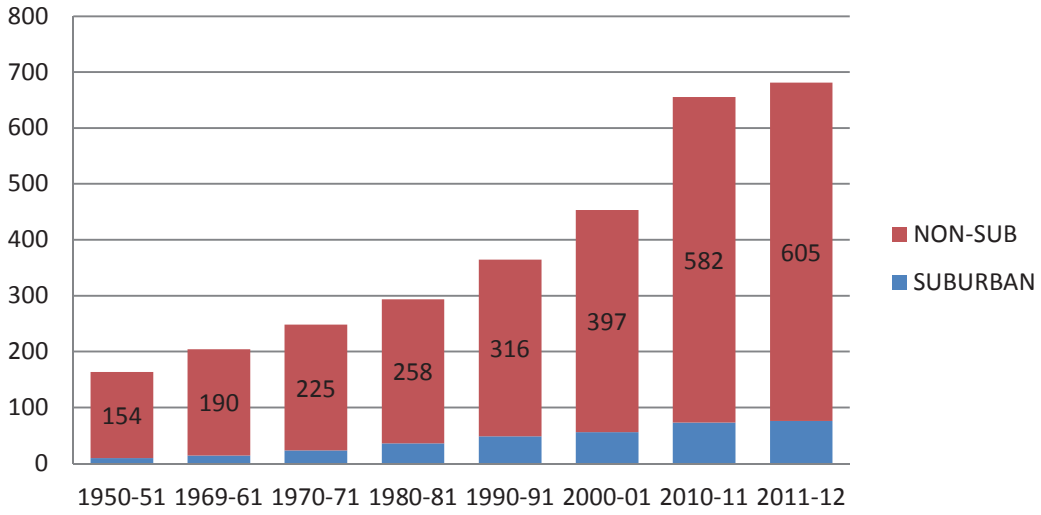



Figure 3.3-17 Growth in Passenger Train Kilometres.

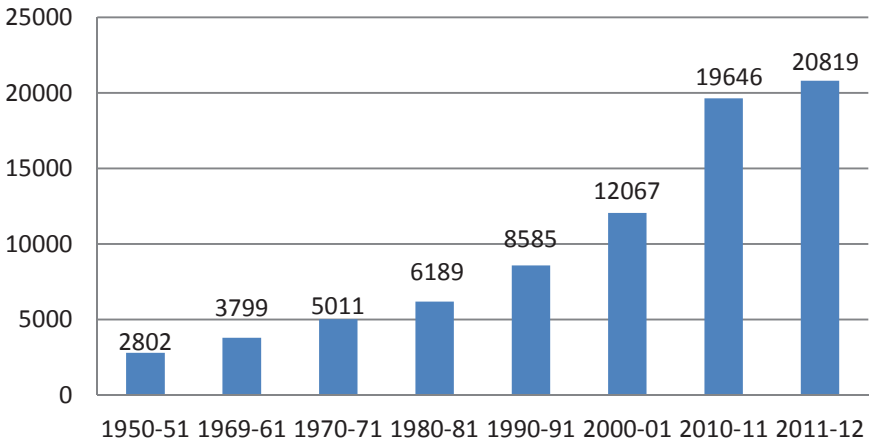



Figure 3.3-18 Growth in Vehicle Kilometres

### (4) Maintenance – Permanent Way

1) The Permanent Way or track structure consists of a formation, ballast, sleepers, rails and track fastenings. IR follows a system of both manual and mechanized systems of track maintenance. The maintenance function in the Division is under the charge of a Senior Divisional Engineer who has under him a hierarchy of Divisional Engineers, Assistant Engineers and Permanent Way Inspectors or Sectional Engineers. Under the Sectional Engineers there are Gangs of 20-25 men under a mate consisting of Trackmen responsible for specific sections of the line. In addition there is a key man who is responsible for inspecting daily, on foot 6 to 8 Kilometers of the line in his charge. He attends to deficiencies and ensures the line in his beat is safe for train running. The gangs are given an annual programme for maintenance which typically consists of carrying conventional through packing of the entire gang length. Through packing consists of opening of the road, examination of rails, sleepers & fastenings, squaring of sleepers, correcting of alignment, gauging, packing of sleepers, repacking of joints and boxing of ballast section along with tidying up. In addition the gang on nominated days pick up slacks, attends to bridge approaches, level crossings and points and crossings. Prior to the monsoon the gang devotes time to clearing of side drains, clearing waterways, repairing formation and cess. During the monsoon greater attention is required to track, particularly in attending to bad spots, cleaning to side water and catch water drains. Apart from the conventional method of through packing in some areas a method of a measured shovel packing is adopted. In this the basic principle is to leave the sleeper bed of ballast undisturbed as it is well compacted by traffic. In order to eliminate unevenness caused over time a fixed measure of stone chips is put under the sleeper. This is a suitable technique for flat bottom sleepers.

#### 2) Maintenance by Track Machines

Progressively IR is inducting more Track maintenance machines such a Tie Tamping Machines and Ballast Cleaning Machines. With the use of these machines the requirement of manual maintenance is coming down. IR follows detailed procedures for use of Track maintenance machines. Various Pre-Tamping steps that should be taken are defined for example ensuring adequate availability of ballast, heaping of ballast in the tamping area, ensuring adequate cess, tightening of fittings and fastenings and replacing worn out fittings, replacing broken or damaged sleepers, squaring of sleepers and removing obstructions that may come in the way of tampers. Similarly some post tamping attention is required such as tightening of fittings that may have got loose, attention to cross levels and alignment, dressing of ballast and proper consolidation of ballast between sleepers. As IR operates on ballasted track the ballast requires periodic cleaning with a view to ensure resilience and elasticity of the ballast bed. This is done manually or with the help of ballast cleaning machines. Another aspect is the need to regularly inspect the condition of rails and whether they have any internal flaw developing inside that could result in a rail fracture. Ultra sonic rail flaw detectors are now being utilized for this purpose as per a laid down schedule.

#### 3) Maintenance of Permanent Way – Track Geometry

One of the important functions of Inspections and Maintenance is to ensure proper Track Geometry. The parameters that constitute Track geometry are Gauge, Alignment, Unevenness and variation in Cross level. Clearly defined tolerances are laid down for each of these parameters. The officials at various levels e.g. Sr. Divisional Engineer, Assistant Engineer and the Sectional Engineer in their push trolley, motor trolley, footplate inspections carefully look for any deficiencies in track Geometry and should they find any they ensure that immediate corrective action is taken. Although experienced engineers are often able to detect track deformities visually during inspections these parameters are also measured periodically through oscillograph/Track recording car runs on the line and each section is graded with respect to quality of maintenance. The maintenance team constantly endeavour to improve the standard of maintenance.

### 4) Maintenance of Permanent Way – Track Renewals

A major component of Maintenance is Track Renewals. These are major works for replacement of Track components either fully or partially on the basis of their condition or the asset having completed its life. Therefore a work could consist of rail renewal, renewal of fittings or sleeper renewal or complete track renewal. In the Annual Plan for 2013-14 the Total Outlay for Track Renewals was Rs 5,500 Crores (Rs 55 Billion). If adequate provision is not made the arrears in Track Renewals tend to accumulate which may become a safety concern. Similarly for Bridge Works the provision was Rs 513 Crores (Rs 5.13 Billion). In 2011-12 a total of 3300 Km of Track Renewal works were executed.

### (5) Maintenance of Rolling Stock

### 1) Coaches

All coaches are assigned to a Base Depot which is responsible for their 'Primary' Maintenance and for various planned Preventive Maintenance Schedules. There are several coaching depots on each Zone. The various Preventive Maintenance Schedules a coach is required to undergo are given in the table3.3-13 below.

Table 3.3-13 Preventive Maintenance Schedules

| MAINTENANCE SCHEDULE | FREQUENCY OF SCHEDULE | LOCATION OF SCHEDULE | WORK DONE |
|---|---|---|---|
| **TRIP SCHEDULE** | EVERY TRIP | PRIMARY /SECONDARY DEPOT WASHING LINE | Washing & Cleaning, oiling, check wheel, suspension, draw & buffing gear, brake rigging, alarm chain & water pipes |
| **SCHEDULE 'A'** | MONTHLY (+/- 3 DAYS) | PRIMARY DEPOT WASHING LINE | Trip Schedule + Flush water tanks, disinfection, train pipe & brake system, grease alarm chain, clean direct Admission Valve, replace brake gear pins,fill oil in side bearers & dash pot |
| **SCHEDULE 'B'** | QUARTERLY (+/- 7 DAYS) | PRIMARY DEPOT WASHING LINE | Schedule 'A' + Ovehaul Alarm Testin Apparatus, Release Valve, Touch up painting check & fill oil in side bearers. |
| **INTERMEDIATE OVER HAUL (IOH)** | 9 MONTHS (+30/-0 DAYS) | PRIMARY DEPOT* SICK LINE | Schedule 'B' + Lift Run out bogies- overhaul bogies, check slack adjuster, shock absorber, vestibules, corrosion repair, Brake System, Draw & buffing gear |
| **PERIODIC OVERHAUL (POH)** | 18 MONTHS** | COACH REPAIR WORKSHOP | Complete Overhaul of all parts |
| *IOH of Rajdhani/ Shatabadi Coaches in Workshop ** New Coaches given POH after 24 months | | | |

### 2) Wagons (Train Examination)

Unlike Coaches freight Wagons are not assigned to any specific base depot and are mostly 'pooled' to move freely across the country. Indian Railways maintains a fleet of 239,321 wagons of which 26% are Covered, 54.2% High Sided Open, 3.2 Low sided open and 11% other types and 5.6% Departmental Wagons. Freight trains are at present given an 'Intensive' examination. Examination is carried out before loading or after unloading. Trains are given a rolling in examination while it is entering the yard to check for overheated axle boxes, flat tyres, broken springs etc. In the yard an Intensive examination includes examination of all under gear and fittings, wheel tyre defects through wheel tapping and testing of brake cylinders and brake rigging, replacement of brake blocks if required, checking of draw and buffer gear & buffer height and an exhaustive examination of the Air brake system to ensure brakes are effective on all wagons. In recent years train examination has been rationalized. Now as an operational practice to improve wagon productivity a freight train can undergo several loading and unloading operations between a C&W examination as current policy is that (i) in case of Closed

Circuit (CC) Rakes examination is done at interval of 6000 Kms or 20 days or 7500 Km and 35 days on specified circuits whichever is earlier, (ii) In case of a 'Premium Examination' after 12 days and may be relaxed for a further 3 days to enable a loaded rake to reach its destination and (iii) in case of 'Intensive Examination' the train may proceed from 'end to end' i.e. from originating point to its destination without any intervening examination.

### 3) Wagons (Preventive Maintenance)

Wagons undergo schedules of preventive maintenance. These are (i) Routine overhaul (ROH) which is carried out at an interval of 18 months and involves lifting of the wagon and extensive attention is given to the bogies and under frame members. This schedule is carried out at nominated depots where facilities have been created for this purpose. (ii) Periodic Over Haul (POH) are carried out at a frequency of 6 years for covered wagons BCNA type and in case of open BOXN type wagons it is at an interval of 6 years for new wagons and 4 ½ years for subsequent schedules. This schedule which involves a thorough examination and overhaul of all components and is carried out at Wagon Repair Workshops. The date a Wagon is due ROH or POH is painted on the side of the Wagon to facilitate it being booked for the next schedule. For Carriage and Wagon Maintenance substantial maintenance infrastructure has been created in terms of Carriage Depots, Wagon Depots with their own Sick lines, ROH depots and for periodic overhaul and Carriage Workshops and Wagon Workshops which carry out heavy repairs and periodic overhaul. Indian Railways have 246 Carriage & Wagon sick lines and Central Repair Depots and 45 Workshops for Rolling Stock

### 4) Diesel Electric Locomotives

IR utilizes a range of Diesel Electric Locomotives and a few Diesel Hydraulic Locomotive types. These include the WDM2 – 2636 H.P.; WDG3A – 3100 H.P; WDP3A – 3100 H.P.; WDP4D – 4500 H.P.; WDG4D – 4500 H.P. and WDG5 – 5500 H.P. All these BG Diesel Locomotives have a CO-CO Wheel Arrangement. Whereas the earlier designs were based on the ALCO Diesel Locomotives initially acquired from the United States then manufactured at Diesel Locomotive Works (DLW), Varanasi the new WDP4, WDG4 and WDG5 locomotives are General Motors/ EMD designs and are now also being produced at DLW, Varanasi. IR currently maintains a fleet of over 5200 Diesel Locomotives. The maintenance philosophy is based on Unit Exchange principle at the Diesel Shed where the entire Assembly is replaced instead of repairing or changing sub-assemblies. For this purpose a pool of important sub-assemblies or unit exchange spares is maintained in each shed. There are number of maintenance schedules a Diesel Locomotive has to undergo which are mentioned in the Table 3.3-14 below. The equipment to be inspected and attended to or replaced is clearly defined for each schedule. The rebuilding at the end 18 years ensures that latest technological improvement and up-gradation are incorporated in the rebuilt locomotive.

Table 3.3-14 Schedules for Diesel Locomotives

| SCHEDULE | TIME INTERVAL | LOCATION |
|---|---|---|
| **TRIP** | 20/30/40 DAYS | ANY SHED |
| **M4** | 4 MONTHS | HOME SHED |
| **M8** | 8 MONTHS | HOME SHED |
| **M12** | 12 MONTHS | HOME SHED |
| **M24** | 24 MONTHS | HOME SHED |
| **M48** | 48 MONTHS | HOME SHED |
| **POH** | 8 YEARS | WORKSHOP |
| **RE-BUILDING** | 18 YEARS | DMW* PATIALA |

*DIESEL LOCO MODERNIZATION WORKS

### 5) Maintenance of Rolling Stock – Electric Locomotives

IR operate a wide range of Electric locomotives with B-B, Bo-Bo and Co-Co wheel arrangements. As initially sections on Indian Railways were electrified on 1500 V DC system there were also D.C. Locomotives for Mixed (Passenger & Goods use) such as the WCM1, WCM2, ... WCM5. However as the major electrification was on 25 KV system there were a large number of loco designs for AC Traction. There are separate designs for Passenger and Freight trains. In case of Goods the more common class of locomotives currently in use are WAG5, WAG7 and WAG9 – all with Co-Co wheel arrangements. In case of passenger locomotives the WAP1, WAP3, WAP4 and WAP7 Co-Co models and WAP5 Bo-Bo are in operation. IR also had locomotives that could work on AC and DC traction to avoid change of Locomotives such as the WCAM1 and WCAM2. IR also maintained a range of mixed Class locomotives which were considered suitable for both Passenger and Freight Traction like the WAM4. A few characteristics of Electrical Locomotives are given in the Table 3.3-15. For freight operations the main workhorses are (i) the WAG 7 which is a front line freight locomotive. Often used in multiple operation to haul heavy freight trains on graded sections. This is a 5000 HP engine, weighs 123 tonnes and is capable of a maximum speed of 100 km/h. It uses DC series motors, controlled by a tap changer and has a high capacity transformer, rectifier, traction motor, compressor and fabricated high adhesion bogies. (ii) The WAG 9 which is a 6000 HP, 3 – Phase, AC thyristor controlled state of the art locomotive employing 3-phase technology and computerized control. It is the most powerful locomotive on IR. In case of passenger operations the latest locomotives being manufactured and in use are (i) the WAP 5 which is a 5400 H.P., 3-Phase main line Passenger locomotive, with microprocessor based braking system for speeds up to 160 km/h. Speed can be increased to 200 km/h if required. (ii) The WAP 7 is also state of the art and is variant of the WAG 9 6000 HP locomotive capable of hauling heavy Passenger trains of 24 to 26 coaches at speeds of 130 km/h. This Locomotive is also based on 3- phase technology and has microprocessor based braking system.

Table 3.3-15 Some characteristics / features of certain Electric Loco Classes

| | ELECTRIC LOCO CLASS | | | | | | |
|---|---|---|---|---|---|---|---|
| **CHARACTERISTIC** | **WAG 5** | **WAG 7** | **WAG 9** | **WAM 4** | **WAP 3** | **WAP 4** | **WAP 5** |
| TYPE OF SERVICE | FREIGHT | FREIGHT | FREIGHT | MIXED | PASSENGER | PASSENGER | PASSENGER |
| YEAR OF INDUCTION | 1978 | 1992 | 1998 | 1971 | 1987 | 1995 | 2000 |
| CONTINUOUS RATING IN KW & (HP) | 2840 (3850) | 3675 (5000) | 4500 (6122) | 2676 (3640) | 2764 (3760) | 3675 (5060) | 4000 (5362) |
| WHEEL ARRANGEMENT | CO-CO | CO-CO | CO-CO | CO-CO | CO-CO | CO-CO | BO-BO |
| AXLE LOAD | 20.5 | 20.5 | 20.5 | 18.8 | 18.8 | 18.8 | 19.5 |
| MAX SPEED IN KMPH | 80 | 100 | 100 | 120 | 140 | 140 | 160 |
| TRACTIVE EFFORT (START) t. | 33.5 | 42 | 46.9 | 30 | 22.2 | 37.5 | 26.3 |
| BRAKING FOR LOCO | AIR, RHEOSTATIC & HAND | AIR, RHEOSTATIC & HAND | AIR, REGENERATI-VE & PARK. | AIR & HAND | AIR & HAND | AIR & HAND | AIR, REGENERATI-VE & PARK. |

### 6) Electric Loco Maintenance Schedules

As in the case of all other Rolling Stock there are detailed schedule of Inspections and Maintenance that Electric Locomotives have to undergo. The schedules, frequency and location are mentioned in the Table 3.3-16

.

Table 3.3-16 Electric Locomotive Maintenance Schedules

| SCHEDULE NAME | FREQUENCY* | LOCATION |
|---|---|---|
| **TRIP INSPECTION PASSENGER LOCO.** | EVERY 3000 KM. BUILT INTO THE PASSENGER LINK | OUT STATION OR HOME SHED |
| **TRIP INSPECTION GOODS LOCO.** | TAO Traction Motors 15 Days<br>Hitachi Traction Motors 22 Days | OUT STATION OR HOME SHED |
| **IA (Monthly)** | 40 +/- 3 DAYS | HOME SHED |
| **IB (Bi-Monthly)** | 80 +/- 3 DAYS | HOME SHED |
| **IC (Four Monthly)** | 120 +/- 3 DAYS | HOME SHED |
| **ANNUAL OVER HAUL (AOH)** | 18 MONTHS +/- 15 DAYS | HOME SHED |
| **INTERMEDIATE OVER HAUL (IOH)** | 36 MONTHS +/- 1 MONTH OR 0.4 MILLION KM | HOME SHED OR NOMINATED WORKSHOP |
| **PERIODICAL OVER HAUL (POH)** | 6 YEARS +/- 3 MONTHS OR 0.8 MILLION KM | NOMINATED WORKSHOP |

* In certain Class of Locos like WAG5 & WAG7 the interval between schedules has been further increased.

The main components of a Locomotive on which maintenance is focussed are (i) A.C. Loco equipment which consists of the Pantograph, Transformer, Tap Changer and Silicon Rectifier (ii) the Locomotive Bogies, (iii) the Power Transmission & Drives, (iv) the Power Control and Auxiliary Circuits, (v) Air Compressor, (vi)Wheels and (vii) Braking system. Detailed checklists for items to be inspected and work to be done in each trip Inspection and maintenance schedule are clearly specified in the A.C. Traction Manual. It will be noted that the interval between schedules has been progressively increased based on experience gained over time. What was earlier a monthly schedule is now carried out every 40 days and the earlier Annual overhaul is now done every 18 months. This has helped improve the availability of Locomotives for traffic use.

