CHAPTER 0

EXECUTIVE SUMMARY

0.1 Introduction

0.1.1 Background

Gujarat Infrastructure Development Board (GIDB) engaged Delhi Metro Rail Corporation for preparation of the Detailed Project Report for Metro Rail System for Ahmedabad and Gandhinagar and Regional Rail System for Ahmedabad. This report deals with Metro Rail system only.

The study has been divided into two stages. Stage-I was to prepare feasibility report for selecting the corridors to be taken up for Metro construction and Regional Rail system. The report was submitted in August, 2004 and was accepted by Gujarat Government in October, 2004.

Based on Stage-I study, the Detailed Project Report is prepared for Phase-I of Ahmedabad Metro. The report deals with the following:

- Estimation of travel demand and projection of sectional and station traffic loads for the horizon years.
- Appropriate technical solutions to carry the projected volume of traffic.
- Environmental Impact Assessment and Environmental Management Plan.
- Estimation of Construction cost.
- Proposed Fare structure and project viability.
- Financing plan and Economic viability.
- Implementation strategy.

0.2 Traffic Demand Forecast

Four stage transport planning process has been adopted to carry out transport demand forecasts. This comprises of trip generation, trip distribution, modal split and trip assignment.

Projected Per Capita Trip Rate (PCTR) for motorised mode for the years 2003, 2010, 2025 and 2035 are given in **Table 0.1**.

Table 0.1 Vehicular PCTR Values

Year	PCTR Value
2003(Observed)	0.72
2010	0.80
2025	0.90
2035	1.00

The observed modal split in favour of public transport is just 28% which shows deficiency in Public Transport System in major routes of the city. With the introduction of Mass Transport System, the modal split in favour of public transport is expected to increase and likely to be 70% & 75% in the years 2025 & 2035 respectively.

Various alternative corridors were considered during the feasibility stage to work out the most desired network for Regional Rail System and Metro System. These alternatives were discussed in details in the feasibility report.

Based on the Techno – Economic (Traffic forecast and reconnaissance of engineering feasibility) considerations the following corridors are identified for the Phase I and full system of Metro.

Metro Corridor (Phase I)

- APMC / Vasna – Akshardham (Gandhinagar) (via Ashram Road, Motera, Koba Circle) -32.65 km (Dead end to dead end)

- Ahmedabad Junction – Thaltej (via Delhi Darwaja) -10.90 km. (Dead end to dead end)

Metro Corridor (Full System)

- Changodar-Sarkhej – Makatpur – APMC Vasna –ITO – Sabarmati – Motera – Koba Circle – Gandhinagar-Akshardham
- Kalupur – Prem Darwaja – ITO – Manav Mandir – Drive in Cinema – Thaltej
- APMC Vasna - Manav Mandir – Naranpura – RTO
- Sarkhej – ISKON Temple – Thaltej-Khodyar – Indroda Circle

0.2.1 The ridership on Phase-I Metro Corridors is also worked out with two scenarios

Scenario 1: Metro corridors will be available without dedicated Regional Rail corridors. The Regional Rail system will be available at present without augmentation.

Scenario 2: Metro corridors will be available with dedicated Regional Rail corridors.

The transport demand for the two different scenarios has been worked out and summarized in the **Tables 0.2**. It has been observed from the tables that the number of passengers, passenger km. and pkm/km are much higher in Scenario 2 as compared to Scenario 1. This shows that the Regional Rail System is also required to make the metro system more cost effective.

Table 0.2 SUMMARY OF TRANSPORT DEMAND – 2010

Section	Length (Km)	Number of Passengers (lakh)	Pass-Km (lakh)	Pass-Km/Km. (lakh)	Average Lead (km.)
Scenario 1	41.71	5.38	48.23	1.16	8.97
Scenario 2	41.71	6.75	56.47	1.35	8.37

Phase I of Metro system in the year 2010, comprising of about 42 km. network would carry 6.75 lakh passengers daily. The passenger km. carried would be 56.47 lakh and passenger density of utilization (passenger km. carried per km.) would be 1.35 lakh for the year 2010. Corridor wise details of transport demand forecast is given in Table - 0.3

Table 0.3 SUMMARY OF TRANSPORT DEMAND – 2010-PHASE-1

Section	Length (Km)	Number of Passengers (lakhs)	Pass-Km (lakhs)	Pass-Km/km (lakhs)	Average Lead (km.)
Line – 1: APMC-Vasna Aayakar Bhavan-– Akshardham	31.88	4.16	39.00	1.22	
Line – 2: Ahmedabad Jn.-Aaykar Bhavan - Thaltej	9.83	2.59	17.47	1.78	
TOTAL	**41.71**	**6.75**	**56.47**	**1.35**	**8.37**

0.3 System Selection

0.3.1 Types of Rapid Rail Transit Systems

(A) Classification based on Right of Way

Rail based mass transport in cities can be brought mainly under three categories based on their Right of Way (ROW):

- Underground
- Surface, and
- Elevated

Underground System: The underground system is required to be built in congested area where the space is not available to construct surface or

elevated system. However this system is the costliest of the three due to construction methodology, requirement for air conditioning and safety measures.

