

An overview of present & Future of

Bangalore Metro Rail Project



N. Sivasailam
Managing Director

Bangalore Metro Rail Alignment - Phase I



Nagasandra

North Extension

Reach - 3

Under Ground

B HALLI TERMINAL

Reach - 2

MYSORE ROAD TERMINAL

Reach - 1

Reach - 4

RVROAD

South Extension

East West Corridor	
Elevated Section	13.02 Km
Underground Section	4.88 Km
Elevated Stations	12
Underground Stations	4
North South Corridor	
Elevated Section	20.20 Km
Underground Section	4.00 Km
Elevated Stations	21
Underground Stations	3

METRO RAIL

- ELEVATED CORRIDOR
- UNDERGROUND CORRIDOR
- AT GRADE
- STATIONS

Bangalore Metro Rail Project



PHASE 1

EAST – WEST CORRIDOR 18.10 KMS

NORTH-SOUTH CORRIDOR 24.20 KMS

TOTAL 42.30 KMS

Elevated Stations 33

Underground Stations 7

Total 40

GAUGE Standard Gauge

TRACTION 750V dc Third Rail

SPEED Max 80Kmph ; Avg. 34Kmph

TRAVEL TIME 33 / 44 Mins.

Train Operation



Parameter	On Opening	2021
Designed phpdt	30075	40100
TRAIN HEADWAY	4 Min	3 Min E-W 4 Min N-S
TRAIN COMPOSITION	3 CARS	6 CARS

Parameter	On Opening	2021
Daily Ridership (lakhs)	12.22	19.72
Daily Passenger kms (lakh)	99.31	162.92
Avg.trip Length (km)	8.12	8.26

Construction Cost (42.30km)



Total Length: Elevated 33.48km & Underground 8.82km

SL No	Particulars	Completion Construction Cost in	
		Millions (Rupees)	Millions (US\$)
1	Land	14084.2	312.43
2	Civil Engineering Works	57379.8	1272.84
3	Electrical Works	11045.3	245.02
4	S & T Works	8152.3	180.84
5	Depots	4191.4	92.98
6	Rolling Stock	17490.7	387.99
7	Total	112343.7	2492.10
8	General charges including administration, contingency etc.	6745.5	149.63
	GRAND TOTAL	119089.2	2641.73
9	Interest During Construction	700	15.53
10	Less : Expected tax reimbursement	(3700)	(82.08)
	TOTAL PROJECT COST	116089.2	2575.18
	Exchange Rate Taken 1US\$ = 45.08		2.5 billion US\$

Funding Pattern in Crores

Sl. No.	Particulars	GoI	GoK	Total
1	Equity	1635	1635	3270
2	Subordinate Debt	1090	2215	3305
3	Sub total (1+2)	2725	3850	6575
4	Senior Term Debt (JICA & Others)	-	-	5034
5	Grand Total (3+4)	-	-	11609 (100%)

Senior Term Debt

- JICA	2849
- ADB	1250 (under finalization)
- SBI	800
- HUDCO	700

UNIQUE LAND PACKAGE
Rehabilitation Allowances
Residential / Commercial Properties



RESIDENTIAL

Shifting Allowance* Avg.	Rs. 15000/- one time payment
Inconvenience Allowance* Avg.	Rs. 30000/- one time payment
Transitional Allowance	Rs. 75000/- one time payment
Rental Income Lost	Rs. 10/- per sq. ft. lost
Right to salvage material	Full
TDR	As applicable

COMMERCIAL

Shifting Allowance* Avg.	Rs. 15000/- one time payment
Loss of Business* Avg.	Rs. 75000/- one time payment
Business Re-establishment* Avg.	Rs. 240/- per sq. ft. for area lost
Rental Income lost	Rs. 20/- per sq. ft. lost
Right to salvage material	Full
TDR	As applicable

