Metro Rail system
for
Ahmedabad and Gandhi Nagar

EXECUTIVE SUMMARY

1. 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 Executive Summary deals with Metro Rail system only.

1.1 The study has been divided into two stages.

Stage 1 study presents –

- Results of traffic and transportation studies for identified Corridors
- Estimates of Rider-ship
- Approximate cost estimates for each Corridor
- Examining the potential for development of new townships between Sabarmati and Gandhinagar
- Selection of most feasible corridor for detailed engineering survey to analysis in stage II

The Feasibility Report leading to selection of the corridors was submitted in August, 2004. The Report was accepted by Gujarat Government in October 2004.

Stage II study will be the DPR for the identified corridors and will present:

- 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.
- Implementation schedule.
- Proposed Fare structure and project viability.
- Financing plan.

1.2 The Detailed Project Report comprising the above shall be finalized and submitted to the State Government shortly. However, an interim executive summary covering most of the above items of reference has been prepared and is submitted herewith. The cost estimates presented here are tentative and the financing plan for the project is under evaluation. However the final outcome may not be much different from the details provided herein.

2.0 Traffic Demand Projection

The study area consists of Ahmedabad Urban Development Authority area, Ahmedabad Municipal Corporation area and Gandhinagar. The study area totals to 1351 sq. km. As part of the study detailed traffic surveys were conducted to prepare the database for working out traffic demand. The surveys include:

- Road Network Inventory
- Speed and Delay Survey
- Mid – block Traffic Volume Counts
- Screen Line Traffic Volume Counts
- Outer Cordon Surveys
- Bus and Shared Auto Passengers Boarding and Alighting Counts
- Rail Passengers Survey
- Household Travel Surveys

2.1 Population

The population of study area grew from 2.058 million in the year 1971 to 5.463 million in the year 2001. The annual growth rate of population in Ahmedabad was about 3.15% during 1991-2001. The population of AUDA, AMC area and Gandhinagar is expected to be 7.02 million in the year 2011 and 8.45 million in the year 2021 and 10.13 million in the year 2035.

2.2 Employment

The employment of study area was 1.17 million in 1991 and 1.74 million in the year 2001. The annual growth rate was 3.98%. The employment of study area is expected to be 2.1 million in 2011 and 2.64 million in 2025 and 3.18million in 2035.

2.3 Registered Vehicles

The registered vehicle population in study area was 1.73 million in the year 2003. 2-wheelers account to around 88% of total vehicles registered. This is an indirect indication of dilapidated stage of public transport (bus) services in the study area. The increase in use of private vehicle directly contributes to increase in total vehicle kilometers traveled and emission levels of pollutants, which would deteriorate the quality of health.

2.4 Public Transport System

The existing public transport in Ahmedabad mainly comprises bus system, Seven Seater and Shared Auto rickshaws. The modal share by public transit system in Ahmedabad at present is about 28% of total vehicular transport demand. This shows that a large proportion of demand is being met by personalized mode of transport, which is resulting in increased road congestion and higher emissions.

The ideal modal share in favour of public transport should be 70-75% for the city of size of Ahmedabad. Public Transport should be the back-bone soul of a city transport system. The presence of a good public transport System can deliver better environmental conditions, faster speed of travel, better mobility growth and economic growth.

2.5 Earlier Studies

Metropolitan Transport Project Organisation / Railways (MTP/R) Ahmedabad had made out a detailed traffic study and identified a number of corridors, most of them following existing rail routes, and in addition, one circular route around the Central Business District (CBD). This study was made at the instance of Ahmedabad Urban Development Authority (AUDA) and Ahmedabad Municipal Corporation (AMC).

RITES in association with SOFRETU have supplemented the study carried by MTP/R. The study has recommended a Broad Gauge EMU conventional type system on the Kalupur-Barejadi corridor, a separate elevated corridor for most of the length for the CBD area i.e. Sarkhej – Kalupur – SP Stadium and partly elevated and mostly surface corridor from Kalupur –Gandhinagar via Asarva.