Surface System: The surface system is most economical for construction and operation and can be constructed either with mixed right of way (along with road based traffic) or segregated right of way. The system with mixed right of way (e.g. tram ways) has following drawbacks:

- Unsafe due to high rate of accidents with road vehicles
- Low average speed
- Affected by congestion on road
- Overhead electric traction system causes visual intrusion
- Low capacity (generally less than 10,000 phpdt)

The surface system with exclusive right of way eliminates all the above disadvantages but has following disadvantages:

- Continuous open areas along the proposed alignment generally not available.
- Bifurcates the whole stretch of corridor in two parts.
- Requires road under bridges or over bridges for road traffic.
- Require to be fenced as trains run at high frequency.

The last two requirements increase the cost of construction.

Elevated System: The elevated system can be provided on a single pier on limited space (like median of the road) and its cost is about 25% higher than the surface system (with exclusive right of way) but less than half of the underground system. The elevated systems are generally preferred over surface systems but has following limitations:

- The minimum 20 m right of way is required on roads.
- The curves within the city may require relocation of properties on corners.

(B) Classification Based on Capacity

The other mode of classification for rail-based systems is the carrying capacity during peak hour. The classification is as follows:

Table –0.4
RAIL BASED SYSTEM: CLASSIFICATION BY CAPACITY

Mode		Carrying capacity (passengers/hour/direction) (phpdt)
(i)	Mono Rail System	Upto 8,000
(ii)	Medium Capacity Metro System	10,000-40,000
(iii)	Heavy Capacity Metro System	40,000-80,000

a) The monorail system has to be an elevated system and has been popular at many places but has following limitations:
   - The route is within small area (as in amusement park) or covering part of the city, generally upto 30 kms.
   - Speed is related to number of cars (and load) in each train. The average speed is about 30 kmph with a maximum capacity of about 8,000 phpdt.
   - O&M cost per passenger-km is substantially higher than that of medium capacity or heavy capacity Metro.

b) The other two metro systems are essentially similar except that the number of coaches per train is as per requirement with certain advanced operational features for higher capacity trains. The main advantage of these systems is the flexibility for expansion - either in increasing the capacity or in selection of right of way. The system can be built as elevated, surface or underground or any combination of these. Thus the same system can run on surface as well as on elevated guide way or underground and cover open areas as well as CBD. The capacity of the system can be increased with requirement of traffic in future by increasing the number of coaches per train or by increasing number of trains per hour (i.e. running of trains at close intervals of upto 120 seconds).

c) Since, the number of commuters to be dealt is relatively less in medium capacity metro, the train consist of 3 to 4 coaches and other related infrastructure is also of a smaller size. As mentioned above the capacity can be increased in future.

d) Heavy capacity metro systems have to deal with large traffic densities ranging from 40,000 to 80,000 phpdt. Accordingly, the trains have 4 to 8 coaches and other related infrastructure is also of large size. Beyond the traffic level of 80,000 phpdt, additional parallel lines are normally planned. The metro system being planned for Delhi (Population 14 million) is heavy capacity system.

0.3.2 Recommended Rapid Rail Transit System for Ahmedabad

Considering the future requirements of East-West and North-South corridors, provision of Medium capacity Metro Rail System, elevated corridor is considered most suitable. This system requires little space of road, can be accommodated generally within the available right-of-way of roads, can negotiate sharp curves encountered in urban areas and also can negotiate steep gradients.

0.3.3 Permanent way

Choice of Gauge

Standard Gauge (1435mm) is invariably used for metro railways world over due to its unlimited advantages. During the last decade, 20 new metros have been constructed in various cities of the world. All these metros have

gone in for Standard Gauge even though the national gauge for mainline railways in some of these countries was different from Standard Gauge. In India the national gauge is Broad Gauge (1676mm). The reasons for selection of gauge is described in the report.

Track Structure

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus it is imperative that the track structure selected for Metro Systems should be long lasting and should require minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. Ballastless track with long welded head hardened rails has been proposed as mainline track. In depot ballasted track has been proposed as the depots are at grade.

0.3.4 Traction System

Traditionally, electric traction is used in Metro Systems for requirement of high acceleration and pollution-free environment in urban areas. There are 3 standard and proven systems of electric traction for use in Metro lines, viz., 750V DC third rail, 1500V DC overhead catenary and 25kV AC overhead catenary system. Keeping in view the ultimate traffic requirements, standardisation and other techno-economic considerations, 25kV AC overhead catenary system is considered to be the best trade-off.

