PROJECT BRIEF

0.1 INTRODUCTION

Chennai is the fourth-largest city in India. It is a coastal city with the second largest beach in the world. The climate is hot and humid but the breeze blowing from the sea makes the climate bearable. It is India's major leather-producing center and the quality of leather compares with the finest in the world. The City with its present population of about 8 million generates about 11 million trips in a day, with about 6 million vehicular trips. The ever growing vehicular and passenger demands coupled with constraints on capacity augmentation of the existing network have resulted in chaotic condition during peak hours of the day.

POPULATION

The population of Chennai in1639 was 40000 and today the city is estimated to have a population of 7.5 million, which gives a population density of about 6482 per sq. km. It is observed that with the population growth between 1921 and 1981 has been very rapid and similar trend continues.

INDUSTRIAL AND EMPLOYMENT SCENARIO

Economic growth of CMA has been slower in the large-scale formal industrial sector compared to the growth in the small and marginal sectors in trade, commerce and transport. Per capita income in CMA is rather low compared to other metropolitan cities; it was Rs. 1760 per capita /month as per the house hold survey carried out in 2005. About 65 percent of the population can be classified as economically weaker section.

LAND USE POLICY

In 1973, the Chennai Metropolitan Development Authority (CMDA) was set up and it was entrusted the task of implementation of the Master Plan. The detailed plan, which was prepared for a time frame of over 20 years commencing from 1971, deals with land development, traffic and transportation, housing and slum clearance. At present the Master Plan for the year 2026 is under finalization. This report is based on the draft Master Plan 2026.

RAIL NETWORK

The rail infrastructure in the Metropolitan area basically comprises of following sections of railway which are treated as suburban sections:

(I) North line towards Gummidipoondi (BG line)

(II) West line towards Arakkonam (BG line) and

(III) Southern line towards Chinglepattu

Chennai Central - Gummidipundi (48km, 16 stations) have been running on this line since 1985.

Chennai Central to Arakkonam (69 km, 29 stations) .

Beach to Tambaram (30km, 18 stations) is the Chennai suburban system.

Apart from the above, a Rapid Transit System (RTS) on north-south corridor along Buckingham Canal alignment from Chennai Beach to Velachery also exists. The Rapid Transit System from Chennai Beach to Velachery with a route length of 20 kms is designed as Broad Gauge Double Line with 25 kV AC Traction and with conventional EMU trains. The extension from Velachery to St. Thomas mount is sanctioned and is being taken up for execution.

ROAD NETWORK AND TRAFFIC

The road layout in the metropolitan area is of radial pattern with 3 principal radial arterials, viz. NH-5, NH-4, NH-45, to the north, west and south respectively. In addition, there are two more radial arterials,(i) along the coast on the northern side (Thiruvotriyur High Road) and (ii) between NH-4 and NH-45 (Arcot Road).

TRANSPORT PROBLEMS

Previous study in 1992 show that 33.8 percent of total road length has a Volume /Capacity Ratio of more than 1.0 in the peak hours. Most of the roads in CBD are congested and roads in older areas have inadequate or poor geometries. An inadequate orbital road system, with lot of missing links, has put tremendous strain on the radial network.

PAST STUDIES

A number of transportation studies were carried out in the past for Chennai Metropolitan Development Authority (CMDA). These studies discussed travel pattern, network characteristics and the degree of traffic saturation on the existing roads in the Study Area. The following studies which recommended transportation improvements in CMDA , have been reviewed.

Comprehensive Traffic and Transportation Study (CTTS) for Chennai

The Study was carried out in 1992-95 for Chennai Metropolitan Authority (CMA) along with the preparation of Second Master plan. As part of the CTTS study short, medium and long-term measures for improvement of road and transport infrastructure were identified and prioritized for investment purpose.

Multi modal Outer ring Road Project

The Study as carried out SOWIL indicate the modalities of implementing 62 km

long PRR project as a multi-modal corridor with area development on either side to a depth of 25 meter at a approx cost of Rs. 800 Crores in the public-private-partnership mode.

0.2 SELECTION OF CORRIDORS

A feasibility study was carried out in 2003 to select and priortise the corridors for Chennai metro. Based on detailed traffic surveys, following corridors were recommended:-

Corridor-1: NH-45 (Airport)- Guindy- Sardar Patel Road- Kotturpuram High road - Cenotaph Road- Anna Salai – Gemini – Spencers - Tarapore Towers - Along Cooum River upto Rippon building - Central Station - Broadway (Prakasam Road) – Old Jail road - Tiruvottiyur High Road (upto Tiruvottiyur)

Corridor-2: Along Poonamallai High Road (Corporation limits) - EVR Periyar Salai - Rajaji Road (North Beach Road) covering Koyambedu - Anna Nagar Arch - Aminjikarai – Kilpauk Medical College – Egmore - Central-Fort- Beach

Corridor-3: Ambathur Industrial Area (Mogapair) - Ring Road - Arcort road - Panagal Park - Theagaraya road - Eldams road - Luz Church Road - RK Mutt Road - Adyar Bridge - Lattice Bridge Road - Tiruvanmiyur

Corridor-4: Porur – Kodambakkam (Arcort Road) - Panagal Park - Theagaraya road - Eldams road - Luz Church Road - Kutchery Road - Kamrajair Salai

Corridor-5: Ring road

Corridor-6: Radhakrishnan Salai **-** Nugambakkam High Road- Mc. Nickols Road - KMC

Corridor-7: Along NH 5 Road

Out of these corridors, following 2 corridors have been selected in consultation with state govt. for phase 1:-

1. Corridor-1 Airport to washermenpet
2. Corridor-2 Fort - Anna Nagar- Ring road- St. thomas Mount

0.3 TRAFFIC FORECAST

A detailed household survey was carried out to assess traffic demand. A detailed model was developed and calibrated and traffic demand forecast made based on land use planning and detailed surveys.