Louis Berger Associates have carried out feasibility study for Integrated Public Transport System (IPTS) for Ahmedabad. They have formulated three alternative project scenarios for IPTS system. These alternatives are intended to be complementary rather than mutually exclusive. Some of the broad recommendations are improvement of road cross sections, implementation of grade separation at key junctions, decentralization of AMTS bus terminals, implementation of inner city bus loop services, provision of dedicated bus lanes along Relief Road and Gandhi Road and on other key routes. Development of IPTS consisting of 7-rail corridors and 8-bus corridors without using Indian Railways ROW or development of 9 rail corridors and 8 bus corridors by using Indian Railways ROW, development of five peripheral interception terminals for multi-modal facilities, development of North-South transit corridor from Makarba to Gandhinagar via Kalupur and Sabarmati and development of East-West corridor between Kalupur and Kalol or Sola to Shilaj to Vasna.

2.6 Result of Primary Surveys

The primary traffic surveys carried out as part of this study have brought out the following:

- The average peak hour journey speed of public transport on the study area road network is about 17 km/h and of private vehicles is about 22 km/h.

- More than one-lakh vehicles are recorded on Sardar Bridge, Nehru Bridge and Gandhi Bridge on Sabarmati River.
- More than one million persons cross the Sabarmati River everyday.
- About 71,000 persons board and alight daily at Ahmedabad (Kalupur) station.
- The total per capita trip rate (PCTR) recorded as 1.16, while PCTR for vehicular trips is 0.72.
- Out of 6.65 million passengers trips made per day in AUDA and Gandhinagar Area, 28% trips are made by public transport i.e. buses & IPTs (7 Seater, Autos and Shared Autorikshaw).
- The lower share of public transport indicates insufficiency of public transport system in the study area.

2.7 Transport Demand

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 detail 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)

- Vishala – Akshardham (Gandhinagar) (via Ashram Road, Motera, Koba Circle) – 32.65 km (Dead end to dead end).
- Kalupur – Thaltej (via Delhi Darwaza) – 10.90 Km (Dead end to dead end).

Metro corridor (Full System)

- Chandgodar – Sarkhej – Makatpur – Vishala – Vasana – ITO – Sabarmati – Motera – Koba Circle – Gandhinagar - Akshardham
- Kalupur – Prem Darwaja – ITO – Manav Mandir – Drive in Cinema – Thaltej
- Vishala – Manav Mandir – Naranpur – RTO
- Sarkhej – ISKON Temple – Thaltej – Khodiyar – Indroda Circle

The transport demand had been summarized for the year 2010 for Phase I Metro system. It is seen that, with a network length of about 42 km, would carry 0.673 million passengers per day. The passenger kilometers would be 5.603 million and the intensity of utilization (passenger km. carried per km.) would be 0.133 million.

2.8 The summary of transport demand forecast for full system of Metro for year 2035, comprising of about 100 km network, would carry 2.998 million passengers daily. The passenger km. carried would be 28.783 million and passenger density of utilization (passenger km. carried per km.) would be 0.289 million for the year 2035.

Table 1 SUMMARY OF TRANSPORT DEMAND – 2010 – PHASE I

Section	Length (Km)	Number of Passengers (million)	Pass-Km (million)	Pass-Km/km (million).
A) Metro System				
Line – 1: Vishala- ITO - Sabarmati – Akshardham	31.85	0.415	4.004	0.123
Line – 2: Kalupur- ITO-Thaltej	9.845	0.258	1.599	0.166
Total	**41.695**	**0.673**	**5.603**	**0.133**

Table 2 SUMMARY OF TRANSPORT DEMAND – FULL SYSTEM - 2035

Section	Length (Km)	Number of Passengers (millions)	Pass-Km (millions)	Pass-Km/km (millions).
A) Metro System				
Line – 1: Changodar - Vishala-ITO-Sabarmati – Akshardham	45.10	1.327	12.685	0.281
Line – 2: Kalupur-ITO-Thaltej	9.845	0.628	5.281	0.547
Line – 3: Vishala – RTO	12.50	0.225	2.056	0.165
Line – 4: Sarkhej – Indroda Circle (NH8C)	31.85	0.818	8.761	0.270
Total	**99.295**	**2.998**	**28.783**	**0.289**

3.0 System Selection

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 - 3 (a)
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 Disneyland) 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.