0.3.5 Signalling, Telecommunication and Automatic Fare Collection

SIGNALLING

The signaling system shall provide the means for an efficient train control, ensuring safety in train movements. It assists in optimization of metro infrastructure investment and running of efficient train services on the network. Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting Continuous Automatic Train Control (CATC) consisting of ATP (Automatic Train Protection), and ATS (Automatic Train Supervision) sub-systems. This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provides safety and enforces speed limit on section having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed / Distance to Go status in his cab

enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in bad weather.

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

  Signalling & Train Control system on the line is planned for design headway of 2 minutes so as to meet sustained train operation at upto 2.5 minutes interval during peak hours.

TELECOMMUNICATION

The telecommunication system acts as the communication backbone for signalling systems and other systems such as SCADA, AFC, etc. and provides telecommunication services to meet operational and administrative requirements of metro network. The telecom system caters to the following requirements:

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

Important features are mentioned below:-

i) Optical Fibre Cable - Main Telecommunication Bearer

The main bearer of the bulk of the telecommunication network is proposed with optical fibre cable system with nodes at OCC, Depot and at each station.

ii) Mobile Radio Communication

Mobile Radio Communication System is proposed for on-line emergency communication between Motorman (Front end and Rear end) of moving train and the Central Control. The system shall be based on Digital Trunked Radio Technology.

iii) Passenger Announcement System

The system shall be capable of announcements from the local station as well as from OCC. Announcements from OCC will have over-riding priority in all announcements.

iv) Centralized Clock System

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

v) Train Destination Indicators

These are located at convenient locations at all stations to provide visual indication of the status of the running trains and will typically indicate information such as destination, arrival/departure time, and also special messages in emergencies.

vi) Network Monitoring and Management

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

AUTOMATIC FARE COLLECTION

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

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

1. Less number of staff required.
2. Less possibility of leakage of revenue due to 100% ticket check by control gates.
3. Recycling of ticket fraudulently by staff avoided.

4. Efficient and easy to operate, faster evacuation both in normal and emergency.
5. System is amenable for quick fare changes.
6. Management information reports generation easy.
7. System has multi-operator capabilities. Same Smart Card can be used for other applications also,

AFC systems are the worldwide-accepted systems for Metro environment.

The latest ticketing system is Contactless Smart Token/Card type. Equipment and installation cost of Contactless Smart Card/Token based AFC system is similar to magnetic ticket based AFC system, but Contactless system proves cheaper due to reduced maintenance, less wear and tear and less prone to dusty environment.

INTEGRATION OF AFC WITH FEEDER SERVICES

Common Smart Card based ticketing will require installation of AFC system for feeder system also. A Clearing House system will also be required for separation of revenue among various operators. However, the proposed system has multi-operator capability and in future it will be possible to integrate various transport providers and other agencies.

0.3.6 ROLLING STOCK

The rolling stock for the Ahmedabad Metro has been selected based on the following criteria:

- Proven equipment with high reliability
- Passenger safety features, including fire resistance
- Energy efficiency
- Lightweight equipment and coach body
- Optimised scheduled speed
- Aesthetically pleasing Interior and Exterior
- Low life cycle cost and
- Flexibility to meet increase in traffic demand

The controlling criteria are reliability, low energy consumption, light weight and high efficiency leading to lower annualized cost of service. The coach should also have high rate of acceleration and deceleration.

Keeping the above features in mind, 2.88 m wide stainless steel lightweight coaches are proposed for the Ahmedabad Metro, with a length of 20.50 m for trailer coach and 20.90 m for motor coach. The height of coach will be 3.90m. The train length for 3 car train will be 64.10 m and for 6 - car train 128.30 m. The Axle load will be about 14 t for which the structures are to be designed.

The trains will have regenerative braking system to save energy cost. Trains will be air-conditioned and provided with automatic door closing and opening system. The trains will have state of the art cab signalling with

continuous automatic train control, automatic train protection. The trains will have passenger information and announcement system as well.

The coaches will have longitudinal seats with a seating capacity of 43 person per driving motor car and 50 person per trailer car and total dense crush capacity of 786 for 3 car train and 1626 for 6 car train, at 6 persons/sqm.