Summary of total boarding, passenger kilometers, average trip length and passenger km/km for various years is presented in **Table 0.3.1.**

Table 0.3.1
Summary of Transport Demand

Year	corridors	Daily Pass	length km	Pass-km	Av. Lead km	Pass km/Km in lakh
2011	Corr-1 (Airport to washermenpet)	318532	22.5	2632748	8.27	1.2
	Corr-2 (Fort - Anna nagar-Ring road- St. thomas Mount)	254144	21.3	2137984	8.41	1.0
	Total	572676	43.8	4770732	8.33	1.1
2016	Corr-1 (Airport to washermenpet)	403169	22.5	3280363	8.14	1.5
	Corr-2 (Fort - Anna nagar-Ring road- St. thomas Mount)	353297	21.3	2866624	8.11	1.3
	Total	756466	43.8	6146987	8.13	1.4
2026	Corr-1 (Airport to washermenpet)	542444	22.5	4575592	8.44	2.0
	Corr-2 (Fort - Anna nagar-Ring road- St. thomas Mount)	521605	21.3	4323905	8.29	2.0
	Total	1064048	43.8	8899496	8.36	2.0

The traffic demand by taking 5.2% growth rate is as follows:-

Year	**2011**	**2016**	**2026**
Total Trips (in Lakhs)	5.73	7.74	12.85

Note:

Recent experience is that the existing rail-based modes of travel have seen significant increases in ridership. Growth in passenger traffic in the suburban rail system was 23% in 2006-07 and 12% in 2007-08. The MTP (elevated railway system) Phase II was recently extended upto Velachery in November, 2007 and there has been a 300% increase in ridership.

0.4 SYSTEM SELECTION

A. PERMANENT WAY

CHOICE OF GAUGE

Standard Gauge (1435mm) is invariably used for metro railways world over. During the last decade, many metros such as Cairo, Madrid, Bangkok, Manila, and Beijing etc. 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 Standard gauge are 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 and in Depot (except inside the Workshops, inspection lines and washing plant lines, in under ground and elevated stretches. The track will be laid with 1 in 20 canted rails and the wheel profile of Rolling Stock should be compatible with the rail cant and rail profile.

B. TRACTION SYSTEM

The alignment of proposed corridors is on elevated viaducts in southern section (near airport) of Corridor – 1. The height of metro structure including train heights needs to be restricted to less than 12 meter in air funnel area. Also 25 kV AC traction with overhead wires provides cluttered looks to the system. Keeping in view the ultimate traffic requirements, height restrictions, aesthetics, standardization and other techno-economic considerations, 750V dc third rail traction system is considered to be the best trade-off and hence, proposed. The third rail will be provided with suitable shrouds for safety of passengers as well as maintenance personnel.

C. SIGNALING AND TRAIN CONTROL

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 ‘Distance to go’ ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) signaling systems.

D. TELECOMMUNICATION

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

The telecommunication facilities proposed are helpful in meeting the requirements for

1. Supplementing the Signaling system for efficient train operation.
2. Exchange of managerial information
3. Crisis management during emergencies
4. Passenger information system

The proposed telecom system will cater to the following requirements:

- Train Traffic Control
- Assistance to Train Traffic Control
- Maintenance Control
- Emergency Control
- Station to station dedicated communication
- Telephone Exchange
- Passenger Announcement System and Passenger Information and Display 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 Signaling, SCADA, Automatic Fare Collection etc.

E. 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.

F. ROLLING STOCK

Rolling stock for Chennai Metro is similar to the one adopted for Delhi Metro. Rolling Stock has been selected based on the following criteria:

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

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

The following optimum size of the coach has been chosen for this corridor as mentioned below.

Size of the coach

	Length	Width	Height
Driver Motor Car	21.64 m	2.9 m	3.9 m
Motor/Trailer car	21.34 m	2.9 m	3.9 m

0.5 CIVIL ENGINEERING

GEOMETRIC DESIGN NORMS

The design parameters related to the Metro system described herewith have been worked out based on a detailed evaluation, experience and internationally accepted practices. Various alternatives were considered for most of these parameters but the best-suited ones have been adopted for the system as a whole. Horizontal curves are provided with

	Underground Section	**Elevated Section**
Desirable Minimum	300 m	200 m
Absolute minimum	200 m	120 m*
Minimum curve radius at stations	1000 m	1000 m
Maximum permissible cant (Ca)	125 mm	125 mm
Maximum cant deficiency (Cd)	100 mm	100 mm

*** JBIC recommends a minimum of 150 m.**

Underground sections

Rail level at midsection in tunneling portion shall be kept at least 12.0 m below the ground level so that a cover of 6m is available over the tunnels. At stations, the desirable depth of rail below ground level is 12.5m, Track centre in underground section to be constructed by Tunnel Boring Machine (TBM) is 15.05m to

accommodate a 12 m wide island platform. Track centre in underground section to be constructed by cut and cover method is 4.5m.

Gradients

Normally the stations shall be on level stretch. In limiting cases station may be on a grade of 0.1 %. Between stations, generally the grades may not be steeper than 2.0 %. However, where existing road gradients are steeper than 2 %, gradients or for Switch Over Ramps upto 4% (compensated) can be provided in short stretches on the main line.

Design Speed

The maximum sectional speed will be 80 km/h. However, the applied cant, and length of transition will be decided in relation to normal speeds at various locations, as determined by simulation studies of alignment, vertical profile and station locations.

DESCRIPTION OF ALIGNMENT

Corridor 1

The corridor- 1 starts from Washermanpet and ends at the Chennai Airport. Dead end to dead end length of Corridor is **23.085** km, out of which **14.300**km is underground, 8.785 km is elevated. Total 18 nos. of stations have been planned along this corridor.