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.

4 System Details

4.1 ROLLING STOCK

The required transport demand forecast is the governing factor for the choice of the Rolling Stock. Considering the projected Peak Hour Peak Direction Traffic (PHPDT) as indicated in previous section, use of medium capacity Rail Vehicle is considered for Ahmedabad.

4.2 Passenger Carrying Capacity

In order to maximize the passenger carrying capacity, longitudinal seating arrangement is recommended. The whole train is proposed to be vestibuled to distribute the passenger evenly in all the coaches. Criteria for the calculation of standing passengers are 3 persons per square meter of standing floor area in normal state and 6 persons in crush state of peak hour. About 267 passengers can be carried per coach during peak hour.

4.3 Coach Design and Basic Parameters

The rolling stock to be provided shall represent state of the art and employ systems, sub-system and components of proven reliability. The important criteria for selection of rolling stock are as under:

- Proven equipment with high reliability
- Passenger safety feature
- Energy efficiency
- Light weight equipment and coach body
- Optimised scheduled speed
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost
- Flexibility to meet increase in traffic demand

Heavy rush of passenger can be experienced occasionally. It will be advisable to design the coach with sufficient strength so that even with this overload, the design will not result in over stresses

4.4 TRAIN OPERATION PLAN

Considering projected transport demand, three car trains are proposed to be introduced during initial years. Each train will have peak capacity of around 800 passengers. Number of trains and carrying capacity *during peak hours* are given in the **Table 3**. Requirement of cars and average speeds assumed are also indicated therein. Maximum running speed is envisaged as 80-100 kmph.

Table 3
TRAIN OPERATION PLAN

Corridor	Length (km)	Train Frequency (Peak hours) (Minutes)	Scheduled Speed (km/h)	Hourly Capacity pax	Number of Cars
E-W	9.845	5	32	9600	36
N-S	31.85	5	35	9600	87

Each train shall consist two motor coaches and one trailer coach. Trains with 6 cars at more frequent intervals can be operated in future to cater for increase in transport demand.

Trains can be worked from 0600 hours to 2300 hours. Remaining 7 hours will be available for inspection, repair and maintenance of the system. A minimum train frequency of 15 minutes is proposed during lean period to ensure high level of attraction for the users.

4.5 TRACTION SYSTEM

Traditionally, electric traction is used in Metro systems for requirement of high acceleration and pollution-free services in urban areas. There are three standard and proven systems of electric traction for use in suburban and metro lines, viz.: **750 V dc third rail, 1500 V dc overhead Catenary and 25 kV ac overhead Catenary system.**

(a) **750 V dc** third rail system has been extensively used in metros and more than 60% of existing metro systems in the world utilize 600-750V dc third rail system. The system does not negate the aesthetics of the city as it is laid alongside the track (and also requires smaller tunnel diameter for underground section compared to other systems). For elevated system there is no visual intrusion as third rail is along side the track and not visible. The surface system requires exclusive right of way due to safety reasons. However the system does not suit a heavy Metro system with phpdt of 60,000 and above. Few recently commissioned Metro systems with 750V dc third rail are Bangkok Transit System (1999), Ankara Metro (1997), Vienna Metro (1997), Athens Metro (2000), Istanbul Metro (2001) and Tehran Metro (2000). Picture of 750v dc third rail on elevated viaduct is shown in **Figure 1.**

(b) **1500 V dc** catenary system has been adopted by some of heavy metros to overcome the limitation imposed by 750V dc system for catering to traffic level of 60,000-80,000 PHPDT (e.g. Singapore, Hong Kong, Guangzhou etc.) or long length of corridors. This system requires use of catenary masts and messenger wires on surface or elevated viaducts thereby affecting aesthetics of the city.