0.4 CIVIL ENGINEERING

0.4.1 Design Norms

The design norms for Ahmedabad Metro are generally evolved from the Delhi Metro. However Ahmedabad requires a medium capacity system as compared to Delhi Metro which is a heavy Metro System. The salient features of the proposed system are as follows:

Gauge :	Standard Gauge (1435 mm)
Minimum Radius of Curve:	120 m on running line and depot 1000 m at Stations All curves are with Transitions
Gradient:	4% maximum, Flat at station
Vertical Curves:	At every change of grade. Minimum radius 1500 m
Design Speed	Max. 90 kmph

0.4.2 Alignment

Corridor 1 (North–South Corridor): The corridor starts near the junction of Ashram road with NH 8A near APMC Vasna. The alignment moves on the central verge of the Ashram Road towards North covering Vasna, Paldi, V.S. Hospital, Town Hall and reaches ITO junction. At this location the North – South corridor crosses the East – West corridor. It further moves north via Usmanpura, Vadaj, Subhash Circle via in front of Gandhi Ashram. Alignment crosses the Chimmanbhai bridge and railway lines to Sabarmati very close to Sabarmati Metre Gauge station and parallel to Chimmanbhai Bridge. The alignment further moves on the median of the road toward Motera and passes in front of Sardar Patel Gujarat Cricket Stadium. Further the alignment reaches on SH-43 near Radha Swamy Satsang Vyas up to Koba Circle. From Koba Circle, the alignment turns left and continues on the central median of SH 71 towards Gandhinagar. Before reaching Indroda Circle, a connection to the depot is provided from Dhaula Kuva station, as Depot is adjacent to these stations near Indroda circle in front of Infocity. The alignment continues in Gandhinagar area on the central median and passes in front of the secretariat and moves forward. The alignment is terminated at CH-6 near road to Akshardham temple.

The total route length is 32.65 km and the whole alignment is elevated, mostly on the central median. The 26% length is in curves and sharpest radius of curve is 130 m radius. The maximum gradient is 2.00% at ITO junction where both the corridor are crossing each other. Total 31 stations are proposed on the corridor out of which 5 are for future.

Corridor 2 (East – West Corridor): The corridor starts at Ahmedabad Railway station at Kalupur. The alignment moves on to the central median and skirts around the walled city on the eastern and northern side. The alignment moves on/along the periphery road of walled city and Kasturba Gandhi road and passes close to Prem Darwaja, Delhi Darwaja and Shahpur Darwaja. Alignment is taken on 20 m south of Gandhi Bridge and again comes to the central median short of Aayakar Bhawan (and North – South corridor). Few buildings are to be relocated from this area for alignment and integration of the two corridors. The alignment further moves towards west over the MG railway line, crosses SP five road crossing, Commerce crossing and further moves straight on Manav Mandir Marg and Drive in road via Gujarat University, 132' road crossing before reaching Thaltej on NH 8C. For the purpose of depot and stabling lines, the alignment crosses NH 8C and turns right to reach depot area.

The total route length is 10.90 km and the alignment is elevated throughout on the central median. A total of 11 stations are provided on the corridor. 53% of corridor is on curves with minimum radius being 130 m. The steepest gradient is 2.87 % while crossing the Sabarmati River.

0.4.3 Stations:

Total 42 stations have been provided on the two corridors out of which 5 are to be made in future on North-South line when the traffic demand picks up. All the stations are elevated and mostly on the median. The stations are provided with elevated concourse and at grade concourse on the sides of the road where sufficient land is available along the roads.

The Platforms are 135 m long to accommodate 6 car trains. The length for elevated concourse is 90 m below the platforms. For at grade, the size of concourse will be 45mx25m. The concourse provides ticketing facilities and access to the platforms. The concourse is divided into paid and unpaid areas for the commuters by the ticketing gates. All operational facilities are provided in the paid areas.

Escalators are provided from ground to concourse and concourse to platform for going up though these can be reversed in emergencies. The staircase widths are designed for emergency evacuation. In case of emergency the platforms can be evacuated in 4 minutes while the whole station can be evacuated in 8 minutes. Lifts are also provided for Handicapped persons.

Traffic Integration areas have been provided at most of the stations with required parking.

0.4.4 Construction Methodology:

The elevated structures shall contain 9.1 m wide **'U'** shape PSC girder carrying two tracks as superstructure and RCC piers with pile foundations.

The 'U' girders shall be casted in casting yards in the form of prestressed segments and brought to site through low level trailers. These segments shall be launched by specially fabricated launching girders at site and joined together by epoxy gluing and prestressing.

The foundations shall be of 1200 to 1500 mm diametre bored piles 25 to 30 m deep in soil. Pile cap shall be cast over piles and single pier shall be cast along with pier cap in single lift. Bearings for the superstructure shall be elastomeric bearings for standard span and pot bearing for long spans.

During construction about 9 to 10 m width of road shall be required during substructure work. This will require traffic management schemes during the construction period.

Identification of utilities have been done and details of utilities requiring diversion forms part of the main report.