### (6) Maintenance of the Traction Distribution System

Apart from Electrical Rolling Stock such as Electric Locomotives and Electrical Multiple Units there is an extensive Traction Distribution System (TRD) which has to be maintained in good fettle to ensure reliable operation of Electrical Rolling Stock as well as safety of rail operations, staff and the general public. The Traction Distribution (TRD) organization on a Zonal Railway and Divisional is responsible for the maintenance of 'Fixed Infrastructure' for Electric traction. These consist of three broad categories viz. (i) Overhead Equipment (OHE), (ii) Power Supply Installation (PSI) and (iii) Remote Control Equipment. The Power Supply Installations consist of Traction Sub Station (TSS) which receive Electric power from State Electricity Boards / Power Distribution Companies at 220/132/110 KV (normally 132 KV) and steps it down 25 KV AC Single phase 50 Hz which is fed to the OHE. In addition there are Sectioning and Paralleling Posts (SP) which helps in preventing the pantograph of a locomotive from bridging the supply from different phases as it crosses from one zone to another. A neutral zone is provided between supply from different phases and the switching station at the Neutral Zone is the Sectioning Post. The Overhead Equipment consists basically of the Catenary and Contact wire from where the pantograph picks up current, however there are a large number of other components viz. Masts, Portals, insulators, droppers etc. It is essential to maintain the contact wire at a fixed height from the rail level which is done with the help of an anti creep arrangement and auto tensioning devices. Appropriate horizontal stagger also has to be provided to avoid wear of the pantograph contact surface. For maintenance of Overhead equipment and elaborate schedule of inspections by officers and supervisors is laid down as is a schedule of maintenance. These include foot patrolling, trolley inspection, current collection tests, Special checks, Annual Maintenance and OHE Inspection car and Periodical overhaul. While most items need attention during annual or periodical maintenance some items require more frequent

attention such as Insulators, isolating switches in yards, bimetallic clamps, Earth connections, OHE on Steel girder bridges, removal of bird's nests. A detailed check list is available for Annual maintenance of Masts, Portals cantilever supports; Contact & Catenary Wire; Droppers; Turn Outs; Section Insulator Assemblies; Isolators; Neutral sections; Checking of stagger; Contact Wire thickness Level crossings; Bonds & earthing etc. The Periodical Overhaul (POH) aims at reconditioning the entire equipment and is done every four years. Depending on condition the Rehabilitation of OHE may be planned every 20 years.

### (7) Maintenance of the Signaling Equipment

There is a wide range of signaling equipment in use on IR. Moreover, signal technology has undergone rapid change over the last few decades. For example signals in use at various stations may be 2 aspect lower quadrant semaphore signals, multiple aspect upper quadrant semaphore signals or multiple aspect color light signals. In addition on Indian Railways 4 standards of Interlocking have been laid down. The characteristics of the 4 standards are summarized in the Table 3.3-17 below.

Table 3.3-17 Standards of Interlocking followed on IR with their main features

| | Item | **Standard I** | **Standard II** | **Standard III** | **Standard IV** |
|---|---|---|---|---|---|
| 1 | Max. Speed over Main Line Facing Point | 50 km/h | 110 km/h | 140 km/h | 160 km/h |
| 2 | Isolation of Main Line from Loop Lines | Yes | Yes | Yes | Yes |
| 3 | 2 Aspect / Multiple Aspect Signals | 2A or MA | 2A or MA | MA | MA |
| 4 | Requirement Double Distant Signals | No | Yes if Braking Distance more than 1 km | Yes | Yes |
| 5 | Point Operation (Mechanical or Elect.) | Mech. | Mech. / Elec. | Mech. / Elec. | Mech. / Elec. |
| 6 | Type of Point Locking | Key/FPL[+] /HPL[++] | FPL/Point Machine | FPL/Point Machine | Direct |
| 7 | Requirement of Lock Detection | No | Yes | Yes | Yes |
| 8 | Type of Interlocking | Key / Mech. | Mech. / Elec. /Electronic | Elec./Electronic | Elec./Electronic |
| 9 | Requirement of Track Circuiting | No | If Elec. /Electronic: All Running Lines | All Running Lines | All Running Lines |
| 10 | System of Block Working | Token | Token/SG* | SGE/TC** | SGE/TC |
| 11 | Preventing Passing of Signal at Danger | No | No | No | Yes - Desirable |

[+] FPL – Facing Pont Lock; [++] HPL- Hand Plunger; *SG - Siemens or GE Lock & Block Instruments; TC – Track Circuiting

A major thrust has been in introducing Panel Interlocking at small stations in which all the points and signals are operated from a combined indication diagram cum control panel located in the Station Master's Room. The route is set by operating individual point buttons on the panel. For large stations where there are more frequent movements Route Relay Interlocking has been introduced where in an automatic route setting facility is available and the operator has to simply operate entrance and exit buttons. In relay interlocking the interlocking is achieved by relay circuitry at a centralized location. More recently electronic interlocking is being introduced through Solid State Interlocking (SSI). The modular design of the SSI systems enables easier installation, less power consumption and fewer relays. In addition IR operates long lengths of Automatic Signalling Sections where the passage of the train operates the signals. Automatic signalling requires continuous track circuiting and is adopted in very busy sections such as the entire 500 Km route from Ahmedabad to Mumbai. To get a perspective of the up-gradation of signal systems on IR the different types of modern electrical and electronic systems at various locations on IR is indicated in the Table 3.3-18 below.

Table 3.3-18 Extent of Implementation of new Signalling Systems on IR as on 31.03.2012

| | | |
|---|---|---|
| 1 | No. of Stations with Panel interlocking | 4079 |
| 2 | No. of Stations with Electronic Interlocking | 535 |
| 3 | No. of Stations with Route Relay Interlocking | 257 |
| 4 | No. of Stations with Colour Light Signalling | 5391 |
| 5 | Total Route Kilometers of Automatic Block Signalling | 2286 |
| 6 | Last Vehicle Check by Axle Counters (No. of Block Sections) | 3410 |
| 7 | No. of Stations with L.E.D. lit Signals | 4814 |

For the Maintenance of assets the Sr. Divisional Signalling & Telecommunication Engineer (Sr. DSTE) is responsible under whom there are DSTEs, ASTEs and Supervisors such as the Sr. Section Engineers and Junior Engineers below whom are Mechanical Signal Maintainers and Electrical Signal Maintainers. A schedule of inspections is laid down at all levels. For example the periodicity for checking and attending various signal gear viz. Lever Frame, lead outs and cranks, rodding run, wire transmission, points, detectors and signals is specified for the maintainer, Junior Engineer and Section Engineer and the work to be done is also mentioned in the Signal Engineering Manual. Similar instructions exist for maintenance of electrical signal equipment where checks and maintenance action is laid down for Colour Light Signals, signal machine, reversers, point machines, electrical detectors, key transmitters, lever locks, arm and light repeaters etc. Most of the signalling, and interlocking equipment including relays is maintained and repaired by IR staff and in Signal Workshops on the Railways. However, with a range of new equipment being inducted in many cases the Railways are now entering into Annual Maintenance Contracts with equipment suppliers such as in case of Integrated Power Supply Systems, microprocessor based Electronic Interlocking equipment and axle counter units.

### (8) Maintenance of the Telecom Equipment

1) IR operates a very extensive network of communication Systems in order to meet various functional requirements. These include (i) Operational Communication such as Control Circuits, Hot Lines for train operation, Magneto phones for communicating from station to level crossing Gates, Block instrument communications, Mobile communications for Train Crew. (ii) Telecommunication Systems within Station Yards which include Public Announcement Systems, Paging equipment, Walkie Talkie sets with yard staff, CCTV etc. (iii) Passenger Amenities related systems such as Data Communication systems for the passenger reservation system, Train Indicator boards, Public Enquiry Systems, Interactive Voice recorded Systems etc. and (iv) Disaster Management Communication Systems which includes VHF communication sets, Satellite Communication via Inmarsat Satellite and High Frequency SSB Sets. These apart there is a nationwide Administrative Telephone network, extensive data networks for supporting Freight Operating Information Systems, Passenger Reservation System and various other IT applications. There have been very significant developments over time in Telecommunication. IR traditionally used overhead lines maintained by the Post & Telegraphs Department, and then used Microwave Channels for some requirements and today its main backbone is on Optical Fiber Communication, the network for which is maintained by RAILTEL Corporation which is a subsidiary Company of IR. In addition for station to station Communication it uses 6 quad underground cables. Some idea of the Telecom assets with IR may be had from Table 3.3-19 where a few of the important telecom assets are listed.

Table 3.3-19 Some Telecommunications installations on IR as on 31.03.2012

| | | |
|---|---|---|
| 1 | Optical Fibre Communication for Control Communication | 40,332 Route Km |
| 2 | Quad Cable | 47,181 Route Km |
| 3 | Digital Microwave (7 GHz) | 5,937 Route Km |
| 4 | Mobile Train Radio Communication (GSM-R Based) | 1710 Route Km |
| 5 | Railway Telephone Subscriber Lines (Nos.) | 3,62,551 |
| 6 | Passenger Reservation System / UTS circuits (No of Stations) | 8,556 |
| 7 | Freight Operation Information System Circuits (Stations) | 1,789 |

### 2) Telecom Equipment Maintenance

The maintenance team works under the Sr. DSTE at the Divisional level who may have a DSTE and ASTE (Tele) under him. The total division is divided into sections under the charge of a Senior Section Engineer (Tele) who is assisted by Section Engineers and Junior Engineers. The Junior Engineer has technicians under them and assisting staff. Technicians are in various categories viz. Telecommunication, wireless, Cable Jointer, Lineman, motor mechanic etc. The Telecommunication Manual provides for very detailed maintenance instructions specifying frequency at which Inspections should be conducted at various levels viz. technician, Sectional Engineer (SE), Senior Sectional Section Engineer (SSE). It also indicates measurements to be taken, instruments to be used and tolerances that are permissible. For example with respect to Repeater & Amplifier Equalizer of the quad cable system the equipment and batteries must checked and maintained weekly at the technician level, monthly at SE level and quarterly at the SSE level. The checks involve checking power supply, various cards and section wise end to end line up of all cards. In case of batteries tightening of all connections and measurement voltages and specific gravity needs to be done. Elaborate check lists and work schedules are specified for all equipment.

## (9) Safety

### 1) Safety Organization

Safety is the responsibility of every individual from bottom to top in organization who is involved in Train Operations & Maintenance. There is, however, a Safety Organization with Chairman Railway Board at the apex an Advisor Safety in Railway Board, Chief Safety Officers on each Zone and a Sr. Divisional Safety Officer on each Division to focus on safety issues. They conduct periodical safety drives, inspections, ensure training schedules are maintained and safety inspections are carried out at each level. Inter divisional and Inter-Zonal checks are also carried out. The Safety directorate at Board level and Safety officers in the Zone also ensure accidents are enquired into and corrective action is taken in each case. The organization also helps in planning safety related works being implemented in order to minimize possibility of accidents.

### 2) Safety Performance

Consequential Train Accidents on IR are classified into a few main categories viz. (i) Collisions, (ii) Derailments, (iii) Accidents at Level Crossing Gates, (iv)Fire in Trains and (v) Miscellaneous Accidents. As a result of induction of new technology in all spheres viz. track, signaling and rolling stock as well as greater emphasis on human resource development and Training there has been a sharp decline in accidents as will be seen from Figure 3.3-19 and -20. A major concern is level crossing gate accidents which have not declined significantly in view of rapid growth in both road vehicles and volume of rail traffic.

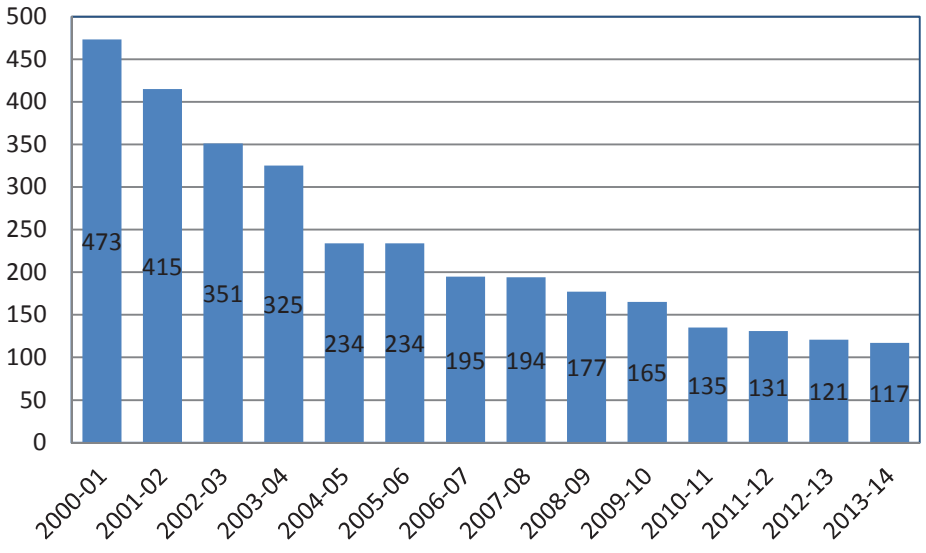



Figure 3.3-19 Number of Train Accidents on IR 2000-01 to 2013-14

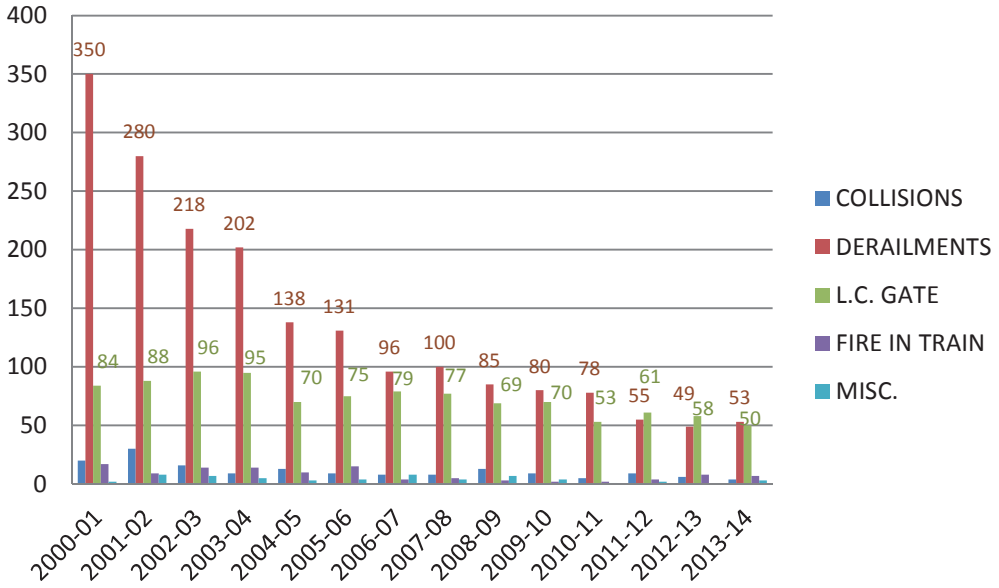



Figure 3.3-20 Typewise Train Accidents on IR 2000-01 to 2013-14

### 3) Causes of Accidents

The Table 3.3-20 below gives the various causes for train accidents. It will be seen that human failure remains amongst the major causes although it has been declining. The other main cause is failure of other persons which is basically the failure of road users at level crossing gates. Despite educational drives, publicity campaigns, surprise checks for road users the problem persists. It has therefore been decided to replace all Level Crossing Gates with Road Over Bridges or Road under Bridges in a time bound manner. The impact of other causes is small.

Table 3.3-20 Causes of Train Accidents on Indian Railways 2000-01 to 2013-14

| | 00-01 | 01-02 | 03-04 | 03-04 | 04-05 | 05-06 | 06-07 | 07-08 | 08-09 | 09-10 | 10-11 | 11-12 | 12-13 | 13-14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FAILURE OF RAILWAY STAFF | 293 | 249 | 186 | 161 | 119 | 120 | 85 | 87 | 76 | 63 | 56 | 52 | 45 | 52 |
| FAILURE OF OTHER PERSONS | 109 | 103 | 118 | 107 | 78 | 86 | 84 | 81 | 75 | 75 | 57 | 63 | 59 | 53 |
| EQUIPMENT FAILURE | 33 | 24 | 18 | 18 | 14 | 8 | 9 | 9 | 0 | 6 | 5 | 5 | 6 | 1 |
| SABOTAGE | 19 | 14 | 10 | 18 | 4 | 6 | 8 | 7 | 13 | 14 | 16 | 6 | 3 | 4 |
| COMBINATION OF FACTORS | 4 | 0 | 2 | 2 | 1 | 0 | 1 | 0 | 4 | 1 | 3 | 1 | 0 | 0 |
| INCIDENTAL | 11 | 20 | 15 | 17 | 16 | 11 | 7 | 8 | 5 | 4 | 4 | 3 | 7 | 4 |
| CAUSE NOT ESTABLISHED | 4 | 5 | 2 | 2 | 2 | 3 | 1 | 2 | 4 | 2 | 0 | 1 | 1 | 3 |
| TOTAL | 473 | 415 | 351 | 325 | 234 | 234 | 195 | 194 | 177 | 165 | 141 | 131 | 121 | 117 |

The safety of the railway system is measured in terms of Accidents per Million Train Kilometers which has also been progressively improving in view of Accidents declining while traffic volume is progressively increasing. IR's performance today compares well with the most advanced Railways of the world. This index is depicted in the Figure3.3-21 below.

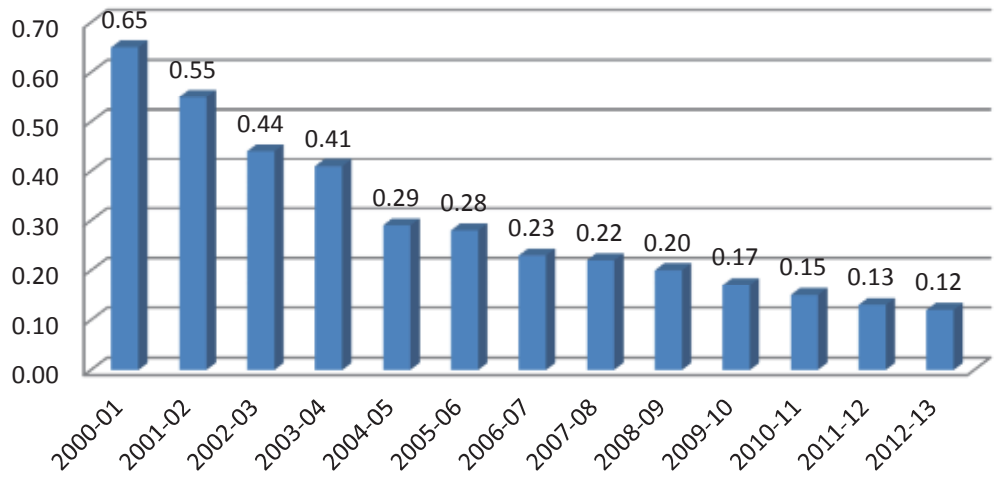



Figure 3.3-21 Index of Train Accidents per Million Train Kilometres

4) Steps to improve safety

A number of steps have been taken to improve safety over the last and up-gradation of technology is an on-going process. During the period from about 2002 the Government allocated Rs. 17000 Crores (Rs. 170 Billion) for clearing a backlog of arrears for replacement of over aged assets. Under the programme which lasted over seven years substantial track renewal works were carried out, new Signaling systems were introduced, extensive track circuiting works were executed and overage rolling stock replaced. The results are there to see in terms of the sharp decline in train accidents. The current focus is on developing a device to prevent collisions. A GPS based Anti Collision Device was locally developed, now a train Collision Avoidance System is being developed. Track Circuiting from Fouling Mark to Fouling Mark on Main Lines has been completed on most of the important routes and is now being introduced on

other routes. Pilot projects of Train protection Warning System (ETCS Level I) have also been implemented on two routes and approved for 3330 Route kilometers. Track up-gradation is also an on-going process with the use of 60Kg. /90 UTS rails being laid on Concrete Sleepers, progressively shifting to flat-butt welding of rails and introducing improved methods for ultra sonic flaw detection in rails, use of sophisticated Track Recording and oscillograph cars. In case of Rolling Stock crashworthy coach designs are being developed, suspension systems improved and wheel impact detectors installed. Fire in Trains has been a cause for anxiety and the focus is on use fire retardant furnishing material and electrical cables in coaches. A Pilot Project for a comprehensive Fire and Smoke detection system has been taken up in one Rajdhani Express train formation.