Figure 1 Picture of 750 V dc Third Rail on Elevated Viaduct

(c) **25 kV ac** traction has the economical advantages of minimal number of traction sub-stations and potential to carry large traffic (60,000-90,000 PHPDT). The system requires catenary masts on surface/elevated section, thereby affecting aesthetics and skyline of the city. Suitable measures are required for mitigation of Electro-magnetic interference (EMI) caused by single-phase 25 kV ac traction currents. In addition, 25 kV ac train requires heavy transformer & converters to be carried in each motor coach. Picture of 25 kV ac catenary wires and masts is shown in **Figure 2.**

Figure 2 Picture of 25 kV ac Catenary Wires & Masts

Traffic requirements for the Ahmedabad Metro have been projected in the range of 40,000 in horizon year 2035 and likely to be higher in future. The proposed RRS has to be operated on 25 kV AC traction system as the system is integrated with Indian Railways which is run on similar system. By adopting the same system for the Metro, the requirement of substations can be optimized. Though the alignment of proposed corridors is on elevated viaducts, keeping in view the ultimate traffic requirements, standardization and other techno-economic considerations, 25 kV AC overhead traction system is considered to be the best trade-off. For auxiliary loads, auxiliary substation of appropriate capacity will be provided at each station on the two corridors.

4.6 SIGNALLING

The signalling system shall provide the means for an efficient train control, ensuring safety in train movements. It assists in optimisation 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 optimisation of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting an automatic signalling based on Automatic Train Protection (ATP) and automatic train supervision system. This will:

- Provide high level of safety with trains running at close headway (2 to 4 minutes), 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.
- 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 the cab enabling him to optimise the speed potential of the track section. It provides signal/speed status in the cab even in bad weather.
- Increased productivity of rolling stock by increasing line capacity and train speeds, and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stock.
- Improve maintenance of signalling and telecommunication equipments by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

4.6.1 A signalling and control system needs to be provided on all running tracks of the metro including car shed except for lines used mainly for local shunting. At all stations with points and crossings, computer based interlocking is provided for operation of points and crossings/setting of routes including track of adjacent station. The control of train operation is done from computer based operation control centre (OCC) and supervised by Traffic Controller.

4.6.2 The recommended design parameters for Ahmedabad Metro system shall have following features:

- Design Headway - 90-secs
- Operating Headway - 120-secs
- Maximum Train Length - 135-m
- Maximum Attainable Speed - 90-kmph
- Average Speed - 30/35-kmph
- Station Dwell Time - 30-secs

4.6.3 Continuous Automatic Train Control (CATC) comprising Automatic Train Protection (ATP) System and Automatic Train Supervision (ATS) System with cab signalling has been provided for the Metro system operation transporting a high volume of passengers at tight headways to ensure strict safety enforcement monitoring. Line side LED signals shall be provided at all stations and at diverging routes from the main line (i.e. at points & crossings), which shall serve for backup signalling in the case of failure of CATC system.

4.6.4 The system shall be 'Distance-to-Target' based of fixed block type using coded Audio Frequency Track Circuits. All the Stations with points and crossings shall be provided with independent SSI with facility to operate these points and crossings locally as well as being Centrally Controlled from OCC. All the software/hardware subsystems for signalling & train control shall follow the relevant CENELEC standards.

4.6.5 Power supply for the signalling & train control equipment provided at the stations, depot & rolling stock shall have at least 3 levels i.e. mains power supply from the State Electricity Supply, traction power supply and UPS/battery backup/Diesel Generator to support uninterrupted train operations.

4.7 TELECOMMUNICATIONS

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.