The alignment starts from old Washermanpet on southern side of old Washermanpet Railway Station, for reversal, tracks have been extended from 400m toward north after crossing railway tracks.

On exit from Washermanpet station alignment passes under old Jail road at km 0.261 and runs under Seven Wells North and Bander Rama Garden localities, after having a left turn through 300m radius curve Alignment turns right at km 1.161 along Prakasham Road (Broadway). It passes under Broad way as well Esplanade road for a length of about 1.0 km.

At the end of Esplanade Road it turns right, passes for a short distances under Muthuswami Road, enters Government Dental College and Hospital area land (where Chennai fort station is proposed) before aligning parallel to the Government General Hospital and Railway Station Road.

Corridor – 1 and Corridor –2 are parallel to each other on Government General Hospital Road for a length of about 500m. Corridor – 1 and Corridor – 2 are underground. Chennai Central metro station is proposed under the parking area of Chennai Central Station. Location of Chennai Central Metro Station has been decided keeping in view its integration with Chennai Central Railway Station, Chennai Central Railway Station (Sub-urban) and Chennai Park Railway Station.

Chennai Metro Station shall cater dispersal of local as well long distance traffic.

Corridor further moves forward and after having left turn with 250m-radius curve, crosses Poonamalle High Road, Railway lines and align itself along Kuvam River. CMDA Station has been planned on the Western Bank of Kuvam River. It crosses Kuvam River in underground position at km 6.500 and aligns along Dams Road and after having a 210m-radius right hand curve aligns itself along Anna Salai (Mount Road). Further it runs below Mount Road and by the side of Gemini Fly over and up to Adayar River. Alignment has been deviated from road on the approach of Adyar River to off road position on the East of Mount Road. It emerges out from under ground position and crosses Adyar River above HFL and achieves elevated position at Cinnamalai Junction (Little Mount). Further the Alignment runs upto Airport on center of Road except Guindy and Alandur where it is "Off road" position. Alandur is an interchange Station between corridor 1 & 2. A stabling area is provided at Trisulam opposite to Airport. Available ROW of Mount Road varies from 25m to 40m, which is sufficient to accommodate metro corridor. Detailed route alignment has been shown in the drawings **DMRC/ CHENNAI /2105-21/COR-1/ALIGN.PLAN.Sheet 1 to 31**, submitted separately with this report. [Exact locations will only be finalized after Final Location Survey.]

Breakup of Alignment length

Total Elevated length	=	8.785km
Total Underground length	=	14.300km
Total Alignment length	**=**	**23.085km**

Corridor 2

Corridor – 2 starts from Chennai Central and ends at St. Thomas Mount. Dead end to Dead end Corridor length is **21.961**km. Corridor is partly under ground and partly elevated. First station is Chennai Central, and last station is St Thomas Mount. Corridor-2 runs underground along the Periyar EVR Salai Kilpauk Medical College and up to Pachaiappa's College. It takes a right turn and passes across Shenoy Nagar & Thiru V. K. Park. It further takes left and aligns itself along 2nd Avenue Road of Anna Nagar and it reaches Tirumangalam after crossing Anna Nagar Roundtana. It further takes left at Tirumangalam Junction and follows central verge position on Jawaharlal Nehru Road up to Kuvam River. It turns right and runs on the Southern bank of Kuvam River. It turns left and aligns along the median of Tiruvalluvar Street crossing NH4 Bangalore Highway in Koyambedu. It further take left turn and runs straight, passes over bus sheds of Moffusil Bus Terminal (CMBT) and aligns itself along the median of Jawaharlal Nehru Road at km 12.800. It follows road median path upto Ashok Nagar. It deviates from Central verge position beyond Ashok Nagar Station, turns right & then left (reverse curve) between km 16.400 to km 16.900, further it follows Jawaharlal Nehru Road median upto Adayar River, crosses this River on the Western side of

existing Road bridge and it again takes central verge of Jawaharlal Nehru Road. It runs straight after SIDCO Industrial Estate along Jawaharlal Nehru Road and goes over the Kathipara Road Fly Over to km 20.200 and places on the Southern Side of Kathipara Junction. It crosses to Mount Road at km 20.100 and aligns parallel to the Mount Road in Alandur Area where Alandur Station has been planned. It takes left turn beyond Alandur station and runs West of Railway Station Road up to St. Thomas Mount. Here it turns right and became parallel to the Southern Railway lines where St. Thomas Mount Station has been planned. Detailed route alignment has been shown in the drawings **DMRC/ CHENNAI /2105-21/COR-2/ALIGN.PLAN.Sheet 1 to 28**, submitted separately with this report. [Exact locations will only be finalized after Final Location Survey.]

Break-up of alignment length
Alignment length is 22.000 from dead end to dead end.

1. Inter Connection: Two corridors are proposed to be Inter connected at Alandur for transfer of rakes from corridor 1 to corridor 2 for taking to Koyambedu Depot.