#### 5) Recommendations of Recent Safety Review Committee

In February 2012 MOR received the Report of a High Level Safety Review Committee also known as the 'Kakodkar Committee'. Their recommendations included a number of institutional and policy issues such as need for independent safety regulation, urgency to improve financial health of the organization, strengthening the Research facilities and opening 5 new research Centers, to introduce ETCS II signaling system based on continuous track circuiting, improvement in maintenance diagnostic, measurement and maintenance practices and greater delegation of powers to field managers for implementing Safety works. The Government is examining the recommendations and it is expected some of the recommendations will be implemented in a phased manner.

### (10) IR Operations & Maintenance Practices & High Speed Railway

#### 1) Some Conclusions from Review of O&M Practices on IR

What the study of IR Operations and Maintenance Systems reveals is that IR follows systematic and well thought through policies and procedures which are appropriate to the scale and size of its network, ownership of rolling stock and volume of traffic transported. The procedures are laid down in codes, manuals, policy instructions, procedure orders and rules which are implemented by field staff all over the system. In a rapidly changing technological environment IR has been progressively inducting new technology in order to improve productivity, capacity and safety standards. In view of its very large scale of operations often adopting the latest technology has been difficult in view of the costs involved and the need for following uniform systems all over the system. The approach has therefore been incremental adoption of new technology; however, the results speak for themselves in terms of growth achieved in both freight and passenger operation and an improving trend in safety performance. Without very sound operating and maintenance practices IR would not be one of the leading Railway Systems of the World. The Safety performance, although, considerably improved is still some distance from achieving the 'Vision 2020' objective of 'Zero' accident on IR. There are a number of areas where improvement is still required.

#### 2) Operating Practices & HSR

IR manages extremely complex operations, particularly, as the same track caters to both freight and several categories of passenger services. Even with passenger services there are vast differentials in maximum permissible speed and booked speed of different categories of trains, differences in the composition of trains in types of accommodation provided and maintenance schedules. Time Tabling of Trains is therefore complex especially in case of Trains going from one end of the country to another over several zones with distances over two thousand kilometers. IR also has IT based sophisticated crew management systems and maintenance scheduling of rolling stock. Despite the line capacity constraints IR manages it passenger & freight train operations the task admirably. New IT based Passenger Train Tabling applications are also currently being developed in the country. HSR operations over an independent section with possibly two types of services and common train composition is therefore likely to be a

relatively simple and IR management should be able to effectively manage HSR operations so as to ensure optimal management of rolling stock, line capacity and crew and on board support services in view of the extensive professional experience in these areas.

### 3) Maintenance Practices & HSR

IR has very elaborate maintenance systems for its Fixed Infrastructure and Rolling Stock. This is borne out by the fact that it utilizes most of its assets over an exceptionally long life span until the time that the technology becomes virtually obsolete. It has adopted maintenance procedures that are based on the original equipment manufacturers recommendations, its own experience in maintaining the assets and based on the demands of operations without compromising on safety. The maintenance schedules are elaborate, well documented and rigidly enforced. The target for rolling stock availability for operations are also extremely high, for example, only 4% of the Wagon fleet and 10% of the diesel loco fleet is targeted to be 'ineffective' at any time owing to maintenance schedules, repairs etc. These targets are invariably achieved. When the need has been felt for change it has introduced new systems. Moreover, the maintenance systems have constantly undergone change, for example in the case of Track the organization is currently transitioning from manual maintenance systems to mechanized maintenance of Track with the help of track machines of various types. Similarly new diagnostic equipment is being installed for detecting warm boxes, flat tyres, functioning of locomotive components, rail flaw detection, measuring track parameters and in case of electronic Signal Interlocking data loggers monitors health of various components. The longevity of assets may be gauged from the fact that it has an exclusive production unit for rebuilding locomotives which have lived a life of 18 years which enables technology up-gradation. The organization also has the capacity to maintain several generations of equipment at the same time. For example on a single division there may stations with Standards I to IV levels of signal & point interlocking, both semaphore and colour light signaling, mechanical, electrical and electronic interlocking. It also has a vast network of in-house training facilities where staff at all levels may be imparted new skills and maintenance techniques for new technologies that the organization may import. Therefore IR has experience in adopting new technology as required from time to time. It should therefore be effectively able to cater to the maintenance needs of HSR in all spheres including track, bridges & structures, rolling stock, signaling & telecommunication, electric traction and creating the necessary, depot repair and workshop facilities to support High Speed Railway operations.

### 4) Safety Performance & HSR

The review of safety performance also reveals that there have been very significant improvements in terms of reducing the number of train accidents as well as improvement in the safety index which reflects the number of accidents per million train kilometres. The organization has also set itself a target of zero accident in its Vision Statement. There are, however, few issues that still need to be tackled. These include preventing collisions even if the train crew or other staff commits a mistake. This will involve adopting an ETCS II type system with continuous track circuiting being installed. IR is developing its own TCAS (Train Collision Avoidance Device) in order to meet this requirement. IR also has the problem of running trains during foggy weather when visibility of signals is poor and in order to overcome the project IR is associating the Indian Institute of Technology, Kanpur to find a solution. There is also concern regarding occasional accidents on account of fire in trains and solutions are being sought to overcome potential hazards. There is also the recognition that much greater effort needs to be put into Research into various aspect of Railway Engineering and management with a view to enhance safety performance. Induction of new technology and better training and Human Resource Development should help IR further improve safety performance. HSR will need to be designed, operated and maintained in such a manner so that there is no chance of an accident. As globally such technologies exist there should be no difficulty in adopting such technologies on IR, particularly, if the HSR is developed as an independent Railway system that is not connected to IR's existing network.

### 3.3.4 Procedure for Opening New Line in IR

#### (1) Role of Ministry of Railways in Safety Management

The Ministry of Railways is the Apex body with respect Railway Policy. They are responsible for deciding Policy, procedures and rules for all aspects of Railway operations and maintenance. They lay down the maximum moving dimensions for different gauges of Railway, set the standards in all aspects of Railway functioning like track, Signalling and Telecommunication, Traction, Rolling Stock, approve new designs, decide on the Rules for Train Operation etc. They also issue all Codes and Manuals and Rule Books relating to different departments that lay down procedures and practices to be followed in the field.

The Ministry also monitors safety performance in the field analysing statistical data relating to different category of accidents, such as Collisions, Derailments, Level crossing Accidents and Fire in Trains. They carryout exhaustive cause wise studies, ensure each accident is inquired into and ensure corrective action is taken. They also recommend preventive measures that need to be taken through regular and surprise safety inspections, regular training of staff, counselling of field staff, conduct of Safety drives from time to time.
The Ministry also takes major policy decisions relating to safety in terms of investments and technology up-gradation to prevent accidents for example construction of road over or road under bridges to replace level crossing gates, providing driver and guard communication systems development of a 'Train Collision Avoidance System', improvements in signalling systems, implementation of 'Automatic Warning System' & 'Train Protection & Warning System' (ETCS – 1), up-gradation of track structure etc.

In terms of organisation at the Railway Board level under the Chairman / Member Transportation there is an Advisor Safety with Executive Director and or Directors under him who monitors Safety performance on the Zonal Railways. They Railway Board regularly discusses Zonal Railway Performance and deliberate on Safety issues. The Ministry regularly is in touch with the Commission of Railway Safety and in their annual meetings takes note of issues raised by the Chief Commissioner of Railway Safety. It should be noted that the Commission of Railway Safety while inquiring into an accident or inspecting a New Line which is to opened for Passenger Traffic checks whether, policies, procedures and rules laid down by the Ministry of Railways/ Railway Board are being correctly followed and implemented in the field.

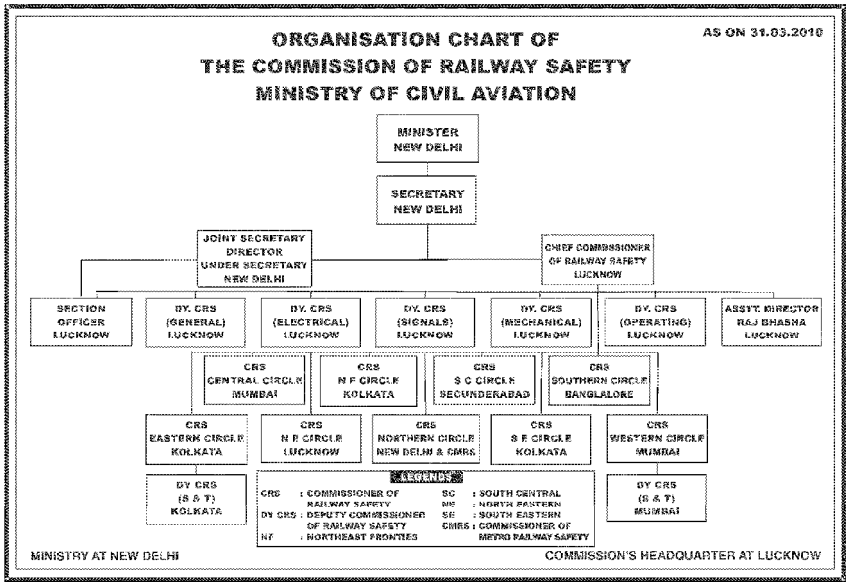
#### (2) Role of Commission of Railway Safety

The Central government under Section 5 of The Railways Act 1989 is empowered to appoint a Chief Commissioner of Railway Safety and in addition also appoint one or more Commissioners of Safety as it may consider necessary. At present the Chief Commissioner of Railway Safety (CCRS) and Commissioners of Railway Safety (CRS) function under the Ministry of Civil Aviation so that they are independent of the control of the Ministry of Railways and can freely inspect, Railway Lines, Rolling Stock and investigate railway accidents. The duties of a Commissioner are laid down in Section 6 of the Railways Act and are mentioned below:

a) Inspect any railway with a view to determine whether it is fit to be opened for the public carriage of passengers and report to the Central government as required by or under the Act.
b) Make such periodical inspections of any Railway or of any Rolling Stock used on the line as directed by the Central government
c) Inquire into any accident on the railway
d) Discharge any other duties as are conferred on him by or under the Railway Act.

The Commissioner of Railway Safety is empowered to inspect any Railway or rolling stock on it, or require the attendance of any official of the railway and obtain information as he deems fit or require the Railway administration to produce any book or document or material object which he may wish to inspect. The Railway administration is also required to provide all reasonable facilities to the CRS for discharge of his duties and exercise of his powers.
Commissioner of Metro Railway Safety performs similar statutory functions laid down in Delhi Metro Railways (O&M) Act, 2002.

At present the Commission is headed by a Chief Commissioner of Railway Safety (CCRS), at Lucknow, who also acts as Principal Technical Advisor to the Central government in all matters pertaining to Railway Safety. There are nine Commissioners of Railway Safety (CRS) under the control of the CCRS who have jurisdiction over one or more Zonal Railways. They have their Headquarters at Mumbai (2), Kolkata (3), New Delhi, Bangalore, Lucknow and Secunderabad. There are 5 Deputy Commissioners at the Lucknow Office to assist the CCRS and 2 field Deputy Commissioners from the Signal & Telecommunication disciplines located at Kolkata and Mumbai to assist the Commissioners of Railway Safety (Figure 3.3-22).




Source: Annual Report of Commissioner of Railway Safety (2009-2010)

Figure 3.3-22 Organization Chart of the Commission of Railway Safety

### (3) Certification of the new line

The certification of the new line is done under prevailing laws for the opening of a New Line as provided for under the Indian Railways Act, 1989. In terms of Section 22 of the Railways Act, 1989 and rules made under section 28, 29 and 198 of the Act, the Commissioner of Railway safety has to carry out his statutory inspection of the new railway line, its appurtenances, various sub-grade and accommodation works etc. and submit his report to the central Government stating whether the Railway can be opened without any danger to the public using it. In case the Railway, for some reason cannot be opened without danger to the public the CRS shall clearly state the grounds for this and mention the requirements which he feels need to be complied with before sanction is given by the Central Government. On receipt of the Report of the CRS, the Central government may confirm, modify, or cancel the sanction given by the CRS, subject to such conditions, alterations or relaxation, as may be considered necessary, after giving due consideration to the suggestions or the conditions subject to which the CRS has opened the Railway.

The Ministry of Railways has notified the Opening for Public carriage of Passenger Rules 2000 issued on 21.07.2000 (GSR No. 625 (E)) and 08.10.2001 (GSR No. 762(E)) under which the Commissioner of Railway Safety has been authorized to sanction the opening of new railway Lines for public carriage of passengers, after his inspection, subject to such conditions as he may consider necessary to impose.

### (4) Procedure for opening a new line

For the opening of any new line for the public carriage of passengers the sanction of the Central Government (Ministry of Railways) is necessary. However, no new line or section of a line can be opened for passenger traffic unless the Commissioner of Railway Safety (CRS) has inspected it and sanctioned its opening.

The line is offered for inspection to the Commissioner by the Chief Engineer in charge of the Project. Before it is offered for inspection the new line must be complete and fully equipped in all respects. According to the Indian Railway Engineering Code before the opening all station buildings and staff quarters should be complete and ready for occupation, all station yards, locomotive yards provided in the construction estimate should be complete, Track must be thoroughly packed and boxed throughout (in case of ballasted track), all signals and point indicators must be in position and perfect working order, points and crossings are required to be correctly and truly laid and it also must be ensured all maintenance staff along the line are posted and in a position to perform their duties and they have the necessary tools and rule books. Similarly all station staff should be in position with necessary Rule Books, working instructions, station diagrams, stationery, tickets etc.

At least one month's clear notice is required to be given to the CRS prior to the date on which it is desired the line be inspected. Normally the inspection should be scheduled one week prior to which it is planned to open the section for passenger train running so that any deficiencies pointed out during the inspection may be rectified and the line may be transferred from the construction organization to the open line that shall operate the line.
After carrying out the inspection the CRS may recommend (i) that the railway be opened unconditionally, (ii) the railway be opened to subject to certain stated restrictions or (iii) the opening of the railway be postponed until certain stated conditions have been fulfilled. The CRS on his part is also required to submit a report to the Railway Board who may or may not accept his recommendations. After the CRS has granted permission for opening of the line the assets are transferred from the Construction organization to the open line organization and the Operating department.

### (5) Duration of Inspection

Depending on the length of the line the inspection by the Commissioner of Railway Safety may take a couple of days to several days. The duration of the inspection will be at the discretion of the Commissioner of Railway Safety. The CRS will inspect the entire section including bridges, the signalling arrangements and the electrification works etc and will issue the sanction for opening of the line if he is satisfied the line is safe for carriage of passengers.

## 3.4 Review of Existing Related Plans & Studies

There are several large cities such as Mumbai (including Greater Mumbai, Navi Mumbai and Thane), Surat, Vadodara and Ahmedabad along Mumbai – Ahmedabad High-speed Rail Corridor. For the planning of the corridor, existing related plans and studies in each city are reviewed here.

### 3.4.1 Mumbai

Mumbai is the capital city of Maharashtra state with a population of approx. 12.5 million (Census of India, 2011), it is the most populous city in India and is known as the commercial and entertainment capital city of India.

MMR which consists of 8 municipal corporations, 9 municipal councils and more than 1000 villages is one of the fastest growing metropolitan areas in India. It spreads over an area of 4,355 $km^2$, the region is the second largest metropolitan region in India after the National Capital Region (NCR). The population and its annual compound growth rate of MMR is show in the table below:

Table 3.4-1 Profile of Mumbai

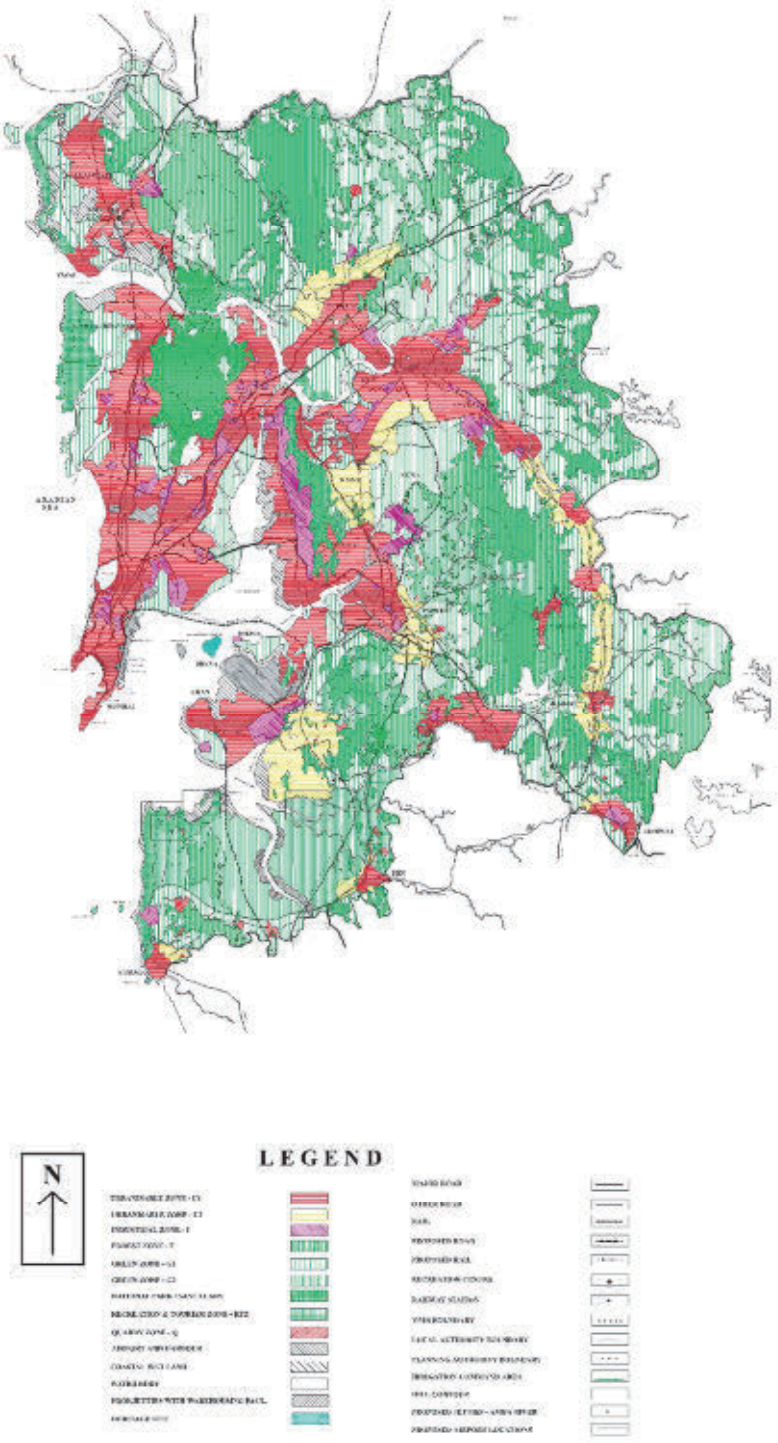
| | | |
|---|---|---|
| **Population in 2011 (2001)** | | |
| Mumbai City | 3,145,966 | (3,326,837) |
| Mumbai Suburban | 9,332,481 | (8,587,000) |
| Greater Mumbai (Total) | 12,478,447 | (11,913,837) |
| MMR | 20,748,395 | (18,414,288) |
| **Decadal Growth Rate (%)** | | |
| Mumbai City | | (-) 5.75 |
| Mumbai Suburban | | 8.01 |
| Greater Mumbai (Total) | | 4.74 |
| **Area (2011)** | | |
| Mumbai City | | 157 $km^2$ |
| Mumbai Suburban | | 446 $km^2$ |
| MMR | | 4,355 $km^2$ |
| **Per Capita Income (2010-2011)** | | Rs 1,41 lakh |
| **GDDP at Constant Price in 2010-2011(2004-2005 Prices)** | | Rs 1,689,730 million |
| **Key Industry Sectors** | IT industries<br>Chemicals and Fertilizers<br>Food processing<br>Textiles<br>Pharmaceuticals | Hoteling<br>Automobile manufacturing<br>Electrical & Electronics<br>Drugs<br>Others |

Source : A Study on the Mid/Long Term Railway Networks in India (2012-2013), TERI

The Mumbai Metropolitan Region Development Authority (MMRDA) is a Maharashtra state government organization overseeing the development in MMR such as town planning, city development, transportation, etc.