AFFORESTATION

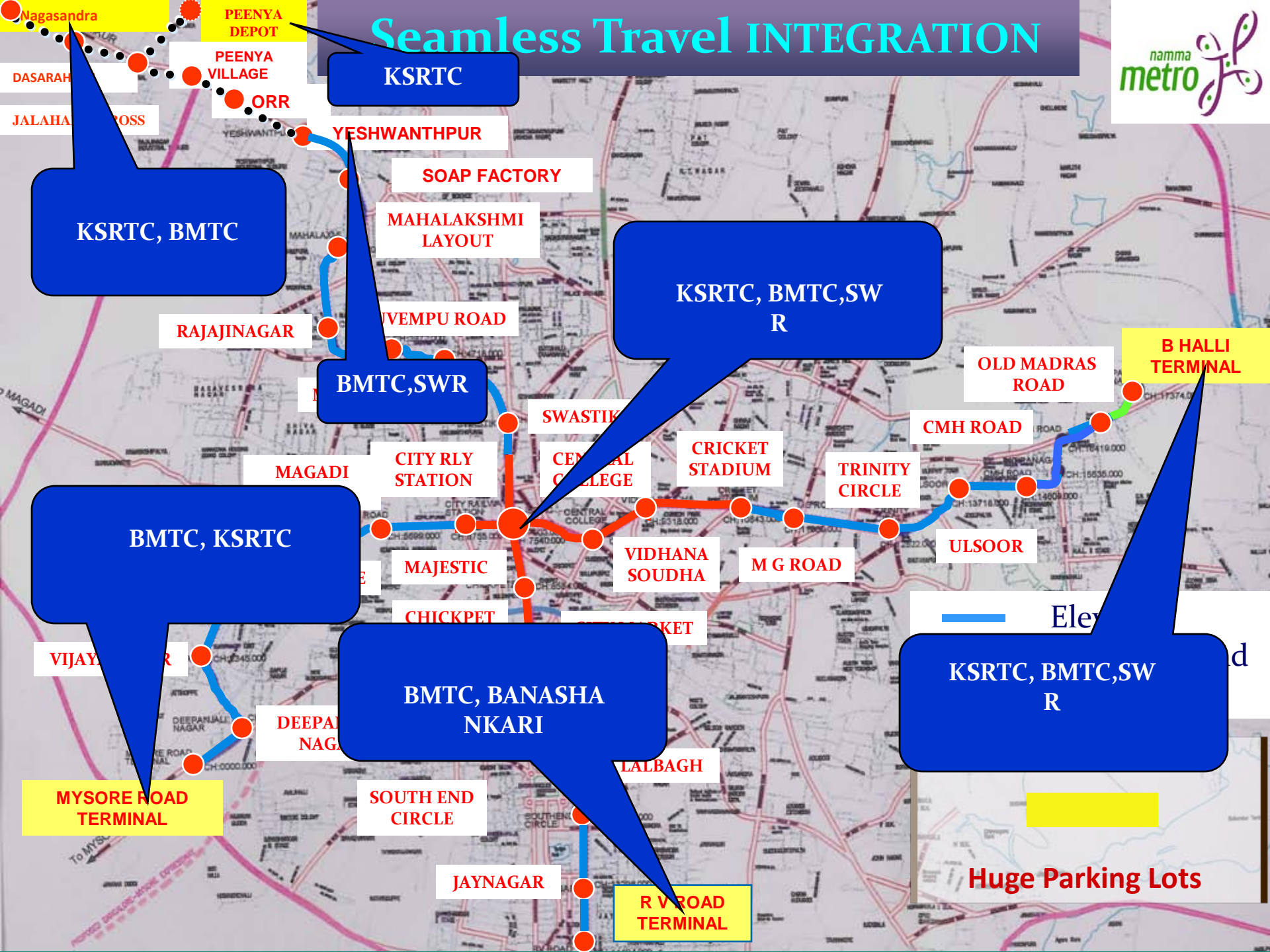


Slum Rehabilitation



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Seamless Travel INTEGRATION



KSRTC

KSRTC, BMTC

BMTC, KSRTC

BMTC, SWR

BMTC, BANASHANKARI

KSRTC, BMTC, SWR

KSRTC, BMTC, SWR

MYSORE ROAD TERMINAL

B HALLI TERMINAL

R V ROAD TERMINAL

Huge Parking Lots

Nagasandra
DASARAH
JALAHAL CROSS
PEENYA DEPOT
PEENYA VILLAGE
ORR
YESHWANTHUR

YESHWANTHUR

SOAP FACTORY

MAHALAKSHMI LAYOUT

RAJAJINAGAR

IVEMPUR ROAD

SWASTI

CITY RLY STATION

CENTRAL COLLEGE

CRICKET STADIUM

TRINITY CIRCLE

OLD MADRAS ROAD

CMH ROAD

MAGADI

MAJESTIC

VIDHANA SOUDHA

M G ROAD

ULSOOR

VIJAYANAGAR

DEEPANAGAR

CHICKPET

HALBAGH

SOUTH END CIRCLE

JAYNAGAR

Elevated

Underground

Aerial view of Cubbon Park UG Station

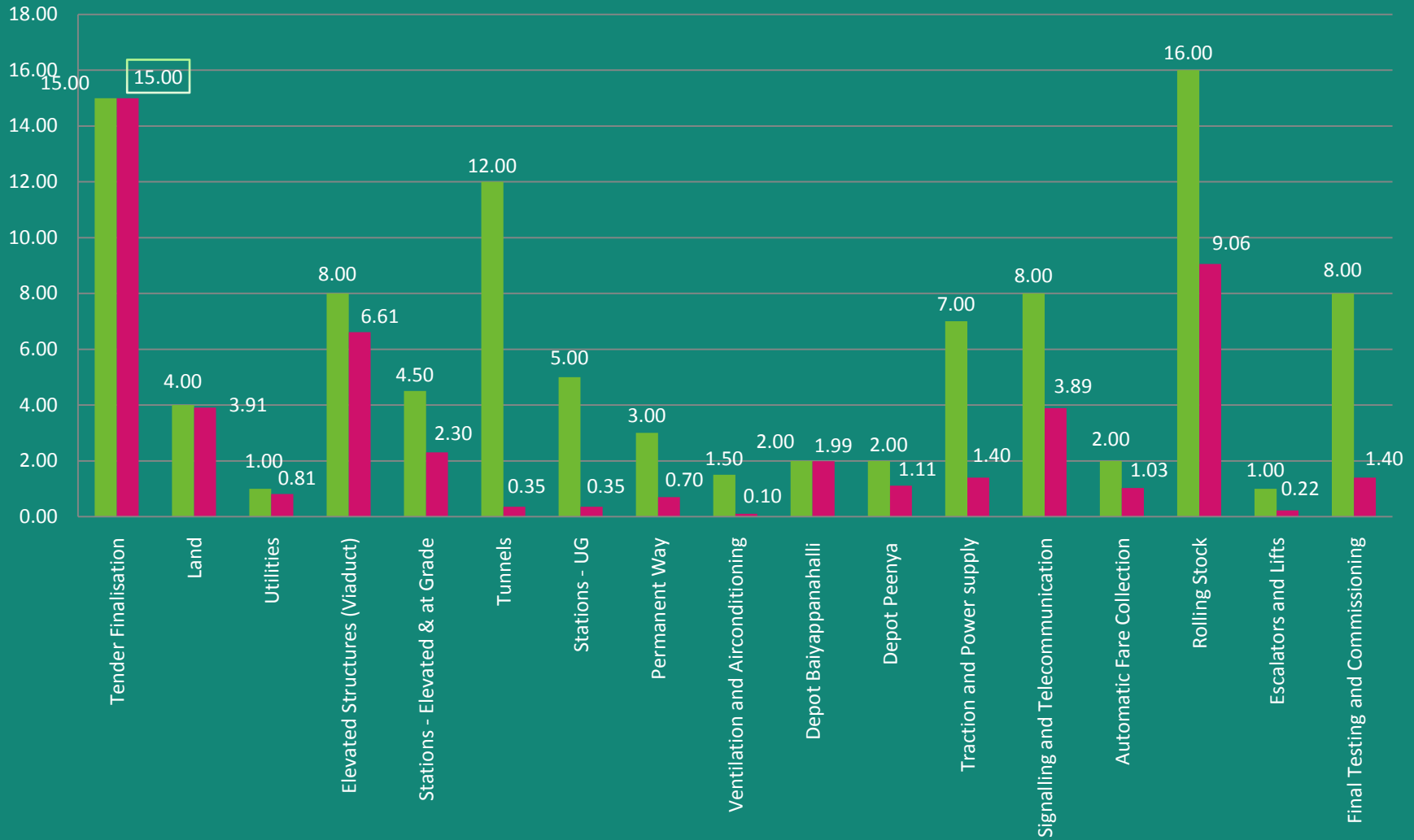


Bangalore Metro Rail Project

REACH 1 : The 7 km of Reach 1 is commissioned on 20th Oct 2011.



Progress Of Bangalore Metro Rail Project as on Jan'2012



Overall Progress – 54%

Bangalore Metro Rail Project



Physical Progress up to Jan 2012

Percentage in terms of work executed	54.52%
Percentage in terms of tenders awarded	99%

