MUMBAI METROPOLITAN REGION DEVELOPMENT AUTHORITY

PLANNING, DESIGN AND IMPLEMENTATION ASSISTANCE FOR BRTS, UNDER MUIP

Draft Techno Economic Feasibility Report

Volume-I (Main Report)

May 2009

CONSULTING ENGINEERING SERVICES (I) PRIVATE LIMITED

NEW DELHI MUMBAI KOLKATA

in association with

MAUNSELL CONSULTANTS PVT. LTD.

PLANNING, DESIGN AND IMPLEMENTATION ASSISTANCE FOR BRTS IN MUMBAI UNDER MUIP

TECHNO-ECONOMIC FEASIBILITY REPORT

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LIST OF ABBREVATIONS

AAI	Airport Authority of India
AC	Air Conditioner
AGLR	Andheri Ghatkopar Link Road
BEST	Brihan Mumbai Electric Supply and Transport Undertaking
BKC	Bandra Kurla Complex
BOM	Bus Operation Monitoring and Control
BRTS	Bus Rapid Transit System
CBD	Central Business District
CCTV	Closed Circuit Tele Vision
CDMA	Cod Diversion Multiple Access
CETPs	Common Effluent Treatment Plants
CMSWMF	Common Municipal Solid Waste Management Facility
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CPCB	Central Pollution Control Board
CPZ	Controlled Parking Zones
CR	Central Railway
CRI	Cost Recovery Index
CSE	Center for Science and Environment
CST	Chhatrapati Shivaji Terminus
CTTS	Comprehensive Traffic and Transportation Study
DIMTS	Delhi Integrated Multimodal Transport System
DME	Di Methyle Ether
DMRC	Delhi Metro Rail Corporation
DPR	Detailed Project Report
DTC	Delhi Transport Corporation
DTM	Digital Terrain Modeling
EEH	Eastern Express Highway
EPZ	Export Processing Zone
ETB	Electric Trolley Bus
ETVM	Electronic Ticket and Verification Machine
FOB	Foot Over Bridge
GMLR	Ghatkopar Mulund Link Road
GOI	Government Of India
GOM	Government Of Maharashtra
GPS	Global Positioning System
GSB	Granular Sub Base

HC	Hydro Carbon
HOV	High Occupancy Vehicle
ICE	Internal Combustion Engine
IPO	Initial Public Offer
IPT	Intermediate Public Transport
ITS	Integrated Transport System
IUT	Institute of Urban Transport
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
JVLR	Jogeshwari Vikhroli Link Road
LCD	Liquid Crystal Display
LPG	Liquefied Petroleum Gas
LRTS	Light Rail Transit System
MbPT	Mumbai Port Trust
MCGM	Municipal Corporation Of Greater Mumbai
MCT	Municipal Corporation of Thane
MIS	Management Information System
MMPMTS	Mumbai Modal Public Mass Transport System
MMR	Mumbai Metropolitan Region
MMRDA	Mumbai Metropolitan Region Development Authority
MOEF	Ministry of Environment and Forest
MRVC	Mumbai Rail Vikas Corporation
MTSU	Mumbai Transformation Support Unit
MUIP	Mumbai Urban Infrastructure Project
MUTP	Mumbai Urban Transport Project
NMV	Non Motorized Vehicles
NO	Oxides Of Nitrogen
NUTP	National Urban Transport Policy
PCU	Passenger Car Unit
PIS	Passenger Information System
PM	Particular Matter
PPP	Public Private Participation
PWD	Public Works Department
PWDs	Person with Disabilities
RCC	Reinforced Cement Concrete
ROW	Right of Way
RPM	Respirable Particular Matter
RFID	Radio Frequency Identification Device
SCLR	Santacruz Chembur Link Road
SEEPZ	Santacruz Electronics Export Processing Zone

SEIAA	State Environment Impact Assessment Authority
SEZ	Special Economic Zone
SO2	Sulphar Dioxide.
SPM	Suspended Particular Matter
SPV	Special Purpose Vehicles
SPS	Stated Preference Survey
TC	Transport Commissionerate
TP	Traffic Police
TSDFs	Treatment Storage net Disposal Facilities
TTIV	Travel Ticket Issue and Verification
ULB	Urban local Bodies
ULSD	Ultra Low Sulphar Diesel
VMU	Vehicle Mounted Units
WEH	Western Express Highway
WR	Western Railway
MTHL	Mumbai Trans Harbour Link
LF	Load Factor

EXECUTIVE SUMMARY

1. MMRDA, on the initiative and the advice of Government of Maharashtra in their endeavor to plan and develop an integrated, multi-modal transport system for Mumbai Metropolitan Region (MMR), have initiated the process for planning, development, operation and management of Bus Rapid Transit System (BRTS) as an integral component of the total transport system. In this connection, they have identified 2 corridors - one from Dahisar to Bandra along WEH and the other from Cadbury Junction in Thane to Sion along EEH and have initiated the study, planning and development process. The Feasibility and Engineering Design study of BRTS along the above corridors is being carried out by M/s Consulting Engineering Services (India) Pvt. Ltd. The study is divided into 2 phases. The first phase is the Feasibility Study and the second, Engineering Study. The Feasibility Study is presented in this report.

   In the context of accelerating growth of Metropolitan cities and other urban areas, in recognition of the contribution of urban areas to national socio-economic development and in appreciation of the role of urban transport in enabling cities to be efficient, productive and competitive, the Government of India (Ministry of Urban Development) has approved a National Urban Transport Policy (NUTP) to promote and facilitate the concerted and integrated development of Transport in the urban areas of the country. The NUTP lays stress on the importance of Public Mass Transport System (PMTS) to cater the mobility needs of the people and encourages the city authorities and other concerned agencies to plan and develop PMTS, of appropriate technologies, on a concerted and co-ordinated manner. The planning and development of BRTS in Mumbai is in the context and framework of NUTP.

2. BEST is the present bus service system in Mumbai. It carries about 5 million passengers' everyday. Of this, nearly 2.5 million passengers are fed into the suburban Rail System. BEST has the reputation of achieving high levels of productivity in their operations. However, BEST suffers from inadequate capacity and stagnation in its fleet size. To appreciate the operational characteristics of BEST along the 2 BRTS corridors a detailed study has been carried out based on data and information as available in BEST records. Overall during the period 1999-2000 to 2007-08, BEST fleet size is at stagnation, fleet and vehicle utilization have come down, load factor has increased, passengers carried per day has comedown and losses have increased. BEST needs rejuvenation. 15 routes involving 121 buses operate along EEH and 48 routes involving 635 buses operate along WEH. A number of these routes overlap on the identified BRTS corridors. A number of routes operate along the corridors and others operate transverse to the corridors. The former components are potential BRTS routes and the latter potential feeder routes to BRTS. No route is profitable. Present Bus terminals along the corridors have inadequate terminal facilities. Introduction of BRTS is an opportunity to review, reorganize and rationalize BEST Operations.

3. In India,BRTS is being planned, developed and operated in a number of cities like Ahmedabad,Delhi,Nashik,Surat,Vijayawada,etc .Delhi is one of the first cities in India to plan the BRTS. To benefit from the experience of Delhi an "Appreciation and Evaluation" study of the Delhi BRTS pilot project was carried out. Delhi BRTS planning provides many interesting features in terms of the specific objectives formulation, the placing of BRTS lanes, the road re-engineering, allocation of road space for pedestrians and Non Motorized Vehicles (NMVs), the design features of the different physical components, etc. The study has also brought out the negative aspects in terms of absence of an integrated plan, ad-hocism in decisions, lack of transparency, inadequate capacity allocation for private modes, poor intersection control leading to long delays, absence of involvement and participation by important stakeholders, poor enforcement, mix of a variety of buses on the corridor leading to loss of brand image etc. The evaluation study has helped in organizing the planning process of Mumbai BRTS including all stakeholders, building consensus and systematic planning.

4. BRTS has been developed and operated in a number of cities around the world over the last few decades. To formulate guidelines out of international experience, a study of BRTS in a few cities have been carried out. The cities studied included Beijing, Curitiba and York. The study focused on the policy issues related to planning and design of the main elements of BRTS. The study indicated that a variety of options are adopted suited to local conditions. However, there were strong indicators of the preference for a number of elements like placing of the bus lanes at the median side, closed system of operation, Trunk & Feeder service pattern, use of high capacity buses, application of ITS etc.

5. Extensive traffic surveys and studies have been carried out to appreciate the traffic characteristics along the 2 corridors and generate base data for planning and design purpose. The surveys included classified Traffic Volume Counts, Intersection Turning Movement surveys, Speed & Delay survey, Bus on Board Survey and Stated Preference Survey of different mode users along the corridors. In addition, data from previous studies have been collected. Important amongst them is the Comprehensive Transport Study alias TranSforM recently carried out by M/s LEA International Ltd., for MMRDA. A report on Traffic Characteristics has been submitted.

6. Estimate of Travel demand on the proposed BRTS along the 2 corridors is important to estimate fleet size and design the system physical infrastructure. Mumbai has the benefit of a large number of transport studies, the latest being CTS study alias TranSforM. The demand forecast, by 2031, for overall MMR made in CTS study has been the base for forecast of demand on BRTS. The BRTS traffic forecast has been made by constructing growth rate and probability of modal shift models. Present levels of travel in terms of persons, by mode, by sub-sections along the 2 corridors

have been established based on field surveys carried out. The growth rates of person trips, by modes, have been estimated based on CTS data. The probability of shift from other modes into BRTS under different levels of cost increase and time saving have been derived from Stated Preference Survey. Potential BRTS traffic has been estimated under 3 scenarios (Optimistic, Realistic and Conservative). Realistic scenario outputs have been adopted. BRTS person forecast by subsections, have been converted into BRTS bus trips and total bus kms, along each of the corridors, during peak hours (morning & evening) have been estimated. Under policy assumptions of fleet utilisation, vehicle utilization and load factor the bus fleet size in different cardinal years has been estimated. With a cap of 22.5 sec. on frequency of operation, the mix of vehicles by size and capacity has been estimated. The physical infrastructure requirement for BRTS in terms of depots, terminals and bus stops & shelters has been identified. A Total of 852 buses, are required to be procured. To service the buses 9 depots are required with 6 depots to start with. A number of existing BEST depots are recommended to be assigned to BRTS. 5 Terminals at different locations have been identified. Terminal at BKC will be critical to provide anchor to the system and integrate with proposed Metro lines.

The capital cost is estimated to be Rs.800.35 crores. The details are as follows:-

Cost Heads	**WEH**	**EEH**	**Total (Rs.crore)**
Civil Engineering works	360.00	170.00	**530.00**
Bus procurement	205.15	113.00	**318.15**
ITS	9.85	9.85	**19.70**
Total	**552.50**	**247.85**	**800.35**

7. BRTS is a system with a number of component elements interacting and influencing each other. Planning of total BRTS calls for policy decisions on the different component elements. Important amongst them are; placing of BRTS lanes, bus technology, system of operation; type of service pattern; bus stop location and design; ticketing system; ITS application; and institutional arrangement for the management of BRTS. Based on international experience and detailed analysis various options under each component were identified, analyzed and recommendations made. The Steering Committee considered recommendations and gave its guidance/decisions. They have been adopted in system planning and design.

8. The BRT Services should be clear, direct, frequent and rapid. The service design should meet customer needs while also attracting new riders. Fares should permit rapid boarding of buses. Marketing should focus on BRT's unique features and further reinforce its identity. To achieve these objectives the general guidelines have been provided. The existing BEST operations on Eastern Express Highway and

Western Express Highway have been analyzed and Operational Plan suggested for design of Trunk and Feeder System besides some direct services during the transition. The service types, operating hours and service frequencies for the proposed span of operation have been elaborated. As fare policies are important compliments to the Operational plan, the various options available are elaborated. Similarly the BRT marketing activities should be people centered and focus on the product, promotion and the price.

9. Western Express Highway and Eastern Express Highway are two major arterials in Mumbai. Major commercial activities, airports, institutions, hotels are along WEH where EEH act as residential as well as industrial belt. BRTS corridor is proposed on both of these corridors because of their importance. BRTS is proposed at the center of the road and staggered bus stops are proposed to optimize the horizontal width of main carriageway. Central BRTS Lane are proposed on existing flyovers without any kerbs as separator. During off-peak hours normal traffic may use BRTS land on flyovers. Bus stops are designed on Modular basis. At each bus stop, escalator and staircase are proposed for passenger transfer. BRTS is integrated with other transit systems like feeder buses, IPT, existing suburban stations, proposed Metro station etc through skywalks. BRTS turnouts are proposed for mid-stretch BRTS. Terminals are proposed at Dahisar, Andheri and BKC on WEH and Ghatkopar & Cadburay or Hiranandani on EEH. Rigid pavement is proposed for BRTS lane and traffic control devices are proposed on BRTS Corridor. Lighting at Stop and on the corridor is proposed. Engineering cost of BRTS on WEH is Rs. 3600 Millions and on EEH it is Rs.1700 Millions.

10. Use of Intelligent Transport System (ITS) technology is important to improve the operational efficiency of system on the one hand and user convenience on the other. A number of ITS technologies for vehicle tracking, passenger information on board and off board, traffic signal prioritization and fare collection have been identified. The total cost of ITS is estimated to be Rs.19.70 crores.

11. A good traffic management program should help in ensuring safe vehicle and pedestrian crossings of bus lanes and bus ways and minimize delays to BRT vehicles and general traffic. It is proposed to construct the BRTS at the middle of the WEH and EEH. The BRTS runway will pass on the existing flyovers. During re-engineering of BRTS bus lanes, construction of bus stops and Bus Terminals the existing traffic some times need to be diverted from the existing road so as to carry out the work without much delay to through traffic flow, until the work is over at that particular stretch of the road. There is one road running parallel to WEH (Swami Vivekananda Road) which covers the maximum stretch), and another road running parallel to EEH (Lal Bahadur Shastri Marg). The traffic management measures that would be adopted include, road closures with signed diversions; lane closures; changes to traffic signal timings; temporary speed limits; parking suspension and

relocation and/or reallocation of parking bays; and tightening enforcement of restrictions on vendor activity.

12. Preliminary Environmental Impact Analysis of the proposed BRTS has been made. The base year condition of ambient air quality along the corridors is not good with RSPM values and ambient noise level values higher than prescribed standards. Introduction of BRTS would reduce the number of buses required to carry the given demand and hence would positively contribute to environment quality. On the other hand reduction in road capacity for movements of other modes of traffic would reduce their speeds and may result in higher levels of exhausts of gases. Mitigation measures in terms of cap on age of motor vehicles, automobile fuel policy, disincentives for use of private modes, efficient traffic management and rigorous enforcement would help in reducing negative impacts on the environment.

13. Financial and Economic analysis of the proposed system has been carried out. The cost includes provision of BRTS lanes, reorganization of road cross section, provision of Bus stops, pedestrian skywalks, procurement of buses in different years including replacement after 8 years of service, installation of ITS and other miscellaneous provisions. All costs have been converted into economic cost at a factor of 0.9. Benefits include savings in VOC's and VOT's with our without BRTS. Savings in BEST bus investments with BRTS has also been considered. The VOC's and VOT's has been calculated based on traffic volumes and speeds, with or without BRTS. The EIRR works out to 37.38% for WEH and 41.87% for EEH. Sensitivity analysis indicates the range of variation of EIRR between 37.38% and 22.47% for WEH and 41.87% to 24.71% for EEH. The project is economically viable. It is possible to achieve higher EIRR by resorting to high degree of automation and reducing manpower cost over a period of time.

14. The organizational form selected and institutional set up have a great impact on the functioning of the BRT System. Presently a number of agencies control urban transport system and this multiplicity of control leads to institutional weaknesses. The various options available for managing proposed BRT System (5 options) are analysed with respect to their advantages vs., disadvantages and formation of Special Purpose Vehicle (SPV) with BEST, MMRDA, MCGM and MCT as promoters has been approved by the Steering Committee. The institutional set up of SPV for Mumbai BRT has been detailed with respect to the Composition of Board Members, main functions of SPV and proposed management structure of the Company.

15. Business Plan Model (BPM) is important to carry out the development and operations on business lines with sound commercial principles. The Public Private Partnership (PPP) model is essence of the proposed BPM. The BRTS will be owned and managed by a Special Purpose Vehicle (SPV) to be set up which will be responsible for planning, setting standards and specifications, contracting services, monitoring

and controlling quality of services. The physical assets like buses will be procured by private enterprises while infrastructure like roadways, station etc., will be developed and maintained by public agencies.

The Business Plan recommends: System of hiring buses; the fare fixation and collection system including Tariff policy and fare structuring; outsourcing of fare collection; integration with other transit services and method of distribution of revenues. The overall Business Plan of Mumbai BRTS aims at providing acceptable quality transport services to the users at affordable prices on a sustainable basis.

Chapter 1.0
MUMBAI BRTS FEASIBILITY STUDY

1.1 Introduction

Mumbai, the administrative capital of Maharashtra and the financial capital of India, is endeavoring to transform into an international financial centre and a world-class city. The MMR vision envisages "Transforming MMR into a World Class Metropolis with a vibrant economy and globally comparable quality of life for all its citizens".

A number of goals and objectives have been formulated as part of the vision. Important amongst them are accelerated economic growth of 8 to 10% and improvement of the transport system to provide high mobility. An objective target set is to ensure a bus for every 1000 persons. This would mean bridging a gap of nearly 7000 buses in Brihan Mumbai and a provision of about 16000 buses by the year 2031.Transport plays a key role in realizing the vision.

Mumbai, compared to the other cities of India, has a reasonably well-organized and efficient transport system comprising the suburban railways and the city bus system (BEST). Together they carry nearly 10 million passengers' everyday. However, accelerated increase in the travel demand and increasing congestion and other negative impacts calls for intensive development of transport systems.

Development and operation of the Bus Rapid Transit System (BRTS) as an integral component of the transport system is an important program. The Mumbai Metropolitan Region Development Authority (MMRDA), the apex planning and coordinating authority, have initiated the study on Planning, Design and Implementation Assistance of a BRTS along the two identified corridors. The study is being carried out by the M/s Consulting Engineering services (India), Pvt. Ltd. This Techno Economic Feasibility Report is submitted as one of the deliverables of the study.

1.1.1 Background

The Mumbai city is currently experiencing rapid growth in population and vehicle ownership leading to traffic congestion, pollution and various other traffic related problems. The annual growth rate of population in Greater Mumbai is only about 1.84% (1991-2001), however the addition in terms of absolute numbers, is large (0.2 million/year). The change is in the relative growth rates and concentration in suburbs vis-à-vis the Island City (Suburbs: annual growth rate 2.43%, addition 1, 84,000 / year, Island City: annual growth rate 0.47%, addition 16,000/year). The average population density of Greater Mumbai is about 27,000-persons/sq km, which is among the highest in the world. This level of urbanization has caused heavy strain on urban infrastructure including transport, which is inadequate to handle the generated demand. As per Census 2001, the population of Greater Mumbai is 11.91 million. The distribution and forecast of population is shown in following Table.

Table 1.1 Population Projections for Greater Mumbai

Region	1991	2001	2011 *	2021*	2031 *
Island	3,134,072	3,326,837	3,552,933	3,840,699	4,080,000
West Suburbs	3,947,979	5,095,685	5,986,947	6,637,641	7,145,000
East Suburbs	2,767,226	3,491,876	4,041,070	4,441,005	4,760,000
Greater Mumbai	9,849,277	11,914,398	13,580,736	14,917,463	15,985,000

Source: TranSforM-2005
**Forecast*

1.2 National Urban Transport Policy

1.2.1 Genesis

The Government of India, (Ministry of Urban Development), have formulated and approved a National Urban Transport Policy (NUTP). The genesis of the NUTP lies in the recognition of the urbanization phenomenon the country is experiencing; the role of urban areas in national development; the large contribution of urban areas to national GDP; the need for urban areas to be competitive, productive and bankable; the role and importance of urban transport in enabling cities to be efficient, cohesive, productive and competitive; the low levels of development of urban transport; and the need for an integrated, multi-modal urban transport system and services to enable the cities to grow, change and be sustainable.

1.2.2 NUTP Vision

- To recognize that people occupy center-stage in our cities and all plans would be for their common benefit and well being
- To make our cities the most livable in the world and enable them to become the “engines of economic growth” that power India’s development in the 21st century
- To allow our cities to evolve into an urban form that is best suited for the unique geography of their locations and is best placed to support the main social and economic activities that take place in the city.

1.2.3 Objectives of NUTP

The objective of this policy is to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents to jobs, education, recreation and such other needs within our cities. This is sought to be achieved by:

- Incorporating urban transportation as an important parameter at the urban planning stage rather than being a consequential requirement
- Encouraging integrated land use and transport planning in all cities so that travel distances are minimized and access to livelihoods, education, and other social needs, especially for the marginal segments of the urban population is improved
- Improving access of business to markets and the various factors of production
- Bringing about a more equitable allocation of road space with people, rather than vehicles, as its main focus
- Encouraging greater use of public transport and nonmotorized modes by offering Central financial assistance for this purpose
- Enabling the establishment of quality focused multi-modal public transport systems that are well integrated, providing seamless travel across modes
- Establishing effective regulatory and enforcement mechanisms that allow a level playing field for all operators of transport services and enhanced safety for the transport system users
- Establishing institutional mechanisms for enhanced coordination in the planning and management of transport systems
- Introducing Intelligent Transport Systems for traffic management
- Addressing concerns of road safety and trauma response
- Reducing pollution levels through changes in traveling practices, better enforcement, stricter norms, technological improvements, etc.
- Building capacity (institutional and manpower) to plan for sustainable urban transport and establishing knowledge management system that would service the needs of all urban transport professionals, such as planners, researchers, teachers, students, etc
- Promoting the use of cleaner technologies
- Raising finances, through innovative mechanisms that tap land as a resource, for investments in urban transport infrastructure
- Associating the private sector in activities where their strengths can be beneficially tapped
- Taking up pilot projects that demonstrate the potential of possible best practices in sustainable urban transport

1.2.4 The NUTP

- Promotes preparation and implementation of integrated, land use transport plans for cities and towns
- Supports planning, development, operation and management of urban transport giving priority for public transport
- Encourages differential services and tariffs on public transport to enable access to the poor
- Encourages city specific public transport technology based on proper evaluation of all prevalent technologies
- Encourages set up of Special Purpose Vehicles (SPV) to plan and develop high capacity public transport system
- Supports restoration of para transit system to their normal role
- Supports priority measures and programmes for enhanced safety and use of non-motorised modes
- Promotes management of parking through amendment of building byelaws and provision of parking complexes
- Recognizes the importance of and problems of freight traffic in urban areas and encourages development of facilities for freight vehicles and goods
- Recommends setting up of Unified Metropolitan Transport Authorities in all million plus cites
- Supports capacity building, at the state and city levels, to address issues and undertake task of developing sustainable urban transport systems
- Promotes use of cleaner technologies of urban transport and encourages research, development and commercialization of cleaner technologies
- Encourages innovative financing mechanisms including levy of dedicated taxes, set up of urban transport fund, partnership with private sector, commercial use of land resources, etc
- Encourages involvement of private sector in providing public transport services
- Supports major awareness campaigns that educate people on the ill effects of the growing transport problems in urban areas.
- Supports pilot projects in a sample set of cities to demonstrate the potential benefits of NUTP measures.

The NUTP provides a great opportunity for city governments to plan and develop efficient transport system and services to cater the travel needs of the city.

1.3 MMR – CTS

MMRDA have carried out the Comprehensive Transportation Study for Mumbai Metropolitan Region (MMR) (Draft) referred as TranSforM report. The study, by M/s LEA International Ltd., Canada, has carried out extensive traffic surveys and studies; constructed Transport Demand Models; conceptualized development scenarios, evaluated and selected the optimal one; proposed a multi-modal transport plan for MMR; and has recommended a number of other supporting measures like legal and institutional reforms and restructuring for the co-ordinated development of the proposed transport system. The recommended transport plan includes in main extensive highway system (1661 kms), modernized Sub-urban Railway System (248 kms) and an extensive metro system (435 km.). In addition are developments of BRTS through provision of exclusive Bus lanes along highway, strengthening of Bus system, development of Passenger Water Transport and provision of terminals. The preliminary cost for the proposed transport network for horizon year 2031 is estimated to be Rs.2, 06, 661 crores.

The present study for planning and operation of BRTS along the 2 corridors is in the framework of the Comprehensive Transport Study and Plan.

1.4 Study Objectives

MMRDA has formulated the following overall objectives for the development of the BRTS.

- To improve the overall transportation scenario in Mumbai especially road based public transport and to compliment all forms of mass transportation in MMR
- To increase the public transport share by bringing in substantial improvement in BEST (Public Bus) services by providing dedicated /priority Right of Way (ROW)
- To consider improved mass transport operations, other contract buses, inter city services & High Occupant vehicles on selected corridors
- To reduce the private vehicle/IPT utilization and reduce automobile related pollution
- To develop a citywide integrated rapid transit system covering suburban railway/MRTS and associated facility
- To finalize proper fleet and operating system specification that would meet the above objectives of BRT
- To select the strategy for developing BRTS

1.5 Study Phasing

The study is divided in to two phases as follows:

Phase-I: Covering the planning design and implementation of BRTS on the two corridors as identified above, on priority basis
Phase-II: Covering feasibility study of city wide BRTS and the integration of BRTS with other modes of transportation in Mumbai.

The objectives of Phase-I part of the study in more detail are as under.

Phase-I

Part-I (Feasibility Study)

i. To examine the feasibility of introducing BRTS on WEH from Bandra to Dahisar and on EEH from Sion to Thane.
ii. To decide on the best lane orientation of BRTS operation: median vs. kerb-side
iii. To identify the inter modal points with regard to the railways, and other forms of transport (both existing and proposed)
iv. To identify the connectivity of the above BRTS with the road network of the rest of the suburban and the Island City
To identify the most suitable vehicle/mix of vehicles for the BRT route
To design the BRTS on the selected route
To design the signaling system for the BRTS
To provide estimates of capital cost and operating cost for
a) Infrastructure
b) Buses
c) Management Control and Real Time Passenger Information Systems
d) Enforcement

1.6 Reports & Working Papers

As part of the study the following Reports and Working Papers have been submitted.

1. Inception Report
2. Working paper on Policy Issues for Decision
3. Approach Paper on Travel Demand Model and Estimation
4. Traffic Surveys and Analysis Report
5. Working paper on Review of International Experience
6. Working paper on BEST operations
7. Working Paper on Delhi BRTS
8. Draft Techno Economic Feasibility Report

1.7 Presentations & Interactions

The following presentations to and interactions with, concerned stakeholders have been held during the course of the study,

- Review meeting by Project Manager, MTSU in MTSU on 21/06/2008.
- Review meeting by Principal Secretary, Transport in Mantralaya on Policy Issues on 15/07/2008.
- Review meeting by Chief, T&C Division, MMRDA in MMRDA on 22/08/2008.
- Technical Advisory Committee in MMRDA on 27/10/2008.
- Steering Committee Meeting in MMRDA on 05/02/2009.
- No. of meetings with the officials of MTSU, MMRDA and BEST.

1.8 Steering Committee Meeting

The Steering Committee set up by MMRDA, to guide the study, met on 5th February, 2009 and deliberated on each policy issue related to planning, design, operation and management of BRTS, considered the recommendations by the Consultants and gave its guidance. The Feasibility Report has been prepared in the frame work of the decisions and guidance of the Steering Committee.

1.9 Report Structure

This Techno-Economic Feasibility Report is submitted in accordance with the Terms of Reference of the Study. The methodology as submitted in the Inception Report has been followed for carrying out the required work.

Chapter 1 : Mumbai BRTS Feasibility Study

This chapter consists of the background of the Mumbai City and with a caption of "Transforming MMR into a World Class Metropolis with a vibrant economy and globally comparable quality of life for all the citizens". It also discusses about NUTP, its vision, objectives also about the MMR - CTS including the study objectives of the present study. This chapter at a glance brings out the submissions of report and Working Paper along with the presentation and interaction with the concerned stakeholders.

Chapter 2 : An Overview of BEST Operations

This chapter deals with an overview of BEST operations. This comprises of BEST operation planning, revenue of existing operation, operating environment, fleet and its carrying capacity, route span distribution, fare structure, market segmentation, performance of Depots / Zones. Comparative performance of different classes of services, performance in trends, existing operations of BEST on EEH & WEH respectively and a review on existing Bus Terminals.

Chapter 3 : Delhi Bus Rapid Transit System - An Evaluation

This chapter introduces the Delhi BRTS from Ambedkar Nagar to Moolchand Corridor - An Evaluation. It analysis how the failure occurred within Delhi and also reconstructs the strategy of its triumphant. This particular chapter deals with as a case study and describes how the system failed to work and what was the root cause behind its failure.

Chapter 4 : BRTS Review of International Experience

This chapter describes about the BRTS and the review of International Experience. This chapter in particular discusses various case studies of certain prominent places where the BRTS system is in operation. Certain places like Beijing BRT, Curitiba BRT & York BRT (Canada). Mainly it reviews the key theme like planning process, Design components, Marketing and Mode shift, Control Management and standards and Ticketing Management and standards, Ticketing Fare and validation, implementation strategy.

Chapter 5 : Traffic Survey & Analysis

This chapter includes the present Traffic Survey Analysis over both the respective corridors EEH & WEH. This includes the TMC, TVC, Speed & Delay, Boarding Alighting, on board survey. This simulates the present data and produces the outcome for the existing traffic flow over the proposed corridor for BRTS.

Chapter 6 : BRTS - Travel Demand, Fleet Size and Infrastructure

This chapter gives the travel demand for both the corridors, fleet size requirement and infrastructure for the BRTS.

Chapter 7 : BRTS Components - Design Policies

This deals with BRTS components and design policies.

Chapter 8 : BRTS Services and Operation Plan.

This includes the general guidelines for BRTS service planning.

Chapter 9 : Preliminary Engineering

This gives the preliminary design details for both the corridors for BRTS.

Chapter 10 : Application of ITS

This chapter includes the Road way application design with respect to Traffic Signal prioritization and cost estimation of ITS for both EEH & WEH.

Chapter 11 : Traffic Management

This chapter describes the Traffic Management Plan and proposed diversions.

Chapter 12 : Preliminary Environmental Issues

This chapter describes the baseline Environment of EEH & WEH and preliminary Environmental issues.

Chapter 13 : Financial and Economic Viability Analysis

This chapter describes the methodology for Financial and Economic Evaluation and Project Viability.

Chapter 14: Institutional Arrangement for BRT - Mumbai

This chapter comprises of entire Institutional Arrangement of BRT - Mumbai.

Chapter 15: Business Plan

This chapter comprises of the overall business plan of BRT.

Chapter 2.0
AN OVERVIEW OF BEST OPERATIONS

2.0 Introduction

There is a need to understand conventional Bus Operations in the city, before attempting to design BRT System. The financial performance reveals, the growing gap between Revenue and Cost of operations, resulting in increased deficits. BEST fleet size has almost stayed the same, during the past decade, in a situation where population has grown significantly. Further, the personalized vehicles have registered phenomenal growth. This means, reduction in market share of BEST. The performance of AC services has been very disappointing. The load factor has been less than 30%, and the Cost Recovery Index is very low, nearly half of limited and ordinary services. This means, the so called premium services for the elite passengers are a burden to the organization and to the customers of ordinary bus services. There are large number of routes, which are operated for social benefit nearly 28% of routes have less than 50% cost recovery and similarly 20% of routes have less than 50% load factor. There is a need to formulate “subsidy policies” for sustaining services, socially desirable yet financially not viable. The average speeds of Feeder Services (54% of routes) are very low at about 11 kmph. There is a need to undertake TSM studies including bus priority measures for these services, to improve bus productivity. The Intercity Services (5% of routes) have comparatively better performance than the other segments, i.e. Feeder, Trunk and East-West routes. The telescopic fare structure is advantageous to the long distance passengers. Nearly 33% of routes have, “Route Span” more than 20 km. The fare policies towards A.C. and BRT Services need detailed market research study. The load factors on these services are disappointing. The breakeven load factor is at more than 100%, which means that for the present fare structure and cost structure, BEST can not achieve financial viability. The fare box earnings can meet on an average only about 70% of the cost of operations. There is need to review Financial Strategies for sustaining the present services.

2.1 BEST Operations Planning

2.1.1 Review of Existing Operations:

The Brihan Mumbai Electric Supply and Transport (BEST) undertaking which runs the city bus services is one of the largest bus undertakings in India. It has about 3852 buses, employing over 30,905 workers in the Transport Division as on 01-08-2008. It services daily 4.6 million Passengers. The Bus operations receive cross subsidy from BEST’s electric distribution.

2.1.2 The operations of BEST are broadly reviewed under two categories. Viz

(i) Operations environment.

(ii) Physical and Financial Performance.

The detailed observations are as follows.

2.1.3 The review of operating environment involves study of :

- Fleet and Carrying Capacity
- Route span distribution
- Fare Structure
- Market Segmentation
- Market Share
- Average Speeds

2.1.4 The review of Physical and Financial performance involves study of the following.

- Performance of Depots and Zones.
- Load Factor
- Cost Recovery Index (CRI)
- Comparative performance of different class of services
- Performance trends since 1999-2000 till 2007-2008.

2.1.5 The detailed observation for each of the study areas are given in the subsequent sections.

2.2 Operating Environment:

2.2.1 Fleet and its Carrying Capacity:

The ***Table 2.1*** shows the details of Fleet and its Carrying Capacity as on August 2008.

Table 2.1: Fleet and its Carrying Capacity

Sr. No.	Type of Bus.	Number of Buses	Percentage	Carrying Capacity/ Bus
1.	Single Deck	2022	52.49	71
2.	CNG Single Deck	737	19.13	67
3.	Single Deck (MUTP)	644	16.72	71
4.	Ultra Low Floor(Single Deck)	31	0.80	46
5.	Double Deck	182	4.72	89
6.	Midi (Diesel)	63	1.64	48
7.	Midi (CNG)	102	2.65	55
8.	Air Condition (Diesel)	51	1.32	45
9	Air Condition (CNG)	20	0.52	47
	TOTAL	**3852**	**100**	**2,69,005**

Ref: Monthly Statistical Review (Part I) of BEST- August 2008.

Average Carrying Capacity is 70.

2.2.2 Route Span distribution:

The distribution of Route Span (Route Length) of BEST Routes is detailed at ***Table 2.2***.

Table 2.2 Distribution of Route Span

Sr.No.	Route Span	Number of Routes	Percentage	Cumulative percentage
1.	0 – 5.0	80	20.46	20.46
2.	5.1-10.0	79	20.19	40.65
3.	10.1-15.0	63	16.11	56.76
4.	15.1-20.0	41	10.49	67.25
5.	20.1-25.0	55	14.07	81.32
6.	25.1-30.0	45	11.51	92.83
7.	30.1-35.0	20	5.12	97.95
8.	Above 35.1	8	2.05	100.00

Ref: Allocation of Fleet and Staff for the quainter commencing from 1st November 2008-BEST Traffic Planning Section.

2.2.3 Fare Structure.

The fare structure of BEST operations is given at ***Table 2.3.***

Table 2.3 Fare Structure for BEST Operations

Distance (Kms)	Ord/Ltd/Exp. (Rs.)	Air Condition (Rs.)	BRT (Rs.)
2	3	10	10
3	4	10	15
5	5	10	15
7	6	15	20
10	8	15	25
15	10	20	30
20	12	25	35
25	14	30	40
30	15	40	50
35	16	50	60

Source: BEST planning Division

2.2.4 Market Segmentation.

The present daily ridership of 4.6 million Passengers can be segmented into the following four categories.

- **Feeder Services**: These services are designed to get people to and from stations on the Railway Net work.
  The Share is about 47 percent.

- **East – West Services**: These services filling in the gaps in the rail net work about half a million trips.
  The share is about 11 percent.

- **Trunk Services**: These services link various parts of Mumbai, and provide alternative to Railway transport.
  The share is about 33 percent

- **Intercity Services**: These services satisfy the travel demand to Mira- Bhayandar, Navi Mumbai and Thane.
  The share is about 9 percent.

The Characteristics of BEST market segments are given at ***Table 2.4.***

Table 2.4 - Characteristics of Segmentation (2005)

Item Description	Feeder	East West	Trunk	Intercity	BEST
Routes (No.)	193	38	111	18	360
Routes (%)	54	10	31	5	100
Buses (No.)	1246	407	1178	256	3087
Buses (%)	41	13	38	8	100
Route Span (Km)	1662	958	2667	560	5807
Av Route Length (Km)	9	25	24	31	16
Vehicle Utilization (km)	177	236	220	316	213
Av. Speed KMPH (peak hour)	11	14	14	18	
Av. Speed KMPH(Non peak)	16	20	20	22	
BEST Passengers (Lakhs)/day	21	5	15	4	45
Passengers (%)	47	11	33	9	100
Passenger Lead (Km)	5	10	8	12	7
Passengers /Bus/day	1579	1097	1195	1277	1344
Revenue/Bus (Rs) day.	6621	7123	6816	10,177	7809
Cost /Bus (Rs) day	9119	9707	9472	11,459	9939
Loss/Bus (Rs) day	2498	2584	2656	1282	2130

Ref: IDS & MIS study of BEST by T.C.S. -2007

2.2.5 Market Share

The Market Share of BEST in different segments is given at ***Table 2.5***

Table 2.5 - Share of BEST in different Market Segments

Item Description	Feeder	East West	Trunk	Intercity	BEST
BEST Passenger Trips Daily – (Lakhs)	21	5	15	4	45
Other Modal Trips Daily – (Lakhs)	8	2	65	3	78
Market Size in Trips Daily (Lakhs)	29	7	80	7	123
BEST Market Share (%) 72	72	71	18	57	37

Ref: IDS & MIS Study of BEST by TCS- 2007

2.2.6 Average Speeds

The average speeds of BEST Buses on various market segments. Is given at ***Table 2.6***

Table 2.6 - Average Speeds of BEST Buses

Route Category	Routes	Average Speeds in KMPH	
		Peak Hours	Off peak Hours
Feeder	193	11.31	15.10
Trunk	111	14.40	19.75
East West	38	14.47	19.58
Intercity	18	17.76	21.51

Ref: IDS & MIS Study of BEST by T.C.S. - 2007.

2.3 Physical and Financial performance - A brief Review

2.3.1 Performance of Depots / Zones:

BEST has 25 depots, which are grouped, into 5 zones. Each zone has 5 depots for administrative and operational control. The details of zones and depots are given below.

South Zone: Back bay; Colaba, central; Worli and Wadala depots
East Zone: Deonar, Sivaji Nagar, Ghatkopar, Vikhroli and Mulund depots.
Central Zone: Anik, Prateeksha Nagar, Dharavi , Santacruz and Bandra depots
North Zone: Kurla, Marol, Majas, Dindoshi and Magathane depots.
West Zone: Goregaon, Oshiwara, Malvani, Poisar and Gorai depots

The performance of Zones: is detailed at ***Table 2.7.***

Table 2.7 - Performances of Zones

Zone	Average Fleet	Vehicle Utilization (Km)	Load Factor (%)	Passenger Lead (Km)	Cost Recovery Index (%)	Passengers Carried (%)	Revenue (%)
South	582	176	69	6.1	65	20	19
Central	771	190	73	7.5	66	23	24
East	645	216	79	9.0	68	18	20
North	723	195	83	7.5	75	22	22
West	631	183	79	7.0	74	17	15
Total	3352	192	77	7.5	70	100	100

Ref: Monthly Statistical Review (Part II) of BEST – August 2008.

2.3.2 Load Factor

Load Factor, is an important performance parameter of any Bus undertaking .It is the percentage ratio of actual earning to expected earnings. The load factor classification for BEST for the month of August 2008 is given at ***Table 2.8.***

Table 2.8 - Load Factor Classifications

Sr. No.	Load Factor (%)	Number of Routes	Percentage	Cumulative Percentage
1.	1 to 20	11	3	3
2.	20.1 to 30	14	3	6
3.	30.1 to 40	47	12	18
4.	40.1 to 50	107	27	45
5.	50.1 to 60	98	25	70
6.	60.1 to 70	68	17	87
7.	70.1 to 80	30	7	94
8.	80.1 to 90	14	4	98
9.	Above 90	6	2	100
	Total	***395***	***100***	

Ref: Monthly Statistical Review (Part II) of BEST – August 2008.

2.3.3 Cost Recovery Index (CRI)

CRI is the percentage ratio of total earnings to the total cost of operation. It indicates % of cost recovered by earnings. The CRI of various routes for the month of August 2008 is given at ***Table 2.9.***

Table 2.9 - Cost Recovery Index (CRI)

Sr. No.	Classification	Number of Routes	Percentage	Cumulative Percentage
1.	1 to 50	110	28	28
2.	50.1 to 60	117	30	58
3.	60.1 to 70	108	27	85
4.	70.1 to 80	50	12	97
5.	80.1 to 90	8	2	99
6.	90.1 to 100	2	1	100
		395	**100**	

Ref: Monthly Statistical Review (Part II) of BEST – August 2008.

2.3.4 Comparative performance of different class of services:

BEST primarily operates three classes of services: i.e. Air condition; Limited and ordinary. The comparative performance of these three classes of services is provided at ***Table 2.10.***

Table 2.10 - Comparative Performances of Different Class of Services

Sr. No.	Item of description	Air condition	Limited	Ordinary	BEST
1	Number of Buses	46	1010	2298	3354
2	Vehicle Utilisation (Km)	143	224	180	193
3	Passengers/Bus/day	226	906	1619	1385
4	Earnings/Bus/day (Rs)	3447	6207	7402	6987
5	Cost /Bus/day (Rs)	10,904	10,513	9813	10,039
6	Loss/Bus/day (Rs)	7457	4306	2411	3052
7	Passenger Lead (Km)	8.2	6.2	7.8	7.5
8	Load Factor (%)	29	36	99	77
9	Break even load Factor (%)	92	61	131	111
10	Cost Recovery Index (%)	32	59	75	70
11	No. of Routes	8	83	291	383

Ref: Monthly Statistical Review (Part II) of BEST August 2008.

In the given environment of fare level, load factor, and cost structure, the financial viability for BEST may be a distant dream. ***Table 2.11*** shows the financial performance of BEST during the last 6 months.

Table 2.11 - Financial performances from March to August 2008

Month	Earnings (Rs./Km.)	Cost (Rs./Km.)	Loss (Rs./Km.)	Load Factor (%)	Break Even Load Factor (%)
March 08	34	48	14	64	90
April 08	35	48	13	70	96
May 08	33	46	13	66	93
June 08	35	53	18	71	108
July 08	35	50	15	73	105
August 08	36	52	16	77	111

Ref: Monthly Statistical Review (Part II) of BEST - Aug 2008

2.3.5 Performance Trends 1999-2008

The operational and financial performance of BEST for the period 1999-2008 is given at ***Table 2.12***.

Table 2.12 - Performance Trends 1999-2008

Sr. No	Parameter	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08
1	Fleet	3458	3430	3380	3380	3386	3391	3395	3406	3570
2	Fleet Utilization (%)	94	92	90	91	91	91	91	91	90
3	Vehicle Utilization(Km)	211	212	210	212	215	214	214	211	200
4	Load Factor (%)	56	55	54	57	58	60	58	61	67
5	Loss of Kms (%)	3	3	4	3	3	4	5	6	7
6	Income (Rs in Cr)	567	646	663	702	726	756	795	795	795
7	Cost (Rs in Cr)	793	870	857	890	947	1125	1098	1254	1227
8	Loss (Rs in Cr)	226	224	194	188	221	369	303	459	432
9	Passengers /day (Lakhs)	46	41	41	43	44	45	41	41	42

Ref: Monthly Statistical Review (Part II) of BEST –Aug 2008.

The Performance of BEST has been stagnant for over decade except for minor variations.

2.4 Summing up the Review

BEST maintains detailed information on operational and Financial Performance. The Financial Performance reveals the growing gap between revenue and cost of operations, resulting in increase of deficit. BEST fleet size has almost remained the same, while there has been 29.4 percent increase in the number of two wheelers and 12 percent increase in the number of cars over the last 5 years. Passenger rider ship over the last ten years has also remained stagnant. In the growing travel market, this means, effective reduction in the market share of BEST.

There is a need to give priority for Public Transport, including reservation of Road for Buses. The Public Transport system needs to be made competitive in terms of quality of service, to wean people form private modes. BRT is one of the options before the city authorities, to improve quality of Public Transport. However, financial viability appears to be a great challenge before BEST.

2.5. Existing Operations of BEST on Eastern Express Highway (EEH)

Presently there are 15 BEST routes involving 121 buses, which are serving 1.2 lakhs commuters per day, and these routes overlap the Eastern Expressway Highway. The details of those BEST routes and the extent of overlap are given at ***Table 2.13.***

Table 2.13 - Existing Operations of BEST on Eastern Express Highway

Sl No.	Route No.	Route details		Route Length KM	No of buses	Over-lapping on BRT (KM)	Overlapping on BRT (%)
		From	To				
1	353	Wadala Depot	Tagore Nagar	20.1	7	10.6	42
2	354	RG Gadkari Chowk	Kannamwar Nagar	19.1	5	11.7	47
3	368 Ltd.	P Thakre Udyan	Guwanpada	27.9	6	15.5	62
4	373	Bandra Bus Station	Vaishali Nagar	32.9	12	18.2	73
5	385	Tardeo Bus Station	Ghatkopar Depot	24.1	11	10.1	40
6	27	Worli Depot	Vaishali Nagar	32.2	19	14.3	57
7	BRTS-1	Backbay Depot	Cadbury House	42.5	11	25.0	100
8	399 Ltd	Trombay	Marathon Chowk	27.1	15	1.7	7
9	388 Ltd	Kannamwar Nagar	SEEPZ Bus Station	17.0	8	3.8	15
10	350	Shivaji Nagar Depot	Kurla Station (E)	6.6	9	1.7	7
11	366	Shivaji Nagar Terminus	Kurla Station	6.6	3	1.7	7
12	377	Lalubhai Compound	Kurla	7.1	3	1.7	7
13	382	Anushakti Nagar	CSIAP	26.1	11	7.5	30
14	329	Shivaji Nagar Depot	Andheri Station	20.2	11	2.2	9
15	510 Ltd	Barve Nagar	MIDC (Navi Mumbai)	27.8	7	1	4

Source: Planning & control Section -Traffic Department - BEST

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2.5.1 Performance of BEST Routes Operating on EEH

The performances of BEST Routes, which are operated on the Eastern Express Highway, are detailed at ***Table 2.14.***

Table 2.14 - Performance of BEST Routes Operated on EEH

Sr No.	Route	Earning Per day (Rs.)	Cost Per day (Rs.)	Classi-ficat-ion	CRI	No.of Passen-gers	L.F (%)	Passen-ger lead (kms)	Vehicle Utilisation (kms)
1	353	5,115	10,233	C	50	767	44	9.5	232
2	354	7,498	12,297	C	61	1056	51	10.3	297
3	368 Ltd	5,322	11,910	C	45	728	50	12.9	293
4	373 Ltd	6,468	11,661	C	55	918	64	14.0	283
5	27	6,462	10,916	C	59	1018	63	10.9	250
6	385	5,232	9,543	C	55	841	68	10.9	186
7	382 Ltd	5,037	10,336	C	49	760	49	11.2	221
8	388 Ltd	3,434	9,644	C	36	549	38	8.4	179
9	510 Ltd	5,030	10,119	C	50	713	63	13.2	214
10	BRTS-1	3,335	11,653	C	29	185	20	9.2	170
11	350	8,240	10,060	B	82	1512	60	5.8	199
12	366	6,673	9,225	B	72	1214	59	5.7	159
13	377	6,897	10,533	B	65	1207	49	5.9	211
14	399	7,420	11,042	B	67	1092	69	11.6	240
15	329	7,491	9,875	B	76	1215	80	9.0	187

Source: Monthly Statistical Review (Part II) of BEST for August 2008

2.5.2 Analysis of Routes based on Profitability (EEH):

The routes of BEST are classified into 3 Categories (A, B & C) based on profitability. The definitions of A, B, C are as follows:

A: Routes Operating at Profit
B: Routes Covering variable Cost and some portion of Fixed Cost
C: Route not covering even the variable cost

Out of the 15 routes operated on EEH, 5 routes belong to 'B' and the rest 10 routes belong to 'C' class. The analysis of Routes, operated on EEH is given at ***Table 2.15.***

Table 2.15 - Analysis of Routes based on A, B, C classification on EEH

Sl No.	Item Description	Category of Routes	
		B Class	***C Class***
1	Number of Routes	5	10
2	Passengers per Bus	1248	754
3	Passenger Lead (kms)	7.6	11.1
4	Average Route Length (km)	13.5	26.9
5	Vehicle Utilisation (km)/day	199	233
6	No. of Buses Operated	37	93
7	Cost Recovery Index (CRI) %	72	49

Source: Monthly Statistical Review (Part II) of BEST for August 2008

The following general observations may be drawn:

- Shorter routes have better profitability (Feeder Routes).
- Lesser Passenger Leads give better performance.
- More number of passengers per bus gives better performance.
- 33% of route belongs to B Class, while 67% are C Class.
- BRTS performance is poor compared to ordinary and limited services.
- Vehicle Utilization of B Class routes is lesser than C Class routes.
- Cost recovery index of B Class routes is much higher than C Class routes.

2.5.3 Review of Existing Bus Terminals on EEH

Bus terminals ensure quality of bus services to the customers. The present bus terminals of BEST which serve the bus routes operating on EEH are detailed at ***Table 2.16.***

Table 2.16 6- Bus Terminals Serving the Routes Operating on EEH

Sr. No.	Location	Buses	Routes	Trips	Depots	Details of Depots
1	Sion	84	6	376	6	ANK, BND, DH, DNR, MJ & MLV
2	Kurla Station (E)	88	15	886	2	ANK& SHD
3	Ghatkopar Station (E)	7	4	56	2	DNR & SHD
4	Ghatkopar Bus Station	41	5	162	3	DNR, GKD & MLV
5	Vikhroli Station	6	2	256	1	GKD
6	Kannamwar Nagar	14	2	97	1	GKD
7	MHADA Bus Station	8	2	34	1	MUL
8	Guwanpada	16	2	53	1	MUL

Source: Planning & Control Section – Traffic Dept.-BEST

Most of the Bus Terminals are having inadequate infrastructure facilities. The deficiencies include land, buildings, platforms, civic amenities, manpower and information to customers. There is a need to upgrade these facilities to provide reasonable quality of services.

The proposed BRT operations of EEH needs many of these terminals, as conventional buses which pass through these terminals, perform the role of feeder buses to the BRT System.

2.6 Existing operations of BEST on Western Express Highway (WEH)

Presently there are 48 BEST Routes involving 635 Buses which are serving 4.65 lakhs commuters per day on the Western Express Highway (WEH). Out of these 48 Routes, 7 Routes involving 93 Buses, only cross the Western Express Highway, (which means, no overlapping) while 41 Routes, involving 542 Buses over lap the BRT Route. The extent of overlapping of BEST routes on BRT corridor varies from 1 % to 100 %. The details of those BEST Routes and the extent of overlap are given at **Volume-II, Annexure II.1**.

The seven BEST routes which do not overlap the BRT corridor, but only cross the Western Express Highway are detailed at **Volume-II, Annexure II. 2.**

2.6.1 Over lapping of BEST Routes on BRT Corridor

The overlapping of BEST routes on the BRTS of Western Express Highway may be classified into 4 categories based on the extent of overlapping. The details of overlapping of various categories are as follows:

a. Extent of Overlap: Less than 2.5 kms or less than 10% of BRT.
Number of Routes: 11

Details of such Routes (Route numbers) : 459 Ltd; 209; 300; 400; 701 Ltd; 703 Ltd; 312; 330 Ltd; 255Ltd; 341 and 345.

b. Extent of overlap: Above 2.5 kms, but less than 7.5 kms i.e.10 to 30 percent of BRT.
Number of Routes: 13
Route Numbers of routes: 37, 91 Ltd, 181, 322, 523 ltd, 460 Ltd, 708 Ltd, 321 Ltd, 374 Ltd, 349, 488 Ltd, 398 Ltd and 489 Ltd.

c. Extent of over lap: Above 7.5 km, but less than 12.5 kms i.e., 30 to 50% of BRT.
Number of Routes: 10

Route Numbers of such Routes: 2, 35, 39,180, 226 Ltd. 461 Ltd, 524 Ltd, A-461, 709 Ltd & 309 Ltd.

d. Extent of Overlap: Above 12.5 kms,. i.e. above 50% of BRT Route
Number of Routes: 7

Route Numbers: 40 Ltd, 348 Ltd, 448 Ltd, 449 Ltd, 40 Exp. 225 and BRTS -2.

The extent of overlapping of the present BEST Routes on the proposed BRTS corridor, on WEH has implications for taking up Route Rationalization studies. Generally, as a matter of policy, if the overlapping is fairly high, such routes should be merged with BRT Route. Conversely, if the overlapping is insignificant, such routes may have to be continued as direct services. Whenever, routes are merged with BRTS Route, the need to operate “Feeder Routes” to be studied in detail, such that connectivity is maintained.

2.6.2 Performance of BEST Routes Operating on WEH

The performances of BEST routes, which are operated on the Western Express Highway, are detailed at **Volume-II, Annexure II.3**. The details include both Physical Performance (vehicle utilization, Load Factor, Passenger lead & number of passengers and Financial Performance (earning / bus / day; cost / bus / day; cost recovery index and classification of route based on profitability).

2.6.3 Analysis of Routes based on Profitability (WEH):

The routes of BEST are classified into 3 categories (A, B & C) based on profitability. The definitions of A, B, C are as follows:

A: Routes operating at profit.
B: Routes covering variable cost and some portion of fixed cost.
C: Routes, which do not cover even the variable cost.

Out of 41 Routes operated on WEH, 18 Routes (44%) belong to B class and the rest 23 routes (56%) belong to C class.

The analysis of routes operated on WEH is given at ***Table 2.17.***

Table 2.17 - Analysis of Routes based on ABC classification on WEH

Sr. No.	Item Description	Category of Routes	
		B Class	C Class
1.	Number of Routes	18	23
2.	Passengers / Bus/ day	1090	816
3.	Passenger lead (kms.)	10.5	11.5
4.	Average Route Length (kms)	24.6	28.5
5.	Vehicle Utilization/day (kms.)/bus	205	220
6.	Number of Buses operated	273	255
7.	Cost Recovery Index (%)	68	52
8.	Load Factor (%)	78	58

The following are the observations, on the above analysis:

- More number of passengers per bus gives better profitability.
- Lesser passenger leads, give better performance.
- Shorter routes have better profitability
- BRTS and AC services performance is poorer than ordinary or limited services.
- Vehicles utilizations of B class routes are lesser than C class routes.

- Load factor and cost Recovery Index of B class Routes is much higher than C class Routes.

2.6.4 Review of existing Bus Terminals on Western Express Highway

Bus terminals ensure quality bus services to the customers. The present bus terminals of BEST which serve the Bus routes operating on WEH are detailed at **Volume-II, Annexure II.4**.

Most of the Bus Terminals are having inadequate infrastructure facilities. The deficiencies include, land, buildings, platforms, civic amenities, manpower and information to customers. There is a need to upgrade these terminals to provide reasonable facilities to the customers.

The proposed BRT operations on WEH needs many of these terminals, as conventional bus services which pass through these terminals, perform the role of feeder buses to the BRT system. In addition to these, we need additional facilities on the BRT Corridor itself to provide integration of physical facilities with other modes like 2- wheelers, Autos etc. The existing BEST Bus terminals are shown in **Fig 2.1**.

Chapter 3.0
Delhi Bus Rapid Transit System
Ambedkar Nagar to Moolchand Corridor- An Evaluation

3.0 INTRODUCTION

Delhi has been experiencing rapid growth in population size and activity concentration. The population increased from 6.22mn in 1981 to 13.85 mn in 2001 and is forecast to increase to 23.49 mn in 2031. Consequently the travel demand within, to, from and through Delhi has increased phenomenally. In 2007, a total of 21.98 million passenger trips/ day were generated in the city out of which 14.36 million passenger trips/ day were vehicular. Simultaneously there has been an explosion of vehicle numbers in the city. From a low of 2.24 million vehicles in 1994, the vehicle numbers have exploded to 5.53 million in 2007. Consequently there has been an intense congestion and long delays in the movement of traffic. In response, the authorities have taken extensive transport projects, an important component of which is the proposed development and operation of a Multi Modal Public Mass Transport System (MMPMTS).

3.1 The Bus Rapid Transit System

The Bus Rapid Transit System (BRTS) has been envisaged as an integral component of the proposed MMPMTS which would include the Metro Rail, LRTS, Monorail, Tram System and the Bus system. The BRTS is proposed with many objectives – low cost compared to Metro / LRTS, appropriate with respect to demand, short gestation period, modernization of existing bus system, proved and successful in other cities of the world etc. In the enthusiasm it is also claimed that BRTS can offer same capacities as that of a Metro with much less costs.

3.2 BRTS Corridors

BRTS has been planned along 7 corridors of Delhi (Fig 3.1).Amongst them the corridor from Ambedakar Nagar to Delhi Gate has been selected for implementation as a pilot project. The corridor, of length 19.0 Km, starts at Ambedkar Nagar bus terminal along MB road, runs along Pushpa vihar road – Joseph Bronz Tito Marg - Lala Lajpat Rai Marg - Mathura Road - Bahadur Shah Zafar Marg ending at Delhi Gate. The road corridor is one of the main radial arterial roads. The corridor, in its run, inter-connects many use types starting with Ambedkar Nagar, a high density residential resettlement complex; Pushpa Vihar a central Govt. staff residential complex; Pushpa Bhavan a Central Govt office complex; Birla Vidya Mandir a major educational institute; Jahanpanah forest area, a green recreational area; Chirag Delhi an Urban village of historical importance; middle / high income group residential areas(Panch Sheel enclave, Lajipat Nagar Defense colony, Jungpara, Bapa Nagar etc.); a Major Hospital (Moolchand Hospital); Lajpat Nagar Market, which is transforming as a sub CBD; Jawaharlal Nehru Stadium, where important activities of the proposed Commonwealth Games 2010 are being held; the Cental Government office Complex; Lodi and Oberoi Hotels; the Zoo; Pragati Maidan Complex where trade and cultural fairs are held on a regular basis; the Indraprastha Estate Office complex; the Jaya Prakash Narayan hospital and Ferozeshah_Kotla stadium venue of the Cricket and Football matches. Delhi Gate is one of the entry points to the historical CBD (Chandini chowk - Sardar Bazar) of Delhi. The corridor in its run crosses the Outer Ring Road at Chirag Delhi, Mahatma Gandhi road (Middle Ring Road) at Moolchand and Inner Ring Road at Lodi Hotel. Thus the corridor interconnects a variety of activities and is expected to be a high intensity travel corridor. (**Figure 3.1)**

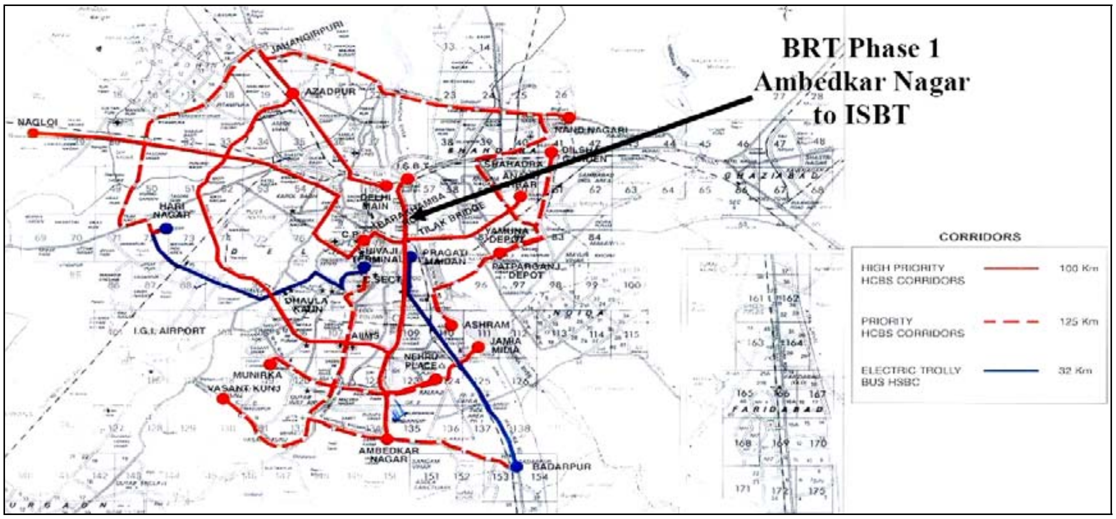


Figure 3.1: BRT Corridors in Delhi

The Corridor in general has a right of way of 45 m. The carriage way generally is of 6 lanes, divided. It is already a high intensity travel corridor.

It was not possible to have access to Pre Feasibility and Detailed Project Report (DPR) of the BRTS Project. Media reports indicate that there was no DPR prepared and the project was sanctioned and taken for implementation perhaps based on a Conceptual Note. Hence it is difficult to evaluate the outputs / outcomes of the project against pre- established bench marks. The present study is based on a few limited surveys carried out.

The brief details of important characteristics of Delhi BRTS with regard to BRTS Lane Configuration, Bus Lane Pavement, Bus stop, Intersection Signal Control, Signage, Bus Shelter, Lighting, Lane Markings and Coloring, Drainage, Other Features, Operating System, Service Pattern, Feeder Services, Vehicle Technology, Fare Structure, Ticketing, Enforcement, Traffic Management, Safety, Impact is listed in **Appendix 3**

3.3 Impact

As the BRTS corridor is half built, it is not fair to evaluate the impact at this stage. It is also difficult as no bench marks seem to have been established pre implementation. However some trends could be assessed to learn lessons. Some important impacts / outputs are discussed below.

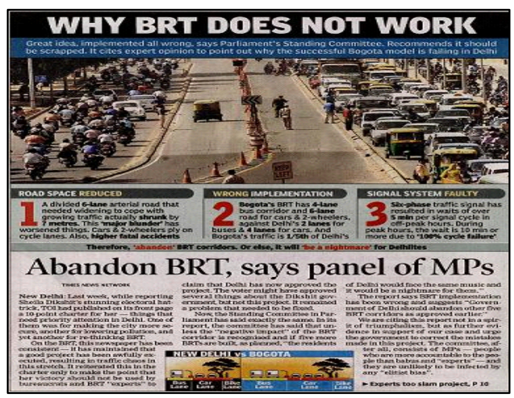
Capacity Augmentation: Increase in bus system capacity is a basic objective. In Delhi BRTS project no capacity augmentation has been achieved. On the other hand there may have been a reduction in the capacity. This is due to the fact that no rationalization of bus service pattern and schedules have been made by the operating agencies.

Bus Productivity: An important objective is to increase the productivity of the Bus system. For example increased speed and minimization of delays should lead to increase in vehicle utilization resulting in higher capacity, more revenue, etc. However due to absence of any rationalization of services, translation of any bus trip time saved into higher productivity has not been achieved. It is important that the service operator is fully involved in the system planning, design, operation and management. The only beneficiaries of trip time savings, if any, are the crew with increased lay over time and the bus passengers.

Modal shift: No modal shift on to the public transport (BRTS) from private modes seems to have taken place. Perhaps the stage is immature to assess this impact.

User Benefits: The only benefit to BRTS user is probably reduction in trip time. However even that seems to be in doubt as BRTS buses also suffer long delays at intersections due to poor control and management.

Impact on non – users: The major impact on non-BRTS users are highly negative. The private and other vehicles mode users along the corridor suffer acute congestion and long delays. In a short stretch from Khanpur to Kendriya Vidyalaya the delays during morning and evening peaks are 15.83 minutes and 7.12 minutes. From Kendriya Vidyalaya to Khanpur the delays during morning and evening peaks are 11.46 inutes and 11.87minutes. This has caused intense unrest and opposition to the BRTS. This is reflected in the negative coverage in the media. The Parliamentary Standing Committee on Surface Transport has highly criticized the BRTS and has recommended abandonment along the other proposed corridors.