**Land-use Plan in Mumbai**

The latest land-use plan in Mumbai has been unveiled in 1999 (Figure 3.4-1).



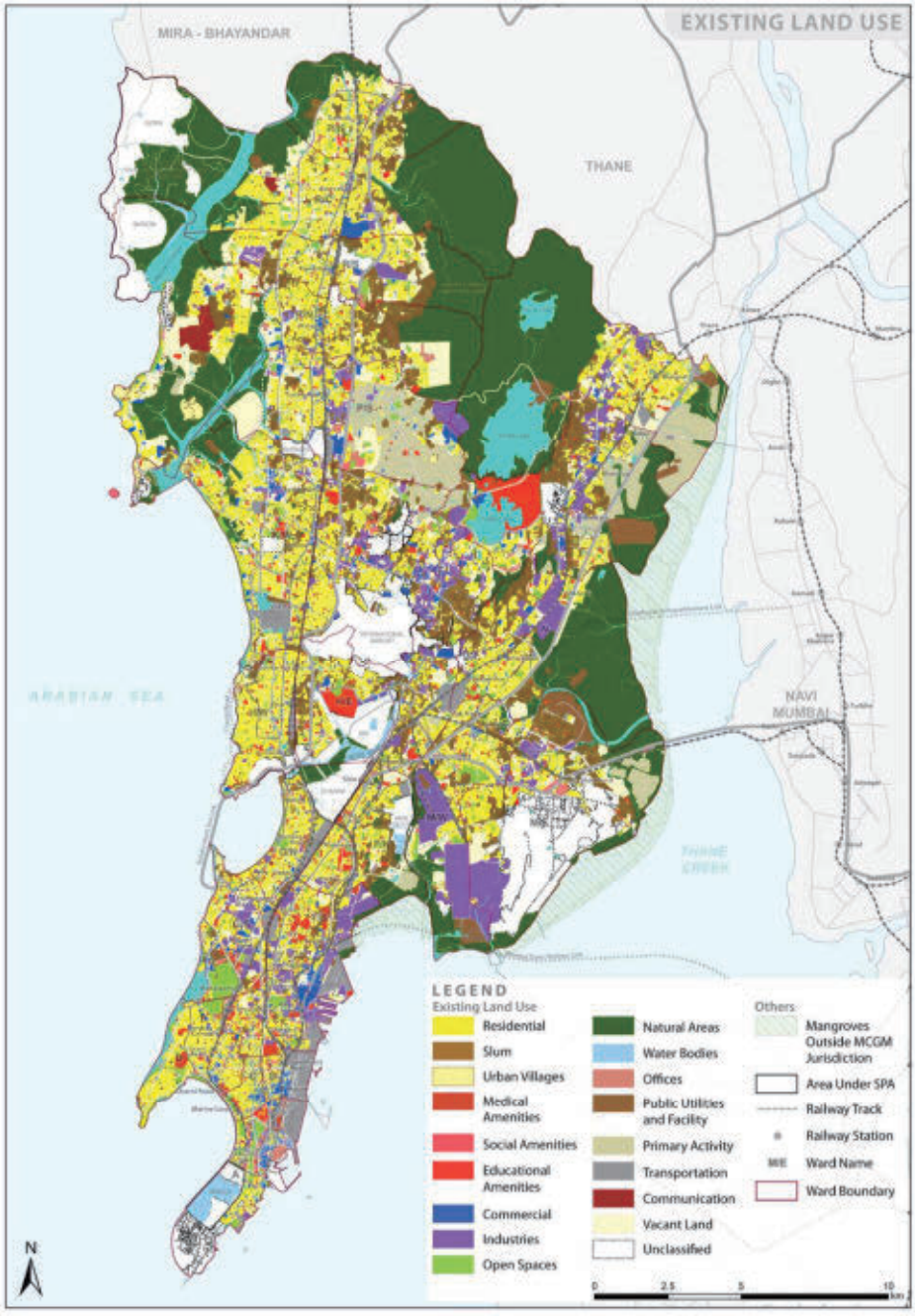

Source : MMRDA

Figure 3.4-1 Regional Plan MMR Land-use Plan 1996-2011

In the land-use plan, zones are distinguished Development areas such as Urbanisable Zone -1, 2, Industrial Zone, Recreation &Tourism Zone and Development Zone from Conservation areas such as Green Zone-1, 2, Forest Zone, National Parks and Sanctuaries & Heritage Sites. Greater Mumbai and

The most populated and urbanized areas such as Greater Mumbai, Navi Mumbai and Thane, etc.

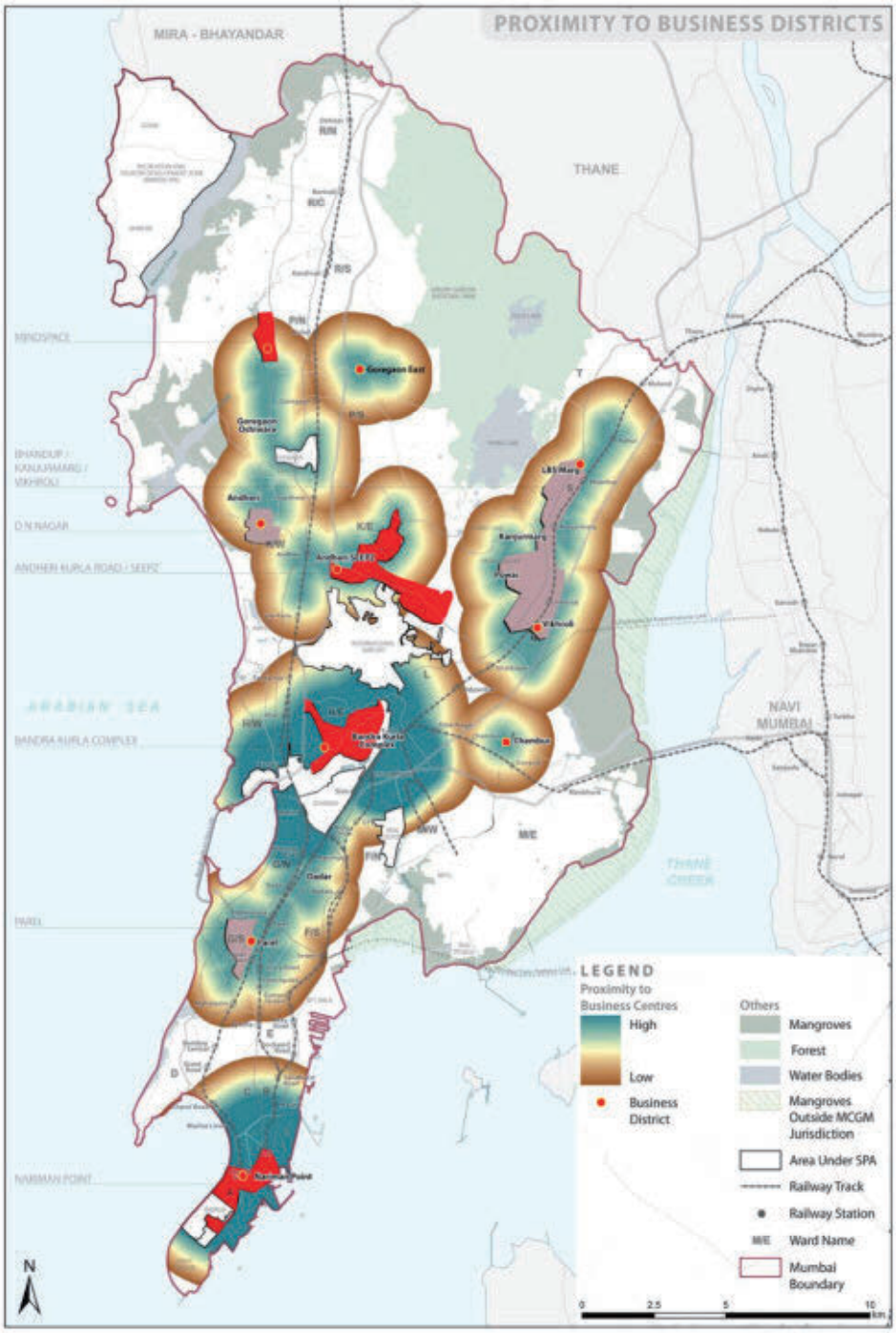
are categorized as Urbanizable Zone -1.2 or Industrial Zone.
Besides, regarding land use plan in each municipality, the development plan (2014-2034) of Greater Mumbai is being prepared by the Municipal Corporation of Greater Mumbai (MCGM) and existing land-use map was prepared in this process. (Figure 3.4-2)




Source : Municipal Corporation of Greater Mumbai

Figure 3.4-2 Existing Land-use Map of Greater Mumbai

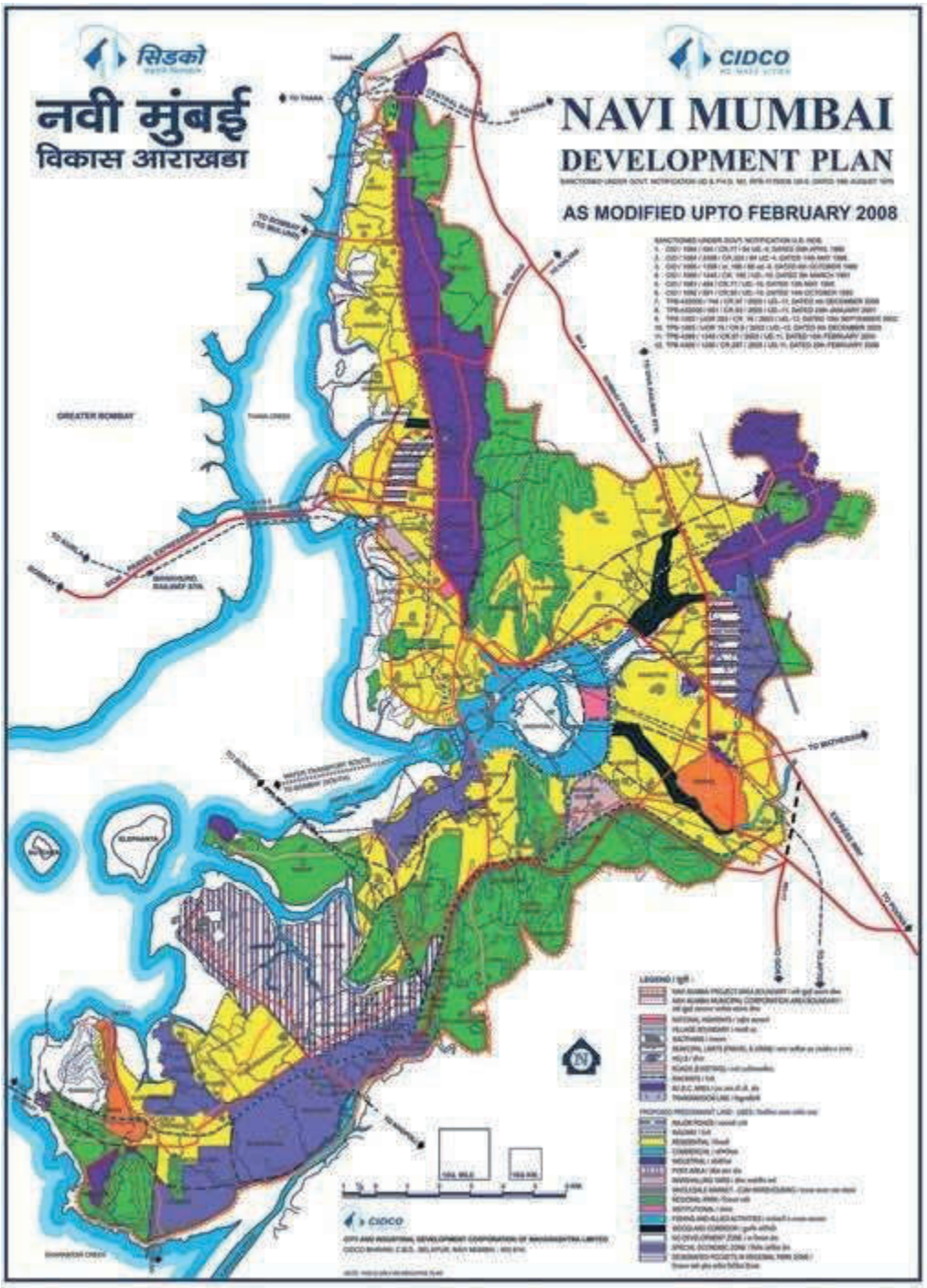
Additionally, location of existing Central Business District (CBD) is also investigated (See Figure3-28). Nariman Point-Fort is the CBD of Greater Mumbai and Worli, Bandra Kurla Complex and Andheri are existing second CBD.




Source : MCGM

Figure 3.4-3 CBD in Greater Mumbai

There is the city development plan of Navi Mumbai by City and Industrial Development Corporation of Maharashtra Limited (CIDCO). Land-use plan is shown in it (See Figure 3.4-4).




Source : CIDCO

Figure 3.4-4 Land-use Plan of Navi Mumbai

**Transport projects under planning and under construction in Mumbai**

There are several transport projects under planning and implementation within Mumbai. To create good connectivity of HSR with main places of Greater Mumbai, it is important to consider the connection of HSR with planned transport infrastructures.

**Within Greater Mumbai**

***Roads***

**Eastern Freeway**: This is a controlled-access freeway that connects the eastern suburbs with South Mumbai. It links P. D'Mello Road in South Mumbai to The Eastern Express Highway (EEH) at Ghatkopar. It is 16.8 km long and has been initiated by MMRDA. A 13.59 km stretch of the freeway comprising two of three segments is currently operational, with the remaining stretch under construction.

**Mumbai Trans Harbour Link (MTHL)**: The link will improve connectivity between Greater Mumbai and Navi Mumbai. The connection includes a 22.5 km long 6 lane bridge connecting Sewri on Greater Mumbai to Nhava on Navi Mumbai with interchanges at Sewri and near Chirle village on NH48. The road includes a 16.5 km ling sea ling and 5.5 km viaducts on land. (See Figure 3-30)

**Coastal Road (West)** : Joint Technical Committee (JTC), Govt. of Maharashtra has proposed access controlled coastal road along the western coast from Nariman point to Malad 35.60 km long, with interchanges at 18 locations connecting to other major roads. The proposed coastal road is expected to provide high-speed connectivity to Western Suburbs and South Mumbai.

***Railways***

**Metro Rail**: Metro Rail System is proposed for a total length of 146 km (within MCGM limits) (See Figure3.4-5). The Metro lines are under various stages of implementation and planning. Metro Line3 goes through the area of Greater Mumbai from north to south and connects the airport and CBD which locates on the southern part of the island.

**Mono Rail**: Mumbai Monorail was opened to the public on February 2014. Its length is 19.54 km and there are 17 stations between Chembur and Walada Depot (See Figure3-30).

**Western Railway**: Additional elevated rail corridor from Oval Maidan to Virar has been proposed by the Western Railway.

**Within Navi Mumbai**

***Railways***

**Navi Mumbai Metro Rail Project**: The project is divided into 5 lines/corridors and is distinguish on the basis of propriety. Priority 1 includes Line 1 is being developed by CIDCO while priority 2 which comprised of Line 2 and Line 3 will be developed by MMRDA and Priority 3 which consists of Line 4 and Line 5 is to be developed by Navi Mumbai Metro Corporation (NMMC). The project is set to be a 106.40 km (See Figure3.4-6).

***Air***

**Navi Mumbai International Airport**: Navi Mumbai International Airport is proposed and to be built in the Kopra-Panvel area of MMR. CIDCO is the nodal agency for the project. The planned Mumbai Trans Harbour Link will connect the airport with Mumbai.

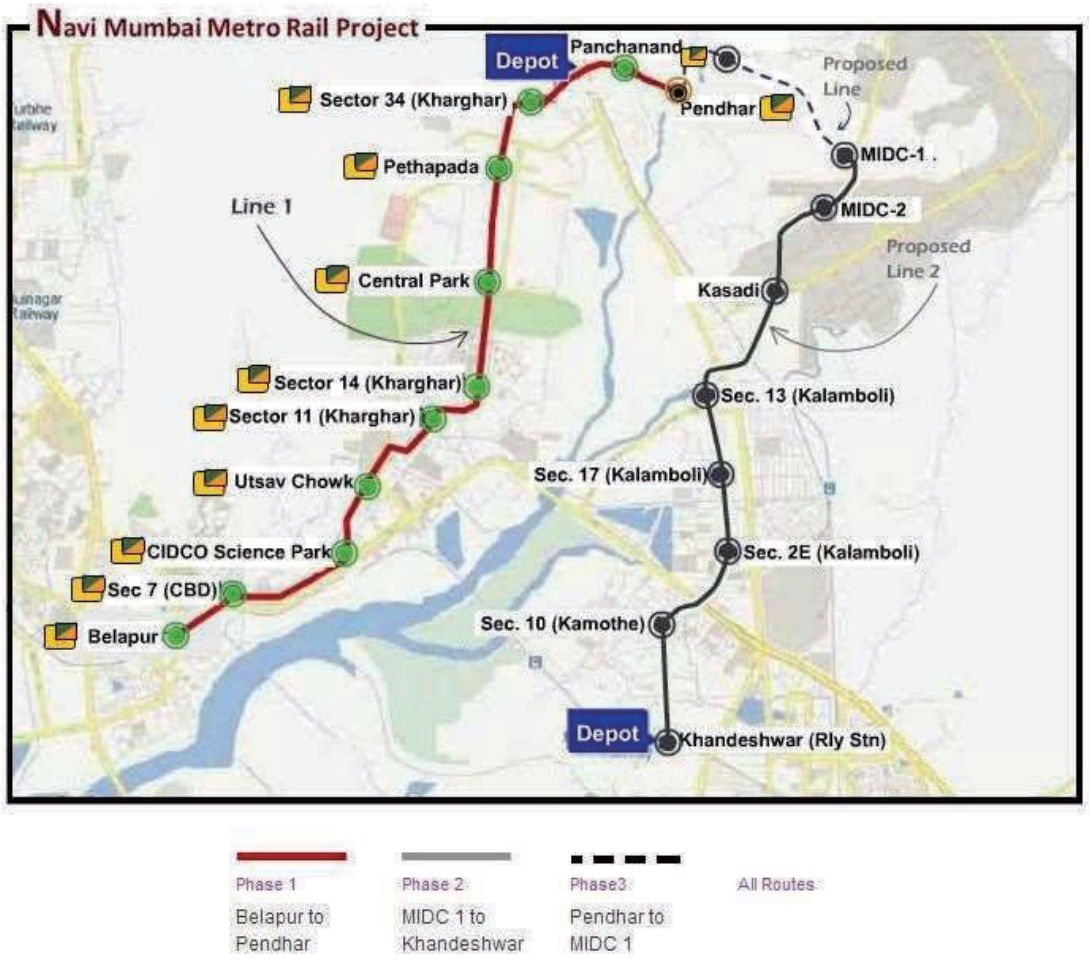
**Within Thane**

***Railways***

**Mass Rapid Transit System for Thane City**: MRT was proposed in Thane city and its Detailed Project Report has been carried out. Total length will be 45.75km (See Figure3.4-7).