0.4.5 Land Requirement

Every effort has been made to keep land requirement to the barest minimum and acquisition of private property minimal. Land is mainly required for depots and route alignment on sharp bends, station buildings, platforms, entry/exit structures, traffic integration, power sub-stations, ventilation shafts, administrative buildings and temporary construction depots / work sites etc.

Land requirement on the project is estimated at about 69.89 hectares out of which about 60.24 ha. belongs to Government and public sector / municipal organisations while about 9.65 ha. is private land. The estimated land cost is Rs. 52 crores.

0.4.6 Geo-technical Investigation

Geo-technical investigations have been carried out all along the proposed Metro Corridor. A total of 56 boreholes were drilled upto a maximum depth of 30.0m below the existing ground level along the alignment and 8 boreholes for a depth of 10m has also been drilled in depot area. The soil samples were collected and tested in laboratory.

The soils are mainly sandy silt with gravels (SM-ML) and silty sand with gravels (SM). The soil is non-plastic nature with a proportion of gravels. Rock is not encountered to the maximum depth of investigation.

Since the strata is sandy silt with gravels (SM-ML) and silty sand with gravels (SM), it is suggested that Bored Cast-in-situ piles are used in

substructure and the piles shall be terminated in dense stratum having factor of safety against liquefaction more than one.

0.4.7 Utilities

The proposed Metro alignment is passing along major arterial roads of the City, which are serving institutional, commercial and residential areas. A large number of surface and sub-surface utility services viz. sewers, water mains, storm water drains, telephone cables, electric poles, traffic signals etc. are existing along the proposed alignment. The details of the existing utility services along the proposed alignment have been collected from the concerned local authorities. The affected portions of the services with reference to the proposed alignment were identified and temporary diversion & relocation proposals of the affected services or change in span/pile layout have been indicated.

0.5 Train Operation Plan

A Metro system is made attractive by providing high frequency services both during peak and off-peak hours. For this purpose short trains (3 coach consist) are proposed initially at 5 minutes frequency during peak periods and 15 minutes frequency during off peak periods of the day. The 3 coach train with high frequency service to be suitably increased to 6 coaches as the demand picks up.

The salient features of the proposed train operation plan are:

- Running of services for 19 hours of the day (5 AM to midnight) with a station dwell time of 30 seconds
- Make up time of 5-10%, with 8-12% coasting
- Scheduled speed of 32 kmph

For the purpose of planning, the peak hour peak direction traffic demand for N-S line 13,000 in the year 2010, 24,000 in the year of 2025 and 37,000 in the year 2025 and for E-W line 13,000 in the year 2010, 18,000 in the year of 2025 and 26,000 in the year 2025 has been taken.

Each 3-coach train will consist of two driving motor coaches (DMC) and a trailer coach (TC), while 6 coach train will consist of 2 DMCs, 2 MCs (motor coaches) and 2 TCs(Trailer Coach). The capacity of each coach and trains is given below:

DMC	: 253 passengers,	MC and TC	: 280 passengers
3-Car Train	: 786 passengers,	6 Car Train	: 1626 passengers

The train operation plan for the year 2011 and 2021 during the peak hours and capacity provided is summarised in **Table 0.5**.

Table 0.5 Train Frequency and Capacity Provided in 2010, 2025 & 2035

Year	Peak Headway (min.)	Capacity per hrs. (No. of Pass.)
Line – 1 (APMC Vasna - Akshardham)		
2010	5	9432
2025	3	15720
2035	3	32520
Line – 2 (Ahmedabad – Thaltej)		
2010	5	9432
2025	4	15720
2035	2.5	18864

Table 0.6 Requirement of Rolling Stock in 2010, 2025 & 2035

Corridor	Number of Coaches		
	2010	**2025**	**2035**
Line – 1 (APMC Vasna - Akshardham)	87	135	270
Line – 2 (Ahmedabad – Thaltej)	33	54	60
Total	**120**	**189**	**330**

0.6 Power Supply

Electricity is required for operation of Metro system i.e., for running trains, for station services, workshops, depots & other maintenance infrastructure. Power requirement has been assessed for the year 2010, 2025 and 2035 (**Table 0.6**).

Table 0.6 Power Demand Estimation (MVA)*

Corridor		Year		
		2011	**2025**	**2035**
North - South Line	Traction	10	18	36
	Auxiliary	14	15	15
	Sub-Total	**26**	**33**	**51**
East - West Line	Traction	4	4	8
	Auxiliary	7	7	7
	Sub-Total	**11**	**11**	**15**
	Total	**37**	**44**	**66**

* MVA – Mega Volt Ampere

The high voltage power supply network of Ahmedabad city was studied in brief. The city has 220, 132, 66, 33 and 11kV network to cater to various types of demand in vicinity of the proposed corridor. Series of meetings were held with M/s Torrent Power AEC Limited (Licensee of the area) and

various sub-stations sites were inspected to finalize the Input Power Supply sources & Supply Voltage.

