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TRANSPORTATION RESEARCH AND INJURY PREVENTION PROGRAMME

BRT PROJECTS IN INDIAN CITIES

STATUS REPORT

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WHO COLLABORATING CENTRE

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INDIAN INSTITUTE OF TECHNOLOGY DELHI

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STATUS REPORT

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Abbreviations

Bus Rapid Transit (BRT)

Central Pollution Control Board (CPCB)

Delhi Integrated Multimodal Company (DIMTS)

Delhi Transport Corporation (DTC)

Infrastructure Development Finance Company (IDFC)

Jawaharlal Nehru National Urban Renewal Mission (JnNURM)

Ministry of Urban Development (MoUD)

National Urban Transport Policy (NUTP)

Persons Peak Hour per Direction (pphpd)

Right of Way (ROW)

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1 Introduction

The level of service provided by the existing public transport system in Indian cities is not up to the mark in terms of reliability, comfort, safety and security. Even with the prevailing hostile conditions there is a high usage of the public transport system. As such, patronage for the public transport system is on the decline and people are shifting to the use of personal motorized vehicles adding to environmental and health problems. Given the socio-economic profile and development pattern of Indian cities, bus systems are a viable option and if planned properly can provide high capacity at a fraction of the cost of a rail based system (Advani and Tiwari, 2006; Mohan, 2004). Bus Rapid Transit (BRT) projects are in different stages of implementation in 10 Indian cities of which 9 cities are supported by the Jawaharlal Nehru National Urban Renewal Mission (JNNURM).

The report looks into the existing status of BRT projects in all the 10 Indian cities that have been approved and where they are in the different stages of implementation. For the study, the data of all the 10 cities has been collected from different sources like local authority's websites, organizations involved in projects, published reports and studies and media prints. The data is classified into two sets i.e. the socio-economic profile of the cities (population, income levels and percentage of people living in slums); and BRTS project details like brief descriptions of BRT corridors (planned and executed length of the BRT corridor, type of system, location of BRT corridor, width of the bus lanes, segregation mechanism), bus operational details (bus capacity, planned frequency, distance between bus stops, location of bus stops with respect to intersections) and details about integration with other modes of transportation (Annexure 1). The report at the end compares the designs and strategies adopted in all the 10 cities.

2 History of BRT systems in Indian cities

The proposal for BRTS was first mooted in Delhi in 1996. This recommendation was a part of a report "Delhi on the Move" submitted to the Central Pollution Control Board (CPCB) of India. The main motivation behind this proposal was to address the problem of growing road traffic injuries and fatalities and pollution in the city (Mohan et al., 1997). The report was examined by the transport department of Delhi and policies were initiated to take it forward. Finally, an international workshop was organized by Delhi Transport Corporation (DTC) and Infrastructure Development Finance Company (IDFC) in 2001 to enable a detailed discussion about the concept among international experts and stake holders. Following this, the government set up the committee on sustainable transport chaired by the Chief Secretary of Delhi. On the recommendation of this committee, RITES was awarded the contract to prepare a detailed feasibility report and plans for implementing BRT on five selected corridors in Delhi in 2003. Detailed designs were prepared based on new (2003-2004) traffic surveys at all 33 junctions along the corridor. The detailed topographical survey included exact locations of all services and trees along the entire length of the carriageway where the BRT was to be introduced.

Furthermore, the low level of service of the existing transport situation has led to the aggravation of more problems: increasing number of private vehicles, inefficient transport systems and degrading air quality in many other Indian cities. Concerned about these issues, the National Urban Transport Policy (NUTP) was adopted by Ministry of Urban Development (MoUD) in 2006 which focused on the development of infrastructure to encourage the use

of non-motorized modes (walking and cycling) and public transport systems. This was followed by JNNURM funding available from 2007 that provided support for the projects that complied with the NUTP. As a result, nine Indian cities excluding Delhi have started with development of BRT systems and 53 cities in total have started to improve the public transport system by purchasing new low floor buses and improving operation of existing bus services in the cities (JNNURM, 2009a; JNNURM, 2009b; LEA Associates South Asia Pvt.Ltd., 2009).

Table 1: Approved share of projects cost by JNNURM

Type of transport related projects	ACA committed (Rs in lakhs)
BRTS	219563.8
Bus procurement	22117.3
Other projects (roads, flyovers, ROB, etc.)	194462.7
Grand Total	**436143.8**

Source: (JNNURM 2009a)

Out of the 10 cities selected for implementation of BRTS, the parts of BRT corridor are operational in 3 cities and the rest are under construction (Table 2). Pune was the first city to experiment with the operation of BRT in December 2006 followed by Delhi in April 2008 and Ahmedabad in July 2009.

Table 2: Status of BRT projects in Indian cities

Sl. No.	City	Stage of implementation	Construction started in	Operation started in	Remarks
1	Delhi	5.6 km operational	Oct 2006	April 2008	
2	Ahmedabad	25km operational	2007	July 2009	
3	Pune	17km operational	2003	Dec 2006	
4	Surat	10.2km under construction		Not yet started	
5	Jaipur	Package 1B constructed	Sept 2007	Not yet started	
6	Indore	11.5km under construction	October 2007	Not yet started	Encroachments and court stays on land parcels and non-availability of traffic diversion links for the pilot corridor
7	Bhopal	Under construction: only 22% in progress	2008	Not yet started	Delay in finalization of the Implementing Agency Delay in transfer of Road from NHAI & MoRTH Railways permission is still awaited for ROB
8	Vishakhapatnam	Under construction	2008	Not yet started	
9	Vijayawada	14.5km ready for operation	June 2008	Not yet started	
10	Rajkot	Under construction	2008	Not yet started	

3 Salient features of BRT projects

3.1 BRT in Delhi

Delhi is the first city in India where discussion for implementation of a BRT project was started and the project was approved in 1996, with a total length of 426 km as an open system to be implemented by 2020 (Delhi Integrated Multi-modal Transit System, 2010). As of now, a stretch of 5.6 km of the pilot corridor of the BRT running from Ambedkar Nagar to Moolchand Flyover is operational since April 2008.

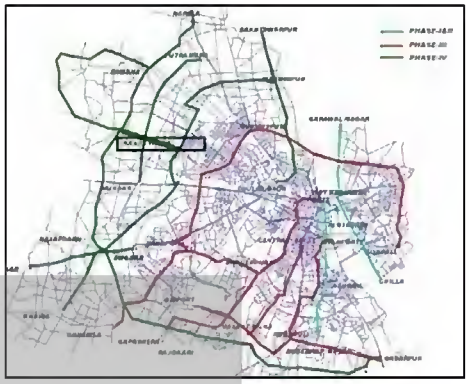

Figure 1: Delhi BRT corridor

CITY PROFILE	Population in lakhs (2001)	128.7
	Existing modal share of Public Transport	47%
	Weighted Average Trip Length	10 km
	Per Capita trip rate	1.56
BRTS DETAILS		
Responsible Authorities	Executing authority	GNCTD
	Funding agency	GNCTD
Cost	Unit Total Cost	Rs 14.89 crores per km
Time line	Construction started	October 2006
	Operation started	April 2008
Bus corridor design details	Type of BRT system	Open
	Total planned	426km
	Total length executed or under construction	5.6km operating
	Width of bus lanes	3.3m (3 m at stops)
	Tools to separate bus lane from mix traffic	0.6 m wide & 0.15 mm high kerbs
	No. of routes catered in open system on corridor	57
	No. of routes in total system (open)	657
Fleet usage	Existing fleet used or not	Yes
	Passenger capacity in bus	Varies
Bus stops	Distance between bus stops (meters)	500-700m
	Bus stop location wrt junction/intersection	Before junction
	Type of bus stop: staggered/island platform	Staggered
Bus operations	Frequency achieved	120-150 buses per hour
	Average speed on corridor (kmph) (achieved)	18 in peak hour
	Planned ridership	20,000 - 24,000 pphpd
	Achieved ridership	13,500 pphpd
Fare collection	Type of fare: fix/progressive	Progressive
	On-board/off-board ticketing	On-board
	Fare amount in INR (with slabs for progressive fare)	<4km: Rs5, 4-10km: Rs10, >10km: Rs 15
Other services & operational details	Space availability for vendors along corridor	Kiosks
	Passenger information: dynamic/static	Static at present, planned for dynamic
	Any other service for public convenience	Public toilets, kiosks, public telephone & dustbins
Integration with other modes	Walk	2m wide footpaths signalized raised zebra crossing
	Cycle and cycle rickshaws	2.5m wide cycle tracks on both side with signalized crossing and parking near intersections, on rent
	IPT	Parking provided near intersections
	Motorized vehicle	On street parking along service lane, stopping bays along main carriageway

Source: (Delhi Integrated Multi-modal Transit System, 2010; Delhi Transport Corporation, 2010; Hidalgo and Pai, 2009; Mohan, 2004; RITES and TRIPP, 2006; TRIPP, 2005)

3.2 BRT in Ahmedabad

Construction of 12.5 km of the corridor, as a part of the first phase of the corridor, started in 2007 and became operational in July 2009. As of now, a total stretch of 25 km of the corridor is operational from RTO to Maninagar and Narol having 38 bus stops since April 2010 (Janmarg, 2010).

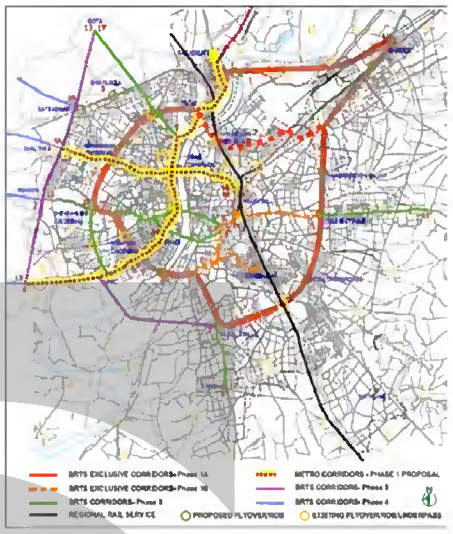

Figure 2: Ahmedabad BRT corridor

CITY PROFILE	Population in lakhs (2001)	45.25
	Existing modal share of Public Transport	8%
	Weighted Average Trip Length	5.3 km
	Per Capita trip rate	1.14
BRTS DETAILS		
Responsible Authorities	Executing authority	Municipal Corporation
	Funding agency	JNNURM
Cost	Total approved cost	Rs. 984.15 crores
	Unit Total Cost	Rs 11.08 crores per km
Time line	Construction started	2007
	Operation started	July 09
Bus corridor design details	Type of BRT system	Closed
	Total planned	88.8 km
	Total length executed or under construction	25km operating
	Width of bus lanes	3.5 m
	Tools to separate bus lane from mix traffic	Railings
	Total no. of routes in existing bus system (open)	150
Fleet usage	Existing fleet used or not	No
	Passenger capacity in bus	60-70
Bus stops	Distance between bus stops (meters)	Average 800 m
	Bus stop location wrt junction/intersection	Far-side of junction
	Type of bus stop: staggered/island platform	Island platform
Bus operations	Frequency planned	2 min in peak hour and 4 min in off-peak hour
	Frequency achieved	2.5 min in peak hour
	Average speed on corridor (kmph) (planned)	30
	Average speed on corridor (kmph) (achieved)	24-26 (peak hour)
	Planned ridership	15,000 – 20,000 pphpd
	Achieved ridership	2350 - 2600 pphpd
Fare collection	Type of fare: fix/progressive	Progressive
	On-board/off-board ticketing	Off-board
	Fare amount in INR (with slabs for progressive fare)	Maximum fare Rs15 for existing route
Other services & operational details	Space availability for vendors along corridor	Yes
	Passenger information: dynamic/static	Dynamic
	Any other service for public convenience	Public toilets, dustbins
Integration with other modes	Walk	Non-continuous 2m wide footpaths, signalized level crossing and sub-ways at mid-block
	Cycle and cycle rickshaws	2 m wide cycle track with signalized crossing, parking at specific locations
	IPT and Motorized vehicles	On street 3m wide parking lane, 50m away from junction, free parking for 679 autos in front of mid-block bus stops and 3624 for 2-wheelers & 425 for 4-wheelers paid parking

Source: (Ahmedabad Municipal Corporation, 2010; CEPT University, 2005; CEPT University, 2008; Janmarg, 2010)

3.3 BRT in Pune

Pune was the first city in India to begin operations of a BRT corridor in December 2006. The total planned length of the BRT system is 117 km of which the pilot corridor is 17 km from Katraj to Hadapsar along the Satara and Solapur road; this is now operational.

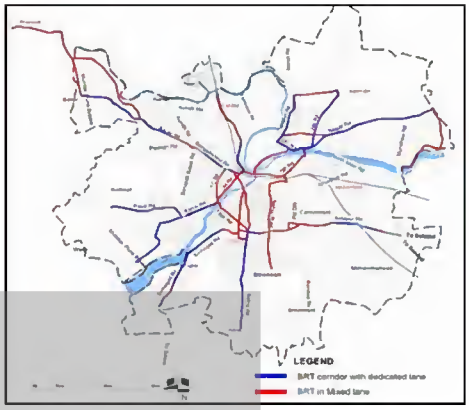

Figure 3: Pune BRT corridor

CITY PROFILE	Population in lakhs (2001)	37.6
	Existing modal share of Public Transport	22%
	Weighted Average Trip Length	6 km
	Per Capita trip rate	1.3
BRTS DETAILS		
Responsible Authorities	Executing authority	Municipal corporation
	Funding agency	JNNURM
Cost	Approved cost	Rs. 1789.16 crores
	Unit Total Cost	Rs 14.78 crores per km
Time line	Construction started	2003
	Operation started	December 2006
BRT design details	Type of BRT system	Open
	Total planned	117km total plannned; 50km is dedicated corridor
	Total length executed or under construction	17 km operating
	Width of bus lanes	3.3m (3m at stops)
	Tools to separate bus lane from mix traffic	0.3 m wide separator with fences
	No. of routes in total system (open)	210
Fleet usage	Existing fleet used or not	Yes
	Passenger capacity in bus	70
Bus stops	Distance between bus stops (meters)	500-700m
	Bus stop location wrt junction/intersection	Min 60m before junction
	Type of bus stop: staggered/island platform	Staggered
Bus operations	Frequency planned	2 min
	Average speed on corridor (kmph) (planned)	25 kmph
	Average speed on corridor (kmph) (achieved)	16-18 kmph in peak hour
	Planned ridership	10000-15000 pphpd
	Achieved ridership	3,600 pphpd
Fare collection	Type of fare: fix/progressive	Progressive
	On-board/off-board ticketing	On-board
	Fare amount in INR (with slabs for progressive fare)	2km: Rs 3, 4km: Rs 5, 6km: Rs6, 8km: Rs7, 10km: Rs8, 12km: Rs9, 14km: Rs10, 18km: Rs12, 22km: Rs14, 26km: Rs16, 30km: Rs17, 34km: Rs18
Other services & operational details	Space availability for vendors along corridor	Yes
	Passenger information: dynamic/static	Currently static, planned for dynamic
	Any other service for public convenience	Sitting areas, toilet and kiosks
Integration with other modes	Walk	Minimum 1.5 m wide barrier free footpaths, with signalized raised zebra crossing
	Cycle and cycle rickshaws	1.5m for cycle lanes and 2.5m for cycle tracks and free parking 60m away from bus stops
	IPT	Parking near junction spaced at 500m, 30m away from bus stop

Source: (Pune Municipal Corporation, 2006; Pune Municipal Corporation, 2010)

3.4 BRT in Surat

Arterial road network of about 125 kilometers in length has been identified for developing the Bus Rapid Transit System in Surat with about 30 km of the network having 31 bus stops and 10 interchange stations to be implemented in phase 1 of the project.

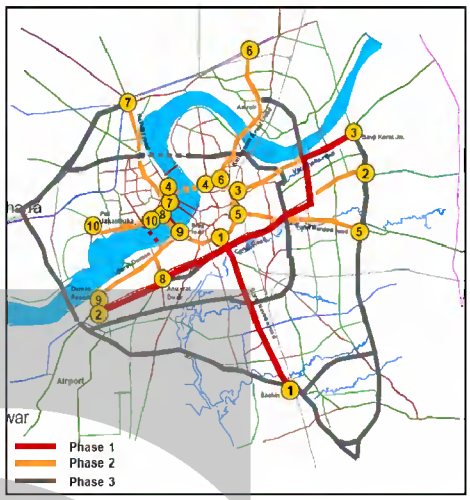

Figure 4: Surat BRT corridor

CITY PROFILE	Population in lakhs (2001)	28.11
	Existing modal share of Public Transport	13
	Weighted Average Trip Length	5.3
	Per Capita trip rate	0.80
BRTS DETAILS		
Authorities	Executing authority	Municipal Corp.
	Funding agency	JNNURM
Cost	Approved cost	Rs. 469.02 crores
	Unit Total Cost	Rs 15.68 crores per km
Time line	Construction started	
Bus corridor detail	Type of BRT system	Closed
	Total planned km	125km planned but 30 km approved
	Total length executed or under construction	10.2km under construction
	Width of bus lanes	3.5m
	Tools to separate bus lane from mix traffic	0.5m wide separator and 3m wide separator between bus lanes
Fleet usage	Existing fleet used or not	No
	Passenger capacity in bus	88 buses for 70 passengers and 19 buses for 140 passengers
Bus stops	Distance between bus stops (meters)	600m
	Type of bus stop: staggered/island platform	Island platform
Bus operations	Frequency planned	2 – 5 minutes
	Planned ridership	20,000
Fare collection	Type of fare: fix/progressive	Progressive
	On-board/off-board ticketing	Off-board
	Fare amount in INR (with slabs for progressive fare)	2-4: Rs4; 4-6: Rs5; 6-10: Rs8; 10-14: Rs10; 14-20: Rs12 (planned)
Other services & operational details	Space availability for vendors along corridor	Kiosks
	Passenger information: dynamic/static	Dynamic
	Any other service for public convenience	Sitting area
Integration with other modes	Walk	3 to 5m wide pedestrian activity areas, underpass; elevated mixed traffic lanes
	Cycle and cycle rickshaws	2m wide cycle track

Source: (CEPT University, 2010; CEPT University and LEA Associates South Asia Pvt.Ltd., 2008; Surat Municipal Corporation et al., 2010)

3.5 BRT in Jaipur

A total stretch of 138 km of the BRT corridor has been identified and approved by Government of India in 2006. The project is to be implemented in three phases where phase-1 is a 42km stretch (Jaipur Development Authority, 2010a). The construction of 26 km stretch of the corridor started in September 2007; a 7km of this stretch is now complete.

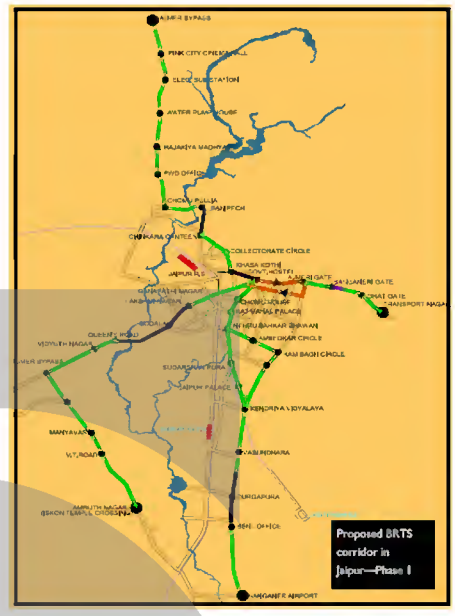

Figure 5: Jaipur Phase-I BRT corridor

CITY PROFILE	Population in lakhs (2001)	23.22
	Existing modal share of Public Transport	14%
	Weighted Average Trip Length	5.3 km
	Per Capita trip rate	0.9
BRTS DETAILS		
Responsible Authorities	Executing authority	Development Authority
	Funding agency	JNNURM
Cost	Approved cost	Rs 479.54 crores
	Unit Total Cost	Rs 10.65 crore per km
Time line	Construction started	September 2007
	Operation started	Not yet started
Bus corridor design details	Type of BRT system	Hybrid
	Total planned km	138km planned and 42 km sanctioned
	Total length executed or under construction	7km of Package 1B completed
	Width of bus lanes	3.3m
	Tools to separate bus lane from mix traffic	Kerb and fences
	No. of routes catered in open system on corridor	3 routes
	No. of routes in total system (open)	54 routes
Fleet usage	Existing fleet used or not	Yes as feeder
	Passenger capacity in bus	66
Bus stops	Distance between bus stops (meters)	300-750m
	Bus stop location wrt junction/intersection	Before junction where staggered bus stops are there
	Type of bus stop: staggered/island	Both staggered and island platform
Bus operations	Frequency planned	2 – 4 min
	Average speed on corridor (kmph) (planned)	25 kmph
	Planned ridership	5300 – 5700 pphpd
Fare collection	Type of fare: fix/progressive	Progressive
	On-board/off-board ticketing	Both
	Fare amount in INR (with slabs for progressive fare)	81 paise per km
Other services & operational details	Space availability for vendors along corridor	Yes
	Passenger information: dynamic/static	Dynamic
	Any other service for public convenience	Toilets, dustbins
Integration with other modes	Walk	2m wide footpath with signalized crossing
	Cycle and cycle rickshaws	2.5m wide cycle track with parking
	IPT	Parking provision
	Motorized vehicles	On street parking

Source: (Consulting Engineering Services (India) Private Limited, 2007; Jaipur Development Authority, 2010b; PDCOR, 2010)

3.6 BRT in Indore

A total stretch of 109 km has been identified for provision of the BRT in the city of Indore. Of this, 27.50 km with 55 bus stops and 5 BRTS interchange stations has been identified along the corridor and is suppose to be implemented as a pilot corridor. Construction of the pilot corridor started in June 2007.

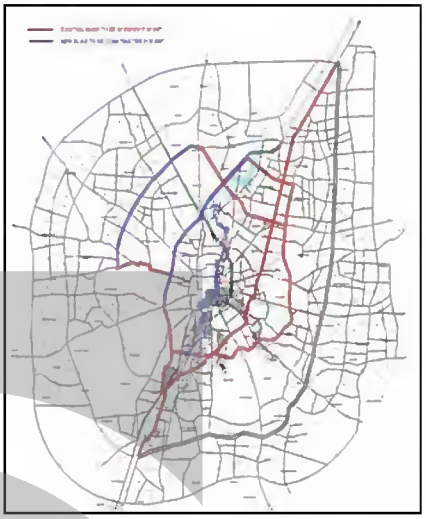

Figure 6: Indore BRT corridor

CITY PROFILE	Population in lakhs (2001)	15.46
	Existing modal share of Public Transport	4%
	Weighted Average Trip Length	5.5 km
	Per Capita trip rate	1.49
BRTS DETAILS		
Responsible Authorities	Executing authority	Development Authority
	Funding agency	JNNURM
Cost	Approved cost	Rs. 98.45 crores
	Unit Total Cost	Rs 4.37 crores per km
Time line	Construction started	October 2007
	Operation started	Not yet started
Bus corridor design details	Type of BRT system	Open
	Total planned km	106km of which 11.5km is sanctioned
	Total length executed or under construction	11.5km under construction
	Width of bus lanes	3.3m
	Tools to separate bus lane from mix traffic	Kerb
Fleet usage	Existing fleet used or not	Yes
	Passenger capacity in bus	60
Bus stops	Distance between bus stops (meters)	Average 525 m
	Bus stop location wrt junction/intersection	Before junction
	Type of bus stop: staggered/island platform	Staggered with overtaking lane
Bus operations	Frequency planned	1.5min
	Average speed on corridor (kmph) (planned)	20
	Planned ridership	10000pphpd upgradable to 20000 pphpd
Fare collection	Type of fare: fix/progressive	Progressive
	On-board/off-board ticketing	Off-board
	Fare amount in INR (with slabs for progressive fare)	Minimum Rs. 5 (paper) and Rs. 4 (smart card) upto 3 km; increment of Rs. 2 for distance slabs of 3-5 km, 5-7 km; 7-10; 10-15, and >15 (maximum fare of Rs. 14 (paper) and Rs. 12 (smart card)
Other services & operational details	Space availability for vendors along corridor	Yes
	Passenger information: dynamic/static	Dynamic
	Any other service for public convenience	Toilets
Integration with other modes	Walk	Barrier free minimum 1.5m wide footpaths, Signalized crossing
	Cycle and cycle rickshaws	Minimum 1.5 m wide cycle tracks, where ROW is not available to be combined with footpaths with cycle box for crossing. Parking near intersections
	IPT	Parking at every junction
	Motorized vehicles	On-street Parking

Source: (Atal Indore City Transport Services Limited et al., 2010; Traffic Mobility Solutions, 2008)

3.7 BRT in Bhopal

4 BRT corridors have been identified in Bhopal to be implemented in Phase-I having a total length of 44km of which first 21.7km have been sanctioned. The corridor from Bairagarh to Misrod is under construction at an estimated cost of Rs 184 crore.

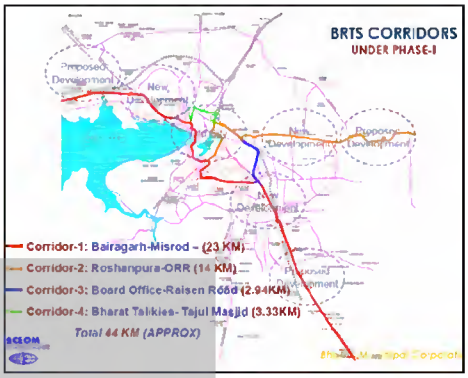

Figure 7: Bhopal phase-I BRT corridor

City profile	Population in lakhs (2001) Existing modal share of Public Transport Weighted Average Trip Length Per Capita trip rate	14.58 48.6% 3.1km 1.0
BRTS DETAILS		
Responsible Authorities	Executing authority Funding agency	Municipal Corporation JNNURM
Cost	Approved cost Unit Total Cost	Rs. 237.76 crores Rs 11.3 crores per km
Time line	Construction started Operation Started	2008 Not yet
Bus corridor design details	Type of BRT system Total planned km Total length executed or under construction Width of bus lanes Tools to separate bus lane from mix traffic	Hybrid 44km planned under phase-1 and 21.7km approved 21.7km under construction 3.3-3.5 m 0.4m wide separator with guard rail
Fleet usage	Existing fleet used or not Passenger capacity in bus	Only as feeder 100
Bus stops	Distance between bus stops (meters) Bus stop location wrt junction/intersection Type of bus stop: staggered/island platform	Average 600m Before intersection Staggered
Bus operations	Frequency planned Average speed on corridor (kmph) (planned) Planned ridership	2-3 min 25 3800 pphpd (existing maximum), 11400 (projected)
Fare collection	On-board/off-board ticketing	On-board and planned for off-board also
Other services & operational details	Passenger information: dynamic/static	Dynamic
Integration with other modes	Walk, cycle and cycle rickshaws	ROW ≤ 20m: 1.5m wide footpaths, no provision for NMV ROW 24 and 30m: 3m wide combined space fro pedestrians and NMV ROW ≥ 45m: 2m wide footpaths and 3m wide NMV lane

Source: (BCEOM India Pvt.Ltd., 2007; Bhopal Municipal Corporation, 2010)

3.8 BRT in Vishakhapatnam

42km of the total planned 105.7km BRT project in Vishakhapatnam was sanctioned by the Government of Andhra Pradesh in November 2007.

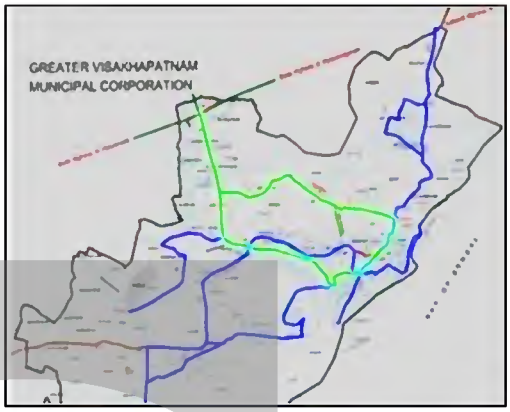

Figure 8: Vishakhapatnam BRT corridor

CITY PROFILE	Population in lakhs (2001)	13.45
	Existing modal share of Public Transport	20%
	Per Capita trip rate	0.82
BRTS DETAILS		
Responsible Authorities	Executing authority	Municipal corporation
	Funding agency	JNNURM
Cost	Approved cost	Rs 452.93 crores
	Unit Total Cost	Rs 9.53 crore per km
Time line	Construction started	2008
	Operation started	Not yet
Bus corridor design details	Type of BRT system	Initially open then closed
	Total planned km	105.7km planned and 42km sanctioned
	Total length executed or under construction	20km under construction
	Width of bus lanes	3.5m
	Tools to separate bus lane from mix traffic	0.5 meter wide kerb stone
Fleet usage	Existing fleet used or not	Yes
	Passenger capacity in bus	40-60
Bus stops	Distance between bus stops (meters)	800m
	Bus stop location wrt junction/intersection	Before intersection
	Type of bus stop: staggered/island platform	Staggered with bus bay
Bus operations	Frequency planned	1-1.5 min
	Planned ridership	Existing 3950-5970pphpd; projected 5750-9100 in 2011
Fare collection	On-board/off-board ticketing	Both
Other services & operational details	Space availability for vendors along corridor	Kiosks
	Passenger information: dynamic/static	Dynamic
	Any other service for public convenience	Sitting area
Integration with other modes	Walk	Minimum 2 m wide footpath, signalized zebra crossing, barrier free
	Cycle and cycle rickshaws	2.25m wide NMV lane on 30 and 36mt ROW, parking at bus stops

Source: (Greater Vishakhapatnam Municipal Corporation, 2007; Greater Vishakhapatnam Municipal Corporation, 2010)

3.9 BRT in Vijayawada

42.45km stretch of the BRT corridor is planned in Vijayawada divided into 5 corridors. Of this only 15.5km of the stretch is sanctioned by MoUD for implementation.

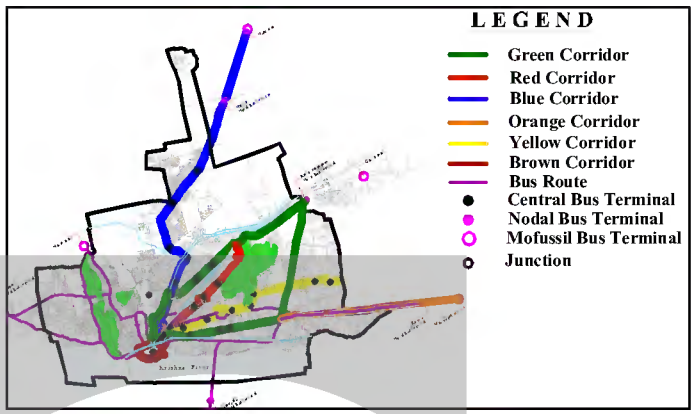

Figure 9: Vijayawada BRT corridor

CITY PROFILE	Population in lakhs (2001)	10.4
	Existing modal share of Public Transport	22.68%
	Weighted Average Trip Length	4.21 km
	Per Capita trip rate	1.36
BRTS DETAILS		
Responsible Authorities	Executing authority	Municipal corporation
	Funding agency	JNNURM
Cost	Approved cost	Rs 152.64 crores
	Unit Total Cost	Rs 3.9 crores per km
Time line	Construction started	June 2008
	Operation started	Not yet
Bus corridor design details	Type of BRT system	Open
	Total planned km	42.45km planned, 15.5km approved
	Total length executed or under construction	14.5km ready for operation
	Width of bus lanes	3.5m
	Tools to separate bus lane from mix traffic	0.5m wide separator with railings
Fleet usage	Existing fleet used or not	Yes
	Passenger capacity in bus	60-70
Bus stops	Distance between bus stops (meters)	600-800m
	Bus stop location wrt junction/intersection	Near intersection
	Type of bus stop: staggered/island platform	Staggered
	Average speed on corridor (kmph) (planned)	22-25kmph
Fare collection	On-board/off-board ticketing	Both
Other services & operational details	Passenger information: dynamic/static	Dynamic
	Any other service for public convenience	Public amenities, dustbins
Integration with other modes	Walk	2m wide footpath with signalized pedestrian crossing, at high demand location grade separated facility, barrier free facilities
	Cycle and cycle rickshaws	2m wide cycle track
	IPT	Parking
	Motorized vehicles	150-200 ECS for every 1km of BRT, Off-street

Source: (Consulting Engineering Services (India) Private Limited, 2006; Vijayawada Municipal Corporation, 2010)

3.10 BRT in Rajkot

A stretch of 63 km has been commissioned for the BRT operation in the city of Rajkot of which 29 km known as the blue corridor is supposed to be completed in phase-I. The project is planned in three phases, other two being named as red and green corridor. As of now, a 10.70 km-long stretch is under construction from Jamnagar crossroad to Gondal crossroad, covering 14 bus stops as part of the Blue Corridor.

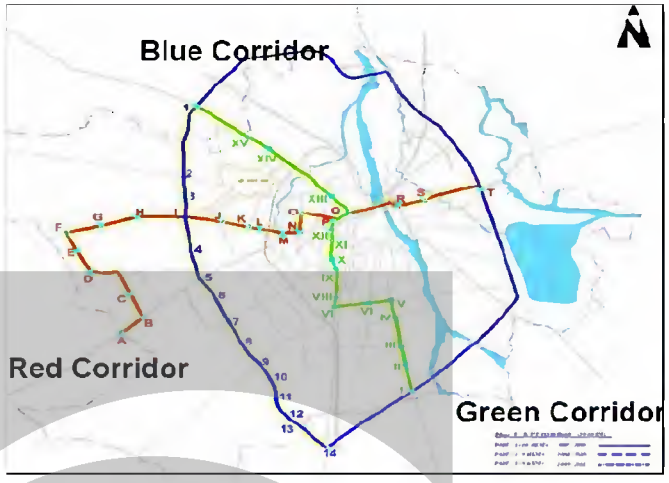

Figure 10: Rajkot BRT corridor

CITY PROFILE	Population In lakhs (2001)	10.3
	Existing modal share of Public Transport	21%
	Weighted Average Trip Length (km)	3.71
	Per Capita trip rate	1.29
BRTS DETAILS		
Responsible Authorities	Executing authority	Municipal Corporation
	Funding agency	JNNURM
Cost	Approved cost	Rs 379.3 crores
	Unit Total Cost	Rs 3.79 crores per km
Time line	Construction started	2008
	Operation started	Not yet started
Bus corridor design details	Type of BRT system	Closed
	Total planned km	63km of which 29 km is sanctioned
	Total length executed or under construction	10.7km
	Width of bus lanes	3.5 to 3.75m
	Tools to separate bus lane from mix traffic	Kerb, rumble strips, railings
Fleet usage	Existing fleet used or not	Yes
	Passenger capacity in bus	60
Bus stops	Distance between bus stops	750 m
	Bus stop location wrt junction/intersection	Before intersection
	Type of bus stop: staggered/island	Staggered
Bus operations	Frequency planned	1.5 minutes
	Average speed on corridor (planned)	35 kmph
	Planned ridership	8000 pphpd
Fare collection	On-board/off-board ticketing	Off-board
Other services & operational details	Space availability for vendors along corridor	Yes
	Passenger information: dynamic/static	Dynamic
	Any other service for public convenience	Toilets, kiosks and second hand car market suggested
Integration with other modes	Walk	1.8m wide footpaths, zebra crossing at junctions
	Cycle and cycle rickshaws	2.2m wide cycle tracks, parking near bus stops
	IPT	Parking near bus stops
	Motorized vehicles	500 for 4-wheelers and 2400 for 2-wheelers on street parking

Source: (Dave, 2009; Rajkot Municipal Corporation, 2007; Rajkot Municipal Corporation, 2010)

4 Comparative analysis

4.1 City profile

4.1.1 Socio-economic profile

Of the 10 cities where the BRT project is in implementation one is a metro city, 4 are medium sized cities and 5 are small size cities with population size as greater than 80 lakhs, 20-50 lakhs and less than 20 lakhs respectively. As per Table 3 and Figure 11 the median monthly household income ranges from 50 to 221 USD with maximum in Delhi and minimum in Surat. A large proportion of the population in these cities is living in slums: 18.7% in Delhi, 19.4% in Pune and 25.77% in Ahmedabad. However, the percentage of people living in slums is comparatively less in small cities as compared to medium size or metro cities.

Table 3: Socio economic profile of 10 Indian cities

Category	Cities	Population in lakhs (2001)	Household income (USD)	Percentage of population in slums
Metro	Delhi	128.7	221	18.7
Medium	Ahmedabad	45.25	114	25.77
	Pune	37.6	124	19.4
	Surat	28.11	52	20.14
	Jaipur	23.22	71	15.9
Small	Indore	15.46	64	17.7
	Bhopal	14.58	152	8.7
	Vishakhapatnam	13.45	93	
	Vijayawada	10.4	60	
	Rajkot	10.3	221	14.7

Source: (Ahmedabad Municipal Corporation et al., 2006; CST India, 2009; Department of Urban Development and IL&FS Ecosmart Ltd., 2006; Mehta & Associates Indore, 2006; Pune Municipal Corporation et al., 2006; Surat Municipal Corporation et al., 2006)

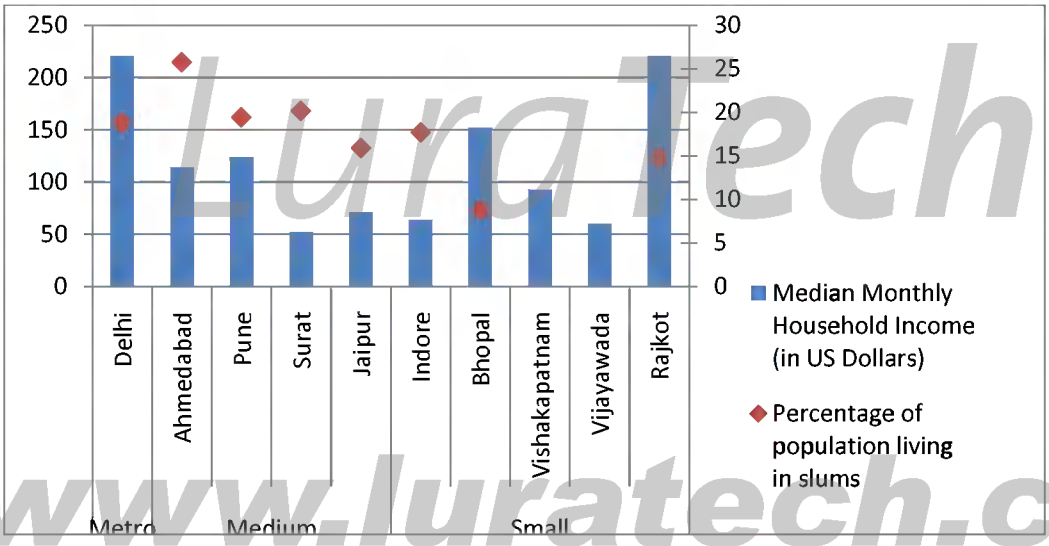

Figure 11: Socio-economic profile of cities

4.1.2 Travel behavior

Average trip length in the metro and medium sized cities is more than 5km and around 85% of the trips made are less than 10 km which is appropriate for bus travel (Table 4). Average trip length in small cities is less than 5km. The existing share of bus use is high in all the 10 cities approved for the BRT project. However, given the fact that the existing public transport service in the cities is not up to the mark in terms of reliability, safety, security and comfort, they all are captive users who tend to shift towards the use of private transport as their income levels increase.

Table 4: Travel behavior in 10 Indian cities

Category	Cities	Trip length	Trip rate	Modal share	
				IPT	Public Transport
Metro	Delhi	10.0	1.56	4	47
Medium	Ahmedabad	5.3	1.14	3	8
	Pune	6.0	1.3	5	22
	Surat	5.3	1.0		13
	Jaipur	5.3	0.9	3	14
Small	Indore	5.5	1.49	16	4
	Bhopal	3.1	1.0	5.7	48.6
	Vishakhapatnam		0.82		20
	Vijayawada	4.21	1.36	12.72	22.68
	Rajkot	3.71	1.29	46	21

Source: (CST India 2009)

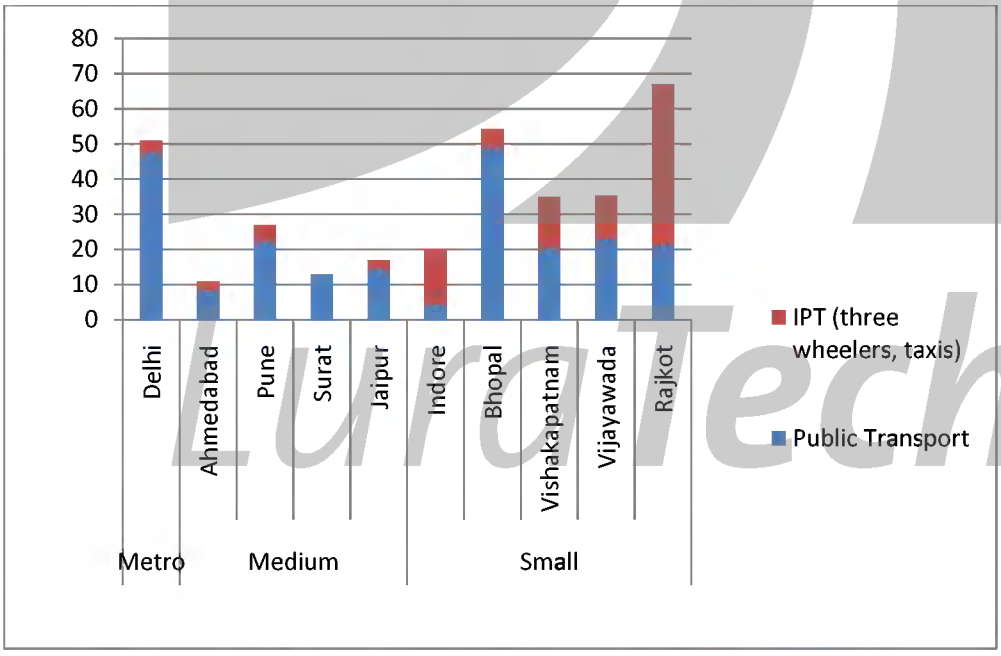

Figure 12: Modal share of public transport and IPT in 10 Indian cities

4.2 BRTS Details

4.2.1 Type of BRT system

There are two types of BRT systems: the closed system and the open system. In the closed system, buses run on a dedicated corridor without the public transport being affected by the mixed traffic (Figure 13). This requires a planned feeder service for the areas where passengers are less in number and hence it's not feasible to provide trunk service. The closed BRT system has been planned in Ahmedabad, Surat, Vishakhapatnam and Rajkot. In the open system, the existing bus services are upgraded by providing dedicated lanes for movement of buses in the congested areas of cities. The system is thus flexible and easily adapts to the existing bus routes and movement pattern. Buses can leave and enter the corridor at intersections thereby reducing the number of interchanges that are required in the case of the closed system (Figure 14). Apart from the closed and open systems there can be a hybrid system. As per Table 5, BRTS in Jaipur and Bhopal are hybrid systems. In the case of Jaipur, an exclusive BRT service has been planned. Along with this, destination oriented services have been planned. Here the BRT service is extended to the areas where dedicated corridors are not there. The system thus is flexible to the existing travel pattern in the city and also provides more frequent services to the areas served by exclusive BRT routes. In Bhopal the system is primarily planned as a closed system except that the buses will run in mixed traffic lanes only in the areas where ROW is not available. Here the existing bus fleet will not be allowed to move on the BRT corridor and will only be used as a feeder service.

Figure 13: Closed BRT system in Ahmedabad

Figure 14: Open BRT system in Delhi

Table 5: Type of BRT system in 10 Indian cities

	Cities										
Type of system	DEL	ABD	PNE	SRT	JPR	IDR	BHP	VSK	VJD	RJK	Total no. of cities
Open	■		■			■			■		4
Closed		■		■				■		■	4
Hybrid					■		■				2
Note:	■ Planned DEL: Delhi; ABD: Ahmedabad; PNE: Pune; SRT: Surat; JPR: Jaipur; IDR: Indore; BHP: Bhopal; VIZ: Vishakhapatnam; VJD: Vijayawada; RJK: Rajkot										

4.2.2 Responsible Authorities

Planning for all BRT systems has been initiated by the local municipal government when central assistance under JNNURM scheme became available. Except for the Delhi BRT all other systems are funded by JNNURM with 50% support from the Centre, 20% from the state government and 30% from the local authorities (Table 6). Delhi government transport department initiated this project and formed a joint venture company with IDFC to plan multi modal transport systems called Delhi Integrated Multimodal Company (DIMTS). Special purpose vehicles have been planned in Ahmedabad, Indore, Pune and Jaipur also.

Table 6: Responsible authorities for BRT projects in Indian cities

Sl. No.	City	Executing Authority	Financial support	Operating authority
1	Delhi	GNCTD	GNCTD	SPV: DIMTS
2	Ahmedabad	Municipal Corp.	JNNURM	SPV: Janmarg
3	Pune	Municipal Corp.	JNNURM	SPV: PMPML
4	Surat	Municipal Corp.	JNNURM	SPV
5	Jaipur	Development Authority	JNNURM	SPV: JCTSL
6	Indore	Development Authority	JNNURM	SPV: ICTSL
7	Bhopal	Municipal Corp.	JNNURM	SPV
8	Vishakhapatnam	Municipal Corp.	JNNURM	SPV
9	Vijayawada	Municipal Corp.	JNNURM	SPV
10	Rajkot	Municipal Corp.	JNNURM	SPV: RTC

4.2.3 Network planning

Out of the 10 cities, BRT in 9 cities is being developed under JNNURM. Except in Pune and Ahmedabad, for all other cities MoUD has approved only phase-I or the pilot corridor for implementation (Table 7). The financial plan for the remaining stretch of the corridor is not yet finalized in these cities. This can pose a hindrance to the full implementation of the planned BRT corridor.

In all the cities BRT corridors have been identified based on the available ROW, traffic demand and existing bus routes in the city. The criteria for selection of the first pilot corridor are based on the ease of implementation in terms of availability of right of way (ROW) except for Delhi, Pune and Bhopal. In Delhi apart from the availability of ROW demand on the corridor is very high and in Bhopal the pilot corridor passes through the congested and dense areas of the city.

Table 7: BRT network plan in Indian cities

Sl. No.	City	Planned Length of the corridor (km)	Approved length of the corridor by MoUD (km)	Criteria for selection of first corridor
1	Delhi	426.00	NA	High Density
2	Ahmedabad	88.80	88.80	ROW
3	Pune	117.00	117.00	ROW
4	Surat	125.00	30.00	
5	Jaipur	138.00	42.00	
6	Indore	106.00	11.50	
7	Bhopal	44.00 (phase-1)	21.70	High Density
8	Vishakhapatnam	105.70	42.00	Travel demand, ROW
9	Vijayawada	42.45	15.50	
10	Rajkot	63.00	29.00	

4.2.4 Bus lane details

The width of the bus lane is either 3.3 meters or 3.5 meters with 3.5 meter and 3.75 meter at bus stops. Different types of tools can be used to segregate bus lanes from the main carriage ways. Use of kerbs only for segregation allows easy removal of dismantled buses from the corridor during operation thus providing better efficiency to the system. In Delhi, Indore and Surat kerbs are being used, whereas railings are being used in the other 6 cities. In Delhi, fences have been used only at intersections to notify exclusive bus lanes from mixed traffic situations. Safe movement of the bus in bus lanes can be assured by the appropriate use of segregation tools. Rumble strips have been used in Delhi, Pune and Rajkot whereas lane marking is being used in Ahmedabad, Jaipur and Bhopal. Wide medians are also being used in Surat and Vijayawada. Use of rumble strips allows buses to overtake in case of problems.

Figure 15: Only kerbs used in Delhi to segregate bus lane from main carriageway

Figure 16: Railings used in Jaipur to segregate bus lane from main carriageway

Table 8: Bus lane detail in 10 Indian cities

		Cities									
		DEL	ABD	PNE	SRT	JPR	IDR	BHP	VSK	VJD	RJK
Width of BRT lane is 3.3m		■		■		■	■	■			
Width of BRT lane is 3.5m			■		■				■	■	■
Tools to segregate bus lane from carriageway	Only Kerb	■			■		■				
	Railings		■	■		■		■		■	■
Tools to segregate two bus lanes	Rumble strip	■		■							■
	Lane marking		■			■		■			
	Divider				■					■	
Note		■ Planned DEL: Delhi; ABD: Ahmedabad; PNE: Pune; SRT: Surat; JPR: Jaipur; IDR: Indore; BHP: Bhopal; VIZ: Vishakhapatnam; VJD: Vijayawada; RJK: Rajkot									

4.2.5 Bus fleet usage

Except in the case of Ahmedabad, Surat, Jaipur and Bhopal existing buses are planned to be used in other cities.

Figure 17: Low floor bus, door on either side, Jaipur

Figure 18: Existing fleet being used in Vijayawada

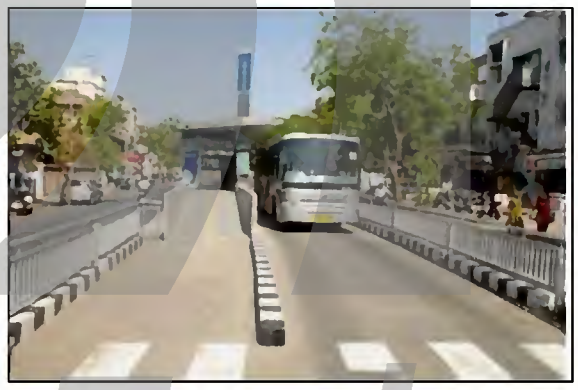

Figure 19: Only BRT bus used on corridor, Ahmedabad

Table 9: BRT fleet details in 10 Indian cities

			Cities									
			DEL	ABD	PNE	SRT	JPR	IDR	BHP	VSK	VJD	RJK
Existing fleet to be used												
Type of vehicle	Floor height of bus	Low										
		Semi										
		High										
	Fuel used	CNG										
		Diesel										
Passenger capacity			100	100	70	70	66	60		60	60	60
Note:			Yes			No						
			DEL: Delhi; ABD: Ahmedabad; PNE: Pune; SRT: Surat; JPR: Jaipur; IDR: Indore; BHP: Bhopal; VIZ: Vishakhapatnam; VJD: Vijayawada; RJK: Rajkot									

4.2.6 Bus stops

The average speed of buses on the corridor depends on the distance between bus-stops. Also the distance between bus stops determines the catchment area of the system and acceptability of the system by the users. The average distance between bus stops in all the cities is 500m except in Ahmedabad, Vijayawada and Rajkot where bus stops are spaced at 800m.

Two types of bus stops are possible in the case of central bus lanes: staggered and island platform. Island platforms have an advantage over staggered platform in terms of saving of space, easier off-board ticketing facility and easy transition and interchange facilities for bus users. However, island platforms do not comply with the existing bus designs having doors on the left side only. Also, if the buses are to be used beyond BRT service then buses have to be designed with doors on both the sides as in Jaipur. Moreover, staggered bus stops can be strategically located before a junction. Bus stops located before intersections have improved flow and speed and also facilitate pedestrian movement. It reduces delays in travel time as the red phase of the signalized intersection is used for boarding and alighting. Moreover, extra pedestrian crossings are not required to access bus stops thereby providing better traffic flow and speed. Wherever intersection spacing is more and points of significant boarding/alighting occur in between intersections, provision has been made for mid-block bus stops.

Figure 20: Staggered platform in Jaipur

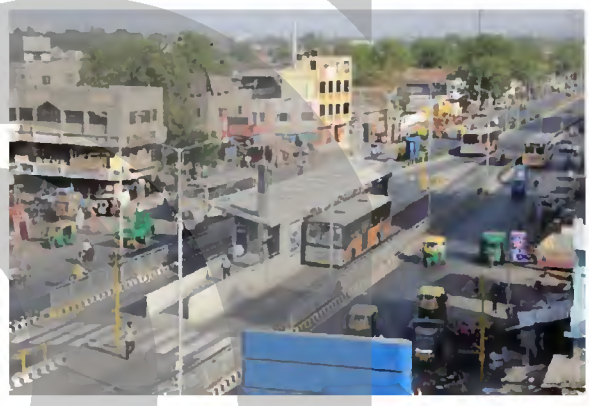

Figure 21: Island platform in Ahmedabad

Figure 22: Bus stop before junction, Pune

Table 10: Bus stop detail in all 10 Indian cities

	Cities									
	DEL	ABD	PNE	SRT	JPR	IDR	BHP	VSK	VJD	RJK
Staggered type bus stops										
Island platforms										
Bus stop before junction										
Bus stop far-side of junction										
Overtaking lane at bus stop										
Average distance between bus stops (m)	500	800	500	600	500	500	600		700	750
Note	Planned DEL: Delhi; ABD: Ahmedabad; PNE: Pune; SRT: Surat; JPR: Jaipur; IDR: Indore; BHP: Bhopal; VIZ: Vishakhapatnam; VJD: Vijayawada; RJK: Rajkot									

4.2.7 Fare collection

Fare collection mechanism and fare policy effect customer's satisfaction, convenience and level of service. Different types of fare collection mechanisms exist ranging from the traditional on-board system to electronically handled off-board systems. The on-board fare collection mechanism is cheaper, faster and simpler for passengers whereas the off-board system reduces human error and uses human resources to enhance user convenience and to detect revenue leakage. In Delhi and Pune the existing system of on-board fare collection is to be continued whereas in Ahmedabad, Surat, Indore and Rajkot, off-board fare collection mechanisms are planned. In the other 4 cities, the existing on-board fare collection system is to be used while providing for the off-board system as well.

	Cities									
	DEL	ABD	PNE	SRT	JPR	IDR	BHP	VSK	VJD	RJK
Off-board										
On-board										
Note	Planned DEL: Delhi; ABD: Ahmedabad; PNE: Pune; SRT: Surat; JPR: Jaipur; IDR: Indore; BHP: Bhopal; VIZ: Vishakhapatnam; VJD: Vijayawada; RJK: Rajkot									

4.2.8 Integration with other modes

Ease of access to the system not only increases the catchment area of the system but also determines the willingness of people to use the system. Four levels of integration can be identified that are necessary for the efficient operation of the planned system. The first level of integration lies with pedestrians as they are the primary users of the system, the second level is with cycles and cycle rickshaws. Cycle rickshaws are very commonly used in Indian cities which are the energy efficient forms of para-transit modes. The next level is integration of the system with auto-rickshaws and the last being with personal motorized vehicles that can help users to shift to private transport. Table 11 presents the summary of the infrastructure provided along the corridor to integrate BRT with other modes of transportation.

Table 11: Infrastructure provision to integrate BRT with other modes of transportation

Sl.No.	Cities	Walk	Cycle & cycle rickshaws	Auto-rickshaws	Motorized Vehicle
1	Delhi	Continuous 2m wide barrier free footpaths on both side with signalized raised zebra crossing	2.5m wide cycle tracks on both side with signalized crossing and parking near intersections, rent and ride service also available	Parking provided near intersections	On-street and off-street parking
2	Ahmedabad	2m both side footpaths, signalized level crossing and sub-ways at mid-block	2 m wide cycle track with signalized crossing	100 m of parking lane reserved for, 679 autos free parking	3m wide parking lanes on both side. Paid parking for 3624 two wheelers & 425 four wheelers
3	Pune	Continuous min. 1.5 m wide barrier free footpaths, with signalized raised zebra crossing	1.5m for cycle lanes and 2.5m for cycle tracks and free parking 60m from bus stops	Parking min. 30m away from bus stop spaced at 500m	On-street parking
4	Surat	3 to 5m wide pedestrian activity areas & elevated mixed traffic lanes at mid-blocks	2m wide cycle tracks		
5	Jaipur	2m wide footpath with signalized crossing	2.5m wide cycle track with parking	Parking provision	On street parking
6	Indore	Barrier free minimum 1.5m wide footpaths, Signalized crossing	Minimum 1.5 m wide cycle tracks, where ROW is not available to be combined with footpaths with cycle box for crossing. Parking near intersections	Parking at every junction	On street parking
7	Bhopal	ROW ≤ 20m: 1.5m wide footpaths, no provision for NMV ROW 24 and 30m: 3m wide combined space for pedestrians and NMV ROW ≥ 45m: 2m wide footpaths and 3m wide NMV lane With signalized zebra crossing and foot over bridge and sub-ways at mid-blocks where demand is high			
8	Vishakhapatnam	Min. 2 m wide barrier free footpath, signalized zebra crossing	2.5 m wide cycle track, parking at bus stops		
9	Vijayawada	2m wide barrier free footpaths with signalized pedestrian crossing, at high demand location grade separated facility	2m wide cycle lane	Parking	Off-street parking for 50-200 ECS for every 1km of BRT corridor
10	Rajkot	1.8m wide footpaths, zebra crossing at junctions	2.2m wide cycle tracks, parking near bus stops	Parking near bus stops	On street parking for 500 for 4-wheelers and 2400 for 2-wheelers

1. **Walk:**
   - Except in Ahmedabad, continuous footpaths have been planned for the safe movement of pedestrians along the corridor which is separate from the NMV lanes. In Bhopal where ROW is less than 20 meters combined 3 meter wide space has been provided for both pedestrians and cyclists.
   - Zebra crossing with pedestrian activated traffic signals have been provided in all the cities both at junctions and mid-blocks where bus stops have been planned. Also in Delhi provision for raised zebra crossings have been made. Also at mid-block bus stops, where demand is high, grade separated facilities have been planned in cities like Ahmedabad and Pune. In Surat, the main carriage way has been elevated to provide at grade crossing for pedestrians. Dedicated routes in all the cities are planned on the central lane thereby reducing crossing distance for pedestrians.
   - In Delhi, to reduce conflicts between pedestrians and motorized vehicles at access of properties speed ramps have been provided.
2. **Cyclists and cycle rickshaws:** Cycle tracks have been planned in the areas based on the availability of ROW. 2-2.5 meter wide cycle tracks have been provided and 1.8meter wide cycle lanes along the corridor depending on the ROW. Bicycle parking has been planned along the corridor near bus stops and junctions in cities like Delhi, Pune, Jaipur and Indore. The Delhi BRT corridor also has rent and ride facilities.
3. **Three wheelers/IPT:** Free parking facilities for auto-rickshaws has been planned along the corridor near bus stops and junctions in Delhi, Ahmedabad, Pune, Jaipur, Indore, Vijayawada and Rajkot.
4. **Motorized vehicles:** Paid on-street parking has been planned in Ahmedabad, Jaipur, Indore and Rajkot. In Vijayawada paid off-street has been planned for 50-200 equivalent car space for every 1km of the BRT corridor. In Delhi apart from off-street parking provisions stopping bays for both cars and heavy vehicles have been planned along the main carriage way.

4.2.9 Other public facilities for bus users

Indian streets are commonly known for street vending activities that not only attract pedestrians but also serve society. BRT corridors can be expected to become a major pedestrian activity area in the city. It is therefore necessary to provide public amenities and organized space for hawkers to incorporate the existing activities.

Table 12: Public amenities on BRT corridor

	Cities									
	DEL	ABD	PNE	SRT	JPR	IDR	BHP	VSK	VJD	RJK
Space for Hawkers										
Public toilets										
Sitting areas										
Note	Planned DEL: Delhi; ABD: Ahmedabad; PNE: Pune; SRT: Surat; JPR: Jaipur; IDR: Indore; BHP: Bhopal; VIZ: Vishakhapatnam; VJD: Vijayawada; RJK: Rajkot									

4.2.10 Financial analysis

As mentioned earlier, except in Delhi, BRT projects in other cities are JNNURM funded. 50% of the funding in JNNURM projects comes from the Central government, 20% from the state government and the rest of the 30% from local authorities.

Table 13: Cost of BRT infrastructure in 10 Indian cities

Cities	Route length approved (km)	Approved cost (crores in INR)	Unit cost (Rs in crores per km)	Ranking
Delhi	426		14.89	2
Ahmedabad	88.8	984.15	11.08	4
Pune	121	1789.16	14.79	3
Surat	29.9	469.02	15.69	1
Jaipur	45	479.54	10.64	6
Indore	22.5	98.45	4.38	8
Bhopal	21.7	237.76	10.96	5
Vishakapatnam	47.5	452.93	9.53	7
Vijayawada	39.45	152.64	3.87	9
Rajkot	29	110.00	3.79	10

As per Table 13 the unit cost of BRT infrastructure in Indian cities varies from Rs 4 to 15 crores per kilometer with the least being in Rajkot and the maximum in Surat. The type of infrastructure provided, materials to be used, location of corridor, relocation of utilities are the major factors in determining the cost of the infrastructure. For example in Ahmedabad and Surat, grade separated facilities have also been planned for efficient operation of the BRTS.

4.3 Evaluating BRT systems of India

4.3.1 Bus operation and efficiency

As discussed earlier, the open BRT system can be easily integrated with the existing intra-city bus system. Approximately, 9% of the total routes in Delhi pass through the BRT pilot corridor (5.8km long from Ambedkar Nagar to the Moolchand Flyover), with buses running at a frequency of 120 buses per direction in the peak hours and average speed of 18 kmph. Whereas, in the case of Ahmedabad closed system, achieved frequency is 30 buses per hour per direction with an average speed of 24 to 26 kmph in the peak hours and catering to 52,000 passenger trips per day. Delhi system has two parallel platforms at the bus stops on the near side of the junction. Each platform can accommodate 4-5 buses boarding and alighting simultaneously. Buses can move in platoon of 10 buses every 2 minutes if the signal cycle is kept at 2 minutes. At present signal cycle is more than 3 minutes sometimes.

Table 14: Efficiency of BRT system in 10 Indian cities

Sl. No.	City	Peak hour average speed (kmph)	Frequency (minutes)	Comments
1	Delhi	18	0.5	Achieved
2	Ahmedabad	24-26	2.5	Achieved
3	Pune	16-18	2	Achieved
4	Surat		2-5	Planned
5	Jaipur	25	2-4	Planned
6	Indore	20	1.5	Planned
7	Bhopal	25	2-3	Planned
8	Vishakhapatnam		1-1.5	Planned
9	Vijayawada	22-25		Planned
10	Rajkot	30	1.5	Planned

4.3.2 Demand assessment

The demand for BRTS which has been planned in all the 10 cities varies from approximately 2600 pphpd being served by Ahmedabad BRT (length 25 km(to the maximum of 13,500 pphpd served by the Delhi pilot corridor (5.6 km). The passenger demand on selected BRTS corridors in many cities is still low as in Bhopal where the maximum existing demand on the selected corridor is 3800 pphpd on route3 which is projected to be 11,400 by 2021. Also in Jaipur the existing demand ranges from 500 - 1,700 pphpd. In Indore the demand in 2009 was 1000-6000 pphpd on the identified corridors that is projected to be 2500—10000 pphpd in 2012 and 6000-25000 pphpd in 2021.

Table 15: Demand assessment on BRT corridor in 10 Indian cities

Stage of implementation	Sl. No.	City	Existing Ridership (PPHPD)	Planned Ridership (pphpd)	Theoretical capacity (pphpd)
Operational	1	Delhi	13,500	20,000 - 24,000	24,000
	2	Ahmedabad	2,400 - 2,600	15,000 - 20,000	3,000
	3	Pune	3,600	10,000 – 15,000	3,000
Under construction	4	Surat		20,000	2,000
	5	Jaipur	500 - 1,700		6,000
	6	Indore	1,000 - 6,000	10,000 - 20,000	4,000
	7	Bhopal	1800 - 3,800	11,400	3,000
	8	Vishakhapatnam	3950 - 5970	5,750 - 9,100	6,000
	9	Vijayawada			
	10	Rajkot		8,000	4,000

5 Summary of BRT projects in Indian cities

Table 16: Summary of BRT projects in India

Status	Operational			Under Construction						
	Delhi	Ahmedabad	Pune	Surat	Jaipur	Indore	Bhopal	Vishakhapatnam	Vijayawada	Rajkot
Length Planned (km)	426	88.8	117	125	138	106	44	105.7	42.45	63
Length approved		88.8	117	30	42	11.5	21.7	42	15.5	29
Infrastructure cost Rs crores per km	14.89	11.08	14.79	15.69	10.64	4.38	10.96	9.53	3.87	3.79
Type of system	Open	Close	Open	Close	Hybrid	Open	Hybrid	Close	Open	Close
Bus lane position	Central	Central	Central	Central	Central	Central	Central	Central	Central	Central
Bus lane width (meters)	3.3	3.5	3.3	3.5	3.3	3.3	3.3	3.5	3.5	3.5
Type of bus stop	Staggered	Island	Staggered	Island	Both	Staggered	Staggered	Staggered	Staggered	Island
Bus technology	Low floor, CNG	Low floor, CNG	Semi-low floor	High floor, CNG	Low floor, Diesel		Low floor	Low floor, Diesel	Low floor, CNG	Diesel
Fare collection mechanism	On-board	Off-board	On-board	Off-board	On-board	Both	Both	Both	Both	Off-board
Ownership & Financing	Transport Depart.	SPV & JNNURM	SPV & JNNURM	SPV & JNNURM	SPV & JNNURM	SPV & JNNURM	SPV & JNNURM	SPV & JNNURM	SPV & JNNURM	SPV & JNNURM

6 Key findings

- **BRT project status:** Execution of the BRT project in all the cities has been moving at a slow pace. As per the presentations made by the responsible authorities, the major hindrances in execution are undefined roles of institutions, unavailability of ROW in cities and permission from different authorities.
- **Requirement for BRT:** Average trip length in the metro and medium sized cities is more than 5 km. However, in small cities it is still less except in Indore. Bus systems are preferable for trip lengths more than 3-5 km. Moreover, closed system has been proposed in small cities also that requires interchanges to be able to use the system. With trip lengths as small as 3 km and considering access and egress distance of 500 meters closed system is not a viable option.
- **Demand assessment:** BRT project can serve upto the capacity of 20,000 to 25,000 pphpd depending on the geometry, bus stop design and operational plans. The appropriate utilization of the capacity of system is recognized only in Delhi of the all 10 cities where the existing demand is 13,500 and the system designs offers for the maximum of 24,000 pphpd. Whereas, in cities like Bhopal or Surat demand is as low as 1700 pphpd and the system is also designed to serve for 3000 – 6000 pphpd only. Such a small demand can be served by only improving the operations of existing bus system in the city rather than investing approximately Rs 100- 150 crores per km for development of BRT corridor.
- **Integration with other modes of transport:** Integration of the system with other existing modes of transportation is required to provide comfortable access and egress to the system from and to origin and destination locations. This can be ensured by providing safe and secure infrastructure for NMV and parking for cycles, auto-rickshaws and personal motorized vehicles. This has been ensured in cities like Delhi, Pune and Jaipur. Whereas in Ahmedabad footpaths and cycle tracks planned are narrow than international standards, non-continuous and not fully compliant for barrier free access (Kost, 2009).

Since 1995 to 2005, Indian cities discussed the relevance and feasibility of BRTS in India. Pune was the first city to construct dedicated central bus lane followed by Delhi. Both cities have an extensive bus system. Pune did not permit the existing bus routes to operate in the dedicated corridor initially. Delhi system made it mandatory for all buses to be in the dedicated corridor. Initially both systems had fatal crashes involving buses and pedestrians crossing the road. Fatal crashes in Delhi system have been reduced by more than 90% in the last two years (Delhi Integrated Multi-modal Transit System, 2010). In Delhi and Pune, there has been reduction in car speeds and improvement in bus speeds by more than 50%. Ahmedabad system has been in operation since July 2009. Buses are operating in the dedicated corridor and car traffic has not faced any reduction in speed because of low volume of vehicles on the corridor. Both in Delhi and Pune media reports have strongly opposed the system primarily listing the reduction in speed and “congestion” faced by car traffic. Ahmedabad has had positive reports from the media as cars have not been affected. At present, most cites are moving very cautiously and slowly for implementing BRT projects. The main concern seems to be to avoid the possible adverse impact on car traffic. Several cities are preparing plans for metro system which is 10-15 times costlier than the BRT and requesting central government for assistance. These projects have strong support from the media as well as the politicians and bureaucrats. However, BRT projects which require less

capital and operating cost and have a potential for transforming the city environment and benefiting a large number of people have had luke warm response from the authorities and the media.

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Annexure 1

Table 17: Indicators to evaluate BRT project

City profile		
Socio-economic profile		Population (million, 2001 census)
		Median Monthly Household Income (in US Dollars)
		Percentage of population living in slums
		Per capita income in slums
Travel behavior	Modal share before implementation	Walk
		Cycle
		IPT (three wheelers, taxis)
		Public Transport
		Private Transport (MTW, personal cars)
	Trip length breakup	< 2 km
		2 - 5 km
		5 - 10 km
		10 - 15 km
		> 15 km
	Weighted Average Trip Length (km)	
	Per Capita trip rate	
BRTS Detail		
Basic concepts	Why BRT?	
	Criteria for selection of first corridor execution?	
	What type of system- open/closed and why?	
Authorities	Executing authority	
	Funding agency	
	Approved cost (lakhs in INR)	
	Support by JNNURM (%age)	
Time line	Construction started	
	Operation started	
BRTS-trunk route details	Bus corridor details	Width of bus lanes at intersection, bus stop and mid-block (meters)
		Position of segregated lanes (central/side)
		Tools to separate bus lane from mix traffic like kerb, fence, lane marking
		Total planned km
		Total executed km
		Total planned km (segregated corridor)
		Total executed km (segregated corridor)
		Total planned km (mixed traffic)
		Total executed km (mixed traffic)
		No. of routes catered in open system on corridor
		No. of routes in total system (open)
	Fleet usage	Existing fleet used or not
		Passenger capacity in bus
		No. of buses operating on corridor in peak hour
		Total no. of buses operating in system in peak hour (open)
	Bus stops	Number of bus stops
		Distance between bus stops (meters)
		Bus stop location wrt junction/intersection[1]
		Type of bus stop: single sided/two-sided
	Bus operations	Frequency planned
		Frequency achieved
		Bus capacity on corridor[2]

[1] **Bus stop location wrt junction/intersection:** Distance of bus stop from junction/intersection. The factor is necessary to determine the time required to change bus route (possible at junctions).

City profile			
		Average speed on corridor (kmph)	
		Planned ridership	
		Achieved ridership	
		Existing bus occupancy factor	
	Cost and fare	Unit Total Cost (million USD per km)	
		Unit Infrastructure cost (million USD per km)	
		Total Estimated Cost (entire planned BRT system) (million USD)	
		Operation and Maintenance cost per passenger (Rs)	
		Type of fare: fix/progressive	
		On-board/off-board ticketing	
		Fare amount in INR (with slabs for progressive fare)[3]	
		Average fare per passenger (Rs)	
		Average fare per passenger km	
		Criteria for fare fixation	
	Other services and operational details	Space availability for vendors along corridor	
		Passenger information: dynamic/static	
		Any other service for public convenience and street furniture: toilets/information booths	
Feeder service[iv]	Walk	Footpaths	Length
			Width
			Single sided/both side
			Continuous/Non-continuous
		Intersection treatment	Signalized crossing
			Level/raised crossing
			Traffic calming tools[4]
			Traffic calming for access to properties
			Intermediate crossing sections
			Crossing distance[5]
		Accessibility	Barrier free access to bus stops[6]
			Barrier free access to footpaths
	Cycle and cycle rickshaw	Lanes	Cycle lanes/cycle tracks/both[7]
			Total length of cycle lanes
			Total length of cycle tracks
			Continuous/Non-Continuous[8]

[2] **Bus capacity on corridor:** Maximum number of buses that can run on one km length of the corridor in one hour considering factors like average speed, distance between bus-stops, bus stop design, frequency, traffic signals, boarding and alighting time.

[3] **Fare amount in INR (with slabs for progressive fare):** For fix fare system amount of fare charged has to be mentioned. In case of progressive fare system, amount of fare is dependent on the length of the system used. Slabs need to define the length of the system usage at which fare amount changes along with the amount of fare charged.

[4] **Feeder service:** Feeder service refers to all the modes of transportation by which BRTs can be accessed. The primary users identified are the pedestrians followed by cyclists and the last being the motorized vehicle user.

[5] **Traffic calming tools:** These vary from warning signs, speed breakers to traffic circles.

[6] **Crossing distance:** Total MV lanes that have to be crossed at a time by pedestrians to reach bus stop while going to or coming back if bus stop are across the road (will be the case either during access/egress in case of side lanes). This determines the risk to which a pedestrian is exposed to during access/egress of bus transport systems and is directly proportional to the number of lanes that a pedestrian has to cross at a time.

[7] **Barrier free access:** Accessibility provided to physically handicapped people.

[8] **Continuous/Discontinuous footpaths and cycle lanes:** Whether infrastructure is provided on the whole length or only in some parts of the corridor

City profile			
			Width of cycle lanes
			Width of cycle tracks
			Both sided/single sided
		Intersection treatment	Signalized intersections
			Traffic calming tools
			Traffic calming for access to properties
		Parking	Number of parking
			Distance of parking from bus stop
			Distance between parking stations
			Parking charges
	Three-wheelers	Number of parking	
		Distance of parking from bus stop	
		Distance between parking stations	
	Bus feeder service (closed system)[9]	Interchange required or not	
		Total planned km	
		Total executed km	
		Number of routes	
		Fleet available	
		Fleet usage	
		Frequency planned	
		Frequency achieved	
		No. of buses operating in peak hour	
		Average speed	
		Distance between bus stops	
		Planned ridership	
		Achieved ridership	
		Existing bus occupancy	
		Integrated fare/not with BRTS trunk service (closed)	
		Fare	
	Integration with MV	Park and ride facility for MV	
		Parking charges	
		No. of lanes for cars	

[9] **Bus feeder service (closed system):** In closed system as buses cannot enter corridor at any point feeder routes and services are required to be planned and designed to cater to the demand in other areas where BRT corridor is not there and also increase the catchment area of the closed system. The entry point of the corridor acts as a hub where most of the interchange activities take place.

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