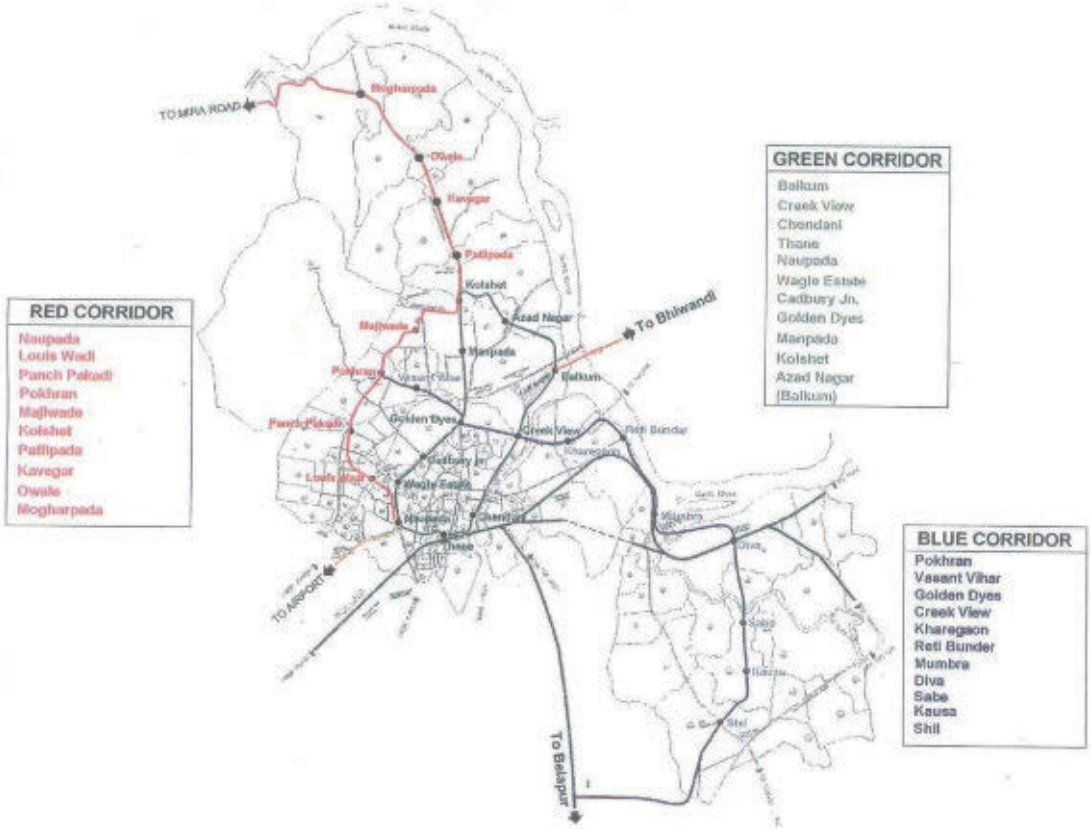

Source : MCGM

Figure 3.4-5 Metro Rail and Mono Rail Alignments in Greater Mumbai




Source : CIDCO

Figure 3.4-6 Metro Rail Project Alignment in Navi Mumbai




Source : Maharashtra State Road Development Corporation ltd. (MSRDC)

Figure 3.4-7 MRT project alignment in Thane city

### 3.4.2 Surat

Surat is known as the second largest city in Gujarat and the eighth largest city in India with population of over 4 million. The city lies midway along the Mumbai-Ahmedabad HSR corridor and is a major bub.

Table 3.4-2 Profile of Surat

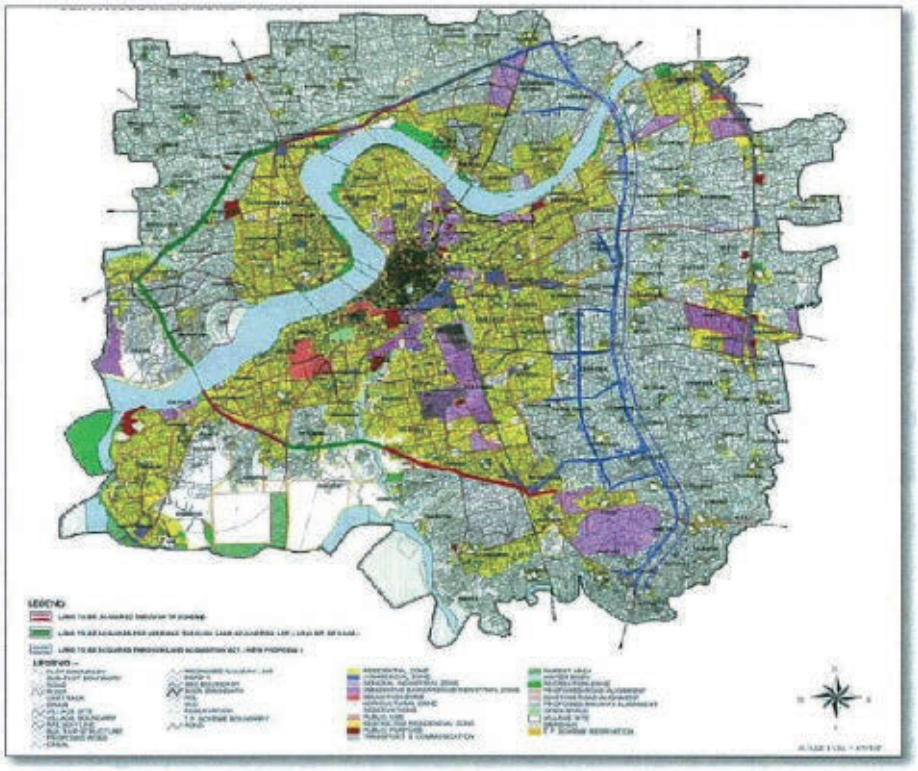
| | | |
|---|---|---|
| **Population in 2011 (2001)** | | |
| Surat City | 4,462,002 | (2,433,835) |
| Surat Metropolitan Region | 4,585,367 | (2,811,614) |
| **Decadal Growth Rate (%)** | | |
| Surat City | | 83.3 |
| Surat Metropolitan Region | | 63.1 |
| **Area (2011)** | | |
| Surat City | | 327 $km^2$ |
| Surat Metropolitan Region | | 4255 $km^2$ |
| **Per Capita Income (2006)** | | Rs 57,000 |
| **DDP at Current Prices 2006-2007** | | Rs 3,333,241(in lacs) |
| **DDP Annual Growth Rate (%) (2001-2006)** | | 11.45 |
| **Key Industry Sectors** | Textiles<br>IT/ITeS Sector | Diamond Processing |

Source : A Study on the Mid/Long Term Railway Networks in India (2012-2013), TERI

**Land-use Plan in Surat**

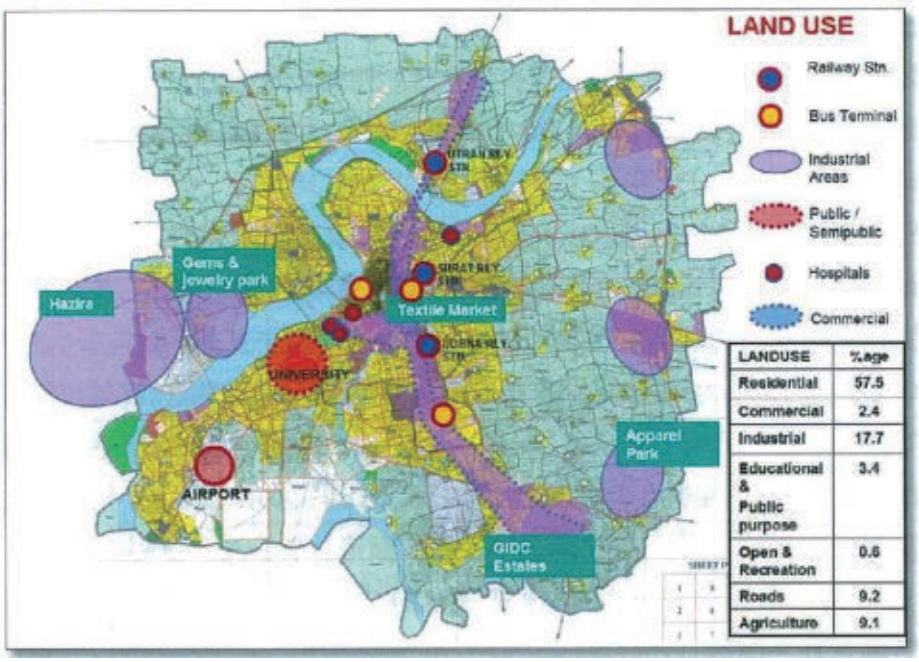
The city has witnessed significant migration from other states due to an increase in employment opportunities and booming industrial growth. The city is expected to grow to be population of 8-9 million by 2031.

As per City Development Plan (2004) by Surat Urban Development Authority (SUDA) (See Figure 3.4-8) the main areas which will generate travel demand within the city includes the areas of Pandesara, Udhna, Sachin, Bhestan, Varachha, Kapodara, Fulpada and Katargam. Figure3.4-10 displays main traffic generating activities within Surat.



Source: SUDA

Figure 3.4-8 Revised Development Plan in Surat (2004)



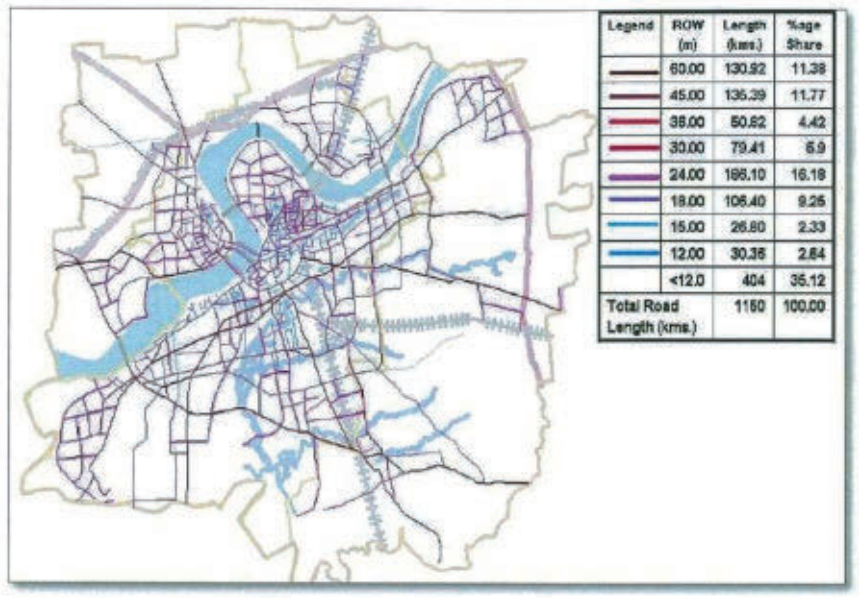

Source: SUDA

Figure 3.4-9 Traffic Generating Activities in Surat

**Transport projects under planning and under construction in Surat**

***Roads***

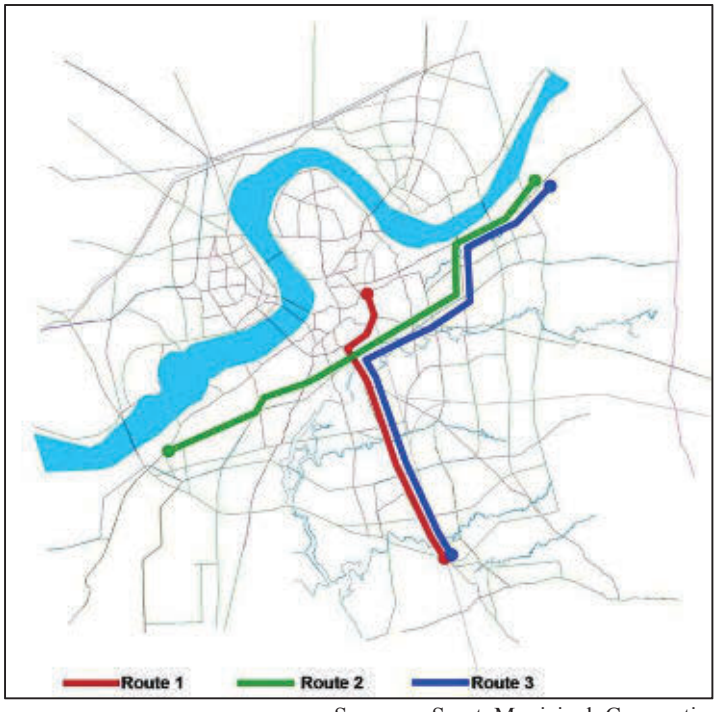
There are several plans to build new flyovers which are expected to 93 by 2015. Existing and proposed road network map is shown in Figure 3.4-10.




Source: SUDA

Figure 3.4-10 Existing and Planned Road Network in Surat

Bus Rapid Transit System (BRTS) in Surat: BRTS is proposed in Surat with around 29.7 km in phase 1 and 58 km in phase 2. A part of the service has been operational since January, 2014. The route map of the project is show in Figure 3.4-11.




Source : Surat Municipal Corporation

Figure 3.4-11 Planned BRTS Map in Surat

***Railways***
**Light Rail Transit System (LRTS) in Surat**: it is proposed to upgrade the BRTS on North-South Corridor to LRT System in the future.

### 3.4.3 Vadodara

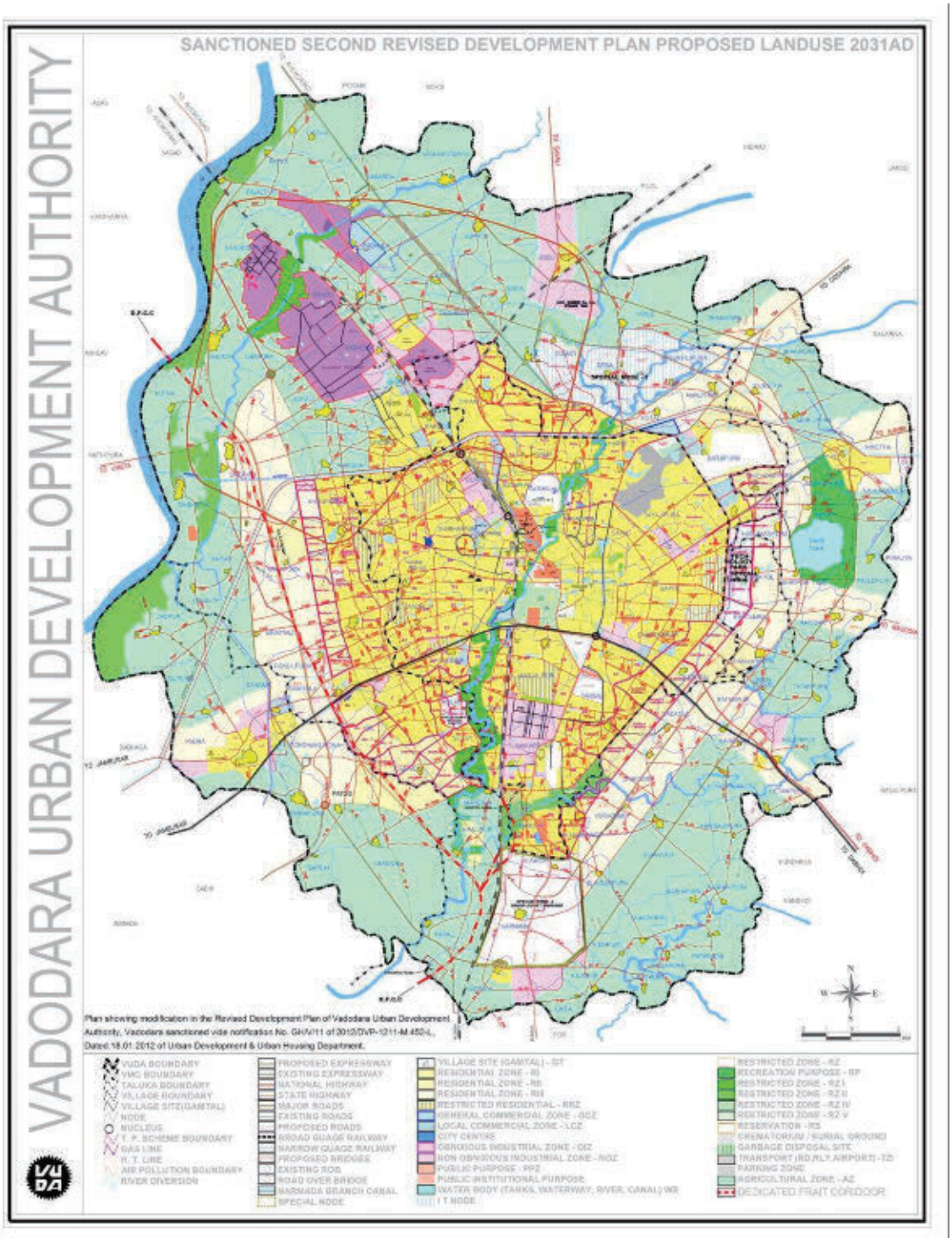
Vadodara is the third largest city in Gujarat after Ahmedabad and Surat. The population of the city was 1.67 million in 2011.

Table 3.4-3 Profile of Vadodara

| | | |
|---|---|---|
| **Population in 2011 (2001)** | | |
| Vadodara City | 1,666,703 | (1,306,227) |
| Vadodara Metropolitan Region | 1,817,191 | (1,491,045) |
| **Decadal Growth Rate (%)** | | |
| Vadodara City | | 27.6 |
| Vadodara Metropolitan Region | | 21.9 |
| **Area (2011)** | | |
| Vadodara City | | 159.95 $km^2$ |
| Vadodara Metropolitan Region | | 402.28 $km^2$ |
| **Per Capita Income (2006)** | | Rs 89,000 |
| **DDP at Current Prices 2006-2007** | | Rs 1,920,536(in lacs) |
| **DDP Annual Growth Rate (%) (2001-2006)** | | 9.83 |
| **Key Industry Sectors** | Chemicals<br>Pharmaceuticals | Petrochemicals<br>Biotechnology |

Source : A Study on the Mid/Long Term Railway Networks in India (2012-2013), TERI

**Land-use Plan in Vadodara**
City Development Plan (2005) was prepared by Vadodara Urban Development Authority (AUDA). The Land-use plan was presented in the plan (See Figure3.4-12). The main features of the Land-use plan are provision of new ring road, wide arterial roads, various types of residential zone and IT zone, Technology and Biotech Park, Health Node, Knowledge Township and Recreation Zone.




Source : VUDA

Figure 3.4-12 Land-use Plan of Vadodara

### 3.4.4 Ahmedabad

Ahmedabad is the fifth largest city and seventh largest metropolitan area in India, with a city population of more than 5.5 million and extended metropolitan population of 6.3 million in 2011.