Keeping in view the reliability requirements, three Receiving Sub-stations (two for N-S line and one for E-W line) are proposed to be set up. This is an economical solution without compromising reliability. Based on the discussions with M/s Torrent Power AEC Limited., it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132 or 66kV voltage through cable feeders: -

Table 0.7 Sources of Power Supply

S. N.	Corridor	Grid sub-station of Torrent Power AEC Ltd. (Input voltage)	Location of RSS of Metro Authority	Approx. length of 132 or 66kV cables
1.	Vishala - Akshardham	Sabarmati Receiving sub-station (132kV)	Sabarmati	1km. (Double circuit)
		Vasna Receiving sub-station (66kV)	Vasna APMC	3km. (Double circuit)
2.	Ahmedabad - Thaltej	Thaltej Receiving sub-station (132kV)	Thaltej Depot	1km. (Double circuit)

Further transmission of electric power will be done through 33kV cables, which will be laid along the alignment on viaduct for catering to traction and auxiliary power requirements.

Auxiliary Sub-stations (33/0.415kV) - Auxiliary Sub-stations (ASS) will be provided at each station and depot for meeting the auxiliary power requirements of lighting, lifts, escalators, fire fighting, signaling & telecom, fare collection etc.

Supervisory Control and Data Acquisition (SCADA) system - The entire system of power supply shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system.

Standby Diesel Generator (DG) sets - In the unlikely event of simultaneous tripping of all the input power sources or grid failure, power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide standby DG sets of 100 kVa to cater to the essential services.

Electric Power Tariff – The cost of electricity is a significant part of Operation & Maintenance (O&M) cost of a metro system and therefore, a key element for financial viability of the Project. Annual energy consumption is assessed to be about 60 million units in initial years (starting from 2010), which may double by horizon year 2035. Therefore, the power tariff for Ahmedabad Metro should be at effective rate of

purchase price (at 33 kV voltage level) plus nominal administrative charges, i.e. at no profit no loss basis. This is expected to be in the range of Rs. 2.75-3.25 per unit. Similar approach is being pursued for Delhi Metro. However for the purpose of working out FIRR, the power tariff has been taken as Rs. 4.50 per unit.

0.7 Depot

The East –West corridor and the North - South corridors are two operational corridors. There would be interlinking between two corridors. Thus, the rakes would be able to move from one corridor to another for IOH and POH. This will facilitate having one mother workshop for the two corridors at Indroda circle on North-South corridor and an inspection shed, which will have the stabling facilities at Thaltej on the East-West corridor, will be required. Adequate facilities for the stabling would be provided at the terminal stations as well as at the depots. All the minor maintenance schedules would be independently taken care in each corridor thus saving the idle run of trains for the minor maintenance. For the IOH and POH the rakes would be taken to the mother workshop. Hence, the transfer facilities of the rakes are to be provided at ITO.

The facilities shall be provided in phases and augmented as the train frequency and formation increases due to growth in traffic. Overhauling of the rakes is also planned at mother depot.

During the discussions with Gujarat Government on 26.5.2005, it was suggested that DMRC should also study alternative arrangements in case of acquisition of land is not possible opposite Prasar Bharati/ Custom House. In that case, it will be necessary to develop Thaltej Depot to do maintenance and repair upto IOH & POH.

0.8 Environmental Impact Assessment & Mitigation Measures

The main aim of the EIA study is to ascertain the existing baseline conditions and to assess the impacts of all the factors as a result of the proposed corridor during its construction and operation phases. The study area Metro Corridors (Phase 1) is from (1) APMC Vasna – Akshardham (via Ashram road) (2) Kalupur – Thaltej (via Delhi Darwaja). The water and soil samples have been tested for chemical analysis. All the parametres of the samples collected from various locations of the alignment are within the permissible limits except the total dissolved solids at four locations. The texture of soil is mainly sandy. Approximately 4889 trees have been observed along the project alignment. As a part of this study, in order to establish the base line data ambient air quality monitoring (AAQM) has been carried out by setting up ambient air quality monitoring stations through mobile van at three locations for the parametres SPM, RSPM, NOx, and SO2, CO and HC. The ambient air quality data indicates much higher values of Suspended Particulate Matter (SPM may be due to more traffic etc. Gujarat has been classified in Zone II, III &IV in various stretches. The project area falls in Zone-III of Seismic Zoning Map of India.

The Indian Meteorological Department (IMD) has considered suitable seismic factor for design purpose for Civil Engineering structures, which shall be suitably incorporated while finalising civil structures.