Financial Progress up to Jan 2012

In Crore	6125
In Percentage	52.76%

Bangalore Metro Rail Project



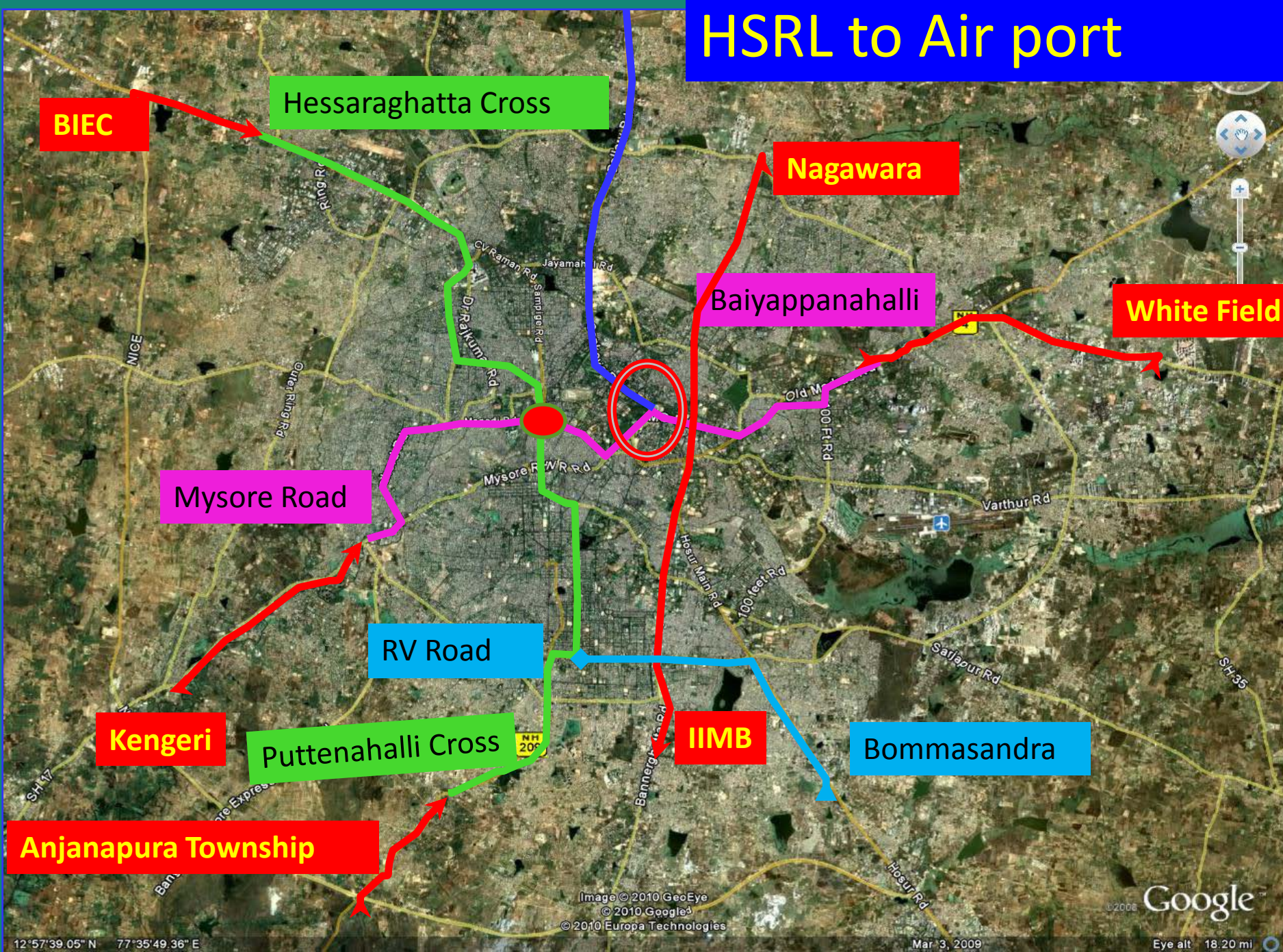
Commissioning Schedule

Peenya Depot - Yeshwanthpur - Sampige Road	December 2012
Peenya Depot - Hessarghatta cross	March 2013
U/G Section E-W corridor	December 2013
City Station - Mysore Road	December 2013
K.R.Market - R.V Road - Puttenahalli cross	December 2013

BANGALORE METRO PHASE-II

Sl. No.	Corridor	Length in kms	Cost in Rs Crs
1.	Hessarghatta Cross to Bangalore International Exhibition Centre (BIEC) on Tumkur Road	3.77	1168.22
2.	Puttenahalli to Anjanapura Township (Nice Road)	6.29	1765.88
3	Mysore Road Terminal to Kengeri on Mysore Road	7.09	1867.95
4.	Extension of East West Line from Baiyappanahalli to ITPL	15.50	4845.00
5.	North-South line from Gottigere IIMB / Nagavara	21.25	11014.00
6.	R V Road Terminal to Bommasandra	18.82	5744.09
	Total	72.72	26405.14

HSRL to Air port



Map

DEVANHALLI AIRPORT – 33.25 KM

YELAHANKA – 15.073 KM

HEBBAL – 8.822 KM

MG ROAD CAT – 0.095 KM

Bangalore Metro Rail Project



Thank You

Comparative Evaluation between Elevated and Underground Metro

Case Study – Mumbai Metro

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Overview of the Presentation

- ❑ **Introduction**
- ❑ **Transport Problems of Mumbai**
- ❑ **Mumbai Metro**
- ❑ **Salient Features of Proposed Metro Corridor**
- ❑ **Study Need**
- ❑ **Issues for Consideration**
- ❑ **Study area**
- ❑ **SP Model Building & Analysis**
- ❑ **Social Cost - Benefit Analysis**
- ❑ **Economic Cost Analysis**
- ❑ **Summary & Conclusion**



Infrastructure as key to Economic Development

Of Late (**about 10 years back**)