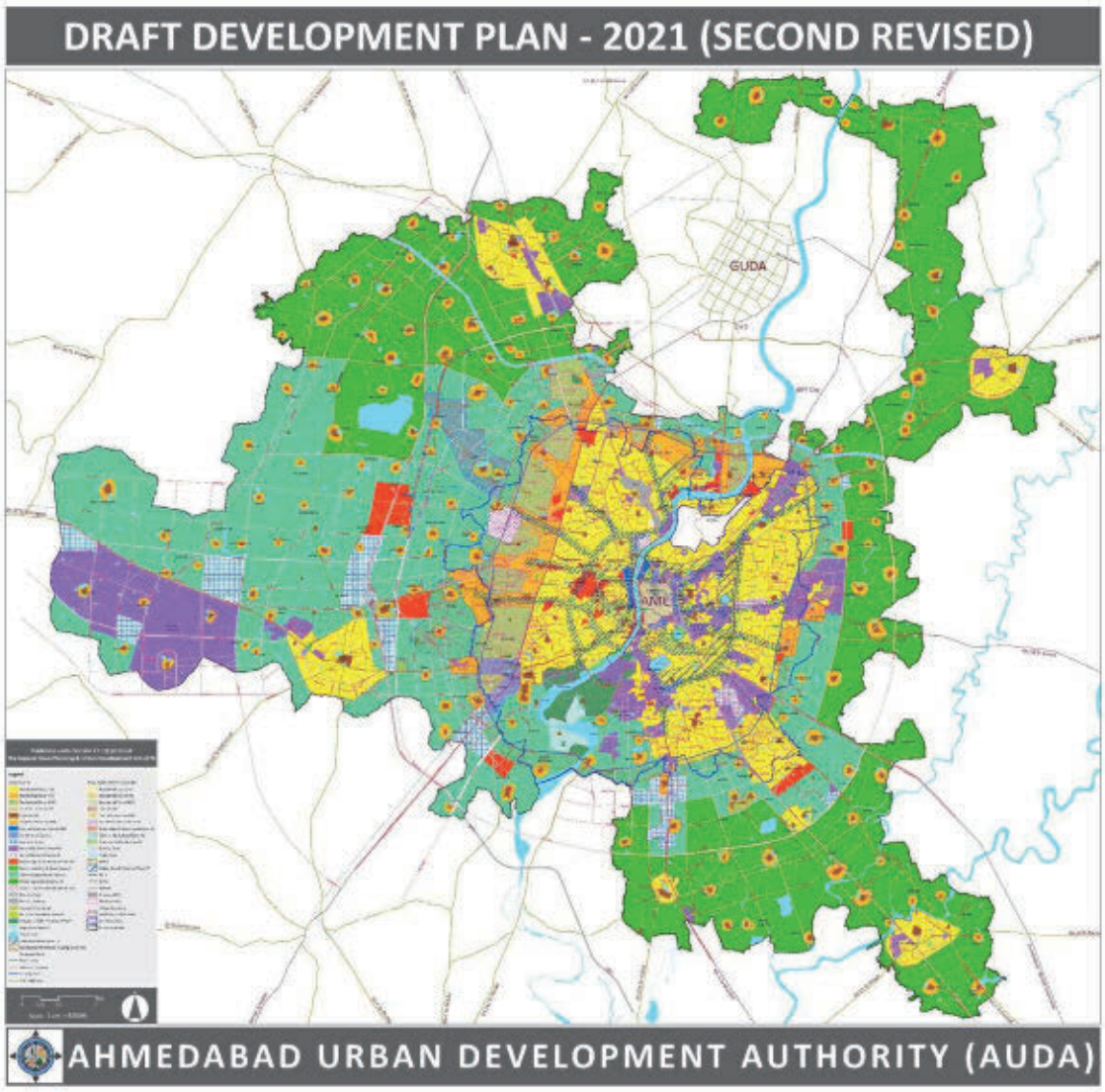
Table 3.4-4 Profile of Ahmedabad

| | | |
|---|---|---|
| **Population in 2011 (2001)** | | |
| Ahmedabad City | 5,570,585 | (3,520,085) |
| Ahmedabad Metropolitan Region | 6,352,254 | (4,525,013) |
| **Decadal Growth Rate (%)** | | |
| Ahmedabad City | | 58.3 |
| Ahmedabad Metropolitan Region | | 40.4 |
| **Area (2011)** | | |
| Ahmedabad City | | 464 $km^2$ |
| **Per Capita Income (2006)** | | Rs 63,000 |
| **DDP at Current Prices 2006-2007** | | Rs 4,010,890(in lacs) |
| **DDP Annual Growth Rate (%) (2001-2006)** | | 9.38 |
| **Key Industry Sectors** | Textiles-apparel<br>Agro-food processing<br>Engineering<br>Diamond Processing<br>Tourism | Drugs-Pharmaceuticals<br>Automobiles<br>Biotechnology<br>IT |

Source : A Study on the Mid/Long Term Railway Networks in India (2012-2013), TERI

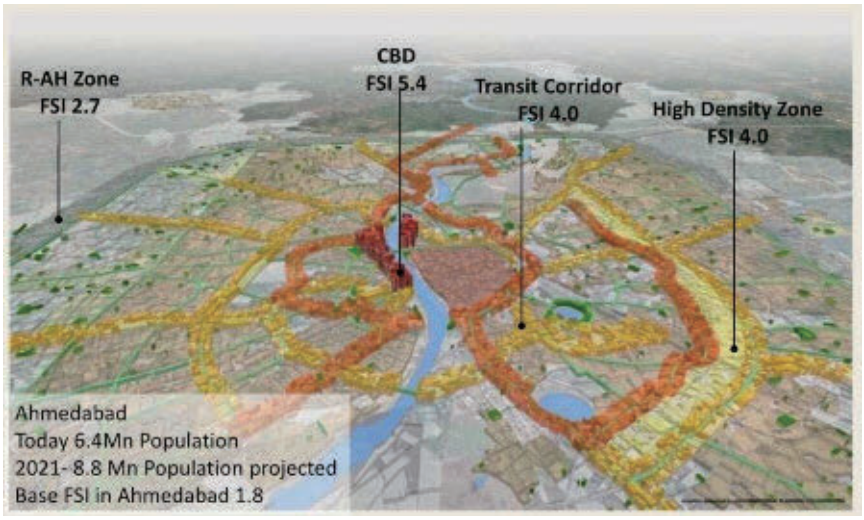
**Land-use Plan in Ahmedabad**

Ahmedabad Urban Development Authority (AUDA) is an organization overseeing the development in Ahmedabad, and Draft Comprehensive Development Plan 2021 has been prepared at present by AUDA (See Figure 3.4-13). A salient feature in proposed land-use plan is to increase the density of proposed Central Business District (CBD) and transit oriented zones (See Figure3.4-14).




Source : AUDA

Figure 3.4-13 Land-use Plan in Ahmedabad



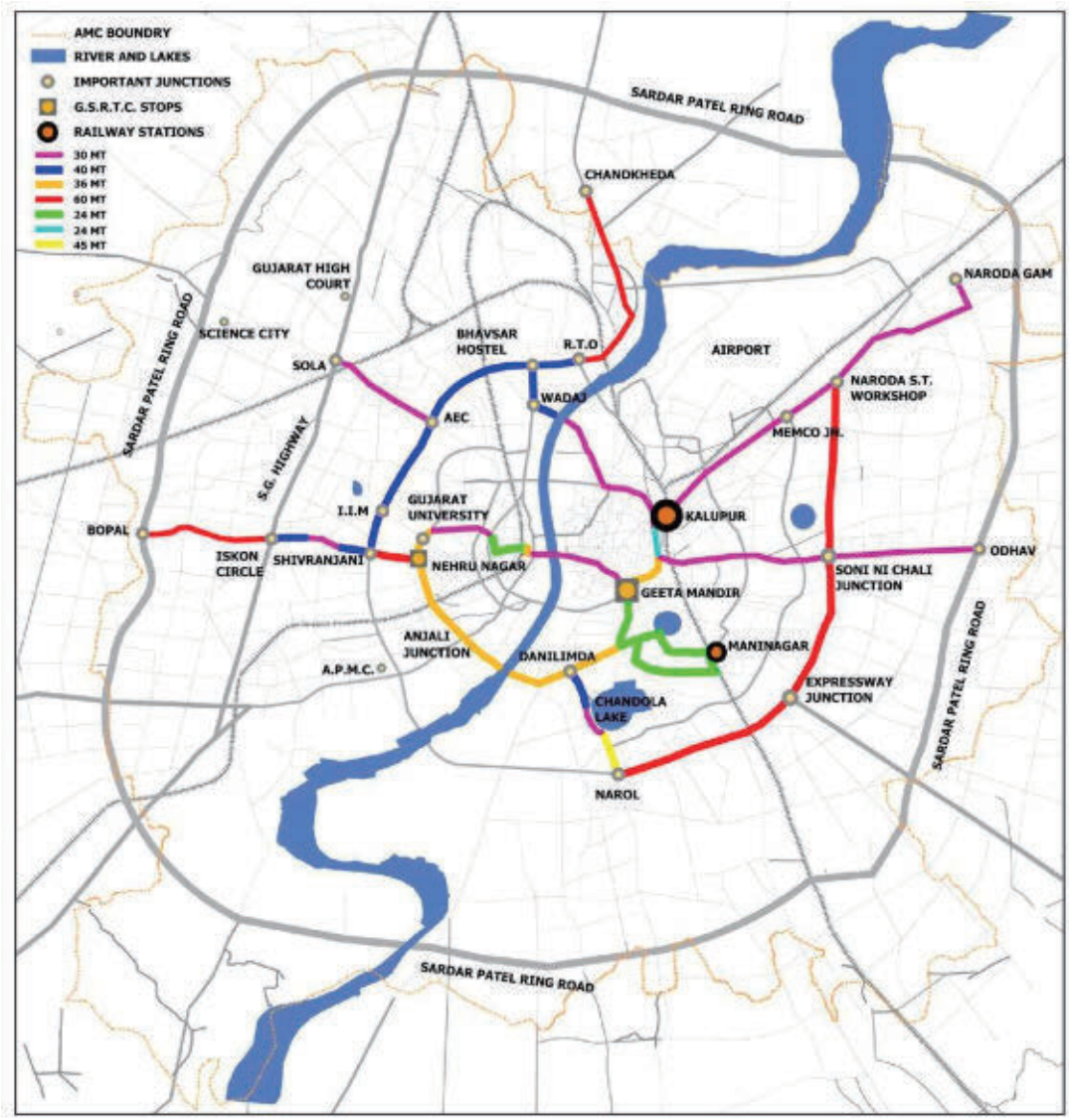

Source : AUDA

Figure 3.4-14 Floor Space Index in Ahmedabad

**Transport Under Planning or Under Construction in Ahmedabad**

***Roads***

**Ahmedabad BRTS**: Ahmedabad BRTS is a bus rapid transit in Ahmedabad which is operated by Ahmedabad Janmarg Limited, a subsidiary of Ahmedabad Municipal Corporation. Route map of Ahmedabad BRTS is shown in Figure 3.4-15.




Source : Janmarg Limited

Figure 3.4-15 Route map of Ahmedabad BRTS

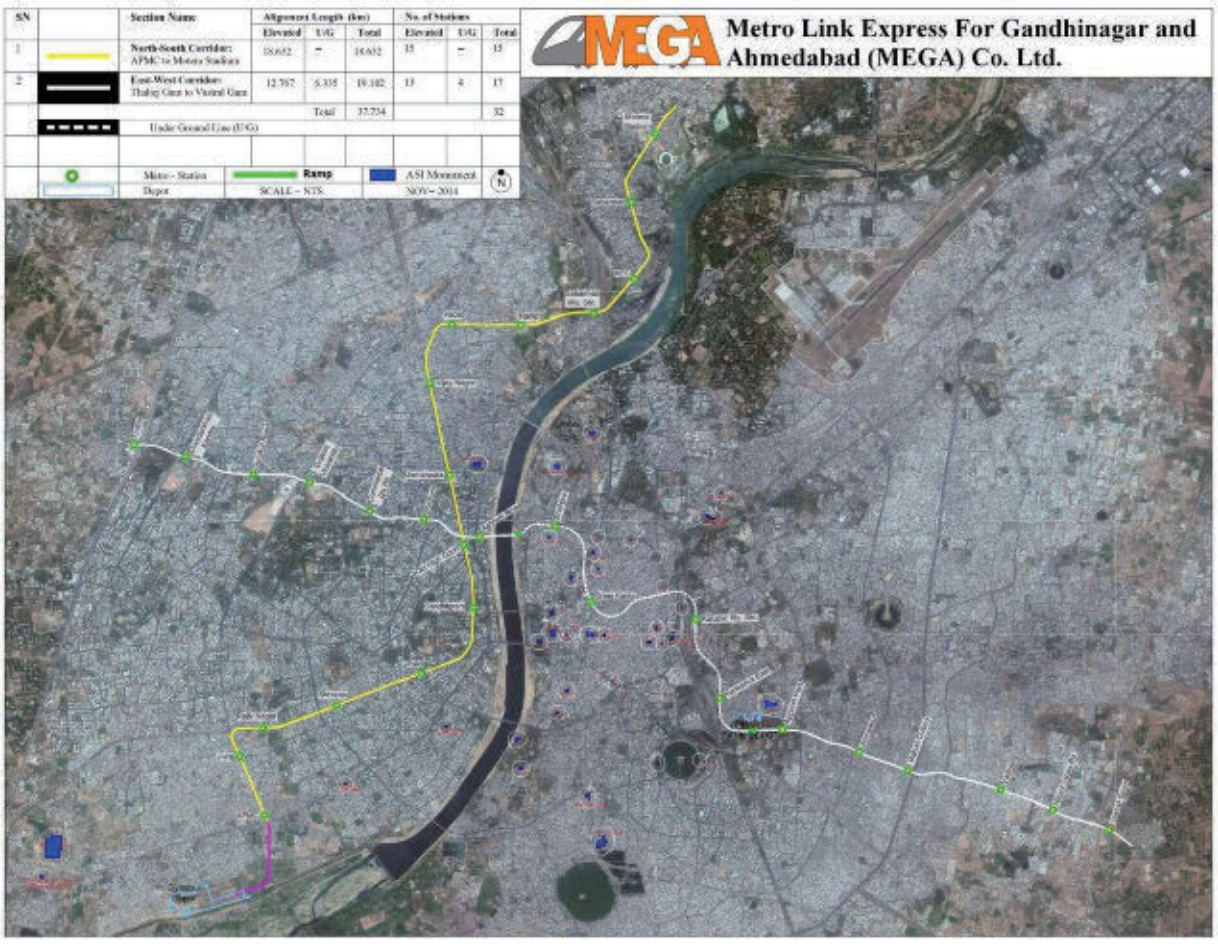
***Railways***

**Metro-link Express for Gandhinagar and Ahmedabad (MEGA)**: A total metro rail network of 82.33 km is planned for the twin cities of Ahmedabad and Gandhinagar. This network covers both the cities as well connects these two twin cities. MEGA is the planning and executing agency for this project. The project is planned to be executed by 2017-2018 for the entire elevated corridor and the underground portion by 2021-2022.

Line 1B (Sabarmati to APMC via Kalupur, length 15.32 kms is planned as a fully underground system and connects Sabarmati with existing Railway station of Ahmedabad. This line along with the Line 2A: (Sabarmati to Paldi, length 12.95 kms) forms a circular ring in the city center. This provides connectivity to existing railway station with the rest of the city.

Table 3.4-5 Length of Various Sections of Ahmedabad Metro

| S. No. | Section Name | Length (km) | | | No. of Stations |
|---|---|---|---|---|---|
| | | Elevated | UG | Total | |
| 1 | Line 1A (Sabarmati to Infocity | 16.6 | - | 16.6 | 12 |
| 2 | Line 1B (Sabarmati to APMC via Kalupur) | - | 15.32 | 15.32 | 10 |
| 3 | Line 2A (Sabarmati to Paldi) | 9.01 | 3.0 | 12.95 | 10 |
| 4 | Line 2B (Paldi to Memco) | 14.85 | 0.0 | 14.85 | 10 |
| 5 | Line 3 (Sabarmati to Airport) | 6.26 | 0.0 | 6.26 | 3 |
| 6 | Line 4 (CH3 to Mahatma Mandir) | 3.7 | 0.0 | 3.7 | 2 |
| 7 | Line 5 (Kasturba Smarak to GIFT City) | 5.85 | 0.0 | 5.85 | 3 |
| 8 | Infocity to Akshardham Ext | 6.5 | - | 6.5 | 4 |
| | Total | 63.71 | 18.32 | 82.36 | 53 |




Source : MEGA

Figure 3.4-16 Proposed Metro Route in Ahmedabad

## 3.5 Public Private Partnership - Legal, Institutional and Financing Framework

In view of the strong needs to develop the country, the Government of India (GOI) has been promoting, starting with the road and power sectors, Public-Private Partnership (PPP) approach since late 1990s. This PPP policy has been further accelerated in since year 2000 and further amplified by a series of the policy support as well as introduction of financing schemes.

The government has increasingly been adopting PPP models across most infrastructure sectors. Despite frequent changes in government, the PPP process in different sectors has steadily matured over the last few years. None of the major decisions relating to PPP have been reversed by subsequent governments. Though there is no comprehensive central PPP legislation or regulation cutting across all sectors and all types of projects, the government has been able to create an enabling environment for private participation with different initiatives.

The new PPP policy rests on three important pillars;

***The first pillar*** of the policy's architecture is to ensure security in legal framework while not becoming excessively prescriptive.

***The second key pillar*** of the PPP policy would be a codification of the vast array of initiatives that have already been undertaken by the Government in the past to promote PPPs in the country.

***The third pillar of the policy*** is the establishment of processes that are required for second generation PPPs with focus on appropriate public oversight and monitoring of PPP projects and ensuring that a value for money rationale is adopted while developing projects.

This section provides the current India's PPP legal framework, institutions related, general procedures and possible financial sources such as Viability Gap Funding (VGF) as well as other possible policy supported financial menu available when a project is implemented under a PPP scheme.

This High Speed Railway system development, implementation and operation project can also be developed as a public sector transport development in view of the nature of its characteristics as one of the public land transport services. The possible funding menu available under that route is reviewed later in Chapter 14 such as overseas development assistance (ODA) loans with concessional rates, for example, from Japan.

### 3.5.1 PPP History, Policy and Strategy in India

Infrastructure development by applying PPP framework in India initiated in 1998, and has been increasing mainly in road and electricity sector since 2000. The Indian Government has further been strongly promoting PPP policy and legal framework as well as funding schemes available for PPP infrastructure projects.

The PPP Policy and its institutional framework are overviewed that the Government set up the Committee on Infrastructure (COI) formed under the chairmanship of Prime Minister. The Public Private Partnership Appraisal Committee (PPPAC) was established in 2008 under the chairmanship of the Prime Minister to streamlining and simplifying the appraisal and approval processes for PPP projects. Around the same time, an Inter-ministerial Commission for appraisal and approving projects for availing Viability Gap Funding (VGF) grant was set up. In 2009, Cabinet Committee on Infrastructure was formed to approve and review policies and projects across infrastructure projects, and more recently, in 2010, the High Level Committee on Financing Infrastructure was established to review existing policies and suggest necessary changes in the investment framework in the high-priority infrastructure.

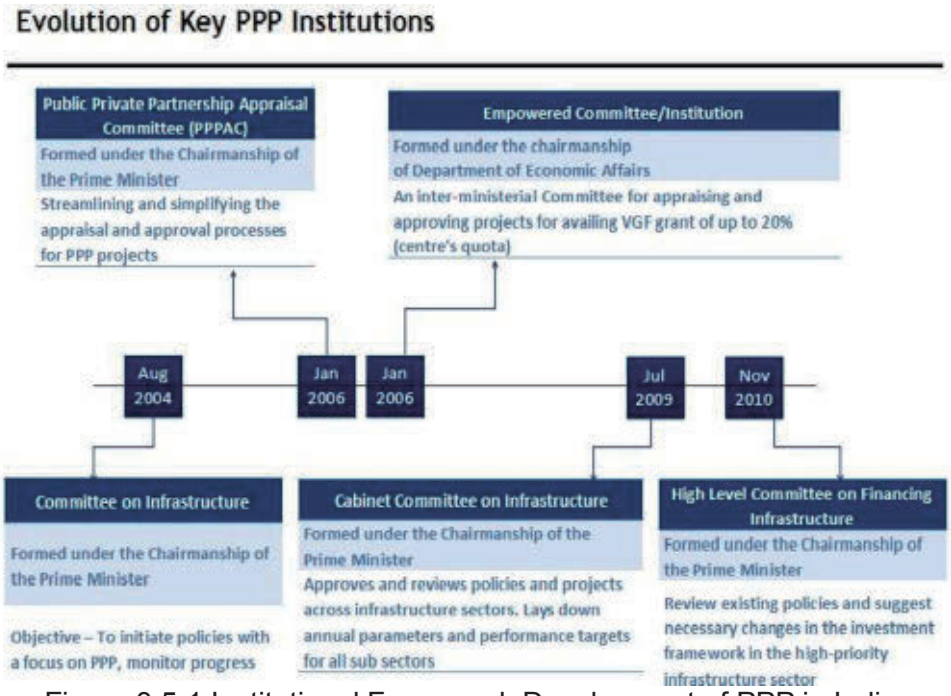



Figure 3.5-1 Institutional Framework Development of PPP in India

(JICA Study Team)

### 3.5.2 PPP Institutional Framework

#### (1) Central Government Level PPP Institutional Framework

With a view to make cross-sectoral high level committee to handle PPP procurement and monitoring process, the Planning Commission, Cabinet Committee on Infrastructure (CoI), High Level Committee on Financing Infrastructure and PPP Appraisal Committee (PPPAC) are established.