STATION LOCATION AND PLANNING

The Stations on the two corridors with their characteristics are as follows:-

Table 0.5.1
STATION LOCATION CHARACTERISTICS

Name of Station	Chainage (in km)	Distance from Previous Station (in km)	Rail Level (RL in m)	Height/ Depth from Adjacent Ground	Platform Type and Nos	Alignment Description
Corridor 1 *Washermanpet - Chennai Central- Airport*						
1. Washermanpet (m)	520		-8.2	-12.009	Island Platform	Underground, straight
2. Mannadi	2050.240	1530.24	-10.5	-13.469	Island Platform	Underground, straight
3. Chennai Fort (m)	3380.72	1330.48	-10.0	-12.499	Island Platform	Underground, straight
4. Chennai Central (m)	4474.10	1093.38	-13.6	-17.203	Island Platform	Underground, straight
5. CMDA	5649.00	1174.90	-11.5	-14.190	Island Platform	Underground, straight
6. LIC Building	7307.27	1658.27	-9.5	-14.096	Island Platform.	Underground, straight
7. Thousand Lights	8387.66	1080.39	-8.2	-13.853	Island Platform	Underground, straight

Name of Station	Chainage (in km)	Distance from Previous Station (in km)	Rail Level (RL in m)	Height/ Depth from Adjacent Ground	Platform Type and Nos	Alignment Description
8. Gemini	9570.74	1183.08	-8.0	-14.569	Island Platform.	Underground, straight
9. Teynampet	10783.00	1212.26	-7.3	-14.069	Island Platform	Underground, straight
10. Chamiers Road	12133.24	1350.24	-7.0	-13.917	Island Platform	Underground, straight
11. Saidapet	13857.20	1723.96	-4.5	-12.482	Island Platform	Elevated, straight
12. Little Mount	15039.53	1182.33	20.5	12.382	2 Side Platforms.	Elevated, straight
13. Guindy (m)	16295.32	1255.79	24.0	13.468	2 Side Platforms	Elevated, straight
14. Alandur	17831.67	1536.35	23.9	9.343	Island Platform	Elevated, straight
15. Officer's Training Academy	18916.65	1084.98	28.6	13.382	2 Side Platforms	Elevated, straight
16. Indian Airlines Colony	20618.74	1702.09	26.7	11.838	2 Side Platforms	Elevated, straight
17. Meenambakkam (m)	21530.61	911.87	30.6	12.929	2 Side Platforms.	Elevated, partly in curve,
18. Chennai airport	22909.72	1379.11	22.4	8.918	2 Side Platform	Elevated, straight
Corridor 2- *Chennai Central- Anna Nagar- St Thomas Mount*						
1. Chennai Central (m)	478.64	00.00	-13.6	-17.203	2 Side Platforms.	
2. Egmore	1865.31	1386.67	-7.3	-14.069	Island Platform	UG – in curve
3. Nehru Park	3090.55	1225.24	-7.3	-14.069	Island Platform	UG – in curve
4. Kilpauk Medical College	3931.32	840.77	-7.3	-14.069	Island Platform	UG Partly in curve
5. Pachaiappa's College	4942.92	1011.6	-7.3	-14.069	Island Platform	UG – in curve
6. Shenoy Nagar	6103.07	1160.15	-7.3	-14.069	Island Platform	UG- straight
7. Anna Nagar- East	7184.62	1081.55	-7.3	-14.069	Island Platform	UG- straight
8. Anna Nagar Tower	8350.17	1165.55	-7.3	-14.069	Island Platform	UG- straight
9. Tirumangalam	9143.40	793.23	-7.3	-14.069	Island Platform	UG- straight
10. Koyambedu	10956.20	1812.80	23.200	13.274	2 Side Platforms	Elevated, straight

Name of Station	Chainage (in km)	Distance from Previous Station (in km)	Rail Level (RL in m)	Height/ Depth from Adjacent Ground	Platform Type and Nos	Alignment Description
11. Chennai Mofussil Bus Terminal (CMBT)	12367.39	1411.19	22.900	13.029	2 Side Platforms.	Elevated, straight
12. Arumbakkam	13700.88	1333.49	22.225	13.395	2 Side Platforms	Elevated, straight
13. Vadapalani	14882.29	1181.41	32.6	21.5	2 Side Platforms.	Elevated, straight
14. Ashok Nagar	16276.34	1394.05	22.405	13.365	2 Side Platforms.	Elevated, straight
15. K K Nagar	17226.30	949.96	22.101	13.297	2 Side Platforms	Elevated, straight
16. SIDCO Industrial Estate	18899.59	1673.29	22.461	13.224	2 Side Platforms.	Elevated, straight
17. Alandur (m)	20378.17	1478.58	29.400	14.843	Island Platform	Elevated, straight
18. St Thomas Mount	21549.89	1171.72	19.700	8.782	2 Side Platforms	Elevated, straight

Geotechnical Investigations

A total of 75 Boreholes were carried out along the corridors. A separate geotechnical report has been submitted as part of DPR.

The area under study constitute a part of the Peninsular India, this is basically composed of Archean Rocks as well as fossiliferous rocks intercalated in some places with marine beds of Neocomian age and earliest marine transgression beds of middle Cretaceous of Upper Albian age. These formations have been found intersected by Doleritic dykes and are covered generally with younger alluvium of varying thickness place to place from 3.00 m to 30.00 m or more at some places has found during investigation. The Archeans are generally composed of Granites and Gneisses of Peninsular Gneissic Complex, composition of duke is mainly Doleritic whereas sedimentary formations are mainly of shale and sand stone with or without fossiliferous beds. The general geological stratigraphic succession may be summarized as:

Recent	Younger Alluvium
Cretaceous	Shale and Sandstone intercalated with Fossilliferous marine beds
Precambrian	Dykes mainly doloritic
Archeans	Dharwar super group

Charnockite series

Unconfirmatory

Granite & Gneisses

Utility Diversions

Besides the details of various aspects e.g. transport demand analysis, route alignment, station locations, system design, viaduct structure, geo-technical investigations etc. as brought out in previous chapters, there are a number of other engineering issues, which are required to be considered in sufficient details before really deciding on taking up any infrastructure project of such magnitude. Accordingly, following engineering items have been studied and described in this chapter:

- Existing utilities and planning for their diversion during construction, if necessary.
- Land acquisition necessary for the project both on permanent basis as well as temporary, including its break up between Government and private ownership.

Details of utility provided in the report are based on information providedby utility agencies and need to be physically verified before taking up construction work.

Land Requirements

Abstract of land requirements for different components of the project is given below. Most of the land proposed for the project is Govt. land.