4.7.1 The telecommunication system will consist of following:

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) Telephone Exchanges (EPABX)
Large EPABX needs to be provided at OCC, one at an intermediate station on each corridor and at the depot. Small exchanges are to be at each station. These are to be connected together through optical fibre, which will provide communication at each stations and depots.

iii) 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.

iv) 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.

v) 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.

4.8 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 maintenance, 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.

4.8.1 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.

4.8.2 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.

4.8.3 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.

5.0 Civil Engineering

5.1 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

5.2 Alignment

Corridor 1 (North–South Corridor): The corridor starts near the junction of Ashram road with NH 8A in Vishala near APMC. The alignment moves on the central verge of the Ashram Road towards North covering Vasna, Paldi, V.S. Hospital, Townhall 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 Sabarmati Ashram. Alignment crosses the Chammanbhai bridge and railway lines to Sabarmati very close to Sabarmati Meter 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. 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 32.650 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 3 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 wall city on the eastern and northern side. The alignment moves on/along the periphery road of wall city and Kasturba Gandhi road and passes close to Prem Darwaza, Delhi Darwaza and Shahpur Darwaza. Alignment is taken on 30 m south of Gandhi Bridge and again comes to the central median short of ITO (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 six road crossing and further moves straight on Manav Mandir Marg road via Manav Mandir, 132" road crossing and Drive in road 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. This corridor also serves Gujarat University 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.

5.3 Maintenance facilities for Rolling Stock

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 over 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.

5.4 Stations:

Total 42 stations are provided on the two corridors out of which 3 are to be made in future when the traffic demand picks up. All the stations are elevated and mostly on the central median. The stations are provided with elevated concourse in Ahmedabad area, while in Gandhi Nagar area the concourse is provided on the sides as sufficient land is available along the roads.

The Platforms are 135 m long to accommodate 6 car trains. However the concourse is provided for 90 m length below the platforms. The concourse provides for ticketing facilities and access to the platforms. Staions are devided into paid and unpaid areas for the commuters by the ticketing gates. All operational facilities are provided in the paid areas.

Escalators are generally provided from 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 provided for Handicapped persons.

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

5.5 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 diameter 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.

Utilities identification work is in progress and details of utilities requiring diversion shall be part of the main report.

6. 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. It was also recommended that a total 3 km width (1.5 km on either side) of the corridor is taken up for such development. Approximately 3000 Ha area was estimated for development for this purpose. Out of this one third of the area (i.e. 1000 Ha) was recommended for development as commercial/institutional area and the balance as residential area.

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. With the land available along the alignment and also other pieces of land within an area of 4 kms from the alignment (including a piece of government land measuring 500 hectares) it would still be possible to raise Rs. 2000 crore.

7. Cost Estimate

Estimates for the Metro system in Ahmedabad are based on the rates obtained for various works for Delhi Metro phase 1. Suitable correction for modification of the system and escalation has been taken care of. These estimates correspond to April, 2004 price level and is based on the assumption that the Central Government and the State Government will provide exemption from payment of taxes and duties for the project and land required for the project would be available free of cost. The land cost for private land is, however, indicated separately.

The Phase-I cost at April 2004 prices estimated as under for the two corridors is Rs. 3591.73 crores (US$ 816 million) excluding the land cost and taxes and duties.