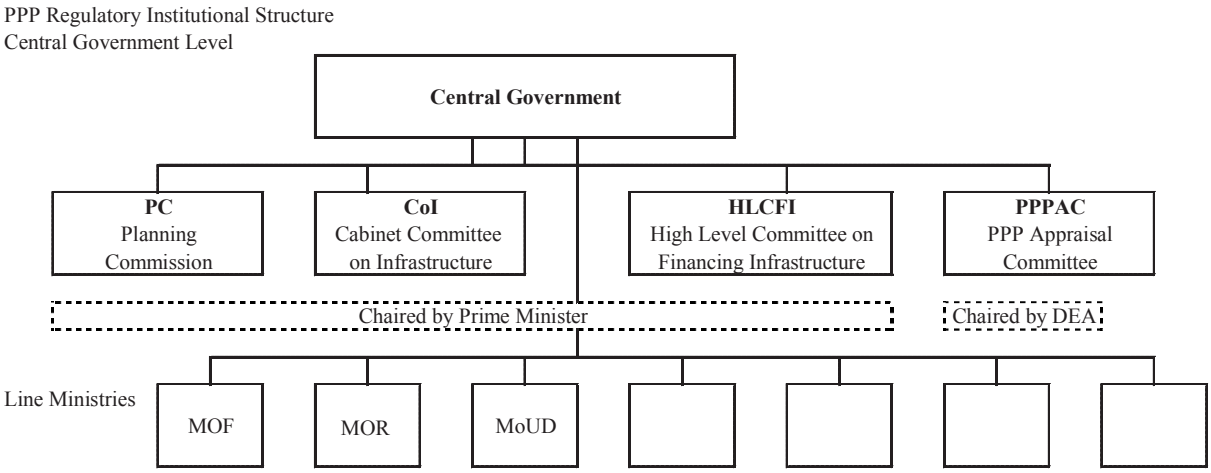



Figure 3.5-2 PPP Regulatory Institutional Structure at Central Government Level

(JICA Study Team)

The role of each agency or organizations is explained as follows.

#### (2) Planning Commission (PC)

The highest level organization established in August 2004 within the Government on the national. PC appraises, instruct necessary changes to PPPAU. PC sets policies across the whole infrastructure sectors.

#### (3) Committee on Infrastructure (CoI)

CoI was formed in August 2004 with an objective to initiate policies that enable creation and management of infrastructure, facilitate mechanisms for PPP, and monitor the progress of key infrastructure projects. The committee has since issued guidelines for implementation of PPP projects including bidder selection guidelines, specifications and standards for projects, model concession agreements, and financing plans.

#### (4) High Level Committee on Financing Infrastructure (HLCFI)

HLCFI was formed in November 2010 and investment framework reviews and recommendations on the high priority projects.

#### (5) PPP Appraisal Committee (PPPAC)

PPPAC was established in 2005 and gives in principle approval to a project put forth by a central government ministry and sends it to DEA, Planning Commission and concerned line ministries for approval. Subsequent to their approval, PPPAC gives final approval to the project.

### 3.5.3 PPP Project Application and Approval Process

Planning Commission has published several Model Concession Agreements (MCAs) with the objective of specifying an appropriate balance of risks and obligations and also for establishing a faster rollout of PPP projects in a fair and transparent manner. The framework that has been evolved in the MCAs is comprehensive and conforms to internationally accepted principles and best practices. In sectors that do not have duly approved MCAs, the project-specific concession agreements should adopt similar provisions.

In the railway sector the following MCAs have been adopted or draft versions have been published;

- MCA for Container Train Operations
- MCA for Container Train Operations
- MCA for Re-development of Railway Stations,
- MCA for Urban Rail Systems
- Procurement-Cum-Maintenance Agreements of Locomotives
- Model Agreement For Construction, Operation and Maintenance of The Rail System on DBFOT Basis (Draft)
- Model Agreement For Construction, Operation and Maintenance of The Rail System through Joint Venture (JV) (Draft)
- Model Agreement for Construction, Operation and Maintenance of a Non-Government Rail System for First Mile/Last Mile Connectivity (Draft)

When a PPP project is planned, the Project promoter is required to submit a feasibility study (F/S) to the central line ministry or the state government concerned. In addition to a detailed F/S, procurement process and preparation for bidding documents are also required. It is also required whether a VGF is needed and its reasoning as well.

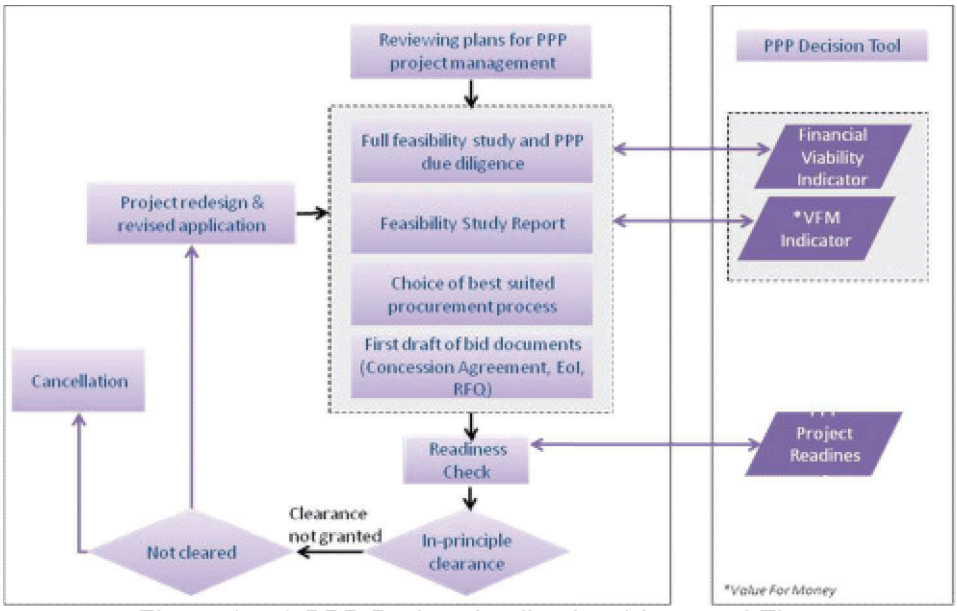



Figure 3.5-3 PPP Project Application / Approval Flow

(Source: PPP India)

AF/S should describe the following contents;

- Project necessity, project outline, social and environmental assessment, technical explanations, cost/benefit analysis, financial and economic analysis including Value for Money (VFM) and project implementation schedule
- Risk analysis, public-private risk allocations, PPP types, funding, government support such as VGF, capacity assessment of the implementation body

### 3.5.4 Project Approval to Bidding and Selection Flow

The responsible ministry will send the project proposal when it exceed INR1 billion to PPPAC and Standing Finance Committee (SFC) / Expenditure Finance Committee (EFC). Once an approval in principle is granted, the responsible ministry announces a Request for Quotation (RFQ) and a short listing of bidders is conducted. The responsible ministry submits RFP draft and the contract draft to PPPAC as well as SFC/EFC. Once the final approvals are granted the RFP is announced. After the issuance of RFP by the line ministry / department, preferential bidders are identified and negotiations start. With successful negotiations, the private developer is appointed.

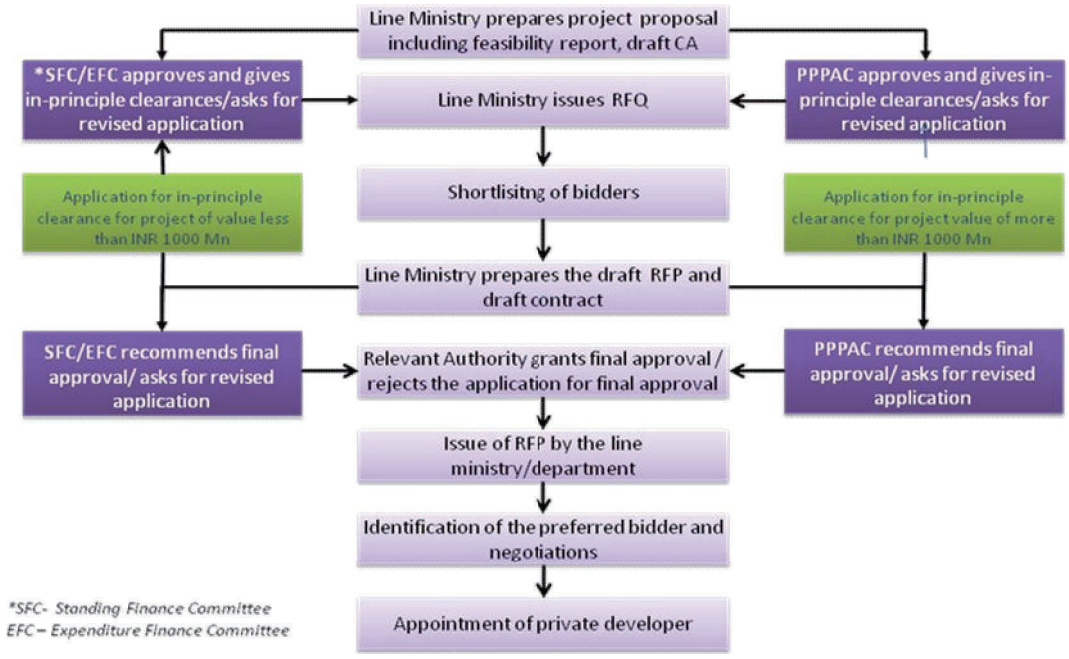



Figure 3.5-4 PPP Project Bidding and Selection Flow

(Source: PPP India)

### 3.5.5 Railway Projects Open to Participation by Foreign Capital

Participation by foreign capital direct investment does not offer any restrictions in principle. Most of the sectors fall under the Reserve Bank of India type application with an automatic approval except for airports with limited foreign participation, or nuclear power and real estate are prohibited to foreign capital.

The Department of Industrial Policy and Promotion (DIPP), under the Ministry of Commerce and Industry, announced a proposal in January 2014 to allow 100% FDI in the construction and maintenance segments of the railway network. This proposal has been adopted and the government notified in August 2014 that the liberalized foreign direct investment norms for rail infrastructure, allowing 100% FDI. DIPP policy for private investment in railway infrastructure has been amended to allow FDI in the railway transport sector including for construction, operation and maintenance of high-speed railway projects; suburban corridor projects through PPP; dedicated freight lines; rolling stock including train sets; locomotives manufacturing and maintenance facilities; railway electrification and signaling systems; freight terminals and passenger terminals; infrastructure in industrial park pertaining to railway line, and mass rapid transport systems.

While private participation based on the PPP model was already allowed by the railways only in MRT, there was a need to harmonize it with the country's FDI policy and Industrial Development and Regulation Act. DIPP has proposed that up to 100% FDI be allowed in high-speed railway networks and dedicated freight corridors. This policy was originally approved in December 2012, where it stated that a foreign direct investor can participate in expansion and modernization work of the railway network only after prior permission from the Foreign Investment Promotion Board (FIPB).

### 3.5.6 Financing Sources under PPP

This project might be expected to be implemented as a PPP project. Domestic budgetary resources or overseas development assistance funding would also be applied but the project future cash flow based financial arrangement needs to be pursued. The Indian government, on the other hand, has been promoting infrastructure development through PPP since 1990s and established new systems such as

Viability Gap Funding (VGF), India infrastructure Finance Corporation Limited (IIFCL) and other public and innovative funding mechanisms with a view to financially support infrastructure project implementation.

### (1) Viability Gap Funding - VGF

VGF is aimed to complement the project feasibility gap for PPP projects that cannot be financially viable due to the long period for preparation and restrictions on the viability of projects.

VGF is a grant offered from the central government to cover up to 20% of the planned project cost at the beginning stage of construction for a public infrastructure project with private sector participation.

#### Key requirements for application are:

- VGF is offered as a subsidy for capital investment during the construction, and is accounted as liability with no maturity, no interest and no need to repay.
- VGF targets projects where the private sector invests more than 51% into a project.
- Eligible infrastructure sectors are road and bridge, railway, port, airport, irrigation, water way, electricity, urban transport, water supply, water treatment, waste management, food cold chain transport and storage, urban infrastructure, infrastructure investment within a special economic zone, international convention center and other tourism infrastructure.
- VGF can only be applied when the procurement is conducted with a competitive bidding and private sector is expected construction, finance, operation and maintenance.
- The project is to offer services on the basis of a fixed tariff (Value to the service rendered should be collected directly from users)
- In addition, a confirmation and/or certificate is obtained from the government or the line ministry.
- Tariff cannot be raised to supplement the project viability.
- The project period cannot be extended to supplement the project viability.
- Capital investment expenditure is calculated in a reasonable and standard manner by referring with similar projects, and it also causes the constraint for the project viability improvement.

#### VGF Application Requirements

VGF can be offered up to 20% of the total PPP project cost primarily by the central government and another 20% by the state government or the state agency. Consequently a maximum of 40% of the project cost can be covered by VGF. For granting a VGF, the equity payment by private sector should be done and VGF is granted in parallel to the debt finance.

#### VGF Application and Approval Procedure

A VGF application is initiated by the implementing agency, namely the state government (or state agency), central government ministry (or implementation agency under the line ministry). A VGF application is reviewed and appraised by Department of Expenditure and Planning Commission at Ministry of Finance, an in-principle approval is given by the approving agency to the project implementation body to proceed to the project with an open competitive bidding. After the selection of the winning bidder and formation of a SPV, and an approval from bank syndicate, the project implementation agency will formally apply a VGF and the approving agency will officially approve the VGF.

### (2) India Infrastructure Finance Company Ltd. - IIFCL

IIFCL was established in 2006 to make direct lending to infrastructure projects, offer refinancing to banks and financial institutions to extend the maturity of loans in order to supplement the sources for infrastructure project financing. IIFCL gives priority on infrastructure project where private sector investment is expected. IIFCL makes loans to commercially viable projects, and PPP projects

implemented by private sector selected by a competitive bidding. IIFCL does not conduct appraisal by them but relies on those done by the major banks.

IIFCL can provide infrastructure project Special Purpose Company (SPC) with refinancing covering up to 20% of the capital cost or making direct lending as a long-term finance for infrastructure projects. Target sectors are road, bridge, railway, port, airport, irrigation, electricity, urban transport, water supply, water management, waste management and urban physical infrastructure, gas pipeline, SEZ infrastructure, international convention center and other tourism facility. IIFCL can also provide direct loan with a maturity of over 5 years or offer refinancing to banks and financial institutions.

IIFCL has set up, in April 2012, an infrastructure Debt Fund through its UK subsidiary with the assistance form ADB. ADB and others invest for USD 1 billion fund. With this resource, IIFCL offers refinancing of up to 85% of senior debt at Indian commercial banks on infrastructure lending, so-called the Take-out Finance scheme. IIFCL will thus succeed claims held by commercial banks who, as a matter of fact, lends virtually all infrastructure projects so that the banks' long-term exposure will be reduced and they are encouraged to offer new loans

### (3) Infrastructure Debt Fund - IDF

The first debt fund was launched in March 2012 with an amount of USD 1 billion. IIFCL, SBI, ICICI, LIC, IFFC, UTI and others are sponsors and they started to inject long term funding to infrastructure projects. Infrastructure projects require long payback period, and require long-term funding for the sustainability and cost and benefit point of view. Debt finance for infrastructure projects, however, rely on bank finance and Indian commercial banks do not have any sources for raising long-term debts, and thus fall into the mismatched situation between assets and liabilities. The Minister of Finance announced the establishment of IDF during the budget 2011-12 to facilitate long term borrowing and its guideline in June 2011.

### (4) Indian Railway Finance Corporation - IRFC

IRFC was created in 1986 by MOR to set up its own financing arm mainly for the rolling stock for MOR. It raises funds from both the domestic and overseas markets and arrange financial lease to MOR. It is rated AAA in the domestic capital market, the highest rating in India and also receives BBB, an investment grade rating from the major rating agencies and also one from Japan. Financed proceeds are used to procure the rolling stock for MOR and are arranged in a form of financial leasing with MOR. About 70% of the rolling stock at IR is financed by IRFC. Its contribution to infrastructure build-up in Railways is very significant.

Lease arrangement is done through the annual MOU with MOR. IRFC raises regularly funds for MOR through the domestic and overseas capital markets in the form of bonds and loans as a corporate finance scheme, and not on project basis funding. As for the domestic bonds, IRFC is authorized by MOF to issue Tax-Exempted Bonds on top of the taxable bonds. The former one gives a good attraction to the Indian institutional investors such as pension funds, banks and high net worth individuals.

### (5) Indian Development Finance Corporation - IDFC

IDFC was established in 1997 to take a leading role to promote private sector into infrastructure investment. The key priority areas are energy, transport, communication, IT, SEZ, industrial park and those categorized as industrial and commercial infrastructure but there is no track record on the urban railway.

### (6) State Level Public Financial Institutions

In addition to those central government level supports, state governments establish and invest through their finance corporations. In the case of the State of Maharashtra, the state finance institutions mainly

focus SMEs or local enterprises, and thus are not interested in large scale infrastructure projects. There are two institutions, MUIDCL, a specialized agency for urban development, and MSRDC, transport infrastructure agency, but both has only limited source of funding and thus the activities are rather marginal.

### (7) Land Value Capture

Possible property mobilization will increase in line with new railway projects. New commercial property construction with new Floor-to-Space Index (FSI) can be introduced in a HSR station as well as areas nearby the station as a Land Value Capture method. The public sector will grant development right for new commercial and residential development that will generate new taxable sources to the public sector which may, in turn, contribute to support infrastructure projects such as HSR. A new concept that was recently introduced is a Transferrable Development Right (TDR) transfer as a possible Land Value Capture mechanism to allow a higher FSI applied to property developments nearby a station from which its unused FSI is offered for sale.

### (8) Real Estate Investment Trust and Infrastructure Investment Trusts – REITs / INVits

Real Estate Investment Trust (REIT) is one of the schemes to promote real estate investment originally born in the USA in 1960s. It is usually established in the form of a company that owns, and in most cases, operates income-producing real estate. REITs own many types of commercial real estate, ranging from office and apartment buildings to warehouses, hospitals, shopping centers, hotels and even timberlands. Some REITs also engage in financing real estate. The REIT structure was designed to provide a real estate investment structure similar to the structure mutual funds provide for investment in stocks. REITs are now found also in Japan, Australia, France, Hong Kong and Singapore but now in India.

The Securities and Exchange Board of India (SEBI) approved, in August 2014, the setting up of real estate investment trusts (**REITs**). REITs are listed entities that mainly invest in income-producing real estate assets, the earnings of which are mostly distributed to their shareholders. They generally get special tax treatment. REITs should operate with an asset pool of at least 5 billion rupees and have an initial issue size of at least 2.5 billion rupees for shareholders. REITs will be allowed to invest only in commercial properties. The SEBI also approved allowing **Infrastructure Investment Trusts (INVits),** a REIT-like structure that would allow developers to monetize their infrastructure assets through a stock exchange listing. According to the guideline issued by SEBI, **Invits** will allow infrastructure developers to monetize specific assets, helping them use proceeds for completing projects.

## 3.6 The Dedicated Freight Corridors (DFC)

### 3.6.1 Background

On IR traditionally Freight and Passenger Traffic has been carried on the same track both on single line and double / multiple line routes. These two traffic streams had not been segregated as is the case in several advanced Railway systems. With a buoyant economy there was continuous growth in both passenger and freight traffic. This had resulted in serious line capacity constraints, particularly because of the speed differential between freight and passenger services. The introduction of new passenger services on the arterial routes meant that capacity for freight traffic was constrained which was likely to become a serious limitation to growth. The problem was particularly acute on IR's arterial routes. The trunk routes linking the metropolitan cities of New Delhi, Mumbai, Kolkata and Chennai, known as the 'Golden Quadrilateral and Diagonals', constitute a length of 10,122 Route Kilometres are the busiest in India and though they constitute only 16% of IR Route Kilometres they carry 52% of Passenger and 58% of the total revenue earning freight traffic. The capacity constraint was severe on the Mumbai – New Delhi route where Export – Import container traffic dealt with at Jawaharlal Nehru Port near Mumbai was unable to move freely by rail to and from up country destinations via Delhi because of lack of rail capacity. With the economy expected to grow at about 8% GDP growth the situation would further deteriorate. Similarly, with the growing demand for power in North India and new thermal power generation capacity being created in Punjab, Haryana and Western Uttar Pradesh there was need to augment capacity for transporting additional volumes of coal from collieries located in West Bengal and Jharkhand. It was with this background that in the year 2004 the Railways began examining the development of the Eastern and Western DFC, the largest Railway Construction Project planned in India after Independence. It is interesting to note that at about the same time MOR was also actively considering the development of a HSR Corridor, however, DFC were given preference in view of their greater role and impact on economic development of the country.