Based on project particulars and existing environmental conditions, potential impacts have been identified that are likely to result from the proposed MRTS project during project construction and during operation of the project. A checklist of the impacts have been prepared and accordingly an environmental Management plan have been prepared for proper implementation of the project and mitigation measures. A detailed environmental cost has been worked out.

The Environmental Management Plan is prepared for (i) Compensation for Loss of Land, (ii) Compensation for Loss of Trees, (iii) Compensatory Afforestation and Fencing, (iv) Compensation for Relocation/Resettlement, (v) Water Supply & Sanitation, (vi) Oil Pollution Control and (vii) Noise Control / Vibration Control. The costs involved in environmental mitigation and management and monitoring to be put on the account of the Project are given below:

Table 0.8 Cost Involved in Environmental Mitigation and Management plan

S. No.	ITEM	Rs. (Lakhs)
1	Compensation for loss of trees	50
2	Compensatory Afforestation & fencing	322
3	Compensation for Resettlement	To be calculated separately
4	Monitoring of Water	6
5	Monitoring of air/noise during construction & operation	19
6	Establishment of Environment Division	31
7	Provision of bins for Railway Station Refuse	8
8	Construction of water treatment plant at depot site	120
9	Provision for Rain water harvesting	10
10	Provision for Sewage &Effluent treatment plants	150
11	Provision for Green belt development	20
12	Health and safety measures	50
	Sub total	785
	Miscellaneous items @10%	78.5
	GRAND TOTAL	864.5

The Environment Management Plan should be implemented in phases and synchronised with the construction schedule.

0.9 Cost Estimate

Cost Estimate has been prepared covering civil, electrical, signaling and telecommunication works, rolling stock, environmental protection, rehabilitation etc. at June 2004 price level.

The capital cost at June, 2004 prices works out to Rs. 3587 crores excluding taxes and duties, but including general charges @ 3% on all items except land, 2% design charges on all items, and 3 % contingencies on all items including general charges and design charges.

The completion cost excluding IDC but including escalation is estimated at Rs. 4295 crore. In addition the taxes and duties are estimated at Rs. 717 crore.

0.10 Fare Structure, Financial Option, FIRR

The financial analysis for the project has been worked out taking into consideration the completion cost, operation and maintenance cost as well as the additional expenditure to be incurred in coming years for additional rolling stock, signalling and telecom and augmentation of power supply system. Fare structure has been suggested with a fare of Rs. 8 for distance upto 2 km, Rs. 9 for distance between 2 to 4 km, Rs. 11 between 4 to 6 km, Rs. 13 between 6 to 9 km, Rs.15 between 9 to 12 km, Rs. 16 between 12 to 15 km, Rs 17 between 15 to 18 km, Rs 19 between 18-21 km, Rs 20 between 21 to 24 km, Rs 21 between 24 to 27 km, Rs 22 between 27 to 30 km, Rs 23 between 30 to 35 km, Rs 24 between 35 to 40km, and Rs 25 beyond 40 km from the year 2010. In addition, earning from advertisement and commercial developments is takes as 10 % of the fare box revenue.

Based on this fare structure, FIRR for the project works out as 4.64%.

0.10.1 Property Development Potential

As indicated during Feasibility Study stage there was a huge potential for development of a few growth centres (Townships) between Koba - Circle to Indroda Circle coming under the jurisdiction of AUDA and GUDA for part funding of the Metro Rail System. The return expected from the property development was about Rs. 2500 crores in 10 to 15 years. The development of these townships was also stated to contribute to the increase in ridership of the Metro.

However, since these recommendations were made by Delhi metro, land along the proposed metro alignment has been allotted and the opportunity for exploiting land along the corridor has been lost. From the remaining land it may not be possible to raise the revenues as envisaged earlier. It is, therefore, recommended that government should freeze further allotment of land along the corridor except for the metro. A further exercise was made in June, 2005 to assess afresh potential property development and is noted in Annexure-I to chapter 10. It is found that with the land available along the alignment between Motera – Koba circle – Indroda Circle and also other pieces of land within an area of 3 kms from the alignment it would still be possible to raise Rs. 1500 crore to part fund the Metro construction.

0.10.2 Financing Strategy

There are two possible models for financing the project.