WHY BRT DOES NOT WORK

Great idea, implemented all wrong, says Parliament's Standing Committee. Recommends it should be scrapped. It cites expert opinion to point out why the successful Bogota model is failing in Delhi

ROAD SPACE REDUCED
1 A divided 6-lane arterial road that needed widening to cope with growing traffic actually shrunk by 7 metres. This 'major blunder' has worsened things. Cars & 2-wheelers ply on cycle lanes. Also, higher fatal accidents

WRONG IMPLEMENTATION
2 Bogota's BRT has 4-lane bus corridor and 6-lane road for cars & 2-wheelers, against Delhi's 2 lanes for buses & 4 lanes for cars. And Bogota's traffic is 1/5th of Delhi's

SIGNAL SYSTEM FAULTY
3 Six-phase traffic signal has resulted in waits of over 5 min per signal cycle in off-peak hours. During peak hours, the wait is 10 min or more due to '100% cycle failure'

Therefore, 'abandon' BRT corridors. Or else, it will 'be a nightmare' for Delhiites

Abandon BRT, says panel of MPs

TIMES NEWS NETWORK

New Delhi: Last week, while reporting Sheila Dikshit's stunning electoral hat-trick, TOI had published on its front page a 10-point charter for her — things that need priority attention in Delhi. One of them was for making the city more secure, another for lowering pollution, and yet another for re-thinking BRT.

On the BRT, this newspaper has been consistent — it has maintained that a good project has been awfully executed, resulting in traffic chaos in this stretch. It reiterated this in the charter only to make the point that her victory should not be used by bureaucrats and BRT "experts" to claim that Delhi has now approved the project. The voter might have approved several things about the Dikshit government, but not this project. It remained a problem that needed to be fixed.

Now, the Standing Committee in Parliament has said exactly the same. In its report, the committee has said that unless the "negative impact" of the BRT corridor is recognised and if five more BRTs are built, as planned, "the residents of Delhi would face the same music and it would be a nightmare for them."

The report says BRT implementation has been wrong and suggests "Government of Delhi should abandon other five BRT corridors as approved earlier."

We are citing this report not in a spirit of triumphalism, but as further evidence in support of our case and urge the government to correct the mistakes made in this project. The committee, after all, consists of MPs — people who are more accountable to the people than babus and "experts" — and they are unlikely to be infected by any "elitist bias".

NEW DELHI vs BOGOTA
Bus Lane | Car Lane | Bike Lane | Bus Lane | Car Lane | Bike Lane

► Experts too slam project, P 10

Impact on NMVs: The NMV mode users

were supposed to be greatly benefited by exclusive lanes /paths for safe and convenient use. In fact, in the early stage, this was identified as a major benefit. But over a period of time, the 2- wheelers, Auto rickshaws and sometimes even cars have encroached on to the cycle lanes and footpaths resulting in a high risk and unsafe condition. This is unfortunate in that it was claimed that BRTS provides equitable distribution of road space amongst different components of road users. Though traffic management and enforcement are important to prevent misuse, design of physical elements is also important to prevent the possibility of misuse.

Environmental Impact: As all bus and other commercial vehicles in Delhi run on CNG, the positive environmental impact of BRTS may be nil. On the other hand the long delays for other vehicular modes and their idling at intersections have resulted in more intense pollution. Unfortunately there are no measurement pre and post BRTS operations. On the overall one may conclude that the environmental impact is negative.

Impact on safety: Safety has been a major casualty along the corridor. It calls for strict observance of all aspects of design; operation and management of the system .Adhoc interventions are deleterious to system health.

Impact on system abuttor: It is too early (as the corridor is only partly operational) to assess impact on system abuttor. Generally they should be happy as it would increase their accessibility. However they may find the entry and exit to the premises restrained due to the system. This is particularly so for educational institutes along the corridor.

3.3.1 Media Perception

The Delhi BRTS has received mixed reaction by the media. Mostly it is negative. Times of India has been consistently opposing and termed it as Big Road Trauma System. To be fair it has called it as a 'good concept badly implemented'. TOI has been consistently criticising the way BRTS has been designed and implemented without taking reasonable care of the non- bus modes which account for almost 95% to 98% of

Chaos forces schools to relax timings

TIMES NEWS NETWORK

New Delhi: School students suffered delays yet again on Tuesday with the BRT mess far from over. While some students had to alter their routine and leave early in the morning, others made sure they took an alternative route to reach school on time. Given the situation, even the schools had to relax their timings and allow the late-comers in.

"We have given our students a leeway of as much as 25 minutes. BRT is badly affecting the students. Even today, they were late by 10-15 minutes. The timings of school buses can be monitored but we have advised those coming on their own to take different routes," said Bharti Sharma, principal, Amity International, Saket.

She added that most school buses coming from Kalkaji, Greater Kailash and Alaknanda could not reach school on time. "I come to my school in Saket from GK II every morning. It is like next door but I have to come via Malviya Nagar to avoid getting stuck in the BRT jam. Even the students get tired standing in the jam. But what can't be cured has to be endured. So our students have been advised to carry reading material to utilize their time," Sharma said.

At Bluebells International School, East of Kailash, students, staff members and guests reported late for a function being held in the school. However, as BRT seems to be a long-running trouble, schools are now thinking of devising plans to fight the mess. "BRT is causing delays but we cannot allow the students to come late everyday. Coming late is no answer to this problem. The culture of discipline has to be inculcated in the students. We will have to discuss this with students and parents to decide how BRT mess can be avoided," said school principal, Suman Kumar.

Though no complaints were received from students in Gyan Bharti School at Saket, the principal said that most students were saved from delays as they were provided bus service by DTC plying on routes other than BRT. "We have only one bus covering the BRT route that too only for over a kilometre. So we were saved from the mess on Tuesday," said R C Shekhar from Gyan Bharti School.

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LATE RUN: Students have altered their routine to reach school early

BRT bust, fiasco continues

Cabs Let Into Bus Lane As Govt Gets Desperate

FREE FOR ALL: Autos, cars and two-wheelers piled on the bus lane on Tuesday, but it still didn't speed up traffic

BIG ROAD TRAUMA

FULL COVERAGE: P 2

MPs cut across party lines to blast scheme

TIMES NEWS NETWORK

traffic volume. Mr. Chandan Mitra, editor of 'The Week' and Member of Parliament in his speech in the Parliament called for scrapping of the BRTS.

3.3.2 NGO's Perception

A few NGOs, active in the area of environmental protection, have been arguing in support of the BRTS. They look upon it as a significant step in the promotion of development of public mass transport system, a professed component of the National Urban Transport Policy of the Government of India. The Centre for Science and Environment (CSE) has strongly supported the system. CSE carried out an opinion survey and have published the report on their web site and in their publication 'Down to Earth'.
The Institute of Urban Transport (India) (IUT, India) has lent active support to BRTS. It organized an International Conference on Urban Mass Transport Technologies, in which BRTS was strongly propagated.

3.3.3 Government Perception

The GOI (Ministry of Urban Development) strongly advocates the BRTS in general. Their explicit policy support through NUTP and financial assistance through JNNURM has resulted in a large number of cities taking up planning of BRTS. Most of them are still in the planning stage and has to wait for system operation. Ministry of Urban Development, GOI has organized a number of workshops to promote the concept of BRTS in Indian cities.

The Govt of NCTD has been an ardent proponent of BRTS of Delhi. In fact it took upon itself the implementation of the project through a special SPV called Delhi Integrated Multi Modal Transport System (DIMTS). The Delhi BRTS project is owned and funded by DIMTS. However, DIMTS has limited role to road re-engineering. Bus operation is left to existing operators (DTC & private operators)

3.4 The Present Scenario

The report of the Panel of Members of Parliament is a big challenge to Delhi BRTS. It is reported that major changes in the system elements for the Second_Phase extension of the corridor from Moolchand to Delhi Gate have been incorporated. The bus lane placement has been shifted from median side to kerb side. The physical barrier between bus lane and other modes lane is given up and is replaced by paint marking. Nothing much is talked about other elements. The result is in fact there will be no difference between BRTS corridor and other bus routes. BRTS has only remained in name but has lost both in form and substance.

3.5 Gainers & Losers

Who are the gainers and losers of Delhi BRTS?
Gainers are

- Bus Drivers (Smooth Driving)
- Crew of Buses (More rest time)
- Passengers (supposed saving in travel time)
- Marshals (Who got jobs for doing nothing)

Losers are

-Non bus users
-System abuttors
-Hawkers
-Road users,
-pedestrians and NMV mode users
-The city (environment)

3.6 Why Delhi BRTS not very Successful?

There are many reasons why Delhi BRTS has not been as successful as it was made out to be. Some of the reasons are:

3.7 Inadequate Preparation

Delhi is a bus based city. Before introducing BRTS it was important that the basic bus system was rationalized and brought to certain level of development and satisfactory level of service. With more than 800 routes operating, Delhi's bus operation is full of confusion and conflicts. If the Direction Oriented Nodal system of operation was reinstated and strengthened, then it would have been easy and successful to convent Node-to-Node services onto BRTS. It was a surprise revelation that no feasibility report or DPR was prepared before start of implementation.


THE TIMES OF INDIA, NEW DELHI
SATURDAY, DECEMBER 20, 2008

THE TIMES OF IDEAS

A THOUGHT FOR TODAY

But we need to take the first 10 steps before taking the 11th one, including... public transport.

N RANGANATHAN, transport planner

Hard Drive

Curbs on private ownership of vehicles unviable without adequate public transport

Under the national action plan on climate change being prepared by the urban development ministry, the mission on sustainable habitat has made several recommendations in order to check the growth of private vehicles in Indian cities and boost public transport. The goal is to reduce greenhouse gas emissions from vehicles which, the mission warns, could increase by 580 per cent by 2035. But while the motive behind the proposal is laudable, pushing public transport as an alternative to private transport will be difficult when there is abysmally poor public transport in most Indian cities.

Sure, the sheer volume of new vehicles being added to roads every day needs to be checked. The growth of registered vehicles has been four times the rate of growth of the population in Delhi, Mumbai, Hyderabad, Ahmedabad, Bangalore and Chennai. Oil consumption by vehicles is slated to increase by 600 per cent in the same period. That's why the government's proposals concentrate on making it more expensive for people to own and drive cars. To that end, the plan seeks to impose a congestion charge on vehicles for entry into busy areas. There is also a proposal to make the parking fee reflect the cost of land, while bringing in differential parking rates.

But before penalising people for turning to private vehicles, the government must provide a clean, efficient and well-connected public transport system, which would include local trains, the metro and buses. Most of the ideas proposed by the mission are hardly revolutionary, though some, such as the one requiring prospective car buyers to demonstrate ownership of a parking spot before purchase, appear unenforceable. Indeed, measures like congestion tax and differential parking charges have been implemented with some success in cities such as London and Singapore. However, both those cities had well-developed and efficient public transport systems in place before they charged people for driving cars to get to work.

The recommendations are typical of urban planning in this country, which has tended to be myopic. As it is, these measures will disrupt public life far more than they will solve traffic blues. If implemented now, these measures will only force people to spend more on purchasing and running a private vehicle. It is unlikely to discourage people from buying cars. Until public transport systems in cities are improved, it is unlikely that there will be a slowdown in the growth of private vehicles. Vehicular emissions are a cause for concern in the fight against climate change. But the government cannot seriously begin to reduce emissions without first putting the infrastructure in place to make it possible for people to give up their cars.

Supply This Demand

Give consumers lower oil prices and lower interest rates

You don't hit an economic crisis-impacted world when it's down. If the Organisation of Petroleum Exporting Countries understood that, it would win hearts. But, since October, the 13-member body has tried to stem an oil price slide that's actually helping the world cope with its economic troubles. We understand OPEC's nostalgia about the July price

3.8 Pilot Corridor Selection

The pilot corridor selection was ad-hoc and did not form part of a conceptual network. The traffic intensity was high with the bus system already carrying about 18,000 to 20,000 pphpd. The other modes traffic was intense and sudden reduction in road capacity for their movement was bound to cause problems, resentment and reaction. Perhaps the corridor was selected as it had a right-of-way of 45m and provided ease of construction.

3.9 Non Involvement of Stakeholders

There was not much transparency in the decision of implementation of BRTS along the pilot corridor. Even the most important stakeholders viz DTC, Private Bus Operators and Traffic Police were not involved. DTC, who should have been the lead advocate for BRTS was indifferent. Delhi Traffic Police, right from the start, had clearly expressed their reservations about the BRTS and opposed the very idea. Many other stakeholders were also not involved including the professionals who had reservation and did not support the concept whole heartedly.

3.10 Absence of Traffic Management Plan

No Traffic Management Plan identifying improvement to alternate routes to divert traffic from the corridor, intersection control, signages etc were in place to regulate traffic during construction and operation. One guess estimate puts that about 5000 PCUs got diverted. This resulted in bottlenecks and delays along other routes leading to general resentment. No alternate parking management plans were in place to regulate on-street parking along the corridor.

3.11 Absence of Enforcement

Jaywalkers' free run continues

Cross Road At Will, Jump Over Railings In Chaos Corridor

TIMES NEWS NETWORK

New Delhi: A day after a traffic marshal and a woman were killed in accidents on the pilot Bus Rapid Transit (BRT) corridor, the ground situation on the stretch between Ambedkar Nagar and Moolchand remains dismal. The under-trial corridor remains to be a death trap for road users, especially pedestrians, as people continue to cross the main road at will and jump over railings to cross the busy road.

The areas around the bus stops, between Sheikh Sarai and Madangir, seem to be the most vulnerable as very few people use the zebra crossing to reach the bus stops. "Most of the people cross the road from the middle and walk through the bus lane to reach the bus shelter. The woman who lost her life at this crossing yesterday also came through like this. We try stopping them but they get aggressive," said Jaseem Khan, a traffic marshal posted at the Sheikh Sarai stop, who witnessed one of the accidents.

BIG ROAD TRAUMA

DESPERATE MEASURES: Lax enforcement encourages pedestrians to jump over railings on the BRT stretch

Due to lack of facilities, and now no enforcement either, there is absolutely nothing that stops pedestrians from jumping over the yellow railings meant to stop jaywalking. A Hanuman temple at Madangir is a pertinent case in point where one person can be spotted jumping over the railings almost every second. A zebra crossing has been provided at a distance but no bothers walking the distance just to cross the road.

The average speed of buses is high and drivers maintain that manoeuvring the buses through the narrow lanes is a tough task. "It is difficult to save the bus from hitting the bus shelters and people insist on hanging from the footboards, however hard we try. As there are very few policemen now, the situation is getting worse," said Rupesh Kumar, who drives a mini bus on the stretch.

After Monday's accident, marshals posted at bus shelters to discipline bus users have also become very insecure and worry about their life.

toireporter@timesgroup.com

NO LANE SENSE: It's evident at Sheikh Sarai marshals are not doing their job

The good idea of providing dedicated space for pedestrians and NMV's got lost with intrusions of motorized vehicles on to these lanes. This has resulted in higher risk to pedestrians and cyclists. In addition, hawkers have encroached on to the space. Jay walking of people along the bus lanes persists. Enforcement along the corridor is virtually absent. Marshals are inefficient and incapable. Traffic police are conspicuously absent.

3.12 Poor Intersection Control

In a road network intersections are the major bottleneck points causing delays. Redesign of intersection control system including modern technology, ITS was critical. Intersection delays to both buses and other modes have been extremely long and frustrating. They are the main cause for the antagonism to BRTS by the general public and media.

3.13 Absence of Passenger Information System

The important sub-system of BRTS is real time Passenger Information System. This has not been designed and put in place. Even the bus stops by routes have not been specified with the result passengers run from one stop to the other, illegally crossing the bus lane.

CCTVs to give real-time info on BRT traffic snarls

Megha Suri | TNN

New Delhi: In a month's time, you will be able to log on to the internet to see real-time photographs of all the intersections on Bus Rapid Transit (BRT) corridor to guage the extent of traffic jams and choose your route accordingly.

In what comes as a first of its kind experiment for Delhi drivers, those using the road stretch will get an idea of the congestion levels at all intersections simply at the click of a mouse button. The Passenger Information System (PIS), which will enable the service, has been developed by transport department Special Purpose Vehicle (SPV) Delhi Integrated Multi Modal Transit System (DIMTS) and is being tried out on the BRT corridor to start with.

"A tender has already been awarded for installation of CCTV cameras at all the intersections, which will gather real-time information to be posted on the internet. The system will be updated every 30 seconds and commuters can use it to plan their journeys," said SN Sahai, managing director, DIMTS. The webpage can be access through a link which will be provided on the DIMTS website www.dimts.in.

The government is expecting that the system will also help bring down congestion levels on the corridor, as people will be able to stagger their journeys after assessing the data.

The website also has a link where the location of all the new Delhi Transport Corporation (DTC) buses is plotted on a Delhi map to enable commuters to ascertain the exact time when a particular bus will reach the desired bus stop. The movement of each bus, along with the registration number and route, is also updated on a 30 second basis. To make this possible, over 120 buses green and red low floor buses have been fitted with Global Positioning System (GPS) and connected to a centralised control room where the current location and movement of every bus can be tracked.

The GPS data has been used to create a PIS for bus commuters. On the website, one can access bus stop wise data on which bus routes will cross the stop and the time taken to reach. Commuters can also see the real-time movement of all the GPS-fitted buses. The website will also have a community for car pool users, where people can get together and find others taking the same route so that the number of cars headed to the same destination can be reduced.

DIMTS is also in the process of coordinating with a UK-based firm to set up a Incident Management System on the BRT corridor, where road users will be able to access data about road blocks caused by vehicle breakdowns or waterlogging on the internet and also on LED screens put up across the corridor.

megha.suri@timesgroup.com

Anindya Chattopadhay

CYBER SOLUTION: Those using the BRT will get an idea of the congestions at click of a mouse

3.14 Incompatibility of Buses

The design of physical elements and the buses permitted along the corridor are not compatible with the "Open" system followed. There has been a variety of buses moving along the corridor. With people hanging out of private buses (as their doors do not close) there is a high probability of injury to the passengers. Occupancy of bus stop space by non-city service bus or other vehicles adversely affect the BRTS buses.

3.15 Absence of Brand Image

Brand image is important to promote positive reaction amongst users and general public. Introduction by DTC of low floor green buses for general service and red buses for AC bus services had created a favorable image. However as the services were not specific for BRTS, it did not gain any advantage. With the "Open" system what little image left was also lost.

3.16 Lessons Learnt and corrective measures

A number of lessons could be learnt from Delhi BRTS (Pilot Project). They are:

- Take the first 10 steps before taking the 11th.
- Avoid adhocism. Have a long range vision and a comprehensive plan
- Be transparent. Involve all stakeholders from the beginning. Strive for consensus.
- Do not compromise on system fundamentals.
- Proper implementation of all component parts of the system is important.
- Road re-engineering is only a starting step. Bus service planning is important to translate benefit on to system productivity and user satisfaction.
- Establish appropriate, capable and accountable institutions for planning, development, operation and management of the system. 'Academic Experts' and 'Consultants' have partial interest and are not accountable.
- Build System Image and public opinion
- Have an advocacy program.

Appendix 3

1 BRTS Lane Configuration

In the Delhi BRTS, bus lanes have been placed at the centre along median side. 2 lanes of 3.3 m each have been planned. A broad based rumble strip divides the two directional lanes. The bus lanes are segregated from the other modal traffic by a narrow Kerb barrier of 0.6m width. The design of these barriers enables a bus to mount it and move onto general traffic lane and discourage other vehicles to mount and move onto the bus lane. But in practice it is observed that other vehicles, particularly two wheelers mount the barriers and move onto the bus lanes.

For some length railing along the barrier has been provided to prevent pedestrian entry into bus lanes. However for other lengths the railing has not been provided.
A special feature of the physical design of the roadway is the provision of foot paths and cycle tracks on either side. There is a conscious effort to recognize the needs of non- motorized, vulnerable modes and provide space for them. These facilities are segregated from vehicular lanes by physical barriers.

For the vehicles other than the buses, only two lanes of 3.3m in each direction has been provided. Perhaps this has proved to be the *Achilles heel* of the system. The traffic volume is too heavy and capacity too inadequate resulting in heavy congestion, long queues and long delays to the non bus modes.

While 2 lanes have been provided for BRTS buses, no passing lanes have been provided. This has constrained operational planning flexibility.

The cross-sectional dispensation of road space for different components of traffic is presented in **Fig 3.2**.

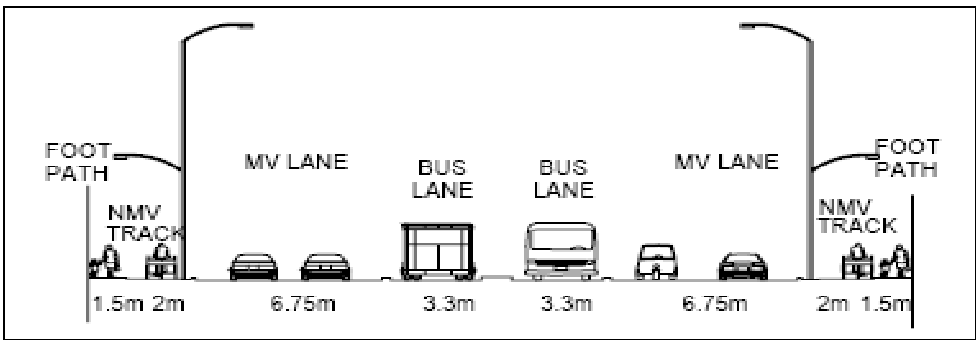


Figure 3.2: Typical BRT Crossection

2 Bus Lane Pavement

Rigid pavement for the first phase section of the corridor has been adopted. However for the subsequent sections flexible pavement has been adopted.

Traffic signals on the blink

Chaos At Big Crossings; Construction, Slow Repair To Blame

Megha Suri & Sapna Verma | TNN

New Delhi: If you have been increasingly getting stuck at chaotic intersections where traffic signals aren't working, you can blame the frenzied construction work in the city, delayed repairs and general indifference of the authorities for your plight.

Times City went around the city to find traffic lights not functioning at some major intersections like the Munirka crossing on Outer Ring Road, Janpath-Rajpath crossing and Khooni Darwaza signal on Bahadurshah Zafar Marg, to name just a few.

At Munirka, a flyover is being constructed and the main traffic light controlling movement of vehicles from Vasant Kunj and Vasant Vihar to Outer Ring Road has been out of order for over a month now. The result is complete chaos as vehicles land at the main crossing from all sides and end up in a gridlock.

Making the situation worse are barricades erected in the middle of the road due to which traffic coming from one side is not visible from any other arm of the crossing. According to the police, accidents at this spot are common but go unreported.

Commuters are outraged at the apathy of the traffic police. Said businessman Sohail Khan: "I deal in electronics and can assure you that repairing a traffic light can't possibly take more than a few hours. If signals like these are not working for days, it's obviously because of negligence and lack of accountability."

Others say that such chaos is a major cause for frayed tempers and even road rage. "When a traffic light conks off, everyone is everywhere. I encounter this problem daily and have often got into fights with other drivers," said Asha Raman, a lawyer, at the Janpath-Rajpath crossing.

One major reason for the problem, claim traffic police sources, is that they have recently cracked down on agencies responsible for maintenance of these signals as they were giving inflated bills for repairs and there were instances of faulty cables being used. To check this, a new system has been put in place. A cop goes to inspect the fault and only after due approvals are repairs carried out. Some faulty cables are also being sent for random quality checks.

Wherever there is a cable fault, it takes about 2-3 weeks for repairs. The fault is first inspected and a detailed estimate is prepared and sanctioned by the department. After this, repair work can take 7-10 days. This smacks of red tape. Why should the procedure take so long?

There are about 1,190 traffic signals and blinkers in the Capital of which about 80 are claimed to be out of order. About half of these signals are installed on roads where construction activity is on. "At such places, the signals are switched off because the utilities need to be shifted.

Depending on the traffic volume, the traffic is managed by either the police or marshals appointed by the construction agency," said an officer. Officials claim there has been no sharp increase in the number of non-functioning signals.

"A number of measures are being initiated to improve the signalling system in the city, including getting the maintenance agencies to improve preventive maintenance like regular cleaning and inspection of signals to reduce breakdowns. Over-invoicing is also being monitored closely and the number of signals in the city is being increased," said S N Shrivastava, joint commissioner of police (traffic).

NO GUIDING LIGHTS: Car drivers jump the lights due to non-functioning signals at Janpath (above), Bahadur Shah Zafar Marg crossing (below right) and Munirka crossing

3 Bus Stop

Bus stops are important component of the physical features of the BRTS. In the Delhi system bus stops are located near the intersection on the near side. The platforms are of 400mm height, to be in line with the low floor buses, 3m wide and 50m long to enable simultaneous boarding / alighting from two or more buses. At major bus stops 2 parallel stop lanes with platforms have been provided.

The main objective of locating bus stop near the inter section is to combine bus stop delay and inter-section delay and thereby minimize lost time. But this objective has been lost due to the long cycle time of the signal system. If the bus is not ready to move during the green phase then it has to suffer long delay.

4 Intersection Signal control

Fixed time signal control system has been adopted. The signal cycle time is generally of 160 sec. No prioritization for buses or inter-linkage of signals along the corridor has been made. Inadequate intersection geometrics and control system has resulted in long queues and delays to the general traffic. During peak period the queue length extends over 600 – 700 m and over laps with the previous intersection. The vehicles would need to wait for 5 to 6 cycles before clearing the inter section.

5 Signage's

There has been a major effort to provide good and adequate signage system along the corridor. Apart from road traffic control signage's as prescribed under MV Act 1988 and IRC guidelines, a number of signage for bus users have been provided. Signage include both by side of traffic lanes and overhead gantry.

6 Bus Shelter

Bus shelter designs are functional and aesthetic. The component elements are of stainless steel, which though initially costly, would be easy to maintain and clean and would be long lasting .Railing has been provided to control and guide the passengers. However gaps along them tend to encourage the passenger to cross the bus lanes at unauthorized locations.

The narrow bus lanes at bus stop, provision of railing and hanging out of passengers at the doors of buses due to over crowding has resulted in unsafe condition. Accidents have happened with passengers hitting the railing and getting injured.

Bus stop and shelter design does not facilitate off board ticketing and potential for introduction of One Man Operation (OMO).

7 Lighting

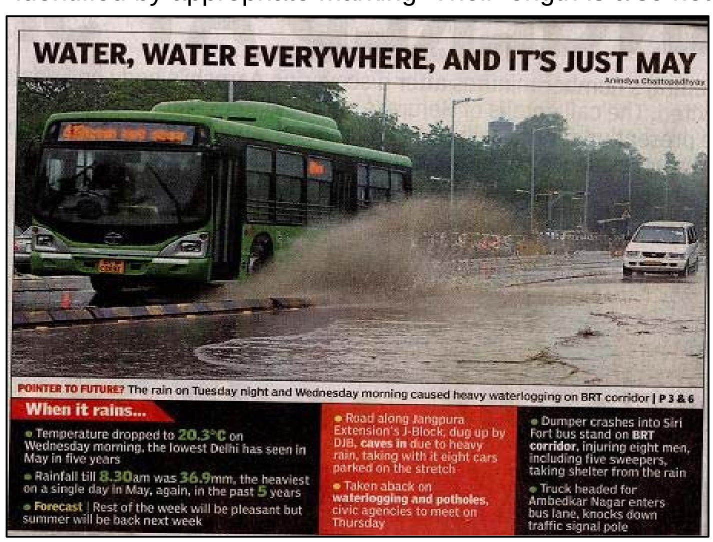
The BRTS corridor is well lighted. There are additional lights for footpath and NMV lanes.

8 Lane Markings and Colouring

Lane marking along the corridor is good and clearly visible. However merging and diverging areas are not well identified by appropriate marking. Their length is also not adequate leading to potential conflict points.

9 Drainage

Drainage of bus lanes has not been given adequate attention. Fortunately rains in Delhi are of low intensity and for a short period. However when it rains it pours causing traffic disruption.



WATER, WATER EVERYWHERE, AND IT'S JUST MAY

POINTER TO FUTURE? The rain on Tuesday night and Wednesday morning caused heavy waterlogging on BRT corridor | P 3 & 6

When it rains...

- Temperature dropped to 20.3°C on Wednesday morning, the lowest Delhi has seen in May in five years
- Rainfall till 8.30am was 36.9mm, the heaviest on a single day in May, again, in the past 5 years
- **Forecast** | Rest of the week will be pleasant but summer will be back next week
- Road along Jangpura Extension's J-Block, dug up by DJB, **caves in** due to heavy rain, taking with it eight cars parked on the stretch
- Taken aback on **waterlogging and potholes**, civic agencies to meet on Thursday
- Dumper crashes into Siri Fort bus stand on **BRT corridor**, injuring eight men, including five sweepers, taking shelter from the rain
- Truck headed for Ambedkar Nagar enters bus lane, knocks down traffic signal pole

10 Other features

Entry from side roads are raised with stone pavement to reduce speed and enable turning vehicles to enter the left most lane and then merge with the main traffic.

11 Operating system

An 'Open' system of operation is presently followed. Buses of all types are allowed access to bus lanes. Fortunately most of the buses along the corridor cater to intra city trips. Emergency and police vehicles are permitted to move along the lanes. A tendency of other vehicles, including private cars, entering and running along the bus lane is observed.

12 Service Pattern

Presently 'direct 'service pattern is followed. Buses starting off the corridor enter the corridor and after getting out end at different locations.

13 Feeder Services

There is no feeder service operation

14 Vehicle Technology

DTC operates low floor bus (60 % 400mm) with many technological features. The normal service buses are green in color. AC buses are red in color. However these are not exclusive BRTS Branded buses. Such buses are operated along other non BRT routes. Private buses operating along the corridor do not confirm to DTC bus specification. This mix has resulted in denying the system a brand image.

15 Fare structure

The fare structure is the same as general bus fare structure in Delhi. No special fare system has been adopted.

16 Ticketing

Ticketing is on board. Modernization including introduction of smart cards, off board ticketing etc have not been introduced.

17 Enforcement

'Marshals' have been employed to 'control 'and 'guide' vehicles and passengers in the use of the system. However they lack 'skill' and 'authority'. Surprisingly enforcement by traffic police seems to be absent. Many violations and misuse like movement of motorized vehicles on NMV lanes and footpaths, movement of private cars on bus lanes, encroachment of footpaths by hawkers etc are observed.

18 Traffic Management

No traffic management plan seems to have been prepared considering a network system including the BRTS corridor .Apart from reengineering of the corridor road cross section, improvements of other roads in the network have not been made to take care of traffic diversions. Some guesstimate puts it that about 5000 PCU's have got diverted from the corridor. The adverse impact is felt on other roads where congestion has increased and delays at intersections have mounted. Ad-hoc attempts at spot solutions like median opening, turning restriction etc are attempted. Intersection control and management along the corridor is poor leading to adverse reaction. Parking management along the corridor is lacking.

19 Safety

Unfortunately Delhi BRTS is saddled with poor safety record giving the system. opponents a good handle to beat the system. A number of accidents, including fatalities, have taken place along the corridor sullying the system.

THE TIMES OF INDIA, NEW DELHI
WEDNESDAY, APRIL 9, 2008

TIMES CITY

Another BRT mishap leaves three injured

TIMES NEWS NETWORK

New Delhi: In what comes as yet another accident in the Bus Rapid Transit (BRT) corridor, a 25-year-old cyclist was severely injured after being hit by a speeding Maruti Esteem on JB Tito Marg in south Delhi late on Monday night.

According to the police, the car (DL 6C 5306) was speeding through the MV lane of the corridor at around 12.15 am. Just as it crossed the main GK-I signal, the driver lost control of the vehicle and hit the cyclist, who was also on the same road. The impact of the accident was such that the cyclist, later identified as Prem, got thrown into the air to land some 15 metres away from the spot of accident.

The car, meanwhile, hit an electric police and came to a standstill. "A couple seated in the car were also injured and taken to AIIMS trauma centre. They are out of danger. A case of causing hurt and rash driving has been registered against them at the Hauz Khas police station, but they are yet to be arrested. The vehicle has been seized," said a police official.

The police maintained that the injured are all out of danger and the car driver was not under influence of alcohol. But investigations are still on to ascertain the exact sequence of events and details of the driver.

toireporter@timesgroup.com

COLLISION COURSE: After hitting the cycle, the car rammed into an electricity pole

TIMES CITY | KILLER WHEELS

BRT claims another life: Woman run over by bus

Pedestrians most at risk here

Chapter 4.0
BRTS - Review of International Experience

4.0 INTRODUCTION

To guide and enable rational decision making in the planning, design, operation and management of the Mumbai BRTS, a review of the features, vehicle technology, stop and interchange facilities, control systems etc. of the operating BRTS in a few international cities was undertaken. The case studies included Beijing BRT, Curtiba BRT, and York BRT (Canada). In addition the feature of a number of other BRTS was also studied. A working paper on Review of International Experience was submitted. The working paper included 2 parts - one a report on the features of the BRTS in the selected case study cities and the other an appreciation of the planning and design of the principal components of BRTS in various cities. The appreciation report is presented identifying some of the problems confronted by the owners, designers, and operators of BRT networks to aid the Planning, Design and Operation of Mumbai BRTS.

This chapter has been structured to follow key themes that we consider are likely to be of greatest importance and interest. These themes are:

- Planning Processes
- Design Components
- Marketing and Mode Shift
- Control, Management and Standards
- Ticketing, Fares and Validation
- Implementation Strategy

4.1 Planning Processes

4.1.1 Government Commitment/Support

Successful planning depends on the effectiveness of the decision makers. In Curitiba, Bogota, Guayaquil and Jakarta the mayor (or another political leader) had a clear vision for better public transport. Therefore planning for implementation received priority and development cycles were short, at least for the initial phases of implementation.

In contrast Leon and Santiago BRTS leadership decision making was not decisive meaning that planning did not receive a high priority and project implementation took several years.

Delays in implementation results in loss of public confidence and also in escalation of the budget cost. An important consideration is that during the construction phase a traffic lane will be removed from use and will lay idle until commissioning of the system. This causes frustration amongst road users who will be experiencing increased congestion/delays. The temptation for road users to enter the completed (but not implemented) sections of the bus way will be high and could make it difficult to cease the practice when implementation of the bus services occurs.

Lessons

- *Must have strong Government support*
- *Construction must move quickly and efficiently once approved*

4.1.2 System Characteristics

There has been significant debate about whether BRTS systems should be designed for open access or be restricted to accredited vehicles. Under an open access regime there are two principle options, access to all forms of buses, and open to all vehicles.

In Jakarta and Delhi the bus way has suffered problems with interference from private motor vehicles competing for space with the BRT vehicles resulting in severe busway congestion, reduction in capacity, increased travel time and unreliability of service delivery for bus passengers. The effect has been a significant decrease in both BRT passenger numbers and average travel speeds of buses. Sometimes, as is the case with Jakarta, private vehicles are admitted to the bus way during peak periods. The logic behind this appears to be that the road is heavily congested but the bus way lane is relatively underutilized. Often such a strategy results from pressures from motorists via politicians, demanding greater access to road space in the light of heavy congestion. The reality is that admitting private vehicles to the bus way during peak times destroys the benefits to be gained from BRTS at the time of day when these benefits are most required and the BRTS will not return the benefits expected from the large investment in its construction.

Figure 4. 1: Cars occupying the Jakarta busway during peak hour

Figure 4. 2: Random access

At first the Bogota BRTS operated as an open system, permitting all bus operators to utilise the infrastructure, but this resulted in excessive congestion with an associated average bus speed as low as 10km/hr. Whilst the busway was quite effective in reducing congestion caused by mixed traffic conditions, it did very little to improve public transport delivery. Today the system operates as a closed system which has dramatically improved travel times and passenger comfort.

Figure 4.3 : Bogota originally operated an open system that created congestion (left), whereas operating a closed system has proven to dramatically improve travel times and customer comfort (right).

Cities that employ open bus systems such us Kunming, Porto Alegre and Taipei mostly use a fairly basic busway design and utilise the existing bus fleet with basic, and varied, design features. Cities with open systems generally experience congestion due to the many operators allowed to service the routes. However, the definition of an open system is not always this clear. Some open systems may still exclude some buses, such as the Quito "Central Norte" corridor. The operational concession for the Central Norte line essentially permits all existing operators to use the busway, however only specific vehicle types were allowed. This resulted in the busway performing more inefficiently but the real driver of ensuring reliable operations appears to be limiting access to an optimum number of operators (and vehicles)

Bus ownership issues are also significant. In Quito there are three independently operated busway corridors. Attempts to integrate corridors have been thwarted due to the existing contractual arrangements. Retrofitting infrastructure had been both physically and financially difficult.

Lessons

- *Admitting general vehicle traffic to the busway will erode the passenger benefits and reduce the return on the infrastructure cost*
- *Uncontrolled access for all buses will be detrimental to reliable operations and will cause delays through congestion*
- *Have a clear plan as to who will use the busway, design the system to suit and do not shift away from that plan*

4.2 Design Components

4.2.1 Overtaking Lanes

Due to limited budget and difficulties with the construction, the Jakarta BRT was designed as a single lane, without overtaking lanes at stops. This means that all buses proceed as a procession and having to stop at all stops, even if they are full. In addition it is not possible to operate express services causing inconvenience to longer distance passengers through slower than necessary journey times which affect the ability of the network to grow mode share. Efforts are being made to now post-fit overtaking lanes, which is a difficult and costly exercise under operational conditions. In Brisbane a miscalculation of demand and the use of standard sized vehicles resulted in severe busway congestion at one major station. The subsequent retrofitting of a passing lane through the station has resulted in an additional cost of US$11.4 million. **(Figure4.4)**

Figure 4.4 : Brisbane miscalculated demand (left, the problem eventually had to be corrected through a somewhat costly retrofit of a passing lane at the station (right)

Other cities with single lane bus ways like Quito and Beijing that have implemented limited stop and express services have had to resort to vehicle overtaking by way of the opposing lane. There is obvious safety issue involved with the risk of head-on collision between rapidly approaching vehicles being a real possibility

Figure 4.5 : By allowing vehicles to overtake in the opposing lane, there are obvious risk of serious collision as evidenced in Beijing

Lessons

- *Seriously consider the benefits of overtaking lanes at design stage*

4.2.2 Traffic Impacts

Introducing a busway into an existing street will create a change in traffic conditions that will need to be address through sound traffic engineering design. The main issues will be:

- *Reduction in road vehicle flow capacity by reallocation of lanes to the busway (but an increase in the number of people that can be moved)*
- *Changes to intersection capacity through narrowing of the roadway and the need to introduce bus cycles into the signaling systems*
- *New vehicle interface points which introduce opportunities for collisions*
- *Changed pedestrian situations*

Experience from the Orange line BRT in Los Angeles lead to the identification of a number of problems which required post-modification of the corridor as follows:

Problems:

i. Several collisions between cars and buses at intersections
ii. Accidents caused by cars entering busway against traffic signals
iii. Lack of crossing gates, local drivers unfamiliar with busway operations

Solutions:

i. changing traffic signal timing to give buses more time to clear intersections
ii. Conventional round green light signals changed to “up arrow” signal
iii. Warning sign “Look Both Ways”
iv. Photo enforcement cameras to deter red--light runners
v. “Keep Clear” pavement markings at intersection
vi. Bus crossing signs at intersections
vii. Flashing “bus coming” sign placed immediately adjacent to right turn locations

Traffic problems occurred in Delhi where a single flyover in the median is built for mixed traffic while BRT buses are forced to use Surface Street. The buses in the median must cross the mixed traffic going over the flyover. This scenario creates either the need for a new signalizes intersection prior the flyover or it requires a merge lane where BRT buses and mixed traffic can cross. This introduces possible delay and confusion for both the BRT system and the mixed traffic. It would be far better to dedicate the flyover (or at least the middle lanes of the flyover) to the BRT system.

Lessons

- *Carefully consider all traffic interfaces and potential impacts during the design process*
- *Incorporate appropriate traffic control and management features such as signals and signage*

4.2.3 People and Access

Public Transport design is not just about the main corridor but also the connecting services which deliver people from home to office or school or shopping centre. Failure to consider this in route design could lessen demand for, and hence the success of, the main corridor. In Bangkok the BRT plan has given relatively little attention to customer destinations. The system is designed such that all corridors terminate prior to arriving in the city centre. Additionally the system routing forces most customers to make multiple transfers prior to even arriving at the final stop. Once arriving at the periphery of the central area, customers are expected to either transfer to the rail system (which only serves a few corridors) or to transfer to other options such us taxis. Unintegrated corridors are also observed in other cities such us Quito and Jakarta.

The placement of stops along a route, and the dimensions of the stops, needs to consider the magnitude and nature of demand. The design of stop placement in Jakarta does not consider integration with other modes. For example, a couple of the busway routes intersect a train line and although stop placement is within walking distance (400 m) of the station there is no formed pathway and the gradient is steep making it hard to walk especially for older persons.

In Bangkok, it was proposed to construct Phase I BRT system along the “Kaset Nawamin” corridor specifically because there was no traffic or congestion on the corridor and it was easy to build. However at the same time, there was virtually no public transport demand along the corridor, so it would not likely be financially viable. This problem also occurred in Beijing’s demonstration phase where construction of the Busway was in a corridor with little public transport demand.

Figure 4. 6: Line along Bangkok BRT (Kaset Nawamin corridor) where there was little demand

The first phase of The Jakarta system and the demonstration phase of the Beijing system both suffered design problems that inhibited the performance of the systems. Jakarta's litany of initial problems included:

a. Existing buses were allowed to continue operating in the mixed traffic lanes along the busway corridor, resulting in much congestion for private vehicles
b. Vehicle and station sizes were too small for the given demand **(Figure 4.7)**

Figure 4.7 : ***Under sizing stop (left) and crowding inside stop (right) that blocking people alighting from bus***

Boarding/Alighting passenger movements require particular design in circulation not only with regard to the size of shelter but also how people will circulate within the space. In Jakarta crowding of people who want to enter the bus blocks people who want to exit from the bus (which only has a single doorway). The solution was to place a security guard on the bus at the doorway but this further reduces the capacity of the doorway and the stop gateway. In Jakarta it is clear that there are too few doorways in vehicles/station to facilitate rapid boarding and alighting in rush hour. Also, the space within the shelter is not optimally used because of gate location in the middle of shelter. It would at least help if the station platforms were wider, and if a distance was provided between the two opposite boarding points to avoid excessive people concentration.

Figure 4.8 : Too few doors to facilitate boarding/alighting in Rush hour in Jakarta Busway

Besides having a well-designed busway system, it is beneficial to have a degree of user discipline to make the network successful.

The layout design of bus stops can also be a significant factor in managing or contributing to passenger congestion. The aim of a good stop design is to distribute people along a platform and allow the people exiting the bus to move clear of those waiting to board. Several designs have been adopted around the world but generally speaking designs that introduce people to the rear of the platform (i.e. the direction from which the buses approach) work better than those where people are introduced at the departure end of the platform.

Lessons

- *Consideration must be given to the passenger experience for the entire journey, not just the portion undertaken on the busway*
- *Design stops to match forecast demand as this will be a critical factor in controlling the efficiency of the system.*
- *Stop design must be considerate of passenger queuing and congestion issues*

4.2.4 Maintenance Issues

Pavement maintenance has been an issue, either due to the use of inadequate pavement structure design, or there was no initial replacement of the pavement, or because of faulty construction Jakarta busway was established initially using the existing road pavement and suffered from major problems of the surface sinking and deteriorating generally but particularly at the stations due to oil dropping onto the bitumen surface and to accommodate the forces resulting from acceleration and deceleration. The solution adopted was for the roadbed to be repaved at selective locations using concrete. Retrofitting the pavement with concrete in stops and at intersection caused much disruption due to the bus having to be diverted into the general traffic flow, causing congestion as well as financial and physical problems.

Figure 4. 9: Busway deterioration in Jakarta ***Figure 4.10: Concrete sections installed at stops***

Bogota had the same problem too, but they chose to resurface the entire corridor in concrete and used brick in the city centre for aesthetic impact. In Quito they utilised asphalt on the runways for the first two corridors, but installed concrete in the station areas. Based on experience with the first two corridors, the latest corridor to be constructed in Quito was built with concrete throughout the system.

Lane segregation devices in some cities (e.g., León and Mexico City) are reported to have experienced early deterioration and required replacement. Damage to the Jakarta lane segregation devices is also evident.

Figure 4. 11: Lane divider damage

Lessons

- *Do not assume that the existing road pavement will withstand the new loadings being imposed on it*
- *Consider the use of concrete pavements in station areas and where ground conditions are inadequate*
- *Research appropriate heavy duty lane segregation devices and secure them well*

4.3 Safety and Security

4.3.1 Access to the Stops

Pedestrian access to the stops has to be designed very careful, especially in Asian cities due to higher levels of traffic congestion and a lower level of discipline amongst users. High quality pedestrian access can be defined through design factors such as:

- *directness and connectivity*
- *aesthetics*
- *ease of movements*
- *legibility*
- *safety and security.*

In Jakarta, even with Sky Bridges provided people still attempt to way across the road and transit way.The use of block lane delimiters is not sufficient to stop people taking a short cut and accidents between people and bus occur. This problem still exists in Jakarta. The only proposed solution has been a fence, particularly near stations however this solution has not been adopted because it is aesthetically unpleasing, is subject to frequent collision damage, and limits contingencies for getting around a broken down bus.

Problems with pedestrian crossing the busway are even worse on Delhi BRT, and has resulted in accidents with buses trying to avoid hitting pedestrian and crashing into a bus shelter and in another case the guard railing.

In Sao Paolo, they removed the dividing fence to improve aesthetics, but the busway now suffers from encroachments from motor vehicles.

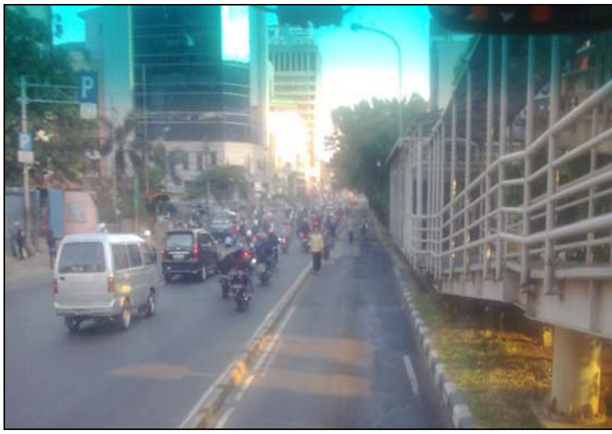


Figure 4.12 : People short cutting across Jakarta bus way ***Figure 4. 13: Fences on the Sao Paolo BRTS before removal***

Lessons

- *Provide safe, grade separated access for pedestrians*
- *Control access to the busway and manage any crossing points*

4.3.2 Platform Gaps

Jakarta busway was implemented with high platforms, which add to the risks of falls. The gap between the bus floor and the station platform ranges from 25 to 45 centimetres, which is several times wider than standard BRT systems, and passengers must take great care entering and exiting the bus. This not only slows down boarding, it also creates dangerous conditions and limits access for disabled persons.

Figure 4.14 : High platforms and excessive gap on the Jakarta BRTS

Lessons

- *Consider vehicle/platform interaction and assess the benefit of localised bus guidance/docking systems*

4.3.3 Personal Safety

Jakarta has experienced personal security problems with many users complaining about pickpockets and women complain about sexual harassment particularly during rush hour. Placing security guards in every shelter and sometime in the bus has not eliminated these problems and it is proposed to introduce CCTV but this has been delayed due to lack of budget.

Pedestrian safety is still an issue along Corridor I in Jakarta due to free left turns, high speed exit and entry ramps, and lack of pedestrian refuge islands at intersections. In some parts of Corridor I, particularly North of Harmoni and South of Senayan roundabout, at-grade pedestrian crossings coupled with improved intersection design need further consideration. At the Kota railway station, a two-phase signal which gives all pedestrians a full phase to cross in each direction would reduce the temptation for people to cross against the red light.

Lessons

- *The passengers are the customers and their needs must be built it to the system at all stages of the design process*

4.4 Marketing and Mode Shift

Poor communication of the new public transit plan to key stakeholders and public can greatly undermine the ultimate viability of the project. Delhi busway experienced this problem because no communication plan, marketing campaign, or system branding was developed to explain or promote the new system. The first week of implementation generally labeled as a disaster. Many infringements of the intended operating plan occurred such as people not using the provided access points, and existing bus, private vehicle, rickshaw, bicycle entered the bus lane.

In contrast, Bogota made a series of short videos about the future BRT systems that aired on national television before the implementation. This allowed the public to gain a sense of what it would feel like to ride on the new BRT system and for private vehicle user will understand the aim of new system and will support it.

To encourage people to shift to BRT people need to perceive that the level of service approaches the comforts they have come to expect from their private car. Issues such as comfortable seats, cleanliness, ride quality and air conditioning need to be carefully considered. Many cities have used existing buses to reduce capital cost but with mixed results. Generally this approach discourages mode transfer.

High quality buses can create a good image of a modern public transit system. Perceive image and status of the public transport system is a major determinant in attracting ridership, especially from non captive public transit user. The image problem is most closely associated with bus technology. Image and status are problems experienced by many cities in Asia and South America. Transjakarta used a marketing campaign to encourage people use bus way, their motto is “New Tradition in transportation” and they invited celebrities, politicians, well-known and political leader to travel by busway. But this is a poor substitute for providing ultra modern vehicles designs such as the samples below.

Figure 4.15 : Examples of modern BRT vehicle designs

Service frequency affects the perception of the system attractiveness and car competitiveness. Reliability that services will turn up either on time (if a timetable is in use) or evenly spaced is also an important customer preference. Jakarta busway experienced frequent problems in a few corridors. Service gaps sometimes reached 45 – 60 minutes and when the bus finally arrived it was often already full. The increasing size of waiting crowds exceeded the capacity of the shelters creating health and safety issues.

Other principle concerns identified internationally that can endanger customer loyalty include:

- *Quito Trolebus and Ecovia are suffering from vehicle crowding during peak hours and large waiting and travel times in feeder services and unintegrated corridors, resulting in demand being below expectation which in turn is affecting the financial performance of the private operators.*
- *In Bogotá, the level of service in the initial corridors has declined, and several measures to counteract this are under way, such as the revision of routes, construction of new connections among corridors, the reduction of parallel routes operated by traditional buses, and expansion of the bus fleet. There is also a project under way to integrate the organised services of TransMilenio with traditional services citywide. Rail alternatives have been discussed for new corridors.*
- *Curitiba is operating close to capacity in some sections leading to insufficient service in peak hours.*

Lessons

- *Document how passengers are to interface with the system and advertise this in advance of the opening date*
- *Consider the image projected by the use of modern specialised equipment as a way of maximising mode shift*
- *Undertake a detailed demand assessment in order to place stops in the best locations and scale them to the task in hand*

4.5 Control, Management and Standards

Transjakarta who operates Jakarta busway faces many obstacles as operator of the network. Some of their experiences are documented below:

- They have a lack of management control over their future:
  - TransJakarta does not have the capacity, the budget, or the clear mandate to do the planning for the future TransJakarta corridors.
  - TransJakarta does not directly control the revenue from ticket sales
  - TransJakarta does not have the power to regulate bus routes in the TransJakarta corridors

- There are no standard operational procedures in place. The Officers stationed at each stop decide whether a bus is full or not without any guidance as to the maximum load factor. The driver decides whether he will stop at the next shelter or not. Jakarta BRT does not have an express route, every bus has to stop in every stop but if the bus is already full and nobody indicates that they wish to alight at the next shelter then the driver can decide to continue. The down side is that customers at the stop complain about the bus not stopping because they think the bus still has space for more passengers.

- Buses are equipped with a communication device for emergency situations, such as if the bus has broken down, so that the driver can talk to the control officer in the central office to ask for advice. However there is no emphasis on using it for customer management/relations so customers complain when a bus full of passenger are dropped off at a full shelter with little explanation or contingency as to how the crowded stop will be cleared with subsequent buses (often already full) or a replacement bus. The control officer at the stop does not have authority to take any action and some of them do not even have a communication device.
- Jakarta system does not have a central control system room that allows system controllers to ensure service to the customer as well as the ability to respond to any problems or emergencies. They rely on the control officers at the stops to provide feedback to the control manager, or if the problem is big, it requires the Transjakarta manager to take action.

Lessons

- *Consider the benefits that can be gained from a centralised control system and associate ITS technologies*

4.6 Ticketing, Fares and Validation

Issues with the Ticketing system in Jakarta include:

- No integrated fare system with fare collection/verification divided into 2 systems: smart card (3 corridors) and paper ticket (4 corridors). Customers buy their ticket or refill the card at the stop and when they enter the barrier they validate the card or give the ticket to the officer. The Smart card has different card reader machines in each corridor resulting corridor 1 can only be used in corridor 1 whilst corridor 2 and 3 are interchangeable.
- Requires many staff, 1 person at every shelter for selling tickets, 1 person every shelter for validation at the barrier, 4-5 persons each corridor to distribute tickets, 4-5 person each corridor to collect the money, 2-3 officers every corridor to verification of money and 2-3 officers every corridor verify tickets sold.
- Most smart cards need to be recharged at the bus stops because there are few off-network retailers (only DKI Jakarta government bank has a machine to refill smart card and there are not many branches with a machine.
- Fare system is on a per trip payment basis, there is no monthly or weekly fare, but there is an off peak fare from 5.00 AM to 7.00 AM.
- Because of high level of cash transactions in shelter/stop, large amounts of cash need to be stored at each shelter thus creating security risks.
- There is no integration of fares with feeder service user have to pay another fare for feeder service. An attempt to integrate the BRT and existing buses failed due to existing operators not accepting the arrangement.
- Splitting the responsibility for operating the fare system and procuring the fare system equipment led to major problems. When problems with the equipment technology emerged, the fare system operator was unable to fix them, and claimed to have no legal responsibility for fixing the problem. The fare system supplier should have been liable but the contract signed did not provide for this eventuality.
- Proposed solution for Jakarta system was to extend the use of smart card with a proper network of retailers and introducing a distance based fare system rather than a flat rate, however this plan has not been successful to date because of objections related to the reduction of employee numbers.

The provision of free feeder services in Bogota has created its own problem due to some customers not utilising the trunk service upon arrival. Since the operators have a financial interest in preventing this type of free rider, to combat the issue TransMilenio system is looking at alternatives to the free feeder services. One option is to utilize a sophisticated fare technology to integrate feeder and trunk services using smart technology such that customers will validate their fare card upon exiting the feeder system and upon entering the trunk system. To make this type of transfer possible, a fairly sophisticated fare technology system must be in place.

Curitiba had employed a coin based fare for three decades; but a change to electronic ticketing in 2006 significantly improved all the system. Quito Ecovia still employ coin based that they claim is without problems.

Some systems such as Jakarta and Beijing are not financially sustainable due to decision makers setting fares as low as possible to make the system as accessible as possible. The fares set by the authority did not reflect actual system cost. In systems with a competitive bidding process (Bogota, Pereira, Santiago) final fares emerged as the result of the bidding process itself. The financial sustainability of many of the systems is also being challenged by renegotiation of agreements between authorities and private operators. This is most common in directly assigned contracts (Mexico City, León, Quito Corredor Central Norte, Jakarta), but also happens in contracts resulting from open bidding processes (Bogotá). Buses subsidies also occurred in Quito, whilst the operators in Beijing and Mexico face possibility of bankruptcy unless fare increases are approved.

Lessons

- *Coin-based fare systems are expensive to operate and inefficient*
- *Smartcards are unlikely to be compatible with the Indian situation due to the need to hold stored value on the card*
- *Consider moving to distance based fare systems*

4.7 Implementation Strategy

Most of the BRT systems reviewed had initial problems. This is largely because they started operations without all the elements being in place. In some cases this was caused by the need to commission the projects before the end of terms of elected officials (e.g., Mexico City, Bogotá, León, Guayaquil). In other cases there was a perceived need to commence using the newly created and empty bus lanes in major roads where traffic congestion had been made worse by inserting the BRTS infrastructure. Most systems solved these problems within the first months of operation but not without a lot of angst and bad public relations.
Some cities failed to finish the project until change in leadership such us Western Cape Province (Cape Town), Dhaka (Banglades), Shanghai (China), Puebla (Mexico) and Virginia Beach (USA).

In general, infrastructure and fare collection systems were the most problematic.

In some cases, there was little time between bus delivery and the start of operations, and drivers' training was incomplete (León, Mexico City).

User education had also been neglected as an important activity prior to system implementation. Lack of adequate user education and contingent plans can cause severe problems, as it was the case in Delhi, Prune, Mexico City and León during the first weeks of operation, or in Bogotá's Phase II expansion.

Protests by affected transport operators were observed in Quito and Bogotá and during an early phase in Santiago (during the Metrobús bidding process). Fear of protests and unrest has caused cities to involve incumbent operators in direct negotiations (Mexico City, León, Jakarta) or to give incumbents extra points in the bidding processes (or to give entry barriers to outside bidders) (Bogotá, Pereira, Guayaquil, São Paulo). Santiago chose to have an open bidding process, which proved successful in promoting competition for the benefit of the system users but generated some barriers in the implementation process. In Jakarta the problem was exasperated because in the 1st and 2nd phase they employ a consortium of existing bus operators and for 3rd phase used open bidding resulting in different price/km contracts. Based on that, the authorities asked the earlier operator to decrease their prices that they refused because a contract had been signed.

Advanced fare collection systems have been difficult to implement. These systems may reduce fare evasion, allow for faster passenger loading, and generate data for operational planning, but implementation times for adapting software applications to local conditions have been too short, resulting in insufficient testing and quality assurance. Furthermore, in some cases, fare collection systems are not integrated with other components of public transport or between corridors (Quito, Jakarta).

Some cities attempted to implement operations with incomplete infrastructure such us stations, terminal, corridors, signage (Quito Central Norte, Bogota, Leon SIT OptibusMexico Metrobus Insurgentes, Tranjakarta Jakarta, Beijing BRt Beijing, Pereira Megabus, Guayaquil Metrovia, Santiago Transantiago all had one or more of these problems).

Some systems failed in provide sufficient capacity to meet the demand offering upon implementation, such us.

- Jakarta, Quito Trolebu, Pereira Megabus, Beijing, Guayaquil and Santiago, insufficient for initial demand, special programming conducted, in fact in Jakarta insufficient busses still exist until now, especially in the peak hour. Quito Central Norte need to temporarily resolve the shortages by using traditional buses.
- Quito ecovia, Curitiba RIT delayed due to lack of finance, the buses were bought by the municipality,

- Insufficient trained drivers were the cause in Jakarta and Mexico.

Lessons

- *Develop a properly documented implementation plan which considers all lead times*
- *Use a risk based management process*
- *Use a really good project manager*

4.8 The following are the Lessons learnt from each element:

1) Under Planning Processes:

a) The Government Commitment/Support

Lessons

- *Must have strong Government support*
- *Construction must move quickly and efficiently once approved*

b) The System Characteristics

Lessons

- *Admitting general vehicle traffic to the busway will erode the passenger benefits and reduce the return on the infrastructure cost*
- *Uncontrolled access for all buses will be detrimental to reliable operations and will cause delays through congestion*
- *Have a clear plan as to who will use the busway, design the system to suit and do not shift away from that plan*

2) Under Design Components:

a) Overtaking Lanes

Lessons

- *Seriously consider the benefits of overtaking lanes at design stage*

b) Traffic Impacts

Lessons

- *Carefully consider all traffic interfaces and potential impacts during the design process*

- *Incorporate appropriate traffic control and management features such as signals and signage*

c) People and Access

Lessons

- *Consideration must be given to the passenger experience for the entire journey, not just the portion undertaken on the busway*
- *Design stops to match forecast demand as this will be a critical factor in controlling the efficiency of the system.*
- *Stop design must be considerate of passenger queuing and congestion issues*

d) Maintenance Issues

Lessons

- *Do not assume that the existing road pavement will withstand the new loadings being imposed on it*
- *Consider the use of concrete pavements in station areas and where ground conditions are inadequate*
- *Research appropriate heavy duty lane segregation devices and secure them well*

3) Under Safety and Security:

a) Access to the Stops

Lessons

- *Provide safe, grade separated access for pedestrians*
- *Control access to the busway and manage any crossing points*

b) Platform Gaps

Lessons

- *Consider vehicle/platform interaction and assess the benefit of localised bus guidance/docking systems*

c) Personal Safety

Lessons

- *The passengers are the customers and their needs must be built it to the system at all stages of the design process*

4) Under Marketing and Mode Shift:

Lessons

- *Document how passengers are to interface with the system and advertise this in advance of the opening date*
- *Consider the image projected by the use of modern specialised equipment as a way of maximising mode shift*
- *Undertake a detailed demand assessment in order to place stops in the best locations and scale them to the task in hand*

5) Under Control, Management and Standards

Lessons

- *Consider the benefits that can be gained from a centralised control system and associate ITS technologies*

6) Under Ticketing, Fares and Validation

Lessons

- *Coin-based fare systems are expensive to operate and inefficient*
- *Smartcards are unlikely to be compatible with the Indian situation due to the need to hold stored value on the card*
- *Consider moving to distance based fare systems*

7) Under Implementation Strategy

Lessons

- *Develop a properly documented implementation plan which considers all lead times*
- *Use a risk based management process*
- *Use a really good project manager*

Chapter 5.0
TRAFFIC SURVEYS AND ANALYSIS

5.0 INTRODUTION

The traffic surveys conducted and analysis made to assess the traffic volume and composition and other parameters required for the design of Bus Rapid Transit system are described in this chapter. A detailed report on this topic was submitted separately.

5.1 Corridor Characteristics

The two identified corridors are:

a) From Dahisar to Bandra along Western Express Highway (WEH).
b) From Cadbury intersection to Sion along Eastern Express Highway (EEH).

5.1.1 Western Express Highway

Of the two highways, the Western Express Highway is currently the main arterial that connects the southern tip of Mumbai with its suburbs as well as the extended suburbs. It is having better roadway geometrics, riding quality and better junction controls with linked signals, providing a partial green channel along the corridor.

The WEH main carriageway has an average 1.5 meters median width and minimum 2-lane service roads on either side. The western railway corridor is located parallel and very close to this alignment.

5.1.2 Eastern Express Highway

The stretch is from Sion Circle to Cadbury Junction (Thane) and it is about 25 km length. The railway corridor is located parallel and very close to this BRTS alignment. The 'vacant' land use was observed on eastern side of this corridor from Thane to Kannamwar Nagar. Mixed land use was observed in the remaining stretch.

The Key Plan of the Western Express Highway and Eastern Express Highway is shown in **Figure 5.1**.

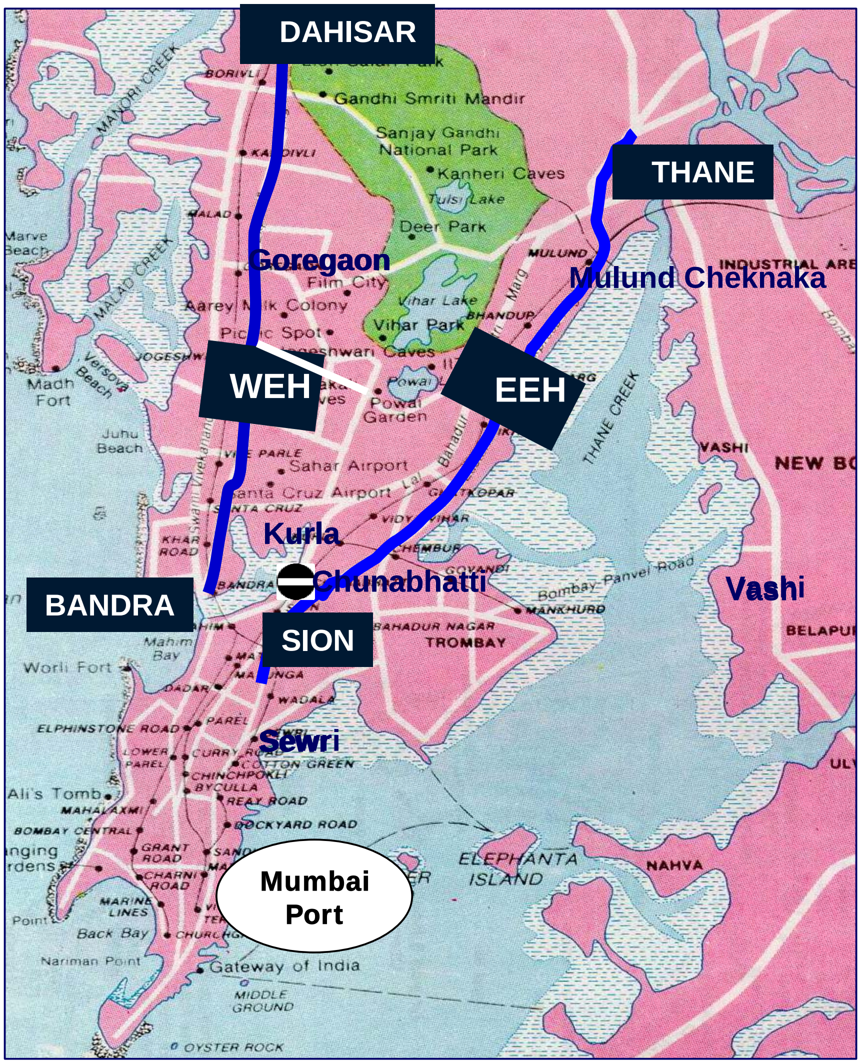


Figure 5.1 Key Plan of WEH and EEH

5.2 High Lights of the Traffic Survey and Analysis

The details of traffic volume, its composition and directional split are presented in this report. The traffic volume is not uniform along the two corridors and the traffic at start points (Bandra and Sion) gets reduced to around 30% at end points, namely Dahisar and Thane. The composition of BEST bus volume ranges from 0.8 to 2.30 % of total volume. The directional split is 52: 48 on WEH and 55:45 on EEH.

5.3 Primary Traffic Surveys

A number of traffic surveys have been carried out on, Western Express Highway (WEH) and Eastern Express Highway (EEH), the BRTS project corridors, in order to find present traffic volume and composition, boarding alighting pattern of bus passengers, turning movements at all intersections and journey & running speed.

The traffic surveys conducted for this BRTS project include:

- Classified traffic volume count at 4 locations in each corridor.
- Turning movement surveys at surface crossing and grade separated intersections.
- Speed-Delay surveys for the two project roads.
- Boarding / Alighting of bus passengers at selected bus stops
- Corridors bus routes On-Board survey
- Stated preference survey covering, 2-Wheeler/Car/IPT/Train/Bus, users
- Pedestrian Volume Count along and across the project corridor at selected locations.

5.3.1 Classified Traffic Volume Count

This study would help in realistic forecast of traffic volume for allocation of road space for BRTS and other vehicles using the corridor, to optimize the cost of improvement and realistic approach in assessing economic and financial viability.

The WEH and EEH BRTS project corridor is divided into four homogeneous traffic sections in each and the classified traffic volume count survey was carried out for 16 hours in a day (continuous, direction-wise).
The vehicle classification system as per IRC: SP- 19:2001 was followed. Classified manual traffic counts have been recorded in 15 minutes intervals, using Tally marks on a standard format.

The survey data was analyzed to bring out the following traffic characteristics:

- The traffic volume
- Average hourly variation of traffic volume
- Average composition of traffic
- Directional distribution of traffic

5.3.2 Traffic Volume on WEH & EEH

The traffic volume count summary at 8 locations on two BRTS project corridor is given in ***Table 5.1*.**

Table 5.1 Traffic Volume Summary (16 Hours)

Location Number	Survey Location	Vehicles	PCU
Western Express Highway			
L1	New Agripada	177032	189703
L2	Gundavali	98614	109634
L3	Dindoshi	108761	110598
L4	Nancy colony	52387	56313
Eastern Express Highway			
L5	Everard Nagar	111575	134466
L6	Chheda Nagar	77328	97248
L7	Godrej	61211	73181
L8	Nitin Co.	38126	49967

The vehicular traffic (16 hours) on the WEH project road ranges between 52387 vehicles at Nancy colony to 177032 at New Agripada location. Two third of the vehicular traffic gets diverted from the corridor before Nancy colony, the near end point of this corridor. This corridor experiences a decreasing trend of traffic flow from start point Bandra to end point Dahisar.

The vehicular traffic (16 hours) on the EEH project corridor varies from 38126 at Nitin Co. to 111575 at Everard Nagar. From start point of Sion to end point of Thane the traffic flow gets gradually reduced. Only one third of traffic travels up to the end point of the corridor.

5.3.3 Average Hourly Variation of Traffic

The hourly flow pattern in terms of Vehicles and PCUs at 4 locations on the WEH, BRTS project corridor is depicted in charts shown in **Figure 5.2** to **Figure 5.5**. Minimum flow per hour varies from 2000 PCU to 4552 PCU and maximum flow (Peak Hour flow) varies from 3950 PCU to 15821 PCU.

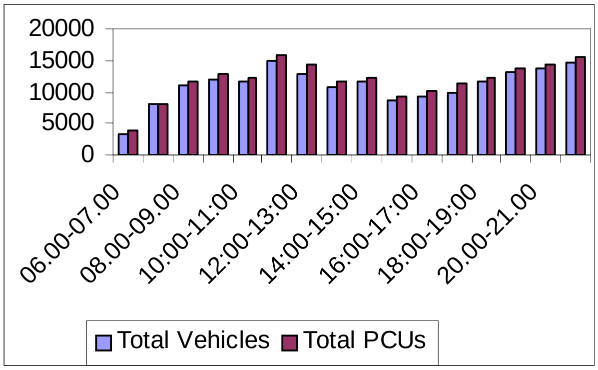


Fig 5.2 Hourly Flow Pattern in terms of Vehicles and PCUs at New Agripada

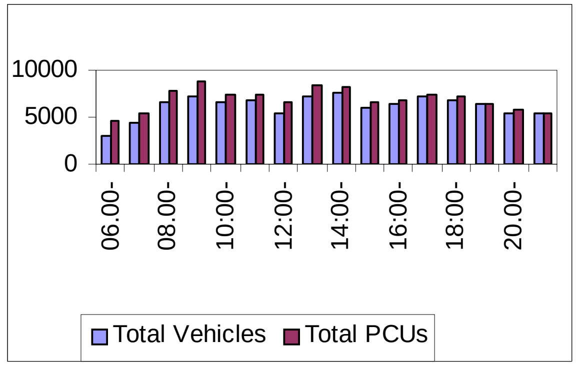


Fig 5.3 Hourly Flow Pattern in terms of Vehicles and PCUs at Gundavali

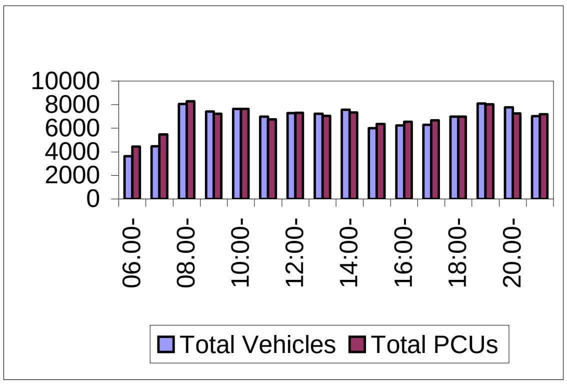


Fig 5.4 Hourly Flow Pattern in terms of Vehicles and PCUs at Dindoshi

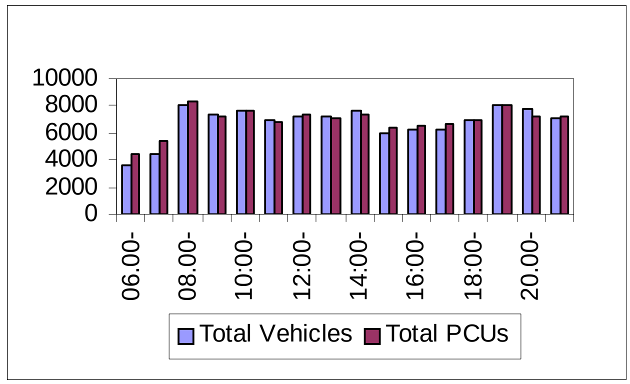


Fig 5.5 Hourly Flow Pattern in terms of Vehicles and PCUs at Nancy Colony

The hourly flow pattern of vehicles at 4 locations on the EEH, BRTS project corridors are depicted in charts shown in **Figure 5.6** to **Figure 5.9**. Minimum flow per hour varies from 928 PCU to 2354 PCU and maximum flow (Peak Hour flow) varies from 3001 PCU to 10242 PCU.

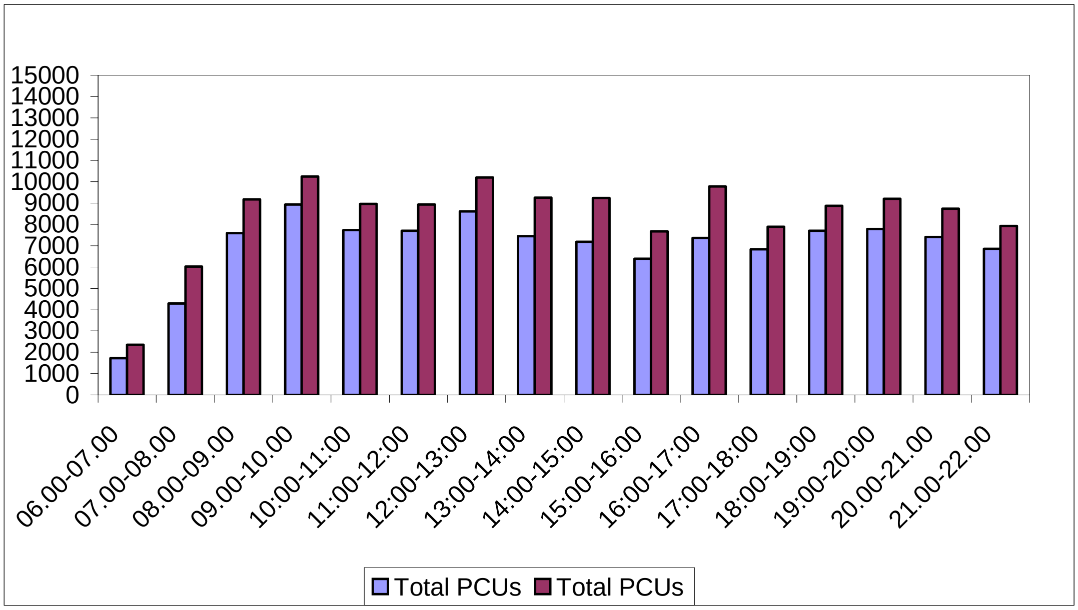


Fig 5.6 Hourly Flow Pattern in terms of Vehicles and PCUs at Everard Nagar

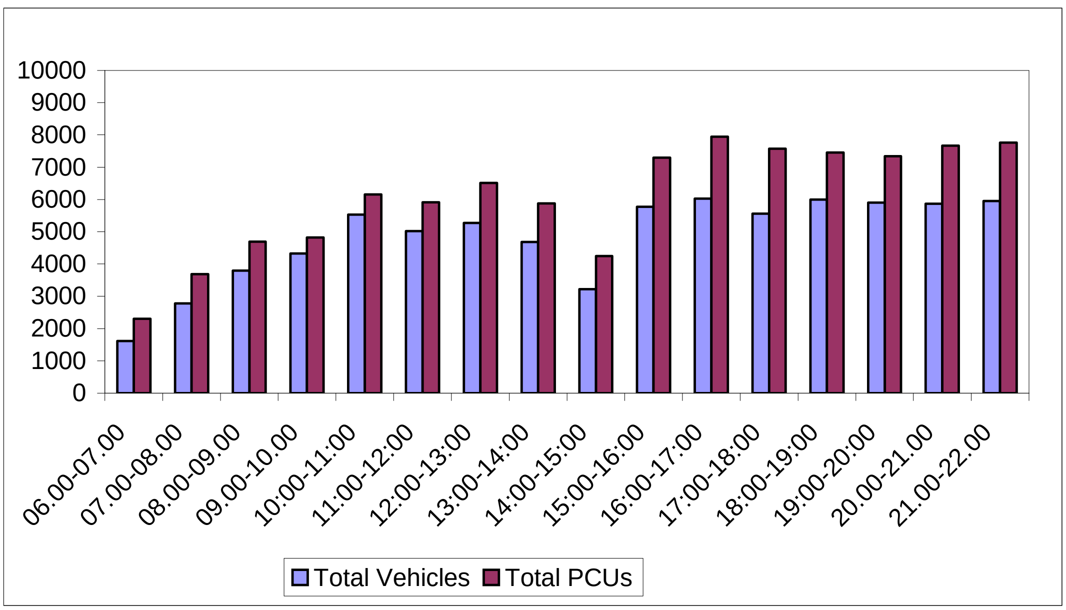


Fig 5.7 Hourly Flow Pattern in terms of Vehicles and PCUs at Chheda Nagar

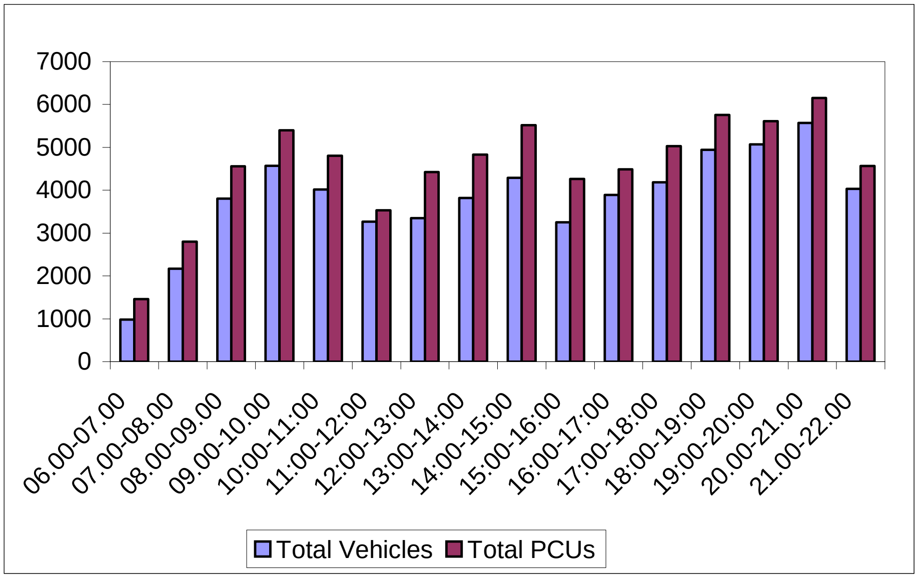


Fig 5.8 Hourly Flow Pattern in terms of Vehicles and PCUs at Godrej Hospital

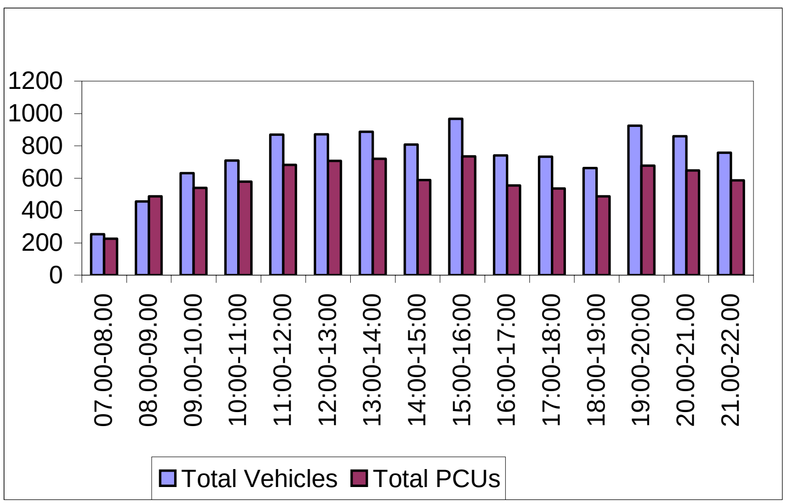


Fig 5.9 Hourly Flow Pattern in terms of Vehicles and PCUs at Nitin Colony

Generally peak flow occurs during 9:00 to 10:00 hours at two locations, 8:00 to 9:00 and 11:00 to 12:00 at other locations in the morning and 20:00 to 21:00 hours at two locations, 14:00 to 15:00 and 16:00 to 17:00 at other locations in the evening. Also peak hour differs for each location depending on local activities. The peak hour volume varies from 8 to 9 % along the corridor. The peak hour volume at various survey locations is given in ***Table 5.2.***

Table 5.2 Peak Hour Volume

Location	Peak Hour Volume (%)	Peak Hour Vehicles	Peak Hour PCU	V/C
Western Express Highway				
L1-New Agripada	8	14823	15821	1.00
L2-Gundavali	8	7670	8138	0.66
L3-Dindoshi	8	8047	8288	0.65
L4-Nancy colony	8	4025	3950	0.31
Eastern Express Highway				
L5-Everard Nagar	8	8936	10242	0.81
L6-Chheda Nagar	8	6027	7945	0.63
L7-Godrej	9	5569	6154	0.49
L8-Nitin Co.	8	2671	3001	0.24

5.3.4 Average Composition of Traffic

The percentage composition of classified vehicles on 4 sections of the WEH, BRTS project corridor is depicted in **Figure 5.10** to **Figure 5.13** with in the project corridor the BEST bus percentage varies from 0.8 to 1.9 percent, cars 27.3 to 51 percent, 2 Axle trucks 3.1 to 7.8 percent of total traffic.

The percentage compositions of classified vehicles on 4 sections of the EEH, BRTS project corridor are shown in **Figure 5.14** to **Figure 5.17**. With in the project corridor the BEST bus percentage varies from 0.8 to 2.3 percent, cars 24.3 to 47.3 percent. The 2 Axle truck percentage varies from 5.3 to 7.1 per cent of total traffic. The percentage Composition of Traffic at 4 locations each on WEH and EEH is presented in ***Table 5.3***.

Table 5.3 Percentage Composition of Traffic

	WEH				EEH			
Vehicle Type	L 1	L 2	L 3	L 4	L 5	L 6	L 7	L 8
Two Wheeler	11.2	14.1	21.3	28.4	14.9	14.0	16.0	26.5
Auto Rickshaw	11.8	17.1	26.6	22.0	13.4	9.4	12.7	13.8
Car/Van/Jeep	51.0	41.9	34.6	27.3	39.2	46.2	47.3	24.3
Taxi	11.9	13.0	3.6	1.9	12.5	9.6	3.3	3.2

	WEH				EEH			
Vehicle Type	L 1	L 2	L 3	L 4	L 5	L 6	L 7	L 8
Mini Bus	0.2	0.8	0.6	0.6	0.4	0.7	0.6	1.2
BEST Bus	0.8	1.1	1.9	1.0	2.3	1.3	0.8	1.7
S.T. Bus	0.2	0.3	0.2	1.0	1.2	0.5	0.3	4.3
Other Bus	0.6	1.3	1.4	1.2	1.3	1.0	1.6	8.5
LCV	8.4	3.7	5.1	7.0	5.8	5.1	7.1	8.9
2 Axle	3.1	3.8	3.9	7.8	6.6	5.9	7.1	5.3
3 Axle	0.6	2.1	0.6	0.7	2.2	4.7	2.7	1.1
Multi Axle	0.2	0.7	0.1	0	0.2	1.4	0.5	0
Non Motorised Vehicles	0	0	0.3	1.0	0	0.1	0	1.0

Note: % is Composition of Traffic form Total Traffic

The passenger vehicles (car/Van/Jeep) dominate the flow with 24.3 to 51 % of total vehicles. All buses (Mini Bus/BEST Bus/S.T.Bus/ Other Bus) constitute less than 2 per cent at start of WEH, New Agripada and 15.7 per cent at end of EEH, Nitin Co location.

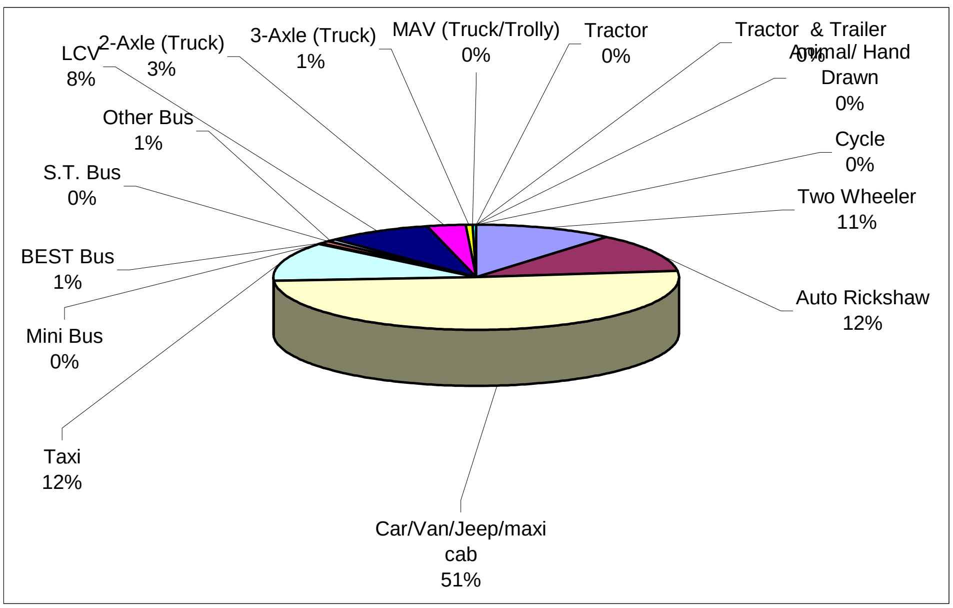


Fig 5.10 Vehicle Percentage Composition at New Agripada

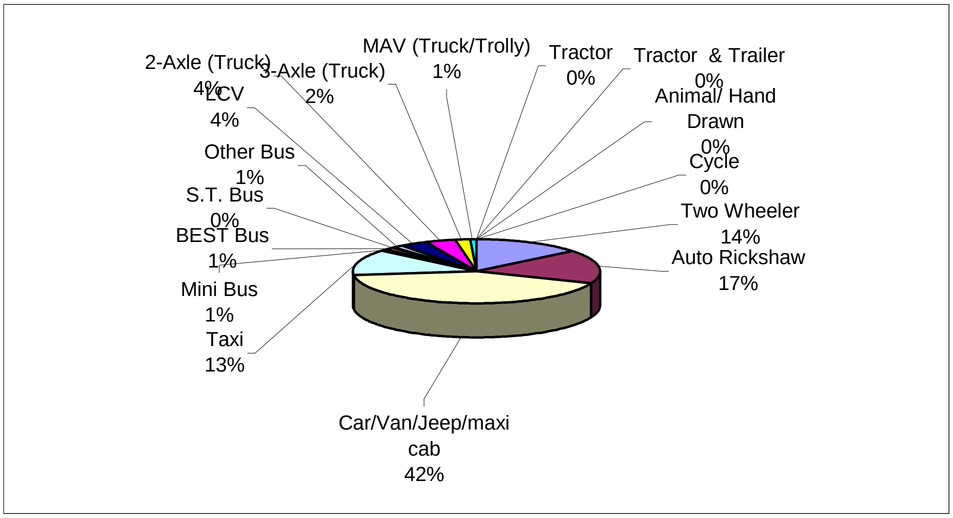


Fig 5.11 Vehicle Percentage Composition at Gundavali

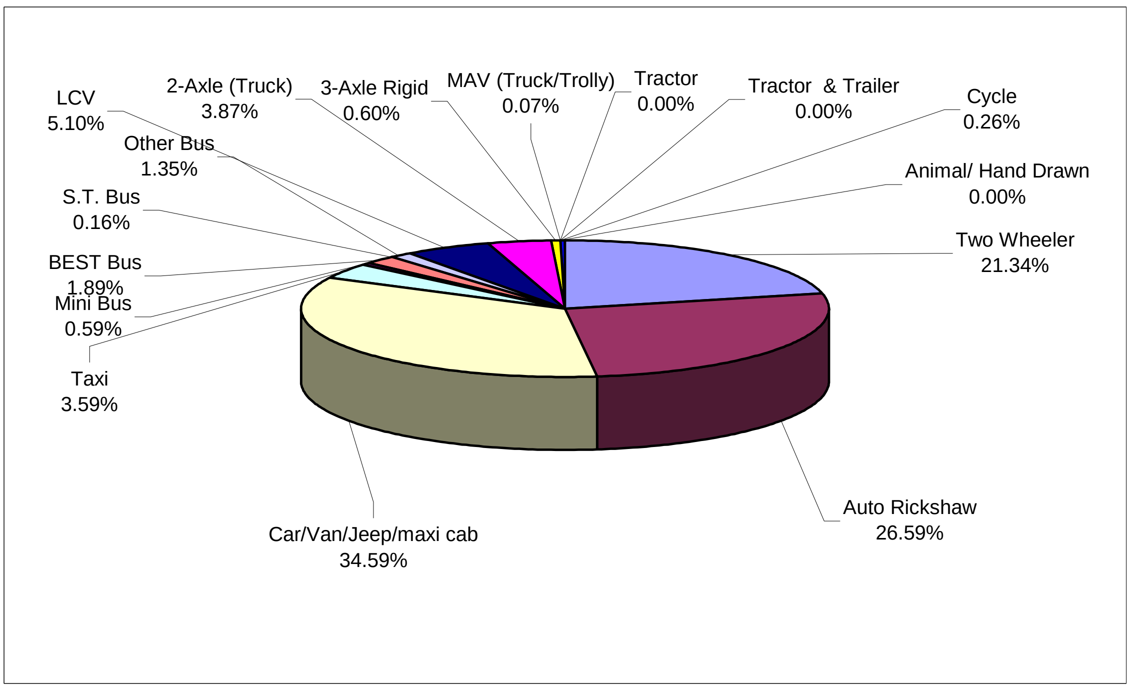


Fig 5.12 Vehicle Percentage Composition at Dindoshi

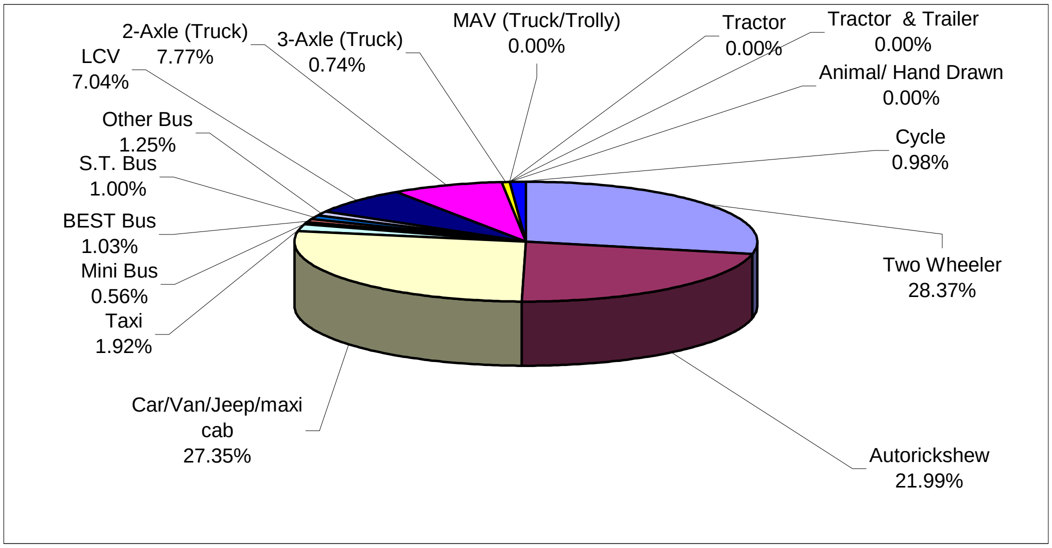


Fig 5.13 Vehicle Percentage Composition at Nancy Colony

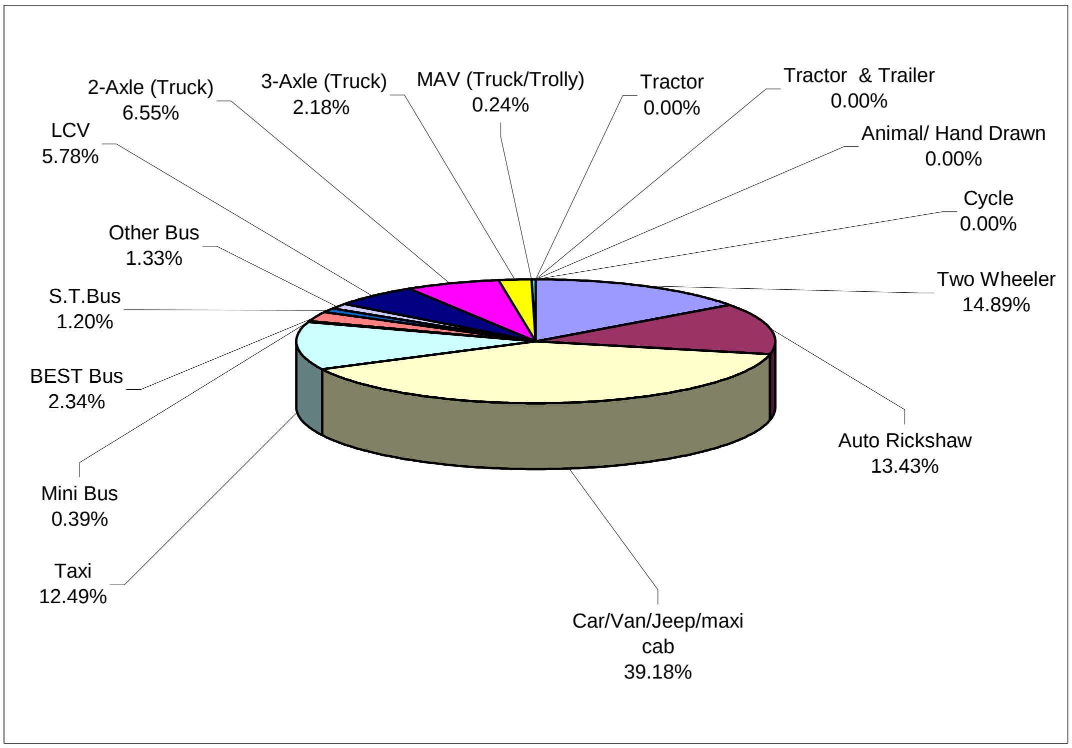


Fig 5.14 Vehicle Percentage Composition at Everard Nagar

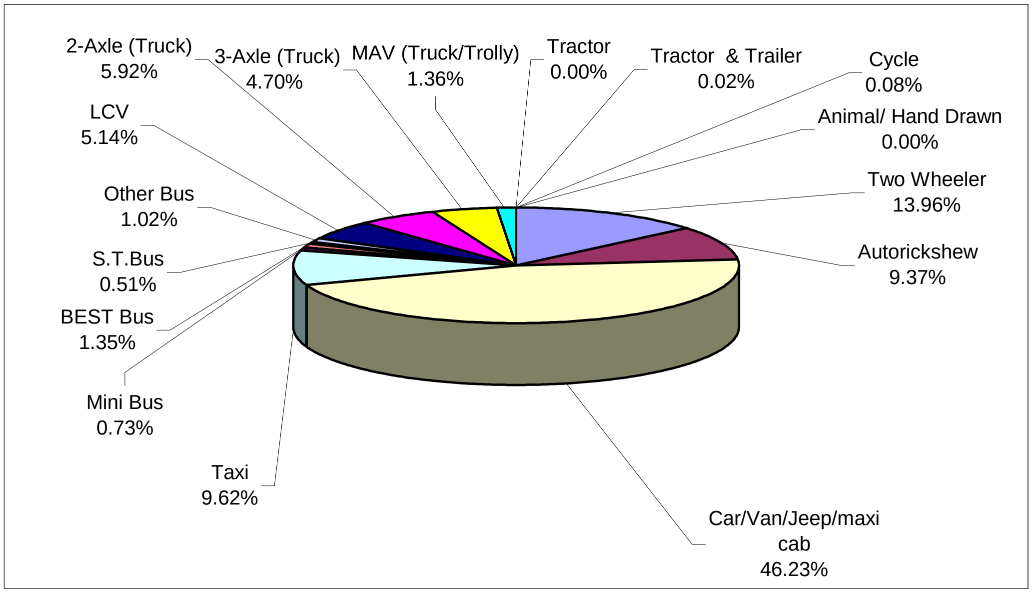


Fig 5.15 Vehicle Percentage Composition at Chheda Nagar

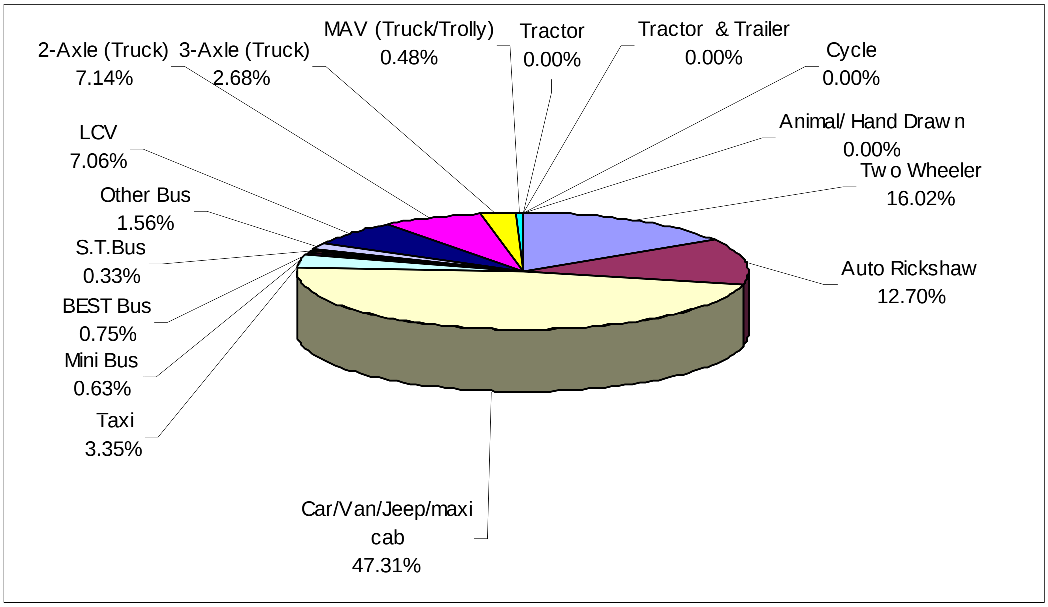


Fig 5.16 Vehicle Percentage Composition at Godrej Hospital

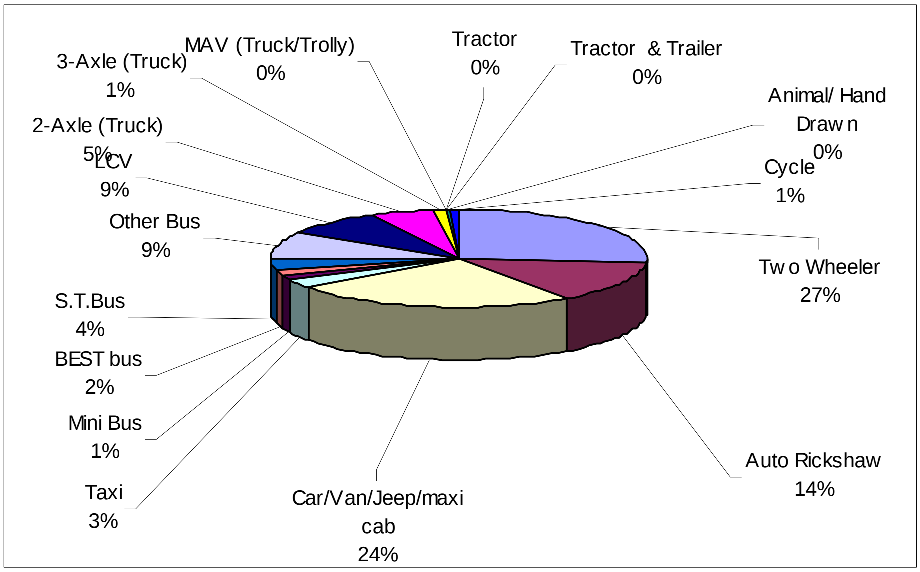


Fig 5.17 Vehicle Percentage Composition at Nitin Co.

5.3.5 Peak Hour Directional Distribution of Traffic

The Peak Hour Directional Distribution of traffic flow at each location on WEH and EEH is shown in ***Table 5.4*** and ***Table 5.5***. This is a useful input for calculating the Passengers Peak Hour Peak Direction (PPHPD).

Table 5.4 Directional Split Percentages on WEH

Survey Location	Bandra To Dahisar	Dahisar To Bandra
Western Express Highway		
New Agripada	54	44
Gundavali	50	50
Dindoshi	56	44
Nancy colony	46	54
Average	**52**	**48**

Table 5.5 Directional Split Percentages on EEH

Survey Location	Sion To Thane	Thane To Sion
Eastern Express Highway		
Everard Nagar	51	49
Chheda Nagar	57	43
Godrej	55	45
Nitin Co.	57	43
Average	**55**	**45**

The Passenger Car Units (PCU) is computed as per IRC: 64-1990 guidelines. The average directional split can be taken as 52: 48 on WEH and 55: 45 on EEH.

5.4 Turning Movement Survey

The Turning movement survey has been carried out during peak hours from morning (8:00 AM to 12:00 Noon) as well as evening (4:00 PM to 8:00 PM) for estimation of peak hour intersection volume in each direction of movement.

The methodology for the surveys was as per IRC: SP: 41-1994. The data derived from the survey will be used to identify the type of BRTS preference to be adopted at each, such as signal priority, construction of Underpasses, Fly-over, and Interchanges etc. Intersections with high traffic volume requiring special treatments either presently or in future are identified.

The survey locations are shown in ***Table 5.6*** and ***Table 5.7,*** for EEH and WEH respectively.

Table 5.6 Survey Type and Locations (EEH)

Location No	Type of Survey	Location	Date (Duration In Hours)
1	TMC	Sion Jun.	26th Sep 08 (8Hrs)
2	TMC	Suman Nagar Jun.	8th Aug 08 (8 Hrs)
3	TMC	Amarmahal Jun.	29th Sep 08 (8Hrs)
4	TMC	Mankhurd Jun.	30th Sep 08 (8Hrs)
5	TMC	AGLR Jun.	30th Oct 08 (8 Hr)
6	TMC	Godrej Company Jun.	8th Aug 08 (8 Hrs)
7	TMC	Godrej Hospital Jun.	8th Aug 08 (8 Hrs)
8	TMC	Vikhroli Jun.	1st Oct 08 (8 Hrs)
9	TMC	JVLR Jun.	1st Oct 08 (8 Hrs)
10	TMC	Airoli Jun.	14th Oct 08 (8 Hrs)
11	TMC	Mulund Jun.	15th Oct 08 (8 Hrs)
12	TMC	Teenhath Naka Jun.	25th Nov 08 (8 Hrs)
13	TMC	Nitin Co. Jun.	16th Oct 08 (8 Hrs)
14	TMC	Cadbury Jun.	14th Oct 08 (8 Hrs)

Table 5.7 Survey Type and Locations (WEH)

Location No	Type of Survey	Location	Date (Duration In Hours)
1	TMC	Kalanagar Jun.	20th Oct 08 (8 Hrs)
2	TMC	Kherwadi Jun.	11th Aug 08 (8Hrs)
3	TMC	Kalina Jun.	20th Nov 08 (8 Hrs)
4	TMC	Vakola Jun.	6th Nov 08 (8 Hrs)

Location No	Type of Survey	Location	Date (Duration In Hours)
5	TMC	Domestic Airport Jun.	23rd Oct 08 (8 Hrs)
6	TMC	Sahara Int.Airport (Bahar Cinema) Jun.	2nd Dec 08 (Hrs)
7	TMC	Goldspot Jun.	26th Nov 08 (8 Hrs)
8	TMC	Andheri Kurla (Darpan Cinema) Jun.	24th Nov 08 (8 Hrs)
9	TMC	JVLR (Jai Coach) Jun.	6th Nov 08 (8 Hrs)
10	TMC	Arey (Goregaon) Jun.	31st Oct 08 (8 Hrs)
11	TMC	ITT Bhatti Jun.	24th Oct 08 (8 Hrs)
12	TMC	Pathanwadi Jun.	24th Oct 08 (8 Hrs)
13	TMC	Bhor Industry Jun.	19th Nov 08 (8 Hrs)
14	TMC	Thakur Complex (BHAD) Jun.	3rd Nov 08 (8Hrs)
15	TMC	Dattapada (Magthane) Jun.	3rd Nov 08 (8Hrs)
16	TMC	Borivali National Park Jun.	23rd Oct 08 (8 Hrs)
17	TMC	Gokul Anad Jun.	5th Nov 08 (8 Hrs)
18	TMC	Ravalpada (Ashok one) Jun.	4th Nov 08 (8 Hrs)
19	TMC	Dahisar Check Naka Jun.	5th Nov 08 (8 Hrs)

A total of 14 intersections on Eastern Express Highway and 19 intersections on Western express highway were selected for conducting turning movement survey. The observed peak hours along with peak hour vehicles/PCUs are given in ***Table 5.8*** and ***Table 5.9*** for EEH and ***Table 5.10*** and ***Table 5.11*** for WEH. The highest 14338 PCU's was observed at Amarmahal Junction during the morning peak hour 9:00-10:00 and the lowest 6241 PCU's was observed at Godrej company during 10:00-11:00 hrs on EEH. Similarly for the evening peak hour the highest 14455 PCU's was observed at Amarmahal junction during 17:00 – 18:00 hrs and the lowest 3931 PCU's at Godrej company at 17:00 – 18:00 hrs. While on WEH during morning peak hour the highest 22014 PCU's was observed at Vakola during 10:00-11:00 hrs and the lowest 5391 PCU's at Bhor Industries at 9:00-10:00 hrs. Similarly in the evening the highest 22524 PCU's was observed at Aarey junction during 19:00 – 20:00 hrs and the lowest 6174 PCU's at Bhor Industries at 19:00 – 20:00 hrs.

Table 5.8 : Summary of Turning Movement Survey for morning peak for EEH

Sr. No.	Location	Morning Peak Hour Duration	Vehicles	PCUs
1	Sion Jun.	9:00 to 10:00	8679	11120
2	Suman Nagar Jun.	9:00 to 10:00	7967	9438
3	Amarmahal Jun.	9:00 to 10:00	11371	14338
4	Mankhurd Jun.	10:00 to 11:00	6705	9061
5	AGLR Jun.	11:00 to 12:00	7366	8870

Sr. No.	Location	Morning Peak Hour Duration	Vehicles	PCUs
6	Godrej Company Jun.	10:00 to 11:00	5936	6241
7	Godrej Hospital Jun.	9:00 to 10:00	5135	5717
8	Vikhroli Jun.	10:00 to 11:00	7204	7098
9	JVLR Jun.	9:00 to 10:00	7520	7957
10	Airoli Jun.	10:00 to 11:00	10405	10087
11	Mulund Jun.	10:00 to 11:00	7012	6744
12	Teenhath Naka Jun.	10:00 to 11:00	10571	10893
13	Nitin Co. Jun.	11:00 to 12:00	8605	8520
14	Cadbury Jun.	11:00 to 12:00	9407	8460

Table 5.9: Summary of Turning Movement Survey for Evening peak for EEH

Sr. No.	Location	Evening Peak Hour Duration	Vehicles	PCUs
1	Sion Jun.	18:00 to 19:00	9141	10942
2	Suman Nagar Jun.	18:00 to 19:00	9298	12354
3	Amarmahal Jun.	17:00 to 18:00	11924	14455
4	Mankhurd Jun.	19:00 to 20:00	10140	12859
5	AGLR Jun.	19:00 to 20:00	9178	10990
6	Godrej Company Jun.	17:00 to 18:00	3679	3931
7	Godrej Hospital Jun.	16:00 to 17:00	5063	5667
8	Vikhroli Jun.	19:00 to 20:00	7311	6726
9	JVLR Jun.	17:00 to 18:00	8315	9127
10	Airoli Jun.	19:00 to 20:00	12112	12100
11	Mulund Jun.	19:00 to 20:00	8679	7763
12	Teenhath Naka Jun.	18:00 to 19:00	10610	10681
13	Nitin Co. Jun.	19:00 to 20:00	12776	12524
14	Cadbury Jun.	19:00 to 20:00	10292	9362

Table 5.10: Summary of Turning Movement Survey for morning peak for WEH

Sr. No.	Location	Evening Peak Hour Duration	Vehicles	PCUs
1	Kalanagar Jun.	11:00 to 12:00	10401	9995
2	Kherwadi Jun.	9:00 to 10:00	13154	12640

Sr. No.	Location	Evening Peak Hour Duration	Vehicles	PCUs
3	Kalina Jun.	10:00 to 11:00	6374	8540
4	Vakola Jun.	10:00 to 11:00	19381	22014
5	Domestic Airport Jun.	11:00 to 12:00	13965	16592
6	Sahara Int.Airport (Bahar Cinema) Jun.	11:00 to 12:00	9067	9181
7	Goldspot Jun.	10:00 to 11:00	11201	12662
8	Andheri Kurla (Darpan Cinema) Jun.	9:00 to 10:00	8437	9468
9	JVLR (Jai Coach) Jun.	10:00 to 11:00	10265	12838
10	Arey (Goregaon) Jun.	9:00 to 10:00	12510	15950
11	ITT Bhatti Jun.	10:00 to 11:00	12337	13862
12	Pathanwadi Jun.	10:00 to 11:00	11314	12909
13	Bhor Industry Jun.	9:00 to 10:00	4335	5391
14	Thakur Complex (BHAD) Jun.	11:00 to 12:00	10801	13716
15	Dattapada (Magthane) Jun.	10:00 to 11:00	9986	13238
16	Borivali National Park Jun.	10:00 to 11:00	7241	7736
17	Gokul Anad Jun.	11:00 to 12:00	9637	12136
18	Ravalpada (Ashok one) Jun.	11:00 to 12:00	10101	11864
19	Dahisar Check Naka Jun.	10:00 to 11:00	6783	8654

Table 5.11: Summary of Turning Movement Survey for Evening peak for WEH

Sr. No.	Location	Evening Peak Hour Duration	Vehicles	PCUs
1	Kalanagar Jun.	18:00 to 19:00	11445	11677
2	Kherwadi Jun.	17:00 to 18:00	11036	10780
3	Kalina Jun.	17:00 to 18:00	7710	9292
4	Vakola Jun.	18:00 to 19:00	20004	22304
5	Domestic Airport Jun.	19:00 to 20:00	14748	15749
6	Sahara Int.Airport (Bahar Cinema) Jun.	18:00 to 19:00	11084	11018
7	Goldspot Jun.	19:00 to 20:00	11565	14201
8	Andheri Kurla (Darpan Cinema) Jun.	19:00 to 20:00	9866	11605
9	JVLR (Jai Coach) Jun.	19:00 to 20:00	14435	20992

Sr. No.	Location	Evening Peak Hour Duration	Vehicles	PCUs
10	Arey (Goregaon) Jun.	19:00 to 20:00	20196	22524
11	ITT Bhatti Jun.	18:00 to 19:00	14174	14906
12	Pathanwadi Jun.	17:00 to 18:00	12577	14655
13	Bhor Industry Jun.	19:00 to 20:00	4540	6174
14	Thakur Complex (BHAD) Jun.	19:00 to 20:00	15830	17561
15	Dattapada (Magthane) Jun.	18:00 to 19:00	9876	12590
16	Borivali National Park Jun.	19:00 to 20:00	8760	9173
17	Gokul Anad Jun.	19:00 to 20:00	10937	12901
18	Ravalpada (Ashok one) Jun.	19:00 to 20:00	10901	11886
19	Dahisar Check Naka Jun.	19:00 to 20:00	8134	9927

The percentage of morning peak Hour flow is presented in Table 5.12 and Table 5.13 for EEH and WEH respectively.

Table 5.12: Morning peak Hour Turning Flow for EEH

Sr. No.	Location	Straight flow Vehicles	Turning / crossing flow Vehicles	% Turning / crossing flow of vehicles
1	Sion Jun.	6038	2314	38
2	Suman Nagar Jun.	4101	3866	94
3	Amarmahal Jun.	5558	6159	111
4	Mankhurd Jun.	3217	3488	108
5	AGLR Jun.	4365	3001	69
6	Godrej Company Jun.	3892	1922	49
7	Godrej Hospital Jun.	4053	2155	53
8	Vikhroli Jun.	4434	2770	62
9	JVLR Jun.	2994	4291	143
10	Airoli Jun.	4512	5893	131
11	Mulund Jun.	2675	4387	164
12	Teenhath Naka Jun.	5079	5492	108
13	Nitin Co. Jun.	5780	2825	49

Table 5.13 Morning peak Hour Turning Flow for WEH

Sr. No.	Location	Straight flow Vehicles	Turning / crossing flow Vehicles	% Turning /crossing flow of vehicles
1	Kalanagar Jun.	7434	2967	40
2	Kherwadi Jun.	9148	3352	37
3	Kalina Jun.	4973	1401	28
4	Vakola Jun.	11455	7723	67
5	Domestic Airport Jun.	7981	5511	69
6	Sahara Int.Airport (Bahar Cinema) Jun.	6140	2927	48
7	Goldspot Jun.	5420	5781	107
8	Andheri Kurla (Darpan Cinema) Jun.	5259	3178	60
9	JVLR (Jai Coach) Jun.	5390	4875	90
10	Arey (Goregaon) Jun.	9420	3090	33
11	ITT Bhatti Jun.	2039	5938	291
12	Pathanwadi Jun.	840	2698	321
13	Bhor Industry Jun.	2841	1494	53
14	Thakur Complex (BHAD) Jun.	4994	5807	116
15	Dattapada (Magthane) Jun.	6476	3510	54
16	Borivali National Park Jun.	1136	4642	409
17	Gokul Anad Jun.	5756	3881	67
18	Ravalpada (Ashok one) Jun.	6639	3462	52
19	Dahisar Check Naka Jun.	1984	2201	111

5.5 Speed & Delay Survey

Speed and Delay studies are intended to provide information of road sections subject to undue traffic congestion and delay. Also the other factors responsible for reduced travel speeds have been noted. These data are used for creating different scenario by varying the journey speed of BRTS and compare the over all benefits.

Speed and delay survey were carried out by moving car observer method. Two round trips were made covering on service roads (surface) and on Flyovers. The results of the survey are shown in ***Table 5.14***.

On WEH, the running speed along the side road and along the flyovers differs by 4 Kmph only, indicating that there is not much delay at the junction points. A difference of 6 Kmph was observed in Thane to Sion direction on EEH.

Table 5.14 Summary of Speed & Delay Survey

Sr. No	BRTS Corridor	Direction of Travel	Dist-ance (km)	Total Time (Minutes: Seconds)	Delay Time (Minutes: Seconds)	% of Delay	Cause of Delay	Journey Speed (Kmph)	Running Speed (Kmph)
1	WEH– Service Road	Bandra- Dahisar	25	0:56:17	0:07:33	13%	Inter-section	28	32.37
2		Dahisar-Bandra	25	0:57:36	0:16:13	28%		25.2	35.22
3	WEH-on Flyovers	Bandra- Dahisar	26	0:43:50	0:01:45	4%	Traffic Cong-estion	38.4	36.85
4		Dahisar-Bandra	26	0:45:08	0:04:15	9%		35.5	39.19
5	EEH-Service Road	Sion - Thane	25	0:38:08	0:06:29	17%	Inter-section	40.44	48.89
6		Thane-Sion	25	0:37:16	0:07:23	20%		41.45	50.2
7	EEH-Flyovers	Sion - Thane	26	0:35:26	0:03:52	11%	Traffic Cong-estion	44.03	49.42
8		Thane-Sion	26	0:33:05	0:15:32	47%		47.51	53.49

5.6 Pedestrian Volume Count Survey

The Pedestrian volume count is carried out at predominant locations during morning and evening peak hours.

The number of pedestrian passing along and across the Project Corridor, during normal business hours, at the predominant locations, is presented in ***Table 5.15***.

Table 5.15 Pedestrian Volumes per Hour along and Across the Project Corridor

Sr. No	Location	Peak Hour	Number of Pedes-trian Crossing Project corridor	Number of Pedestrian Walking along the Project corridor
1	Suman Nagar	9 – 10	329	161
2	Godrej Memorial Hospital	10 – 11	225	33
3	Godrej company	15 – 16	174	84
4	Kherwadi	9 – 10	570	495

The pedestrian peak hour volumes are low.

5.7 Boarding-Alighting Survey

The Boarding Alighting survey of bus passengers is carried out at 13 bus stops on WEH and 6 bus stops on EEH on both directions. A sample hourly variation of Passengers boarding and alighting at Kala Nagar Bus Stop on WEH is presented graphically in **Figure 5.18** to **Figure 5.19.**

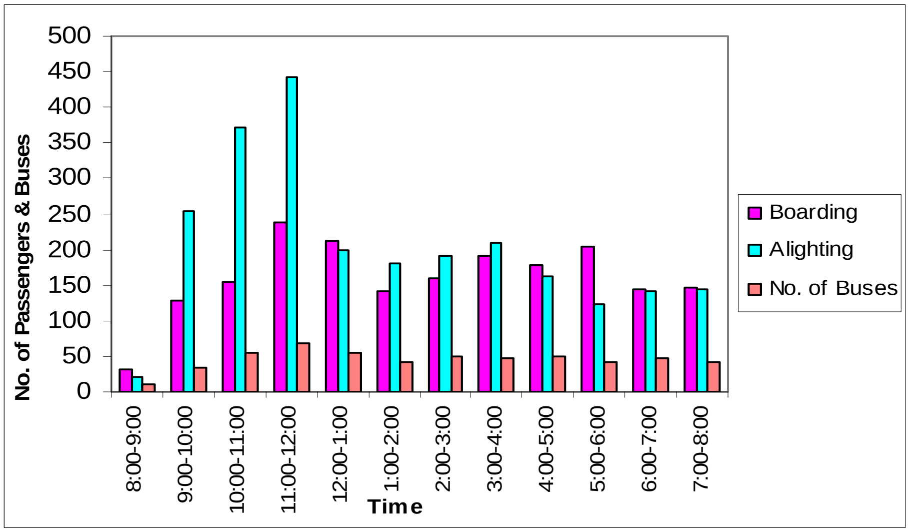


Figure 5.18 No. of Passengers Boarding and Alighting at Kala Nagar Bus Stop (Bandra to Dahisar)

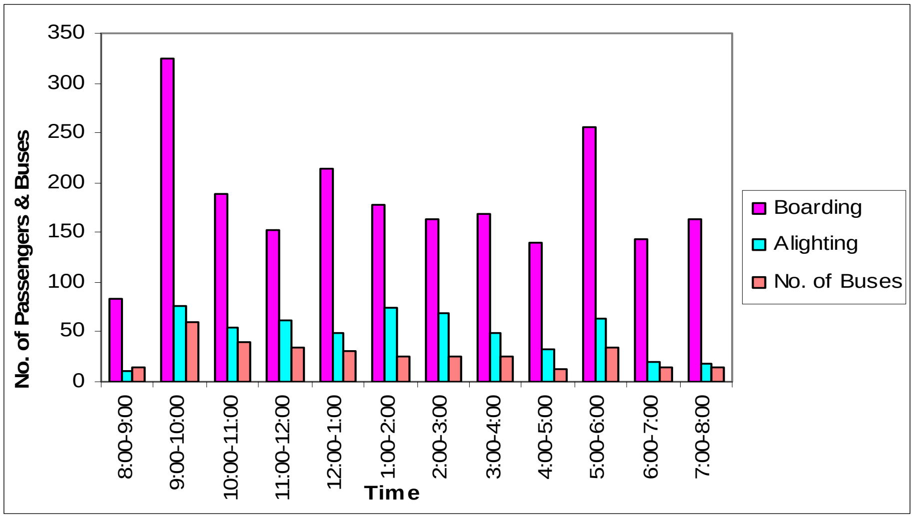


Figure 5.19 No. of Passengers Boarding and Alighting at Kala Nagar Bus Stop (Dahisar to Bandra)

The maximum boarding and alighting, direction wise, and its time of occurrence are given in ***Table 5.16.***

Table 5.16 Maximum Boarding-Alighting at Bus stops

Sr. No.	Bus Stop Location	Direction of travel	No. Of Buses	Max. Hour	Passengers-Boarding	Passengers-Alighting	Total Passengers
Western Express Highway							
1	Kala Nagar	Bandra-Andheri(UP)	67	11-12	238	443	681
		Andheri-Bandra((DN)	59	9-10	324	76	400
2	Kherwadi	UP	41	11-12	184	102	286
		DN	35	10-11	169	190	359
3	New Agripada	UP	57	11-12	132	131	263
		DN	65	8-9	266	249	515
4	Centur Hotel	UP	19	10-11	203	171	374
		DN	21	17-18	75	57	132
5	Bahar Cinema	UP	15	19-20	132	34	166
		DN	12	18-19	139	32	171
6	Jai Coach	UP	44	17-18	171	99	270
		DN	54	18-19	263	127	390
7	Mahananda colony	UP	42	15-16	64	91	155
		DN	39	15-16	80	92	172
8	Virwani	UP	132	17-18	531	442	973
		DN	91	18-19	386	119	505
9	Pathanwadi	UP	42	18-19	228	106	334
		DN	35	19-20	130	141	271
10	Kurar village	UP	101	13-14	159	202	361
		DN	39	19-20	313	170	483
11	B.H.A.D	UP	97	12-13	424	252	676
		DN	72	10-11	590	164	754
12	National Park	UP	80	18-19	115	223	338
		DN	77	9-10	756	108	864
13	Nancy Colony	UP	28	11-12	64	67	131
		DN	27	8-9	19	30	49

Sr. No.	Bus Stop Location	Direction of travel	No. Of Buses	Max. Hour	Passengers-Boarding	Passengers-Alighting	Total Passengers
Eastern Express Highway							
14	Everard Nagar	UP	56	18-19	220	284	504
		DN	70	18-19	367	188	555
15	Suman Nagar	UP	17	18-19	34	23	57
		DN	22	8-9	38	45	83
16	S.G.Barve marg	UP	32	18-19	204	82	286
		DN	36	11-12	114	194	308
17	Amar Mahal	UP	19	18-19	251	32	283
		DN	17	13-14	134	124	258
!8	Chheda Nagar	UP	28	12-13	44	31	75
		DN	32	9-10	58	69	127
19	Vikhroli	UP	6	16-17	29	8	37
		DN	6	17-18	59	23	82

5.8 Bus Routes On-Board Survey

On board survey was carried out in order to assess the bus speeds (Journey & Running) and to identify the locations of delay and to quantify delays at each location. In addition to this the assessment of the load factor by the intersections of route / road and the passenger demand by route, time period was also noted. The bus route numbers and average passengers on-board the bus along the BRTS corridor mean section wise loading for 40 Ltd. bus route (up and down Trips) on WEH is presented in ***Figure 5.20*** to ***Figure 5.21 .***

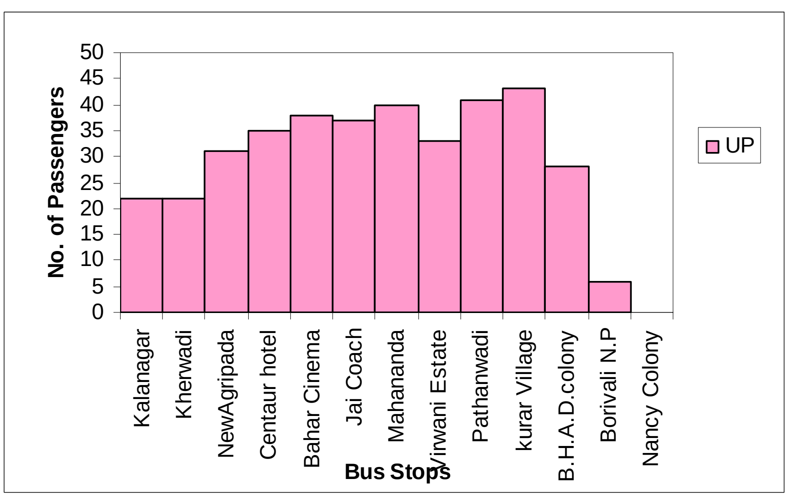


Figure 5.20 Section wise loading of 40 Ltd. Bus Route 1st Round (Bandra to Dahisar)

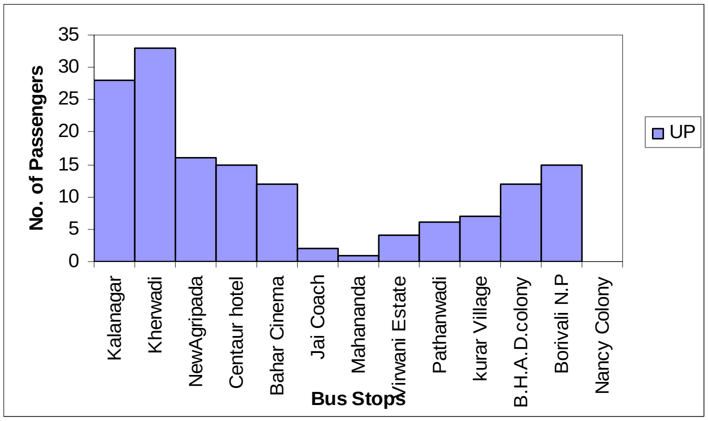


Figure 5.21 Section wise loading of 40 Ltd. Bus Route 1st Round (Dahisar to Bandra)

The WEH is divided in to 13 sections and EEH is divided in to 7 sections and the Average Section wise Journey speed for each bus route on WEH and EEH is presented in ***Figure 5.22*** to ***Figure 5.23***

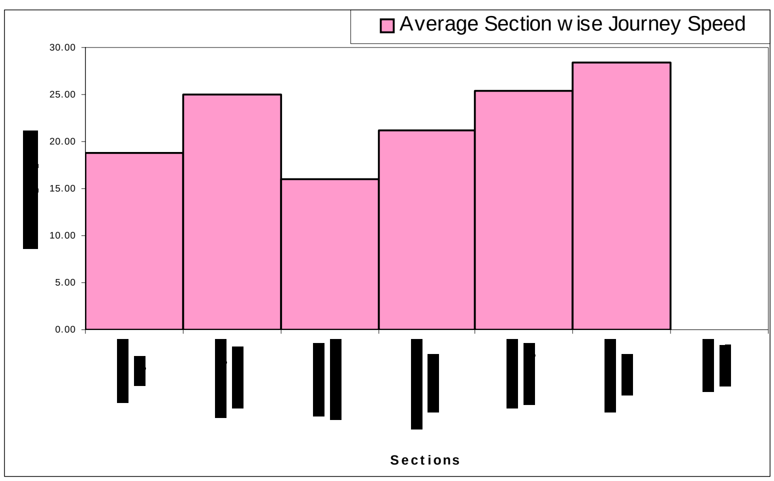


Figure 5.22 Average Section wise Journey Speed of 354 Bus Route on EEH (Thane to Sion)

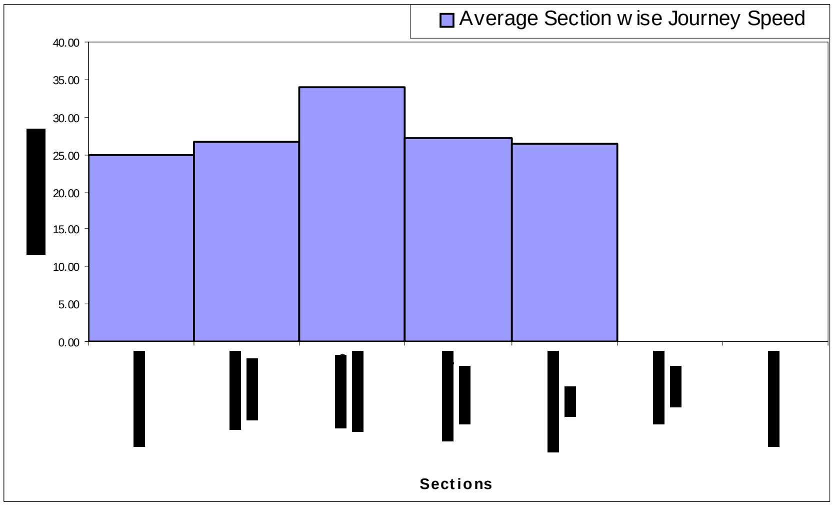


Figure 5.23 Average Section wise Journey Speed of 368 Bus Route on EEH (Sion to Thane)

The average delay at bus stops and due to congestion for each route during on board survey is presented in ***Table 5.17***

Table 5.17 Average Delays at Bus Stops per Passengers and due to Congestion

Sr.No.	Corridor	Bus Route No.	Average Delay per Passenger at Bus Stops	Average Delay Due To Congestion
1	WEH	40 Ltd	0:00:02	0:02:46
2		40 Exp	0:00:11	0:01:47
3		225	0:00:11	0:01:07
4		448 Exp	0:00:02	0:00:07
5		449 Ltd	0:00:03	0:00:07
6		348	0:00:07	0:01:24
7	EEH	373	0:00:25	0:01:28
8		353	0:00:30	0:03:08
9		385	0:00:22	0:01:56
10		27	0:00:13	0:01:05
11		354	0:00:14	0:04:23
12		368	0:00:13	0:02:56

From the above analysis it clear that there is considerable variation in the journey speed of buses of different category (ordinary, Express, Limited etc) and travelling at different time of the day.

5.9. Stated Preference Survey

To assess the adequacy of public transport system and related transport infrastructure stated preference surveys were conducted at different locations along the WEH and EEH corridor.

Trained engineers of CES interviewed the public and private transport users on random sample basis. A structured questionnaire was used for survey.

5.9.1 Sample Size and Distribution

An ad hoc quota of 972 responses was used for the analysis. ***Table 5.18*** and ***Figure 5.24*** shows the tabular and pictorial representation of the sample distribution by mode respectively.

Table 5.18 Samples interviewed on WEH & EEH

Mode Type	WEH BRTS Corridor	EEH BRTS Corridor	Total
2 Wheeler users	103	59	162
Car users	100	100	200
IPT users	114	0	114
Train Passengers	96	100	196
Bus Passengers	150	150	300

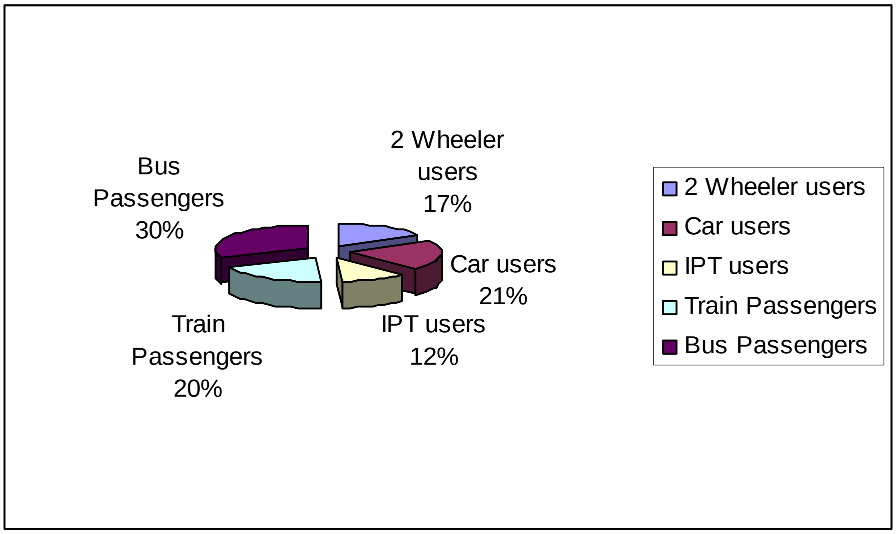


Figure 5.24 Sample Distributions by Mode

5.9.2 Socio-Economic Characteristics of Private and Public Transport Users

The socio-economic characteristics of the private and public transport users along the WEH and EEH corridor have been analyzed to discuss their impact on their travel behaviour and pattern.

5.9.2.1 Age Group

The middle age groups (25-50) predominance is observed among 2-wheeler, car and train users.

5.9.2.2 Occupation

The service occupation is predominant among all users.

5.9.2.3 Monthly Income

This is a significant factor for consideration in planning the transport system and provision of transport service. **Distributions of respondents by Income Group by type of mode used is depicted in *Figure 5.25.***

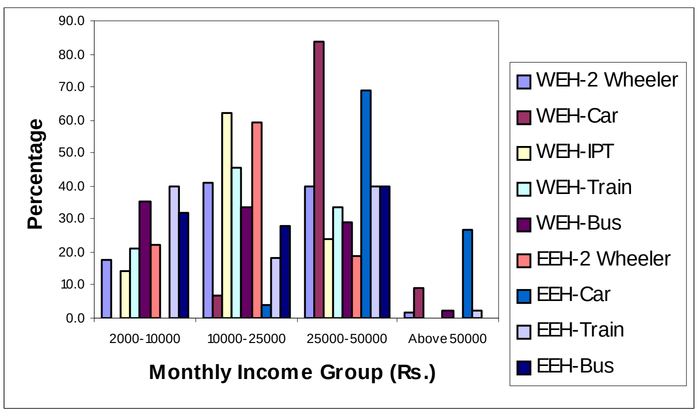


Figure 5.25 Distributions of Respondents by Income Group by Type of Mode Used

5.9.3 Existing Trip Characteristics

The average trip length, average travel time and average travel cost of different mode users on WEH and EEH is presented in ***Table 5.19.***

Table 5.19 Existing Trip Characteristics

Type of Mode User		Average Trip Length (Km.)	Average Travel Time (Min.)	Average Travel Cost (Rs.)
WEH	2 Wheeler	16.1	30.4	20.1
	Car	16.2	32.4	160.8
	IPT	8.9	23.1	32.8
	Train	13.2	20.2	8.8
	Bus	7.2	25.9	10.1
EEH	2 Wheeler	23.7	43.1	35.9
	Car	19.8	45.6	200.0
	Train	12.9	21.0	8.5
	Bus	10.2	22.3	10.3

Source: CES Survey 2008

5.10. Summary of Analysis

1. The width of the roadway is fairly uniform on both WEH & EEH, but the traffic gets reduced from Bandra to Dahisar and Sion to Thane.

2. The Traffic volume (V) of the corridors (WEH & EEH) and the road capacity (C), the v/c ratio was calculated and found to vary from 0.31 at Nancy Colony to 1.00 at New Agripada on WEH and 0.24 at Nitin Co. to 0.81 at Everard Nagar on EEH, considering the level of service "C".

3. 52:48 directional split of traffic was observed on WEH (i.e. Bandra to Dahisar and Dahisar to Bandra). The directional split on EEH was slightly different from the WEH and its value is 55:45 (i.e. Sion to Thane and Thane to Sion).

4. The highest composition of BEST bus on WEH was 1.9 % at survey location Dindoshi and similar figure for EEH is 2.3 % at survey location Everard Nagar.

5. The Peak hour volume is 8% of Daily Volume on WEH & EEH, except at Godrej Junction 9 %.

6. All road crossings (except 3 on EEH and 1 on WEH) are grade separated and implementation of BRTS will not affect the through traffic on these Expressways. In due course, these intersections will also be grade separated.

7. There is 10 Kmph and 6 Kmph difference between the journey speed along the service road and through the flyover on WEH and EEH respectively. Intersection delays were observed along the service road and congestion delays was dominated among the vehicles using flyovers.

8. The average boarding and alighting time per passenger is 6 Seconds on WEH and 20 Seconds on EEH. The boarding and alighting was predominant during the survey day at 4 bus stops on WEH and 1 bus stop on EEH.

9. On-Board bus route survey indicated the difference in average travel time among ordinary, express and limited service buses plying on WEH and EEH. The delay on the routes is insignificant. The travel time of Express bus, Ltd. bus and Ordinary bus was 1hour 44seconds, 1hour 9minutes 55seconds and 1hour 55seconds respectively on WEH. The travel time of Ltd. bus and Ordinary bus was 41minutes 29seconds and 43minutes 14seconds respectively on EEH.

10. The Stated Preference Survey has indicated the percentage of Willingness to shift to BRTS from other modes of travel. The conditions on which the shift will be made also obtained. These details are analyzed to obtain the additional passenger demand on the BRTS corridors from other modes.

11. The absolute probability and conditional probability of shift to BRTS from other modes were obtained and presented. The absolute probability varies from 0.15 to 1.00. The conditional probabilities could be used after deciding up on the type of BRTS components. Depending upon the travel timesaving and fare level the appropriate additional trips from other modes could be estimated.

12. The users of WEH & EEH are willing to patronage a well planned, designed and implemented BRTS, which will ensure travel timesavings, comfort and reliability.

Chapter 6.0
BRTS - TRAVEL DEMAND, FLEET SIZE AND INFRASTRUCTURE

6.0 BRTS - TRAVEL DEMAND, FLEET SIZE AND INFRASTRUCTURE

6.1 Travel Demand Models

To estimate the BRTS fleet size and related infrastructure required by the Horizon Year (2031), it is necessary to estimate the prospective travel demand on the BRTS on each of the 2 corridors. This estimate has been made by adopting a combination of:

- Growth Factor Model and
- Probability of Mode Shift Model

The estimates have been carried out for each of the two corridors separately.

6.1.1 Growth Factor Model:

The BRTS corridors are divided into a number of Sub – Sections.

The WEH Corridor is identified into 24 Sub-Sections and the EEH Corridor into 19 Sub-Sections. The Base Year (2008) traffic volume, by modes, by directions, at each Sub-Section has been assessed based on the extensive traffic surveys carried out as part of the study.

Intersection Turning Movement Survey was carried out at 19 intersections along WEH and at 14 intersections along EEH corridors.

The peak period and peak hour traffic volumes in PCUs and Person Trips, by Sub Sections, have been calculated based on PCU and Occupancy factors by each mode as given in the following ***Table 6.1***.

Table 6.1 - Mode Wise PCU Factor and Peak Hour Occupancy

Mode	PCU Factor	Occupancy
Two Wheeler	0.5	1.0
Car/ Van/ Jeep	1.0	1.25
Auto Rickshaw	0.75	1.2
Taxi	1.0	1.3
Mini Bus	2.0	35
BEST Bus	3.0	70
S.T. Bus	3.0	55
Other Standard Bus	3.0	55

Source: a) PCU Factor: IRC: 64-1990
b) Occupancy Factor: CES Survey, 2008

Highest and Lowest Person Trips in the Base Year on WEH and EEH are presented in **Table 6.2** and **Table 6.3**. The traffic volumes in terms of PCUs and Persons, by Sub-Sections, by Direction, by Mode in the Base Year for Morning and Evening Peak hours on WEH and EEH are given in **Volume-II, Annexure-VI.1**.

Table 6.2 - Mode-wise Person Trips in Base Year on WEH

Base Year (2008)		Morning Peak Hour				Evening Peak Hour			
		Max.		Min.		Max.		Min.	
Sections		Kalina Jn.-Vakola Jn.		Nancy Colony-Gokul Anand Jn.		Kalina Jn.-Vakola Jn.		Nancy Colony-Gokul Anand Jn.	
Directions		UP	DOWN	UP	DOWN	UP	DOWN	UP	DOWN
Modes	Two Wheeler*	910	923	640	642	869	716	603	659
	Auto Rickshaw*	1399	1319	545	769	1343	1052	742	834
	Taxi*	1873	967	554	966	1931	1242	933	1075
	Car/Van/Jeep*	428	518	164	52	566	442	161	108
	Mini Bus*	3745	4008	1295	464	4130	2800	1759	490
	BEST Bus*	12425	11585	2398	1680	8085	11515	2240	1663
	Mini+BEST Bus	16170	15593	3693	2144	12215	14315	3999	2153
	Other Bus*	12733	15153	3314	1650	17078	8553	5321	2090
	Train**	148858	148386	55727	53550	148858	148386	55727	53550
Total Passengers		**182370**	**182857**	**64636**	**59773**	**182859**	**174704**	**67485**	**60468**

*Note: source: * - CES Traffic Survey Data-2008, ** - MTHL Study*
UP for Bandra-Dahisar and DOWN for Dahisar-Bandra

Table 6.3 - Mode-wise Person Trips in Base Year on EEH

Base Year (2008)		Morning Peak Hour				Evening Peak Hour			
		Max.		Min.		Max.		Min.	
Sections		Sion Jn.-Suman Nagar Jn.		Mulund Jn.-Teenhath Naka Jn.		Sion Jn.-Suman Nagar Jn.		Airoli Jn.-Mulund Jn.	
Directions		UP	DOWN	UP	DOWN	UP	DOWN	UP	DOWN
Modes	Two Wheeler*	599	523	628	785	735	855	1098	955
	Auto Rickshaw*	521	398	535	403	669	354	656	295
	Taxi*	1439	1192	953	780	1896	1442	1207	1129
	Car/Van/Jeep*	699	835	48	29	652	895	309	42
	Mini Bus*	2240	1803	1978	735	2853	1838	1680	105
	BEST Bus*	10185	11585	840	595	12005	6230	1855	875
	Mini+BEST Bus	12425	13388	2818	1330	14858	8068	3535	980
	Other Bus*	7150	13860	7398	2970	8278	11110	7563	1925
	Train**	120796	119993	76193	76403	120796	119993	76193	76403
Total Passengers		**143630**	**150189**	**88572**	**82700**	**147883**	**142716**	**90561**	**81729**

*Note: source: * - CES Traffic Survey Data-2008, ** - MTHL Study*
UP for Sion-Thane and DOWN for Thane-Sion

6.1.2 Growth Rate

The CTS Study for MMR referred as TranSforM has established Base Year (2005) trips generated, in MMR, by modes; and has forecast Horizon Year (2031) trip generation, in MMR, by mode. Based on the above the annual growth rate of trips, by modes, has been estimated as given in ***Table 6.4***. These Growth Rates are adopted for estimating mode wise volumes by HY along sub section, of the 2 corridors. CTS projections include development of extensive Metro network. However for BRTS study, it is assumed that Metro system development will be delayed and the projected Metro traffic is redistributed between suburban rail and city bus systems. The Growth rate of Goods vehicles is adopted from TranSforM study report. The Growth Rates, mode wise, are as under.

Table 6.4 - Estimated Annual Growth Rates of Trips by Modes

Mode	Growth Rate %
Two Wheeler	4.63
Car/ van/ Jeep	5.80
Auto Rickshaw	0.54
Taxi	1.54
Buses (Mini/ BEST/ S.T./ Other Standard Bus)	2.67
Good Vehicles (LCV/ 2-Axle/ 3-Axle Rigid/ Multi Axle/ Tractor/ Tractor Trailer)	1.76
Non Motorized Vehicles	0.00

The growth rate of suburban rail traffic has been taken from MTHL Study carried out by the Consultants, wherein the traffic on the sub-urban rail service on Western Railway and Central Railway has been assessed and the forecast growth rates are:

Western Railway: 1.34%
Central Railway: 1.32%

The above growth rates are used to project traffic volume, by Sub- Sections, along the 2 corridors.

6.1.3 Travel Demand along the Corridors

Travel demand along the identified corridors have been estimated based on the growth rates both in terms of Person volumes and Vehicle volumes by adopting the Occupancy and PCU values by mode type. Highest and Lowest travel demand in terms of Person Trips in the Horizon Year on WEH and EEH are presented in ***Table 6.5*** and ***Table 6.6***.

The estimated travel demand by persons and vehicles (PCUs), by Sub-Sections along the two corridors are given in **Volume-II, Annexure-VI.2**.

Table 6.5 - Mode-wise Person Trips in Horizon Year on WEH

Horizon Year (2031)		Morning Peak Hour				Evening Peak Hour			
		Max.		Min.		Max.		Min.	
Sections		Kalina Jn.-Vakola Jn.		Nancy Colony-Gokul Anand Jn.		Kalina Jn.-Vakola Jn.		Nancy Colony-Gokul Anand Jn.	
Directions		UP	DOWN	UP	DOWN	UP	DOWN	UP	DOWN
Modes	Two Wheeler	2576	2613	1812	1817	2461	2028	1709	1866
	Auto Rickshaw	1584	1493	617	871	1520	1190	839	944
	Taxi	2662	1374	788	1373	2745	1764	1325	1527
	Car/Van/Jeep	1566	1895	598	190	2069	1616	588	397
	Mini Bus	6865	7346	2374	850	7571	5133	3224	898
	BEST Bus	22777	21237	4395	3080	14821	21109	4106	3048
	Mini+BEST Bus	29642	28584	6769	3930	22392	26242	7330	3946
	Other Bus	23341	27777	6075	3025	31306	15678	9755	3831
	Train	202315	201673	75739	72781	202315	201673	75739	72781
Total Passengers		**263686**	**265408**	**92398**	**83986**	**264807**	**250192**	**97286**	**85292**

Table 6.6 - Mode-wise Person Trips in Horizon Year on EEH

Horizon Year (2031)		Morning Peak Hour				Evening Peak Hour			
		Max.		Min.		Max.		Min.	
Sections		Sion Jn.-Suman Nagar Jn.		Nancy Colony-Gokul Anad Jn.		Sion Ju.-Suman Nagar Jn.		Airoli Jn.-Mulund Jn.	
Directions		UP	DOWN	UP	DOWN	UP	DOWN	UP	DOWN
Modes	Two Wheeler	1696	1481	1778	2223	2080	2420	3110	2703
	Auto Rickshaw	590	451	606	456	757	401	742	334
	Taxi	2045	1694	1354	1109	2695	2049	1715	1605
	Car/Van/Jeep	2558	3054	174	107	2384	3273	1132	153
	Mini Bus	4106	3304	3625	1347	5229	3368	3080	192
	BEST Bus	18671	21237	1540	1091	22007	11421	3401	1604
	Mini+BEST Bus	22777	24542	5165	2438	27236	14789	6480	1797
	Other Bus	13107	25408	13561	5445	15174	20366	13863	3529
	Train	163258	162173	102976	103261	163258	162173	102976	103261
Total Passengers		**206032**	**218803**	**125614**	**115038**	**213585**	**205472**	**130019**	**113381**

6.2 Probability of Shift Model

With the operation of BRTS service with high capacity and speed, there is a high probability of shift from various modes on to the BRTS. Stated Preference survey of user's of different modes along the two corridors has been carried out and based on the user preference for shift to BRTS based on probable cost and time savings, the probability of shift under three scenarios (Optimistic, Realistic and Conservative) has been derived.

6.2.1 Stated Preference Survey

972 responses for the Stated Preference Survey (SPS) were analyzed. **Table 6.7** details the distribution of responses by mode, by corridor.

Table: 6.7 - SP Survey – Distribution of responses by Mode

Mode Type	WEH BRTS Corridor	EEH BRTS Corridor	Total
2 Wheeler users	103	59	162
Car users	100	100	200
IPT users	114	0	114
Train Passengers	96	100	196
Bus Passengers	150	150	300

*Note: source: * - CES Traffic Survey Data-2008*

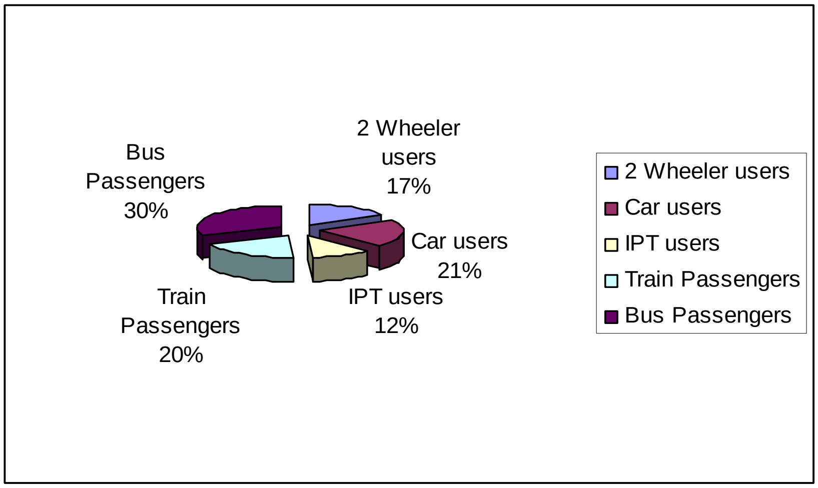


Figure 6.1 - Sample Distributions by Mode

6.2.2 Socio - Economic Characteristics of Respondees

Socio – economic characterizes of the respondees are discussed in detail in the Traffic Survey Report submitted (2008). In main: young and middle age groups predominate; service is the main occupation; students are reasonable in size; Bus and Train users are in the lower and low – middle income group; average monthly expenditure on travel range between 5.1% of income by bus users to 10.7% by car users; average trip length of bus users was 7.2 km along WEH and 10.2 km along EEH; average travel cost per trip for bus users was Rs. 10.1 along WEH and Rs. 10.3 along EEH.

6.2.3 Probability of Shift to BRTS

An analysis of the probability of shift to BRTS by 2-wheeler users, Car users, IPT users, Bus Passengers and Train Passengers has been carried out. The absolute probability of shift to BRTS by 2-wheeler, Car, IPT, Bus, and Train users is given in ***Table 6.8***.

Table 6.8 - Absolute Probability of Shift to BRTS on WEH & EEH

Corridors	2 Wheeler users	Car users	IPT users	Train Passengers	Bus Passengers
WEH BRTS Corridor	0.84	0.25	0.96	0.72	1.00
EEH BRTS Corridor	0.80	0.15	0.96	0.96	1.00

**Note: Absolute Probability of Shift to BRTS on EEH for IPT users is assumed to be same as for WEH*

The conditional probability values with reference to additional cost / fare slabs and savings in travel time have been assessed. The Conditional Probability of Shifting from 2 Wheeler, Car, IPT, Train and Bus are presented in ***Table 6.9*** to ***Table 6.13.***

Table 6.9 - Conditional Probability of Shifting from 2 Wheeler

Western Express Highway				
Extra Cost (Rs)	**0-10 min savings**	**10-20 min savings**	**20-30 min savings**	**Above 30 min savings**
0-5	0.39	0.64	0.72	0.84
6-10	0.28	0.46	0.50	0.60
11-15	0.10	0.17	0.20	0.27
16-20	0.06	0.12	0.12	0.17
Above 20	0.04	0.06	0.06	0.07
Eastern Express Highway				
Extra Cost (Rs)	**0-10 min savings**	**10-20 min savings**	**20-30 min savings**	**Above 30 min savings**
0-5	0.15	0.36	0.56	0.80
6-10	0.12	0.27	0.37	0.56
11-15	0.00	0.07	0.10	0.17
16-20	0.00	0.05	0.05	0.10
Above 20	0.00	0.05	0.05	0.08

Table 6.10 - Conditional Probability of Shifting from Car

Western Express Highway				
Extra Cost (Rs)	**0-10 min savings**	**10-20 min savings**	**20-30 min savings**	**Above 30 min savings**
0-5	0.00	0.02	0.05	0.15
6-10	0.00	0.02	0.03	0.13
11-15	0.00	0.00	0.01	0.09
16-20	0.00	0.00	0.00	0.06
Above 20	0.00	0.00	0.00	0.04
Eastern Express Highway				
Extra Cost (Rs)	**0-10 min savings**	**10-20 min savings**	**20-30 min savings**	**Above 30 min savings**
0-5	0.02	0.14	0.21	0.25
6-10	0.02	0.13	0.20	0.24
11-15	0.02	0.05	0.07	0.10
16-20	0.02	0.05	0.05	0.06
Above 20	0.02	0.04	0.04	0.05

Table 6.11 - Conditional Probability of Shifting from IPT

Western Express Highway				
Extra Fare (Rs)	**0-10 min savings**	**10-20 min savings**	**20-30 min savings**	**Above 30 min savings**
0-5	0.51	0.83	0.90	0.96
6-10	0.39	0.61	0.68	0.75
11-15	0.11	0.22	0.25	0.30
16-20	0.03	0.07	0.09	0.11
Above 20	0.00	0.00	0.00	0.02

Table 6.12 - Conditional Probability of Shifting from Train

Western Express Highway				
Extra Fare (Rs)	**0-10 min saving**	**10-20 min saving**	**20-30 min saving**	**Above 30 min savings**
0-5	0.22	0.42	0.52	0.72
6-10	0.07	0.19	0.25	0.39
11-15	0.03	0.09	0.10	0.21
16-20	0.01	0.04	0.05	0.11
Above 20	0.00	0.00	0.01	0.04
Eastern Express Highway				
Extra Fare (Rs)	**0-10 min saving**	**10-20 min saving**	**20-30 min saving**	**Above 30 min savings**
0-5	0.14	0.52	0.86	0.96
6-10	0.05	0.28	0.50	0.57
11-15	0.01	0.04	0.16	0.22
16-20	0.00	0.01	0.02	0.03
Above 20	0.00	0.01	0.02	0.03

Table 6.13- Conditional Probability of Shifting from Bus

Western Express Highway				
Extra Fare (Rs)	**0-10 min savings**	**10-20 min savings**	**20-30 min savings**	**Above 30 min savings**
0-5	0.20	0.60	0.86	1.00
6-10	0.10	0.35	0.59	0.69
11-15	0.04	0.15	0.33	0.39
16-20	0.01	0.05	0.13	0.16
Above 20	0.01	0.03	0.08	0.09
Eastern Express Highway				
Extra Fare (Rs)	**0-10 min savings**	**10-20 min savings**	**20-30 min savings**	**Above 30 min savings**
0-5	0.21	0.61	0.96	1.00
6-10	0.09	0.27	0.41	0.43
11-15	0.02	0.07	0.09	0.12
16-20	0.02	0.03	0.05	0.06
Above 20	0.01	0.01	0.01	0.03

The Mode Shift Probability Curves contain two types of curves one is Extra Cost Curve/Additional Fare Curve and the other is Time Saving Curve for 2 Wheeler, Car, IPT, Train and Bus users which are depicted in ***Figure 6.2*** to ***6.19.***

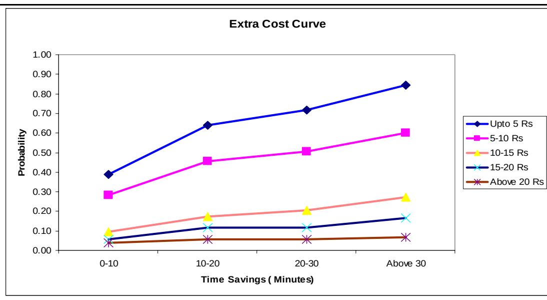


Fig 6.2 Extra Cost Curve of 2 Wheeler users on WEH

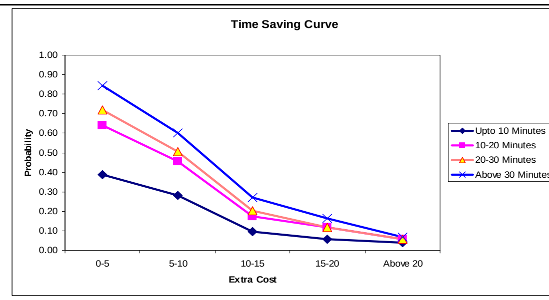


Fig 6.3 Time Saving Curve of 2 Wheeler users on WEH

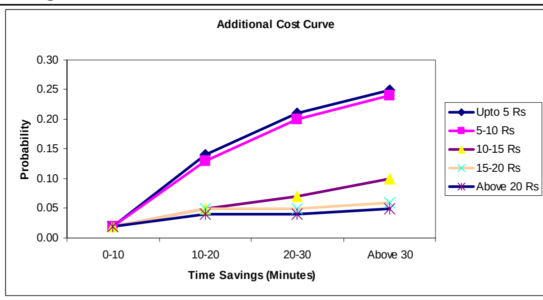


Fig 6.4 Extra Cost Curve of Car users on WEH

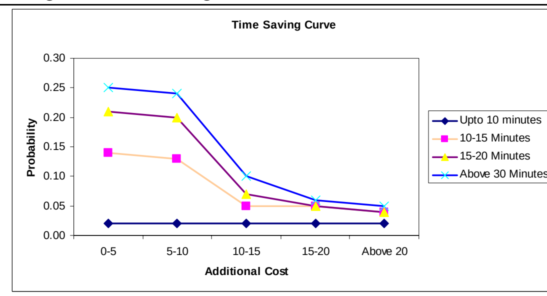


Fig 6.5 Time Saving Curve of car users on WEH

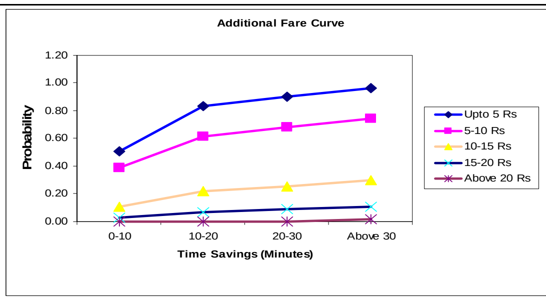


Fig 6.6 Additional Fare Curve of IPT users WEH

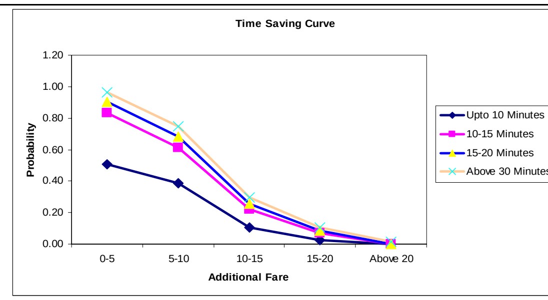


Fig 6.7 Time Saving Curve of IPT users on WEH

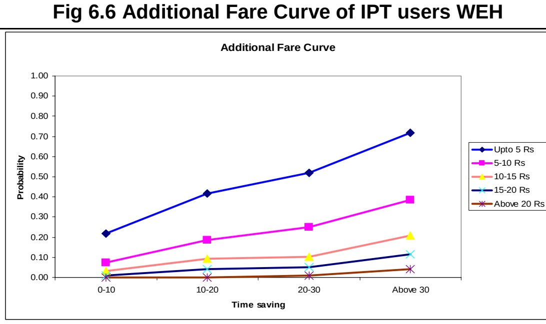


Fig 6.8 Time saving curve of Train Passenger on WEH

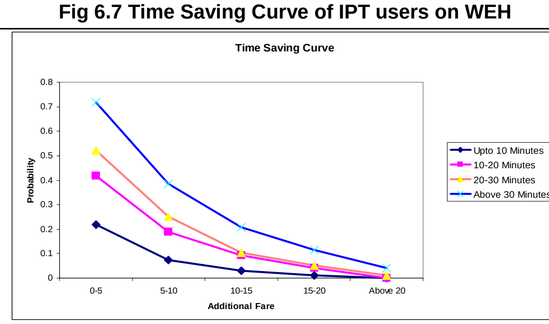


Fig 6.9 Additional Fare Curve of Train Passengers on WEH

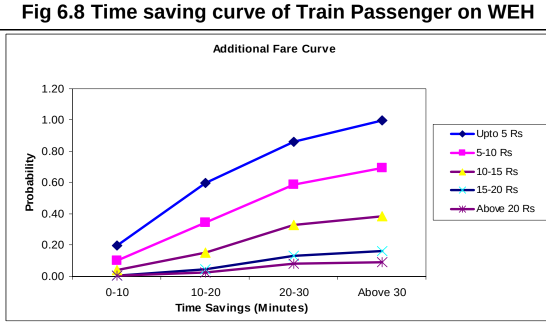


Fig 6.10 Additional Fare Curve of Bus Passengers on WEH

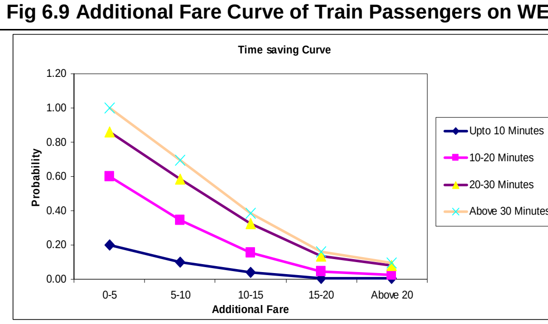


Fig 6.11 Time saving of Bus Passengers on WEH

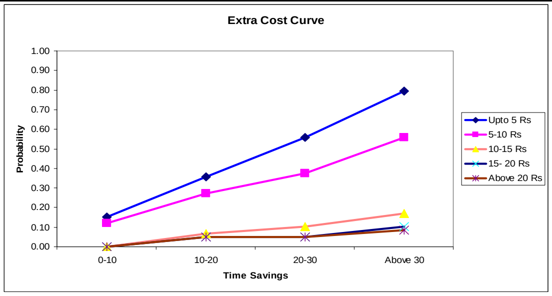


Fig 6.12 Extra Cost Curve of 2 Wheeler users on EEH

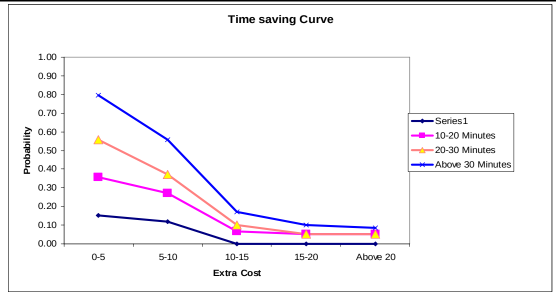


Fig 6.13 Time Saving Curve of 2 Wheeler users on EEH

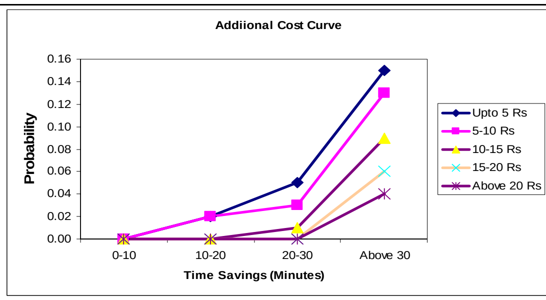


Fig 6.14 Extra Cost Curve of Car users on EEH

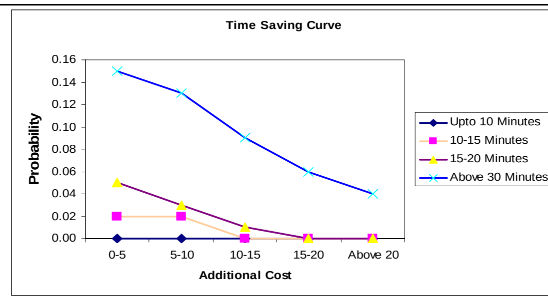


Fig 6.15 Time Saving Curve of car users on EEH

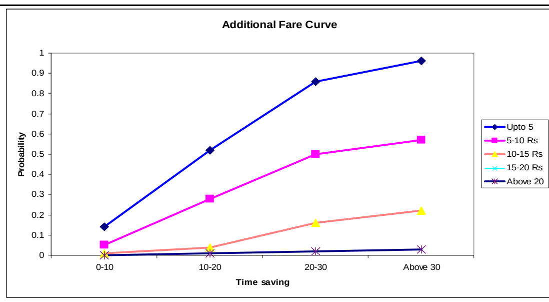


Fig 6.16 Additional Fare Curve of Train Passengers on EEH

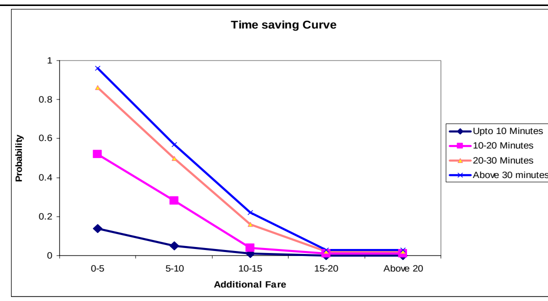


Fig 6.17 Time saving Curve of Train Passengers on EEH

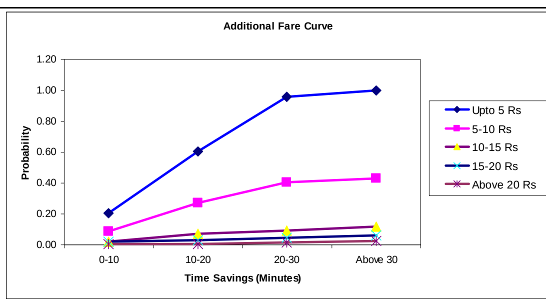


Fig 6.18 Additional Fare Curve of Bus Passengers on EEH

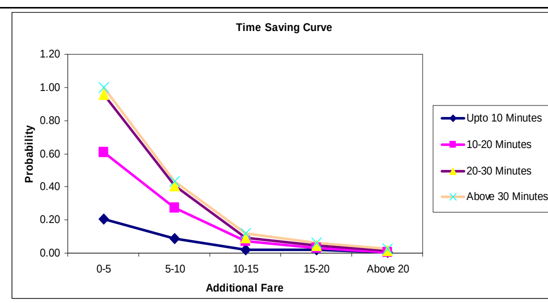


Fig 6.19 Time saving of Bus Passengers on EEH

6.2.4 Estimate of Modal Shift

To estimate the shift to BRTS by other mode users has been made under 3-scenarios: Optimistic, Realistic and Conservative. In the Optimistic scenario lowest extra cost and highest time saving have been assumed. In the Realistic scenario an extra cost of Rs. 6-10 and a time saving of 0-10 minutes have been considered and in the Conservative scenario an extra cost of Rs 16-20 and a time saving of 0-10 minutes have been considered. The probability of shift from different modes to BRTS is detailed in **Volume-II, Annexure-VI.3**.

6.2.5 Selected Scenario Values

Realistic Scenario values have been adopted for estimating the potential travel demand by BRTS. The present BEST services and Mini Bus services along the two corridors have been considered as the potential BRTS service. On to it the shift from other modes based on probability values derived has been added to estimate the potential BRTS passenger traffic demand, by Sub-Sections along the two corridors. However the bus services include those who travel for a short distance along the corridor and move in and out of the corridors. They mainly cater to transfer (to BRTS corridor) trip desires. An analysis of BEST service pattern along the two corridors indicated that the potential trunk service, that is traveling more than 5 km. length on the corridor are 60% and 65% of the total services along the EEH and WEH corridors. This has been considered as the basic BRTS traffic. The demand assessment has been made for peak period assuming a load factor of 1.0 and bus capacity of 70. Highest and Lowest no of BRTS bus trips demand on WEH and EEH is presented in ***Table 6.14*** and ***Table 6.15***. The total no of BRTS bus trips demand by Sub-Sections has been estimated and is detailed in **Volume-II, Annexure-VI.4**.

Table 6.14 - No. of BRTS Bus Trips in Horizon Year on WEH

Horizon Year (2031)		Morning Peak Hour				Evening Peak Hour			
		Max.		Min.		Max.		Min.	
Sections		Kalina Jn.-Vakola Jn.		Nancy Colony-Gokul Anand Jn.		Kalina Jn.-Vakola Jn.		Nancy Colony-Gokul Anand Jn.	
Directions		UP	DOWN	UP	DOWN	UP	DOWN	UP	DOWN
Mini Bus Passengers		6865	7346	2374	850	7571	5133	3224	898
BEST Bus Passengers		22777	21237	4395	3080	14821	21109	4106	3048
Mini+BEST Bus Passengers		29642	28584	6769	3930	22392	26242	7330	3946
Shift from Car, 2 Wheeler, IPT and Train to (Mini+BEST) Bus		16539	15967	6357	6479	16514	15837	6624	6581
Potential BRTS Passengers		46181	44550	13126	10408	38906	42079	13955	10527
BRTS Trips @ 65% of Potential BRTS		30018	28958	8532	6765	25289	27351	9071	6842
Residual Traffic	Two Wheeler	1855	1881	1305	1308	1772	1460	1230	1344
	Auto Rickshaw	966	911	377	531	927	726	512	576
	Taxi	1624	838	480	838	1674	1076	808	932
	Car/Van/Jeep	1566	1895	598	190	2069	1616	588	397
Other Bus Passengers		23341	27777	6075	3025	31306	15678	9755	3831
No. of BRTS Bus Trips with capacity of 70 & L.F. 1.0		**429**	**414**	**122**	**97**	**361**	**391**	**130**	**98**

Table 6.15 - No. of BRTS Bus Trips in Horizon Year on EEH

Horizon Year (2031)		Morning Peak Hour				Evening Peak Hour			
		Max.		Min.		Max.		Min.	
Sections		Sion Jn.-Suman Nagar Jn.		Mulund Jn.-Teenhath Naka Jn.		Sion Jn.-Suman Nagar Jn.		Airoli Jn.-Mulund Jn.	
Directions		UP	DOWN	UP	DOWN	UP	DOWN	UP	DOWN
Mini Bus Passengers		4106	3304	3625	1347	5229	3368	3080	192
BEST Bus Passengers		18671	21237	1540	1091	22007	11421	3401	1604
Mini+BEST Bus Passengers		22777	24542	5165	2438	27236	14789	6480	1797
Shift from Car, 2 Wheeler, IPT and Train to (Mini+BEST) Bus		9445	9184	6130	6042	9806	9420	6503	6247
Potential BRTS Passengers		32223	33726	11295	8480	37043	24209	12983	8043
BRTS Trips @ 60% of Potential BRTS		19334	20235	6777	5088	22226	14525	7790	4826
Residual Traffic	Two Wheeler	1493	1303	1565	1956	1830	2130	2736	2379
	Auto Rickshaw	360	275	370	278	462	244	453	204
	Taxi	1248	1033	826	676	1644	1250	1046	979
	Car/Van/Jeep	2507	2993	170	105	2336	3208	1109	150
Other Bus Passengers		13107	25408	13561	5445	15174	20366	13863	3529
No. of BRTS Bus Trips with capacity of 70 & L.F. 1.0		**276**	**289**	**97**	**73**	**318**	**208**	**111**	**69**

6.2.6 Bus Trips:

The Morning peak hour and Evening peak hour bus trips ranges between 97 to 429 and 98 to 482 respectively along the WEH and 70 to 364 and 16 to 248 respectively along the EEH. The estimate indicates high intensity of bus trips along a few sections and low intensity along a few sections. The strategy is to schedule bus services to meet the average demand along the entire length of the corridor and operate additional services along high demand sections and operate low frequency service along sections of low demand. A variety of services need to be operated along the corridors to meet the travel demand in the most optimal manner.

6.3 BRTS Bus Fleet & Bus Size

6.3.1 BRTS Fleet size

The estimated BRTS bus trips have been converted into bus-kms along the corridors in both directions. With a speed of 25 kmph a fleet utilization of 90%, bus-capacity of 70, the requirement of BRTS buses, by cardinal years, for each of the 2 corridors have been estimated and are detailed in ***Table 6.16*** and ***Table 6.17***.

Table 6.16 - BRTS Bus fleet size, on WEH corridor, by cardinal years

a) Morning Peak Hour

Sr. No.	BRTS Characteristics	2011	2016	2021	2026	2031
1	BRTS Bus Km (Both Directions)	8221	9107	10102	11220	12478
2	Bus Utilisation (Km)	25	25	25	25	25
3	Fleet Utilisation (%)	90	90	90	90	90
4	BRTS Fleet Size (Capacity-70)	362	401	444	494	549
5	A/C Buses (@10% of fleet)	36	40	44	49	55
6	Non A/C Buses	326	361	400	444	494

b) Evening Peak Hour

Sr. No.	BRTS Characteristics	2011	2016	2021	2026	2031
1	BRTS Bus Km (Both Directions)	8283	9172	10172	11296	12561
2	Bus Utilisation (Km)	25	25	25	25	25
3	Fleet Utilisation (%)	90	90	90	90	90
4	BRTS Fleet Size (Capacity-70)	364	404	448	497	553
5	A/C Buses (@10% of fleet)	36	40	45	50	55
6	Non A/C Buses	328	363	403	447	497

Table 6.17 - BRTS Bus fleet size, on EEH corridor, by cardinal years

a) Morning Peak Hour

Sr. No.	BRTS Characteristics	2011	2016	2021	2026	2031
1	BRTS Bus Km (Both Directions)	4548	5020	5549	6141	6806
2	Bus Utilisation (Km)	25	25	25	25	25
3	Fleet Utilisation (%)	90	90	90	90	90
4	BRTS Fleet Size (Capacity-70)	200	221	244	270	299
5	A/C Buses (@10% of fleet)	20	22	24	27	30
6	Non A/C Buses	180	199	220	243	270

b) Evening Peak Hour

Sr. No.	BRTS Characteristics	2011	2016	2021	2026	2031
1	BRTS Bus Km (Both Directions)	4310	4748	5238	5787	6401
2	Bus Utilisation (Km)	25	25	25	25	25
3	Fleet Utilisation (%)	90	90	90	90	90
4	BRTS Fleet Size (Capacity-70)	190	209	230	255	282
5	A/C Buses (@10% of fleet)	19	21	23	25	28
6	Non A/C Buses	171	188	207	229	253

Maximum number of buses, in either morning or evening peak hour, is adopted. A total of 852 BRTS buses, of 70 capacity would be required by (2031). The bus fleet size would increase form 564 in 2011 to 852 in 2031.

6.3.2 Bus Size

To start with BRTS buses of 12 m long, 70 seat capacity, with other features as detailed under Vehicle Technology section, is proposed. As demand on the system increase, with the above bus size, there will arise need to increase the frequency of operation. The highest frequency is recommended to be 15 sec. to meet higher travel demand and 45 sec. to meet lower travel demand. With this cap, there will be a need to introduce stage larger capacity buses by the year 2016. It is recommended that in the second stage single articulated buses of 110 capacities, 18 m long and in the third stage double articulated buses of 170 capacities, 25 m long, be introduced into the fleet. These substitutions to be made with reference to the passenger demand and policy frequency of operation. Selection of buses is detailed in ***Table 6.18***.

The engineering design of bus platforms and other fixed facility are planned to accommodate 25 m long buses, for 3 buses to stop at a time.

Table 6.18 - Maximum, minimum and average peak hour Travel Demands on WEH and EEH along with percentage of sections where peak hour Demand exceeds the max Capacity of a Bus

Year	Corridor	Travel Demand (phpdt) - morning peak			Travel Demand (phpdt) - Evening peak			Percentage of Sections exceeding the Design Bus Capacity of *Exceeding		
		Min.	Max.	Avg	Min.	Max.	Avg.	16800	26400	40800
2011	WEH	4632	19472	11487	4688	19225	11279	5.13	0	0
	EEH	3600	12879	6260	3076	14110	5938			
2016	WEH	5080	21657	12693	5139	21535	12471	12.82	0	0
	EEH	3917	14397	6900	3323	15784	6532			
2021	WEH	5579	24118	14083	5644	24150	13849	14.1	0	0
	EEH	4268	16111	7616	3592	17673	7196			
2026	WEH	6765	30018	17360	6209	27113	15372	25.64	1.28	0
	EEH	4656	18047	8416	3888	19810	7939			
2031	WEH	6765	30018	17360	6842	30473	17068	34.62	6.41	0
	EEH	5088	20235	9313	4212	22226	8770			

Bus fleet is proposed to be divided amongst various sizes of buses as per details given in ***Table 6.19.***

Table 6.19 - Size-wise Distribution of Buses

Financial Year	Bus Type/size wise --- Number of buses			Total no. of buses
	12 m long (includes 10% AC buses)	Articulated 18 m long	Double articulated 25 m long	
FY 2014	600	0	0	600
FY 2016	600	16	0	616
FY 2022	353	180	33	566
FY 2026	353	195	50	598
FY 2031	83	270	159	513

6.3.3 Bus Cost

The cost of the bus varies with the bus type and bus size. The cost of 12m Non-AC bus, 12m AC bus, 15m long articulated bus and 25m long Double articulated bus is given in ***Table 6.20.***

Table 6.20 - Bus Cost of Various Type/size

Bus Type/size wise	Bus Cost in Rs. Lakh
12m Non-AC bus	55
12m AC bus	70
18m long articulated bus	85
25m long Double articulated bus	100

6.4 Bus Infrastructure

6.4.1 Bus Depots

To service BRTS buses, a total of 9 depots each of 2 ha in extent, with necessary plant and machinery, would be required. To start with, the need is for 6 depots. It is recommended that the following present BEST depots may be assigned to BRTS.

- Dharavi
- Ghatkopar
- Dindoshi
- Poisar

In addition Terminal-cum-Depots are suggested at Dahisar and Thane. At Dahisar, at the start of the corridor, adjacent to the bus stand, an extensive truck parking area exists. It is suggested that the area be acquired, integrated with the existing bus stand and developed as Terminal-cum-Depot. In the event of non-availability of the site, then the depot may be located at Kashimira, near to the proposed extension of the WEH BRTS corridor.

In Thane, it is proposed to extend the EEH BRTS corridor upto Ghodbundar road and a terminal is proposed to be developed near Hiranandani Estate. The Thane Municipal Corporation needs to identify and allot land, of required extent of about 3 ha, at this location.

6.4.2 Central Workshop

To carry out major repairs to the buses, at a fleet size of 3000 buses, a full pledged workshop would be required. However the fleet size to start with is of for order of 564 buses which does not make a full workshop optimal. Also in the business model, it is proposed that while buying buses, a life time, maintenance contract may be entered into with the manufacturer. It would relieve the BRTS operator of the responsibility and overall will be a cost effective measure. This model is already being followed by DTC in their recent bus purchases. However, over time period, as fleet size increases, the manufacturer may need space for establishing the workshop. It is necessary to acquire land of about 6 to 8 ha at an appropriate location.

6.4.3 Bus Stops & Shelters

Bus stops & shelters are important physical infrastructure components of BRTS. A number of bus stops on WEH and EEH have been identified. The bus stops are being located before the start of a flyover with the use of flyovers for operation of BRTS buses; this would eliminate intersection delays for BRTS buses. Staggered bus stops integrating both directional bus stops with other facilities like stair case, escalators etc. are proposed. The bus platforms are planned to accommodate 25 m long bus, with provision for simultaneous stopping of 3 buses. Modern bus shelters being provided by BEST as adopted with suitable modifications. Bus shelters would provide adequate space for passenger information and commercial advertising.

6.5 Bus Terminals

Integrated, multi-modal bus terminals are proposed at the following locations.

- BKC (common for both WEH & EEH corridors integrated with metro lines)
- Dahisar (WEH)
- Andheri (WEH) (Integrated with V-A-G metro and existing suburban system)
- Ghatkopar (EEH) (Integrated with V-A-G metro)
- Hiranandani Estate (EEH), Thane

Chapter 7.0
BRTS Components - Design Policies

7.0 BRTS COMPONENTS - DESIGN POLICIES

7.1 BRTS Corridors

MMRDA, in their endeavor to promote integrated development of Mumbai Metropolitan Region, as part of their vision and plan for an integrated multi–modal transport system for MMR, have proposed Development of Bus Rapid Transit system (BRTS) along two corridors of Mumbai. They are:

1. WEH Corridor from Bandra to Dahisar
2. EEH Corridor from Sion to Cadbury Junction in Thane

Both the corridors are of 25 km long each.

7.2 Objectives

The overall general objective of BRTS in Mumbai would be to form an integral component of the multi–modal public mass transport system of the city and the metropolitan region. Within this overall framework some of the objectives, in detail, are to:

- Cater the travel demand of the city, carry larger volume of passengers and increase the overall share of the public mass transport system.
- Promote modal shift from private mode users (car and 2-wheelers) on to the system and thereby reduce traffic volumes on the roads, congestion, delays, energy consumption, environmental pollution, parking demand, etc.
- Improve the productivity of the bus system
- Provide higher level of service to the passenger's in terms of reduced travel time, higher comfort, safety, etc.
- Promote desirable urban form and structure
- Enhance the image of the city

In system planning, design, operation and management some of the above objectives may conflict with each other. While increase in share of the traffic would mean augmentation of capacity supported by a favorable fare policy to keep the service affordable, particularly to low income groups, promoting modal shift would call for provision of high quality service with a high degree of comfort and privacy. The system planning would need to strike a balance between the differing requirements.

A possible measure would be to operate two different types of service, one for the general commuter with fares comparable to other modes of public mass transport service, closely spaced stops, a higher load factor, etc. The other for attracting private mode user by offering high quality of service in terms of high speeds, low load factor, more comfort (air-conditioned), etc, with higher fare levels. The two types of services could be distinguished by distinct colour of the buses – say green for general service and red for the special service.

BRTS planning & operation needs to be multi-objective judiciously balancing the conflicting needs of the city and its people.

7.3 Services Objectives

In undertaking any transport planning task it is very important to understand the specific performance goals for the network so that the design standards can be set accordingly.

A list of potential performance criteria, along with the types of treatments that they invite, is provided below:

- *Reducing transit time*
  - Segregating buses from all other traffic
  - Grade separation of junctions
  - Off board ticketing
- *Improving service reliability*
  - Segregating buses from all other traffic
  - Signal priority
  - Grade separation of junctions
- *Maximizing mode share*
  - Improving passenger comfort
  - Reducing transit time (see above)
  - Route reviews to provide services to high demand nodes
- *Accommodating growth*
  - Network bus throughout capacity
  - Size of bus stops
  - Competition for corridor/road space
- *Improving passenger comfort*
  - New air conditioned buses
  - Real time information systems
  - Attractive stops with air conditioned waiting rooms
  - Ease of accessibility to stops, particularly so for the infirm or disabled

- *Ensuring commercial viability*
  - Ability to charge premium fares
  - Reduced operating costs from improved stop start and fuel consumption
- *Enhancing safety*
  - Reduction in collisions by removing buses from general traffic
  - Signalised or grade separated pedestrian access across roadways to stops
  - Introduction of minimum bus design standards
  - Regulation of the bus industry
  - Increased police supervision/intervention

Whilst it may be desirable to want all of the above criteria satisfied, it must be acknowledged that there will be trade-offs between some of these criteria. For example, Elevation of the transit way will optimize speed and reliability but will reduce accessibility for passengers and reduce viability of the network. Therefore it will be important to test different solutions against these criteria.

7.4 BRTS Specifications

7.4.1 Decision Flowchart

BRTS is a system comprising a number of component parts interacting and influencing each other. The following ***Fig 7.1*** indicates the decision flow chart linking BRTS objectives and elements.

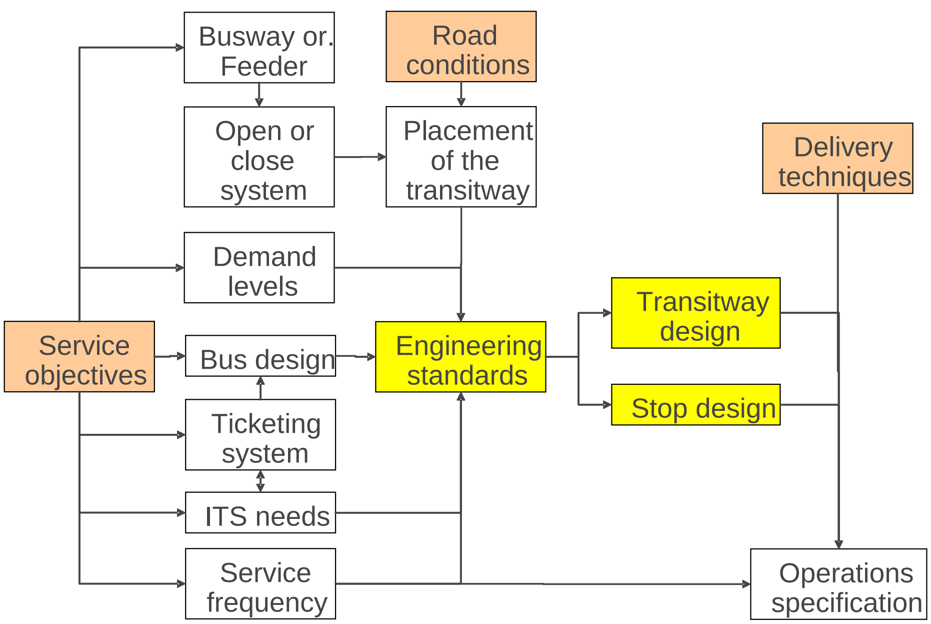


Fig 7.1 – Decision Flow Chart

7.4.2 BRTS Components

Bus Rapid Transit System has many components. Each component has alternative plan, design and operational possibilities. Selection amongst alternatives depends on site/corridors conditions, prevailing practice, traffic characteristics etc. Judicious selection and effective integration of the components is important to enable system efficiency and effectiveness.

Some important components and alternatives within them are:

- Bus Lane Positioning
  - Kerb side
  - Median side
  - Elevated

- BRTS Operation
  - Open
  - Closed
  - Trunk & feeder

- BRTS Routing
  - Direct
  - Trunk & feeder

- Pavement
  - Flexible
  - Rigid

- BRTS Bus Technology
  - Ultra Low Floor (< 400 mm)
  - Low Floor (650 mm)
  - Medium (850 mm)
  - High (1150 mm)

- Bus Fuel
  - Ultra low sulphur diesel
  - CNG
  - ETB
  - Hybrid

- Bus Ownership
  - BEST
  - SPV
  - Hiring

  - Franchise

- Fare Policy
  - Same as BEST
  - Different

- Fare Collection System
  - Onboard
  - Off board
  - Outsourcing

- Institutional Arrangement
  - Under BEST (General)
  - Under BEST (Separate Division)
  - Under BEST – SPV
  - SPV independent of BEST

Issues for decision and recommendations for each of the major components are presented in the following sections.

7.4.3 BRTS - Runway

Runway is an important component of BRTS. It provides the buses high speed and smooth running increasing the productivity and capacity of the bus and reducing travel time to the passenger. The three alternate possibilities of placing the runway are:

- Kerb side
- Medium side
- Elevated

The advantages and disadvantages of the alternatives are as under:

Sr. No.	Aspect	Kerb	Central	Elevated
1	Overall Quality	Medium	Medium	High
2	Capacity (pphpd)	5000 to 10000	5000 to 10000	10000 to 15000
3	Bus Journey Speed	20 to 25 kmph	20 to 25 kmph	30 kmph+
4	Service Flexibility	Low	Low	High
5	Delays to Bus	Maximum	Medium	Nil
6	Side Friction	High	Low	Nil
7	Access to Passengers	High	Medium	Medium to High

Sr. No.	Aspect	Kerb	Central	Elevated
8	Safety	Medium	Medium	High
9	Image (Brand)	Medium	Medium	High
10	Impact (on urban form & structure)	Medium	Medium	High
11	Cost	Low to Medium	Medium	High

A multi-criteria assessment of each of the options is as under:

Criteria / Transitway Placement Option	Speed	Reliability	Mode share	Growth	Comfort	Reliability	Safety
Fully Elevated Network	**G**	**G**	**G**	**G**	**G**	**G**	**G**
Median Dedicated Lanes	**G**	**G**	**G**	**A**	**A**	**A**	**A**
Kerbside Dedicated Lanes	**A**	**A**	**G**	**A**	**A**	**A**	**A**
Shared Traffic Lanes	**A**	**P**	**P**	**P**	**A**	**P**	**P**
Bus Priority Measures	**P**	**A**	**A**	**A**	**A**	**A**	**A**

Legend: G Good
A Average
P Poor

Considering the value of land (road width) that is required for future capacity expansion, the resolution of a large number of issues, and the flexibility for technology up gradation, it is prudent to adopt the elevated viaduct system.

However, considering cost, time for construction and flexibility, the Steering Committee has recommended placing of bus transit way on the median side, partially elevated with effective utilisation of flyovers.

7.5 BRTS Vehicles

7.5.1 BRT Vehicle Selection

Introduction

Vehicles are the most important element of BRT system for providing basic transportation services as also a unique identity and quality image to the system. Choice of an optimal vehicle is hence, the most important aspect of system design and element selection.

Urban transport services in Mumbai City are currently provided by BEST using 3403 standard buses, about 10.5 meters long and high floor levels (1150 mm) and powered by engines of about 110-125 HP. Recently BEST has introduced 31 buses- about 12 meters long with low floor height and wide doors – one each ahead of the front and the rear wheels, with a seating space for 34 and standee space for 35 passengers. These diesel fuelled buses of reduced floor height and modern looks are well accepted by the commuters. BEST also operates 71 air-conditioned buses on some selected routes. BEST operates 859 Compressed Natural Gas fuelled buses. 4.5% buses are air-conditioned. Category wise details of BEST buses are as under.

Table-7.1: BEST Bus Fleet composition

Sr.No.	Type of Bus	Number of Buses	Percentage	Carrying Capacity
1.	Single Deck	2022	52.49	71
2.	CNG Single Deck	737	19.13	67
3.	Single Deck (MUTP)	644	16.72	71
4.	Ultra Low Floor (Single Deck)	31	0.80	46
5.	Double Deck	182	4.72	89
6.	Midi (Diesel)	63	1.64	48
7.	Midi (CNG)	102	2.65	55
8.	Air Condition (Diesel)	51	1.32	45
9.	Air Condition (CNG)	20	0.52	47
	TOTAL	**3,852**	**100**	

In this section, various issues, options and factors related to vehicle propulsion system and fuels, vehicle size, capacity and floor height, door location etc are considered, examined & evaluated for making an optimal vehicle selection.

Estimated passenger carrying capacities (range), in terms of number of passengers carried per hour per direction when operated at varying headways and peak hour load factor of 1, for various types of buses which may be used for BRT operations, are given in ***Table –7.2.***

Table –7.2** - **BRTS capacity in terms of phpdt for varying bus sizes and head ways

Bus type / length	**Carrying capacity of Bus**	**Load Factor**	**phpdt for head ways in secs**			
	Head ways in Secs		**45**	**22**	**15**	Secs
Standard 12 mtr	**70**	**1**	**5600**	**11455**	**16800**	*Min
3 axle 15 mtr	**90**	**1**	**7200**	**14727**	**21600**	
Articulated 18 mtr	**110**	**1**	**8800**	**18000**	**26400**	
Double arti 25 mtr	**170**	**1**	**13600**	**27818**	**40800**	
Double deck 12 mtr	**110**	**1**	**8800**	**18000**	**26400**	
Double Deck arti 25mtr	**230**	**1**	**18400**	**37636**	**55200#**	#Max

The traffic demand on the BRTS corridors, varying from an average of 12150 phpdt in 2011 to an average of 18522 phpdt in the year 2031, can be conveniently and optimally met by one of the above buses, which can service between 5600 - 55200 phpdt at full load during peak hour by varying the headways from 45 to 15 seconds.

Choice of bus size is proposed on the basis of average peak hour loads in terms of phpdt on the corridor. Higher or lower travel demands are proposed to be met by varying the operational headways between 15 to 45 seconds. Higher capacity buses are proposed for demands exceeding the capacities of selected bus at lowest headways. Proportion of higher capacity buses assessed on the basis of percentage of corridor sections where peak hour demand exceeds capacities of the lower size bus.

The average peak hour demand in 2011 optimally matches with the capacity of a standard size 12 meter long bus .for headways of 22 seconds. During the period 2016 and 2031, articulated buses and double articulated buses in higher numbers would meet the average demand of 15000 and 25407 phpdt respectively. Selection of buses on the basis of above discussions is given in ***Table-7.2.***

Percentage of sections peak hour demand exceeds the max capacity of a bus and shown in **Table 7.3.**

Table –7.3: Percentage of Section Peak Hour Demand

Year	Percentage of sections exceeding the design bus capacity of		
	* Exceeding		
	16800	26400	40800
2011	5.13	0	0
2016	12.82	0	0
2021	14.10	0	0
2026	25.64	1.28	0
2031	34.62	6.41	0

On the basis of above analysis, it emerges that the travel demand during evening peaks is higher than that in morning peaks and therefore bus fleets are proposed to be divided amongst various sizes as per details given in ***Table-7.4.***In addition to this the Bus operations would commence in the mid of 2013

Table-7.4: Distribution of Buses-- Size wise

Financial Year	Bus Type/size wise --- Number of buses			Total no. of buses
	12 m long (includes 10% AC buses)	Articulated 15 m long	Double articulated 25 m long	
FY 2014	600	0	0	600
FY 2016	600	16	0	616
FY 2022	353	180	33	566
FY 2026	353	195	50	598
FY 2031	83	270	159	513

Vehicle & fleet selection is made on the basis of service demand level w.r.t. its quantum and frequency; the average vehicle speed and its load factor; route length, average passenger lead, average travel time; comfort level needs of passengers, their paying capability; etc.

While estimating the fleet size, quantum of roadworthy buses required as replacement for those failing on road and for those detained for repair and maintenance activities, etc. be added to the operational fleet. Considering further the public perception of the BRT System, semi-deluxe urban buses as per bus code may be selected as the base line requirement.

Some of the other considerations for selection of buses for BRTS are commuter comfort and affordability of travel costs. Semi-deluxe and Super Deluxe buses for low and high income group of commuters respectively are proposed to be planned following the principle of differential category of services at differential user tariffs.

Initially only two categories of buses namely ordinary and air-conditioned buses are proposed from out of the standard size buses at the rate of 10% of the fleet size. Category wise distribution of the bus fleet may be progressively varied keeping in view the emerging demands for such buses, and or in proportions of income groups of the target population.

Bus category wise options under consideration are thus -- the type I – semi-deluxe, deluxe and super - deluxe buses generally as per Automotive Industry Standard AIS 052 - the super - deluxe buses to cater to the requirement of commuters with higher paying capacity.

The passenger carrying capacity of semi-deluxe – 12 meter long - buses is in the range of 65-75 i.e., an average of 70 passengers. Considering, however, shorter travel time of about 30 minutes for an average passenger lead of about 10-12 km, the seating layout may be modified to provide for larger number of standees and reduced number of seated passengers.

Following above discussions 12 mtr, 18 mtr and 25 mtr long buses are proposed to be inducted in 2011, 2016 and 2026 respectively.

Vehicle Propulsion System and Fuels

The bus operations in BRTS are characterized by frequent stops and starts with a vehicle dwell time of 30-45 seconds at stations and the operational headways of 15-45 seconds—proposed headway being 22 seconds. This calls for a high horse power engine with maximum torque at lower engine rpms but spread over a wider range of rpm. The engine specifications thus need to be worked out by vehicle manufacturers keeping in view the above aspects and the following end-use / functional requirements of the buses:

- Acceleration : 1 Meter / sec / sec
- Gradiability : 17^0
- Peak payload of: 150% of rated capacity of the bus and average weight per passenger of 68 kgs, and each passenger carrying a luggage of about 7 kgs.

The selected power plant shall meet the vehicular emission and noise norms as applicable to Mumbai City from time to time. Power plants meeting minimum BS – III norms and above performance requirements are proposed.

Propulsion Technology Choice

As a large number of buses are crossing any section of the road every hour, low air and noise emission vehicles are the preferred choice for improved acceptance of BRTS by the commuters and the community. Low on-board noise levels, comfortable seats, easy boarding / alighting and affordable fares are some of the other commuter focused attributes of buses.

The following types of propulsion systems, generally used for BRTS, are considered:

- Internal Combustion Engines (ICEs)
- Electric motors using electricity obtained from external overhead contacts
- Hybrid – (ICE with electric drive & on-board storage of fuel)
- Fuel-cell - electric drives

Considering system characteristics, merits and demerits, appropriate choice of the propulsion system would be made for BRT.

The most commonly used propulsion system, all over the world, for transit buses is the internal combustion engine (fuelled by diesel, ultra low sulphur diesel (ULSD), Natural Gas, etc.) Electronically controlled, cleaner diesel engines have significantly reduced levels of exhaust emission gases. ULSD fuelled engines with regenerative type of particulate trap emit even lower particulate matter (PM), HC, CO & NOx than that of natural gas engines. ICEs using diesel fuels are easy to operate, maintain & repair as spares and skills required therefore are readily available in BEST. In contrast, CNG vehicles have higher total system weight, reduced power, high operating & maintenance costs, higher initial capital costs of vehicles. These vehicles also require additional fuelling infrastructure at additional capital costs therefore. Further, NG supply and distribution at Mumbai would require augmentation.

Electric Trolley Buses (ETBs) use a well-established technology producing zero-emission at the point of use though total fuel cycle emissions are comparable with other systems. ETBs are also quieter in operation, giving smooth ride and longer vehicle life. ETBs cost upto three times the cost of a comparable diesel fuelled bus, their infrastructure costs being almost double that of a diesel fuelled bus based BRTS and their operating costs vary with electricity costs. While overtaking is not feasible in the ETB system, the repair and maintenance costs of the system are very high. Longer implementation time is required to build electric conduit network. Route modification is very expensive. Unless supported by an on-board diesel engine or any other captive standby power generation system, power failures would cause service disruptions. To over-come such operational disruptions, additional facilities for ICEs, their fuelling, repair and maintenance have to be created almost at par with those required for a standalone ICE based propulsion technology. As the demerits of electric trolley buses far outweigh the advantage there from, and the technology not being widely used, ETBs may not be considered.

Hybrid buses - Highly advanced technologies such as diesel / CNG hybrid – electrical vehicles and fuel-cell vehicles are undergoing tests in developed & developing countries – though none of the cities are using these buses in large numbers. Hybrid vehicles utilize conventional fuels like diesel, CNG, etc. along with electrical motor / generator and on-board electricity storage system. These vehicles offer superior fuel efficiency, reduced emissions and lower noise levels. M.J. Bradley Inc and the University of West Virginia (2001) reported that hybrid vehicles using clean diesel engines with low sulphur fuels have better emission characteristics than pure CNG engines. Fuel cell buses using domestically produced hydrogen fuel provide zero emissions. The hybrid bus technologies however, have not yet been proved for commercial use and their costs are prohibitively high. In view of complexity of fuel cell & hybrid bus sub-systems, their costs, non-availability of proved & well tried-out technologies indigenously; hybrid-electric and the fuel cell buses may not presently fall in the zone of consideration for Mumbai BRTS.

Dual mode - vehicles, which essentially combine an electric trolley bus with an ICE have the advantages of both ETBs & flexibility of conventional buses using ICEs. These vehicles are attractive for BRT as they combine the performance, environmental and permanence advantages of ETBs with flexibility of conventional ICE buses. However, because of very high vehicle weight, high initial & operating costs; the need for creating and maintaining two different systems/infrastructure & the costs thereof, dual mode buses also appear to be beyond the consideration zone for BRTS.

Following analysis of various issues and options, the Internal Combustion Engine based bus propulsion system meeting the power requirements as above, applicable emission norms (presently BS III emission norms in Mumbai) and applicable noise norms is proposed to be considered for Mumbai BRTS. The propulsion system technologies, however, be upgraded with the emission norms and availability of proved, cost effective and more efficient technologies.

Fuel Options

Most common fuel options for the ICE based buses for BRTS are:

- Standard diesel
- ULSD
- Bio-diesel (mix of bio-mass like oil from Jatropa plants with diesel)
- Natural gas (compressed or liquefied)
- Liquefied Petroleum Gas (LPG)
- Di-methyl Ether (DME)
- Blended fuels like water in oils

Choice of fuel for BRTS is made after examining and evaluating the following factors amongst others:

- Fuel availability & price volatility
- Fuel infrastructure requirements
- Vehicle technology
- Reliability
- Environmental Impact
- Govt. Policies

Main concerns of the above fuel options are qualitatively evaluated in the following ***Table No. 7.5.***

Table –7.5: Fuel options and issues – comparative evaluation

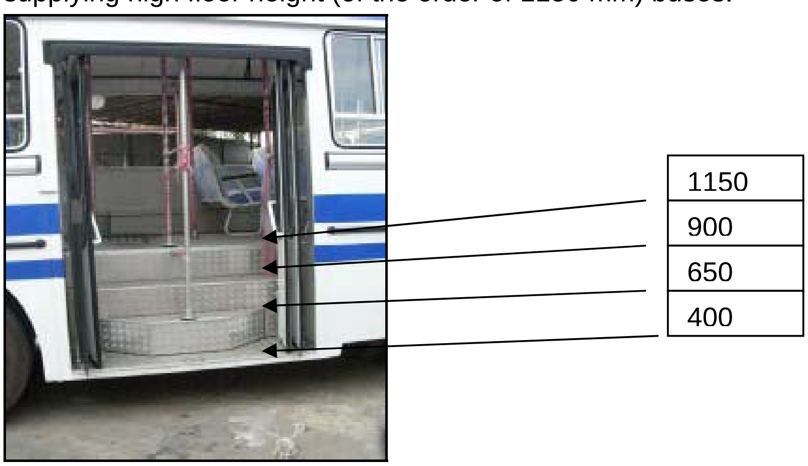
Issues	Diesel		Bio-diesel DME Blended fuels	Natural Gas	LPG
	Std	**ULSD**			
Availability	Ready	Likely during a year or so	Future fuels	available	Overall shortage in the country
Price volatility	Applicable across the country as a Govt. policy		Low	Govt. policy based	
Fuel infrastructure	– Readily available – No additional costs – No gestation period		Marginal efforts / costs involved	– High cost infrastructure – Long gestation period	Lower costs than CNG
Reliability of vehicle technology based on fuel	– Matured Veh. tech. – Highly reliable – Proven tech. – No special skills required		Need long term trials	– Acquired the status of matured tech. – Lower MTBF – Problem in gradient climbing and load pulling	Less mature, not tried on large scale in heavy vehicles in India
Environnemental impact – noise & air pollution	Higher PM, HC, NOx	Comparable with CNG & other alternative fuels	Better than standard diesel vehicles	– Clean fuel but emission reduction performance not much superior to clean diesel. – Higher	Clean fuel quieter engine

Issues	Diesel		Bio-diesel DME Blended fuels	Natural Gas	LPG
	Std	ULSD			
				greenhouse gases – Quieter engine	
Vehicle costs	Nominal	Marginally higher	Marginally higher	Significantly higher	
Govt. policies	No specific benefits provided		Yet to be established	– Tax incentives – Administratively fixed prices if withdrawn shall adversely affect costs.	

Considering merits and demerits of various fuels, diesel & ULSD, CNG fuels clearly emerge as the selected fuel options for Mumbai BRTS & hence fall within the active zone of consideration. However in view of generally emerging policies in the country CNG fuelled buses is proposed.

Vehicle Floor Height

Vehicle floor height above pavement directly influences passenger boarding & alighting time and convenience. Bus manufacturers in the country are still largely supplying high floor height (of the order of 1150 mm) buses.



In these buses, three steps are provided to access the seating or standee spaces on bus floor. Such steps are not only inconvenient for the purpose, particularly for the elderly people, ladies and physically challenged persons but also cause boarding and alighting delays, thereby increasing overall travel time. No step no gap access to these vehicles can be achieved by raising the bus stop platform height to 1150 mm. The raised platforms would however require long ramps for station exit/entry besides involving higher construction costs and causing possible safety hazards. Such buses perceived as conventional buses are not conducive to enhance system image and or provide it a unique identity. These buses become unfit for operation in the mixed traffic beyond the corridor without availability of similar facilities there. These buses however are a least cost option.

Ultra low floor buses with floor heights of upto 400 mm over the entire bus length or for about 60% of bus length, the latest development in buses – envisage optimized and convenient access for passengers. These buses are generally of monologue construction. These buses allow for rapid boarding / alighting even without raised platforms. These buses use latest technologies and create more modern image with the customers. Accessibility of PwDs is however possible with use of an additional platform.

The bus technology for 100% low floor buses is neither readily available in the country nor even tried out successfully for large fleets. Besides less boarding and alighting time, these buses have great advantage of placing the rear door behind the rear wheel – a safety related merit. Mounting of wheel wells, under-floor mechanical equipment, fuel tanks etc. however take away considerable vehicle interior space reducing seating & standees capacity of the bus compared to high floor buses. These buses also have a disadvantage in packing the conventional drive train. Due to above problems, these buses would have 8 – 12 seats less as compared to high floor buses. They pose difficulty in towing down. The initial cost & maintenance cost of these buses is very high. Partially, ultra low floor buses with similar features as above are comparatively more cost effective. These indigenously manufactured buses have been tried out in Delhi. The Delhi Transport Corporation has further ordered more then 1500 such buses for operation in Delhi. These buses have also been recommended for the Common Wealth Games proposed to be held in Delhi in 2010. BRTS Delhi is using similar buses mainly for convenience of commuters and for image building not withstanding their financial un-sustainability as the earnings from these buses fall significantly short of the operating costs. Pune BRTS is understood to be using low floor buses for similar considerations of image building etc though their operation is not expected to be financially sustainable.

Type 1 buses of floor height of up to 650 mm over 60% of floor length are specified as urban buses in the Automotive Industry Standard AIS 052. These buses could have a step less floor or with entrance/exist area lowered to 400 mm and a step of 250 mm provided either parallel or across the bus axis. In the earlier case, the bus stand platform height has to be raised for ease of boarding / alighting. Buses without a step, however prevent (by design), entry/exist of passengers at un-scheduled stops

– a positive safety feature for bus operation. These buses could utilize conventional or upgraded aggregates and passenger access is fast and convenient. These buses can operate smoothly on existing roads riddled with high-rise speed breakers. No special manufacturing, repair and maintenance and operational skills/conditions are required. A number of such buses are successfully operating in India. These buses therefore emerge as one of the choices for the BRT system.

The better choice however is still that of an ultra low floor bus (less than 400 mm floor height) with "most modern image" with initial & operating costs of more than twice those of the other choice (650 mm floor height). In this case, however, the station platform costs would be marginally lower due to reduced height.

Considering various issues buses, with floor height of 400 mm up to nearly sixty percent of bus floor length, are recommended for Mumbai BRTS.

Entry-Exit Gates - Location & Width

The entry/exit gates of the bus may be located ahead of the front wheels, between the front and rear wheels, and or behind the rear wheels. Front gate located ahead of the front wheel is the ideal location for safety of boarding / alighting passengers, as it directly falls within the horizon of vision of the driver which enables him to quickly react to any safety hazard. This location also saves a falling passenger from getting crushed under the front wheel and provides enough time to the driver to react and save him from any hurt by rear wheels. Such a location of the front gate facilitates easy entry and parking of wheel chairs next to the driver. This location of the door facilitates on-board issue / verification of fare tickets by the driver in one-man operation of buses.

The location of the rear door behind the rear wheel though a desirable feature does not afford technical feasibility in 650 mm & 400 mm floor heights (over partial length of the bus) without provisioning of additional steps -- an undesirable feature. It is possible both in 1150 mm floor height and 100% ultra low floor height buses.

Location of both the gates between the wheels – would not only weaken the bus structure but would also cause concentration of boarding and alighting passengers at the same place and consequent friction of their movements. One of the gates being far ahead of the rear axle also becomes a potential safety hazard. Such a location also causes friction in internal circulation of passengers.

Considering various aspects and the necessity of having a rear gate, this doorway, in the low (650mm) and ultra low (400 mm -- partial length) floor height buses be considered as per the bus code (AIS 052) i.e. the rear edge of the gate being 1500 mm ahead of the center line of the Rear Axle.

As the bus stations are generally positioned on left side of the bus, the gates be located on left side of the bus. To cater to emergency requirement of boarding / alighting on central median side locations, one rear gate be positioned on right hand side wall of the bus, ahead of the rear wheel, opposite the left side rear gate,. Such a location of the gate would however reduce seating spaces for 4 passengers.

Provisioning of additional gate i.e. 2 gates on the right hand side of the bus for regular boarding / alighting of passengers at the bus stations on the central median, would hardly leave any space for passenger seats on right hand side of the bus. The bus structure would also need to be strengthened in this case. Further with the bus stations located on central median, passing lane would not be accommodated there, which would reduce system capacity. Provision of two gates on driver sidewall of the bus is therefore not recommended.

The proposed door width of 1200 mm is sufficient to cater to the boarding / alighting quantum of passengers during the suggested dwell time at the station.

The front gate is proposed to be provided with flip down type flaps, automatically operated from driver dash board for providing no gap entry / exit to the general passengers and accessibility to the PwDs. The ramp operating mechanism may also be a manual one for reduced cost and the low usage frequency by the wheel chair passengers.

Following above discussions, two doors of 1200mm width each- one placed ahead of the front axle and the other ahead of the rear axle, as per the bus code, are proposed. Both the gates are proposed to be equipped with jackknife type pneumatically operated door flaps.

Proposed locations of entry- exit gates in low floor bus

Interior Layouts

Considering short passenger lead / travel time, a seating layout of 2 x 2 perpendicular seats on either side of the bus aisle and generally as per AIS – 052 is recommended. A minimum aisle width of over 800mm for ease of internal passenger circulation is proposed.

Wheel chair space for PwDs be provided near the driver with adequate anchorage / strapping arrangement for clamp down / positional retention of the wheel chair.

Passenger seats be comfortable, easy to maintain and aesthetically designed. Adequate number of properly designed handholds and supports of superior quality and looks be provided. Similarly the entire upholstery, flooring (non-skidding), fittings & furnishings be of latest designs and of high quality meeting a minimum of AIS – 052 requirements. Clean, highly visible, panoramic large windows offering larger viewing be provided in the BRT buses.

Vehicle Guidance

For no-step no gap boarding / alighting of passengers, on raised station platforms using flip-down type of ramps at the bus gates, a simple vehicle guidance system may be considered. Although high cost high technology mechanical, electronic and optical systems are available, a low cost optical system is recommended keeping in view lower level of lateral aligning accuracy required for the flip-down ramps equipped vehicles. In this system, the driver focuses on a visual (optical) target line marked on bus lane. A video screen, projecting the target line captured by a camera mounted under the vehicle, is provided on the dashboard for ease of aligning the bus with the platform. This system in conjunction with ramped entry would provide a cost effective lateral alignment of vehicles at the bus station, for ease of boarding & alighting.

No step no gap entry to bus floor

Vehicle contouring, Levery, Identity & Branding

The BRTS buses shall be contoured, painted and branded in such a manner as to give them a superior and a unique identity. All graphics and signages shall be standardized for this purpose.

Life Cycle Costs

On the basis of prevailing bus & fuel prices, bus operational efficiencies, manpower needs, applicable taxes etc, various costs, break-even fares, operational subsidy or initial grants requirement for affordable fare level, etc, be worked out.

Considering loss of a large number of seats, high initial investment, unaffordable levels of fares to be charged for sustainable operation and or very high grants / subsidy required at affordable fare level, ultra low floor (over full length) buses are not recommended. Buses of other floor heights viz. (400 (partial,) 650 and 1150 mm)) emerge as possible options from financial angle. However, buses with floor height of 1150 mm are not considered suitable from operational point of view. Similarly buses with 650 mm floor height would necessarily have a step at the gate or across the aisle in the bus causing boarding / alighting delays and inadequate accessibility for the PwDs. 650 mm floor height buses without a step if considered in conjunction with raised platforms, will not be useful in mixed operations beyond the BRTS corridor. For their operation in non-BRT corridors bus stops platform height will have to be raised to 650 mm, which then becomes incompatible with other buses operating on the corridor. No such issues would arise for buses with 400 mm floor height.

Following above discussions, buses with 400 mm floor height (upto 60% length) emerge as the preferred option. These buses are more users friendly and create a better identity and image of the BRTS. The bus stop platform height even in mixed operations, may require only marginal improvement if any over the existing kerb height. Initial Investment and fare per passenger km generally could be in line with the current fares through restructuring the operations.

Even without restructuring operations subsidy / grant required for financial sustainability of operations at the currently applicable fare levels would be much less than that required for full length ultra low floor buses.

In view of the above discussions, low floor height (400 mm –partial length) buses emerge as the clear choice for Mumbai BRTS.

Proposed bus type for Mumbai BRTS

Summary of recommendations for BRTS buses

Recommendations for various aspects of BRTS buses are summarized in ***Table-7.6.***

Table-7.6 - Recommendations for various aspects of BRTS

Sr No	Bus characteristics	Recommendations for BRTS
1	**Vehicle type, Size and Capacity**	
1.1	*Type*	Type 1 urban bus generally as per AIS 052
1.2	*Bus size*	Length 12 meters minimum to start with. Higher length buses as demand grow. 25 meters long buses for system design.
1.3	*Bus capacity*	As per ***Table-7.2***. For optimally servicing travel demand, of 70, 110 and 170 passengers, 12, 18 & 25 mtr long buses respectively are proposed
2	**Propulsion Technology**	Internal Combustion Engines
3	**Fuel Options**	Ultra Low Sulphur Diesel (ULSD) and or Compressed Natural Gas (CNG)
4	**Vehicle Floor Height**	400mm up to about 60% of bus length.
5	**Entry-Exit Gates - Location & Width**	2 gates- one each ahead of the front and the rear axles. Gate width of 1200mm each. Gates provided with jackknife doors- electro-pneumatically operated in less than 4 seconds each.
6	**Interior Layouts**	2*2 seating arrangement

7.5.2 BRTS Operations

Introduction

BRT system offers tremendous flexibility in route structuring to meet the commuter needs of avoiding transfers and consequent saving in travel time, the later providing most efficient passenger movement and thus rendering the system itself as an efficient one. However as routing options offered by the above system increase the complexity of the system and its management increases calling for use of costly technological interventions.

Considering various aspects, it is necessary to decide whether to have a directional oriented route structuring or destination oriented and or a mixture of the two as all the options have their merits and demerits. The direction-oriented system involves one or more transfers between origin and the destination and thus causes inconvenience to passengers but tends to improve system efficiency. Reverse happens in the destination-oriented system.

It is further to decide whether on the BRTS corridor only BRT buses should operate and or other vehicles / buses be allowed to enter the corridors as free entry of other vehicles on the corridor causes congestion related problems, whereas use of only BRTS vehicles reduces the system utilization. For obtaining maximum advantages of the system only BRTS buses may be allowed to operate. However for various considerations a few other categories of vehicles are also allowed to ply.

Open and Closed System:

A Closed System relates to a transit way that is operated by nominated vehicles, whilst an open system allows all buses to utilize it (and in some cases other HOV transport).

The advantages and disadvantages of open and closed systems are provided in the following ***Table No.7.7.***

Table No.7.7 - Advantages and disadvantages of open and closed systems

Sr. No.	Aspects	Closed System	Open System
1	Operational Efficiency	High	Low to Medium
2	Brand Image	High	Low
3	Productivity	High	Low to Medium
4	Off board ticketing	High	Low
5	Existing Operators Preference	Low to Nil	High
6	Political Acceptability	Low	High

In addition to the BEST-owned route buses, there are a number of private, charter and tourist bus operators plying the corridor. Considering that in the future, Government may wish to diversify and/or introduce a competitive operation, then consideration should be given to allowing private route bus operators access to the network provided that their buses meet minimum design standards. Other operators should be excluded from the network. The reasoning behind this is based on the risk of overloading the network capacity (or absorbing capacity best allocated to suburban route buses) and the fact that other vehicles will wish to operate express on the network and it is likely that the network will be designed for no or only partial express running (this is a function of station design which is discussed later)

HOV vehicles include taxis and other forms of vehicle carrying 2 or more people. It is strongly recommended that these vehicles be excluded from the transit way. Apart from the obvious issues of the impact on bus speed and reliability, there is a particular issue with bus stop design and access to platforms without the need to queue.

Based on the above analysis, Consultants recommendations are:

- Operate the network as a Regulated Closed System.
- During the transition allow all BEST buses onto the network, but set a minimum design standard for replacement vehicles in order to deliver a service quality improvement over time.
- Allow only approved private operators (should there be any) onto the network should their vehicles meet the minimum design standard as set
- Do not allow charter/tourist buses on the network
- No not allow any other vehicles onto the network (incl. taxi, hire cars etc)
- Design for access by emergency vehicles
- Review these policies after the bus way has been commissioned and the effectiveness/capacity of its operation is tested.

7.6 BRTS – Service Pattern

BRTS could offer 2 types of Service pattern

- Trunk & feeder
- Direct

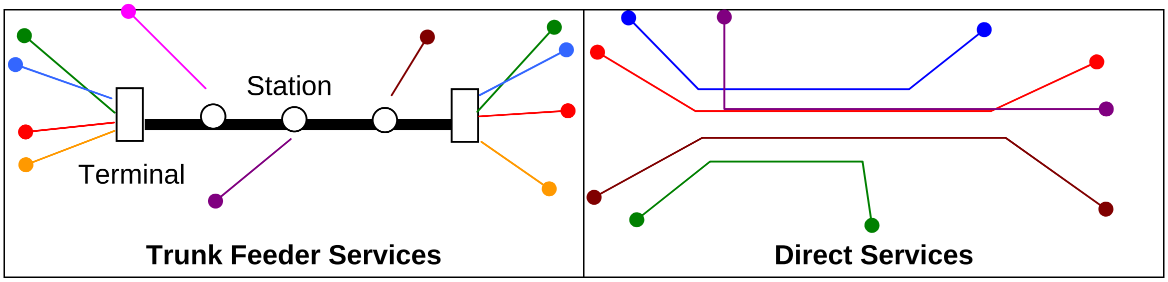


Fig. 7.2 – Types of Service Pattern

In Direct services pattern, buses start from many points off the BRTS corridor, enter BRTS Corridor at some points, run along the corridor for a certain distance, move out of the corridor and end at different points in the city. Direct service provides easy access to the system for the user-minimising walk distance and time and avoids the need for transfer. It also covers a wide catchments area avoiding the need for feeder services. On the other hand the bus, when moving off the corridor suffers the traffic and capacity constraints of the road network and hence losses partly the benefits of high speed and smooth running along the defined BRTS corridors / lanes. There will also be a problem of mismatch between the BRTS vehicles and the physical infrastructure like bus stop platforms of the Corridor. With a mix of a variety of vehicle types, BRTS may loss in brand image.

In “Trunk & feeder” services pattern, BRTS vehicles move only on the identified BRTS corridor / lanes. The bus will have the advantage of dedicated lanes free of other traffic modes and will achieve higher speeds resulting in higher productivity, increased capacity and saving in travel time to the user. The direct catchments area will be limited to walking distance. There is a need to increase the catchments area and patronage by running feeder services.

Proper physical integration of feeder and trunk services is necessary to make the transfer convenient and safe. It is necessary to provide single ticket for both the services.

Table – 7.8 - Comparative Analysis of Services

Sl No.	***Aspects***	***Trunk & Feeder***	***Direct***
1)	User convenience & preference	Medium	High
2)	Need for Transfer	Required	Not Required
3)	Infrastructure Requirements (for transfer)	High	Low

4)	Bus productivity (BRTS Buses)	High	Medium
5)	Compatibility of Infrastructure facility along and off corridors	Not Required	Highly Necessary
6)	Service Scheduling	Difficult	Easy & Flexible
7)	Patronage	Medium	High
8)	Off-board ticketing	High	Low

It is recommended to adopt "Trunk & Feeder Services Pattern However, in the transition period 'Direct 'optimum is permitted.

7.7 BRTS Stop Placements

Bus Stop Placement

To some degree the decision on stop placement should be driven by surrounding land uses and stops should be located as close as possible to where people want to travel to/from.

In most circumstances at-grade stops are located near intersections where pedestrians have the benefit of utilizing the pedestrian crossing access normally associated with those intersections. Locating stops near intersection however creates a number of engineering design issues in terms of road space allocation requirements. It is best practice to widen roads at the approaches to intersections in order to accommodate turning lanes and to also stack up traffic to maximize the number of vehicles through each green light cycle. A typical street arrangement is shown below:

Normal Intersection Configuration

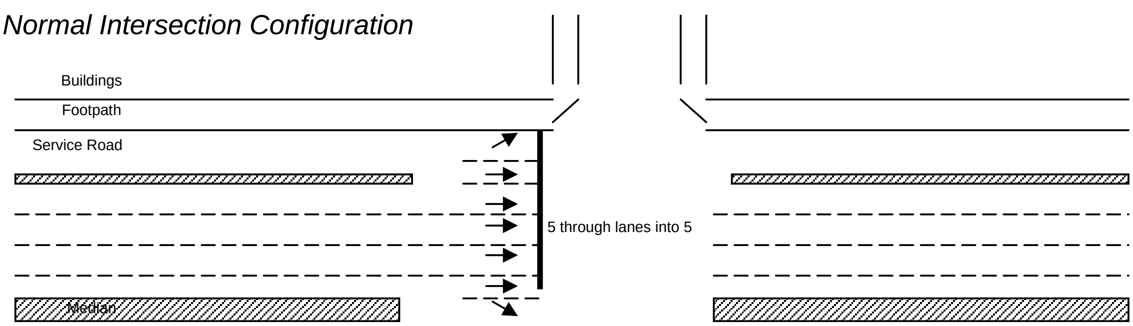


Fig. 7.3 – Normal Intersection Configuration

However a bus way stops also requires space and when inserted on the approach side of intersections competes with space against road users as shown in the diagram below:

Approach Side Stop

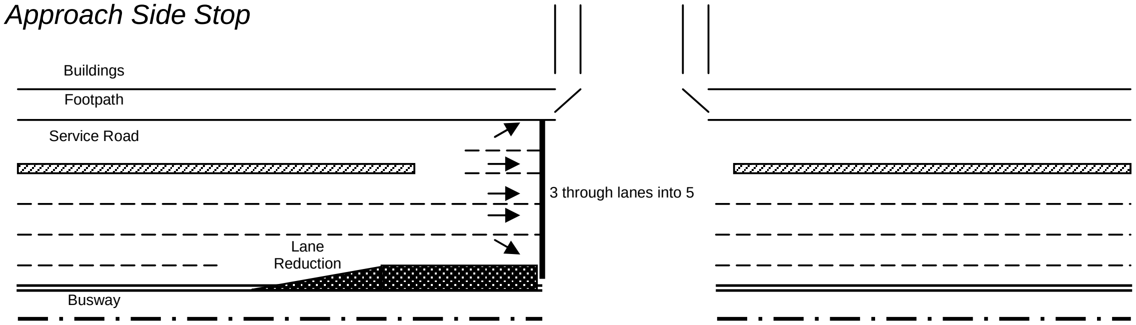


Fig. 7.4 – Approach Side Stop

An alternative solution is to place the stop on the far side of the intersection, which allows the best of both worlds as shown below:

Departure Side Stop

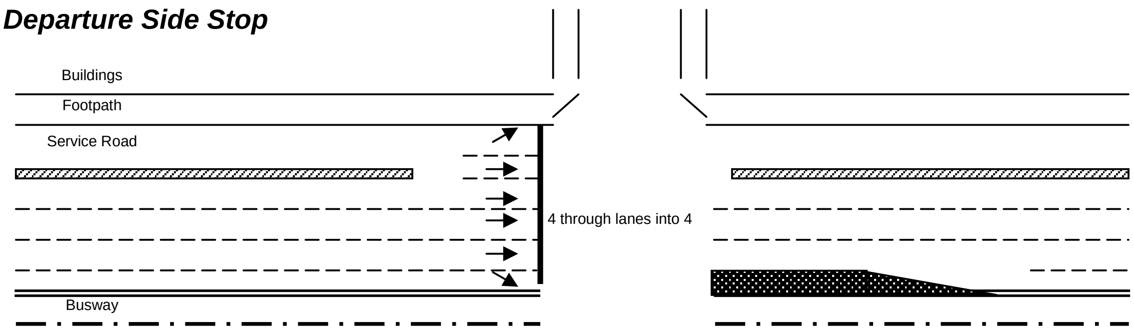


Fig. 7.5 – Departure Side Stop

Mid-block locations are another option needing consideration. In these locations stops can be staggered so that they do not take up as much road space as indicated in the diagram below. There will either be a need to introduce additional sets of traffic signals for a pedestrian crossing, thus further disrupting traffic flow, or will require the use of pedestrian sky bridges (FOB) to deliver people across the traffic. This logic applies equally to both Median or Kerb placed transit lanes. Co-location with an existing mid-block signalized crossing or FOB is also an option. The issue of cost vs. safety will be a necessary consideration with the former suggesting at-grade crossings, and the later, FOB crossings.

Mid-block Stop

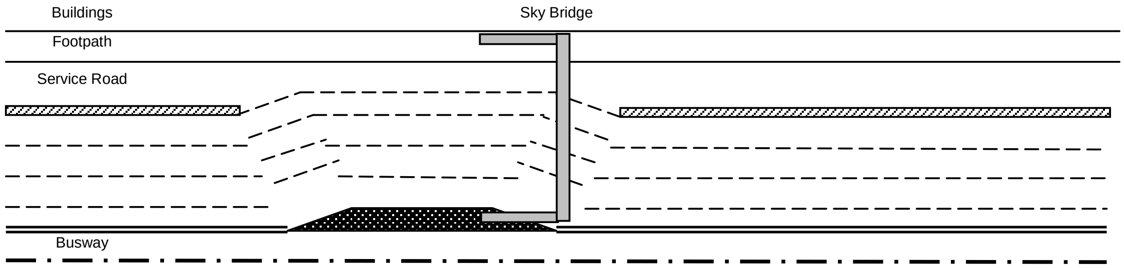


Fig. 7.6 – Mid Block Stop

The impact of stop location becomes even more pronounced if it is desirable to incorporate an overtaking lane into the bus way at the platform locations for use by express bus services. Effectively two additional lanes are required, one on each side. The impacts can be slightly offset at the intersections by offsetting the stops from the centerline and causing the buses to take a weaving path through the intersection, alternatively this could be incorporated effectively into a mid-block as shown below with minimal impact on other road users:

Mid-block Weave Stop

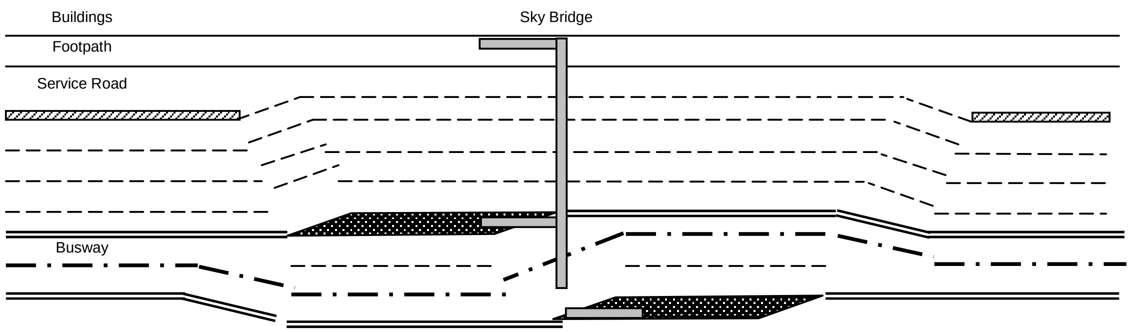


Fig. 7.7 – Mid Block Weave Stop

The following ***Table 7.9*** looks at the advantages and disadvantages of each stop placement option:

Table – 7.9 - Advantages and Disadvantages of each stop placement option

Stop Placement	Advantages	Disadvantages
Approach Side	• Allows passengers to access buses close to crosswalk • Changes the potential for double-stopping at the signal and the stop • Possibility of passengers boarding and alighting while stopped for red light • Allows drivers to look for connecting buses with potential passengers	• Passengers queuing for buses will gather at the entrance to the stop rather than moving along it causing congestion • May result in stopped buses obscuring traffic control devices and crossing pedestrians • May cause sight distance to be obscured for side street vehicles • Increases sight distance problems for crossing pedestrians • Complicates bus signal priority operation, may reduce effectiveness

Stop Placement	Advantages	Disadvantages
Departure Side	• Allows passenger interchange to occur where buses from side streets join the network • Passengers are encouraged to move down the stop to the location of the front door thus allowing the stop to fill • Minimizes sight distance problems on intersection approaches • May encourage pedestrians to cross behind the bus, depending on distance from intersection • Creates shorter deceleration distances design requirements for buses, since the intersection can be used to decelerate • Facilitates arrival predictability for bus signal priority operation, as the element of delay for platform dwell is removed	• May result in intersections being blocked during peak periods if more buses arrive than the stop capacity • May obscure sight distance for crossing vehicles • Can cause a bus to stop far-side after stopping for a red light, thus adding additional delay to bus operations • Could result in traffic being blocked if a bus joining the system cannot fit onto a platform stand
Mid-block	• Does not alter intersection design including capacity • Can be placed at the beginning of flyovers to eliminate the need for an elevated stop on the flyover • Minimizes sight distance problems for vehicles and pedestrians • May result in passenger waiting areas experiencing less pedestrian congestion	• My require alteration to the kerb/service lane to create sufficient road space • Needs to be accompanied by a sky bridge for pedestrians • Temptation for passengers to cross street mid-block (jaywalking) • Increases walking distance for passengers crossing at intersections or interchanging with cross routes • More expensive to construct

Stop Placement	Advantages	Disadvantages
Mid-block Weave	• As above but reduces the total impact on road space	• As above but even more expensive to construct

The design of bus stops for the transit way will be dependent on the positioning of the transit way within the corridor. Hence there will be a number of options and these are discussed below:

- Fully elevated – The key to stop placement design is the access arrangement for passengers, remembering that they will need to be introduced onto the bridge by some form of skywalk. The easiest arrangement is to hang a new platform off each side of the bridge and have the bus lanes along the kerb, but this is a poor result for bus operations because the buses would need to cross lanes of traffic to get there. The most logical pace to locate the bus lanes will be in the median but this causes some interesting engineering challenges. To create the room for the stop width it would be necessary widen the bridge and move the vehicle lanes onto the new structure. The tricky bit is getting people to the stop. This would need to be done from underneath by opening up a hole in the deck for the required access. Key issues will vary for each bridge but will include the structure detail of the bridge, options for access under the bridge for pedestrians, design of the Sky Bridge and space for the placement of the piers for the widened road lanes.
- Median dedicated lanes – For this option it would be best to locate the stops away from intersection to a mid block location so as not to reduce traffic lane capacity at the intersection. A sky bridge would be recommended for each stop to avoid the need for passengers to cross the busy road and the potential impacts on traffic flows should a signalized at-grade crossing be provided.
- Kerbside dedicated lanes – There is much more flexibility in stop placement with this option as a stop can be placed at almost any location depending on design and land use. It would however be advisable to keep the stops some distance from intersections in order to avoid reducing road capacity (lanes lost to create space for the platform) and interactions with turning vehicles. Where services join the corridor from side streets it would be desirable for the stop to be on the departure side of the intersection to encourage immediate interchange to the BRT services.

In line with the guidance given by the Steering Committee as regards transit way placements and also regarding placement of stops, BRTS bus stops are located mid block at the start/end of the flyover, leaving required length for wearing. The BRTS buses are proposed to run over the flyovers. Flyovers are proposed at the present at grade intersections.

Skywalks are provided connecting the BRTS bus stop with other routes bus stops on cross-roads at the intersection. Also bus stop facility for feeder services on the non

BRTS carriageway near the pedestrian over bridge is provided to integrate this two sections.

The advantage of this arrangement is that it completely eliminates delays to BRTS buses at intersections due to signal control. His will increase their productivity.

7.8 BRTS –Lane Pavement Type

Selection of pavement type for the bus way is important as it affects:–

- Design life
- Cost – construction and maintenance
- Riding comfort and a host of other factors

A comparative analysis between the two types of pavement – flexible and rigid are presented below:

Table 7.10: Comparison of Characteristics of Flexible and Rigid Pavements

Item	Flexible Pavement	Rigid Pavement
Design Life	Target design period of 15 to 20 years. The life will be extended by proper rehabilitation	Target design period of 30 years
Resistance against Rutting & Wear	Deformed rutting is likely	Deformation or rutting is unlikely. Wear resistance is large
Noise & Vibration	Less than rigid pavement	Noise due to joints and vibration due to rough surface
Brightness	Surface reflection is weak and inferior	Brighter in darkness
Surface Smoothness	Better than rigid pavement and provide more comfortable riding condition	Need more quality control to achieve acceptable level of surface smoothness
Characteristics in Construction	Fewer constraints in construction. Constructing speed is faster	The following constraints should be taken into account for continuous construction since equipment fleet is generally larger than that of flexible pavement 1) Subgrade is prepared in

Item	Flexible Pavement	Rigid Pavement
		smooth condition 2) Traffic management during construction of PQC.
Maintenance	Frequent maintenance is required but the method is simple	Once damage occurs, heavier and longer repair is required
Construction Economy	Initial stage construction cost is lower than rigid pavement.	Initial construction cost is higher than flexible pavement due to longer life. The cost of maintenance is less compared to flexible pavement except incase of major repairs to the concrete pavement which is high.

Selection of pavement type needs to be based on life cycle cost analysis. The initial cost of rigid pavement is higher than flexible pavement. However, due to skyrocketing the cost of crude oil there would be some increase in the cost of flexible pavement.

Also rainfall is very intense in Mumbai and deterioration of flexible pavement is very fast. Hence, under the MUIP Programme, for major arterial roads, rigid pavement has been recommended. The existing flexible pavement on both the WEH and EEH corridors is being converted to concrete pavement in stretches. In view of this ongoing conversion to concrete and in order to maintain the same pavement type, for the bus way of the BRTS at grade, rigid pavement, is recommended.

7.8.1 Summarized Recommendation & Decision by Steering committee

A presentation was made to the Steering committee detailing the advantages and disadvantage of the alternatives for each of the component elements. After careful deliberations the steering has given its decision, as listed below in ***Table 7.11***.

Table 7.11 – Steering Committee's directions on Consultants Study Recommendation

Issue	Consultants Suggestion	Committee Recommendations	Remarks
Corridor for considération	Eastern Express Highway (EEH):Sion to Thane	EEH: Dadar - Sion- Cadbury junction (Thane) - Ghodbunder Road	Further Extensions to CST/Nariman point by using alternative routes like Eastern freeway, Bandra -Worli Sea link & other alternatives.
	Western Express Highway (WEH): Bandra to Dahisar	WEH: BKC – Bandra - Dahisar - Mira Road	
Placement of Transit way	In the Median with Elevated system	Committee recommended Median lane Segregated, Partially Elevated with effective utilization of flyovers	Optimum use of flyovers along with relocation of the bus stops suitably
Vehicle Technology	To start with 12m Standard Partial Low Floor buses and gradually upgrading	To initially utilize 12m Standard Partial Low Floor and gradually upgrade to 25m articulated buses as patronage and demand rises	BEST desired to use CNG buses
Service Options	Initially Direct. As demand builds up Trunk& Feeder System	Agreed with Consultant recommendations	To consider Feeder services at Andheri & Santacruz Flyovers (long flyovers)
Operations	Regulated Closed System with BEST buses, approved private operators	Regulatory Closed system	Permit use by School buses/ST buses and Emergency Vehicles
Placement of Stops	Mid Block stop with a Spacing of 500-800m	Midblock stops with a spacing of 500-800m with pedestrian access facility	
Organizational setup	Independent SPV + BEST+ other Stake holders	Agreed with Consultants	Consultants to present a detailed structure
Ticketing System	Off Board	Agreed with Consultants	

Chapter 8.0
BRTS - SERVICES AND OPERATION PLAN

8.0 BRTS SERVICES PLANNING

8.1 Introduction

Road corridor re-engineering allocating dedicated lanes to BRTS besides enables improvement of system productivity and capacity. However it is the services plan which provides needed mobility to the users and enhances the patronage of the system. Systematic planning of BRT services which includes routes with end points, type of bus service (ordinary, A/C, Express, etc), bus frequency by time period, time table, etc., is critical and key to the services of the system.

BRT Service should be clear, direct, frequent and rapid. Service design should meet customer needs while also attracting new riders. Fares should permit rapid boarding of buses. Marketing should focus on BRT's unique features and further reinforce its identity.

8.2 General Guidelines

The general guidelines for BRT Service planning are as follows:

- It is generally better to have few high frequency BRT routes than many routes operating at long headways.
- Service should be simple, easy to understand, direct and operationally efficient
- Through service-at least for basic all stops routes-is desirable when the round trip can be made in two hours
- The basic all-stop services should run all day, from early morning to late night, seven days a week and express services depending on customer demand characteristics.
- Emergency vehicles such as police cars, Fire Brigades and ambulances should be given access.
- BRT running ways may be used by all authorized transit operators where vehicle meet established design and safety requirement.
- Fares should be integrated with the rest of the bus system, but may not necessarily the same.
- Fare collection should facilitate multiple doors boarding off board collection performed.
- Marketing activities should focus on the key attributes of BRT, such as service frequency, speed, comfort and reliability.

- Marketing activities should promote BRT identity by providing brochures, maps, schedules and passenger information that are key to overall theme of the BR system.

The above general guidelines provide a starting point that may need an adjustment in specific situations depending upon the local conditions.

8.3 Service Design

On the recommendations of the consultants, the Steering Committee have approved the system operation plan to be ‘Closed’ one and the services plan in the long range to be ‘Trunk & Feeder’. However, as the system is being introduced along the corridors where high intensity of bus services are already being operated, during the transition period it is necessary to have an ‘Open’ and ‘Direct’ system and rationalize the existing routes and services.

Bus routes, frequencies and hours of service should reflect the types of running ways, location of major activities in the corridor, market opportunities and the resources that are available.

8.3.1 Span of Operations

Span of Operation, is very important from customers view point, as it decides the service availability to the customers. Further, the span of operations also effects the resource utilization and cost of operations. Hence the decision has to be very rationale as it effects every partner of the business i.e., customers, operators, management besides the overall image of the city and its Public Transport system.

As BRT is mainly operating its services on the high traffic corridors, the span of operation need be long enough to accommodate the demand of Traffic. Ideally for a city like Mumbai, the Public Transport services need be available through out 24 hours of a day as Mumbai never sleeps. However the frequency may vary according to passenger demand, for example, the BRT corridor may have skeleton services from 00 hours to 04 hours. Even for the remaining 20 hours, the traffic intensity will not be uniform; hence the service frequency varies in tune with the demand.
In Mumbai, the traffic flow is from north to south in the morning direction, while the process gets reversed in the evening. Considering the demand of traffic, the operations could be broadly categorized into the following periods; direction wise:

(i) North to South: (From Dahisar or Thane to BKC)

Sl.No	Period	Traffic Intensity	Summary at a Glance
1	00 to 04	Very Slack	Very Slack – 1 spell - 4 hrs Slack – 2 Spells – 5 hrs Normal – 2 Spells - 11 hrs Peak – 1 Spell - 4 hrs
2	4.00 to 6.00	Slack	
3	6.00 to 7.00	Normal	
4	7.00 to 11.00	Peak	
5	11.00 to 21.00	Normal	
6	21.00 to 24.00	Slack	

(ii) South to North : (From BKC to Dahisar or Thane)

Sl.No	Period	Traffic Intensity	Summary at a Glance
1	00 to 04	Very slack	Very slack - 1 spell - 4 hrs Slack - 2 Spells - 5 hrs Normal - 2 Spells - 10 hrs Peak - 1 Spell - 5 hrs
2	4.00 to 7.00	Slack	
3	7.00 to 16.00	Normal	
4	16.00 to 21.00	Peak	
5	21.00 to 22.00	Normal	
6	22.00 to 24.00	Slack	

The peak period requires many Express/Non-stop /Limited halt buses, While for Slack and normal periods, all stop services are preferable, it is a great challenge to match the supply and demand, in a city like Mumbai, especially with unidirectional traffic.

8.3.2 Service Types, Operating Hours and Service Frequencies

In the long range the proposed BRTS will operate as a 'Closed' system with 'Trunk & Feeder' services pattern. A variety of services would be organized to meet the varied needs of the user groups. They are:

- General service through the day
- Peak period special services
- Limited stop services
- Express services
- Air Condition services

As the travel demand along the sections of the corridor varies widely, to optimize the fleet, it is necessary to run services of limited lengths along the corridor. Again a variety of options are available such as:

- End to End services
- End to Mid point services
- Mid point to Mid point services

A judicious combination of type and length of services would optimize the capacities, maximize patronages and revenues and increase the brand image of the system.

For each type of service, the operating hours (Service Plan) need to be finalized depending upon the service opportunities. For example the all stop services would operate from early morning to late night, while peak period special services would operate only during that period. Special, services would operate only during that period. Similarly the Air Conditioned Services need to be operated depending upon the demand characteristics of the route.

8.4 Rationalization of Bus Services during Transition

Bus services along the corridors must change from the prevalent BEST services pattern to the proposed BRTS service pattern. The existing routes and services along the corridors need to be reorganized. The transition is important to ensure little inconvenience to the bus passengers. Also the change in quality of service should encourage modal shift from cars, 2-wheelers, IPTs and train on to BRTS.

The process is briefly discussed in the subsequent paragraphs.

8.5 Route Planning for BRTS on Eastern Express Highway Corridor

As proposed the EEH starts from Sion and ends near Cadbury junction in Thane. However it is recommended to start from Hiranandani estate on Ghodbundar road. There is land space for development of a proper terminal. It covers grater catchments to increase patronage. Also it is in line with the recommendations made in Thane CMP study. At the south end it is proposed to extend the corridor from Sion to Bandra-Kurla-Complex (BKC). A terminal at BKC is very important as operation for 2 BRTS corridors, 2 Metro lines are emerging at this location.

8.5.1 Existing Scenario on Eastern Express Highway (EEH)

Presently there are 15 BEST routes involving 121 buses, which are serving 1.2 lakhs of commuters per day, and all these routes overlap the proposed BRT route on EEH.

The overlapping of BEST Routes over the proposed BRT Route on EEH has been classified into 4 categories based on the extent of overlap. The details of overlapping on various routes are given at **Volume – II, Annexure XIII.1.**

8.5.2 Design of Trunk and Feeder Routes on BRTS on EEH:

As a matter of policy, if the overlapping is fairly high (say above 40%), such routes are merged with BRT Route. Conversely, if the overlapping is insignificant, such routes are allowed to be continued as direct services. Wherever, routes are merged with BRT Route, the original route is modified suitably making it a feeder route, wherever possible.

In the first phase, the BEST Routes to be merged with the Trunk Route of BRT on EEH are those, which have significant portion of overlap (say about 40% and more), on the proposed BRT route. Initially, routes with 9 km overlap are considered for merger. Such routes, which are proposed for merger, are given in **Volume – II, Annexure XIII.2.**

The total number of buses involved are 71, from the above 7 routes serving about 57,000 passengers per day. As these Bus Routes are merged with BRT Trunk Route, on EEH, there is need to provide feeder services to the Trunk Route, either at Terminal or at Bus stop where the existing BEST Route mergers with BRT route. People have to transfer from feeder to trunk, to reach their respective destinations. However, as BRT is planned to have high frequency there would be reduction in the total journey time (Running time + waiting time).

8.5.2.1 Design of Feeder Routes:

As it is proposed to merge some routes into BRT Route, the need arises for starting new feeder routes to maintain connectivity. In **Volume – II, Annexure XIII.3** gives the details of new feeder routes Proposed as consequence of merger of some routes with BRT to adopt ‘Trunk and Feeder System’.

8.5.2.2 Modification to Existing Routes consequent to commissioning BRT route:

Consequent to the merger of some routes into Trunk route of BRT (Refer Para 8.5.2) those routes get modified as detailed in **Volume – II, Annexure XIII .4.**

8.5.3 Design of Direct services

In the transition period, it is proposed to allow some ‘Direct service’ on the BRT corridor, as the overlapping of these routes is too insignificant (4% - 30%) and the route characteristics need direct services. Such of those routes, which are proposed to offer ’Direct services’, are detailed at **Volume – II, Annexure XIII.5.** The total number of buses involved are 67, from 8 routes, serving 61000 commuters per day.

8.6 Route planning for BRTS on Western Express Highway (WEH)

The BRT Route proposal is from ‘Bandra’ to ‘Dahisar’ (25 km) As BRT envisages, shifting of people’s choice from personal modes to public transport ,adequate parking area has to be provided at the terminals (both at origin and destination) so as to facilitate inter modal integration.

In the light of the requirement for modern terminals, the 'Origin" of BRT route is recommended to be at BKC and the 'Destination' near 'Kashimira' Junction on the highway .As a matter of policy about 20% of the capacity of BRT Buses need be the starting load at terminals, to ensure financial viability of operations. This means, selection of suitable places for 'Origin' and 'Destination' of BRT service is imperative.

8.6.1 Existing Scenario on Western Express Highway (WEH)

Presently there are 48 Routes involving 635 buses which are serving 4.65 lakhs of commuters per day on WEH. Out of these 48 Routes, 7 routes involving 93 buses only cross the WEH, which means no overlapping.

The remaining 41 BEST Routes, involving 542 buses overlap the BRT route. The over lapping of BEST Routes over BRT Route on WEH, has been classified into 4 categories based on the extent of overlap. The details of overlap on various routes are given at **Volume – II, Annexure XIII.6**.

8.6.2 Design of Trunk and Feeder routes for BRTS on WEH

In the first phase, the BEST routes to be merged with the Trunk Route of BRT on WEH, are those which have significant portion of Overlap (say more than 40%), on the proposed BRT route. Initially, routes with 9 km Overlap are considered for merger. Such routes, which are proposed for merger, are given at **Volume – II, Annexure XIII.7.** The total number of buses Involved are 120 from the above 9 routes serving about 1, 03,000 Passengers per day.

8.6.3 Modification to routes consequent to introduction to BRT on WEH

Consequent to the merger of Nine Routes into Trunk route of BRT on WEH, those routes get modified as detailed in **Volume – II, Annexure XIII.8**.

8.6.4 Design of Direct services:

In the transition period, it is proposed to allow some "Direct services" on the BRT Corridor, as the over lapping of these routes is too insignificant and the route characteristics need direct services. Such of those routes, which are proposed to offer 'Direct services', are detailed at **Volume – II, Annexure XIII.9.** These are categorized into 4, based on Overlap.

8.7 Fare Collection:

BRT fare policies are important complements to the operating plan. They entail two basic aspects: the fare structure and how fares are collected.

8.7.1 Fare Structure:

BRT fares should be integrated with fares for the rest of the bus system, but BRT fares do not necessarily have to be the same. The fare structure should be kept as simple as possible.

8.7.1.1 Same Fare:

BRT fares can be the same as for other bus services. The unified fare structure is easy for riders to understand and facilitates transfers between connections (feeder) buses and trunk line BRT service.

8.7.1.2 Premium Fare:

A surcharge could be established for BRT service, especially where it is highly differentiated from other services. The rationale is that a premium service warrants a premium charge and that premium service has higher cost than the conventional service.

8.7.1.3 Fare collection options:

- Off board collection
- On board Collection

Off board collection is customer friendly and allows the use of all bus doors for boarding, there by reducing passenger service times, station dwell times, bus travel times and operating costs. It may be achieved by several ways.

- Pre payment
- Auxiliary platform personnel
- Vending machines

On board collection of fares works well at low volume stations and during off peak hours and eliminates the need for special fare collection provisions on side walks and stations. It can be achieved by several ways.

- Conventional on board collection
- Pay enter inbound, Pay leave outbound
- Passes
- Smart Cards

8.8 Marketing BRT Service:

Marketing BRT service has two basic objectives: To emphasize the unique features of BRT and to create a unified system image and identity by coordinating marketing with the overall BRT theme used throughout the system. Like any form of public transport marketing, BRT marketing activities should be people centered and focus on the product, promotion and price.

8.8.1 Image

Marketing for BRT should establish the general image associated with BRT and emphasize its unique attributes of speed, reliability and identity. A special brand identity should be established for BRT

8.8.2 Passenger Information

Passenger Information is the backbone of BRT marketing effort. Route and service identification and vehicle design and graphics are the two important aspects of passenger information.

8.8.3 Maps, Schedules and Brochures

BRT passenger information should clearly convey the BRT color and logo themes. It should also display thematic messages such as “Ride the Rapid” that emphasizes the unique features of BRT services.

System Maps, and Schedules should display BRT routes and stations in the same way as rail transit lines are display.

Information brochure should advise passengers when service is introduced or changed, as well as furnish general information regarding the features of BRT.

8.8.4 Promotional Programs:

Promotional programs contain three related aspects: 1) advertising and public information 2) service innovations 3) pricing incentives. These programs should be keyed to different market segments of existing and potential BRT riders. The goals of these programs are to answer questions about BRT services and to persuade potential customers to use the service

Chapter 9.0
PRELIMINARY ENGINEERING

9.1 General

The initial objective of the Phase - 1 study is to test the techno-economic viability of implementation of BRTS on Western Express Highway (WEH) and Eastern Express Highway (EEH) Corridors. Therefore, it was necessary to first define a possible set of BRTS elements and conceptual planning for providing the bus lanes. Various alternatives of providing BRTS lanes viz. Median side, Kerb side and Elevated on the above project corridors were discussed in detail in Chapter 7 and therefore not covered in this Chapter. The alternatives were discussed in the Steering Committee Meeting held on 5-2-09 in MMRDA. The Committee had directed the consultants to adopt the median side BRTS with segregated bus lanes and with effective utilization of existing flyovers. The committee also suggested providing elevated BRTS in some locations where right of way is restricted and corridor is passing through congested areas. The development of suggested alternative gave rise to several general and specific engineering requirements, which warranted preliminary design to arrive at a realistic cost estimate. The suggested option in detail and the design considerations are described in the subsequent sections of this chapter.

9.2 Study Corridors

MMRDA wants to develop BRTS along two major corridors in Mumbai namely Western Express highway and Eastern Express Highway in the first phase. Salient features of these corridors are as follows:-

1. Western Express Highway (WEH) from Dahisar to Bandra.
   - Length: 25 Kms.
   - ROW: 61 to 76 m
   - Intersections: 21
   - Flyover: 14 (3 under construction)
   - Structure:
     - 13 minor bridges
     - 5 vehicular underpasses
     - 2 RoBs
     - 1 Skywalk
     - 2 Subways
   - Bus Stops: 35
   - No. of Routes 51
   - No. of Buses 654

2. Eastern Express Highway (EEH) from Cadbury junction in Thane to Sion.
    - Length: 25 Kms.
    - ROW: 61 m
    - Intersections:
        - 12 major
        - 3 minor
    - Flyover: 10 (2 under construction)
    - Structure:
        - 2 ROBs
        - 8 Minor Bridges
        - 2 vehicular subways
    - Bus Stops: 17
    - No. of Routes 14
    - No. of buses 126

9.3 Topographic Survey

Topographic survey has been carried out on the two study corridors to get the details of existing features. The objective of Topographical surveys is to establish the centre line for the proposed BRTS and to know the existing features at site. The survey has been carried out using Total Station Instrument ('TREIMBLE' equipped with PK01 programme cord), which has the advantage of speed and accuracy to 1 sec., as well as automatic recording of data.

The topographic survey has been carried out in two parts:

Leveling Survey & Contour Survey
Ground Feature Survey

Survey stations have been established using the 'Local Grids'. The survey stations have been established along the road at appropriate locations. Generally the survey station locations have been decided by the directional changes in the alignment, terrain condition and visibility. These survey stations have been used for picking up existing feature details and later for setting out the horizontal alignment.

Temporary Bench Marks have been established on permanent features such as existing culverts, structures etc. These bench marks have been used for taking the ground/road levels. As the topography is mostly plain, ground levels have been taken at interval of 10 m longitudinally and 10 m transversely thus forming a grid of 10 x 10m. As the topographic survey is carried out for roads, the coordinates and levels have been taken along the center line, median, road edges, drain, footpath, etc. for plotting L-section and X-sections of the same. Recorded levels have been fed to the design software and Digital Terrain Modeling (DTM) has been prepared to generate contours at 1 m interval.

Co-ordinates of all physical and topographic features have been picked up by Total Station from established traverse station as discussed earlier. All the details of existing roads, cross roads have been taken. Details regarding flyover, pier locations, median, crash barrier etc have been picked up in the survey. All existing structures like bus stops, FOB, subways, building lines, hutments, compound wall etc. have been surveyed. Visible utilities like electric poles, light post, water pipe line etc. has also been taken in the survey. All existing features have been coded for feeding into Total Station. This data has then downloaded in the computer by using software.
All the data has been processed and contours have been developed and existing feature drawing is prepared.

9.4 Design Standards

Geometric design of highway is dictated by land availability, requirements of traffic and economic considerations. The geometric design involves design of several elements such as horizontal alignment, vertical profile, cross section components, embankments, intersection layouts, bridges, structures, etc. The safety, efficiency, economy and comfort of vehicle operation are governed by the adequacy of geometric standards used for specific interchange / highway facility.

In the present case, existing WEH and EEH have been developed to full ROW and as such geometry is fixed horizontally and vertically, there is little scope to change the geometry. Design standards have been formulated as per IRC: 86- 1983 'Geometric Design Standards for Urban Roads in Plains' (***Table 9.1***) and discussed in following para.

Table 9.1 - Geometric Design Standards

S. No.	Description	Design Standards
Design Speed		
1.	Design Speed	60 kmph
Geometric Design		
2.	Horizontal Alignment	As Existing
3.	Vertical Alignment	As Existing
4.	Gradient Maximum Desirable Minimum In kerbed sections Desirable Minimum Absolute Minimum Desirable Maximum for Pedestrian Ramps	 5% 2% 0.5% 0.5% 0.3% 10%

S. No.	Description	Design Standards
5.	Maximum grade change not requiring a vertical curve	0.8%
6.	Minimum vertical clearance to road bridge over road	5.5m
7.	Minimum vertical clearance to road bridge over rail	6.75m
8.	Super elevation	As Existing
9.	Rate of change of super elevation	1 in 150
10.	Median Width of Median / Bus Shelter (raised) Transition in Median	 3.0 m 1 in 15 to 1 in 20
Intersection Design		
11.	*Intersections*	
	Length of storage lane (including 50m taper) for right turning	130 m
	Minimum length of acceleration lane (including 80m taper)	180 m
	Minimum length of deceleration lane (including 80m taper)	120 m
	Maximum radius for left turn	30 m
	Minimum radius for right turn	15 m
	Width of turning lane (inner radius of 30 m)	5.5 m
	Rate of taper (minimum)	1 in 15
	Minimum size of channelising island	4.5 sq m
	Offset of island from vehicle path	0.3 – 0.6 m
	Desirable angle of intersection arm	60 – 90 degrees

Camber

The values of camber on straight sections (i.e. without super-elevation) of BRT Corridor have been considered as given below:

Element	Camber (%)
Bus Lane / Mixed Carriageway	2.0
Median	3.0
Main carriageway	2.5/As per Existing

Super-elevation

Where the transition curve is not applied, two-third of super-elevation was provided before the start of circular curve in runoff length and one-third from the start of curve in run out length and vice versa.

Various IRC Codes are referred for traffic management and regulations. List of IRC codes are given in following **Table 9.2**.

Table 9.2: Design Codes

IRC - 2-1968	Route Marker Signs for National Highways (First Revision)
IRC-32-1969	Standard for Vertical and horizontal Clearances of Overhead Electric Power and telecommunication Lines as Related to Roads
IRC 35 -1997	Road Markings
IRC-38 - 1988	Guidelines for Design of Horizontal Curves for Highways and Design Tables
IRC-54 - 1974	Lateral and vertical clearances at Underpasses for Vehicular Traffic.
IRC 67-2001	Codes of Practice for Traffic Signs
IRC - 73-1980	Geometric Design Standards for Rural (Non-Urban) Highways
IRC - 86 - 1983	Geometric Design Standards for Urban Roads in Plains
IRC - 92 -1985	Guidelines for the Design of Interchanges in Urban Areas
IRC:SP:19 -1977	Manual for Survey, Investigation and Preparation of Road Projects
IRC:SP:23 -1983	Guidelines for Vertical Curves for Highways
IRC : SP- 41-1994	Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas
AASHTO	A policy on geometric design of highways & streets – 2001

9.5 Geometrics

Placement of BRTS at the center or at Kerb side are discussed in earlier chapter and presented to Steering Committee in February 2009. It has been decided by the committee to provide BRTS at the center of the road.

Existing corridors have median in the center which varies from 1.2 m to 5 m. It is suggested that demolition and construction of new median would be uneconomical and therefore it has been decided to retain existing median to the extent possible.

At Bus Stop locations, staggered bus stops are proposed, will require demolition of existing medians for a length of 400 m. In this case, new medians of 1.0 m width are proposed for separation of BRTS lanes and continuity of existing medians. **Drawing No.2008069/RH/BS- 001** shows the typical arrangement of staggered BRTS Stops.

Taper Length is proposed in ratio of 1:15. Wherever bus stops are proposed before start of flyover, weaving length for buses for turnout is proposed as 150 m. some flyovers along the corridors particularly on WEH, are closely spaced. At that location weaving length of 100 m is available.

Horizontal Alignment

There are total 89 numbers of horizontal curves on Western Express Highway. Eastern Express Highway has 45 numbers of curves. As BRTS is proposed at center of the road, alignment will follow the same geometrics of existing road.

Vertical Alignment

Vertical alignment of Western Express Highway is roller-coaster because of number of flyovers and subways along the road. BRTS is proposed to follow same vertical profile of existing with minimum vertical clearance of 5.5 m under flyover.

On Eastern Express Highway some of the flyovers like at Vikhroli and Ghatkopar facilitate only one way traffic. BRTS lanes, therefore, will be split up and follow flyover for one lane and at grade for another lane.

9.6 Road Cross Section

ROW for Eastern Express Highway is 61 m while for Western Express Highway the ROW ranges from 75 m to 61 m. From Kalanagar to Airport it is 75 m and the rest up to Dahisar the ROW is 61 m. BRTS is proposed in the center of the road. Typical sections of road with BRTS are presented below.

BRTS in Mid Section

BRTS Lane	-	2 x 3.5 m
Median	-	As Existing
Carriageway	-	1
Drain/Footpath	-	
Service Road	-	As Existing (7.5-8.5 m)
Footpath	-	As existing (1.5-2.5m)

Drawing No.2008069/RH/TCS-002 shows the typical cross section of proposed BRTS in Midway Section

BRTS on Flyover

On the flyover/ROB since the width is not adequate to accommodate segregated bus lanes, it is proposed to run BRT in mixed traffic flow, the segregation of BRT lanes ends about 150 m before the approach of flyover/ROB and thus run in mixed traffic with lane marking of bus lane following the central median. The bus stop will be provided at the junctions before and after the flyover/ROB.

BRTS Lane	-	2 x 3.5 m
Median	-	As Existing
Carriageway	-	7-7.5 m
Slip Road	-	As Existing (7.5-8.0 m)
Divider	-	As existing (1.5-2.0m)
Slip Road	-	As Existing (7.5-8.5 m)
Footpath	-	As existing (1.5-2.5m)

Drawing No.2008069/RH/TCS/ - 001 & 003 shows the typical cross section of proposed BRTS on flyover section

BRTS at Bus Stop Location

BRTS Lane	-	2 x 3.5 m
Passing Lane	-	3.5 m
Median	-	1.0 m
BRTS Bus Stop	-	3.0 m
Carriageway	-	2 x 11.00 m
Divider	-	As existing (1.5-2.0m)
Slip Road	-	As Existing (7.5-8.5 m)
Footpath	-	As existing (1.5-2.5m)

Drawing No.2008069/RH/TCS/ - 001 shows the typical cross section of proposed BRTS in at proposed Bus Stop Location

9.7 Pavement Design

There are two types of pavements normally adopted for major arterial roads depending upon loading, design life, maintenance etc. These are flexible (bituminous) and rigid (Cement Concrete) pavements. The over all cost of pavement is a major criterion for choice of pavement type, flexible or rigid. There is a common notion that the cost of construction of roads with concrete pavement is substantially more when compared to flexible pavement and requires large quantity of cement and other aggregate materials
Selection of pavement type for the bus way is important as it affects:–

- design life
- cost - construction and maintenance
- riding comfort and a host of other factors

A comparative analysis between the two types of pavement - flexible and rigid is already discussed in Chapter-7.

Selection of pavement type needs to be based on life cycle cost analysis .An analysis of asphalt versus concrete pavement was made for the selection of pavement type for BRTS. The results showed that capital and maintenance costs were very similar. Inclusion of other costs namely road users cost, traffic delay cost during overlays and salvage returns would tend to favour the concrete pavement option. Therefore, concrete pavement has been recommended.

Also rainfall is very intense in Mumbai and deterioration of flexible pavement is very fast. Hence, under the MUIP Programme, for major arterial roads, rigid pavement has been recommended. The existing flexible pavement on both the WEH and EEH corridors is being converted to concrete pavement in stretches. In view of this ongoing conversion to concrete pavement and in order to maintain the same pavement type, for the bus way of the BRTS at grade, rigid pavement, is recommended. As the conversion of asphalt to concrete pavement is still in planning stage, it will not be economical to construct rigid pavement for full carriageway width and for total length under the BRTS implementation program with respect to not only for cost but operation difficulty during construction due to the heavy traffic plying on the road. It is therefore suggested to provide rigid pavement for bus lane only. For other parts of carriageway asphalt overlay will be sufficient to adjust the longitudinal and cross profile.

Pavement Composition for Bus Lane

Pavement Quality Concrete (M40 Grade)	-	320 mm
Dry Lean Concrete (M10 Grade)	-	150 mm
Wet Mix Macadam	-	150 mm
Granular Sub Base	-	150 mm Min.

Thickness of GSB will be 150 mm minimum. As it will act as drainage layer, thickness should be matched with existing GSB layer. Joint of flexible pavement with rigid one will be properly designed.

During execution, center lanes will be completely cordoned off and excavation of existing pavement will be carried out to the required depth of rigid pavement crust and then each layer will be constructed as per design thickness. It is suggested that rigid pavement should be constructed with slip form paver to get good finish of road surface.

Overlay on existing Pavement

Width of 3.5 m of main carriageway by the side of Bus Lane will be provided with asphalt overlay. The thickness of overlay is 40 mm Bituminous Concrete. However, stretches of overlay will be decided after pavement inventory study on both the corridors. **Drawing2008069/RH/RC- 001** shows the typical section of pavement**.**

9.8 Drainage Arrangement

Full fledge drainage system is already provided by MMRDA under MUIP. There are existing drains between service road and main carriageway. These drains are at some locations are open drains or covered RCC drains. On property side, all RCC drains are available through out the length. Drains are connected with Cross Drainage works which are at frequent interval.

As BRTS is proposed in the center, it is proposed to lay discontinuous kerbs of 500 mm length with gap of 500mm. Surface runoff will run through these gaps, flow on main carriageway and will then discharge into existing drains through runner pipes of 150 mm dia which are provided at 5 – 7 m interval. **Drawing2008069/RH/RC- 001** shows the typical drainage arrangement.

9.9 BRTS Corridor on Western Express Highway

The Alignment of BRTS starts from the end of Mahim Causeway. It traverses over Kalanagar flyover and crosses Kherwadi Junction. A BRTS stop is proposed after the Kherawadi junction, which will cater the catchment nearby by that area. Existing Bandra station is at a distance of 500 m from the proposed BRTS Stop and hence it is suggested to provide skywalk up to Bandra Terminus. The available ROW of WEH at Kherawadi is 75-80 m. Therefore 5 lanes are available for other traffic in each direction for main carriageway excluding Bus Lanes. To optimize the space required for proposed BRTS Bus Stops, staggered arrangement is proposed for up and down bus traffic. **Drawing 2008069/RH/BS- 001** shows the typical arrangement of staggered bus stops.

BRTS alignment then continues along the center of the road. Cardinal Gracious School BRTS stop is second BRT station on this corridor. After this station. Vakola flyover of length 1.33 Km covers three existing bus stops. As per traffic study and analysis, no BRTS Stop is proposed along the length of flyover. Hence, catchments from Hyaat Road and near by areas will use Cardinal Gracious School BRTS Stop, Skywalk of 4m width is proposed on east side only from Hyaat Road to Cardinal Gracious School BRTS Stop. Vakola flyover continues on University road junction which is major junction on the corridor with respect to catchments. Santacruz Bus Station and railway station are connected by skywalk with Agripada BRTS Stop which is proposed after the end of Vakola flyover. Agripada BRTS Stop is proposed in between Vakola Flyover and Agripada subway. As the distance between existing flyover and subway is hardly 250 m, BRTS stop is proposed on down lane only. Bus stop for up lane is proposed after Agripada subway. Bus stops are proposed to be connected by skywalk.

After Agripada Bus Stop, next Bus Stop is at Centaur Hotel which is proposed between Agripada Subway and New Flyover at Domestic Airport Junction at a distance of 400 m. Skywalk is proposed from this bus stop to Airport for transfer of passengers. Skywalk at west side of airport flyover is also proposed for passengers from feeder buses. BRTS is proposed at the center at flyover locations also. It is suggested that BRTS lane on flyover is segregated by other lanes by providing lane marking and studs at 5 m interval. No physical barrier is proposed so that during off peak hours other traffic may use BRTS lane on flyovers.

After crossing airport flyover, next BRTS Stop is near Hanuman Road. BRTS will ply on Andheri flyover of length 1.50 Km. There are three existing bus stops on slip roads in the stretch of flyover. As it is difficult to provide BRTS stops on flyover as traffic capacity point of view, they are proposed at both the ends of the flyover. Hanuman Road BRTS Stop will be on south end and Gundavali BRTS stop will be on North end of flyover. Skywalk is proposed from Hanuman Road Stop to Sahar Road as this area is of large catchments of higher commercial activities. Moreover, construction of Varsova-Andheri-Ghatkopar Metro is under progress. Andheri MRT station is proposed near Andheri suburban station and WEH MRT is station is proposed near Mahakali Caves Road. It is suggested to integrate all system like BRTS, MRTS and suburban rail system. Therefore, skywalks are proposed from proposed BRTS Stops to Andheri Station and WEH Station of Metro. Skywalks are also proposed from Sahar road to Andheri Ghatkopar Link Road for transfer of passengers.

After passing Gundavali Stop, next stops are Shankarwadi Stop and Ismail Yusuf College Stop. As ROW is 61 m, dual 4 lanes are available throughout the corridor. From Ismail Yusuf College, skywalk is proposed up to existing Jogeshwari Station.

Alignment then crosses Jogeshwari Flyover which is 3 lane dual carriageways. After this flyover, Vanrai Mhada Colony Stop, Vidya Marg and Gen. Ashok Kumar Stops are proposed along the corridor. After Dindoshi, there are existing subways & flyover which are closely spaced. BHAD Colony Stop and Dattani Park Stops are proposed before Magthane Flyover. Magthane BRTS Stop is proposed for down BRTS lane between flyover and subway and for Up lane Stop is proposed after the flyover. Omarkeshwar Mandir and Ketki Pada Stops are proposed in between the flyovers.

Proposed BRTS corridors with Bus Stops on part of Western Express Highway from Bandra to Jogeshwari are shown in **Drawing 2008069/RH/WEH/PL- 001 to 005, Volume-II, Annexure-IX.1.** These drawings show the typical arrangement of Bus stop and skywalks. It will be detailed out in Phase II of the TOR.

Extension of BRTS on WEH to Bandra-Kurla Complex

BRTS on Western Express Highway starts from Bandra. Bandra Kurla Complex is major hub for employment and it is necessary to cover this area under BRTS.

Alignment of BRTS starts before Kherawadi junction and follow the Kalanagar flyover. However, one arm of BRTS lane will divert follows the slip roads of existing flyover. BRTS then cross I.R. Kelkar Junction and follow MMRDA Road. It will then take right turn at ‘Wockhardt Building’ and follow existing road. It will terminate at BRTS Bus Depot at BKC. **Fig.9.1** shows the extension of alignment to BKC. Length of this alignment extension is app.2.00 km. proposed location of BRTS opposite to Income Tax Building. App. Cost of extension is 260 Millions.

Extension of BRTS on WEH to Kashimira- Bhayandar

BRTS on Western Express Highway ends at Dahisar. From Dahisar Toll Plaza, Bhayandar is one of the areas of large catchments which are presently connected by suburban rail connectivity to Mumbai. It has been suggested to extend Kashimira road. Length of this extension would be 3.0 km.

Alignment of BRTS from Dahisar Toll Plaza will start and will follow NH 8 up to Kashimira Junction which is about 3 km **Fig.9.2** shows the extension of alignment to Bhayandar. AT spacing of 1 km, three BRTS Bus Stops may be provided on this extension. App. Cost of extension is 390 Millions.

9.10 BRTS Corridor on Eastern Express Highway

Alignment of BRTS starts from Sion on Dr. Ambedkar Road. First BRTS station is proposed at Rani Laxmi Bai Chowk. This BRTS stop is proposed below Sion flyover. Existing ROW at Sion flyover section is 30 m. BRTS alignment runs along existing road at center, crosses Suburban rail on existing ROB. Everard Nagar Bus Stop is proposed Everard Nagar flyover for catering the catchments near by Sion and Wadala area. Passengers from Priyadarshini Bus Stop, RCF will also use the same BRTS Stop.

Alignment then runs along Eastern Expressway at the center of the road. ROW of highway is 61 m to accommodate 4 lane dual highway and 4 lane service roads with BRTS lanes. Alignment then runs along Kurla Flyover at the center. No divider is proposed in between BRTS lane and other part of carriageway on the flyover. Only road marking with studs at 5 m interval is proposed which will act as separator.

After crossing Kurla flyover, next stop is Postal Colony Bus Stop which will cater Kurla, Chembur and Ghatkopar Area. Skywalk from Amar Mahal Junction is proposed on either side of road or other cross roads like Aacharya Marg, Shanta Jog Marg are connected to these skywalks for capturing catchments of that area.

Alignment crosses Amar Mahal Flyover and runs over Cheda Nagar Flyover. This flyover is one way for Mumbai bound traffic. Therefore, BRTS up lane will be at grade and down lane will be at flyover. After Cheda Nagar Flyover, BRTS stop is proposed to cater the passengers from the same area. Ramabai Nagar BRTS stop is proposed before Ghatkopar flyover. Car depot of VAG (Versova – Andheri - Ghatkopar) MRTS is proposed in Preliminary Exhibition Ground. It is suggested to integrate BRTS with VAG MRTS for passenger transfer of both systems. Alignment runs at the center of the road for length of 4 km without any bus stop as there are no catchments on either side of the road because of marshy land and no development zone. Though alignment covers Godrej Company, passengers will be very less and hence it is not suggested to propose BRTS Stop at Godrej Company Location.

Kannamwar Nagar BRTS stop is proposed before JVLR flyover. This flyover is also one way and hence BRTS Bus up lane will be at flyover and down lane at grade. Next Stop is proposed near Navghar Junction before Toll Plaza. This stop will cater Mulund area which is on west side of the corridor. On east side, no development zone and salt pans are available.

Alignment will cross Toll plaza and center two lanes of toll plaza will be used for BRTS Lanes. Alignment then enters in Thane Municipality Area and will cross existing Kopri Bridge. First BRTS stop in Thane area on EEH will be Dyan Sadhna College before Teen Haath Naka Flyover. As per Detailed Project Report of Thane MRTS –Year 2002 prepared by M/S CES (I) Pvt Ltd., Naupada Station is proposed on Green Corridor in Phase I and on Red Corridor in Phase II. It is suggested to integrate Thane MRTS with BRTS and hence skywalk is proposed from these stations to BRTS.

ROW of Eastern Express Highway is 61 m and developed with full corridor. Alignment is proposed at the center of the road. Next stop is Louis Wadi BRTS stop between Nitin Casting Flyover and Teen Haath Naka Flyover. Alignment will run on Nitin Casting Flyover and cross ESIS Junction and Cadbury Junction. BRTS depot is proposed in area of J. K. Chemicals near Cadbury Junction. BRTS will end at this depot and will take U turn below Golden Dyes Flyover.

Proposed BRTS corridors with Bus Stops on part of Eastern Express Highway from Sion to Cadbury are shown in **Drawing 2008069/RH/EEH/PL- 001 to 013, Volume-II, Annexure-IX**. These drawings show the typical arrangement of Bus stop and skywalks. It will be detailed out in Phase II of the TOR.

9.10.1 Extension of BRTS on EEH to Bandra-Kurla Complex

BRTS on Eastern Express Highway starts at Sion which also may be extended up to Bandra Kurla Complex.

Consultant proposed two alterative alignments to connect the WEH corridor with EEH. The alignment alternatives are

Alignment 1 - In this alternative, Alignment will follow Sion-Dharavi Link Road after taking right turn at V.G.Tapse Chowk. Alignment then follows Sion-Bandra Link road and takes right turn toward MMRDA Road. Alignment will enter in Bandra-Kurla Complex and will end in Proposed BRTS Bus Depot.

As DP width of Sion-Dharavi Link Road is 27.50 m, there is no lateral space for BRTS. Hence it has been suggested to provide elevated BRTS from Sion-Dharavi Link Road to MMRDA Road. Three intermediate BRTS Bus Stops may be provided along this alignment. **Fig. 9.3** shows the extension of alignment from Sion to BKC with proposed BRTS bus stops. Length of this alignment is 3.00 km out of which 1.64 km will be elevated. Cost of this extension is Rs. 1160 Millions.

Alignment 2 - In this alternative, Alignment in stead of following Sion Station Road, will run along Laxmibai Kelkar Marg up to Sion Hospital. It will then follow Sulochana

Shetty Marg (S.S.Marg). It takes right turn to Mahim-Sion Link Road and follows Sion-Bandra Link Road. It will then follow MMRDA road same as in alternative 1.

DP width of Laxmibai Kelkar road is 61 m and hence BRTS will ply in the median. As the width of S.S.Marg is 27.5 m, BRTS will be proposed elevated. There is existing drain nalla along S.S.Marg on south side. It has been suggested to provide elevated structure at edge of nalla so that lane capacity of S.S.Marg will not be reduced. Elevated BRTS will continue up to MMRDA Road and then will be at grade up to BRTS Bus Depot at BKC. **Fig. 9.4** shows the extension of alignment from Sion to BKC. Length of this alignment is 4.00 Km out of which 2.32 km will be elevated. In this alternative three BRTS bus stops may be provided at Sion Hospital, at Sion – Mahim Link Road and Income Tax Building. Cost of this extension is Rs.1600 Millions.

9.10.2 Extension of BRTS on EEH to Ghodbunder Road

Thane is fast growing city and most of the developments are being taking place along Ghodbunder Road. Lot of residential and commercial developments is taking place between Golden Dyes Flyover and Patlipada. It is suggested to extend BRTS from Cadbury junction to Patlipada. **Fig. 9.5** shows the extension of alignment from Cadbury to Patlipada.

ROW of Ghodbunder road is about 45 m and BRTS can be accommodated in the median of this road. Length of Alignment is 3.2 Km. Approximate cost of extension is Rs 390 Millions.

9.11 Integration of BRTS Corridor with Existing & Proposed Transit Systems

9.11.1 Integration with Existing Suburban Rail System

Western Express Highway is running parallel to Western Rail Line. Some of the existing stations are very near to WEH and therefore it is advisable to integrate BRTS Stops with stations. Bandra Terminus is at a distance of 500 m from proposed Kherwadi BRT Stop which is proposed to connect by skywalk. Santacruz station and BEST Station are also integrated with proposed Agripada BRT Stop by skywalk. Ismail Yusuf College and Omkarehswar Mandir BRT Stops are connected with Jogeshwari and Borivali Stations by skywalks.

On Eastern Express Highway, no integration is suggested as the distance between existing suburban station and proposed BRTS stop is more than 2 km or so.

9.11.2 Integration with Proposed Metro

MMRDA has planned MRTS and Monorail corridor in Mumbai. Construction of Versova-Andheri-Ghatkopar is under progress. Charkop-Colaba and Bandra-Mankhurd MRTS are in the pipelines. Construction of Wadala-Chembur Monorail has been recently started. It is proposed to integrate BRTS with MRTS to encourage people for using all transit system efficiently.

Andheri and WEH stations on VAG MRTS are proposed to connect with Gundavali BRT Stops.

Fig. 9.6 shows the plan showing integration of BRTS with proposed MRTS and Existing Suburban Rail System**.**

9.11.3 Integration with Feeder Buses

BRTS is also proposed to be connected with Feeder Bus Service. **Drawing No.2008069/RH/FB- 001** shows the typical schemes of integration of BRTS with Feeder Buses.

9.11.4 Integration with IPT

BRTS Stops are proposed to be connected with IPT mode of transport. **Drawing No.2008069/RH/IB- 001** shows the typical arrangement of integration with IPT.

9.12 Bus Turnouts

BRT Bus may ply on the corridor from Bandra to Dahisar and also in mid sections. It is necessary to provide turnouts for BRT Buses. As number of junctions on WEH is grade separated, BRT Bus will take U Turn under flyover. As BRT bus will travel from center to edge of the carriageway, kerbs are not proposed for weaving length of 150 m. It is also suggested to provide overhead signal for the locations where turnouts are proposed. **Drawing No.2008069/RH/BTU- 001** shows the typical arrangement of BRTS Turnout.

9.13 Bus Stops & Terminals

Along the BRTS trunk line (Infrastructure), the points (facilities) where this system directly comes face to face with user requiring the system to cater to the public efficiently; there is need for creating mainly following three levels of facilities:

- Bus stops
- Bus stations
- Bus terminals

9.13.1 *Bus stops*

Bus Stops are the most frequently used elements of the transit by the public. They are planned to be simple shelters with the provision of:

- ✓ An appropriately designed bus bay(s) for stoppage of buses and with platform for convenient boarding and alighting of commuters including those with disabilities.
- ✓ Covered roof,
- ✓ Proper sitting space for passengers,
- ✓ Adequate space for displaying passenger oriented information
- ✓ Suitable space for display of commercial boarding to generate revenue
- ✓ An area to house telecommunication gadgets for vehicle tracking, etc.
- ✓ A sturdy structure to support the above
- ✓ Space for easy ingress and egress of commuters from the bus stops.

Success of any Transit System depend upon the locations of 'Stops/Stations' on the corridor and catchments it serves.

Following points are considered for location of proposed BRTS Stops.

1) Maximum catchments area so that people use BRTS more frequently
2) Proximity to other stations of existing sub-urban rail system
3) Easy integration with proposed Metro/monorail Stations
4) Space requirement
5) Sufficient weaving length before and after flyover for BRTS Turnouts

As per reconnaissance survey, it is observed that entire WEH is provided with flyovers, vehicular subways and ROB etc. Location of the BRTS stops therefore become rather constrained, as it is necessary to locate them in such a way that adequate breaking distance is obtained after descending from a slope of the flyover, to stop at the last slot of the station. Several bus stops are identified during the survey but due to the constraints some are proposed to be combined with other stops.

On EEH, as such catchments are less as compared to WEH because of no development zones on east side of express highway.

After detailed survey and ridership estimation, following location of bus stops are proposed on WEH and EEH. Catchments area and integration with other systems are also briefed for each stop.

Table-9.3 : Location of BRTS Bus Stops on Western Express Highway

Sr.No.	Name of BRTS Stop	Catchment
1	Prior to Kalanagar flyover	Bandra Reclamation Area
2	After Kalanager flyover	Bandra Kurla Complex, Bandra Station through skywalks
3	Kherawadi	Kherawadi area, GOM Colony, Kala Mandir, Integrated with Bandra Terminus through proposed skywalks
4	Cardinal Gracious School	Hyaat Road and near by area
5	Vakola Police Station	Vakola, Kalina University
6	New Agripada	Kalina University, Santacruz Station and BEST bus station
7	Milan Subway	Vile Parle Station approach, Airport and near by area
8	Centaur Hotel	Airport and near by area
9	Hanuman Road	Brahman Wadi, Subhash Nagar, Paranjape Nagar, Sahar Road
10	Gundavali	Andheri Station , MRTS Station Andheri & EEH through skywalks, Chakala Area, Andheri Area
11	Shankarwadi	Hinda Nagar, Azad Nagar, Hari Nagar
12	Ismail Yusuf College	College Campus , Meghawadi, Janata Colony, integrated with Jogeshwari Station through skywalks
13	Jai Coach	Industrial Area and near by commercial areas
14	Vanrai MHADA Colony	Industrial Area, MHADA Colony, Goregaon Area
15	Virwani Industrial Estate	Industrial Area, Vishvesahri Nagar
16	Gen. A.K.Vaidya	Malad Area, Hanuman Tekadi
17	BHAD Colony	Samta Nagar, Ganga Nagar, Ashok Nagar
18	Pushpa Park	Pushpa park and near by area
19	Dattani Park	Saraf Chowdhary Nagar, Samata Nagar
20	Magethane Tel. Exchange	National Park
21	Devipada	Borivali National Park other conjunctions
22	Omkareshwar Mandir	Borivali, Integrated with Borivali Station
23	Prior to Gokulanand underpass	Gokulanand and surrounding areas
24	Ovripada/Ketakipada	Ketkipada & near by area
25	Dahisar Check Naka	Dahisar and some part of Kashimira

Table- 9.4 Location of BRTS Bus Stops on Eastern Express Highway

Sr.No.	Name of BRTS Stop	Catchment
1	Rani Laxmi Bai	Sion Area
2	Everard Nagar	Wadala Area, Chunnabhatti
3	Priyadarshini Park	Priyadarshini circle, ONGC and other commercial areas
4	Postal Colony	Chembur, Ghtkopar, MHADA Colony, Shankar Nagar, skywalks are proposed to Chembur, Ghatkopar
5	Amarmahal	Commercial areas and other conjunctions
6	Chheda Nagar	Chheda nagar, Sagar Colony
7	Nalanda Society	Sagar Colony and near by surroundings
8	Ramabai Nagar	Ghatkopar East
9	Ghatkopar	Ghatkopar Junction
10	Godrej Soaps	Godrej Company
11	Godrej Beyoce	Godrej Company and near by area
12	Vikhroli	Vikhroli Junction, MHADA region
13	Kannamwar Nagar	Tagore Nagar, Mahada Colony, Vikhroli East
14	Vikhroli Police Station	Vikhroli East,nearby areas
15	Kanjurmarg	Kanjurmarg and nearby surrounding area
16	Bhandup Village	Bhandup Pumping Centre
17	Bhandup Pumping Centre	Bhandup region
18	Mitha Nagar	Mulund and Navaghar Area
19	Mulund toll Naka	Mulund region
20	Dhyan Sadhana College	Thane East, Colleges, Malls , integrated with proposed Thane MRTS at Naupada Station
21	Louis Wadi	Louis Wadi, Integrated with Naupada Station
22	Nirmala Devi	Nirmala nagar, Anand Nagar other near by areas
23	Shivaji nagar/Nitin Co.	Nitin company and its surroundings
24	Cadbury Junction	Cadbury industry, Pokharan, Raymonds Industry etc

Fig. 9.7 Shows the location of BRTS stops on WEH and EEH respectively and a strip plan showing the number of proposed bus stops for both the corridors is shown in **Drawing No.2008069/RH/SP/001 & 002**.

Design concept

Features

Location - staggered

Length 30 meters (extension to 105 m length)

Width 3.0 meters

Ramp: 1 in 15

At Bus stops, additional passing bus lane is proposed which requires more lateral space. As BRTS is proposed at the center of the road, it will eat extra lane from main carriageway at Bus Stop location. Therefore, it is suggested to provide staggered bus stop. **Drawing No. 2008069/RH/BS- 001** shows the typical arrangement of Staggered Bus Stop.

At bus stops, taper of 1:15 is proposed in the median. Total length of bus shelter is proposed as 110 m for horizon year. Out of 110 m , 30 m bus shelter will be constructed for accommodating two 12 m long BRT buses and 80 m will be landscaped and will be constructed in future as per requirement. Thus modular arrangement is proposed in the design of Bus Stop. Bus stops are staggered by 90 m length of 3.0 m staircase & escalator can be fitted so that both shelters can be accessed from equidistant.

9.13.2 Bus Stations

The Bus Station Area planning; the architectural works are designed to comply with the relevant Laws and Regulations of the Government of Maharashtra and laws of Greater Mumbai Municipal Corporation.

The architecture of the stations presents an image to the general public and is designed to encourage commuters to use the system.
The design of the station addresses the following basic issues.

- Traffic, Road and Pedestrian requirements.
- Utilities.
- Structural requirements
- Passenger forecasts and the resulting entrance location requirements.
- Interfaces with proposed and potential future development projects
- Buildability and disruption due to construction
- Flexibility in design to allow stations to respond to site specific requirements
- Future expansion

This section sets out the design criteria adopted in the planning and design of Stations in order to ensure consistency in layout, form and identity system-wide. It is also intended that there is a consistency in planning passenger circulation, operation and maintenance procedures throughout the system.

Station Layout & Modular Design

The layout of the stations is influenced by the road geometry; operational requirements, predicted passenger flows and electrical and mechanical requirements. It is shown in **Drawing No. 2008069/AR/BS- 001**

Plans have been developed in such a way it is passenger friendly accommodating facilities like ticket counter and information centre, ticket machines, stairs and escalators. Ticket machines are positioned to minimise cross flows of passengers and provide adequate circulation space.

Modular Design

Complete bus station development is developed through modular designing. Modular design is based on the length of bus and is flexible to have bus length of 12 m standard, 15 m axel, 18 m articulated, 25 m double articulated, 12 m double deck, 25 m double deck articulated.

Station Module is of 25m x 3m, accommodating facilities like ticket counter, information counter, passenger accommodating space / queue, ticket checking machine, landing space, kiosks and commercial advertisement space.

Structurally module is developed in stainless steel pipe material of grade 304 which gives open type of structure from light and ventilation point of view. Column is 100 mm dia stainless steel pipe and 50mm dia pipe acts as ribs/ beam for the support of roof. Roof is made of polycarbonate sheet and is rested on aluminum composite panel. Roof is of polycarbonate sheet which gives ample of natural light during day time.
75mm dia pipe railing is provided with 16 gauge stainless steel perforated sheet seating 2000 wide. In perforated sheet space is also provided for BRTS logo and remaining space can be exploited for commercial use.

Module provides public information through sign boards, route plate, route indicator panel, station entrance signs, bus indicator panels and other information panels.

Module is flexible for its commercial exploitation in terms of kiosks and advertisement. Aluminum composite panel with back lighting is used for advertisement.

Complete development of bus station is of 105m x3m, which comprises of three module with space of 15m in between.

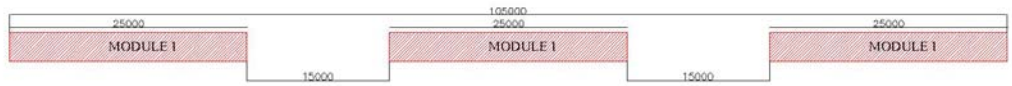


Fig. 9.8: Complete Development of Bus Station

Landing space Design

Finished Floor to underside ceiling of Station is minimum 3750 mm. A floor finishes zone of 100 mm is provided. The floor finish contains all necessary floor cable trucking for the provision of Ticket machines.

Within the concourse area provisions are made for free standing (Automatic Teller Machines (ATMs), vending machines, photo booths , fire standing and/or wall mounted advertising panels.

Entrances

Station entrances provide the link between the station concourse and the surrounding street .Entrance at Street Level is easily identifiable. The position of entrances have been determined by the bus stop lane and passing bus length, space availability and flow directions of passenger traffic. The materials used within stations are hard wearing and maintenance free. Floor finishes are laid to adequate falls in order to allow for the occurrence of any seepage, rainwater (from foot traffic), washing water, etc. Drainage provisions, including sumps and pumping facilities are included.

Escalator, Stair and Lift Design Standards

Stair design

Stairs are provided for both upward and downward movement. The rise of steps is limited to 150 mm while tread is 300 mm minimum.

The width of the staircase is 2000 mm and both side handrails are provided on the stairs.
The combined capacity of stairs and escalators is capable of satisfying the emergency evacuation requirements or normal passenger handling requirements, whichever are the greater. It is shown in **Drawing No. 2008069/AR/BS- 002**

Stairs

These standards refer to all stairways used by the public. All staircases comply with local regulations. All treads, nosings and intermediate landings have non slip surfaces. All stairs are provided with handrails on both sides. The width of a staircase is measured from the finished surfaces of the inside faces of the balustrades. No open risers are proposed.

Escalators

All escalators are of the heavy-duty reversible type and conform to the approved standard. Suitable railing has been provided around the gaps between escalators or between the escalators.

Advertising will be an important source of revenue for the BRTS but the extent of the demand for advertising will depend on market forces. Potential sites for advertising within a station are located so as not to conflict with the principal requirement of the provision of signage to direct passengers, especially in an emergency.

There are advertising media that are to be used both within and outside the station which include:-

- Dimensional Advertising
  3D Media - large models of products or company logos
  Display Cabinets - for company products

- Dimensional Electronic Advertising
  Light Emitting Diode - Newscaster, information services
  Neon Sign - Company Logo / Product information

- Audio Advertising

Radio style advertising, pre-recorded and played over station / train intercom.

- Mechanical Advertising
  Collapsible Billboards
- Retractable Screen
- Flipsides - Billboard with 3 times space, routes when required to reveal different adverts.
- Q Boards - Successor to the flipside giving space for Many more advertisements.
  - Moving Image
  TV Monitors- used in either single units or in blocks of Screens
  Holograms
  Lasers
  Truemation

- Dimensional
  Directly applied - advertisements directly painted onto Surfaces.
  Superlites - back-lit advertisements
  Projection - still image directly projected onto screens or

Walls
Billboards / Posters -conventional media

A combination of many of the above means of advertising is proposed to be adopted at stations. All these media are integrated into the station design and not treated as an add on element. All wiring and fixings are concealed. Provisions are made for cast in conduit and fixings for advertising media at identified sites whether or not the media is installed at the opening of the railway. Attention is paid to ensuring maintenance access to these zones.

Commercial Areas within the Stations

Passenger information signs located at stations are sufficient in number and varied ranging from station entrance signs to bus indicator panels and information panels.

Signs are provided in three language format. All signage hardware is of a consistent size and proportions. Location of clock and public information system are clearly identified. All stations are provided with public telephones.

Refuse bins are located throughout the station and approaches for disposal of small items of rubbish. The size of the bins is restricted to minimise the fire risk.

9.14 Provisions for Fare Collection

Ticket vending in concourse of a station consists of ticket issuing machines. Machine type is a Passenger-Operated Machine (POM) which is located in station accessible to entering passenger.

Ticket counter and Enquiry counter

Ticket & enquiry offices are located in the landing space. Care has been taken to ensure that queuing areas associated with this facility does not obstruct normal passenger flow.
Speech transfer facilities will be required in the windows and induction loops.

Station Store Room

Room to store materials, some of which may be flammable or toxic, mops, brooms, dusters and other cleaning tools. Space for powered cleaning machines is provided. Mops, dusters etc. is of size 10 s.qm at an appropriate location and with appropriate ventilation system.

The store is with automatic smoke / heat detection and Sprinkler systems plus portable fire extinguishers.

Electrical / Power Room

To house main electrical panel, distribution boards, switchgears, Generator, UPS and batteries an Electrical / Power room, for a size as required depending on equipment requirement, is provided.

The room is provided with automatic heat detection plus portable fire extinguishers and a provision is made for airconditioning.

Commercial Outlets and Kiosks

Commercial outlets and kiosks are provided in designated areas. They are located within the station complex in such a manner that there is no interference with passenger flow. Their location is subject to approval from relevant authorities and they may be limited in size and the amount and type of goods for sale in that these may be a fire or safety risk affecting either the safety of passengers or operation of the BRTS

Foot Over Bridges/Subways

Foot Over Bridges (FOBs) have been provided at every Bus Stops as cross over facility. Subways may be provided at some locations depending upon the less hindrance in construction because of underground utilities. In present case, only FOBs are considered in the estimate.

Skywalks

Skywalks are proposed for connecting Proposed BRTS Bus stops with Feeder Bus Services, proposed MRTS stations and existing suburban stations. Location of skywalks and length are given ion **Table 9.5 & 9.6**. Skywalks may be of steel structure or RCC structure. MMRDA has a policy of providing steel skywalks, same are considered and unit rate of steel skywalks are considered.

Table 9.5 List of Proposed Skywalks on WEH

Skywalks	Length (m)
From Kherwadi to Bandra Terminal	795
From Kherwadi to Kherawadi Road (feeder Bus)	257
From Hyatt Hotel Road to C.G. School BRTS Stop	700
From Agripada to Vakola University Road	1000
From Agripada to Santacruz Station	1500
From Centuar Bus Stop to Airport	1500

Skywalks	Length (m)
From Cetuar Bust Stop to Airport Junction for Feeder Buses	500
From Gundavali to Andheri Station	1535
From Gundavali to WEH Station of Metro	685
From Hanuman Road to Sahar Road	1100
From Ismail Yusuf College to Jogeshwari Station	1000
From Omkareshwar Mandir to Borivali Station	1000

Table 9.6 List of Proposed Skywalks on EEH

Skywalks	Length (m)
From Postal Colony to Amar Mahal Flyover	650
From Dhyan Sadhana to Naupada MRTS Station	620
From Louis Wadi to Naupada MRTS Station	400

9.14.1 Bus Terminals

The bus terminals are the contact points between the customers and the Bus Rapid Transit System (BRTS). The terminals create an impression, amongst public transport users nearly as significant as its vehicles and quality of services. Hence, the need to provide best of the services at bus terminals.

Functions of Bus Terminals

Bus terminals perform mainly the following functions, which need to be considered, for their design and settings along with other characteristics:

- Provide a facility for stoppage of buses to facilitate fast, safe and convenient boarding and alighting of passengers including the persons with disabilities.
- Provide passenger information regarding ‘arrivals’ and preparation of services,
- Provide seamless integration of trips by facilitating easy transfer/ interchange amongst passengers traveling by various modes, perhaps involving trunk and feeder services as well as amongst trunk services themselves.
- Provide facilities for sale of tickets/verification of fare payments,
- Provide sheltered space along with basic conveniences for waiting passengers
- Facilitate change of mode of journey by providing adequate parking spaces for cars, two wheelers, IPTs and other PTS vehicles.

- Act as information centers for passengers, tourists, and first time visitors to the city, through supply of route maps, travel guides, hotels, etc
- Act as a catalyst for planning high density land use – being points of easy accessibility for large number of passengers thereby becoming favorable locations for residential colonies, offices, shopping complexes etc of high commercial value.
- Other aspects relating to their functioning are:
- Places for accumulation of trips from different origins and destinations
- Places for crew change/restrooms and management
- Points of physical integration with other modes
- Sources of revenue earning through commercial exploitation of their structures and other spaces,
- Act as multi-use, multi-activity complexes

Bus Terminal Planning

The success of an efficient planning process for above elements is reflected by the extent of compatibility of the basic infrastructure and the facilities for efficiently and optimally serving the user. In planning, ***Infrastructure*** is the trunk and the point where it directly comes face to face with the public is the ***Facility.***

The plans are accordingly conceptualized for *creating harmony between the infrastructure, the facility and The User.*

Bus Terminals which facilitate seamless interchange of passengers amongst various transport modes including the BRTS handle much larger volumes of commuters and variety of personal and pubic transport vehicles. The integrated BRTs terminal Concept Plan is shown in **Drawing No. 2008069/RH/BT/- 001** The terminals facilitate efficient integration of walk trips with the multi modal public and personal transport systems' trips; provide for vehicle circulation and parking facilities besides their minor repairs and fuelling; facilitate crew interchange; and provide all other facilities afforded by the bus stations and bus stops. The terminals also provide for enough spaces for their commercial exploitation to, at least, part finance their financial needs. Their planning is hence proposed for minimization of conflict between the pedestrian movements and the vehicular movements. The large volumes of passengers and vehicles at the bus terminals need a variety of public amenities and facilities like:

- Passenger platforms to board and alight,
- Waiting lounges
- Basic shopping and commercial facilities
- Utilities, services and amenities
- Audio video passenger Information systems
- Ticketing facilities, enquiry booths etc

- Restaurants and snack bars, tea stalls and soft drink kiosks,
- Parking spaces for Idle buses, IPT vehicles etc
- Parking spaces for vehicles of ‘park and ride’ passengers
- Bus cleaning, washing, and repairing facilities,
- Office and other commercial complexes
- Crew rest and change rooms,
- Citywide bus route maps and guide maps
- Night parking and garaging facilities for bus fleet of the BRTS to facilitate early morning trips without any dead mileage
- The terminals at the end of BRTS corridors serve as destination ends

Constraints and potentials in planning of terminals are:

Constraints

- ✓ Availability of required land space in the city center which serves as destination/interchange hub for commuters from different directions of the BRTS corridors, the feeder services and commercial areas within short distances and easy accessibility,
- ✓ Conflicts between the users and the systems.

Potentials

- ✓ Availability of ample land in the outskirts (at the end of the BRTS corridors) Affording opportunities for development of such places as bus depot cum terminals

  Therefore the entire design process is worked around, weaving constraints and potentials and the common concept is planned to be achieved by:

  - ❖ Minimizing conflicts between the pedestrian movements and vehicular traffic flows
  - ❖ Providing accessible community spaces, shopping areas, and basic public amenities.
  - ❖ Creating user-friendly BRTS by direction oriented color coding of buses for ease of identification of desired buses,
  - ❖ Creating separate vehicle circulation loops for different corridors to minimize conflicts between the vehicular movements.
  - ❖ Creating central zone for public facilities and conflict free commuter circulation facilitating fast and easy accessibility to four quadrants of the terminals.

Location of BRTS Bus Terminal

To facilitate seamless transfer of passengers from different modes and effective integration of various public transport modes, five bus terminals are planned, for the BRT operations.

Apart from Central terminal, Nodal terminals have been proposed at the end of each corridor. The probable locations for Nodal Terminals have been identified, keeping in view the land availability and bus operations. These locations have been discussed below based on the respective corridors. **Fig.9.9** shows key map indicating location of BRTS terminal at BKC.

On Western Express Highway

Bandra Kurla Complex and Dahisar Bus Depot are two end terminals are proposed on Western Express Highway. Intermediate terminals are proposed at Andheri.

Bandra Kurla Complex is hub of commercial activities. Moreover, Mankhurd-Bandra Metro has proposed MRTS station and depot at BKC. It is suggested to locate BRT Bus Terminal at BKC. In BKC area, presently vacant land is available and there are number of locations in this area. Photographs of some of these locations are shown below However, one of these locations will be finalized in consultation with MMRDA.

Location of BRTS Terminal at BKC

Near Ambani School

Near American Consulate

Vacant Area in BKC for Proposed BRTS Terminal

Vacant Area in BKC for Proposed BRTS Terminal

At another end of corridor, Dahisar Bus Depot location is idle place for BRTS Terminal. Both the depots can be well integrated at this place.

Existing Bus Depot at Dahisar

Vacant area in front of Dahisar Bus Depot

On Eastern Express Highway

BRTS Bus Depot/Terminal on Eastern Express Highway is proposed at following locations.

BKC is the place for locating BRTS Terminal. BRTS on EEH will follow proposed elevated Sion -BKC road for reaching BKC Terminal.

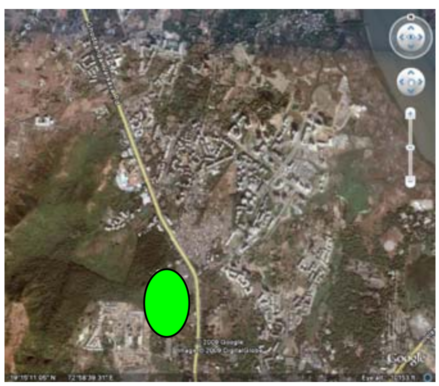
Vacant area in Evarard Nagar may be used for BRTS Bus Depot on EEH if Sion-BKC elevated road is not constructed.

Ghatkopar Depot is also available and near to Eastern Express Highway. This is most idle place for depot as VAG MRTS depot and existing BETS Bus Depot can be integrated for passenger transfer to either systems.

Depot at end point is proposed at **Cadbury junction** Vacant Land is available in J.K. Chemicals industry which may be used for Bus Terminal. Cadbury MRTS Station is proposed for Thane MRTS which may be integrated with this depot. As this is private land, it may be taken on lease or purchased.

Location of Bus Terminal near Cadbury Junction

In case land at Cadbury junction is not available, depot can be located near Patli pada



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Location of Bus Terminal near Patlipada(Hiranandani Estate)

9.15 Existing Utilities

Utilities on ground are surveyed for complete length of corridor. Underground utilities will be collected from MCGM.

9.16 Electrical System & Street Lighting

Both the corridors are already provided with well illuminated lighting system. However, after reconnaissance survey, Western Express Highway is highly illuminated as compared to Eastern Express Highway. Location of lamp posts is picked up in the topographic survey.

9.16.1 Existing Lighting System

Site survey is carried out for existing lighting system on both the corridors. Following observations are made.

1) All poles are galvanized octagonal type of 10 m height with lighting fixtures suitable for 250 W HPSV lamps and are arranged with 30 m spacing.

2) At Eastern Express Highway all lighting fixtures are of GE make.

9.16.2 Proposed Electrical System

Street Lighting

Presently major arterials in all metro are being upgraded to 50 to 55 Lux. As Mumbai is one of the metro, and WEH and EEH are two main corridors, it is suggested to increase the illumination of these corridors. There are two options to increase the illumination of road up to 50 Lux.

Option 1- If existing luminaries is suitable for 400 W, required illumination level of 50 lux may be achieved by replacing the lamp/fixture provided other parameters shall be as per relevant codes.

Option 2 -In order to achieve required illumination level arrangement / spacing of poles will have to be changed.

All these can be finalized after detailed survey of existing lighting system.

Bus Stop

Weather proof lighting will be provided to each bus stop. At each bus stop 8 no. of escalators will be provided. Each escalator has been assumed of 10 KW load. Supply to each escalator will be provided through armoured XLPE aluminium cable.

Sr No.	Highway	No. of Escalators	Total Load (KW)
1	Eastern Express Highway	80	800
2	Western Express Highway	144	1440
TOTAL		**224**	**2240**

Bus Depot

Each bus depot will be provided with high mast to illuminate the area. Load for that is assumed 5 KW.G.I. Pipe earthing will be provided for street lighting, escalators and required substation.

To cater the load of escalators substation will be provided at suitable location.

Requirement of Sub station

a) One no. of 1250 KVA Compact Sub Station for Eastern Express Highway.

b) One no. of 2000 KVA Compact Sub Station for Western Express Highway.

c) Existing feeder pillars will be used to supply the streetlights in case of poles will be rearranged.

9.17 Landscaping

Proper landscaping provisions is being considered while designing the BRTS Corridor to fit in with the surroundings for pleasing appearance, reducing headlight glare and adverse environmental effects such as air pollution, noise pollution and visual intrusion.

Planting of shrubs, hedges is proposed in the existing median as well as propose median. Total BRTS platform area for the horizon year will be about 105 m out of which 30 will be constructed in Phase I. Remaining 75 m area may be landscaped.

9.18 Road Furniture

Traffic signs, signals, railing are some of the road furniture items which are proposed along BRTS Corridor.

Traffic Signs

Information sign boards, cautionary and mandatory sign boards are proposed on BRTS Corridor. In addition, traffic blinkers are proposed wherever bus turnouts are provided. At Bus Turnouts, though weaving length of 150 m is proposed, it is advisable to install overhead traffic signal. Typical arrangement of traffic signage is shown in **Drawing No.2008069/RH/TS- 001**. Glove studs are proposed at 5 m interval along BRTS Corridor.

Railing

Railing is proposed for a complete length of Bus Stop at footpath and for Bus lane to force the passengers to use staircase or escalators for entering in to BRTS Bus Stops.

9.19 Block Cost - Engineering

Block cost estimate is worked out for proposed BRTS on both the corridors separately. Following items are considered for block cost.

1 Construction of Rigid Pavement for Bus Lane
2 Construction of Overlay on Main Carriageway
3 Bus Stop Constructions
4 Bus Shelter
5 Road Furniture
5 Foot Over Bridge
6 Skywalks
7 Electrical
8 Miscellaneous Items like traffic management, ancillary facilities environmental etc.

Unit Rates

MMRDA is implementing Jogeshwari-Vikhroli Link Road under MUTP. For the most of the items, quoted rates of contactor are considered for estimate purpose. Rates of escalator, traffic devices etc are considered from market enquiry. Rates of skywalks and FOB are enquired from MMRDA. Unit rate of Bus Stop is taken from BEST.

Block cost of proposed BRTS for Western Express highway is Rs. 3600 Millions and given in **Table 9.7.**

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Block cost of proposed BRTS for Eastern Express Highway is Rs.1700 Millions and given in **Table 9.8**.

It is observed that major cost of work is because of proposed skywalks and escalators. It is suggested that 50 % cost of skywalks and escalators should be taken in economic evaluation because some of the skywalks may construct under MUIP program. The construction activities are expected to take 3 years, with 30% of the cost incurred in 2010-11, 40% in 2011-12 and remaining 30% in 2012-13. Both the BRT corridors of the WEH and EEH (52 km) will be operational from mid of 2013-14.

Chapter 10.0
APPLICATION OF ITS

10.0 INTRODUCTION

Intelligent Transport Systems (ITS) help transit agencies increase safety, operational efficiency and quality of service. Advanced technologies are used to collect process and disseminate real time data from vehicles and the roadway sensors. The data is transmitted through a dedicated communication network to a central processing system where the data is transformed into useful information for the operator, the driver, and the commuter.

In this chapter, ITS technologies for vehicle tracking; passenger information - on-board and off-board; traffic signal prioritizing etc. are discussed for use in BRT for Mumbai.

10.1 Roadway Application Design

10.1.1 Traffic Signal Prioritization

The BRT corridors are proposed to be signal free in due course of time. Till such time however, the GPS based traffic signal prioritization system is proposed to be utilized for signal prioritizing for the BRT buses. On identification of the bus arrival at a certain location, the signal controlling device either extends the 'green' or shifts the 'red' to green to enable a faster pass to the BRT vehicle.

10.1.2 Vehicle Guidance System/ Docking

For no gap no-step boarding /alighting of passengers, using raised station platforms and flip-down type of ramps at the gates, a simple vehicle guidance system is recommended. Although high cost high technology mechanical, electronic and optical systems are available, a low cost, manual, optical system is recommended keeping in view lower level of lateral aligning accuracy required for the flip-down ramps equipped vehicles. In this system, the driver focuses on a visual (optical) target marked on the road. Drivers focus on the visual target shall be enhanced by providing a magnified video screen fed by a small camera mounted under the vehicle. This system in conjunction with ramped entry would provide a cost effective lateral alignment of vehicles at the bus station, for ease of boarding & alighting.

10.2 Bus Application Design

10.2.1 Passenger Information System - On-board

In operations Management, information to Passengers about services becomes very crucial as such information improves quality of services and brings satisfaction to customers.

A Passenger on-board the bus and while awaiting for a bus on a bus stop, needs to know the bus route & destination to enable him to board the right bus and while on the bus, he needs to know about the next stop, the next change over connection, etc. for convenience of alighting.

Pre-recorded micro-processor based audio-video information about route details, stop details, etc. shall be disseminated to the commuters using electronic video display system mounted on the front, side & rear of the bus for external displays for information and guidance of commuters waiting at bus stands and the one mounted inside the bus for on-board commuters. The audio messaging devices - duly synchronized with visual displays - shall be mounted inside the bus and at the entry - exist gates. The messages about the route, next stop, driver/conductor identity, etc. shall be displayed & changed by GPS based interventions / manual intervention by the designated bus crew. The messages shall be communicated alternatively in English and Marathi.

10.2.2 Vehicle Tracking and operations monitoring

10.2.2.1 Vehicle tracking

An automatic vehicle tracking system for monitoring and control of vehicle location, schedule & operation, delays, speeds, incidents etc is contemplated for BRT. The system could use either G P S based or R F I D technology. GPS based technology having wide range of applications is preferred for BRT. RFID based technology is however more cost effective of the two systems.

In the vehicle tracking system, GPS based vehicle mounted units continuously identify its location and communicate the same, through the dedicated communication lines, to the central control room, where not only vehicle movement is displayed on a monitor but report about vehicle delays etc., is also brought out by exception for necessary corrective action. The information so generated could further be used for future planning and scheduling operation.

10.2.2.2 Operations monitoring, ITS, PIS and AFC

Intelligent Transport Systems (ITS), Passenger Information system (PIS), Travel Ticket Issue and Verification (TTIV) as also Bus Operations Monitoring and control (BOM) systems are highly inter-related and inter dependent. The operation of the PIS, TTIV and the BOM systems is generally ITS based.

It is important to improve the patronage of Mumbai BRTS services not only by retaining the existing users but also by attracting the non-users by providing more comfortable, easily accessible and user friendly, highly efficient, reliable and safe services besides making them more attractive and giving the Mumbai BRTS a modernized look. Various ITS applications in bus operations could go a long way in achieving the said objectives, keeping in tune with the advancements of its operations.

Benefits of ITS applications in BRT operations interalia include:

- Improved bus safety, improved operational efficiency & system control.
- Improved quality of service.
- Improved system integration.
- Reduced need for voice communication.
- Improved transit service and visibility within the community
- Increased customer convenience.
- Enhanced compliance to Disabilities Act requirements.
- Less overcrowding in buses.
- Willingness to use the transit system.

10.2.2.3 Fare collection system

Mumbai BRT System is planned to handle a large number of passengers. Fare transaction is the most direct contact between the operating personnel and the commuter. Issue of tickets and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system has to be simple, easy to adopt/operate and maintain, easy on accounting system, capable of issuing single/multiple journey tickets, amenable for quick fare changes and should involve as little manpower as possible.

On reviewing various technology options for fare collection such as coin/token systems, paper systems, magnetic strip technology and the smart card technology. Hand held Electronic Fare Collection Machines are proposed for on board user tariff collection.

The proposed fare collection system primarily consists of:

a) On-Board hand held Electronic Ticket Vending and Verification Machines
b) Additional Ticket Issue Counters in the catchment areas of the corridors

Automated Ticket Vending Machines at bus terminals and or at high traffic density bus stations with appropriate security provisions and access controls.

All the above systems and their units are highly technical in their design, operations and maintenance and completely different from bus technology. Skills and technical expertise for such systems is neither expected to be available with Mumbai BRTS nor desirable to acquire the field of required specialization being vast, varied and basic domain knowledge based. It may also not be economically viable to acquire all the gadgets and tools for their maintenance. However adequate exposure of BRTS staff to these areas is essential to enable them to understand, appreciate and facilitate efficient use of such systems by their active participation.

The entire system is proposed to be outsourced as a composite facility for design, system configuration and specifications finalization; sub systems development and their integration; procurement and try out; installation, commissioning, operations and maintenance besides any other related tasks for efficient functioning of the system and its sub systems.

Any other system of out sourcing would require subsequent integration of all the sub systems to operate as a composite unit. Such segregation may though appear to be more suitable for sub system ownership, responsibility fixing and their security; it lacks system knowledge, expertise and functional responsibility for the system as a whole. It may hence be advisable to outsource the system as one composite unit for all the activities.

"On board" fare collection system using ETVMs

The proposed 'On board' fare collection system envisages a hand held Electronic Ticketing and verification machine for issue and verification of tickets by the conductor. Every conductor, after completing his spell of duty for the day, hands over not only cash realized during his spell of duty but also "Data" stored in the ticket-issuing machine. The Fare collection agency shall deposits the cash in the bank and the data (way bills etc) collected from Ticket issuing machines shall be downloaded into the central control room server for further analysis. This data, which includes denomination wise ticket sales, number of passengers, load factor at each stage of the route etc are, stored in the computer, for further analysis. Based on this data, Management Information System (MIS) section of BRT would prepare Route wise analysis - a basic document for constant monitoring and future planning of operations.

This data will be of great help for route/trip restructuring, route analysis, introduction/ curtailment of routes/trips etc; hence the need for proper storage and retrieval of this "data base" and its management becomes crucial.

"Off Board" Fare Collection System

The Fare collection system selected for BRT operations would be "on board" system. However, at the Terminals where a large number of passengers arrive / depart regularly, the "off board" fare collection system is proposed to be adopted progressively. This system would not only reduce the load of on board ticketing but would also reduce station dwell time by faster boarding of partly ticketed passengers. Adequate number of turn stills are proposed at the bus terminals—maximum being at the BKC terminal – the high intensity interchange hub of both the BRT routes and other transport modes.

10.3 Bus Station Application Design

10.3.1 Passenger Information System

On receipt of on line information about arrival of a particular route bus at a bus station the CPU processes the data using the dedicated software and communicates the probable time of arrival of that bus to the following bus stations. The process repeats for all the buses operating on different routes. The data so received may also be displayed on board the bus, on the electronic display board, for the information of passengers. In the intervening periods revenue generating commercial messages are planned to be displayed on these boards.

Route wise bus schedules of the first and the last bus along with its frequency of operation will be flashed periodically on the electronic display boards at the bus stations.

The dedicated communication system provided at the bus stations would also be utilized for alerting the intersection signal controller for providing priority pass to the approaching BRTS buses.

10.3.2 Other Information Systems (Signage, Time Tables, Posters, etc.)

Relevant signs are proposed to be displayed at the bus stops and the bus stations. Posters and commercial advertisements would be displayed as hard copies on the panels of the bus stops/stations. Station/stop information is planned to be prominently displayed at suitable locations all along the routes. Route maps and operation time tables route-wise would be displayed at the bus terminals. On the bus stations, as discussed above, next bus arrival time, route operation schedules etc., would be displayed on the electronic display boards. Availability of facilities for persons with disabilities would also be appropriately displayed at the bus stops/stations and the terminals.

10.4 Web based passenger information

A web site of the total BRTS operations etc would be hosted where all information about routes, time table, fares, type of services, connecting routes and their operational timings etc would be provided.

10.5 System Integration

As discussed in other chapters, the BRTS would be a lean organization mainly performing the task of planning; setting standards for service quality and other performance/operational areas; collection, compilation and processing of operational data for day to day monitoring of service quality and for future planning; out sourcing of services and monitoring their performance; revenue collection and disbursement amongst the service providers besides MIS reporting on exceptional basis and ensuring integration with-in the BRTS' service providers as also amongst other operators/stakeholders.

The ITS duly supported by dedicated communication system, well equipped hardware and relevant software is designed to be the main tool for efficient performance of the said tasks in an integrated manner. On-line tracking of vehicles is automatically integrated through system software to operational performance of buses and their payments after offsetting penalties for deficiencies in service quality simultaneously providing requisite passenger information/commercial advertisements at the bus stations through the dedicated communication lines and the electronic display boards.

For the purpose of collection, processing and dissemination of the entire data, a central control room, duly equipped with necessary tools, equipments, software, etc. and manned by adequately skilled manpower, shall be established.

10.6 Central Control Room

For the purpose of collection, processing and dissemination of the entire data, a central control room, duly equipped with necessary tools, equipments, hardware, software, etc. and manned by adequately skilled manpower, shall be established

10.7 Cost Estimates and Revenue Generations

10.7.1 System components

Estimation of cost of acquisition of ITS, the following main sub systems / components of the ITS infrastructure are considered:

- Vehicle Mounted Units (VMUs) such as GPS, GPRS, modems, etc
- On board microprocessor based electronic (audio/video) route destination display system for commuters "on board" and "off board" the bus including for persons with disabilities (PWDs)--- visually / hearing challenged.
- Electronic (LED/LCD type) PIS boards on the bus and on the bus stops / stations / terminals and for commercials on board
- Electronic Ticketing and Verification Machines (ETVMs) "on and off board" with GPS, GPRS, CDMA, ZigBee compatibility
- Travel Ticket Verification machine and commuter access control system mainly at bus terminals and the bus stations with adequate access control and security provisions
- Control rooms and their equipments, hardware and soft ware etc
- Travel Ticket / Pass issue centers along the BRTS catchment areas
- Communications and other miscellaneous systems / equipments / facilities
- Security systems for the above particularly in view of the location and spread of the sub-systems

10.7.2 Cost Estimates

Sub system wise /component wise costs have been taken from the respective manufacturers directly or indirectly. These rates are considered for making cost estimates given in Table10.1

Table 10.1 - Cost Estimate for ITS Operations - WEH & EEH Corridors of BRTS

Item No.	Description of Item	Unit	Quantity	Rate (Rs.) in lakhs	Amount (Rs.) in lakhs
A	**Passenger Information System**				
1	Display Boards, mounting structures, electrical accessories, data acquisition and communication network complete with installation and commissioning for Bus Stations on	sets	100	2.50	250
2	As above for 6 bus terminals @ 10 sets per terminal on an average	sets	60	2.50	150
3	Total for passenger information system	sets	160	2.50	400
B	**Ticket Issue and Verification - off board at terminals**				
1	Fare collection/Ticket verification equipment at 6 terminals complete	Set	15 sets	30	450

Item No.	Description of Item	Unit	Quantity	Rate (Rs.) in lakhs	Amount (Rs.) in lakhs
	with ticket verification, turn stills, barriers and controller software including installation and commissioning (@ 1 set each for 5 terminals and 10 sets for I terminal at BKC)				
C	**Vehicle tracking, signal prioritization, bill payment system etc**				
1	**GPS and other vehicle mounted units for Vehicle tracking complete with all accessories**	sets	**564**	**1.50**	**846**
a)	Dedicated data communication land line with accessories upto central control rooms or any other communication system etc.				
	Route length (km) (up)	kms	50	0.25	12.5
	Route length (km) down	kms	50	0.25	12.5
	6 terminals and misc.	kms	50	0.25	12.5
	Total (km)	kms	130	0.25	37.5
b)	Control room server and other hardware (5 sets per route per direction for 2 routes)	set	20	1.00	10.00
c)	Required software for: (i)vehicle tracking, (ii)PIS, (iii) MIS (iv) other applications	sets	10	3.00	30.00
d)	For vehicle-wise data ware housing, processing and exceptional reporting	sets	2	3.00	6.00
e)	Bill payment for hired vehicles		2	3.00	6.00
f)	Misc. expenses on other items, devices, system software, installation and commissioning @ 5% of above	sets			46.80
	Sub Total of 1				982.30
2	**System for signal prioritization - lump sum** for 15 intersections for Signal Controller Software, for signal prioritization, Misc. hardware, etc		15	2.00	30.00
3	**Bill payment for hired vehicles--** Hardware (lump sum)				5.00
4	**Contingencies @ 10% of 1 to 3**				107.70
	Total Cost (Rs. in lacs)sum of 1 to 4				1119.00
	Total for ITS (A+B+C) Rs. In Lakhs				**1969.00**

The cost for ITS operations is assessed as Rs 19.69 crores.

10.7.3 Revenue generation

The ITS systems, sub systems and the infrastructure constitute a potential source of revenue generation for the BRTS through advertisements. The revenue generation from advertisements, which will be displayed on the screens of Passenger Information System etc is estimated on block assessment basis. The revenue potential is assessed as 2% of the fare box revenue. The revenue which will be generated from this has been included in the overall revenue generation from advertisements.

Chapter 11.0
TRAFFIC MANAGEMENT

11.0 TRAFFIC MANAGEMENT

11.1 BRTS Corridors - WEH & EEH

It is proposed to construct the BRTS at the middle of the WEH and EEH. The BRTS runway will pass through existing Flyovers. There are 21 intersections, 14 flyovers and 35 bus stops located along WEH corridor. Except Kherwadi junction all other road crossing / joining are grade separated with flyovers. The implementation of BRTS at the median side will not disturb the cross- road traffic movement. The WEH main carriageway has an average 1.5 meters median width and minimum 2 lane service roads on either side. The right of way available from Bandra to Santa Cruz is 76.2 meters and balance stretch up to Dahisar is 61 meters. There are 5 vehicular under passes, 3 pedestrian under passes and 2 Foot Over Bridges. The Sky walk provided at Kala nagar is about 1 kilometer length.

The right of way available on EEH is 61 meters. There are 15 intersections, 10 flyovers and 17 bus stops located along this corridor. Except three inter sections, all others are having flyovers. There are about 5 numbers of Foot Over Bridges (FOB) and 5 numbers of pedestrian subways.

During re-engineering of BRTS bus lanes, construction of bus stops, and Bus Terminals the existing traffic some times need to be diverted from the existing road so as to carry out the work with out much delay to through traffic flow till the work is over at that particular stretch of the road.

As of now there are four link roads which connects both the WEH & EEH, namely Santacruz Chembur Link Road (SCLR), Andheri Ghatkopar Link Road (AGLR), Jogeshwari Vikhroli Link Road (JVLR) and Goregaon Mulund Link Road (GMLR). There is one road running parallel to WEH, (S.V.Road (Swami Vivekanada Road) which covers to the maximum extent), and another road running parallel to EEH (Lal Bahadur Shastri Marg).

11.2 Importance of Traffic Management

Traffic-Transit operation is an essential component of the planning, design and operation of BRTS. A good traffic management program should help in ensuring safe vehicle and pedestrian crossings of bus lanes and bus ways and minimize delays to BRT vehicles and general traffic. A reasonable allocation of street space among competing uses- BRT, other buses, and kerb side access for general traffic and pedestrians. The assessment of the new BRT system on mixed traffic will play an important role in the design process. A clear idea of the specific traffic impacts of the project to be developed for informing the road users and any adverse traffic impacts mitigated ahead of time. The motorists, taxi operators, and others currently using Western Express Highway (WEH) and Eastern Express Highway (EEH) have to reassure that the development of the BRT system will not lead to deteriorating traffic conditions.

Most of the time, adverse mixed traffic impacts of new BRT systems are concentrated at either the bus stop / terminal area, where more road space is needed for the BRT system, or at intersections, where the reduction of road space available to mixed traffic have the most significant adverse impact on mixed traffic speeds.

11.3 Traffic Management Measures

There will be a wide range of temporary traffic management measures required to facilitate BRTS construction and implementation works. These will include:

- Pedestrians - narrowing or temporary closure of footways and footpaths with signed diversions;
- Buses - diversion of bus routes; suspension and relocation of bus stops and stands;
- Taxis - relocation of pick up points;

11.3.1 Traffic

- Road closures with signed diversions;
- Lane closures;
- Introduction of one-way streets and banned turns;
- Changes to traffic signal timings;
- Temporary speed limits;
- Parking - Suspension and relocation and / or reallocation of parking bays;
- Tightening enforcement of restrictions on vendor activity

11.4 Planning of Traffic Management

Before the start of construction, Traffic Management Plans need to be prepared which will provide more details of the division of the project into contract areas, the likely construction programme and the general strategy for traffic management. Once contractors have been appointed, regular traffic liaison meetings will be arranged with highway authorities and the Police, BEST and other bus operators, taxi trade representative and other emergency services as appropriate. These meetings will provide an opportunity for contractors to present proposals for future works affecting the highway including methods of construction and proposed programme and for a review of the associated traffic management requirements.

The planning of the works will include consideration of the access and servicing requirements of affected residential and commercial premises. Access and servicing will be maintained as far as reasonably practicable, within the constraints of the works and the need to ensure the safety of the public, although this may involve diversions, temporary traffic controls and the use of temporary footways and roadways

The identified agency will require contractors to undertake regular communication with parties affected by the works. Local residents and businesses will be informed in advance of the dates and durations of closures and will be provided with details of diversion routes at least two weeks in advance or when final details are available.

Some traffic management proposals may require Traffic Regulation Orders to cover measures such as the introduction of one-way streets, banned turns, temporary speed limits and the suspension of parking places. These will be discussed at the liaison meetings and applications for these Orders will be made to the relevant traffic authority.

11.5 Proposed Traffic Diversions on WEH & EEH

11.5.1 The possible diversion of traffic for various sections of WEH are presented below:

In WEH stretch from Kalanagar to Vakola junction, the traffic can be diverted to the S.V. Road through Hakim Chowk Road No.7 and the diverted traffic can come over to WEH through LIC Colony, Azad Road and Nehru Road.

In between Andheri and Jogeshwari the traffic can be diverted through the N.S.Phadke Marg and it can enter the WEH from the station road Ismayil Yousuf College at Jogeshwari.

For the stretch from Jogeshwari to Aarey Junction the diversion can be made through the Ismayil Yousuf College and moving through the S.V.road it may enter the WEH from the Aarey milk colony road.

During the engineering work from Aarey to Dindoshi and Pathanwadi the traffic can approach through the Aarey road and again get back to the WEH through the GMLR also from the Chinchdwali road.

The stretch from Pathanwadi to Bhor Industries, the traffic can be diverted through the Dattatray road and Datta marg and again can join the WEH from the Akurli station Road.

From Bhor Industries towards MHADA colony the traffic can take the diversion from the Aakurli Road and again get into WEH from the Dattapada Road.

If the engineering work occurs on the stretch from MHADA colony to Borivali National Park the traffic may be diverted through the Dattapada road and get back to the corridor from the M.G.Road (Sukar Wadi).

Ahead of the Borivali National Park i.e. towards the Dahisar the traffic can get diverted through the M.G.Road (Sukar wadi) and passing through the S.V.Road and where the S.V.Road terminates it can merges with the WEH.

11.5.2 The possible diversion of traffic for various sections of EEH is presented below:

If the work progresses from Sion to Sumannagar the traffic can be diverted from the Central Labour Institute through the V.N.Purav marg (Sion Trombay Road) and can join the EEH.

From Sumannagar-Amarmahal-Chedda Nagar the traffic can get diverted through the S.G.Bave Marg and passing through MHADA colony and Shankarnagar and joins EEH.

During the engineering works from Chedda nagar to Ghatkopar (AGLR Jn) the traffic can move from the Mahatma Gandhi Marg and pass through to L.B.S.Marg and enters EEH through the Patil Marg, which is quite a lengthy route. Also the traffic can move from the Barristal Nath Road through M.G.Road and can reach the in between section of the EEH.

Further from Ghatkopar to Vikhroli the traffic may be get diverted from the Patil Marg and can approach the Godrej Food's factory marg and can enter on EEH.
In Vikhroli to Jogeshwari (JVLR) section the traffic can take the diversion from the Godrej Foods factory marg and pass through the L.B.S marg and can joins the JVLR from the JVLR link road.

In section from JVLR to Airoli the traffic may be diverted from the JVLR link road and proceeds further towards the Airoli over EEH through Veer Sawarkar marg.

Airoli towards Mulund section the diversion can occur from the GMLR Link road and approaches through the Jawahar Lal Nehru road and get in to EEH from the Navjeevan Road.
In the stretch from Mulund to Teenhaath naka the diversion can occur from the Navjeevan road through Gavanpada connecting ACC Road and approaches L.B.S.marg and joins EEH.

For final stretch from Teenhaath naka towards Thane the traffic can move through the Pokhran road passing through Vartak Nagar and finally joins on EEH.

11.6 Non-motorised Traffic

Where ever the BRT system narrows side-walks or increases mixed vehicle speeds, it can have a fairly adverse impact on non-motorised travel. If BRT system is implemented simultaneously with improved facilities for cycling and walking, the improved corridors may lead to significant modal shift from motorized trips to walking and cycling trips. This modal shift will help contribute to improved traffic speeds in the mixed traffic lanes.

All temporary traffic management will be implemented and maintained in accordance with relevant guidance and IRC codes.

11.7 Parking Facilities along the Project Corridor

Parking 2-whelers, Car,Taxi, Auto rickshaw, and Light commercial vehicles along the road side of WEH & EEH corridors were noticed during the on-street parking survey. On survey day the number vehicles parked along the road side is shown below:

WEH - Road stretch	Number of vehicles parked
Kalanagar - New Agripada	121
New Agripada - Goregon	43
Goregon - BHAD	145
BHAD - Dahisar	125

EEH - Road stretch	Number of vehicles parked
Sion - Suman nagar	52
Suman Nagar – Godrej junction	76
Godrej junction – Cadbury Junction	81

During construction of BRTS lanes, these on-street parking of vehicles, in the respective section of work in progress, are to be strictly prohibited through enforcement.

11.8 Proposed Parking Policy for MMR

In order to reduce congestion due to on-street parking and improve the traffic movement within the Greater Mumbai and Rest of the Region, Parking Policy for MMR has been prepared as part of Comprehensive Transportation Study (CTS). The Policy on supply of parking spaces includes:

- Private sector shall be encouraged to build and operate parking facilities to augment parking capacity in deficient zones. A standard and transparent procedure shall be adopted for selection of private enterprises.
- Effort shall be made to develop park and ride facilities at all public transport interchanges in the city.
- While imposing restriction to the movement of specific types of vehicles effort shall be made to provide adequate vehicle parking facilities at the terminal or interface points.
- Existing statutes shall be amended to make it mandatory for owners and operators of stage and contract carriers to park their vehicles in garages when the vehicles are not in use.
- Adequate parking spaces shall be reserved for Taxis in all public parking places

The Policy on enforcement and regulations includes;

- The local Police shall be responsible for enforcing parking regulations as notified by the Police Chief.
- Police department shall assign adequate number of Police personnel of appropriate rank for surveillance and enforcement of parking regulations in each zone. Each zone shall have a tow truck to facilitate eviction of offending vehicles.

The Policy on operation and maintenance includes;

- Concerned Local Authorities (Municipal Corporation or Municipal Council) shall be responsible for the efficient operation and maintenance of public parking facilities.
- Private sector should be encouraged to operate and maintain the public parking facilities on behalf of the Local Authorities.

11.9 Innovative Ways of Managing Parking Demand

The innovative parking management listed below, to be implemented where ever possible along the WEH & EEH.

1. Residential parking permit zones
2. Promote parking garages in residential areas
3. Controlled parking zones
4. Multi-storey parking facilities in highly commercial areas / CBDs

Residential parking permit zones are designed to reduce the impacts caused by students, customers, and employees who do not park in the spaces provided in the spaces provided in the nearby schools, businesses, or factories. This scheme forbids non-residents from parking in these areas during certain hours. The ULB will issue a window sticker to the residents to park the vehicles.

Promote parking garages in residential areas, by constructing multi-storied parking garages instead of residential building having the parking spaces. The parking garages can be either sold or leased.

Controlled parking zones (CPZ) help to manage the competing demands of different demands of different user groups in areas of acute parking pressure. CPZ are the way forward to relieve congestion on roads due to occupation of road space by vehicles parked for longer durations.

Multi-storey parking is usually granted by increasing the permissible FSI. This increased FSI is given for commercial development to landowner.

Parking spaces have to be selected so as to least impact the flow of traffic. Space should be allocated to allow easy and convenient access to sub-urban stations, major rail-terminals, major bus terminal etc.

Provision of sufficient spaces for Auto / Taxi stands and enforcement of the same is almost required as these modes usually wait for riders on the roads and create major obstruction to traffic.

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Chapter 12.0
PRELIMINARY ENVIRONMENTAL ISSUES

12.0 PRELIMINARY NVIORNMENTAL ISSUES

12.1 The project Proposal

MMRDA have proposed development of Bus Rapid Transit System (BRTS) along two corridors of 25 Km. length each. The corridors are:-

1. Along Western Express Highway (WEH) from Dahisar to Bandra.
   - Length: 25 Kms.
   - ROW: 61 to 76 m
   - Intersections: 21

2. Along Eastern Express Highway (EEH) from Cadbury junction in Thane to Sion.
   - Length: 25 Kms.
   - ROW: 61 m
   - Intersections: 12 major, 3 minor

The proposed BRTS will have significant ramifications on the various environmental components. Hence objective is to identify the issues which would have significant environmental impact due to the proposed BRTS system.

12.2 Existing Environmental Status:

Existing environmental condition of the study corridor was ascertained by collecting available data from the various sources.

12.2.1 Ambient Air Quality

Ambient air quality levels along the project corridors are as follows.

Location	Parameters		
	SO_2 ($\mu g/m^3$)	Nox ($\mu g/m^3$)	RSPM ($\mu g/m^3$)
Sion	2	57	215
Mulund	50	37	122

Source: MPCB

Note: SPM: Suspended Particulate Matter
RPM: Respirable Particulate Matter
NOx: Oxides of Nitrogen

SO_2: Sulphur Dioxide
CO: Carbon monoxide
HC: Hydrocarbon

The results reveal that RSPM Values at both monitoring stations are more than CPCB permissible limits (100 $\mu g/m^3$). The concentration of SO_2 and Nox were found within CPCB limits.

Table 12.1 - Ambient Air Quality Standards (CPCB)

Pollutant	Time Weighted Average	Industrial Areas	Residential Rural And Other Areas	Sensitive Areas
Sulphur Dioxide (SO_2) ($\mu g/m^3$)	Annual Average 24 hours	80 120	60 80	15 30
Oxides of Nitrogen (Nox) ($\mu g/m^3$)	Annual Average 24 hours	80 120	60 80	15 30
Suspended Particulate Matter (SPM) ($\mu g/m^3$)	Annual Average 24 hours	360 500	140 200	70 100
Respirable Particulate matter (RPM) ($\mu g/m^3$)	Annual Average 24 hours	120 150	60 100	50 75
Carbon Monoxide (CO) (mg/m^3)	8 hours 1 hour	5 10	2 4	1 2

12.2.2 Ambient Noise Levels

In order to assess the existing noise levels, baseline noise level data for the following locations was collected and presented below:

Table 12.2 - Ambient Noise Quality Stations

Sl. No.	Station	Dist. From C/L	Ht from Ground Level	Landuse
1.	Santacruz Airport	1.66m	1.33 m	Urban commercial
2.	Goregaon	1.40m	2.30m	Industrial
3.	Ghatkopar	1.80 m	1.31 m	Urban commercial
4.	Chembur	1.33m	2.29m	Urban commercial

Table 12.3 - Ambient **Noise Level**

Stations	Noise Level dB(A)				
	Leq(day)	Leq(night)	L10	L50	L90
Santacruz	74.6	72.6	77.2	74.6	72.1
Goregaon	72.9	71.1	73.8	73.0	71.8
Ghatkopar	78.8	71.2	80.9	77.9	75.8
Chembur	79.2	70.4	86.9	78.3	73.4

Source: MPCB

Table 12.4 - **Permissible Noise Level (CPCB Standards)**

Area	Category of Area	Permissible Limit	
		L_{eq} Day time	L_{eq} Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Note - 1 Day time is reckoned in between 6.a m and 10 p.m.

Note - 2 Nighttime is reckoned in between 10 p.m. and 6 p.m.

Note - 3 Silence zone is defined as areas upto 100 m around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by the Competent Authority.

Note - 4 Mixed categories of areas should be declared as one of the four above-mentioned categories by the Competent Authority and the corresponding standards shall apply.

From table, it is observed that Leq values during day & nighttime are exceeding the permissible limit prescribed by CPCB (55-45 dB (A)) at all the locations except Goregaon (Leq (Day)) along both BRTS corridor.

12.2.3 Climate

The study area experiences a typical tropical coastal climate. The moderating effects of the nearby sea and the fairly high amount of relative humidity in the atmosphere have restricted the variability.

The four seasons are as follows:

Winter	:	Dec	-	Feb
Pre-monsoon (Summer)	:	March	-	May
Monsoon	:	June	-	September
Post-monsoon	:	Oct	-	Nov.

The seasonal variations of temperature follow closely the course of sun. January is invariably the coldest month and May the warmest. With the onset of monsoon in early June there is a reversal of temperature curve and the temperature during the period of monsoon remains very uniform at about 27ºC. The slight rise in temperature in it falls gradually till it reaches the lowest in January. Based on past data, the mean daily temperature during the year varies from 16.9º C to 33.4º C. Highest recorded temperature is 40.6ºC. (Ref.: IMD Data from Santacruz Observatory).

The Relative Humidity (RH) ranges between 63% to 80% in the monsoon period. Between November to January i.e. in the winter months, the relative humidity varies from 57% to 72%. The relative humidity generally is higher than 60% throughout the year. (Ref.: IMD Data from Santacruz Observatory)

Monsoon generally sets in around the second week of June and continues till late September. July and August are the wettest month all over the region. There is a hardly a day without rain in these two months. Towards the later part of the season, there are breaks in between when the oppressive hot weather is associated with high humidity along the coast. The average rainfall in the region is nearly 2000 mm. (Ref. : IMD Data from Santacruz Observatory) Average monthly rainfall for Mumbai is indicated in following table.

Table 12.5 - Normal Rainfall at Mumbai (Based on 50 years data)

Month	**Rainfall in mm**
January	4.1
February	2.0
March	1.5
April	1.5
May	18.3
June	464.8
July	613.4
August	328.9
September	286.0
October	64.5
November	17.5
December	2.3
Annual	**1804.8**

Winds

The predominant direction of wind during October to May is from North-East in the morning and North-West during the afternoon. However during the monsoon months

i. e June to September the wind is predominantly in South-West quarter, both in the morning and in the afternoon. The maximum wind speeds for most of the time during the year is from North-West quarter with strong wind predominant during south-west monsoon period.

12.3 Environmental Issues:

The project proposal has been studied keeping in mind environmental and social aspects. Primarily following issues are identified which would have environmental impacts due to the proposed BRTS. These includes

- Drainage - The project being in the high rainfall area, drainage arrangement need to be designed for the rainfall intensity based on the BRIMSTOWAD Report and its amendments.
- Ambient Air Quality – During construction, ambient air quality may get affected but during operation it is expected to improve due to use of environmental friendly buses, shift of private vehicle users to the BRTS, thus reducing the no of private vehicles and pollution.
- Ambient Noise Levels – Reduction in ambient noise levels compare to the existing levels is anticipated.
- Impact on traffic and transportation during construction is expected, however the same is expected to improve due to the proposed BRTS.
- Impact on utilities – Utility identification and its relocation needs to be done in proper and timely manner.
- Aspects like drainage, ventilation, illumination, disaster management, commuter safety will need in-depth study before taking up for implementation.

12.4 Environmental Implications

12.4.1 Policy and Legal Framework

The Government through specific legislations regulates the environmental management system in India. The ministries / statutory bodies responsible for ensuring environmental compliance by project promoters and general public include:

- The Ministry of Environment and Forest (MOEF), Govt. of India
- Central Pollution Control Board (CPCB)
- State Pollution Control Boards
- Ministry / Department of Environment in the States

The Environment (Protection) Act, 1986 is the most comprehensive law on the subject. The law grants power to the central government to take all measures necessary to protect and improve the quality of environment and to prevent pollution of the environment. Under Section 5 of the Act, the Central Government has delegated its powers and performance of its functions to the State Government.

The central government has also issued the Environment (Protection) Rules, 1986 under the above Act which contain, inter alia (a) the standards for emission or discharge of environmental pollutants from the respective industries, operations or processes, (b) Ambient Air Quality Standard in respect of Noise, (c) Standards for emission of smoke, vapour, etc. for motor vehicles, (d) General Standards for discharge of environment pollutants, and (e) National Ambient Air Quality Standards. Where the discharge of environmental pollutant in excess of the prescribed standards occurs or is apprehended to occur due to any accident or other unforeseen act or event, the person in charge of the place shall forthwith intimate the fact to the prescribed authorised person or agencies.

12.4.2 Administrative Framework

As per the EIA Notification issued on 14th September 2006 and its amendments makes EIAs statutory requirements for 8 project types/ activities. All development projects, under Schedule -1 of the notification are required to obtain clearance from MOEF/State Government.

The various administrative and legal requirements discussed above shall be applicable to road projects depending upon the environmental set-up of the specific locations. The relative importance of various environmental parameters will vary from location to location.

As per the notification "the required construction of new projects or activities or the expansion or modernization of existing projects or activities listed in the Schedule to the notification entailing capacity addition with change in process and or technology shall be undertaken in any part of India *only after* the prior environmental clearance from the Central Government or as the case may be, by the State Level Environment Impact Assessment Authority, duly constituted by the Central Government under sub-section (3) of section 3 of the said Act, in accordance with the procedure specified in the notification".

12.4.3 Requirements of prior Environmental Clearance (EC)

As per the notification, the following projects or activities shall require prior environmental clearance from the concerned regulatory authority, which shall hereinafter referred to be as the Central Government in the Ministry of Environment and Forests for matters falling under Category 'A' in the Schedule and at State level the State Environment Impact Assessment Authority (SEIAA) for matters falling under Category 'B' in the said Schedule, before any construction work, or preparation of land by the project management except for securing the land, is started on the project or activity:

(i) All new projects or activities listed in the Schedule to the notification;

(ii) Expansion and modernization of existing projects or activities listed in the Schedule to the notification with addition of capacity beyond the limits specified for the concerned sector, that is, projects or activities which cross the threshold limits given in the Schedule, after expansion or modernization;

(iii) Any change in product - mix in an existing manufacturing unit included in Schedule beyond the specified range.

12.4.4 Legal Implications in the present Context

As per the schedule to the notification, projects/activities are classifieds under 8 different types. The projects/activities of Physical Infrastructure including Environmental Services are covered under Sr No 7 of the schedule. In the present context, the proposed BRTS is to be constructed along the existing Eastern and Western Express highway within the available ROW; hence no land acquisition is required. Further, the as per the notification, the construction of BRTS is not included in the schedule to the said notification and hence the project is *not* required to obtain environmental clearance from state/central government. (Copy of the schedule (Sr No 7) to the notification is enclosed).

SCHEDULE (MoEF Notification No. S.O. 1533 dt 14th September 2006)

LIST OF PROJECTS OR ACTIVITIES REQUIRING PRIOR ENVIRONMENTAL CLEARANCE

Project or Activity		Category with threshold limit		Conditions if any
		A	B	
(1)	(2)	(3)	(4)	(5)
7		**Physical Infrastructure including Environmental Services**		
7(a)	Air ports	All projects	-	-
7(b)	All ship breaking yards including ship breaking units	All projects	-	-
7(c)	Industrial estates/ parks/ complexes/ areas, export processing Zones (EPZs), Special Economic Zones (SEZs), Biotech Parks, Leather Complexes.	If at least one industry in the proposed industrial estate falls under the Category A, entire industrial area shall be treated as Category A, irrespective of the area. Industrial estates with area greater than 500 ha. and housing at least one Category B industry.	-Industrial estates housing at least one Category B industry and area <500 ha. Industrial estates of area> 500 ha. and not housing any industry belonging to Category A or B.	Special condition shall apply Note: Industrial Estate of area below 500 ha. and not housing any industry of category A or B does not require clearance.
7(d)	Common hazardous waste treatment, storage and disposal facilities (TSDFs)	All integrated facilities having incineration &landfill or incineration alone	All facilities having land fill only	General Condition shall apply
7(e)	Ports, Harbours	≥ 5 million TPA of cargo handling capacity (excluding fishing harbours)	< 5 million TPA of cargo handling capacity and/or ports/ harbours ≥10,000 TPA of fish handling capacity	General Condition shall apply
7(f)	*Highways*	*i) New National High ways; and* *ii) Expansion of National High ways greater than 30 KM, involving additional right of way greater than 20m involving land acquisition and passing through more than one State.*	*i) New State High ways; and* *ii) Expansion of National / State Highways greater than 30 km involving additional right of way greater than 20m involving land acquisition.*	*General Condition shall apply*
7(g)	Aerial ropeways		All projects	General Condition shall apply
7(h)	Common Effluent Treatment Plants (CETPs)		All projects	General Condition shall apply
7(i)	Common Municipal Solid Waste Management Facility (CMSWMF)		All projects	General Condition shall apply

12.5 Resettlement and Rehabilitation (R&R)

Resettlement and Rehabilitation is one of the important components in any developmental project in the urban environmental setting. This aspect has been studied for the proposed BRTS along WEH and EEH. Since the proposed BRTS is planned along the median of the WEH and EEH within the available ROW, no displacement of population is anticipated. However, displacement of some persons may be required due to the proposed BRTS Car Depot.

If at all required, the rehabilitation of PAP's can be carried out based on the prevailing R&R policy of GoM or R&R policy of MUTP. The brief details of the policy are given below.

Resettlement and Rehabilitation (R & R) Policy and Entitlements

Government of Maharashtra has formulated policy for resettlement and rehabilitation of persons affected by Mumbai Urban Transport Project vide GR, Housing and special assistance department, No MIS 1094/CR 558/slum 2, dt. March 12, 1997. The schemes under MUTP include Roads, ROBs, Traffic Management schemes as well as various rail projects. The objectives of the policy are:

- To develop and execute resettlement plans in such a manner that displaced persons are compensated for their losses at replacement cost just prior to the actual move.
- To accord formal housing rights to PAPs at the resettlement site.
- To Develop and implement the details of the resettlement programme through active community participation by establishing links with the community based organisations.
- To make efforts to retain existing community network in the resettlement area, wherever this is not feasible to make efforts to integrate the resettled population with the host community, and to minimize the adverse impact, If any, on the host community.
- To prepare community Environmental Management Plan and Rehabilitation & Resettlement Plan.

As per the policy, PAPs include households, business units including their workers and owners of assets like land and buildings affected by the project shall be considered as PAPs and may include non residential land owners (including farmers and horticulturist); non resident lessees; resident landlord (including farmers and horticulturist); resident lessee, tenants or sub-tenants of buildings; squatters (non resident structure owners, resident structure owners, tenants; Pavement dwellers, Households for this purpose means all the males/females; their family members and relatives staying in a house/tenement/hut.

The eligibility of PAPs for R&R has also been mentioned in this policy. As per the policy the site for resettlement shall be selected out of the feasible options in consultation with the affected community as a part of RAP preparation. The principal criteria for site selection shall include access to employment opportunities, infrastructure and social services. The compensation for PAPs depending upon the category of RAP is given in policy.

Chapter 13.0
FINANCIAL AND ECONOMIC VIABILITY ANALYSIS

13.0 Introduction

This chapter examines the financial and economic viability of the BRT project, to be developed along selected two road corridors viz. WEH & EEH.

A. FINANCIAL ANALYSIS

The basic parameters and assumptions made for **financial analysis** are discussed below:

13.1 Project Costs

A preliminary analysis, based on block cost estimates for two identified corridors, is discussed in **Chapter 9**. The total estimated cost of the two corridors is Rs. 7914.45 Milions Rs. 4726.32 Millions for WEH and Rs. 3188.13 Millions for EEH. The project is envisaged to be completed in three years.

The cost components are as follows:

		WEH	EEH
(i)	Cost of The road and Road Infrastructure	2177.55*	1700.00
(ii)	Bus Procurement and Bus Depot	2450.32	1389.68
(iii)	ITS	98.45	98.45
	Total	**4726.32**	**3188.13**

(Rs. In Millions)

***** *50% cost of the Skywalks (Steel), FOB's, & Escalator is considered*

Sources of Funds: It is envisaged that the project will be financed from the internal resources of MMRDA and BEST.

13.1.1 Operation & Maintenance Cost

The operation and maintenance cost includes annual routine and periodic (every 5 years) maintenance cost of road infrastructure and bus operation. The year wise maintenance and operation costs of road infrastructure and buses of BRT corridors are given in ***Appendix- I*** & ***Appendix- II***.

13.2 Project Revenues

The project revenues include fare box collections, and commercial advertisements on stations, on buses, etc.

Fare box Revenue: The fare box revenues have been estimated on the basis of following assumptions:

- Fare box collection at the average fare of Rs 1.02 per passenger-km and,

Advertisement Revenue: The advertisement revenue is assumed to be 5% of the fare box collection every year

The following table gives the source wise estimate of income flow for WEH and EEH

Table 13.1 BRTS Operating Revenues

(in Rs. Millions)

	FY 2013	FY 2016	FY 2021	FY 2026	FY 2031
WEH					
Fare box revenue	1480.01	1818.39	2575.34	3624.04	4791.86
Advertisement Revenue	74.00	90.92	128.77	181.20	239.59
Total Revenue	1554.01	1909.31	2704.11	3805.24	5031.45
EEH					
Fare box revenue	800.22	983.18	1392.45	1959.47	2590.90
Advertisement Revenue	40.01	49.16	69.62	97.97	129.54
Total Revenue	840.23	1032.34	1462.07	2057.44	2720.44

13.3 Financial Viability Analysis:

To ascertain the financial viability of the project investments following returns have been worked out:

(i) Return on total investment
(ii) Return on BEST Operation

As stated earlier, it is assumed that the project will be financed from the internal resources of MMRDA and BEST. The Consultants therefore have attempted to estimate the Return on total Investment during the assumed study analysis period at constant prices based on the above discussed cash flows. In addition consultants have also worked out return on investment on BEST operation separately.

The following table gives the return on investment in terms of Return on Investment for WEH and EEH:

Table 13.2: Results of Financial Analysis for WEH and EEH

Scenario	WEH	EEH	Combined
Return on Total Investment	4.83%	2.13%	3.79%
Return on BEST Operation	18.17	18.17	18.17

Note: The above estimates of Return on Investment do not envisage any grant for purchase of BEST buses.

The details of cash flow statements are given in ***Appendix*** - ***III*** to ***Appendix*** - ***VIII*.**

B. ECONOMIC VIABILITY ANALYSIS

13.4 Approach

Economic viability of the proposed two BRTS corridors have been assessed within the broad framework of "Cost-Benefit Analysis", wherein benefits are computed for the economy as a whole rather than for the individual entity making the investment. The analysis involves comparison of project costs and benefits in economic terms under the "with" and "without" project conditions and determining the Economic Internal Rate of Return (EIRR) of the project using discounted cash flow technique. This shows the return, which the society could expect from the proposed investment during the project life, i.e. analysis period. The EIRR is then compared with the opportunity cost of capital.

The economic viability analysis have been carried out for two identified BRT Corridors separately & combined under 'with' and 'without' project scenario. The existing situation is one of congestion on these corridors and low vehicular speeds. In the "with project" situation, exclusive bus ways have been envisaged to be provided for the BRT vehicles. This will result in higher speeds of buses. It may be mentioned that only passenger modes have been considered for the study.

13.5 Project Costs & Scheduling

The Road & Infrastructure capital cost of the identified BRTS Corridors is estimated to be Rs. 4523.90 Millions; Rs. 2525.45 Millions for WEH and Rs. 1998.45 Millions for EEH respectively. The cost component only includes; capital cost of infrastructure for BRT system, Bus Depot cost and installation of ITS. It excludes the capital cost of procurement and cost of operation of BRT buses.

The construction activities are expected to take three years with 30% in the first 40% in the second & 30% in third year respectively.

Economic analysis requires the conversion of financial costs into economic costs to take care of distortions in prices due to market imperfections. Taxes and duties are removed from financial prices, as these are not real costs to the economy, but are only transfer payments. The financial costs have been converted into economic costs, by applying the standard conversion factor of 0.9. In most of the recent World Bank Funded Projects this conversion factor has been applied for estimating economic cost of the project.

13.6 Project Benefits

The major positive benefits expected from the BRTS are;

(i) Savings in cost of operation and
(ii) Savings in travel time to the traffic on BRTS corridor.

The implementation of the project will reduce the existing road capacity of the two corridors. This is assumed to result into deterioration of speed of the traffic remaining on the corridors on implementation of BRTS. The consultant have considered the resultant increase in VOC and VOT to the traffic remaining on the corridor for estimating net VOC and VOT benefits of the project.

The segregation of buses is likely to result in higher speeds of both BRT vehicles and the feeder buses and consequent time savings and saving in VOC.

The time savings have been worked out as the difference of travel time under "with" and "without" project situations. The annual streams of time savings are calculated on the basis of value of time (VOT). The Consultants have adopted the values of time (VOT) from available studies, which are based on the wage rate approach. The VOT values adopted for different vehicles are presented below.

Table 13.3: Values of Time (VOT) by Vehicle Type

Vehicle Type	VOT/vehicle (Rs/hr)
2 Wheelers	52
Auto rickshaw	28
Car/Taxi	45
Bus (per passenger)	28
LCV	8.55
2-Axle	7.78
Tractor	8.55

Source: CTTS report

The Corridor wise details of estimates of VOC and Net VOT benefits for WEH and EEH are given in ***Appendix– IX*** *and* ***Appendix – X*****.**

13.5.1 Other Benefits

Other intangible benefits of the BRT include:

Improved travel comforts by BRTS buses, reduction of pollution on the BRT corridors, reduction of accidents in the city and enhancement of safety, reduction in congestion in the suburban trains etc. These indirect benefits, however, have not been quantified in the analysis.

13.6 Economic Internal Rate of Return (EIRR)

The Economic viability of the project is assessed in terms of Economic Internal Rate of Return (EIRR). The following table gives the estimates of EIRR

Table 13.4: Base case EIRR for WEH, EEH and Combined Project

	EIRR (%)	NPV (Rs. In Millions)
WEH	47.54	6,425.73
EEH	41.62	3,861.33
Combined	44.97	10,287.06

The Corridor wise net cash flow statements for WEH and EEH are given in ***Appendix-*** **XI to Appendix - XIII.**

13.7 Sensitivity Analysis:

Sensitivity analysis has been carried out to establish the impact of change in main variables on the index of economic viability (EIRR)

The main cases considered are as follows:

Case I – 20 % increase in cost
Case II – 20% decrease in benefits
Case III – Combined effect of 20 % increase in cost and 20% decrease in benefits

The results of the Economic analysis for the project are summarized in following table.

Table 13.5: Summary of EIRR for WEH, EEH and Combined project

Cases	EIRR (%)			NPV (Rs. In Millions)		
	WEH	EEH	Combined	WEH	EEH	Combined
Base Case	47.54	41.62	44.97	6,425.73	3,861.33	10,287.06
20 % increase in cost	40.60	35.32	38.32	6,029.14	3,546.11	9,575.25
20% decrease in benefits	39.18	34.03	36.96	4,744.00	2,773.84	7,517.84
Combined effect of 20 % increase in cost and 20% decrease in benefits	33.42	28.79	31.43	4,347.41	2,458.62	6,806.03

13.8 Conclusion:

It is observed from the above analysis that the project as a whole is not financially viable but economically viable EIRR varying from 44.97% to 31.43%.

Appendix - I

Operation and Maintenance cost for BRTS Road Infrastructure

(Rs. in Millions)

	EEH		WEH		Combined	
Year	Routine	Periodic	Routine	Periodic	Routine	Periodic
2013-14	17.98		22.75		40.74	
2014-15	17.98		22.75		40.74	
2015-16	17.98		22.75		40.74	
2016-17	17.98	89.92	22.75	113.77	40.74	203.70
2017-18	17.98		22.75		40.74	
2018-19	17.98		22.75		40.74	
2019-20	17.98		22.75		40.74	
2020-21	17.98		22.75		40.74	
2021-22	17.98	114.77	22.75	145.21	40.74	259.97
2022-23	17.98		22.75		40.74	
2023-24	17.98		22.75		40.74	
2024-25	17.98		22.75		40.74	
2025-26	17.98		22.75		40.74	
2026-27	17.98	146.47	22.75	185.32	40.74	331.80
2027-28	17.98		22.75		40.74	
2028-29	17.98		22.75		40.74	
2029-30	17.98		22.75		40.74	
2030-31	17.98		22.75		40.74	

Appendix – II

Operation and Maintenance cost for BRTS Buses

(Rs. in Millions)

Year	EEH	WEH	Combined
2013-14	743.93	1375.90	2119.83
2014-15	758.72	1403.25	2161.96
2015-16	775.58	1434.43	2210.01
2016-17	794.68	1469.75	2264.43
2017-18	816.18	1509.53	2325.72
2018-19	842.52	1558.23	2400.75
2019-20	901.55	1667.41	2568.96
2020-21	964.30	1783.46	2747.76
2021-22	1162.90	2150.79	3313.70
2022-23	1206.44	2231.31	3437.75
2023-24	1253.72	2318.76	3572.49
2024-25	1305.11	2413.80	3718.91
2025-26	1360.89	2516.97	3877.86
2026-27	1421.76	2629.54	4051.29
2027-28	1522.00	2814.93	4336.93
2028-29	1628.48	3011.87	4640.36
2029-30	1854.39	3429.69	5284.08
2030-31	1943.46	3594.42	5537.88

Appendix - III

Financial Analysis for WEH Corridor on Total Investment

(Rs in Millions)

Years	Road Infrastructure cost			Bus related Cost		Total Cost	Revenue		Total Revenue	Net Cash flow
	Capital Cost	Routine Maintenance	Periodic Maintenance	Bus cost	Cost of Operation		Fare box Revenue	Advertisement Revenue		
2010-11	682.64					682.64				-682.64
2011-12	910.18					910.18				-910.18
2012-13	832.64					832.64				-832.64
2013-14		22.75		2200.32	1375.90	3598.97	1480.01	74.00	1554.01	-2044.96
2014-15		22.75		44.14	1403.25	1470.14	1585.78	79.29	1665.07	194.94
2015-16		22.75		44.14	1434.43	1501.32	1698.44	84.92	1783.36	282.04
2016-17		22.75		44.14	1469.75	1536.64	1818.39	90.92	1909.31	372.67
2017-18		22.75	113.77	44.14	1509.53	1690.20	1946.09	97.30	2043.39	353.20
2018-19	50.00	22.75		49.65	1558.23	1680.64	2086.84	104.34	2191.19	510.55
2019-20		22.75		49.65	1667.41	1739.82	2236.81	111.84	2348.65	608.83
2020-21		22.75		49.65	1783.46	1855.87	2396.55	119.83	2516.38	660.51
2021-22		22.75		2211.03	2150.79	4384.57	2575.34	128.77	2704.11	-1680.47
2022-23		22.75	145.21	92.17	2231.31	2491.43	2759.59	137.98	2897.56	406.13
2023-24		22.75		92.17	2318.76	2433.68	2955.82	147.79	3103.61	669.93
2024-25		22.75		92.17	2413.80	2528.72	3164.78	158.24	3323.02	794.29
2025-26	50.00	22.75		92.17	2516.97	2681.89	3387.24	169.36	3556.60	874.71
2026-27		22.75		97.68	2629.54	2749.98	3624.04	181.20	3805.24	1055.27
2027-28		22.75	185.32	104.17	2814.93	3127.18	3886.26	194.31	4080.58	953.40
2028-29		22.75		104.17	3011.87	3138.80	4165.65	208.28	4373.93	1235.13
2029-30		22.75		2170.46	3429.69	5622.91	4477.35	223.87	4701.22	-921.68
2030-31		22.75		145.71	3594.42	3762.89	4791.86	239.59	5031.46	1268.57
									FIRR	4.83%

Appendix - IV

Financial Analysis for EEH Corridor on Total Investment

(Rs in Millions)

Years	Road Infrastructure cost			Bus related Cost		Total Cost	Revenue		Total Revenue	Net Cash flow
	Capital Cost	Routine Maintenance	Periodic Maintenance	Bus cost	Cost of Operation		Fare box Revenue	Advertisement Revenue		
2010-11	539.54					539.54				-539.54
2011-12	719.38					719.38				-719.38
2012-13	689.54					689.54				-689.54
2013-14		17.98		1189.68	743.93	1951.60	800.22	40.01	840.23	-1111.36
2014-15		17.98		23.86	758.72	800.57	857.41	42.87	900.28	99.72
2015-16		17.98		23.86	775.58	817.43	918.32	45.92	964.24	146.81
2016-17		17.98		23.86	794.68	836.52	983.18	49.16	1032.34	195.81
2017-18		17.98	89.92	23.86	816.18	947.96	1052.23	52.61	1104.84	156.88
2018-19		17.98		26.85	842.52	887.35	1128.33	56.42	1184.75	297.40
2019-20		17.98		26.85	901.55	946.38	1209.41	60.47	1269.88	323.51
2020-21		17.98		26.85	964.30	1009.13	1295.78	64.79	1360.57	351.45
2021-22		17.98		1195.47	1162.90	2376.36	1392.45	69.62	1462.08	-914.29
2022-23		17.98	114.77	49.83	1206.44	1389.02	1492.07	74.60	1566.68	177.65
2023-24		17.98		49.83	1253.72	1321.54	1598.17	79.91	1678.08	356.54
2024-25		17.98		49.83	1305.11	1372.93	1711.15	85.56	1796.71	423.78
2025-26	50.00	17.98		49.83	1360.89	1478.71	1831.44	91.57	1923.01	444.30
2026-27		17.98		52.82	1421.76	1492.56	1959.47	97.97	2057.45	564.89
2027-28		17.98	146.47	56.33	1522.00	1742.78	2101.25	105.06	2206.32	463.53
2028-29		17.98		56.33	1628.48	1702.79	2252.31	112.62	2364.93	662.14
2029-30		17.98		1173.54	1854.39	3045.91	2420.85	121.04	2541.89	-504.02
2030-31		17.98		78.79	1943.46	2040.23	2590.90	129.54	2720.44	680.22
									FIRR	2.13%

Appendix - V

Financial Analysis for Mumbai BRTS Combined on Total Investment

(Rs in Millions)

Years	Road Infrastructure cost			Bus related Cost		Total Cost	Revenue		Total Revenue	Net Cash flow
	Capital Cost	Routine Maintenance	Periodic Maintenance	Bus cost	Cost of Operation		Fare box Revenue	Advertisement Revenue		
2010-11	1222.17					1222.17				-1222.17
2011-12	1629.56					1629.56				-1629.56
2012-13	1522.17					1522.17				-1522.17
2013-14		40.74		3390.00	2119.83	5550.56	2280.23	114.01	2394.24	-3156.32
2014-15		40.74		68.00	2161.96	2270.70	2443.20	122.16	2565.36	294.65
2015-16		40.74		68.00	2210.01	2318.75	2616.76	130.84	2747.59	428.85
2016-17		40.74		68.00	2264.43	2373.17	2801.57	140.08	2941.65	568.48
2017-18		40.74	203.70	68.00	2325.72	2638.15	2998.32	149.92	3148.23	510.08
2018-19	50.00	40.74		76.50	2400.75	2567.98	3215.17	160.76	3375.93	807.95
2019-20		40.74		76.50	2568.96	2686.19	3446.22	172.31	3618.53	932.34
2020-21		40.74		76.50	2747.76	2865.00	3692.33	184.62	3876.95	1011.95
2021-22		40.74		3406.50	3313.70	6760.93	3967.79	198.39	4166.18	-2594.75
2022-23		40.74	259.97	142.00	3437.75	3880.46	4251.66	212.58	4464.24	583.78
2023-24		40.74		142.00	3572.49	3755.22	4553.99	227.70	4781.69	1026.47
2024-25		40.74		142.00	3718.91	3901.65	4875.93	243.80	5119.73	1218.08
2025-26	100.00	40.74		142.00	3877.86	4160.60	5218.68	260.93	5479.61	1319.01
2026-27		40.74		150.50	4051.29	4242.53	5583.51	279.18	5862.69	1620.15
2027-28		40.74	331.80	160.50	4336.93	4869.96	5987.52	299.38	6286.89	1416.93
2028-29		40.74		160.50	4640.36	4841.60	6417.96	320.90	6738.86	1897.26
2029-30		40.74		3344.00	5284.08	8668.82	6898.20	344.91	7243.11	-1425.71
2030-31		40.74		224.50	5537.88	5803.12	7382.76	369.14	7751.90	1948.78
									FIRR	3.79%

Appendix - VI

Financial Analysis for EEH Corridor on BEST Investment

(Rs. in Millions)

Years	Cost			Revenue			Net Cash flow
	Bus cost	Cost of Operation	Total Cost	Fare box Revenue	Advertisement Revenue	Total Revenue	
2013-14	1189.68	743.93	1933.61	800.22	40.01	840.23	-1093.38
2014-15	23.86	758.72	782.58	857.41	42.87	900.28	117.70
2015-16	23.86	775.58	799.44	918.32	45.92	964.24	164.80
2016-17	23.86	794.68	818.54	983.18	49.16	1032.34	213.80
2017-18	23.86	816.18	840.05	1052.23	52.61	1104.84	264.79
2018-19	26.85	842.52	869.36	1128.33	56.42	1184.75	315.38
2019-20	26.85	901.55	928.39	1209.41	60.47	1269.88	341.49
2020-21	26.85	964.30	991.14	1295.78	64.79	1360.57	369.43
2021-22	1195.47	1162.90	2358.38	1392.45	69.62	1462.08	-896.30
2022-23	49.83	1206.44	1256.27	1492.07	74.60	1566.68	310.40
2023-24	49.83	1253.72	1303.56	1598.17	79.91	1678.08	374.52
2024-25	49.83	1305.11	1354.94	1711.15	85.56	1796.71	441.77
2025-26	49.83	1360.89	1410.73	1831.44	91.57	1923.01	512.28
2026-27	52.82	1421.76	1474.57	1959.47	97.97	2057.45	582.87
2027-28	56.33	1522.00	1578.32	2101.25	105.06	2206.32	627.99
2028-29	56.33	1628.48	1684.81	2252.31	112.62	2364.93	680.12
2029-30	1173.54	1854.39	3027.93	2420.85	121.04	2541.89	-486.04
2030-31	78.79	1943.46	2022.24	2590.90	129.54	2720.44	698.20
						FIRR	18.17%
						NPV	464.61

Appendix - VII

Financial Analysis for WEH Corridor on BEST Investment

(Rs in Millions)

Years	Cost			Revenue			Net Cash flow
	Bus cost	Cost of Operation	Total Cost	Fare box Revenue	Advertisement Revenue	Total Revenue	
2013-14	2200.32	1375.90	3576.21	1480.01	74.00	1554.01	-2022.20
2014-15	44.14	1403.25	1447.38	1585.78	79.29	1665.07	217.69
2015-16	44.14	1434.43	1478.57	1698.44	84.92	1783.36	304.79
2016-17	44.14	1469.75	1513.89	1818.39	90.92	1909.31	395.42
2017-18	44.14	1509.53	1553.67	1946.09	97.30	2043.39	489.73
2018-19	49.65	1558.23	1607.88	2086.84	104.34	2191.19	583.30
2019-20	49.65	1667.41	1717.06	2236.81	111.84	2348.65	631.59
2020-21	49.65	1783.46	1833.12	2396.55	119.83	2516.38	683.26
2021-22	2211.03	2150.79	4361.82	2575.34	128.77	2704.11	-1657.71
2022-23	92.17	2231.31	2323.47	2759.59	137.98	2897.56	574.09
2023-24	92.17	2318.76	2410.93	2955.82	147.79	3103.61	692.68
2024-25	92.17	2413.80	2505.97	3164.78	158.24	3323.02	817.05
2025-26	92.17	2516.97	2609.14	3387.24	169.36	3556.60	947.47
2026-27	97.68	2629.54	2727.22	3624.04	181.20	3805.24	1078.02
2027-28	104.17	2814.93	2919.10	3886.26	194.31	4080.58	1161.47
2028-29	104.17	3011.87	3116.05	4165.65	208.28	4373.93	1257.88
2029-30	2170.46	3429.69	5600.15	4477.35	223.87	4701.22	-898.93
2030-31	145.71	3594.42	3740.13	4791.86	239.59	5031.46	1291.32
						FIRR	18.17%
						NPV	859.30

Appendix - VIII

Financial Analysis for Mumbai BRTS Combined on BEST Investment

(Rs in Millions)

Years	Cost			Revenue			Net Cash flow
	Bus cost	Cost of Operation	Total Cost	Fare box Revenue	Advertisement Revenue	Total Revenue	
2013-14	3390.00	2119.83	5509.83	2280.23	114.01	2394.24	-3115.58
2014-15	68.00	2161.96	2229.96	2443.20	122.16	2565.36	335.39
2015-16	68.00	2210.01	2278.01	2616.76	130.84	2747.59	469.59
2016-17	68.00	2264.43	2332.43	2801.57	140.08	2941.65	609.22
2017-18	68.00	2325.72	2393.72	2998.32	149.92	3148.23	754.51
2018-19	76.50	2400.75	2477.25	3215.17	160.76	3375.93	898.69
2019-20	76.50	2568.96	2645.46	3446.22	172.31	3618.53	973.08
2020-21	76.50	2747.76	2824.26	3692.33	184.62	3876.95	1052.69
2021-22	3406.50	3313.70	6720.20	3967.79	198.39	4166.18	-2554.02
2022-23	142.00	3437.75	3579.75	4251.66	212.58	4464.24	884.49
2023-24	142.00	3572.49	3714.49	4553.99	227.70	4781.69	1067.21
2024-25	142.00	3718.91	3860.91	4875.93	243.80	5119.73	1258.82
2025-26	142.00	3877.86	4019.86	5218.68	260.93	5479.61	1459.75
2026-27	150.50	4051.29	4201.79	5583.51	279.18	5862.69	1660.89
2027-28	160.50	4336.93	4497.43	5987.52	299.38	6286.89	1789.47
2028-29	160.50	4640.36	4800.86	6417.96	320.90	6738.86	1938.00
2029-30	3344.00	5284.08	8628.08	6898.20	344.91	7243.11	-1384.97
2030-31	224.50	5537.88	5762.38	7382.76	369.14	7751.90	1989.52
						FIRR	18.17%
						NPV	1,323.92

Appendix - IX

Section Wise VOT and VOC for WEH

Sections	2013		2016		2021		2026		2031	
	VOT	VOC	VOT	VOC	VOT	VOC	VOT	VOC	VOT	VOC
Kalanagar Jun.-Kherwadi Jun.	-2.03	0.91	-2.15	0.96	-2.33	1.05	-2.48	1.11	-2.55	1.09
Kherwadi Jun.-Kalina Jun.	-4.19	1.80	-4.44	1.84	-4.86	2.05	-5.26	2.19	-5.56	2.16
Kalina Jun.-Vakola Jun.	-3.49	1.46	-3.60	1.62	-3.70	1.75	-3.59	2.07	-3.14	2.49
Vakola Jun.-New Agripada	1.40	2.16	1.79	2.33	2.73	2.78	4.20	3.42	6.51	4.40
New Agripada-Domestic Airport Jun.	3.21	6.25	4.19	6.63	6.61	7.54	10.47	8.89	16.78	11.16
Domestic Airport Jun.-Sahara Int.Airport (Bahar Cinema) Jun.	0.74	2.40	1.03	2.66	1.77	3.19	2.95	3.63	4.70	4.54
Sahara Int.Airport (Bahar Cinema) Jun.-Goldspot Jun.	0.07	1.11	0.15	1.24	0.33	1.44	0.62	1.71	1.06	2.19
Goldspot Jun.-Andheri Kurla (Darpan Cinema) Jun.	0.81	3.03	1.23	3.41	2.33	3.96	4.12	4.66	7.10	5.70
Andheri Kurla (Darpan Cinema) Jun.-Gundavali	0.39	5.54	0.75	6.10	1.64	7.25	3.04	8.69	5.27	11.10
Gundavali -JVLR (Jai Coach) Jun.	4.01	11.73	5.13	12.61	7.82	14.13	11.92	16.20	18.29	18.55
JVLR (Jai Coach) Jun.-Arey (Goregaon) Jun.	21.60	15.03	27.73	16.80	42.66	20.82	65.42	26.58	99.79	33.80
Arey (Goregaon) Jun.-ITT Bhatti Jun.	4.56	6.55	6.23	7.24	10.47	8.86	17.41	10.55	28.82	13.40
ITT Bhatti Jun.-Dindoshi	0.12	1.05	0.19	1.11	0.35	1.36	0.60	1.67	0.98	2.00
Dindoshi-Pathanwadi Jun.	0.59	2.68	0.81	2.94	1.36	3.38	2.21	3.72	3.58	4.36
Pathanwadi Jun.-Bhor Industry Jun.	0.36	3.06	0.59	3.26	1.17	3.87	2.09	4.30	3.56	4.91
Bhor Industry Jun.-Thakur Complex (BHAD) Jun.	1.08	8.25	1.94	9.12	4.10	10.29	7.50	12.32	12.89	14.87
Thakur Complex (BHAD) Jun.-Dattapada (Magthane) Jun.	1.74	4.71	2.45	5.24	4.18	6.09	6.85	6.97	11.03	8.29
Dattapada (Magthane) Jun.-Borivali National Park Jun.	-0.98	3.34	-0.94	3.63	-0.80	4.16	-0.53	4.78	-0.06	5.72
Borivali National Park Jun.-Nancy Colony	-0.12	1.08	-0.08	1.19	0.02	1.36	0.18	1.59	0.44	2.00
Nancy Colony-Gokul Anad Jun.	0.11	1.66	0.17	1.79	0.30	2.16	0.51	2.54	0.81	3.23
Gokul Anad Jun.-Ravalpada (Ashok one) Jun.	0.41	2.72	0.54	2.89	0.84	3.63	1.28	4.24	1.95	4.99
Ravalpada (Ashok one) Jun.-Dahisar Check Naka Jun.	0.21	2.38	0.31	2.66	0.54	3.09	0.89	3.76	1.41	4.41

Appendix - X

Section Wise VOT and VOC for EEH

Sections	2013		2016		2021		2026		2031	
	VOT	VOC	VOT	VOC	VOT	VOC	VOT	VOC	VOT	VOC
Sion Jun. - Suman Nagar Jun.	6.02	7.00	7.54	7.71	11.18	9.35	16.90	11.50	26.15	13.77
Suman Nagar Jun. - Everad Nagar	0.58	1.31	0.70	1.45	0.97	1.80	1.34	2.36	1.89	2.92
Everad Nagar - Amarmahal Jun.	4.50	7.48	5.62	8.52	8.26	10.91	12.25	13.23	18.47	16.21
Amarmahal Jun. - Chedda Nagar	0.51	1.64	0.63	1.74	0.90	2.12	1.29	2.71	1.86	3.18
Chedda Nagar-Mankhurd Jun.	0.98	2.07	1.21	2.30	1.71	2.71	2.44	3.27	3.54	3.85
Mankhurd Jun. - AGLR Jun.	2.02	4.29	2.48	4.62	3.54	5.80	5.08	7.53	12.49	12.18
AGLR Jun. - Godrej	0.46	1.44	0.55	1.57	0.76	1.89	1.04	2.31	1.45	2.93
Godrej - Godrej Company Jun.	0.14	0.93	0.17	1.00	0.23	1.13	0.32	1.33	0.44	1.53
Godrej Company Jun. - Godrej Hospital Jun.	0.14	1.15	0.18	1.24	0.26	1.39	0.37	1.64	0.54	1.93
Godrej Hospital Jun. - Vikhroli Jun.	0.79	3.45	0.96	3.76	1.36	4.43	1.93	5.18	2.73	6.34
Vikhroli Jun. - JVLR Jun.	1.19	3.83	1.45	4.26	2.01	5.09	2.81	6.24	3.97	7.76
JVLR Jun. - Airoli Jun.	2.46	5.00	2.91	5.64	3.90	6.97	5.28	8.32	7.28	9.55
Airoli Jun. - Mulund Jun.	2.81	8.16	3.32	9.14	4.46	10.82	6.04	12.70	8.29	16.42
Mulund Jun. - Teenhath Naka Jun.	0.83	4.80	0.98	5.09	1.32	5.88	1.78	6.79	2.41	8.13
Teenhath Naka Jun. - Nitin Co.	0.51	2.59	0.60	2.75	0.79	3.14	1.06	3.60	1.42	4.22
Nitin Co. - Nitin Co. Jun.	0.58	1.62	0.68	1.75	0.87	2.08	1.14	2.46	1.50	2.99
Nitin Co. Jun. - Cadbury Jun.	1.13	2.35	1.34	2.67	1.79	3.50	2.43	4.27	3.36	5.22

Appendix - XI

Economic Analysis of EEH on MMRDA Investment

Year	Cost				Benfits			Net Benefits
	Road Infrastructure Cost	Routine	Periodic	Total	VOT Passenger	Mode wise VOC	Total	
2010-11	485.58			485.58	0	0	0.00	-485.58
2011-12	647.44			647.44	0	0	0.00	-647.44
2012-13	620.58	16.19		636.77	205.25	472.60	677.84	41.08
2013-14	0.00	16.19		16.19	219.58	489.09	708.66	692.47
2014-15	0.00	16.19		16.19	234.67	505.67	740.34	724.16
2015-16	0.00	16.19		16.19	250.58	521.59	772.18	755.99
2016-17	0.00	16.19	80.93	97.12	269.15	541.27	810.42	713.31
2017-18	0.00	16.19		16.19	288.76	565.69	854.45	838.27
2018-19	0.00	16.19		16.19	309.48	583.35	892.84	876.65
2019-20	0.00	16.19		16.19	331.36	607.14	938.50	922.31
2020-21	0.00	16.19		16.19	354.46	632.04	986.50	970.32
2021-22	0.00	16.19	103.29	119.48	381.73	658.34	1040.07	920.59
2022-23	0.00	16.19		16.19	410.63	680.16	1090.79	1074.60
2023-24	0.00	16.19		16.19	441.25	712.01	1153.26	1137.08
2024-25	0.00	16.19		16.19	473.68	733.88	1207.56	1191.38
2025-26	45.00	16.19		61.19	508.04	763.51	1271.54	1210.36
2026-27	0.00	16.19	131.83	148.01	554.36	799.82	1354.17	1206.16
2027-28	0.00	16.19		16.19	604.48	829.71	1434.18	1417.99
2028-29	0.00	16.19		16.19	658.81	881.15	1539.96	1523.78
2029-30	0.00	16.19		16.19	717.87	919.79	1637.66	1621.47
2030-31	0.00	16.19		16.19	782.26	953.10	1735.35	1719.17
							EIRR	41.62%
							NPV	3,861.33

Appendix - XII

Economic Analysis of WEH on MMRDA Investment

Year	Cost				Benfits			Net Benefits
	Road Infrastructure Cost	Routine	Periodic	Total	VOT Passenger	Mode wise VOC	Total	
2010-11	614.37			614.37	0	0	0.00	-614.37
2011-12	819.16			819.16	0	0	0.00	-819.16
2012-13	749.37	20.48		769.85	244.89	711.22	956.11	186.26
2013-14	0.00	20.48		20.48	278.84	732.40	1011.24	990.76
2014-15	0.00	20.48		20.48	315.36	756.34	1071.70	1051.22
2015-16	0.00	20.48		20.48	352.13	778.08	1130.22	1109.74
2016-17	0.00	20.48	102.40	122.87	397.77	802.91	1200.68	1077.80
2017-18	0.00	20.48		20.48	447.18	828.85	1276.03	1255.55
2018-19	45.00	20.48		65.48	500.51	860.68	1361.19	1295.71
2019-20	0.00	20.48		20.48	558.08	887.61	1445.69	1425.21
2020-21	0.00	20.48		20.48	620.26	913.53	1533.79	1513.31
2021-22	0.00	20.48	130.69	151.16	691.73	952.24	1643.96	1492.80
2022-23	0.00	20.48		20.48	769.27	978.29	1747.56	1727.08
2023-24	0.00	20.48		20.48	853.29	1017.43	1870.72	1850.24
2024-25	0.00	20.48		20.48	944.40	1051.38	1995.78	1975.30
2025-26	45.00	20.48		65.48	1043.27	1084.76	2128.03	2062.55
2026-27	0.00	20.48	166.79	187.27	1154.86	1131.05	2285.91	2098.64
2027-28	0.00	20.48		20.48	1276.22	1180.47	2456.69	2436.21
2028-29	0.00	20.48		20.48	1408.30	1213.56	2621.87	2601.39
2029-30	0.00	20.48		20.48	1552.22	1289.07	2841.29	2820.81
2030-31	0.00	20.48		20.48	1709.22	1322.84	3032.06	3011.58
							EIRR	47.54%
							NPV	6,425.73

Appendix - XIII

Economic Analysis of BRT Combined on MMRDA Investment

Year	Cost				Benfits			Net Benefits
	Road Infrastructure Cost	Routine	Periodic	Total	VOT Passenger	Mode wise VOC	Total	
2010-11	1099.95			1099.95	0	0	0.00	-1099.95
2011-12	1466.60			1466.60	0	0	0.00	-1466.60
2012-13	1369.95	36.67		1406.62	450.13	1183.82	1633.95	227.33
2013-14	0.00	36.67		36.67	498.41	1221.48	1719.90	1683.23
2014-15	0.00	36.67		36.67	550.03	1262.01	1812.04	1775.38
2015-16	0.00	36.67		36.67	602.72	1299.67	1902.39	1865.73
2016-17	0.00	36.67	183.33	219.99	666.91	1344.19	2011.10	1791.11
2017-18	0.00	36.67		36.67	735.95	1394.54	2130.49	2093.82
2018-19	45.00	36.67		81.67	809.99	1444.03	2254.03	2172.36
2019-20	0.00	36.67		36.67	889.44	1494.74	2384.19	2347.52
2020-21	0.00	36.67		36.67	974.72	1545.58	2520.30	2483.63
2021-22	0.00	36.67	233.97	270.64	1073.46	1610.57	2684.03	2413.39
2022-23	0.00	36.67		36.67	1179.90	1658.45	2838.35	2801.68
2023-24	0.00	36.67		36.67	1294.54	1729.44	3023.99	2987.32
2024-25	0.00	36.67		36.67	1418.08	1785.26	3203.34	3166.68
2025-26	90.00	36.67		126.67	1551.31	1848.26	3399.57	3272.91
2026-27	0.00	36.67	298.62	335.28	1709.22	1930.87	3640.09	3304.80
2027-28	0.00	36.67		36.67	1880.69	2010.18	3890.87	3854.21
2028-29	0.00	36.67		36.67	2067.11	2094.71	4161.83	4125.16
2029-30	0.00	36.67		36.67	2270.09	2208.86	4478.95	4442.28
2030-31	0.00	36.67		36.67	2491.48	2275.93	4767.41	4730.75
							EIRR	44.97%
							NPV	10,287.06

Chapter 14.0
INSTITUTIONAL ARRANGEMENT FOR BRT- MUMBAI

14.0 INSTITUTIONAL ARRANGEMENT FOR BRT- MUMBAI

14.1 Introduction

The Organisational form selected and institutional set-up has a great impact on the functioning of the Bus Rapid Transit (BRT) System. How well the Government is able to manage the BRT system will have long term consequences for the quality of Public Service and the sustainability of the system. As the setting up of management structures and new government institutions can take time, this process has to begin simultaneously with the physical and operational design process.

Deciding which or what type of agency will be responsible for administering the new BRT System is often a contentious process. The earlier this issue can be settled, the faster the BRT System can be designed and implemented. The legal process to form the management entity will take time, so the process need to start long before the planned launch date of the system.

As overall planning, development, growth, regulation and functioning of the transport system in a city, encompasses many more functions and activities than running a BRT system, an institutional set up is suggested to be developed, to facilitate management of BRT with focussed attention and without treating BRT operation as just another responsibility of a large department handling much complex and time consuming issues.

14.2 Present Scenario

The urban transport system interalia envisages development of urban transport master plan, detailing transport infrastructure requirements besides the quantum of public transport vehicles; operational manpower and its training needs; vehicle inspection and certification facilities etc. It also lays down system related policies and standards and regulates transport operation as per motor vehicle rules.

It encompasses registration of vehicles; issue of driving licenses; fixing of public transport tariffs; administration of motor vehicle taxes; enforcement of vehicle emission related norms, conducting of traffic demand assessment through surveys; etc besides host of other activities.

While some of the transport related activities are performed by the local government, a host of them fall under the purview of State and the Central Governments. These activities are divided in a number of departments making coordination difficult, time consuming and non-responsive to the expectations of the citizens. Mumbai city transport system is no exception to the above situation.

Legally, 74th amendment of the constitution devolves the responsibility of urban development and therefrom the urban transport as one of the primary responsibility of the State/Local Governments.

Currently transport related functions in Mumbai City, as in any other Indian Cities, performed by various agencies are listed in ***Table 14.1.***

Table 14.1- Institutional Involvement in Urban Transport System

Sl. No.	Organisation	A Few Urban Transport Related Functions
	Central Government	
1	Ministry of Urban Development Government of India (GoI)	• Urban Transport Policy formulation
2	Department of Road transport and highways, GOI	• Construction and maintenance of national highways • Motor vehicle act., its preparation, notification and administration
3	Ministry of Petroleum and Natural Gas, GoI	• Regulation of Transport fuel supply, quality and price
4	Ministry of Environment and Forest, GOI	• Setting Vehicular Emission Norms
5	Central Railways (CR)	• Operation of intercity railway services and part of Mumbai Suburban Rail System (CST-Karjat)
6	Western Railway (WR)	• Operation of intercity railway services and part of Mumbai Suburban Rail System (Church gate - Virar)
7	Mumbai Rail Vikas Corporation (MRVC)	• Undertaking Coordinated Planning and Implementation of Mumbai Suburban Infrastructure Projects
8	Mumbai Port Trust (MbPT)	• Providing Sea Transport
9	Airport Authority of India (AAI)	• Providing Air Transport
	State Government	
10	Mumbai Metropolitan Region Development Authority	• Planning and Coordinating Authority for MMR
11	Public Works Department (PWD), GoM	• Construction and Maintenance of State Roads
12	Traffic Police (TP)	• Traffic Enforcement in Greater Mumbai
13	Transport Commissionerate (TC)	• Grant Licences, Issue permits and Collect MV Taxes
14	Department of Environment, GoM	• Air quality assessment and monitoring - vehicular emissions related.
15	Department of Labour, GoM	• Administration of Labour Act/ Laws such as Transport Workers act, Minimum Wages act, etc.
16	Department of Finance ,GoM	• Budget and Finance related functions for transport system.

Sl. No.	Organisation	A Few Urban Transport Related Functions
17	Department of Transport ,GoM	• Transport Policy Formulation and its Administration
	Local self Government	
18	Municipal Corporations Greater Mumbai, Thane, Navi Mumbai etc	• Road and related Infrastructure
19	Municipal Councils Vasai, Virar, Panvel etc	• Road and related Infrastructure
20	Municipal Transport Undertaken BEST,TMT, NMTC, KDTC, etc	• Operation of bus services in respective municipalities

It is observed from above table, that a number of agencies control urban transport system. Such multiplicity of control leads to:

- Inter organisational conflicts where disagreements can over-ride shared values between agencies.
- A need for very high level of coordination
- Fragmentation of functional responsibilities
- Lack of local expertise
- Lack of focussed attention and integrated approach in planning, budgeting, operation and control of the urban transport.
- “Passing the Buck” approach to stakeholder needs, expectations and grievances from urban transport system.
- Urban planning and transportation issues lacking in a coherent approach.
- Multiplicity of command and control.
- Paucity of expertise in innovative approach to raising finances for public transport.

Even the World Bank, in one of its reports published, noted that “Institutional Weaknesses” are the sources of many observed failures in urban transport in developing countries. This is applicable to Mumbai and its Region. In this context, it is more than imperative that institutional aspects are addressed to overcome the present deficiencies meet and manage the challenges that are likely to be posed by the introduction of the BRT system.

14.3 Options available for Institutional Arrangement

There are five options about the management of BRT operations

- BEST- Existing System
- BEST- An Independent self sufficient department
- BEST- Establishing subsidiary organisation
- Special Purpose Vehicle (SPV) - BEST ,MMRDA, MCGM and MCT
- Special Purpose Vehicle (SPV) - BEST ,MMRDA, MCGM,MCT and Private Sector Participation

To finalize Institutional arrangement, the merits and demerits, under each of the options need to be analyzed.

14.3.1 BEST- Existing System

Advantages:

- The experience of BEST would be available for BRT services
- The increased fleet, will give scale economics to BEST
- There would be better coordination between BRT and conventional bus services
- The infrastructure and other costs for BRT would be considerably reduced, as they can make use of BEST infrastructure.
- Regulation by government would be become easy since they have to deal with one agency only.

Disadvantages:

- BRT is a premier service, compared to conventional bus. By clubbing both the classes of services, quality of BRT will come down.
- The BEST with a history of over 5 decades, operates with traditional systems, manual methods, and high man power costs. BRT will suffer all such disadvantages.
- New Technology with respect to office management, cash collection, fare systems etc is easier for a new organization
- BRT has to follow all the union agreements of BEST with respect to wages and other privileges. It is a heavy burden to the new business.
- The BEST may not be able to pay attention to BRT services due to high volume of conventional buses, its revenues, its staff and resultant problems.

14.3.2 BEST- An Independent self sufficient department

Advantages:

- The expertise of BEST would be available to BRT operations
- There would be better coordination between BRT & conventional bus services
- Regulation by government will become easy
- Special attention would be available to BRT, as a new departments is created, to look after the BRT services
- Infrastructure cost would be less, as it is used by both by conventional and BRT buses.

Disadvantages:

- Though a new department is carved out, from union point of view, it is a single entity; hence all old agreements will become applicable to the new BRT department.
- Though a new department is carved out, the systems and procedures of BEST will be imported into the new department.

- Managerial innovation will be restricted.
- Top management attention will be more towards conventional buses, because of its size, revenues and problems.
- The capital resources to BRT, has to come from MCGM. They may dwindle in course of time. Further, BEST may also share the same resources. Hence, there could be competition and conflict between BRT and conventional services for requirement of additional capital.

14.3.3 BEST- Establishing subsidiary organization

Yet another option for BEST is to establish a subsidiary organization to manage BRT operations. This option may ensure more operational autonomy for BEST to manage the special services of BRT. However the following advantages and disadvantages are envisaged in this system:

Advantages:

- The expertise of BEST would be available to BRT operations
- There would be better coordination between BRT & conventional bus services
- Regulation by government will become easy
- Special attention would be available to BRT, as a new organisation is created, to look after the BRT services
- Infrastructure cost would be less, as it is used by both by conventional and BRT buses.

Disadvantages:

- Though a new organisation is carved out, from union point of view, it is a single entity, hence all old agreements will become applicable to the new BRT subsidiary organisation.
- Though a new organisation is carved out, the systems and procedures of BEST will be imported into the new subsidiary organisation.
- Managerial innovation will be restricted.
- Top management attention will be more towards conventional buses, because of its size, revenues and problems.
- The capital resources to BRT, has to come from MCGM. They may dwindle in course of time. Further, BEST may also share the same resources. Hence, there could be competition and conflict between BRT and conventional services for requirement of additional capital.

14.3.4 Special Purpose Vehicle (SPV) to be established by - BEST, MMRDA, MCGM and MCT

Advantages:

- New work culture can be introduced with modern management techniques

- Full autonomy to the organization in all aspects, covering operations, wage structure, personnel polices etc
- Better attention to operations, service quality and customer relations
- New systems for fare collections, Fare polices etc can be implemented, with better marketing approach and customer orientation
- Scope to attract capital resources, to expand to full potential as MMRDA is one of the promoters.
- The expertise of BEST may be available as BEST is one of the promoters.

Disadvantages:

- There could be problems of Co-ordination with BEST with respect to feeder services operations
- Cost of infrastructure will be high, in the initial periods
- The SPV may require subsidy in the initial period
- The Government may find yet another organization, for institutional Co-ordination, which has become a major issue for transport sector management.

14.3.5 Special Purpose Vehicle (SPV) to be established by - BEST, MMRDA, MCGM, MCT and Private Sector Enterprise

In Addition to option listed under 14.3.4 Private Sector Participation will bring in managerial experience and expertise in to the SPV besides additional capital.

14.3.6 Recommendation

It may be seen that all the five options have some advantages and disadvantages. However the option IV Establishment of SPV with BEST, MMRDA, MCGM and MCT as promoters has been approved by the steering committee. Hence an independent SPV may be preferred option for managing the proposed BRT system.

14.4 Ownership of BRT BUSES

Ownership has vital role in ensuring effective and efficient service delivery to the customers.

Three options exist, to choose the most appropriate option.

(i) Hiring
(ii) Franchising
(iii) Own vehicles

Hiring of Private buses for BRT Option

This is a Public - Private feature adopted by many BRT firms, around the world. The hiring of Private buses, as a strategy can be adopted either by BEST or SPV who owns BRT operations.

The modern concept in Public Transport is to use Public sector for planning, monitoring and controlling of quality of services, while the private sector participation is used for execution, where it is effective and efficient.

Franchising of BRT Route

This method is widely followed in the western countries. However, the Motor Vehicle Act 1988 in our country does not provide "Franchising" as a method to mange Public Transport. Thus amending of State rules become necessary to adopt this method to manage BRT operations.

Own Vehicles

In a situation where private sector participation is not forthcoming as an economical and feasible option, there is no other way than owning the fleet for operations.
These issues are dealt in more detail in the chapter on Business Plan.

14.5 Institutional Set Up of SPV for Mumbai BRT

As discussed in the earlier paragraph, the SPV shall be a Public Sector Company. The administrative set up will be as follows:
The administrative set up of the BRT envisages its institutionalisation as a Special Purpose Vehicle (SPV) under the companies act 1956 incorporated as a public limited company comprising of the Board of Directors at the administrative level, the Chief Executive and other managers at the management level for its day to day management, including monitoring and control of private service providers provisioning and operation of the services.

The equity of the company may be shared amongst Mumbai metropolitan Region Development Authority (MMRDA), Municipal Corporation of Greater Mumbai (MCGM), Municipal Corporation of Thane (MCT) and Brihanmumbai Electric Supply and Transport Undertaking (BEST). On obtaining favourable financial results for 3 or 4 years of operation the equity may be offered to private sector and or to the public through initial public offer (IPO).

The composition of SPV is proposed as under

Board of Directors of Mumbai BRT Co.

Mayor, Municipal Corporation of Greater Mumbai	Chairman
Chief, T & C Division, MMRDA	Member

Municipal Commissioner, Municipal Corporation of Greater Mumbai	Member
Municipal Commissioner, Thane Municipal Corporation	Member
General Manager, BEST	Member

A professional having sufficient experience in urban development/Urban Transportation could be appointed as **Managing Director.**

The management of the BRT is proposed to be through a Chief Executive Officer (CEO) - designated as Managing Director. For effective provisioning of transport service, the SPV is proposed to perform the following main functions:

- Planning, regulation and operational control - network and route planning, services planning and scheduling, setting service quality, standard, monitoring and control of services, integrating feeder services and other transit services with BRT services.

- Data acquisition and processing - contracting of services for acquisition, communication, warehousing and processing of data for planning besides monitoring and control of services.

- Contracting of fleet operators - both for trunk line as well as feeder line operations in a transparent manner.

- Contracting of station management and revenue collection services - for on board as well as off-board fare collection - where-ever planned necessary equipment shall be owned and maintained by the private sector.

- Projects planning and management, coordination for maintenance of roads,

- Human resource management, legal and company affairs, administration, grievance handling, etc
- Financial services - preferably through a separate agency.

- Any other function necessary for the BRT such as marketing of BRT. Creating public awareness and support, selection of technologies, advising UMTA on tariff fixing/revising etc.

- The above mentioned set up of the SPV and the functions proposed to be managed by the SPV is expected to provide an optimal mix of Public Private Participation for operation and management of the BRT system.

It is also proposed that as the construction phases progressing, a strategic partner from the private sector could be inducted in to the SPV to take over the long term operation and maintenance of the BRTS. While the GoM could appoint the chairman, the strategic partner could come up with the managing director and professional managerial team in to the SPV.

The management structure of the BRT is proposed as shown in Figure 14.1:

Proposed Management Structure of BRT

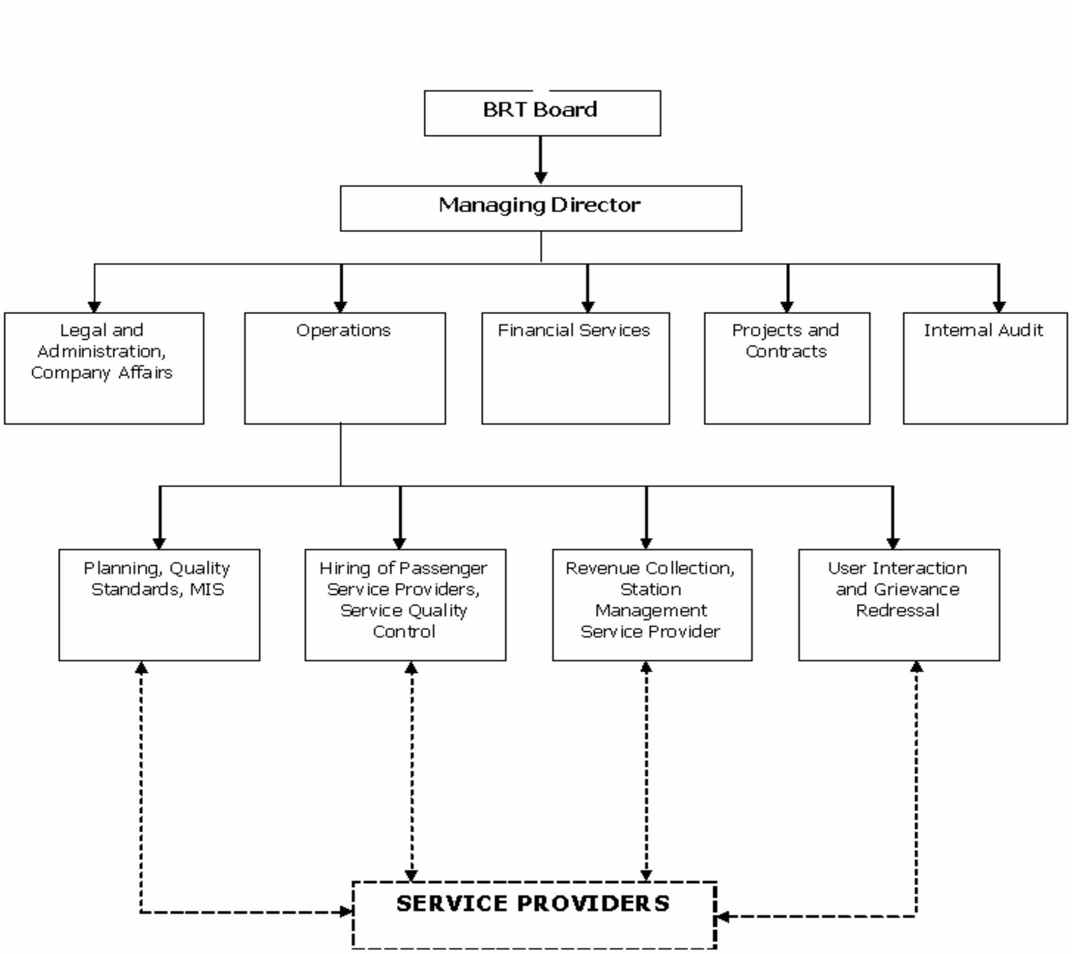

Fig: 14.1 Flow chart for proposed structure of BRT

14.6 Conclusion

It may be concluded that Public-Private Participation (PPP) is necessary to bring in the private funds; the business oriented concepts, professionalism and expertise of the private sector coupled with competition in the market; etc. It also brings in the collective bargaining power and professional expertise of the private sector to guide the authorities in tariff policy/structuring more realistically on the basis of scientific analysis and economic rational rather than the political or administrative conveniences. The system also retains planning, regulating, standard setting, quality assurance, and overall control of transport system for the satisfaction of all stake-holders in the hands of the Government i.e. the Government continuing to plan regulate and control the services while the private sectors investing, owning assets and managing the business.

It may further be noted that most of the successful BRTs, particularly in Latin America - the home of BRT - operate on PPP concepts.
The proposed institutional set up with private sector participation would help provide an effective and sustainable transport system, planned and regulated through the lowest possible level of government except initial stage of construction, based on competition and largely private sector operation, which reduces system costs and improve customer service in order to meet customer and governmental objectives for user cost, travel times, choice and safety.

Chapter 15.0
BRTS - Business Plans

15.0 BRTS- Business Plan

15.1 Introduction

The BRT system attempts to ensure, adequate, affordable, efficient, comfortable, reliable, well co-ordinate, safe and sustainable mobility for residents of Mumbai to jobs, education, recreation and other needs. The BRT System shall be an important element of the total Public Transport System especially operating on high density corridors and aiming at significantly improving the share of public transport system.

The BRT system - incorporated as Special Purpose Vehicle under the BEST or any other set up shortly termed as (SPV) - shall carry out its operations on business lines with sound commercial principles.

The main approach to BRT operations is through the Public Private Partnership (PPP) model. The SPV will be responsible for planning, setting standards and specifications, contracting services / bus providers, monitoring & controlling of quality of services. The physical assets like buses will be procured by private enterprise and contracted by the SPV as per a predefined scheme, while infrastructure like roadways, stations etc. will be developed by Mumbai Metropolitan region Development Authority, Mumbai Municipal Corporation and PWD through public funds.

The business philosophy of the SPV envisages that the operation would be customer driven and customer oriented. A passenger information system will be developed to regularly inform the customers about the operations and quality of services. The organization will endeavor to conduct "market research" periodically to keep in tune with changing customer needs and aspirations. The marketing mix (price, product, promotion & placement) and market segmentation shall be the basis for evolving business strategies.

The Business Associates (bus providers / operators) selected for BRT operations shall have a minimum fleet of about 100 vehicles. The bus providers / operators should have sufficient experience in transport sector and should have professional staff, which is qualified and competent, to carryout the business operations. While contracting bus providers the single bus owners shall be discouraged for BRT operations as it would be difficult to regulate them. The operators shall have long term interest in this business and own a viable fleet to sustain employment of professional staff. Similarly, other business associates for station management; data acquisition, communication, processing and warehousing; etc. shall have adequate expertise and capability in their respective fields.

The overall business plan of BRT aims at providing acceptable quality transport services to maximum number of commuters at affordable prices on a sustainable basis. It needs to be profitable for being free from any external influences. For the said purpose, overall cost of operating the BRT and the likely tariff structures besides its operational viability needs to be worked out.

In this section operational and other costs including revenues involved in operating BRT buses and providing related services are estimated and an indicative minimum fare per unit, for full cost recovery including reasonable return on equity is estimated and a tariff plan after evaluating various tariff plan options for BRT is brought out for consideration. The details are displayed in ***Volume - II, Annexure XV.1 to XV.4*** *respectively.*

15.2 Business Plan of the BRT

The business plan of the BRT system broadly envisages various functions / activities involved in operationalisation of its services. In that, the institutional set up of BRT, as discussed elsewhere, once firmed up shall be the key organization for undertaking all activities to meet its objective of providing efficient and affordable public transport services.

The policies of the Government generally aim at sustainable growth of public transport for providing affordable mobility even to the lower income citizens on one hand and cause other economic and fiscal benefits to the society on the other hand by way of reduced road congestion, faster travel, reduced air pollution and consequently lower expenses on health services, besides safer operations, etc.

The infrastructure requirements and its costs are too large to allow the public transport to be affordable to the poor people. In view of above, the investments in road infrastructure, bus stations, bus terminals, etc., are made by the Governmental agencies. Similar arrangements are envisaged for terminal land & buildings. The maintenance, replacement and up gradation of the above facilities are also planned at public cost. The cost of ticketing equipment, data acquisition & communication equipment, passenger information systems etc. are included in the business plan.

The BRT – SPV shall be responsible for efficient use of the facilities ensuring their continued serviceability.

15.3. PPP Options for induction of buses

Buses are planned to be provided by private bus owners / operators as per specifications etc. laid out by the BRT- SPV:

a) **Gross cost system**

Buses could be hired on “gross cost” basis, simply stated on “kilometers operation” basis (km scheme) - wherein the bus owner purchases the bus, owns it, operates, maintains and replaces it at his cost besides meeting all statutory, regulatory and legal requirements associated with the bus, its ownership and operation. He operates the bus on routes, schedules, and terms / conditions as stipulated by the BRTS. The bus operator is paid for his services on the basis of kilometers operated by his buses. Even out of the scheduled km operations, the quantum of kilometers operation would be linked to passenger load factor (LF) – reduced LF reducing his quantum and vice-versa. His payments are also planned to be linked to agreed fare box revenues. These arrangements are expected to restrain him from operating larger quantum of bus kms without picking up all or some passenger’s enroute. Such terms and conditions are proposed to be incorporated in the tender documents / agreements prepared for engagement of bus operations in a transparent manner.

User Tariff Collection

User tariff revenue collection for above operations could either be arranged by the BRT staff or outsourced, through open tenders, from a third party. As in-house user tariff revenue collection is charactrised by the problems of over-staffing, absenteeism, inefficiency and high labour costs, outsourcing this operation is a better option. Outsourcing charges could be decided either per passenger ticket issued basis or as a fraction of revenue collected. As the charges for fare collection are significantly lower than the per passenger fare, the service provider may be tempted to resort to misappropriation (this situation may occur even when revenue collection is made by in-house BRT staff). The terms and conditions set out for engaging the service providers, have to take care of this aspect, possibly by correlating revenue generation – the range of planned quantum of trips, the fare level, etc. considered as the basis. The service provider be engaged through a competitive and transparent process at least cost. Outsourcing or in-house collection of fare revenues is conducive to avoid complicated procedures for apportioning fare revenues collected through off-board ticket sale (through advance booking conductors or through off board tickting machines or both), amongst the number of bus operators. It also helps in providing integrated ticketing arrangement between BRTS, feeder line bus if any / BEST operation so that the passenger is required to buy ticket once for his journey. It also helps in trouble free / dispute free apportioning of revenue collected from multiple journey tickets and or monthly / seasonal travel passes. In this system, whenever the costs of social services provided by the BRTS are reimbursed by the beneficiaries, the same does not become a bone of contention for sharing amongst various service providers. Similarly, payments for expenses on common services would be directly made from the revenues instead of apportioning it amongst the service providers in any adhoc or disputable manner.

b) **Net cost system**:
The other system of outsourcing bus services could be the "net cost" basis wherein the bus operators pay administrative and operational control (AOCC) charges or system management contribution to the BRT – SPV or the SPV reimburses certain amounts to the bus provider to subsidize the uneconomic operations . In this system, the bus provider, in addition to owning, operating and maintaining buses as in KM scheme, also collects fare revenues and pays certain pre-determined AOCC charges to BRT – SPV or gets paid certain amounts by the SPV. Although the system is simple to operate and manage with full responsibility of providing specified quality services and financing resting with the bus provider, it is fraught with the problem of providing integrated ticketing (though to a lesser extent here), distribution of certain common revenues and expenses discussed in earlier scheme. Also, this system is conducive to cause avoidable rash driving and consequential safety hazard due to excessive competition amongst bus providers for picking up more and more passengers as obtained in Delhi's blue line bus system. While there is no problem of revenue leakage in this system, the BRT – SPV is fully deprived of the vital travel / operational information data required for planning, monitoring, controlling and upgrading the public transport system as it currently happens in Delhi for private operators' buses Specially designed / high cost technology based solutions could possibly mitigate the said problem to some extent.

c) **Own and Operate system**
The third alternative of providing buses is that the BRT – SPV owns, operates, maintains buses as is currently done by the STUs – whose physical and financial performance records suggest to desist following this route.

Considering the above discussions, the gross cost system simply stated the Kilometer scheme of hiring buses(option "a") with outsourced revenue collection appears better than other options. The scheme also facilitates integration of bus station / terminal management; passenger information management; and data acquisition and communication activities with revenue collection – all being closely related physically and operationally.

15.4 Vehicle Tracking and Monitoring

An automatic vehicle tracking system for monitoring and control of bus schedules & operations is contemplated for the BRTS. The system could use either G P S based or R F I D technology. In view of the versatility of GPS based system in vehicle tracking, PIS, MIS and even in automatic fare collection system, the GPS based system is proposed for Mumbai BRTS.

In this system, GPS / GPRS, the Vehicle mounted unit (VMU) keeps track of vehicles on a continual basis and communicate the data through the dedicated communication lines to the central control room, where not only vehicle movement is displayed on a monitor but report about vehicle delays etc., is also brought out by exception for necessary corrective action. The information so generated could further be used for future planning and scheduling operation. Details of the said system are discussed in the chapter on ITS applications.

15.5 Fare Fixation and Collection System

15.5.1 Tariff Structuring

a) Technical fare is the fare worked out on the basis of reasonably achievable physical performance levels in respect of various parameters such as vehicle productivity, traffic demand effecting bus load factor, fuel efficiency, etc; current levels of costs of input materials and manpower, etc. Technical fares, varying with price variation of the input cost elements, are proposed to be computed on regular basis for effecting changes in customer fares.

b) Customer fare is the fare charged from bus commuters. It is worked out after adding certain amount towards unavoidable contingencies to the technical fare. Customer fare thus should change with technical fare for cost recovery or profitability and sustainability of the BRT system. However such changes might be required very frequently particularly in view of wild fluctuations in fuel costs, etc. As such frequent changes in customer fare are neither desirable from organizational credibility point of view nor from commuter acceptability, the customer fare, at the most could be varied twice a year, though efforts be made to restrict it to once a year. This long gap may however leave certain costs uncovered by fares causing losses to the system and affecting quality of service.

c) The contingency charges added to the technical fare should hence be a reasonable amount and credited to a separate fund called contingency fund. All deficiencies in revenue due to fluctuating costs, travel demands, any other performance parameters etc. be met from out of the contingency fund. While actual level of contingency amount could be worked out by a detailed study and analysis of past data of input costs, as available, at this stage it may be taken in the range of 5 to 10% of the technical fare depending upon the factors discussed above. For example, if contingency is taken as 8% (middle of the said range), the customer fare should be at least 1.08% of technical fare.

d) Assuming the cost per passenger kilometer (ppk) of BRT services as 'x' paise for BRTS buses, the customer fare could be planned as 1.08 times of 'x' = 1.08x paise, out of which 0.08x paise per passenger kilometer be credited to the contingency fund.

As fares chargeable from commuters have to be in easily understood user friendly terms i.e. fare between certain origin – destination points / fare stages, the fppk be accordingly converted to passenger friendly system.

15.5.2. Tariff Policy and fare Structuring

a) For long term sustainability of the BRT system and its sub-systems like operating contracts, the tariff structure should ensure not only full recovery of all costs of inputs but should also cater to wild fluctuations therein. The fare structure should not be so high as to cause hardships to low income commuters and in turn cause socio-political problems. A bad tariff policy hence may undermine the long term viability of the BRT system on one hand or lead to social turmoil on the other hand. Though efficient BRT system makes it possible to maintain low fares and still keeps itself profitable, an optimal fare be fixed in the beginning of the system.

b) As the technical / customer fare is estimated on the basis of input costs, it does not consider its affordability by the commuters and the latter's effect on demand elasticity. The optimal fare level on the other hand is arrived at after considering system profitability, customer convenience and ridership. In the event of optimal fare being less then customer fare, the BRT system design has to be changed till both fares are almost at similar levels.

c) The tariff policy formulation and fare structuring therefore should decide / lay down guidelines for the following amongst others:

- Fare level
- Fare adjustments- quantum and periodicity
- Discounts on fares- concessional fares
- Fare types - Flat fare, distance based or time based
- System revenue estimates

d) On the basis of operational costs the customer fare level is proposed to be worked out for BRT buses and the optimal fare level be fixed at or above this level for financial sustainability of the BRT system on long term basis. The fare level be suitably adjusted for cost fluctuations for upto two times a year, as per a scientifically developed formula. Further as the fare level worked out above does not consider fare concessions or discounts to various categories of commuters (a number of categories of commuters are charged concessional fares with concessions ranging upto 100% of fares by BEST), appropriate financial compensation is proposed to be timely made to the BRT system by the beneficiary, in these cases mostly governmental authorities. The compensation clause and the formula therefore would form an integral part of fare policy. Similarly discounts offered for multiple trips, for off-peak period travel, etc need to be suitably incorporated in fare structuring.

e) Further effect of fare variation, w.r.t. customer fare as base, on travel demand, total BRT system revenues, and its profitability, fleet deployment etc. be worked out taking travel demand elasticity of one, in the traffic demand model.

f) The current fares charged by public transport buses – alongwith the percentage of passengers in various trip lengths for Mumbai City are as given in Table 15.1

Table 15.1 - Current Fare Structure, Patronage, Revenues and Fare Per Passenger Kilometer (FPPK)

Range of Trip Length kms	***%age of Passengers in each range***	***Fare Charged (Rs.)***	***Revenue (Rs.)***	***Fare paid passenger km***
		Ordinary	***Ordinary***	
A	***B***	***C***	***D (B X C)***	***E= A* x B***
0-2	*26.54*	*3*	79.62	53.08
2-3	*22.04*	*4*	88.16	66.12
3-5	*53.70*	*5*	158.2	158.2
5-7	*12.04*	*6*	72.24	84.28
7-10	*4.78*	*8*	38.24	47.8
10-15	*2.18*	*10*	21.8	32.7
15-20	*0.55*	*12*	6.6	11
20-25	*0.17*	*14*	2.38	4.25
25-30	***0.05***	*15*	0.75	1.5
30-35	***0.01***	*16*	0.16	0.35
Total	***100***		**468.15**	**459.28**

Notes :

1. Passenger travel entitlement taken upto the end of trip length for corresponding fares

2 .FPPK for ordinary buses assessed as : 468 / 459 = 102 paisa

3. Above FPPK is worked out on the assumption that all passengers are full fare paying passengers. However, BEST provides upto 100% fare concessions to a number of categories of passengers. The range is understood to be 10 – 20%. While working out revenues, it could be reasonable to assume a minimum of 10%

passengers paying nil fare and another 10% paying only 50% of applicable fare.

4. *Although overall Load factor in BEST is 0.61(FY 07) Load Factor (LF) of ordinary buses may be taken as 0.70 for revenue assessment purposes, however, LF of low floor buses is likely to reduce if there is fare difference. Accordingly, a correction be made in revenue collections assuming travel demand elasticity as one.*

5. *Average passenger lead in BEST is 6.79 kms (FY07)*
   From the above table, currently applicable average fare per passenger kilometer is assessed as 102 paise (for ordinary buses,). Fares worked out per passenger kilometer are on the assumption that all commuters are in full fare paying category, as data about concessional fare passengers is not available. Application of such concessions would reduce.

   i) The BRT system elements may be re-designed with

   a. *Investments in fare collection / verification equipments, data acquisition and communication system equipments, passenger information system facilities be made by the station management and revenue collection contractor. This is likely to increase the fare per passenger km.*
   b. *Ultra low floor bus costing about Rs.55 lacs could be selected for the BRT system. While this option increases the fare level, it provides better system image, improved loading / alighting convenience even in mixed traffic and non-BRT routes. About 10 % of the bus low floor standard length bus fleet is proposed to be air conditioned to attract private vehicle users to BRTS buses.*
   c. *Higher level of ITS system such as on line GPS based vehicle tracking system for obtaining data even on non-BRT corridor operation of BRT buses is proposed.*

   ii) The technical fare level for the designed BRT system has been worked out for full complement of BRT buses in 1st year of operation of BRT. But with the reduced travel demand if any in the initial years, the BRT operation could face viability problems.

   iii) Charging current fare level of 102 paise ppk, may help BRT absorb some of the social costs or discounts for various categories of passengers.

g) ***Flat fares versus distance or time based fares****:*

Based on the above unit fares, the fare structuring could be distance based, time based or a flat one. The merits and demerits of the three structures are discussed herein.

*i. **Flat fare** – implies that same fare is charged to a customer regardless of the distance traveled. Flat fares are equitable if low income group travelers, staying in outskirts of the city travel long distances to the places providing employment opportunities, and accessibility to health, education and other facilities located mainly in and around the city centres. Flat fare would help achieve social equity as flat fare would act as cross subsidy from higher income residents in central parts of the city to lower income residents located in sub-urban areas. Flat fare permits use of simpler fare collection systems/technologies and does not involve any travel distance verification on exiting thereby avoiding queues and improving system efficiency. Ticket-less option such as coin-based machines may be used in flat fare system. In fact, flat fares reduce the level of complexity in fare collection by an order of magnitude.*

*ii. **Distance based fare** structure most closely mirrors the operating costs and thus provides a truer measure of expenses for the system operators. This does not involve any cross subsidy and therefore the low income residents of sub-urban areas end up paying up more and spending large portion of their household income on travel. Distance based fare structure requires more sophisticated fare collection and fare verification system which cost more and cause customer queuing.*

*iii. **Time based fare** structure buys the right to enter / travel in the system for a given time. This type of system is used as a mechanism for providing free transfers say between trunk line and feeder line particularly where such transfers are not physically integrated. Such fare structures are also used for charging peak period and off-peak period tariffs to facilitate even spread of travel demands during the day. Time based travel restrictions also prevent unwanted loitering of some customers in the premises of the system. Time based tariffs like distance based tariffs require more sophisticated ticketing system technology.*

iv) An optimal combination of above fare structures is proposed to be selected by reducing the number of fare stages to a maximum of 6 on each of the routes. Before a final decision however efforts be made to explore the possibility of having integrated fares with the BEST services as also with other transport modes like metro rail etc.

15.5.3 Fare Collection System

The Fare collection system selected for BRT operations would be "on board" system for BRT on surface. Thus every BRT vehicle shall have a conductor, who will collect the "Fare" as approved by the management. However, at Terminals and Bus stations, where there are large number of passengers, the "off board" fare collection

system, would be adopted. Thus "off board" fare collection system would be restricted to only locations of high traffic density. Suitable machines for "Fare collection" would be installed at terminals / Bus stations.
In case of elevated BRT corridor however, fare collection would be "off board" only.

The "fare collection system" is proposed to be "out sourced" by following competitive tendering. A suitable agency be appointed to collect "fares" from all BRT buses and fare revenues so collected be deposited with an independent financial services company, who would then make payment to the service providers as per rates, terms and conditions for providing such services in order of priority communicated by the BRT administration.

Every conductor, after completing his spell of duty for the day, hands over not only cash realized during his spell of duty but also "data" stored in the ticket-issuing machine. The fare collection agency shall deposit the cash in the bank and the data (way bills etc) collected from ticket issuing machines shall be downloaded into the central control room server for further analysis. This data communication may aiso be done continuously using GPRS compatibale Electronic Ticketing and Verification Machines(ETVM) The data, which includes denomination wise ticket sales, number of passengers, load factor at each stage of the route etc are stored in the computer, for further analysis. Based on this data, Management Information System (MIS) section of BRT would prepare route wise analysis, which is a basic document for constant monitoring and future planning of operations. As soon as possible direct transfer of data from ETVMs / ticketing equipments to the designated sub system/central control room through CDMA / GSM / GPRS / ZeeBee etc be explored. Data collected as above will be of immense help for route restructuring, route analysis, extension / curtailment of routes etc, hence the need for proper storage and retrieval of this "data base" and its management becomes crucial.

15.5.4 Checking Revenue Leakage

Conductors" of BRT vehicles would collect "fares" from passengers for nearly 16-17 hours daily, during vehicles operatinons. Considering that collection of "fares" leaves scope for revenue leakage, a suitable "ticket less travel checking system" be established.

As the "fare collection System" is out sourced, the agency selected for this purpose, should design a proper checking system for preventing possible revenue leakages. The agency would provide requisite manpower for such services as an integarl part of the contract for "fare collection".

In addition to the arrangements made by "fare collection" agency for "checking of revenue leakage", the BRT administration has also to make its own "checking squad" as a cross check, to ensure full realization of "fares". This should be considered as a "quality" check, on the agencies' personnel, on a sample basis. The "checking squad" personnel should possess requisite professional skills and proven integrity to carry out their duties effectively. GPS compatible ETVMs would provide assistance in ticketless checking as also in issue of appropriate denomination tickets.

15.6. Integration of BRT with other transit services – physical and ticketing integration

a. For an efficient operation of the public transport system and for providing acceptable and convenient mobility to the commuters , it is desireable to identify all the operators in the system, understand their roles and integrate all modes with the ultimate goal of providing a system that could be safe, efficient, clean and fair to all.

b. Keeping the above objectives in view, the operating characteristics of conventional bus system, and other modes currently providing urban transport services are reviewed and their strengths and weaknesses analyzed. Appreciating their roles, various transit modes are optimally integrated with the BRT System to provide quality of service and route design that is desired by the commuters, requires least travel time, involves minimum wait for a bus and least number of transfers during the journey.

c. BRTS is thus aimed to be an important sub-system of Public Mass Transport System for providing customer-oriented transit delivering fast, comfortable and cost effective urban mobility by :

- Providing sufficient system capacity to handle expected passenger demands.
- Minimising travel time by improving vehicle operational speeds and station dwell time.
- Minimising waiting time by improving service frequency.
- Minising number of transfers to travel between various origins - destinations , such that all modes of MPTS not only co-exist with the proposed BRTS but also integrate in an efficient, effective and acceptable manner with the operations plan and route structuring of BRTS.

d. For providing integration of transit modes, the system design and provisioning of physical facilities conducive to achieve the above objectives have been accordingly modeled.

e. The routes have been structured as 'trunk routes

f. Physical integration of various types of transit modes / routes terminating at / passing across the BRTS corridors , a central terminal with all the required facilities is proposed at the BKC, where transfer from BEST buses, the IPTs, and the private vehicles etc would seamlessly occur. Intra BTRS routes transfers would similarly occur there.

g. BEST and other buses operating on suburban routes would have access to the other bus terminals, where all facilities including those required for seamless transfer from one mode to another are provided. These terminals are proposed at / near the ends of the EEH and the WEH BRTS corridors, at suitable intermediate locations, etc. Some of the proposed locations for terminals include the Hiranandani complex, existing truck and bus terminal at Dahisar, Ghatkopar at the end of the LRT line, BKC, etc.

h. For efficient and customer oriented operations of any multi-modal urban transit system, integration of their physical facilities, their ticketing system, their service planning, monitoring and passenger information systems is an essential ingredient. The BRTS has accordingly been designed to cater to these requirements.

i. As discussed else where in the report, the BRTS – SPV would focus mainly on planning, setting standards, contracting, monitoring service quality, coordinating with various stakeholders, service providers and the governmental agencies besides outsourcing almost all the services from private firms/persons. The BRTS-SPV is thus proposed to be a thinly manned organization of highly professional persons. The man power of the BRTS-SPV is proposed to be restricted to a maximum of 0.5 employees per bus. Efforts be however made to manage the system with about 0.3 employees per bus for cost effectiveness and sustainability of the system.

j. At the apex level MMRDA set up takes care of the overall city level planning, financing and coordination activities of the transport system. The BRTS effectively participates there. On the other hand the BRTS board comprising of the representatives of the MMRDA, the Brihan Mumbai municipal corporation, BEST, Thane Municipal Corporation and chaired by the Mayor of the BMC - a public representative, would effectively help in systemic and institutional level integration of various transit modes.

k. Buses are planned to be provided by private bus owners / operators as per specifications etc. laid out by the BRTS where the bus owner purchases the bus, owns it, operates, maintains and replaces it at his cost besides meeting all statutory, regulatory and legal requirements associated with the bus, its ownership and operation. He operates the bus on routes, schedules, and terms / conditions as stipulated by the BRT-SPV. The bus operator is paid for his services on the basis of kilometers operated by the buses hired. This system facilitates integrated planning of service quality, service frequencies, and in formulating an integrated operational schedule in the form of a time table.

l. Fare revenue collection for above operations is planned to be outsourced, through open tenders, from a third party. Outsourcing collection of fare revenues as above is conducive to avoid complicated procedures for apportioning fare revenues collected through off-board ticket sale (planned at the terminals initially), amongst the number of bus operators inducted into the BRTS at any time. It would help in providing integrated ticketing between BRTS and BEST bus operation so that the passenger is required to buy ticket once for his journey. It also helps in trouble free / dispute free apportioning of revenue collected from multiple journey tickets and or monthly / seasonal travel passes. In this system, whenever the costs of social services provided by the BRTS are reimbursed by the beneficiaries, the same does not become a bone of contention for sharing amongst various service providers. Similarly, payments for expenses on common services would be directly made from the revenues instead of apportioning it amongst the service providers in any adhoc or disputable manner. A system of ticketing integration with BEST's urban services allowed to be operated on BRTS corridors if any and or as feeder services, would also be similarly designed.

m The other system of outsourcing bus services on the basis of administrative and operational control (AOCC) charges by the bus provider where, in addition to owning, operating and maintaining buses as in KM scheme, also collects fare revenues and pays certain pre-determined AOC charges to BRT – SPV. Although the system is simple to operate and manage with full responsibility of providing specified quality services and financing resting with the bus provider, it is fraught with the problem of providing integrated ticketing, distribution of certain common revenues and expenses discussed in earlier scheme. Also, this system is conducive to cause avoidable rash driving and consequential safety hazard due to excessive competition amongst bus providers for picking up more and more passengers. In this, the BRT – SPV is fully deprived of the vital travel / operational information data required for planning, monitoring, controlling and upgrading the public transport system as it currently happens in Delhi for private operators' buses. In view of the said deficiencies the later system has not been selected for Mumbai BRTS.

n. The fare collection and ticket verification system selected for the BRTS would integrate not only ticketing, but also revenue distribution and data collection and ware-housing besides analysis etc. for service quality monitoring on day to basis and planning/growth of services in the long term.

15.7 Setting up of Common Utility Offices at Terminals / Major Interchange Points

a. Six major terminals have been planned for the BRTS to provide seamless transfer of passengers from one system to another. There are five terminals at the corridor ends and a central terminal at BKC to provide common facilities for parking and frictionless circulation of vehicles, private as well of public, boarding and alighting platforms, passenger circulation/resting spaces and conveniences, off-board ticketing facilities, route wise time table display boards, passenger information and enquiry counters, stalls and canteens, etc besides office spaces for the service providers. Crew rest rooms and cash collection centers for the third party fare collection agency be also planned.

b. Facilities for idle parking of buses, their washing and cleaning, fuelling, minor repairs etc. are proposed to be provided.

c. Other built up spaces for servicing common utilities such as collection of bills for electricity and water, taxes etc may be provided. Offices for station management, service quality checking and monitoring staff etc have been provided.

d. Shops for general commuter needs have been planned besides commercial utilization of the available space for offices etc to generate revenues. Details for the later aspect would be separately worked out on PPP model.

15.8 Cost Estimates

15.8.1 Operational Investments and Cost Estimates

The operational investment estimates of BRT system are worked out on the basis of the following business and investment plans:

a) All infrastructural investments are made by the government and its agencies. In that, all investments in pre-feasibility project studies, project design, laying/ re-laying and construction of roads and related facilities like bus stops, bus stations, bus terminals, road intersections, road over bridges, pedestrian facilities, parking spaces, lighting, road markings and signage's, etc are made by the government agencies without any burden on BRT. Similarly investments in land acquisition, land development and construction of buildings for bus terminals etc are also made by them. Above infrastructure is maintained at their costs.

b) Investments in fare collection / fare verification equipments including their maintenance initially planned only for bus terminals are funded by the BRT-SPV. Similarly data acquisition and communication, passenger information facilities are provided, by the BRT-SPV for their acquisition and/or maintenance.

c) Replacement investments for above are also to be made on similar basis by the BRT-SPV

d) However, on working out costs, revenues and system profitability, if reasonable surplus is generated, then some of the initial investments, replacement investments, and/or maintenance costs may be charged to BRT and the BRT system re-designed accordingly. Similarly if costs far exceed the possible revenues of BRT system at affordable fare levels, then also the system design such as bus technology selection etc need a re-look and be redesigned using lowered down technology. These issues could be considered after making an initial assessment of costs and revenues.

e) The investments required for fare collection equipment, data acquisition and communication equipment, passenger information system etc is estimated at Rs. 1969 lacs which may be financed in the ratio of 1:4 as equity to Debt. This equity of Rs 400 lacs would be provided by BRT-SPV.

f) For a initial bus fleet of 564 standard buses in the year 2013 the investment requirement works out to Rs.318.15 crores and additional buses will be procured over the study period under Operational & Maintenance Head.

g) To maintain a lean BRT with a lower capital base the buses are planned to be hired on rates per kilometer operation on competitive basis preferably from established companies/associations of existing transport operators/cooperative societies and or individuals offering a minimum of 100 buses. This is required for ease of managerial and operational control by the BRT by dealing with a few organizations rather than a large number of fragmented single bus owners. The terms and conditions for hiring shall include rewards and penalties related to quantifiable and easily measurable service quality and revenue enhancing performance parameters, so that the operators are adequately motivated for revenue growth and delivery of quality service. The buses provided shall conform to the specifications finalized by the BRT.

h) Fare collection may either be done by the bus provider or by an independent agency. In the earlier case the bus operators would only have entire data in fragmented form depriving the BRT management of vital information required for future planning and growth of the BRT system. Even monitoring of service quality may be difficult in absence of such data. On the other hand, the fare collection system assigned to third party on competitive basis, along with bus station management, data acquisition and data communication besides passenger information system management on bus stations, would avoid such a situation. While working out operational costs, the later option i.e. out sourcing revenue collection through an agency different from bus providers is considered.

i) As a lesser number of persons are expected to board from a large number of bus stations/stops, off-board fare collection involves heavy investments in fare collection/verification equipments, leading to increased costs and fares, initially, on-board fare collection is considered with additional off-board facilities at terminals. Should however, in due course, the trip intensity and system profitability, warrants use of off-board ticketing the same could be considered.

j) Investments in central control room facilities for on line tracking of vehicles, office computer hardware and software, auxiliary vehicles, office equipments is considered to be made by BRT.

15.8.2 Distribution of Revenues

a) Following assessment of system profitability, it would appear that all the system costs as worked out earlier could be paid from out of fare box revenues distributed in a fair and transparent manner amongst the service providers, with adequate checks and balances in place for stage-wise verification of costs, revenues and payments, in accordance with clear set of rules and procedures.

b) As discussed earlier, all fare revenues would be collected by an independent agency, and deposited with an independent financial services company, preferably a bank, who then makes payment to the service providers as per rates, terms and conditions of providing such services in order of priority communicated by the BRT administration.

The terms and conditions of inviting competitive bids in respect of various services have to be carefully drafted for ensuring fair play, ease of implementation, encouraging improvements in service quality and penalizing defaulters in an exemplary and transparent manner. The contracts should provide handsome incentives for improved performance. The incentive process/scheme be transparent, clear and simple to interpret/understand. It should last for the entire contract period irrespective of change in administrative or political set ups. While entering into "quality incentive contracts" with the service providers, effective mechanism to encourage them to deliver excellence in service be stipulated e.g. quality incentive contract would indicate how operators performance is tied to his financial compensation.

Annexure XV.1

Operational Costs, revenues, profits/Losses(-) for Mumbai BRTS

	Financial Year wise details (FY 2014 is Financial Year 2013-2014 and so on)																		
Sr. No.	**Description**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
1	**No of buses inducted during the year on replacement and additions a/c**																		
	12 m long	540	0	0	0	0	0	0	0	282	0	0	0	0	0	0	0	0	0
	12 m AC	60	0	0	0	0	0	0	0	71	0	0	0	0	0	0	0	83	0
	18 m long	0	8	8	8	8	9	9	9	121	12	12	12	12	13	13	13	178	17
	25 m long	0	0	0	0	0	0	0	0	33	4	4	4	4	4	5	5	125	8
	Total	600	8	8	8	8	9	9	9	507	16	16	16	16	17	18	18	386	25
2	**Fleet held during the yr.**																		
	12 m long	540	540	540	540	540	540	540	540	282	282	282	282	282	282	282	282	0	0
	12 m AC	60	60	60	60	60	60	60	60	71	71	71	71	71	71	71	71	83	83
	18 m long	0	8	16	24	32	41	50	59	180	184	188	192	196	200	204	208	265	270
	25 m long	0	0	0	0	0	0	0	0	33	37	41	45	49	53	58	63	155	159
	Total	600	608	616	624	632	641	650	659	566	574	582	590	598	606	615	624	503	512
	Breakup of Fleet between EEH / WEH		0.3509																
	Fleet-EEH	211	213	216	219	222	225	228	231	199	201	204	207	210	213	216	219	177	180
	Fleet-WEH	389	395	400	405	410	416	422	428	367	373	378	383	388	393	399	405	326	332
3	**Cost of buses purchsed Rs in Lakhs**																		
	Total during the yr.																		
	12 m long	29700	0	0	0	0	0	0	0	15510	0	0	0	0	0	0	0	0	0
	12 m AC	4200	0	0	0	0	0	0	0	4970	0	0	0	0	0	0	0	5810	0
	18 m long	0	680	680	680	680	765	765	765	10285	1020	1020	1020	1020	1105	1105	1105	15130	1445
	25 m long	0	0	0	0	0	0	0	0	3300	400	400	400	400	400	500	500	12500	800
	Cost of buses purchased	33900	680	680	680	680	765	765	765	34065	1420	1420	1420	1420	1505	1605	1605	33440	2245
	Cummulative cost of purchases Rs in Lakhs	33900	34580	35260	35940	36620	37385	38150	38915	72980	74400	75820	77240	78660	80165	81770	83375	1E+05	1E+05
4	Avg cost/ bus current rates Rs Lakhs	56.5	56.9	57.2	57.6	57.9	58.3	58.7	59.1	69.0	69.4	69.7	70.0	70.3	70.6	70.9	71.3	87.1	87.2
5	**Outstanding Loan amount, Loan as 80% of bus cost, paid up in 5 equal annual instalments Rs in Lakhs**																		
	12 m long	23760	19008	14256	9504	4752	0	0	0	12408	9926	7445	4963	2482	0	0	0	0	0
	12 m long AC	3360	2688	2016	1344	672	0	0	0	3976	3181	2386	1590	795	0	0	0	4648	3718
	18 m long	0	544	979	1306	1523	1700	1754	1795	9438	8133	6773	5372	3930	2516	2570	2611	13858	11900
	25 m long	0	0	0	0	0	0	0	0	2640	2432	2160	1824	1424	960	1040	1104	10752	9104
	Total	27120	22240	17251	12154	6947	1700	1754	1795	28462	23672	18763	13750	8631	3476	3610	3715	29258	24722
6	**Cost of loan of 80% of bus purchase value @15% / annum on balance amount. Loan repaid in equated instalments in 5 yrs.Rs in Lakhs**																		
	12 m long	3564	2851	2138	1426	713	0	0	0	1861	1489	1117	744	372	0	0	0	0	0
	12 m AC	504	403	302	202	101	0	0	0	596	477	358	239	119	0	0	0	697	558
	18 m long	0	82	147	196	228	255	263	269	1416	1220	1016	806	590	377	386	392	2079	1785
	25 m long	0	0	0	0	0	0	0	0	396	365	324	274	214	144	156	166	1613	1366
	Total	4068	3336	2588	1823	1042	255	263	269	4269	3551	2814	2062	1295	521	542	557	4389	3708
7	Return on Investment @ 15% of equity capital invested	1017	1037	1058	1078	1099	1122	1145	1167	2189	2232	2275	2317	2360	2405	2453	2501	3504	3572
8	**Depreciation Rs Lakhs @ 12.5% of bus purchase costs**																		
	12 m long	3713	3713	3713	3713	3713	3713	3713	3713	1939	1939	1939	1939	1939	1939	1939	1939	0	0
	12 m long AC	525	525	525	525	525	525	525	525	621	621	621	621	621	621	621	621	726	726
	18 m long	0	85	170	255	340	436	531	627	1913	1955	1998	2040	2083	2125	2168	2210	2816	2869
	25 m long	0	0	0	0	0	0	0	0	413	463	513	563	613	663	725	788	1938	1988
	Total	4238	4323	4408	4493	4578	4673	4769	4864	4885	4978	5070	5163	5255	5348	5453	5558	5479	5583
9	**Cost of hiring buses excluding intt on borrowed capital, and depreciation with 5% annual increase(Ref Annexure I) Rs in Lakhs.It also exludes costs related to reveue collection, SPV expenses etc.**																		

	12 m long	12449	13071	13725	14411	15132	15888	16683	17517	9605	10085	10590	11119	11675	12259	12872	13515	0	0
	12 m AC	1728	1814	1905	2000	2100	2205	2316	2431	3021	3172	3331	3497	3672	3856	4048	4251	5218	5479
	18 m long	0	286	601	947	1325	1783	2283	2829	9063	9727	10436	11191	11995	12852	13764	14736	19712	21089
	25 m long	0	0	0	0	0	0	0	0	2098	2470	2873	3311	3786	4300	4941	5635	14557	15680
	Total	14177	15172	16231	17358	18558	19877	21282	22777	23786	25454	27229	29118	31128	33266	35625	38137	39488	42247
	Avg annual increase @5% pa	1	1.05	1.103	1.158	1.216	1.276	1.340	1.407	1.477	1.551	1.629	1.710	1.796	1.886	1.980	2.079	2.183	2.292
10	**Cost of Revenue collection, PIS, Data acquisition.etc Rs in Lakhs(Ref Annexure XV.2)**																		
	12 m long	1176	1235	1297	1362	1430	1501	1576	1655	907	953	1000	1050	1103	1158	1216	1277	0	0
	12 m AC	131	137	144	151	159	167	175	184	228	240	252	264	278	292	306	321	395	414
	18 m long	0	35	73	116	162	218	279	345	1106	1187	1273	1365	1464	1568	1679	1798	2405	2573
	25 m long	0	0	0	0	0	0	0	0	299	352	410	472	540	613	705	804	2077	2237
	Total	1307	1407	1514	1628	1750	1885	2030	2184	2541	2732	2936	3153	3384	3631	3907	4200	4877	5224
	Avg annual increase @5% pa																		
11	**BRTS organisational expenses Rs Lakhs with an annual increase of 5%pa(Ref Anexure XV.3)**																		
	12 m long	413	434	456	479	503	528	554	582	319	335	352	369	388	407	427	449	0	0
	12 m AC	46	48	51	53	56	59	62	65	80	84	89	93	98	103	108	113	139	146
	18 m long	0	6	14	21	30	40	51	64	204	219	234	251	269	289	309	331	443	474
	25 m long	0	0	0	0	0	0	0	0	37	44	51	59	67	77	88	100	259	279
	Total	459	489	520	553	588	626	667	710	640	682	726	773	822	875	932	993	841	898
	Avg annual increase @5% pa																		
12	**Misc. Expenses and contingencies @ 5% of all costs**																		
	12 m long	1066	1065	1066	1069	1074	1081	1126	1173	732	740	750	761	774	788	823	859	0	0
	12 m AC	121	126	131	136	142	148	154	160	330	327	323	315	305	292	306	321	861	793
	18 m long	0	24	50	76	103	135	168	204	677	707	739	773	810	850	904	962	1364	1430
	25 m long	0	0	0	0	0	0	0	0	162	185	209	234	261	290	331	375	1022	1077
	Total	1187	1216	1247	1282	1319	1364	1448	1537	1900	1959	2020	2083	2149	2219	2364	2516	3247	3301
13	**Total cost of bus operations per annum Rs in Lakhs**																		
	12 m long	22381	22369	22395	22459	22564	22711	23652	24639	15363	15541	15747	15983	16251	16551	17277	18039	0	0
	12 m AC	3055	3054	3058	3068	3083	3104	3231	3365	4877	4922	4973	5029	5093	5163	5390	5627	8036	8116
	18 m long	0	519	1054	1610	2188	2866	3575	4337	14377	15014	15695	16426	17210	18061	19210	20428	28819	30219
	25 m long	0	0	0	0	0	0	0	0	3405	3878	4380	4913	5481	6086	6945	7867	21466	22626
	Total	25436	25942	26508	27137	27835	28681	30458	32342	38022	39355	40795	42352	44034	45860	48822	51961	58320	60961
	Avg annual increase @5% pa in all costs except dep&intt.																		
14	**Quantum of operations per annum**																		
14.1	Bus fleet kms in lakhs																		
	12 m long	532	532	532	532	532	532	532	532	278	278	278	278	278	278	278	278	0	0
	12 m AC	59	59	59	59	59	59	59	59	70	70	70	70	70	70	70	70	82	82
	18 m long	0	8	16	24	32	40	49	58	177	181	185	189	193	197	201	205	261	266
	25 m long	0	0	0	0	0	0	0	0	33	36	40	44	48	52	57	62	153	157
	Total	591	599	607	615	623	632	641	649	558	566	574	581	589	597	606	615	496	505
14.2	**Passenger kms Lakhs**																		
	12 m long	26076	26076	26076	26076	26076	26076	26076	26076	13618	13618	13618	13618	13618	13618	13618	13618	0	0
	12 m AC	1449	1449	1449	1449	1449	1449	1449	1449	1714	1714	1714	1714	1714	1714	1714	1714	2004	2004
	18 m long	0	607	1214	1821	2428	3111	3794	4477	13659	13963	14266	14570	14873	15177	15480	15784	20109	20489
	25 m long	0	0	0	0	0	0	0	0	3415	3829	4243	4656	5070	5484	6002	6519	16039	16453
	Total	27525	28132	28739	29346	29953	30636	31319	32002	32406	33123	33841	34558	35275	35993	36814	37635	38152	38945
15	**Operational Costs**																		
15.1	Cost per bus km Rs																		
	12 m long	42.06	42.03	42.08	42.20	42.40	42.68	44.44	46.30	55.28	55.92	56.66	57.51	58.47	59.55	62.17	64.91		

	12 m AC	51.67	51.65	51.72	51.88	52.14	52.49	54.64	56.91	69.70	70.35	71.07	71.88	72.78	73.78	77.03	80.42	98.24	99.22
	18 m long		65.78	66.87	68.07	69.39	70.93	72.56	74.60	81.05	82.80	84.71	86.81	89.10	91.63	95.55	99.66	110.35	113.57
	25 m long									104.70	106.35	108.39	110.78	113.50	116.52	121.51	126.71	140.53	144.40
	Total	43.02	43.30	43.66	44.13	44.69	45.40	47.55	49.80	68.16	69.57	71.13	72.84	74.72	76.79	80.55	84.50	117.65	120.82
15.2	**Cost per pax km Rs**																		
	12 m long	0.858	0.858	0.859	0.861	0.865	0.871	0.907	0.945	1.128	1.141	1.156	1.174	1.193	1.215	1.269	1.325		
	12 m AC	2.109	2.108	2.111	2.118	2.128	2.142	2.230	2.323	2.845	2.871	2.901	2.934	2.971	3.011	3.144	3.282	4.010	4.050
	18 m long		0.854	0.868	0.884	0.901	0.921	0.942	0.969	1.053	1.075	1.100	1.127	1.157	1.190	1.241	1.294	1.433	1.475
	25 m long									0.997	1.013	1.032	1.055	1.081	1.110	1.157	1.207	1.338	1.375
	Total	0.924	0.922	0.922	0.925	0.929	0.936	0.973	1.011	1.173	1.188	1.206	1.226	1.248	1.274	1.326	1.381	1.529	1.565
16	Revenue																		
16.1	**Fare per passenger km Rs**																		
	12 m long	0.768	0.806	0.847	0.889	0.934	0.980	1.029	1.081	1.135	1.191	1.251	1.314	1.379	1.448	1.521	1.597	1.676	1.760
	12 m AC	1.916	2.012	2.112	2.218	2.329	2.445	2.568	2.696	2.831	2.972	3.121	3.277	3.441	3.613	3.794	3.983	4.182	4.392
	18 m long	0.768	0.806	0.847	0.889	0.934	0.980	1.029	1.081	1.135	1.191	1.251	1.314	1.379	1.448	1.521	1.597	1.676	1.760
	25 m long	0.768	0.806	0.847	0.889	0.934	0.980	1.029	1.081	1.135	1.191	1.251	1.314	1.379	1.448	1.521	1.597	1.676	1.760
	Total	0.924	0.970	1.019	1.070	1.123	1.179	1.238	1.300	1.365	1.434	1.505	1.581	1.660	1.743	1.830	1.921	2.017	2.118
	Avg annual increase @5% pa	1.000	1.050	1.103	1.158	1.216	1.276	1.340	1.407	1.477	1.551	1.629	1.710	1.796	1.886	1.980	2.079	2.183	2.292
16.2	**Revenue Per bus km Rs**																		
	12 m long	37.63	39.51	41.49	43.56	45.74	48.03	50.43	52.95	55.60	58.38	61.30	64.36	67.58	70.96	74.51	78.23		
	12 m AC	46.94	49.29	51.75	54.34	57.06	59.91	62.91	66.05	69.35	72.82	76.46	80.29	84.30	88.52	92.94	97.59	102.47	107.59
	18 m long		62.09	65.20	68.46	71.88	75.47	79.25	83.21	87.37	91.74	96.33	101.14	106.20	111.51	117.09	122.94	129.09	135.54
	25 m long									119.14	125.10	131.35	137.92	144.82	152.06	159.66	167.64	176.03	184.83
	Total	38.56	40.78	43.10	45.56	48.14	50.90	53.80	56.85	71.13	75.16	79.40	83.86	88.55	93.49	98.79	104.37	139.16	146.32
	Avg annual increase @5% pa																		
16.3	**Revenues per annum Rs in Lakhs with an annual increase of 5%**																		
	12 m long	20027	21028	22079	23183	24342	25560	26838	28179	15452	16224	17036	17887	18782	19721	20707	21742	0	0
	12 m AC	2776	2914	3060	3213	3374	3543	3720	3906	4853	5095	5350	5618	5899	6194	6503	6828	8382	8801
	18 m long	0	490	1028	1619	2267	3050	3905	4838	15499	16635	17847	19138	20513	21979	23539	25201	33712	36065
	25 m long	0	0	0	0	0	0	0	0	3875	4562	5307	6116	6993	7942	9126	10408	26889	28962
	Total	22802	24432	26168	28016	29983	32152	34462	36923	39678	42517	45540	48759	52187	55835	59875	64180	68982	73828
	Avg annual increase @5% pa																		
17	**Profit /Loss(-) per annum Rs in Lakhs**																		
	12 m long	-2354	-1341	-315	724	1779	2849	3186	3540	89	683	1288	1904	2531	3170	3430	3703	0	0
	12 m AC	-279	-140	2	145	291	439	489	541	-24	173	377	588	806	1031	1114	1201	346	685
	18 m long	0	-29	-26	9	79	184	329	501	1122	1621	2151	2712	3304	3918	4329	4772	4893	5846
	25 m long	0	0	0	0	0	0	0	0	470	684	928	1204	1513	1856	2181	2541	5423	6335
	Total	-2633	-1510	-340	879	2148	3471	4004	4581	1656	3162	4745	6408	8153	9975	11053	12219	10662	12866
18	**Profit /Loss(-) per annum Rs in Lakhs seperately for EEH and WEH**																		
	For EEH	-924	-530	-119	308	754	1218	1405	1608	581	1110	1665	2249	2861	3501	3879	4288	3742	4515
	For WEH	-1709	-980	-221	570	1394	2253	2599	2974	1075	2052	3080	4159	5292	6474	7174	7931	6920	8351

Notes:

1 *All estimates are indicative*

2 ** estimates worked out by including capital costs and the consequential expenses there on.*
20% of the capital cost of buses to be contributed by the bus owners as equity.

3 *CPK – cost per bus kilometer*
CPPK – cost per passenger km
FPPK – fare per passenger km

4 *Costs related to development and operations of depots / terminals etc not included.*

Annexure XV.2

Assessment of bus operating costs – bus owner expenses (standard bus)

(Buses of various lengths and 400 mm floor height, equipped with air suspension, Automatic Transmission, ITS/PIS etc)

Sl. No.	Description	First Year data of buses of lengths of			
		12 Mtr	12 mtr AC	18 Mtr	25 Mtr
		Equivalent standard buses			
		1	1	1.57	2.14
(A)	(B)	(C)	(D)	(E)	(F)
1	Cost of Bus(Rs. in Lacs)	55	70	85	100
	Cost of Capital loan Ist Yr(Rs.Lacs)	6.60	8.40	10.20	12.00
(20% equity + 80% loan) @ 15% p.a. on outstanding loan paid back in 5 years					
2	Life of bus in years	8	8	8	8
	Seats per bus(includes standees)	70	70	110	150
	Bus productivity kms per bus held per /year (300*0.9*365)	98550	98550	98550	98550
	Seat km capcity / bus/yr at load factor of 100%	6898500	6898500	10840500	14782500
	Load Factor as obtained in Best for March 08 for standard/AC buses	0.70	0.35	0.70	0.70
	Passenger kms /bus/yr.	4828950	2414475	7588350	10347750
	Fare per pax km Rs.	0.77	1.91	0.77	0.77
	Revenue / bus / yr Rs in Lakhs	37.18	46.12	58.43	79.68
3	Depreciation @ 12.5% p.a. on straight line method with no scrap value Rs Lakhs	6.88	8.75	10.63	12.50
4	Maintenance cost(Rs. in Lacs) – all inclusive @ 1.1 times of annual depreciation for 8 years	7.56	9.63	11.69	13.75
5	Fuel price Rs per kg of CNG	21.10	21.10	21.10	21.10
	Fuel Effocoemcy kms / kg of CNG	2.93	2.28	2.10	1.47
(CNG efficiency.as obtained in Anik depot(Mar. 08) for standard non AC and AC buses. Single & double articulated buses taken as 75% & 50% of Non AC bus respectively.)					
	Fuel and Lubes cost per bus per year(= fuel cost*1.02)(Rs. in Lacs)	7.24	9.30	10.10	14.48
6	Labour cost /bus /yr Rs Lakhs	1.98	1.98	1.98	1.98
(2.5 drivers per bus and 0.25 administrative staff per bus @ of Rs.72,000 per annum)					
7	Paxr Tax @ 3.5% of revenue	1.30	1.61	2.05	2.79
8	Insrnce @ 3% of bus value/yr.	1.65	2.10	2.55	3.00
9	Registration & licence fees, Other misc. and admin. expenses @ 10% of total cost (Rs. in Lacs)	3.32	4.18	4.92	6.05
10	Cost of opern/bus 1st yr.Rs Lacs	36.53	45.95	54.11	66.55
11	Average cost (Rs)/bus km	37.07	46.62	54.90	67.53
12	Average cost (Rs)/bus km after providing for return on equity @ 15% on equity part of bus cost	38.74	48.76	57.49	70.57

Note: 1. *All estimates are indicative only*
2. *Fuel efficiency taken as obtained in BEST for(CNG) buses(Standard non AC and AC) in March 08.*

It is extrapolated for others
3. Labour costs taken as marginally higher than minimum wage rates

Annexure XV.3				
Cost Estimates for revenue collection, data acquisition, PIS, etc				
		Man power rate per bus of length		
a	Revenue collection(Out sourced)	12M	18M	25M
1	Manpower ratio per bus for on board revenue collection, cash handling and supervision	2.75	5.5	8.25
	Cost per man per yr.Rs in Lakhs	0.72	0.72	0.72
	Cost per bus per year Rs in Lakhs	1.98	3.96	5.94
2	Cost of other activities/bus/yr.Rs Lakhs	0.20	0.20	0.20
	Data acquisition and communication , passenger information syhstem, station management etc @10% of 1 above			
	Total cost of revenue collection etc per bus per year Rs in Lakhs	2.18	4.16	6.14

Annexure XV.4					
BRT Manpower cost assessment – BRT staff					
Manpower Level	**Description**	**Man power ratios**	**Man power in 1st year**	**Average cost to company (Rs. per year per person)**	**Total cost to company per year Rs. in Lacs in 1st yr.**
	In house manpower @0.25 men per bus	0.25	141		
I	Percentage of staff in cat I	0.1	14.1	500000	70.5
II	Percentage of staff in catII	0.4	56.4	300000	169.2
III	Percentage of staff in cat III	0.5	70.5	150000	105.8
	Total		141	245000	345.5
Add Contingencies PF, Gratuity, etc @ 25% of above			0.25	61250	86.4
Total (Rs. in Lacs) manpower cost			141	306250	431.8
	Average cost per BRTS employee in 1st yr Rs in Lacs			3.06	
	Avg annual increase in cost of employee			0.05	
	Avg annual cost per bus Rs in Lakhs			0.77	

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