Table 0.5.2
Summary of Permanent Land Requirement

Ownership	Purpose and Area of Land requirement in Ha.				Total (Ha)
	Corridor 1		Corridor 2		
	Station	Running	Station	Running	
Vacant State Govt.land	1.14	0.53	3.47	0.10	5.24
Other Govt. land	4.34	1.68	3.88	0.38	10.28
Private	2.17	0.00	2.37	3.94	8.47
Maintenance Depot	4.10		20.98*		25.08
				Total	**49.07**

*Vacant state govt. land

In addition to above Govt. land is required to be acquired temporarily for construction depots.

0.6 MAINTENANCE DEPOTS

Two depots are proposed in phase-I. The Koyambedu Depot-cum-Workshop will be the main depot and located on corridor 2. the second depot is at Minambakkam on corridor 1 for stabling & inspection. Koyambedu Depot-cum-Workshop will be used for stabling of Trains and other services, their cleaning, scheduled inspections, wheel re-profiling and minor & major repairs as well as Overhaul.

0.7 Train Operation Plan

Any public transport system, particularly a Metro system, is made attractive by providing high frequency service both during peak and off-peak hours. For this purpose 4 Car trains with different headways of 2.5 minutes to 15 minutes has been examined. The frequency can be brought down to 2.5 minutes in future depending upon the demand. The detailed train operation plan is provided in the report.

Salient Features of the proposed trains 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 for these corridors has been assumed as 34 Kmph

The Capacity of each coach and trains is given below:

4 Car Train: 1038 Passengers (@ 6 persons per sqm of standee area)
6 Car Train: 1580 Passengers (@ 6 persons per sqm of standee area)

No. of coaches required

The no. of coaches required in the year 2014, 2016, 2026 are also given below. These includes operation and maintenance reserve.

Table 0.7.1

Coach Requirement

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
Washermanpet - Chennai Central - Airport	2014	4.5	23	4 car	92
	2016	3.5	30	4 car	120
	2026	3.5	30	6 car	180
Chennai Central - Anna Nagar- St. Thomas Mount	2014	4.5	23	4 car	92
	2016	3	34	4 car	136
	2026	3	34	6 car	204

Total 184 coaches (92 coaches for Corridor 1 & 92 coaches for Corridor 2) are required in the year 2011.

0.8 POWER SUPPLY ARRANGEMENTS

Power Supply System

Power supply is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, tunnel ventilation system, signalling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The major component of power supply is traction requirements for elevated sections and auxiliary requirements for Underground section.

The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following assumptions:-

(i) Specific energy consumption of rolling stock – 70KWh/1000 GTKM
(ii) Regeneration by rolling stock – 20%.
(iii) Elevated/at –grade station load – initially 200KW, which will increase to 300 KW inclusive of Property Development loads in the year 2026.
(iv) Underground Station load – initially 2000 kW, which will increase to 2500 kW in the year 2026.
(v) Depot auxiliary load – initially 2000KW, which will increase to 2500 KW in the year 2026.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2014, 2016 and 2026 are summarized in **table 0.8.1** below :-

Table 0.8.1
Power Demand Estimation (MVA)

Corridor		Year		
		2014	**2016**	**2026.**
Corridor – 1 Washerman Pet – Chennai Central – Airport. [**23.085**km & 18 Stns. (11 U/G)].	Traction	10.3	13.2	18.9
	Auxiliary	31.4	32.1	39.7
	Total	**41.7**	**45.3**	**58.7**
Corridor – 2 Chennai Central – Anna Nagar – St. Thomas Mount. [**21.961**kms & 18Stns(9U/G).].	Traction	10.4	15.0	21.7
	Auxiliary	7.2	8.6	10.1
	Total	**17.6**	**23.6**	**31.8**

Table 0.8.2
Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
Corridor – I Washerman Pet – Chennai Central – Airport.	GMR Vasavi (230 / 110kV)	Jail Complex (110 / 33 kV).	2km. 110kV (Double Circuit cables).
	Guindy Grid Sub Station (230 / 110 kV).	Adiyar **(110 / 33 kV)**	2km. 110kV **(Double Circuit cables).**
Corridor – II Chennai Central – Anna Nagar – St. Thomas Mount.	Koyambedu Grid Sub station (230/ 110 kV).	Koyambedu Depot (110 / 33 kV)	1 km. 110 kV (Double Circuit Cables).

Auxiliary Supply Arrangements for Stations & Depot

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. A separate ASS is required at each depot. The ASS will be located at mezzanine or platform level inside a room. Wherever TSS is required, ASS & TSS will be housed together inside a room. The auxiliary load requirements have been assessed at 300 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415kV) of 400kVA capacity are proposed to be installed at the stations (one transformer as standby). Both the Depot ASSs will also be provided with 2x2500 kVA auxiliary transformers. For Underground station, the auxiliary load requirements have been assessed at 2500 kW, accordingly, three dry type cast resin transformers (33/0.415kV) of 1600kVA capacity are proposed to be installed at the stations (with one transformer as standby).
Initially, 1x2.5MW transformer-rectifier set shall be provided in each TSS with space provisions for an additional set to be accommodated in future as and when train composition is increased to 6 coaches beyond 3 minutes headway. Self-cooled, cast resin dry type rectifier-transformer is proposed, which is suitable for indoor application. From the traction sub-stations, 750V dc cables will be laid up to third rail and return current cables will be connected to running rails.

Supervisory Control and Data Acquisition (SCADA) System

The entire system of power supply (receiving, traction & auxiliary supply) shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fibre provided for telecommunications will be used as communication carrier for SCADA system.