1. Delhi Metro Model: In this model, 40% of the cost to be shared by two governments equally and the cost of private land is to be borne by State Government. Government land shall be provided free of cost. In addition, it is expected that Rs. 1500 crores can be developed by property development and the balance is to be taken as loan.
2. BOT Model: Ahmedabad Metro Project can be part financed through revenue generation from the vast land available between Gandhinagar and Ahmedabad. So, It is recommended that the project is implemented through BOT. The concessionaire shall operate and maintain the system for a period of 30 years before handing over the system to the Government. SPV created for Metro will also do the property development and provide to BOT concessionaire total of Rs 1500 crore in phased manner spread over construction period. The land for development shall be procured by the government and handed over to the SPV at actual cost price. In addition, a viability gap of Rs 1500 crore is to be provided shared equally between the Central and State Governments. Of the balance project cost 33.33% would be funded out of equity investment by the concessionaire and balance funds would be arranged by the concessionaire through debt. The residual value of the investment at the end of the concession would be payable to the concessionaire. The pre tax return on equity of the concessionaire would work out to 14%.

0.11 Economic Analysis

The proposed Metro system for Ahmedabad and Gandhi Nagar will provide a variety of benefits to the City and society, viz. savings in fuel consumption, vehicle operating cost, travel time, reduction in road accidents and air pollution. Economic analysis has been carried out for the proposed Metro corridor by comparing "with" and "without" project scenario. The 'with' project scenario takes into account, estimated total cost that the local economy would be called upon to bear. The 'without' project scenario envisages a situation wherein the existing infrastructure continues to be utilized taking into account increased estimated cost due to higher projected traffic.

The cost and benefit streams arising under the above situations have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

The Economic Internal Rate of Return (EIRR) for the Ahmedabad Metro has been worked out by using Discounted Cash Flow technique to the net benefit stream at economic prices and its value is estimated as 26.95%.

0.12 Implementation Strategy

On approval of Detailed Project Report immediate action is to be taken on the following;

a) Signing of MOU between Gujarat Government and the Central Government (MOUD) for jointly taking up the Project.
b) Arranging institutional setup for implementation of the Project.

It is recommended to form an SPV on the lines of Delhi Metro Rail Corporation (DMRC). The SPV can be named as Ahmedabad Metro Rail Corporation (AMRC) It is proposed that the State Government and the Central Government, each will have total equity of 40% shared equally and share the land cost as an interest free subordinate loan to the SPV. The number of Directors from the State and the Central Government will be equal. While the Managing Director will be a nominee of the State Government, the Chairman should be a nominee of Central Government. The Board of Directors (BOD) are to be vested with full powers to implement the Project with adequate delegation of power to the Managing Director for day to day working.

It is also recommended that a 'High Power Committee' headed by Chief Secretary, Gujarat and comprising secretaries of the concerned departments of the State Government and heads of civic agencies be constituted to sort out the problems connected with implementation of the Project.

The Group of Ministers and Empowered committee set up for Delhi Metro Project by the Central Government could also continue for the Ahmedabad Metro project for granting clearances on behalf of the Central Government.

Implementation Programme

It is recommended that Project be commissioned in different stages. The start date of the project is assumed as 30.11.2005 leaving about 5 months for financial closure after submission of the Detailed Project Report. The proposed date of commissioning of various section is given in Table 12.1 of Chapter 12.

These targets can be achieved if action to set up the SPV is taken in 3 to 6 months and the work for detail design and tendering is started by 01.07.2006.

0.13 Conclusion

This DPR is for phase-I of Ahmedabad Metro system.

For successful implementation of any metro project, which by its very nature is highly technical and complex, huge in size and to be executed in difficult urban environments, political will and commitment is necessary. Decisions are to be taken fast and the implementing agency must have the

required work culture, commitment to targets, safety, quality and cost consciousness.

Metro projects are highly capital intensive. On account of the high costs involved and the need to maintain a fare structure within the affordable reach of ordinary citizens, metro projects are not ordinarily financially viable. But considering the overwhelming economic gains to the society and the fact that cities with a population of more than five million cannot just survive without an efficient metro system, it is strongly recommend that the Ahmedabad Metro system be taken up for implementation in the financial year 2005-06. Each days delay in taking up the project would add Rs. 40 lakh to the cost of the project due to inflation alone.

Based on the details as furnished in the Detailed Project Report the project is to be implemented on priority basis

14. Regional Rail System

DMRC has also carried out a study for upgradation of the Regional Rail System for Ahmedabad. Following Corridors have been identified for upgradation of sub-urban Rail service under this scheme:

• Barajedi – Kalupur – Kalol		43.5 km
• Kalupur – Naroda		8.5 km
	Total	52.0 km

The estimated Capital Cost for upgradation of the Regional Rail System at April 2004 prices is Rs. 1076 crores (US$ 244.5 million). It is proposed that Regional Rail System should be funded with 1:1 debt: equity ratio. The equity portion should be provided in equal proportion by the state Government of Gujarat and the Ministry of Railways. Implementation and operation of Regional Rail System will, however, be done by the Ministry of Railways. The Detailed project Report for Regional Rail System shall be submitted shortly.