Project Cost-Estimates for Ahmedabad Metro

June 04 Price level

			East-West Corridor (Ahmedabad-Thaltej)			North South Corridor (Vishala-Gandhi Nagar)		
			Length = 10.900Km (including ramp portion for entry to depot)			Length = 32.650 Km and 0.30 Km at surface for entry to depot		
			Stations - 11 Nos (Elevated)			Stations - 28 Nos (Elevated) excluding 3 Nos future station		
S. No.	**Item**	**Unit**	**Rate without Taxes** (In Crores)	**Qty.**	**Amount (In Crores)**	**Rate without Taxes** (In Crores)	**Qty.**	**Amount (In Crores)**
1	**Land**							
1.1	**Govt. Land**							
	To be arrange free of cost							
1.2	**Pvt. Land**	Hact.	10.00	5.00	50.00	10.00	10.00	100.00
	Sub Total (1)				**50.00**			**100.00**
2	**Alignment and Formation**							
2.1	Elevated alignment	R. Km.	20.00	10.90	218.00	20.00	32.65	653.00
2.2	Approach to Depots at surface	R. Km.				6.15	0.30	1.85
2.1.3	Extra cost for interchange arrangement at Aaykar Bhawan		LS		25.00	LS		25.00
	Sub Total (2)				**243.00**			**679.85**
3	**Station Buildings**							
3.1	Elevated Stations, type A	Each	9.00	7.00	63.00	9.00	20.00	180.00
	Elevated Stations, type B	Each	10.00	2.00	20.00	10.00	4.00	40.00
	Elevated Stations, type C	Each	11.00	2.00	22.00	11.00	4.00	44.00
	Sub Total (3)				**105**			**264**
4	**Depot**							
4.1	Thaltej & Indroda circle Depot	Each	LS		70.00	LS		100.00
	Sub Total (4)				**70.00**			**100.00**
5	**P-Way**							
5.1	Ballastless track for elevated alignment	R. Km.	4.95	10.90	53.96	4.95	32.65	161.62
5.2	Ballasted track for At-grade alignment	R. Km.				2.97	0.30	0.89
	Sub total (5)				**53.96**			**162.51**
6	**Traction and power Supply**							
6.1	Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators, & VAC							
	a) Elevated & at grade section	R. Km.	5.50	10.90	59.95	5.50	32.95	181.23
6.2	Lifts	Each	0.20	33.00	6.60	0.20	84.00	16.80

6.3	Escalators	Each	0.80	22.00	17.60	0.80	56.00	44.80
	Sub total (6)				**84.15**			**242.83**
7	**Signalling and Telecom.**							
7.1	Sig. & Telecom.	R. Km.	8.30	10.90	90.47	8.30	32.95	273.485
7.2	Automatic fare collection	Stn.						
	Elevated & at-grade Station		2.00	11.00	22.00	2.00	28.00	56.00
c)	Central Computer System and interface with existing AFC system		LS		4.00	LS		10.00
d)	Smart cards/Tickets		LS		3.00	LS		5.00
	Sub Total (7)				**119.47**			**344.49**
8	**R & R hutments**		LS		**25.00**	LS		**25.00**
9	**Misc., utilities, roadworks, other civil works such as median, station signages, environmental Protection**	R. Km.	3.00	10.90	**32.7**	3.00	32.95	**98.85**
10	**Rolling Stock**	Each	4.25	36.00	**153.00**	4.25	87.00	**369.75**
11	Total of all items except Land				**886.28**			**2287.26**
12	General Charges @ 3 % on all items except land				**26.59**			**68.62**
13	Total of all items including G. Charges				**962.86**			**2455.88**
14	2 % design charges on item 13				**19.26**			**49.12**
15	Total of all items				**982.12**			**2505.00**
16	Contingencies @ 3 % on all items				**29.46**			**75.15**
17	Gross Total				**1011.58**			**2580.15**
								3591.73

8. ENVIRONMENTAL IMPACT ASSESSMENT

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) Vishala – Akshardham (via Ashram road) (2) Kalupur – Thaltej (via Delhi Darwaza). The water and soil samples have been tested for chemical analysis. All the parameters 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 parameters 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 India Meteorological Department (IMD) has considered suitable seismic factor to be adequate 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, 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 have been worked out.

The Environment Management Plan should be implemented in phases, so that optimum benefit could be achieved and it should be synchronised with the construction schedules.

9. Financing Plan:

Normally metro projects are financially unviable. In case of Delhi the project is funded by the Central and State Government by 28 % equity and through JBIC loan guaranteed by the Central Government. The FIRR for Ahmedabad metro comes to 6.8%. In case of Ahmedabad the project can be financed through revenue generation from the vast land available between Gandhinagar and Ahmedabad. Similar approach has been very successful in Japan.

It is recommended that the project is implemented on the Delhi model except that the funds raised from Property Development could be from Rs.1000-2000 crore depending on the availability of land and the real estate market. 40% of the project cost would be funded through equity shared equally between the two governments and government land will be made available free of cost by the State Government. The cost of private land will also be borne by the state Government. The balance amount will have to be raised as loan from the domestic market. In case a Government guarantee is available it may be possible to raise loan from the domestic market @ 7.5% p.a.

Detailed financing plan along with the project viability shall be made available with the detailed project report. Various scenarios of financing with varying revenues from PD are annexed.

10. IMPLEMENTATION PLAN

The detailed project report (DPR) is likely to be submitted by middle of May 2005. On receipt of the DPR GIDB has to take following actions:

a. Approval of DPR by State Government of Gujarat
b. Setting up an executing body which will take action regarding
    (i) Preliminary planning
    (ii) Land acquisition
    (iii) Getting legal status for project implementation

(iv) Seeking necessary Tax relieves and other clearances from the Central Government.
(v) Co-ordination with utilities and other Civic and Government Body
(vi) Engaging Consultants for preliminary design and Tendering
(vii) Fixing of BOT concessionaire
(viii) Project & Construction Management (through Consultants)
(ix) Act as Regulatory authority during Operation and Maintenance
(x) Plan for future expansion

a) Approval of DPR by Central Government. The approval is required in principle to provide legal cover and tax concessions.
b) Provide legal cover for the project
c) Process for simultaneous implementation of Regional Rail System along with the Railways.

10.1 The project can be implemented in 4 years after sanction of the project. As stated above the preliminary works can be taken up immediately after approval of DPR by the state government. Actual execution of works can start in early 2006 and commissioned in phases.

10.2 The East – West corridor can be commissioned in 3 years. As the depot on the North – South corridor is at the Gandhinagar end, Gandhinagar – Sabarmati section can be opened in 3 years. The balance section can be opened by March 2010.

11. Legal Framework

Metro rail projects are undertaken in congested urban environment. Metro lines have, therefore, to pass through heavily built-up areas. As vacant land for laying these lines is seldom available, they have to be constructed either as elevated or underground. When elevated, the metro lines are generally located along the medians of the existing roads to obviate the need for acquiring land. Even in such cases, land is to be acquired for siting station buildings, traffic integration areas, etc. Whenever underground, metro lines may have to pass under privately owned buildings, involving use of underground space below such buildings. After construction of a metro line is complete, it has to be certified as ‘safe’ by a statutory authority before it can be opened for public carriage of passengers. For operation and maintenance of a metro line, which has been commissioned for traffic, several crucial issues having legal implications need to be taken care of. These include continued monitoring of safety of train operations, security of metro properties, maintaining law and order within metro premises, enquiries into accidents involving metro trains whenever they happen, deciding the extent of compensation payable for damages/injuries/casualties arising out of such accidents, laying down passenger fares and their subsequent revision etc. There has, therefore, to be a proper legal frame-work to take care of such problems encountered during construction as well as operation of metro rail lines. Hence the need for a comprehensive legislation on Metro Railways.

The comprehensive legislation should, inter-alia, contain provisions for the following:

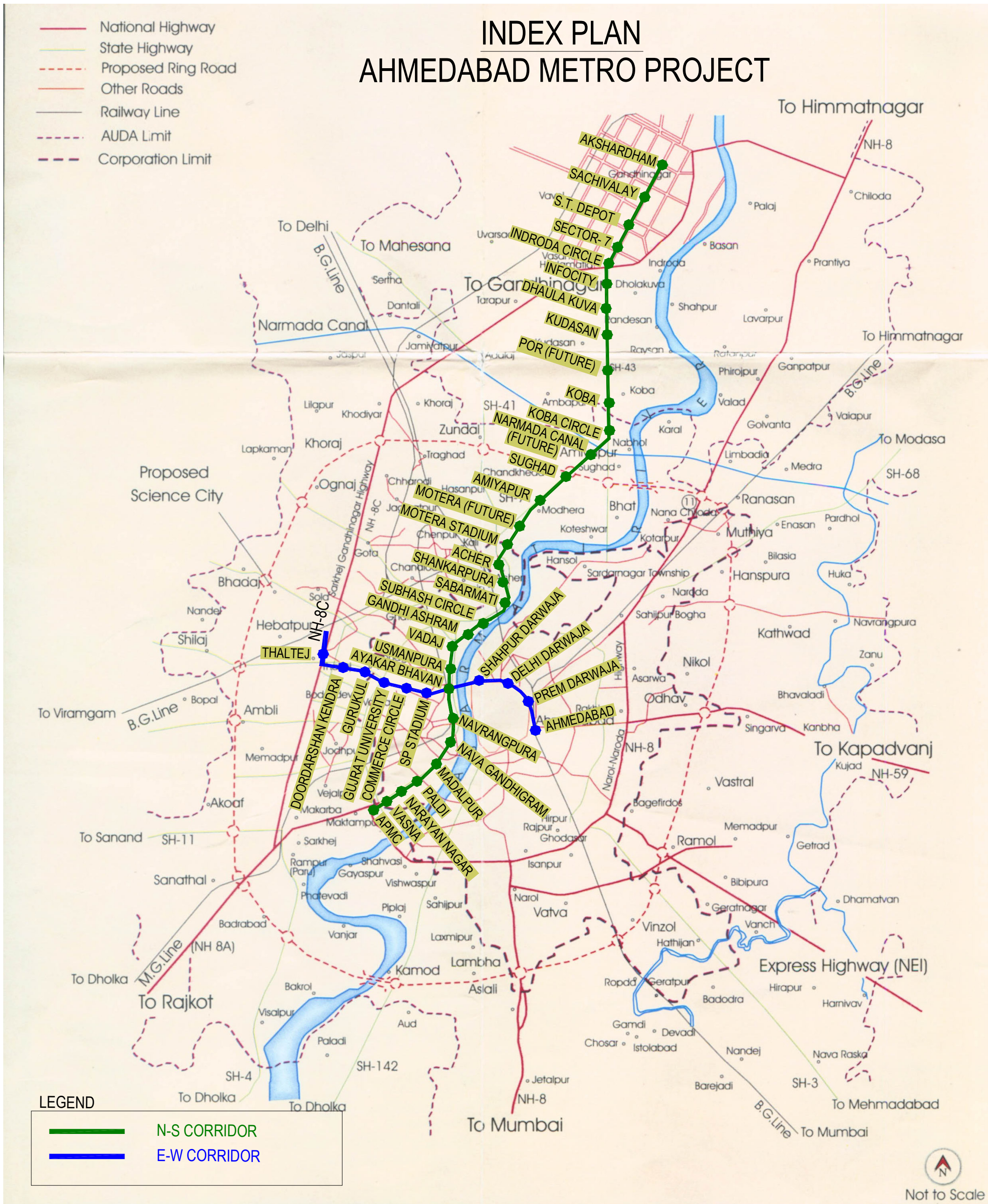
- Functions and powers of the organisation to be entrusted with the tasks of implementing a metro system and its subsequent operation and maintenance. This organisation should be conferred adequate powers to enable it to expeditiously implement the metro system and later to operate and maintain it without any problem.
- Acquisition of land for construction of a metro railway, including acquisition of rights to use underground space below privately-owned buildings for laying a metro line.
- Safety organization for certifying safety of a metro line before it is opened for public carriage of passengers. This organization should also be entrusted with the role of enquiring into the causes of accidents involving metro trains and suggesting remedial measures for avoiding recurrence of such accidents.
- Statutory authority for deciding the compensation payable for losses, injuries, casualties, etc. arising out of accidents involving metro trains.
- Penalty for offences committed in metro trains or metro premises.

12. 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 services 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.



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