Govt realized that the development of **Infrastructure---** will

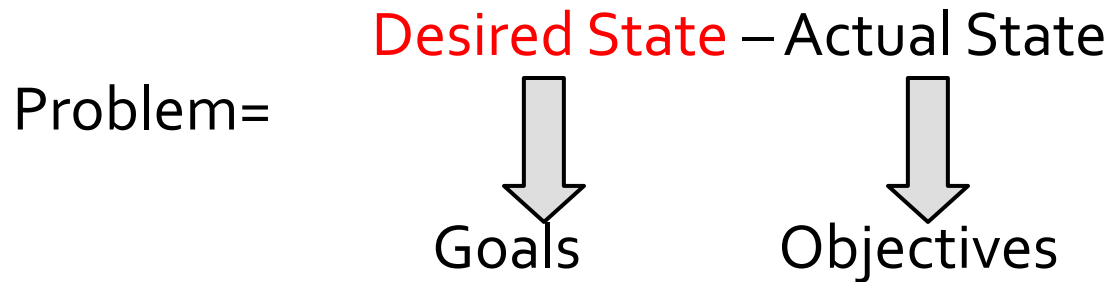
lead to

Economic Development--- but there were many

Uncertainty Issues



Transportation Problem



Desired State → Much more **Dynamic**

Problems or issues can be reduced but can NEVER be eliminated



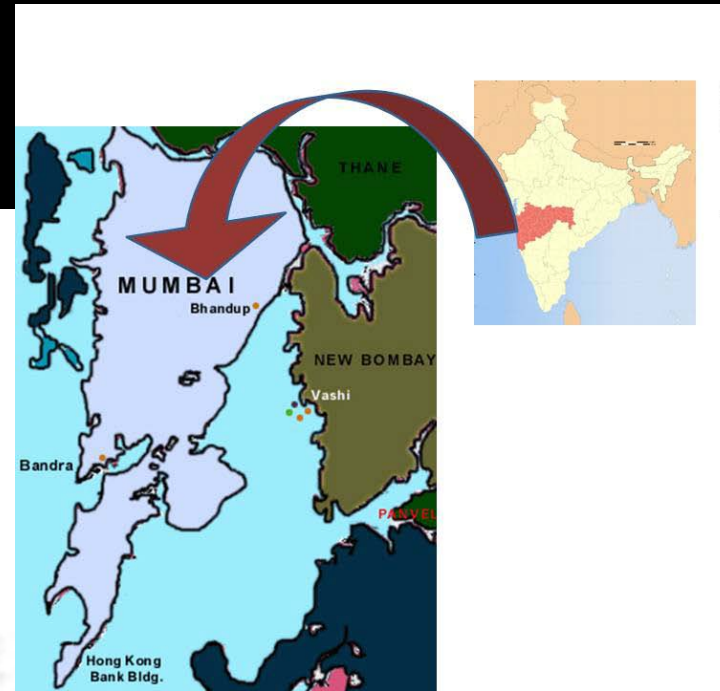
Introduction

Mumbai is divided into three regions

- **Island City**
- **Western Suburbs**
- **Eastern Suburbs**

Area - 438 sq.km

Population - 12.81 million

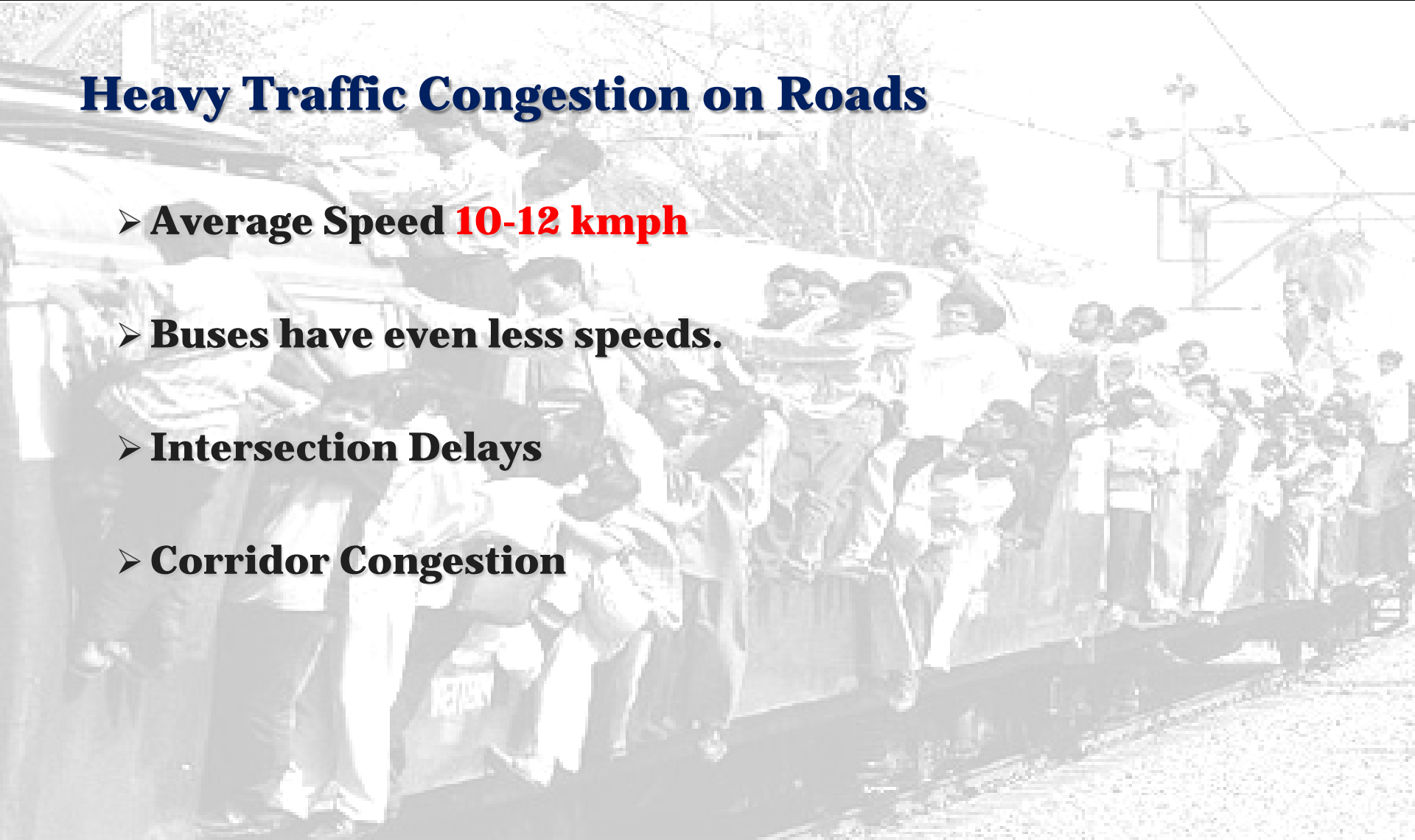




Transport Problems of Mumbai

Heavy Traffic Congestion on Roads

- Average Speed **10-12 kmph**
- Buses have even less speeds.
- Intersection Delays
- Corridor Congestion





Transport Problems of Mumbai

Excessive Travel Time

➤ Components of a Trip

- Residential Collection - Bus, IPT
- Line Haul - Train
- Downtown Distribution - Bus, IPT

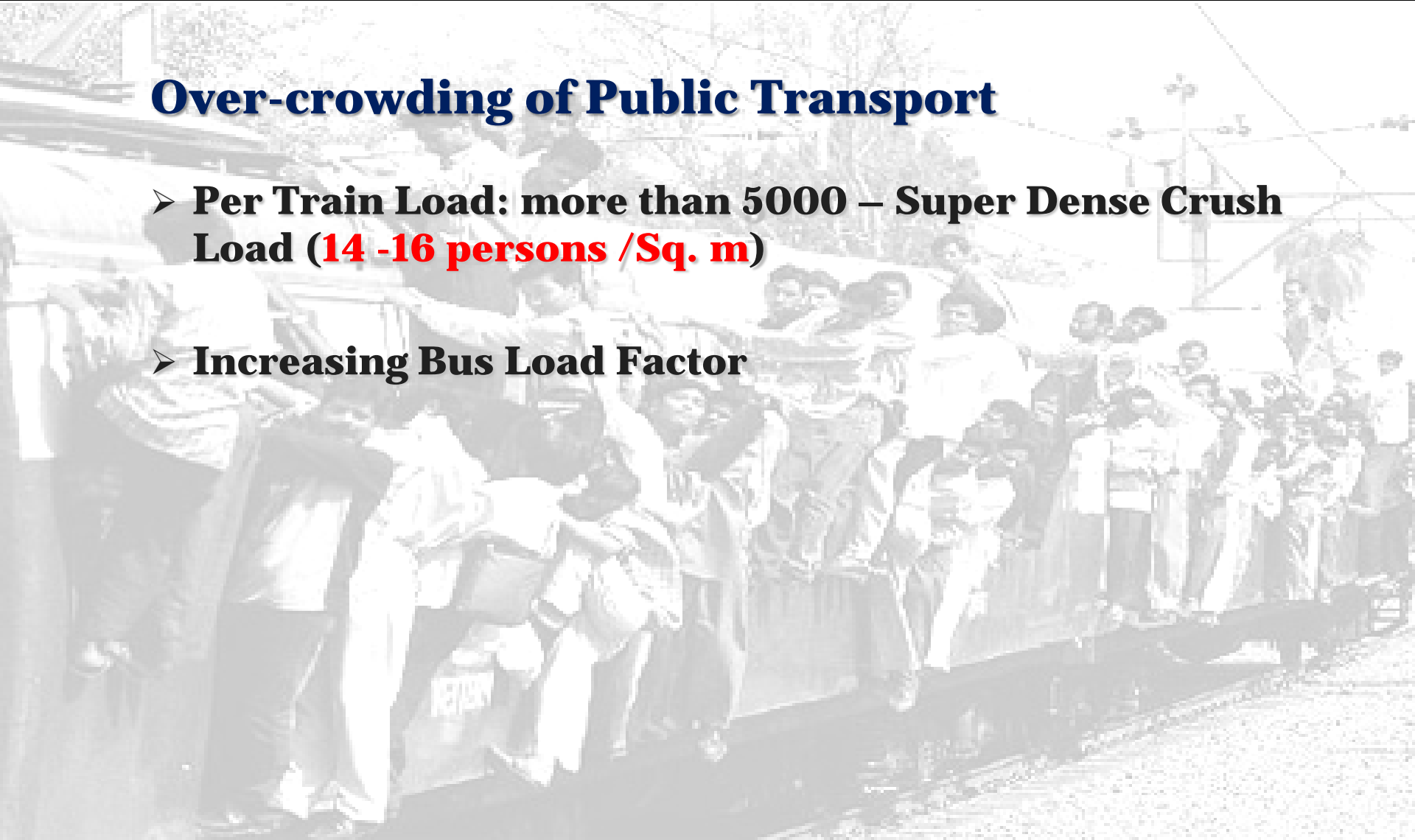
➤ Average Commuting Time is about **1 hour 15 min**