### 3.6.2 Western Freight Corridor

The Western DFC covers a distance of 1546 kilometres from Dadri in the National Capital Region to Jawaharlal Nehru Port (JNPT) in Mumbai. Corridor will consist of four sections viz. (i) Dadri to Rewari (139 Km.), (ii) Pirthala to Tughlakabad (32 Km.), (iii) Rewari to Vadodara (950 Km), and Vadodara to Jawaharlal Nehru Port (425 Km.). All sections are electrified and all sections are double line except Pirthala - Tughlakabad which is single line. Two alternate alignments were examined for the corridor with the JNPT to Vadodara section being common to both. The first was the route from Vadodara via Ratlam, Kota and Mathura to Delhi area and the second from Vadodara via Ahmedabad, Palanpur, Ajmer, Rewari to Delhi Area. It was decided to select the route via Rewari, Ajmer, Palanpur in view of the greater traffic potential of the route and it being better able to serve important ports such as Kandla, Mundra and Pipavav. The Stations along the route where junction arrangements are planned to be provided with IR network on this route are Dadri, Rewari, Phulera, Ajmer, Marwar Jn, Palanpur, Mahesana, Sabarmati, Makarpura, Gothangam, Vasai Road and Jawaharlal Nehru Port as shown Table 3.6-1 Significant volume of traffic is likely to come onto the DFC from Ports located in Gujarat, including Kandla, Mundra, Hazira and Dahej Ports.

Table 3.6-1 Number of Trains Forecast to be run on Western DFC in the 'Up' Direction

| NO. OF TRAINS (UP) | 2016-17 | | | 2021-22 | | | 2031-32 | | |
|---|---|---|---|---|---|---|---|---|---|
| SECTION | CONTAINERS | OTHERS | TOTAL | CONTAINERS | OTHERS | TOTAL | CONTAINERS | OTHERS | TOTAL |
| DADRI-REWARI | 38 | 6 | 44 | 41 | 8 | 49 | 53 | 16 | 69 |
| DELHI-REWARI | 4 | 7 | 11 | 5 | 6 | 11 | 10 | 8 | 18 |
| HISSAR-REWARI | 8 | 6 | 14 | 10 | 5 | 15 | 16 | 7 | 23 |
| REWARI-PHULERA | 50 | 29 | 79 | 57 | 38 | 95 | 79 | 61 | 140 |
| PHULERA-AJMER | 53 | 30 | 83 | 63 | 39 | 102 | 89 | 62 | 151 |
| AJMER-MARWAR | 53 | 30 | 83 | 65 | 38 | 103 | 90 | 62 | 152 |
| MARWAR-PALANPUR | 55 | 28 | 83 | 66 | 37 | 103 | 93 | 60 | 153 |
| PALANPUR-MAHESANA | 42 | 18 | 60 | 50 | 25 | 75 | 67 | 40 | 107 |
| MAHESANA-SABARMATI | 32 | 14 | 46 | 38 | 21 | 59 | 60 | 33 | 93 |
| SABARMATI-VADODARA | 36 | 12 | 48 | 47 | 18 | 65 | 63 | 30 | 93 |
| VADODARA-GOTHANGAM | 38 | 15 | 53 | 50 | 20 | 70 | 69 | 33 | 102 |
| GOTHANGAM-VASAI ROAD | 36 | 15 | 51 | 47 | 19 | 66 | 62 | 32 | 94 |
| VASAI-ROAD-J.N. PORT | 32 | 7 | 39 | 36 | 11 | 47 | 40 | 16 | 56 |

*Source: DFCCIL Draft Business Plan 2012

The main freight commodities expected to move over the line are containers, POL, Fertilizers, Food Grains, salt coal, Iron & Steel and Cement. Container traffic to and from JNPT is the predominant traffic and its share in total traffic is expected to grow over time as substantial volumes at present move by road. The ratio of traffic moving between end terminals and traffic entering at various junction stations en-route is 40:60 and is expected to continue in this proportion. The number of trains forecast to be run on different sections of the alignment based on a 2012 assessment is broadly as indicated in Table 3.6-2 Traffic in 2016-17 is 22.9 t axle load wagons and 25 t thereafter.

Table 3.6-2 Number of Trains Forecast to be run on Western DFC in the 'Down' Direction
(Traffic from 2021-22 onwards is assumed to be in wagons with 25 tonne axle load)

| NO. OF TRAINS (DOWN) | 2016-17 | | | 2021-22 | | | 2031-32 | | |
|---|---|---|---|---|---|---|---|---|---|
| SECTION | CONTAINERS | OTHERS | TOTAL | CONTAINERS | OTHERS | TOTAL | CONTAINERS | OTHERS | TOTAL |
| J.N. PORT-VASAI ROAD | 33 | 7 | 40 | 36 | 12 | 48 | 41 | 16 | 57 |
| VASAI ROAD-GOTHANGAM | 38 | 14 | 52 | 47 | 20 | 67 | 63 | 32 | 95 |
| GOTHANGAM-VADODARA | 40 | 15 | 55 | 51 | 20 | 71 | 71 | 33 | 104 |
| VADODARA-SABARMATI | 38 | 14 | 52 | 47 | 19 | 66 | 63 | 31 | 94 |
| SABARMATI-MAHESANA | 37 | 19 | 56 | 45 | 24 | 69 | 59 | 37 | 96 |
| MAHESANA-PALANPUR | 41 | 24 | 65 | 50 | 29 | 79 | 67 | 46 | 113 |
| PALANPUR-MARWAR | 55 | 37 | 92 | 67 | 44 | 111 | 93 | 70 | 163 |
| MARWAR-AJMER | 55 | 38 | 93 | 65 | 46 | 111 | 90 | 72 | 162 |
| AJMER-PHULERA | 54 | 42 | 96 | 64 | 49 | 113 | 88 | 77 | 165 |
| PHULERA-REWARI | 51 | 34 | 85 | 58 | 42 | 100 | 79 | 66 | 145 |
| REWARI-HISSAR | 8 | 7 | 15 | 11 | 6 | 17 | 16 | 9 | 25 |
| REWARI-DELHI | 4 | 8 | 12 | 6 | 6 | 12 | 10 | 9 | 19 |
| REWARI-DADRI | 38 | 8 | 46 | 41 | 9 | 50 | 52 | 20 | 72 |

*Source: DFCCIL Draft Business Plan 2012

One of the unique aspects of the Western Corridor is that the Maximum Moving Dimensions have been designed to cater to the transport of Double Stack Containers on this route. This is one of the very few Electrified Sections in the World where Double Stack Containers shall be carried. The benefits are tremendous as the throughput capacity doubles due to this design feature. This aspect along with the enhanced axle load of 25 tonnes, speed of 100 km/h and potential for longer 1500 m trains considerably increases the total transport capacity of the line.

### 3.6.3 Eastern Freight Corridor

The Eastern Freight Corridor has a total length of 1839 Km and connects Ludhiana in the North to Dankuni (in Kolkata area) in the East. In this corridor the section between Ludhiana and Khurja (400 Km) is single line and the remaining segments viz. Khurja – Dadri (50 Km), Khurja – Kanpur (342 Km), Kanpur – Mughalsarai (391 Km), Mughalsarai – Sonnagar (122 Km) and Sonnagar – Dankuni (534 Km) are Double Line. The entire route is electrified. The route runs parallel to the existing trunk route from Howrah to New Delhi upto Khurja, following the Grand Chord between Asansol and Gaya and then through the Indo-Gangetic Plain beyond Mughalsarai. The initial project was planned up to Sonnagar, however, was subsequently extended to Dankuni with the Sonnagar – Dankuni section proposed to undertaken under a PPP framework.

The main junction points with the existing IR alignment are proposed at Andal, Gomoh, Sonnagar, Mughalsarai, Chheoki/ Naini, Prempur, Bhaupur, Tundla, Khurja, Meerut, Kalanaur, Ambala, and Dhandari Kalan/ Ludhiana. A network diagram of the Eastern DFC along with main feeder routes is shown in Figure 3.6-1 as the corridor will primarily be carrying coal to various Power Houses and Fertilizer Plants appropriate links have been provided to cater to this requirement.

The main traffic on the corridor in the 'Up' direction i.e. from East to West/North shall be Coal for Power Houses, Coal for Fertilizer Plants, Public Coal, Steel and miscellaneous other Traffic. In the 'Down' direction the traffic shall consist of Fertilizer, Food grains, Cement, Limestone for Steel plants, Salt and miscellaneous other commodities. It is also proposed to set up Logistics Parks on the corridor at locations such as Kanpur and Ladhowal which are Industrial hubs and should generate additional traffic. The growth of traffic on the corridor in terms of number of trains is shown in Table 3.6-3.

Table 3.6-3 Number of Trains Forecast to be run on Eastern DFC in the 'Up' Direction
(Traffic in all years has been estimated on the basis of 25 tonne axle loads)

| NO. OF TRAINS (UP) | 2016-17 | | | 2021-22 | | | 2031-32 | | |
|---|---|---|---|---|---|---|---|---|---|
| SECTION | COAL | OTHERS | TOTAL | COAL | OTHERS | TOTAL | COAL | OTHERS | TOTAL |
| DANKUNI-ANDAL | 3 | 10 | 13 | 4 | 13 | 17 | 4 | 21 | 25 |
| ANDAL-GOMOH | 4 | 10 | 14 | 4 | 13 | 17 | 5 | 21 | 26 |
| GOMOH-SONNAGAR | 24 | 18 | 42 | 27 | 26 | 53 | 32 | 45 | 77 |
| SONNAGAR-MUGHALSARAI | 47 | 20 | 67 | 54 | 27 | 81 | 65 | 48 | 113 |
| MUGHALSARAI-ALLAHABAD | 35 | 20 | 55 | 40 | 28 | 68 | 49 | 50 | 99 |
| ALLAHABAD-KANPUR | 33 | 18 | 51 | 38 | 25 | 63 | 47 | 45 | 92 |
| KANPUR-TUNDLA | 31 | 19 | 50 | 36 | 25 | 61 | 45 | 47 | 92 |
| TUNDLA-ALIGARH | 30 | 14 | 44 | 35 | 19 | 54 | 41 | 37 | 78 |
| ALIGARH-KHURJA | 13 | 11 | 24 | 35 | 19 | 54 | 41 | 37 | 78 |
| KHURJA-DADRI | 13 | 11 | 24 | 15 | 14 | 29 | 19 | 26 | 45 |
| KHURJA-KALANAUR | 16 | 4 | 20 | 20 | 6 | 26 | 22 | 11 | 33 |
| KALANAUR-SIRHIND | 7 | 3 | 10 | 9 | 6 | 15 | 11 | 10 | 21 |
| SIRHIND-DHANDARI KALAN | 3 | 2 | 5 | 5 | 3 | 8 | 6 | 5 | 11 |

*Source: DFCCIL Draft Business Plan 2012

Figure 3.6-1 The Western Freight Corridor

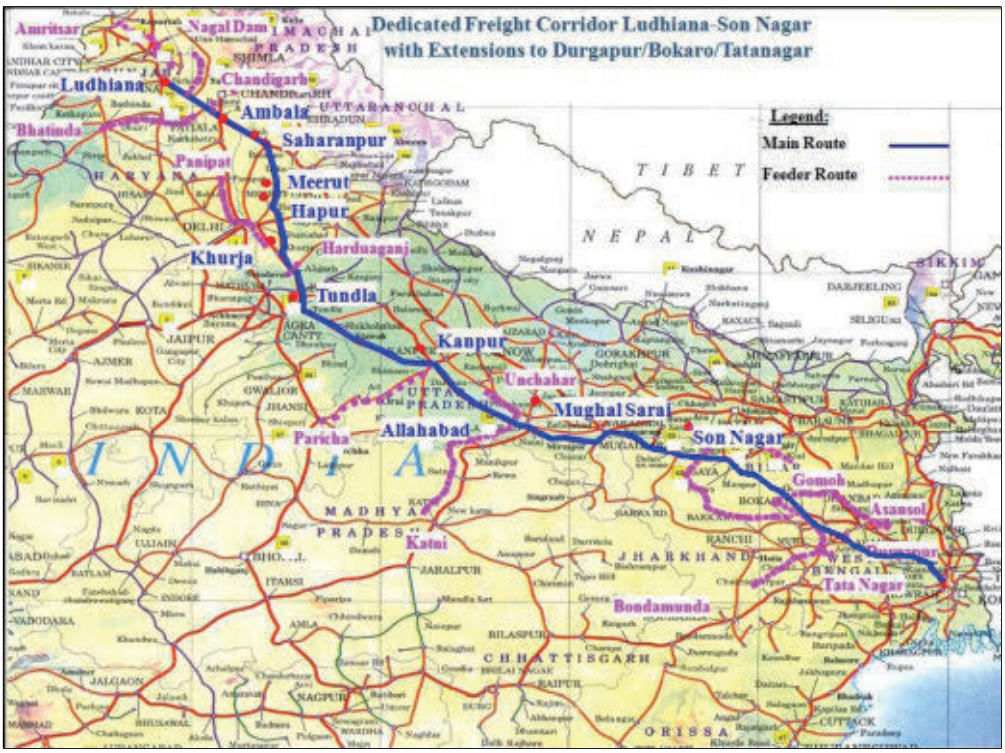


Figure 3.6-2 The Eastern Freight Corridor

The compilation of number of trains on each section of the Eastern DFC has been done on the basis of a 25t axle load wagon from the very first year. Existing and projected Traffic has been assigned to the DFC wherever it would provide the most logical route in terms of being shortest and fastest and where the route over the DFC covers two or more junction stations. Most of the traffic will originate on Indian Railways and terminate on Indian Railways and the total tonne kilometre share of IR and DFCCIL will be in the share of 45:55.

Table 3.6-4 Number of Trains Forecast to be run on Eastern DFC in the 'Down' Direction
(Traffic in all years has been estimated on the basis of 25 tonne axle loads)

| NO. OF TRAINS (DOWN) | 2016-17 | | | 2021-22 | | | 2031-32 | | |
|---|---|---|---|---|---|---|---|---|---|
| SECTION | EMPTIES | OTHERS | TOTAL | EMPTIES | OTHERS | TOTAL | EMPTIES | OTHERS | TOTAL |
| DHANDARI KALAN-SIRHIND | 3 | 1 | 4 | 3 | 2 | 5 | 3 | 4 | 7 |
| SIRHIND-KALANAUR | 7 | 2 | 9 | 9 | 3 | 12 | 12 | 4 | 16 |
| KALANAUR-KHURJA | 17 | 2 | 19 | 20 | 3 | 23 | 23 | 4 | 27 |
| DADRI-KHURJA | 15 | 6 | 21 | 15 | 8 | 23 | 22 | 13 | 35 |
| KHURJA-ALIGARH | 32 | 8 | 40 | 35 | 11 | 46 | 45 | 17 | 62 |
| ALIGARH-TUNDLA | 32 | 8 | 40 | 35 | 11 | 46 | 45 | 17 | 62 |
| TUNDLA-KANPUR | 34 | 9 | 43 | 38 | 11 | 49 | 47 | 18 | 65 |
| KANPUR-ALLAHABAD | 35 | 9 | 44 | 38 | 12 | 50 | 48 | 19 | 67 |
| ALLAHABAD-MUGHALSARAI | 32 | 14 | 46 | 35 | 18 | 53 | 42 | 31 | 73 |
| MUGHALSARAI-SONNAGAR | 49 | 11 | 60 | 54 | 15 | 69 | 66 | 23 | 89 |
| SONNAGAR-GOMOH | 23 | 11 | 34 | 26 | 14 | 40 | 30 | 23 | 53 |
| GOMOH-ANDAL | 4 | 15 | 19 | 4 | 19 | 23 | 5 | 27 | 32 |
| ANDAL-DANKUNI | 3 | 16 | 19 | 4 | 19 | 23 | 4 | 27 | 31 |

*Source: DFCCIL Draft Business Plan 2012

### 3.6.4 Operation & Maintenance

#### (1) Operation

A major focus of DFCCIL is to improve operational efficiency with a view to reduce unit cost of operations. This is planned to be achieved through improvement in asset utilization of rolling stock viz. locomotives and wagons as a result of higher average speeds of 60 to 65 km/h, better payload to tare ratio of wagons, efficient cargo handling at terminals, use of information technology and centralized control of operations. Further improvements are expected through improvements in manpower productivity by ensuring a lean organizational structure. The Operating Plan initially envisages a Line Capacity of 128 trains per day in each direction assuming headway between trains of 7.5 minutes, a 4 hour Maintenance Block per day and an operating efficiency factor of 80%. As traffic volumes grow beyond this level to meet demand it should be possible to augment capacity through further improvement in efficiency in operation reducing headway to 7 minutes, curtailing maintenance blocks to 3 hours and improving efficiency factor to 90% with which line capacity would increase to 162 trains per day in each direction. Beyond this level other throughput enhancing measures will need to be resorted to such as increasing axle loads from 25t to 32.5t and introducing long haul operations by running longer 1500 tonne trains by combining two trains and developing 1500 m loops at appropriate locations.

#### (2) Maintenance

With a view to ensure safety and reliability of assets it is planned to adopt global best practices for maintenance of infrastructure. The maintenance philosophy shall follow a risk based approach by prioritizing maintenance activity based on a risk score so as to achieve a safety risk 'as low as reasonably practicable'. This will involve an initial system design that requires low maintenance on whole life cycle cost basis, strict quality control, a rigorous inspection regime, maintenance practices to minimize asset degradation and a time based renewal criteria for replacement of assets. It is proposed to set up Integrated Maintenance Depots at 160 Km intervals and Sub-Depots at 80 Km from the main depot. The depots shall be common to Civil, Electrical and Signal & telecom engineering. Maintenance procedures shall involve both mechanized systems as well as some traditional labour based systems. Permanent Way Maintenance shall be done through Routine Visual inspections, Video inspections for switches & crossings, Ultrasonic Rail Flaw detection, use of optical fibre sensors for monitoring stress in continuously welded Rail, use of Track recording cars to measure Track geometry and use of Rail Grinding Train to remove defects owing to corrugation etc. With respect to Maintenance of Overhead Line Equipment (OHLE) for Electric traction latest design tower wagons and Motorized Elevated Working platforms will be used, measurement of wire heights, stagger hard spots and wear shall be by train borne measuring systems, modular OHLE fittings shall be used for ease of maintenance and computer based SCADA systems with colour VDUs shall be installed in Remote Control Centres for monitoring the system. In case of Signalling Maintenance practice recommended by the manufacturer shall normally be followed although modern Signalling systems have various diagnostic tools such as data loggers. Automatic Signalling with Multiple Aspect Colour Light Signals at 2 km intervals is being adopted with Solid State Interlocking. Communications shall be based on an Optical Fibre Network and monitored through a Network Monitoring System. In order to ensure Efficiency in Service Delivery and to meet quality of service obligations a set of Key Performance Indicators (KPIs) will have to be met as specified in the Concession Agreement.

### 3.6.5 Design Parameters

The development of two new freight corridors exclusively for the transportation of freight has provided the Indian Railways an opportunity to review their basic design parameters and Standards of Construction for Permanent Way and Rolling Stock. With the objective of enhancing throughput capacity existing standards have been modified for example for facilitating wider body wagons or movement of double stack containers on Western DFC the Ministry of Railways and the revised Standard Schedule of Dimensions for the DFC's have been specified in a new document viz. 'Standard Schedule of Dimensions for Eastern & Western Dedicated Freight Corridors of Indian Railways' which was issued in January 2013. Some of the Basic Parameters proposed to be followed by the DFC's are given in the Table 3.6-5 below: