Chapter 7 CORRIDOR ASSESSMENT AND IDENTIFICATION

7. CORRIDOR ASSESSMENT AND IDENTIFICATION

7.1 Introduction

The purpose of the chapter is to identify the corridors on which opportunities for developing BRTS exist and prioritize for implementation. As discussed in the previous chapters the public transport system supply situation is very poor both in quality and quantity terms. At present there is no single corridor in Ahmedabad on which high frequency public transport services are offered and supply is constrained due to congestion. In the light of this the objective of this effort would then be to develop BRTS as a **strategic intervention**, which would improve public transport image, attract latent transit demand, contribute to improved transit option for people, improve air quality and help city remain a compact city.

7.2 Framework

The guiding principles are that only those corridors would be selected which:

- could accommodate BRTS treatments,
- could be Implemented quickly and inexpensively,
- could contribute to ease the problems of transport in a significant way,
- could improve mobility options of large segment of people,
- provide opportunities for improvements in land use structure/ more compact urban structure,
- Provide potentials for cost-recovery, and
- Integrates well within the overall network including other mass transit modes i.e not compete with other public transit modes.

With these as guiding principles, the process of corridor selection has been carried out in terms of three steps.

Step 1: Identification of Potential BRTS Corridors

Step 2: Carryout assessment of Corridors with regard to

1. Demand (Existing and potential)
2. Technical Feasibility to implement BRTS treatment
3. Overall System-wide Impacts

Classify corridors based on their performance on 5:1 scale and rank them.

Step 3: Prioritization for exclusive BRTS treatment and for mixed operations based on:

1. Implementation considerations
2. Operational considerations
3. Integration issues

7.3 Identification of Potential BRTS Corridors

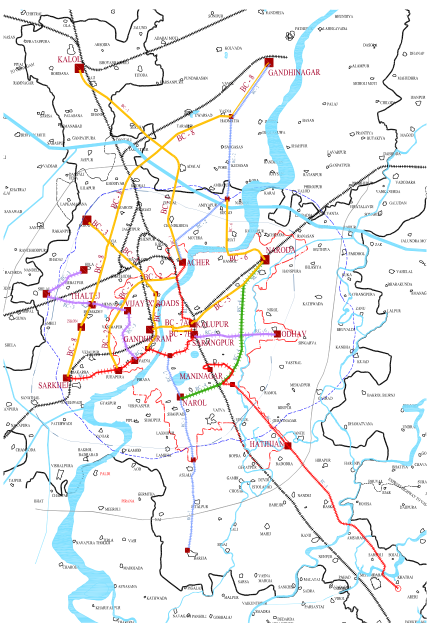
To identify the potential corridors, road network was screened with regard to three criteria.

7.3.1 DP Major Roads

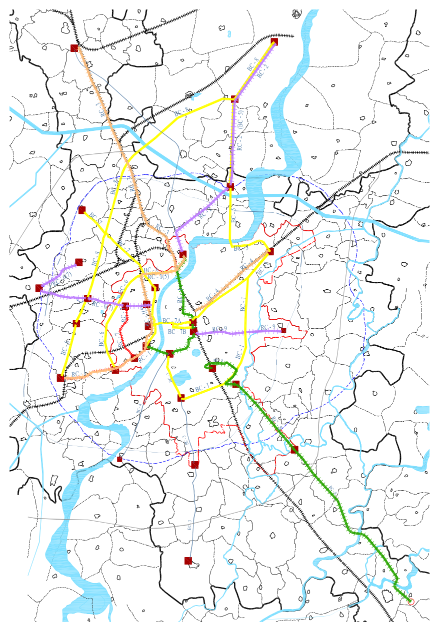
All major AUDA proposed/existing Ring and Radial Roads has been considered as potential candidates for BRTS in the long list.

7.3.2 Proposals in Previous Studies

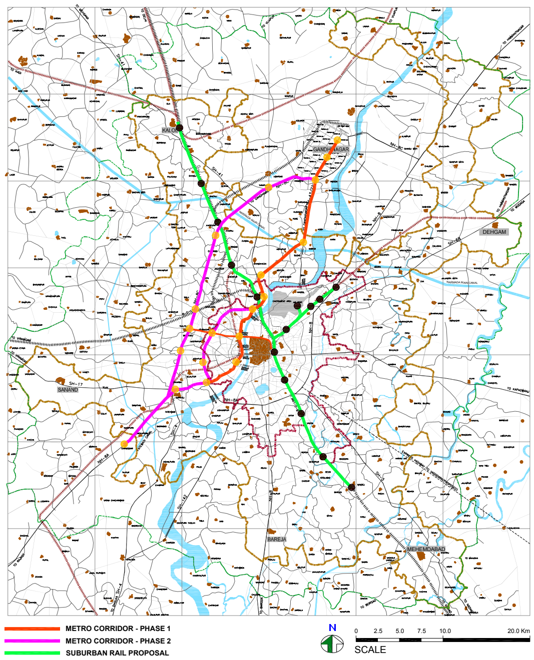
The entire proposed corridors for transit development in the previous studies have been included in the long list. The proposals were primarily from:



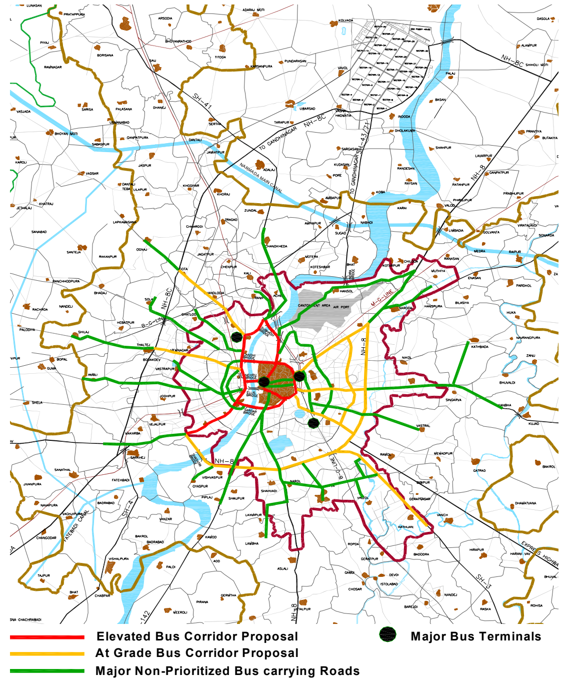
Map: 7.1a: LB Transit Proposal: Alternative 1



Map: 7.1b:LB Transit Proposal: Alternative 2

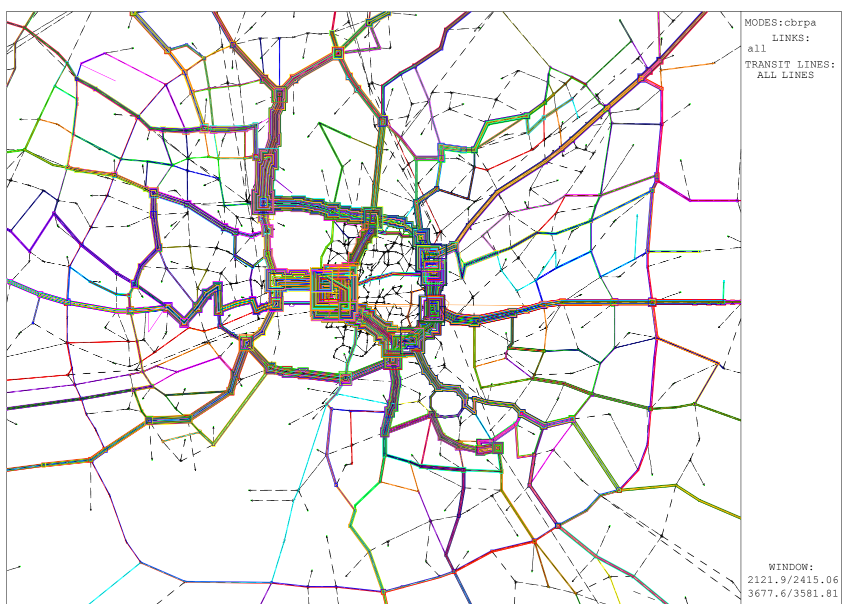


Map: 7.1c: Proposals by RITES and DMRC



Map: 7.1d: CEPT (1995) Proposal–Bus Way

7.3.3 AMTS Routes



Map 7.2: AMTS Corridors

AMTS in the year 2000, with its 150 routes was catering for 8,50,000 lakh trips each day. Fleet size of 900 buses with average fleet on road was 800 approx. AMTS bus route lengths average about 17 kms and range from about 5 to 57 kms. About 55 percent of buses operate on routes with lengths of 10 to 20 kms, with a running time of 30 to 90 minutes. The AMTS average bus stop spacing is 410 meters which is convenient for passengers, but results in longer travel time and delays. In the absence of faster bus services, average operating speed of AMTS is between 12-15 kmph.

Major corridors of public transport have been included as part of the list. It is however to be borne in mind that supply of AMTS has evolved historically and some variation in demand is possible.

Based on the above considerations, a comprehensive list of corridors has been prepared for further evaluation.

Table 7-1: List of Potential Corridors

Corridor No	Name of Corridor	Length of Corridor (kms)
1	VASNA-SABARMATI – NARODA-NAROL	47.5
2	VASNA-SABARMATI	15
3	NARODA-NAROL	18
4A	THALTHEJ TO KALUPUR	9.1
4B	SATTADHAR TO KALUPUR	9.55
5	GHATLODIA TO VADAJ	4.92
6	SABARMATI TO SARKHEJ VIA ASHRAM RD	17.63
7	ISKCON TO KALUPUR	11.09
8	ST TO NAROL TO LAMBHA	8.44
9	ST TO JASODANAGAR CROSSROAD TO HATHIJAN	12.81
10	KALUPUR TO ODHAV	9.49
11	KALUPUR TO NARODA	10.29
12	THALTHEJ TO NAROL TO LAMBHA (UNIV ROAD)	17.15
13	SARKHEJ TO GOTA	12.45
14	PALDI TO ST VIA JAMALPUR (OPTIONAL CONNECTION)	3.25
15	ISKCON TO VASNA VIA. NEHRU NAGAR CIRCLE	6.35
16	SABARMATI – KALUPUR	8.98
17	VADAJ-GOTA	5.75
18	SHIVRANJANI-KALUPUR VIA SHREYAS, NEW BRIDGE, ST	11.57

7.4 Corridor Assessment

The assessment process is carried out in three parts:

1. Travel Demand Assessment
2. Technical Feasibility
3. System-wide Impact

The performance of each of the corridor with regard to these aspects has been discussed below:

7.4.1 Travel Demand Assessment

Potential travel demand on the BRTS would consist of intra-corridor transit trips and interchange transit trips.

Intra-Corridor Transit Trips: With Catchments of about < 250 mts. Distance along the corridor (abutting zone), total trips have been estimated in terms of:

Existing Bus Trips along the corridor: Bus demand has been estimated from the IPTS study travel demand. TAZs falling along the corridor have been identified for the assessment of trips along the corridor. Bus trips along the corridor were assigned on the individual corridors for the estimations of demand.

Modal Shifts in favor of BRTS: Modal split in favor of BRTS from other modes such as Bicycles, Two-wheelers and Auto rickshaws has been estimated using emme/2 based on the total trips along the corridor. The study revealed that trips having trip length less than 4 kms are less likely to shift to bus system. Hence, trips with more than 4 kms along the corridor have only been considered for demand assessment. Modal split for BRTS from other modes has been estimated using the following percentage distributions for various trips lengths and travel modes as shown in table below.

Table 7-2: Assumed Modal Split along the Corridors

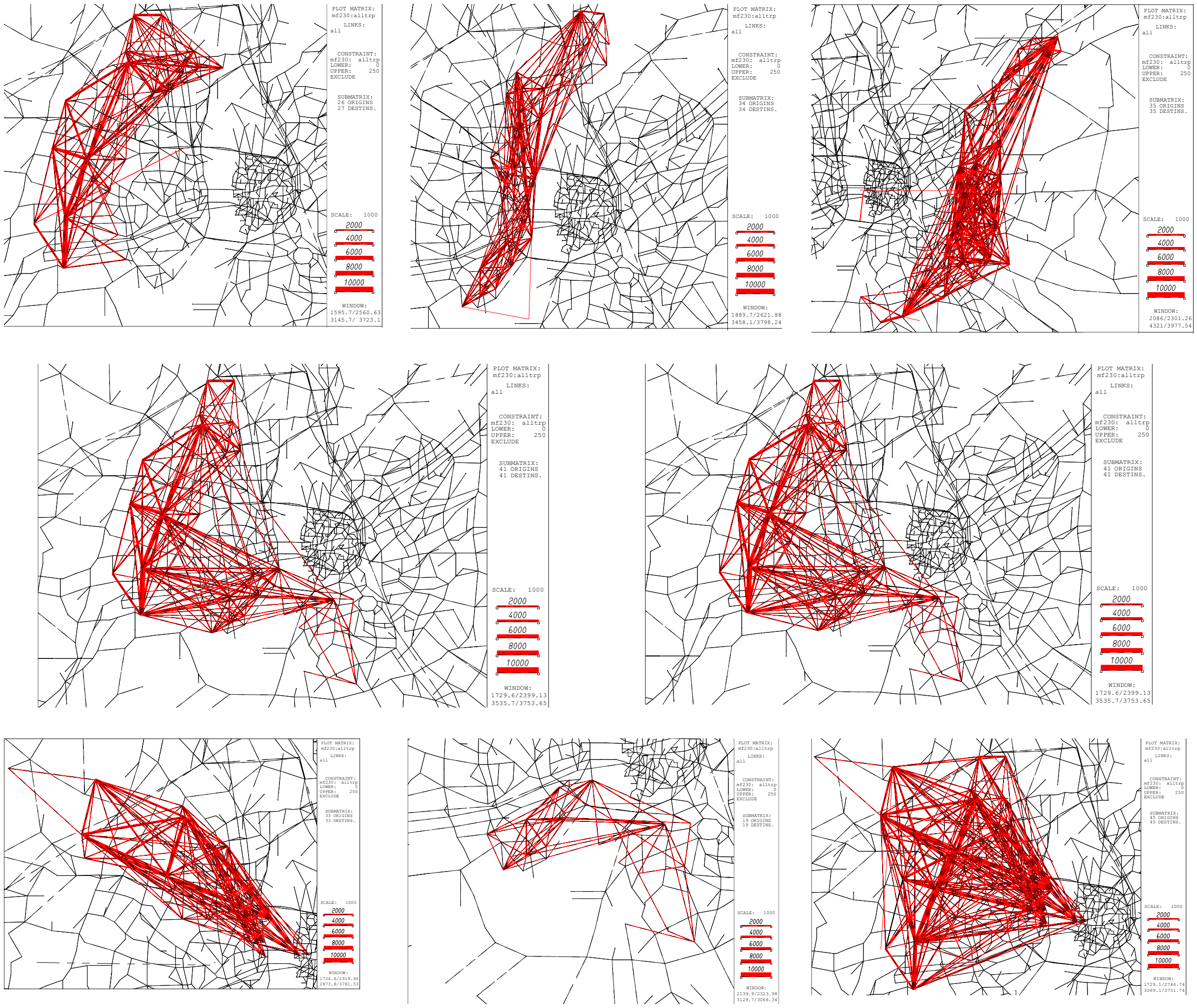
Trip Length Kms	Divertible Trips to BRTS		
	Bicycle	Two Wheeler	Auto Rickshaw
0-4	0%	0%	0%
4_6	20%	20%	40%
6_10	50%	60%	50%
>10	70%	80%	60%

The table below summarizes the study area trips by mode and trip lengths.

Table 7-3: Divertible Trips in the Study Area /Day

Trip Length Kms	Divertible Trips to BRTS			Total	% of Total
	Bicycle	Two Wheeler	Auto Rickshaw		
4_6	391688	799931	190893	1382512	52%
6_10	203776	576227	100056	880059	33%
>10	69768	307232	32011	409011	15%
Total	665232	1683390	322960	2671582	100%
% of Total	25%	63%	12%	100%	

The following figures present desire of the estimated trips along the various potential corridors for BRT system.



Map 7.3 Intra-corridor passenger trips: Desire Line Diagrams for select corridors

The table below presents estimated intra corridor potential BRT trips (including modal shift) for the year 2000.

Table 7-4: Potential BRT Trips

Sl. No	Corridor Name	Total Existing Bus Trips along the Corridor TAZ's	Trips/day along the corridor by Other Modes > 4 km trip length				Estimated Modal Shift to BRTS from Other Modes		Total BRT Trips (2000)
			Cycle	TW	Auto	Total	Trips/ day	% of Trips	
1	VASNA-SABARMATI – NARODA-NAROL	45,889	43,251	62,591	22,407	128,249	28,135	22%	74,024
2	VASNA-SABARMATI	47476	14635	27943	6760	49338	20047	41%	67,523
3	NARODA-NAROL	31584	15528	12504	9546	37578	14957	40%	46,541
4A	THALTHEJ TO Kalupur	25,897	5,432	15,733	3,623	24,788	11,215	45%	37,112
4B	SATTADHAR TO KALUPUR	28,620	6,782	16,763	3,490	27,035	12,374	46%	40,994
5	GHATLODIA TO VADAJ	12,438	2,926	5,174	302	8,402	2,914	35%	15,352

Sl. No	Corridor Name	Total Existing Bus Trips along the Corridor TAZ's	Trips/day along the corridor by Other Modes > 4 km trip length				Estimated Modal Shift to BRTS from Other Modes		Total BRT Trips (2000)
			Cycle	TW	Auto	Total	Trips/ day	% of Trips	
6	SABARMATI TO SARKHEJ	32,239	7,922	13,977	3,939	25,838	6,813	39%	42,435
7	ISKON TO KALUPUR	31,173	4,698	26,218	4,350	35,266	15,809	45%	46,982
8	ST TO NAROL TO LAMBHA	13,826	5,279	3,176	2,421	10,876	3,325	31%	17,151
9	ST TO JASODANAGAR CROSSROAD TO HATHIJAN	17,309	7,692	5,716	3,491	16,899	8,226	49%	25,535
10	KALUPUR TO ODHAV	16,253	9,634	5,332	1,399	16,365	6,169	38%	22,422
11	KALUPUR TO NARODA	20,955	13,440	7,440	5,131	26,011	9,944	38%	30,899
12	THALTHEJ TO NAROL TO LAMBHA (UNIV ROAD)	45,166	8,953	25,023	8,264	42,240	16,306	39%	61,472
13	SARKHEJ TO GOTA	21,370	3,806	7,571	4,333	15,710	6,399	41%	27,769
14	PALDI TO ST CONNECTION VIA JAMALPUR (OPTIONAL)	7,712	1,936	624	1,295	3,855	1,166	30%	8,878
15	ISKCON TO VASNA VIA. NEHRU NAGAR CIRCLE	20,398	4,678	11,560	3,881	20,119	7,587	38%	27,985
16	SABARMATI – KALUPUR	21,291	6,764	13,346	3,080	23,190	9,942	43%	31,233
17	VADAJ-GOTA	17939	5522	7557	567	13646	4601	34%	22,540
18	ISKCON-KALUPUR-VIA NEHRUNAGAR-SHREYAS-PROPOSED BRIDGE (VASNA)	31716	7160	17968	5566	30694	12667	41%	44,383

(B) Interchange Trips with Transfer Facility (AMTS + BRTS)

Assessment of travel demand with feeder/mixed corridors and AMTS services has been performed using emme/2 model transit assignment procedure. In the model, the user preference for choosing services depends up on the ***frequency of services and travel speed***. All existing AMTS and proposed BRTS corridors were modeled.