Transport Problems of Mumbai

Over-crowding of Public Transport

- **Per Train Load: more than 5000 – Super Dense Crush Load (14 -16 persons /Sq. m)**
- **Increasing Bus Load Factor**



- There are innumerable possibilities in the road sector but the major hurdle is the ownership of the facility.
- The earlier provision allowed the tolls to be collected by the Govt. Only, and then to transfer to the private party
- Lack of maintenance funds
- Extremely bureaucratic setup of the administrative structures, not responsive to user needs.
- Lack of clearly defined responsibilities of the central and local governments for managing the network.
- Shortage of qualified technical staff, low salaries and few incentives to perform better.
- Poor management information system.



Virar Local in Japan

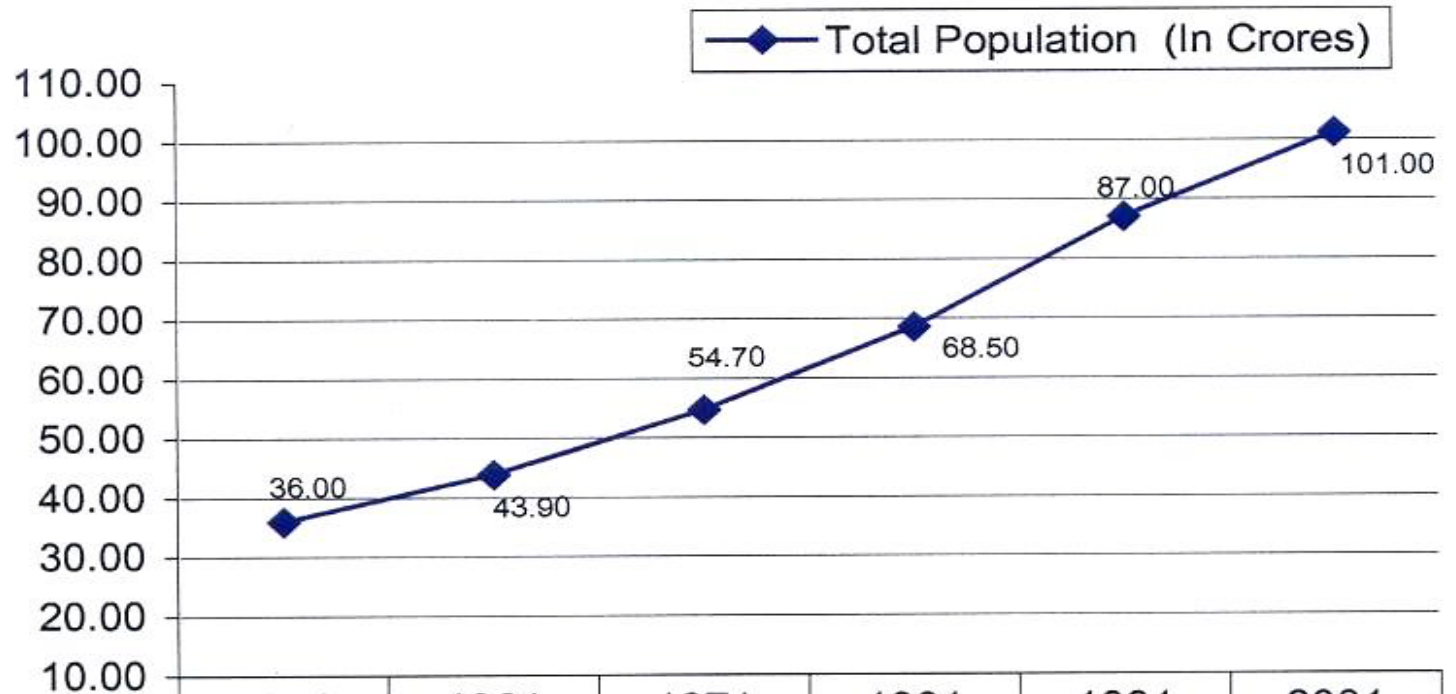


Urbanization trends in INDIA

Census Year	Number of UAs/Towns	Urban Population (in million)	Level of Urbanization %
1901	1827	25.85	10.84
1911	1815	25.20	10.29
1921	1949	28.08	11.18
1931	2072	33.45	11.99
1941	2250	44.15	13.86
1951	2843	62.44	17.29
1961	2365	78.93	17.57
1971	2590	109.11	19.91
1981	3378	159.46	23.34
1991	3368	217.71	25.72

Source: Census of India Report

POPULATION



◆ Total Population (In Crores)