Energy Saving Measures

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O & M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. Following energy saving measures are recommended :

(i) Lightweight and Modern rolling stock with 3-phase VVVF drive
(ii) Regenerative braking
(iii) Effective use of natural light at stations and sectioning of load
(iv) Machine-room less type lifts
(v) Energy efficient, auto sensor escalators with 3-phase VVVF drive
(vi) Energy efficient electrical equipment (e.g. transformers, motors, light fittings etc)
(vii) SCADA system for energy and power factor control.

Electric Power Tariff

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 25-35% of total annual working cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 111.8 million units for Corridor – I and 52.0 Million units for Corridor – II in initial years (2014), which will be about 158.2 Million Units and 92.3 Million Units respectively in the year 2026. In addition to ensuring optimum energy consumption, it is also necessary that the electric power tariff be kept at a minimum in order to contain the O& M costs. Therefore, the power tariff for Chennai Metro should be at effective rate of purchase price (at 110kV voltage level) plus nominal administrative charges i.e. on a no profit no loss basis. This is expected to be in the range of Rs. 2.75 – 3.00 per unit. It is proposed that Government of Tamil Nadu takes necessary steps to fix power tariff for Chennai Metro at “No Profit No Loss” basis. Similar approach has been adopted for Delhi Metro. However, this is subject to the jurisdiction of State Electricity Regulatory Commission.

0.9 VENTILATION AND AIR-CONDITIONING SYSTEM

The proposed alignment has an underground section of about 14 km. This would include 11 underground stations the Ventilation and Air-conditioning (VAC) system requirements for the underground sections of the proposed Chennai Metro alignment. It includes the following:

- Station Air-conditioning System
- Ventilation System for station plant rooms (ancillary spaces)
- Station Smoke Management System

- Tunnel Ventilation System

VAC system design parameters are assumed in the present report.

(1) Outside ambient conditions:
This is based upon ASHRAE recommended design conditions for 2% and 1% criteria, as under

	2% Criteria	**1% Criteria**
Summer :	36.0 DB, 25.2 WB	37.0 DB, 25.2 WB
Monsoon :	31.4 DB, 27.5 WB	32.0 DB, 27.9 WB

- For Chennai Metro Underground Corridor it is suggested to use 2% criteria, which is defined as the conditions, when the DB or WB temperatures are likely to exceed for only 2% of the total time.

(2) Inside design conditions:

Platform areas	-	27 deg. C at 55 % RH
Concourse	-	28 deg. C at 60% RH

(3) Tunnel design conditions

Normal conditions	–	Max. DB 40 deg. C
Congested conditions	--	Max. DB 45 deg. C

(4) Minimum fresh air - 10 % or 18 cmh / person (in station public areas).

0.10 ENVIRONMENTAL IMPACT ASSESSMENT

Provision for environmental impacts of this Metro corridor has been made to cover various protection works, additional compensatory measures, compensation for loss of trees, compensatory a forestation and fencing, monitoring of water quality, air/noise pollution during construction, establishment of Environmental Division. The cost for Environment Management plan has been included in the project cost.

0.11 COST ESTIMATES

Capital costs workout at March 2007 price level as described hereunder

Corridor 1	Rs. 5,997 Crores
Corridor 2	Rs. 5,106 Crores

(Note: Under the 'Fully Underground' considered at one stage as per State Govt.'s request, the cost of Corridor I was Rs. 7408 crores and Corridor II was Rs. 7978 crores which was considered unviable.)

Costs are excluding taxes and duties, but including general charges @ 5% on all items except land and 3% contingencies on all items.

0.12 FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

Investment Cost

The Financial Internal Rate of Return (FIRR), the completion cost without taxes and with central taxes have been calculated by taking escalation factor @5% PA. It has been assumed that Government of Tamilnadu will exempt or reimburse local taxes. The total completion costs duly escalated and shown below

Table 0.12.2
Year–wise Investment

Figs in Rs. Cr.

Financial Year	Without Taxes & Duties	With Central Taxes only
2008-09	**533.00**	**570.00**
2009-10	**2971.00**	**3279.00**
20109-11	**3080.00**	**3484.00**
2011-12	**2705.00**	**3096.00**
2012-13	**1544.00**	**1767.00**
2013-14	**1621.00**	**1853.00**
2014-15	**613.00**	**701.00**
Total	**13067.00**	**14750.00**

The staff is assumed to be provided @ 45 persons per kilometre. The escalation factor used for staff costs is 6% per annum to provide for both escalation and growth in salaries.

The cost of other expenses is based on the O & M unit cost expected for the Delhi Metro Phase-1 project. The rate of electricity assumed in the Delhi Metro study is about Rs. 2.30 per unit whereas at present in Chennai the applicable rate is Rs. 3.00 per unit. The latter has been used for all calculations. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 5% per annum.

Revenues

The Revenue for Chennai metro mainly consists of fare box collection and other incomes from property development, advertisement, parking etc.

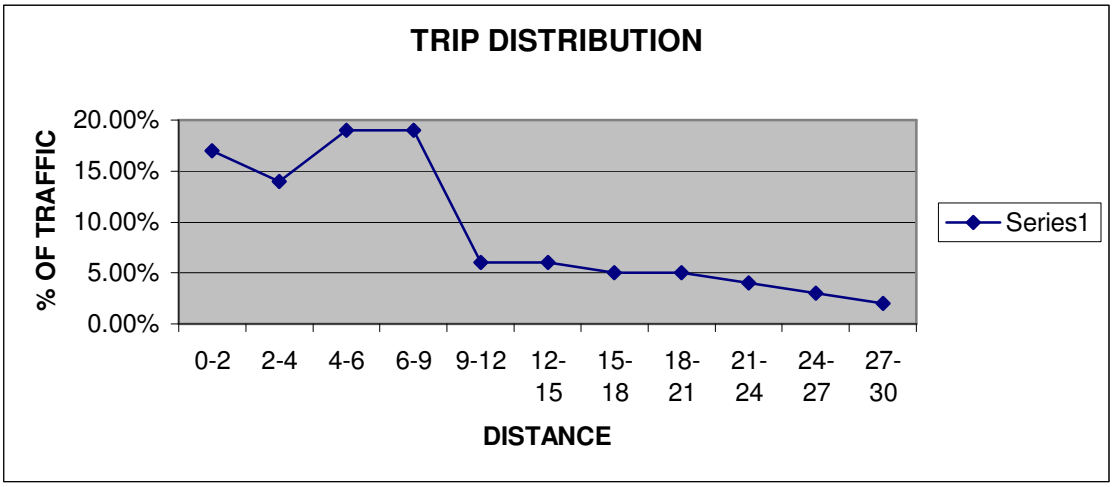
Traffic

The growth rate for traffic is assumed at 5.2% per annum.

Year	Corridor-1 & 2 Trips per day (lakhs)
2013-14	6.66
2016-17	7.75
2026-27	12.87

The trip distribution has been worked out by considering average lead of 8.33 KM and with an assumption that maximum lead is 30 KM, The graphic presentation of the same is placed below.

Figure 0.12.3
Trip
Distribution



FARE STRUCTURE

The prevailing ordinary bus fares of Metropolitan Transport Corporation (Chennai) Limited have been escalated by an overall factor of 20% as the state government has not increased the fare for quite considerable time. The metro fare obtained by multiplying the bus fare by 2 times has been rounded off to the nearest rupee.

Since fares obtained in the above described fashion are much lower than the estimated Delhi Metro fares in 2012-13 by applying 5% escalation for every two years and the project becomes unviable, the fare structure has been assumed based on existing Delhi Metro Fares, which have been fixed by fare fixation committee in 2005 duly escalated @5% for every two years, which is placed in **Table 0.12.3**

Table 0.12.3
Fare Structure in 2013-14

Distance in kms.	Metro Fare (Rs.)
0-2	8.00
2-4	10.00
4-6	11.00
6-9	14.00
9-12	15.00
12-15	17.00
15-18	18.00
18-21	19.00
21-24	20.00
24-27	22.00
>27	23.00

Since September 2007, the Metropolitan Transport Corporation, Chennai has been operating air-conditioned Volvo buses at a higher fare, ranging from minimum of Rs.10 to maximum of Rs. 63. This service, which is a competitive mode for Metro is receiving good patronage. Though the Metro will be faster and more convenient, these higher fares have not been considered in this analysis.

OTHER SOURCES OF REVENUES

10 sites have been identified for Property Development with a total extent of 1.48 lakh sq.mt. which, assuming applicable FSI, will yield a potential plinth area of 4.06 lakh sq.mt. The property development will be undertaken on joint venture basis in most cases though in some cases it will be by outright purchase of the land. Estimated income to CMRL from property development is Rs.248 crores. Details are given in Chapter 5 – para 5.7.3.

Apart from development of property on metro stations and depot it is possible to raise resources through leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding rights to corporate, film shootings and special events on metro premises

Financial Internal Rate of Return (FIRR)

The Financial Internal Rate of Return (FIRR) obtained with the above revenues and costs for 33 years is tabulated as under: -

FIRR

Particulars	Completion Cost Without Taxes	Completion Cost With Central Taxes only
FIRR (%)	**1.40%**	**0.86%**

Note: Under the 'Fully Underground' considered at one stage as per State Govt.'s request, the FIRR was -2.02% without taxes and -2.65% with taxes.

Financing Options

The various possible models of financing metros including BOT model are discussed in the DPR. The recommended funding pattern under SPV model is tabulated as under: -

Table 0.12.4
Funding Pattern under DMRC Model

Particulars	With Central Taxes only	
	% Of contribution	Amount (Rs/Crore)
Equity by GOI	15%	2203.00
Equity by GOTN	15%	2203.00
SD by GOI	10%	1469.00
SD by GOTN	1.5%	220.00
JICA Loan @ 1.30% PA/Market Borrowing @12% PA	58.5%	8590.00
Total	**100.00%**	**14685.00**
Total Contribution of GOTN excluding state taxes		**2423.00**

Since the Chennai Metro is primarily a social project, it is recommended that it should be implemented and operated under a SPV owned by GOI and GOTN. The transport problems of Chennai can be better addressed if an integrated transport system is put in place in the city. With the introduction of Chennai Metro, the city transport system can be designed in a way that other modes of transport

should become complementary to each other. This can be achieved in a better way if the Chennai metro remains under the state control. However, private sector expertise can be associated by engaging property development on the parcels of land owned by Chennai Metro. Since the FIRR of the metro without taxes is 3.20% and with central taxes is 2.69%, it is recommended that the government of Tamilnadu should exempt the state taxes even though the custom and excise duties are not exempted by the central government.

Resource Mobilization

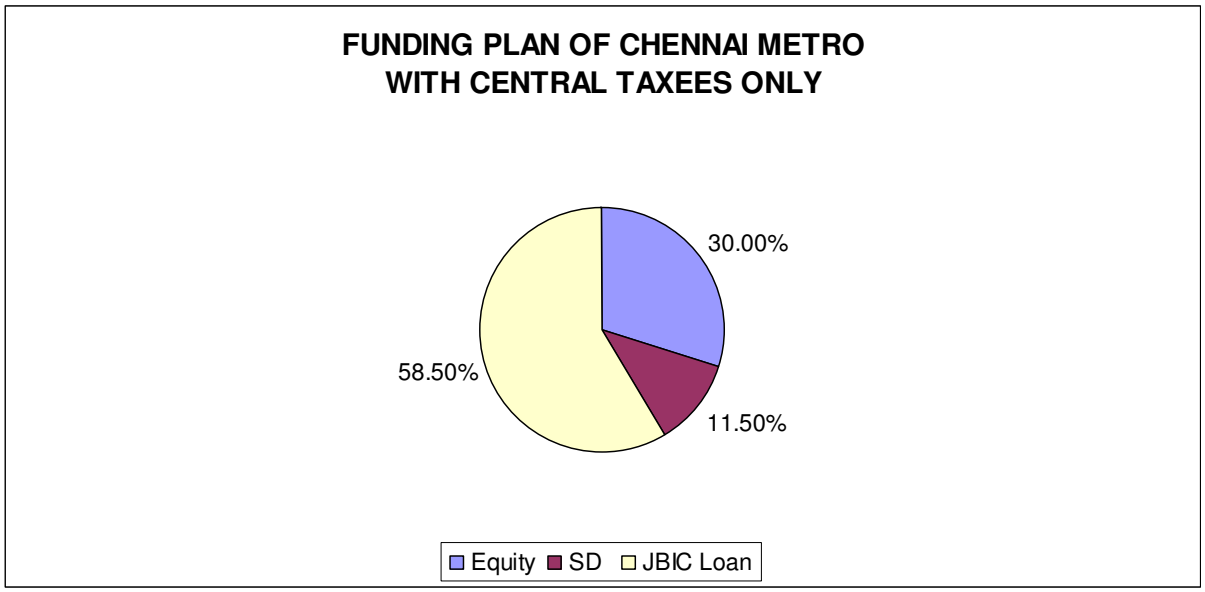
Keeping the above in view and also of the fact that the amount of debt is quite high, to the extent of any additional resources can be raised by dedicated taxes/cesses on both user and non-user beneficiaries of the MRTS project within Chennai City, it is suggested that the Government of Tamilnadu can levy such taxes/cesses e.g. taxes leviable under Article 269 or other provisions of the Constitution), dependence on JBIC loan/market borrowing can be reduced to that extent.

Funding Pattern

The funding pattern assumed under DMRC model is depicted in the pie chart as under.

0.13 Economic Analysis

The EIRR (without taxes) Works out for Scenario (i) is 16.11% and 9.97%



respectively for the Metro project. It is accordingly seen that Scenario (i) of the proposed project is economically viable.
Further, as a sensitivity test, the effect on IRR of 20% increase in capital cost has also been estimated. On the basis of the analysis, the EIRR works out as follows:

S No.	Description	EIRR (without taxes)
1.	Base Case (Scenario (i)	16.22%
2.	Sensitivity test Scenario (i) 20% increase in capital cost	14.21%

0.14 IMPLEMENTATION PLAN

The following action has been taken / will be required for implementing the Corridor-1 & Corridor-2 of Chennai Metro project :

- Approval to the Detailed Project Report to be taken from the Tamil Nadu Government (Cabinet approval): Government of Tamil Nadu vide its Cabinet decision of 7.11.07 approved the project.

- Formation of SPV: The Government of Tamil Nadu approved the formation of SPV in December 2007. The SPV was Registered in December 2007 and has been functioning as Chennai Metro Rail Limited (CMRL). CMRL has appointed Delhi Metro Rail Corporation as Interim Consultants.

- Budgetary Allocation: Budgetary Allocation for Chennai Metro by Government of Tamil Nadu was Rs.50 crore in 2007-08 and an outlay of Rs.300 crore has been approved for 2008-09.

- For any constructions within 50 m. of the proposed alignment a system of No Objection Certificate has been introduced.

- Signing of an MOU between Tamil Nadu Government and Government of India for all details of the Joint Venture bringing out the financial involvement of each party, liability for the loans raised, the administrative control in the SPV, policy in regard to fare structure, operational subsidy, if any, etc.

INSTITUTIONAL ARRANGEMENTS

To enable the Chennai Metro rail project to be implemented without any loss of time and cost-over run, effective institutional arrangements need to be set up. Details of these arrangements are explained below:
Experience of implementing Delhi Metro project has shown that Special Purpose Vehicle (SPV), vested with adequate powers, is an effective organizational arrangement to implement and subsequently operate a Metro Rail project. An SPV should, therefore, be set up for the Chennai Metro rail project and registered under the Companies Act, 1956. This SPV should be on the same lines as Delhi Metro Rail Corporation Ltd. and may be named as Chennai Metro Rail

Corporation (CMRC) or any other name as State Government may decide. Since it is recommended that equity in the SPV for this project should be contributed in equal proportions by the State and the Central Governments, the SPV will have equal number of Directors on its Board from these two Governments. With 50:50 share holding the SPV will neither be a Central PSU nor a State PSU. This will eliminate interference from Ministries and politicians. While the Managing Director of CMRC should be a nominee of the State Government, its Chairman should be the nominee of the Central Government. In order to avoid delays usually associated with bureaucratic process of decision making, the Board of Directors (BOD) of CMRC should be vested with full powers needed to implement the project. The BOD, in turn, should delegate adequate powers to the Managing Director of CMRC to enable him to take all decisions on day to day matters. The Managing Director should be a technocrat with proven track record and of impeccable integrity. A Railway background would be an added advantage. A Metro background would be most desirable.

Implementing a metro project in a congested metropolis is indeed a challenge. In sheer size, magnitude and technical complexity there are no parallels to metro projects. Further, these projects are to be carried out in difficult urban environment without dislocating city life, while at the same time preserving the environment. The project involves integration of a number of complex technical systems – some of these technologies used in these systems are totally new to the country – each one of which is a major project by itself. Interfacing various system contracts is a difficult and highly skilled exercise. Side by side, timely and adequate funds have to be assured for implementation and lands, without encumbrances, have to be taken possession of in time. Clearances from the local authorities have to be taken permission to cut trees, diversion of utilities, management of road traffic, etc., all of which will call for an efficient and competent project implementing agency.