1951

1961

1971

1981

1991

2001

36.00

43.90

54.70

68.50

87.00

101.00

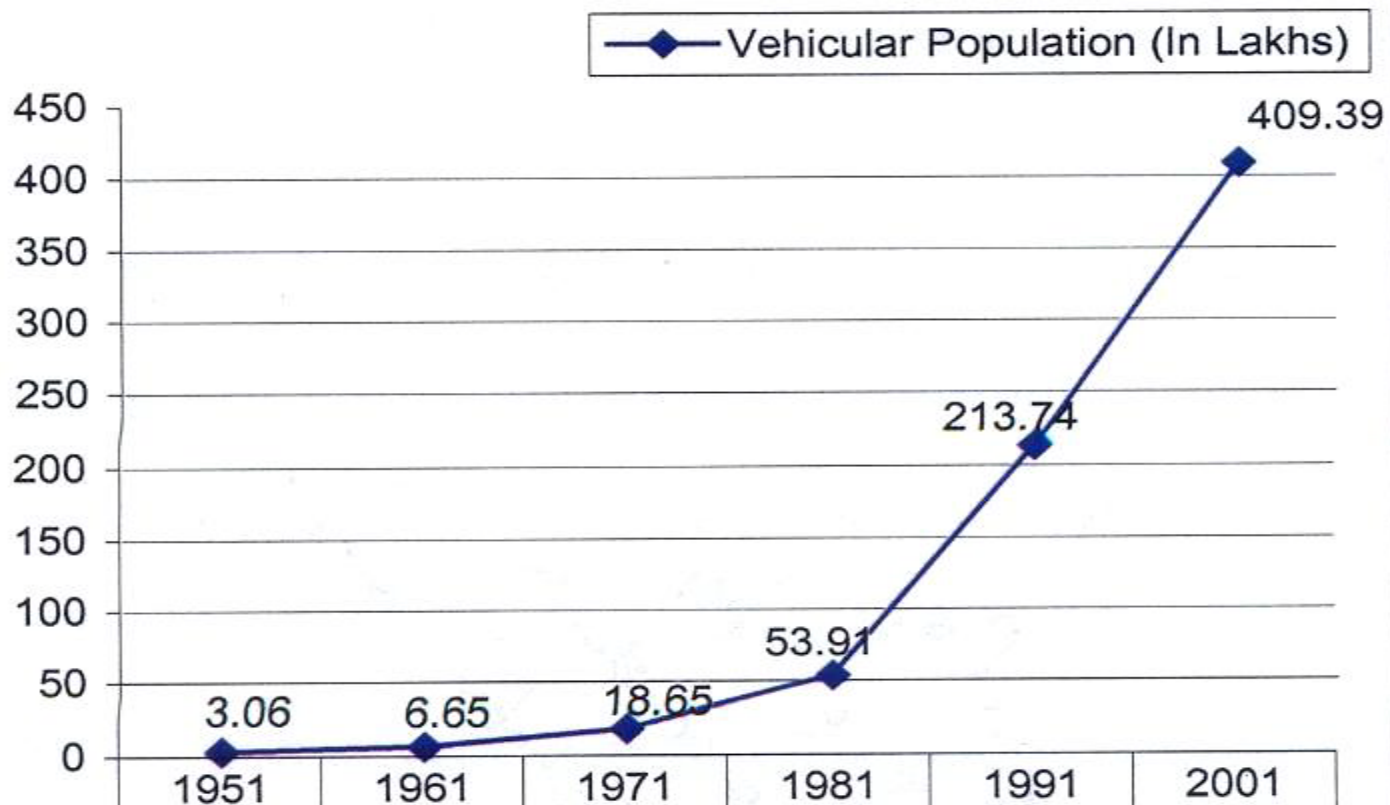
Total Registered Motor Vehicles In Metropolitan Cities of India (1992-98)

Metro Cities	1992	1993	1994	1995	1996	1997	1998
Ahmedabad	419	449	478	510	572	631	686
Bangalore	605	654	716	796	900	972	1130
Bhopal	144	154	165	179	223	242	237
Calcutta	497	517	545	561	588	588	664
Chennai	604	641	689	768	812	890	975
Cochin	32	36	42	52	197	226	NA
Coimbatore	74	93	115	172	241	256	310
Delhi	1963	2097	2239	2432	2630	2848	3033
Hyderabad	485	520	543	557	764	769	887
Indore	238	253	267	289	325	361	399
Jaipur	292	314	339	368	405	449	492
Kanpur	186	196	209	223	247	247	282
Lucknow	235	249	266	282	303	331	360
Ludhiana	220	238	258	291	321	359	NA
Madurai	42	50	57	81	117	122	156
Mumbai	647	546	608	667	724	797	860
Nagpur	168	176	185	198	213	239	270
Patna	191	197	201	209	220	220	245
Pune	296	313	331	358	412	468	527
Surat	223	243	271	301	331	362	399
Vadodara	179	193	212	235	275	332	361
Varanasi	126	135	146	157	169	184	199
Visakhapatnam	163	163	165	183	201	207	219

Data relates to district

N.A: Not Available

VEHICULAR POPULATION



◆ Vehicular Population (In Lakhs)

3.06

6.65

18.65

53.91

213.74

409.39

Air Pollution in Mumbai

Sector wise distribution of Pollution:

Transport	64%
Power	04%
Domestic	15%
Industrial	17%

Ambient Air Quality at Mahim Junction

Item	Observed ($\mu\text{gm}/\text{Nm}^3$)	Limits ($\mu\text{gm}/\text{Nm}^3$)
SO₂	43 – 120	80
No_x	90 – 107	80
SPM	1144 – 3170	200



Reasons for Transport Problems in Mumbai

- **Enormous Growth in Population and Activities (Employment)**
- **Enormous Growth in Vehicles**
- **Skewed Land use Distribution**
- **Highly Inadequate Public Transport**
- **Lack of Pedestrian Facilities**





Mumbai Metro

Phase I (2006 – 2011)

- Versova - Andheri – Ghatkopar - 19.07 Km
- Colaba – Bandra - 20.21 Km
- Charkop- Bandra - Mankhurd - 31.87 Km

Phase II (2011 – 2016)

- Charkop - Dahisar - 7.5 Km
- Ghatkopar – Mulund - 12.4 Km

Phase III (2016 – 2021)

- BKC - Kanjur Marg via Airport - 19.5 Km
- Andheri(E) - Dahisar(E) - 15 Km
- Hutatma Chowk – Ghatkopar - 19.45 Km
- Sewri – Prabhadevi - 3.5 Km

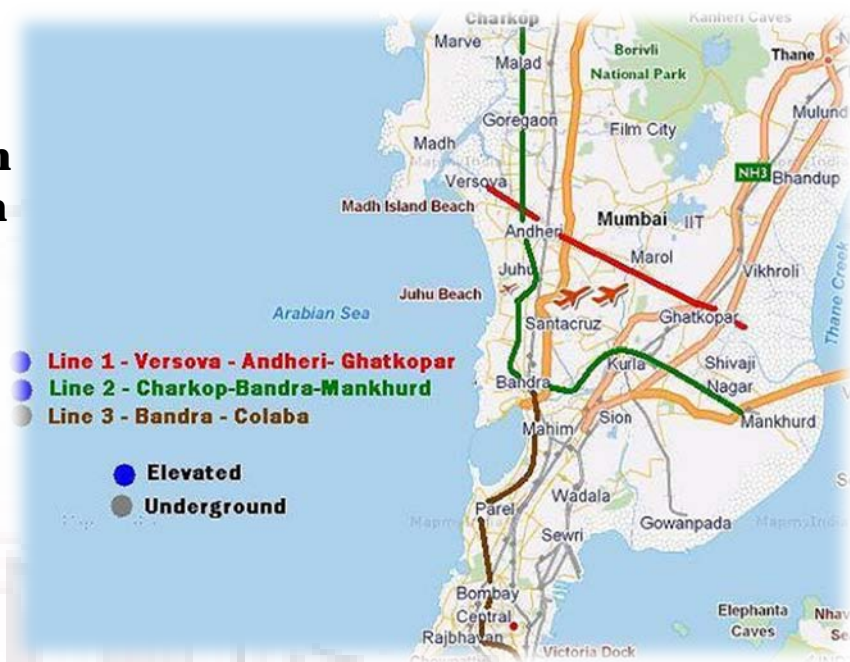


Fig – Metro Line 1,2 & 3

Total Length = 146.5 km
Total Cost in Rs = 19,525 Cr
1 Crore = \$0.2 million



Metro Salient Features



1. **Average Journey Speed 33Kmph**
2. **Cost of Travel will be comparable to BEST Fare**
3. **Trains will be provided at a convenient headway of 3 min.**
4. **Comfortable Standing in A/c environment is assured**
5. **State-of-art computerized ticketing system**

State-of-art safety systems

1. **Automatic door closing with safety precaution**
2. **Power Back-up Facility**
3. **Fire-resistant Coaches**
4. **Emergency Wireless passenger and driver communication system**





Mumbai Metro – Line-2 (C-B-M)

Charkop-Bandra-Mankhurd

Gauge (Nominal)	1435mm
Route Length (between dead ends) Elevated	31.87 Km
Number of stations Elevated	27 Nos.

Traffic forecast

	2011	2021	2031
Daily Boarding (lakhs)	12.75	18.77	22.16
PKM (Lakhs)	95.3	139.8	164.7
Average trip length	7.5	7.4	7.4



Fig - Charkop-Bandra-Mankhurd Route

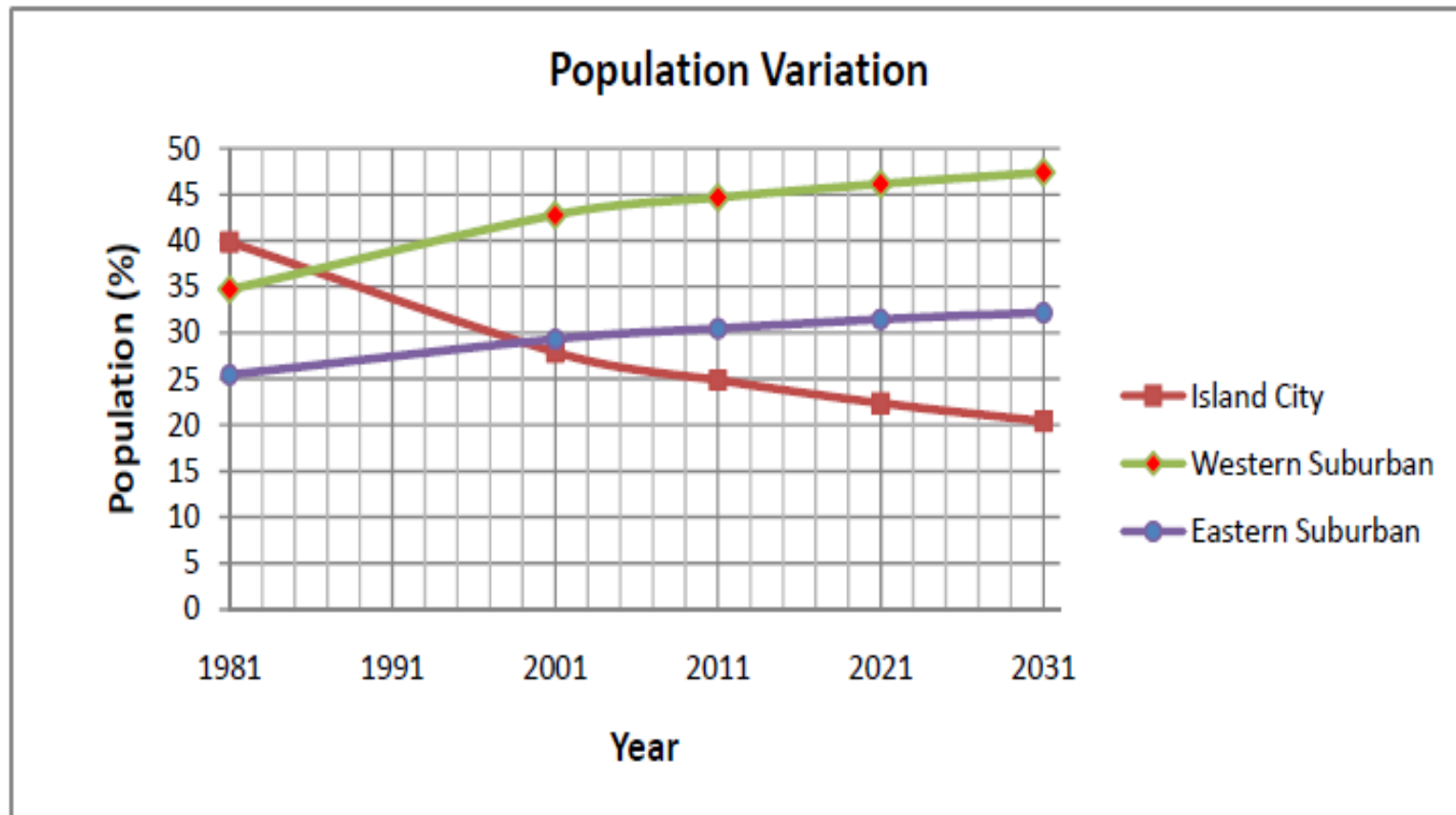
Designed speed 80 kmph

Total estimated cost Rs. 6192 Crores (2007)

(US \$ 1274 million)



Population growth in greater Mumbai





Need of Study

- **Sustainability**
- **Social Need**
- **Obligation from general people to EL metro**
- **To find Long term benefits**



Issues for Consideration

- **Construction Cost**
- **Infrastructure Cost**
- **Land Acquisition Cost**
- **Rehabilitation and Resettlement cost**
- **Litigation Cost**
- **Cost of Delays due to legal or other obstacles**
- **Environmental Cost**
- **Social Cost**
- **Economic Cost**
- **Impact of increase in FSI from**



Study Area

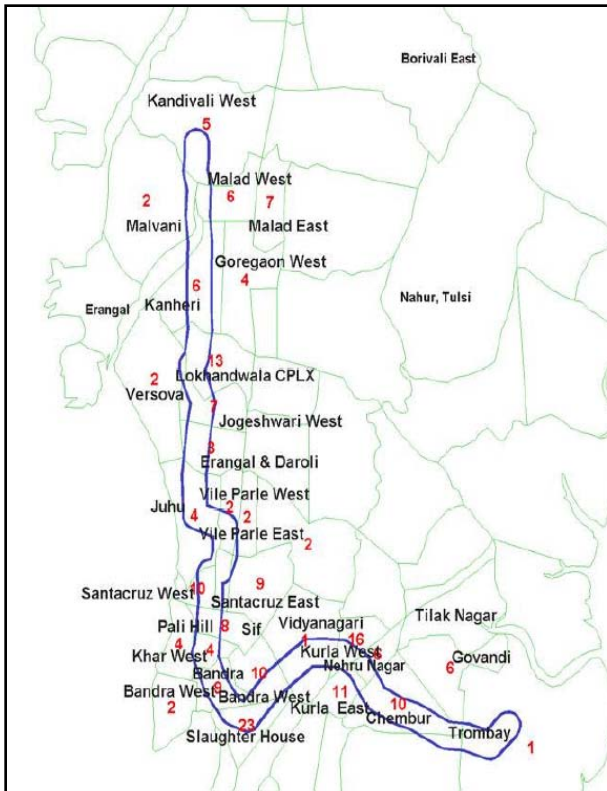
Municipal Corporation of Greater Mumbai (MCGM)

- Metro II (Charkop-Bandra-Mankhurd)
- Area: 438 sq. km
- Population: 12.81 millions (2005)





Stated Preference (SP) Survey



- **500 samples within the influence region of 250 meters**
- **1070 responses**
- **90% of people want underground metro**
- **Willing to pay two times more than the elevated metro fare**

Fig. - Proposed Sample distribution over the influence area of metro corridor



Development of SP Model

➤ Utility Functions

- **Utility function for underground Metro**

$$u_1 = p_{01} * d_{03} + p_{02} * d_{04} + p_{03} * d_{05} + p_{04} * d_{06} + p_{05} * d_{07} + p_{06} * d_{08} + p_{07} * d_{09}$$

- **Utility function for Elevated Metro**

$$u_2 = p_{01} * d_{10} + p_{02} * d_{11} + p_{03} * d_{12} + p_{04} * d_{13} + p_{05} * d_{14} + p_{06} * d_{15} + p_{07} * d_{16}$$

Where,

01 RQ , 02 SA, 03 TTS, 04 AP ,05 NP, 06 CD ,07 PP

PU	Probability for choosing underground metro	PE	Probability for Choosing Elevated Metro
RQU	Riding quality for Underground Metro	Safety U	Safety for Underground Metro
TTSU	TT savings for Underground Metro	APU	Air Pollution for Underground Metro
NPU	Noise Pollution for Underground Metro	CdU	Congestion and delay for Underground Metro
PPU	Parking Problem for Underground Metro	RWE	Riding quality for Elevated Metro
SafetyE	Safety for Elevated Metro	TTSE	TT Savings for Elevated Metro
APE	Air Pollution for Elevated Metro	NPE	Noise Pollution for Elevated Metro
CdE	Congestion and delay for Elevated Metro	PPE	Parking Problem for Elevated Metro



Statistics and coefficient estimates of SP Model

Variable	Coefficient	Standard error	t-stat
Riding quality	-0.48	0.44	-1.1
Safety	-1.69	0.62	-2.7
Travel time savings	1	0.59	1.7
Air pollution	0.6	0.36	1.7
Noise pollution	0.38	0.38	1
Congestion and delays	-0.25	0.4	-0.6
Parking problems	-0.98	0.38	-2.6



Economic - Financial Evaluation

Sr. No.	Particulars	EL Metro (Cost in Crores)	UG Metro (Cost in Crores)	Partial UG / EL (Cost in Crores)
1.	Construction Cost	7438	19642	12,109
2.	EIRR	16.07%	22.70%	20.26%
3.	FIRR	10.41%	4.52%	7.07%

*EL – Elevated, *UG - Underground



Sensitivity Analysis

➤ Sensitivity Analysis for EIRR

Sr. no.	Particulars	EL Metro	UG Metro	Partial UG Metro
1.	Base Scenario	16.07%	22.70%	20.26%
2.	10% increase in Capital Cost	14.94%	19.49%	17.74%
3.	20% increase in Capital Cost	13.95%	16.94%	15.80%
4.	10% increase in O & M	15.84%	22.86%	20.01%
5.	10% decrease in O & M	16.30%	23.22%	20.49%
6.	10% decrease in Capital Cost	17.38%	28.45%	23.69%
7.	20% decrease in Capital Cost	18.91%	38.41%	28.76%

*EL – Elevated, *UG - Underground



Sensitivity Analysis Continued...

➤ Sensitivity Analysis for FIRR

Sr.No.	Particulars	EL Metro	UG Metro	Partial UG Metro
1.	Base Scenario	10.41%	4.52%	7.25%
2.	10% increase in Capital Cost	9.75%	4.02%	6.68%
3.	20% increase in Capital Cost	9.16%	3.57%	6.17%
4.	10% increase in O & M	10.17%	4.34%	7.05%
5.	10% decrease in O & M	10.64%	4.69%	7.45%
6.	10% decrease in Capital Cost	11.17%	5.09%	7.90%
7.	20% decrease in Capital Cost	12.06%	5.74%	8.66%
8.	10% increase in Revenue	11.38%	5.24%	8.08%
9.	10% decrease in Revenue	9.35%	3.72%	6.34%

*EL – Elevated, *UG - Underground



Cost - Benefit Analysis

- **Social**
- **Investment**
- **Operation and Maintenance (O&M) Charges**
- **Revenue**
- **Benefits**
- **By process of Land acquisition**



Economic Benefits of Underground Metro

- **Less number of Vehicles on road with MRTS Implemented**
- **Decongestion Effect**
- **Savings in Time**
- **Savings in Accidents**
- **Savings in Vehicle Operating Cost (VOC)**
- **Savings in the cost of Road Infrastructure**
- **Saving in Land Acquisition Cost**
- **Savings in Pulling Down the Structures**
- **Savings in Shifting of Utilities Service**



Demerits of Elevated Metro

- **Technical Issues**
- **Legal**
- **Social/Quality of Life**
- **Other Infrastructure**
- **Environment**
- **Cost, Finance & Economics**
- **Integrated Transport Plan**



Demerits of elevated metro Continued...

Cost during Construction

- **Vehicle Operating Cost** **Rs. 732.79 crores per anum**
- **Decongestion Cost** **Rs. 41.40 crores per anum**
- **Passenger Time Cost** **Rs. 507.98 crores per anum**
- **Pollution Cost** **Rs. 129.71 crores per anum**

Total

Rs. 1414.28 crores per anum

**Thus for 5 years of construction duration,
citizens will loose over Rs. 7,070 crores
(US \$ 1454.13 million)**

- **Accident Cost** **Rs. 2.40 crores per anum**



Total savings due to UG Metro

Sr. No.	Particular	EL Metro (Cost in Crores)	UG Metro (Cost in Crores)	Partially UG (Cost in Crores)
1	Estimated Cost	7438	19642	12109
2	Over all Saving			
	A) Saving During Construction Phase On account of VOC, VOT, Pollution etc.		10135	5431
	B) Saving During Operation Phase On account of VOC, VOT, Pollution etc.		7525	5052
3	Total Savings		17,660.00 (US \$ 3,627.36 million)	10,483.00

*EL – Elevated, *UG - Underground



Summary and Conclusions

- **Metro Rail System is expected to reduce the traffic on roads.**
- **This is a much needed system to support the present traffic conditions of the metropolis.**
- **The social benefits outweigh for the underground metro compared to the elevated metro.**
- **High direct and indirect cost savings of underground metro compared to elevated metro.**
- **EIIR significance.**
- **On the ground of constitutional right of equity and demand of users, UG metro proves to be the best alternative over EL metro.**

THANK YOU !



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