© Total Potential BRT Trips for future Years and Ranking

The total trips estimated for the future years includes intra corridor as well as interchange trips. The trip density has been estimated to bring the demand at one common scale. Further to this, trip density was classified into five categories as 'very high', 'high', 'moderate', 'low', and 'very low'. Each of these were given a score on the scale of 5:1. The combined score for all the three time periods (2000, 2007, 2015) have been tabulated for final ranking.

Table 7-5: Potential BRT Trips on Various Corridors and Ranking

Sl. No	Corridor Name	Length (Km)	Total BRT Trips/day			Trip Density (trips per day per km)			Score	Ranking
			2000	2007	2015	2000	2007	2015		
1	VASNA-SABARMATI – NARODA-NAROL	47.3	74024	201893	236757	1565	4268	5005	6	7
2	VASNA-SABARMATI	15	67523	127330	151614	4502	8489	10108	14	**1**
3	NARODA-NAROL	18	46541	74563	85143	2586	4142	4730	7	6
4A	THALTHEJ TO KALUPUR	9.1	37112	71782	80810	4078	7888	8880	13	2
4B	SATTADHAR TO KALUPUR	9.55	40994	69798	77421	4293	7309	8107	13	2
5	GHATLODIA TO VADAJ	4.92	15352	13628	15192	3120	2770	3088	7	6
6	SABARMATI TO SARKHEJ	17.63	42435	94905	105118	2215	5383	5962	8	5

			Total BRT Trips/day			Trip Density (trips per day per km)				
7	ISKON TO KALUPUR	11.09	46982	94190	104111	4236	8493	9388	13	2
8	ST TO NAROL TO LAMBHA	8.44	17151	32154	37446	2032	3810	4437	6	7
9	ST TO JASODANAGAR CROSSROAD TO HATHIJAN	12.81	25535	54905	61196	1993	4286	4777	5	8
10	KALUPUR TO ODHAV	9.49	22422	36382	40381	2363	3834	4255	6	7
11	KALUPUR TO NARODA	10.29	30899	50023	54667	3003	4861	5313	9	4
12	THALTHEJ TO NAROL TO LAMBHA (UNIV ROAD)	17.15	61472	50698	60754	3584	2956	3543	7	6
13	SARKHEJ TO GOTA	12.45	27769	27907	37219	2230	2242	2989	4	9
14	PALDI TO ST CONNECTION VIA JAMALPUR (OPTIONAL)	3.25	8878	12412	13263	2732	3819	4081	7	6
15	ISKCON TO VASNA VIA. NEHRU NAGAR CIRCLE	6.35	27985	12829	15870	4407	2020	2499	7	6
16	SABARMATI – KALUPUR	8.98	31233	66400	72635	3478	7394	8089	12	3
17	VADAJ-GOTA	5.75	22540	19648	22479	3920	3417	3909	8	5
18	ISKCON-KALUPUR-VIA NEHRUNAGAR-SHREYAS-PROPOSED BRIDGE (VASNA)	11.57	44383	54197	61069	3836	4684	5278	9	4

7.4.2 Technical Feasibility to implement BRTS treatment

Technical feasibility to implement BRTS treatment includes Road Width, Corridor/Road Length, number and nature of bottlenecks and environmental and social issues.

Road Width: It is possible that BRTS treatment can be included on any road width. However, narrow roads would mean altering the traffic pattern completely through introduction of no entry, one-way system or reserving entire road for bus and slow moving vehicles. These measures may be required in extreme situations and but likely to receive very limited public support.

To be able to provide two exclusive lanes for BRTS and at the same time provide 4 lanes (narrow) for vehicles and bicycles and footpath a critical minimum of 27 meters width is required. However, according to the team suggested critical minimum width for BRTS treatment is 30 meters. Any corridor with lesser width would mean either BRTS runs as mixed operations on those stretches or road widening or road closure for certain vehicles would be required. At this stage implementation of BRTS exclusive lanes on corridor with inadequate road-width would receive less priority.

Corridor Length: From the point of view of operations longer corridors are beneficial in many ways. They are:

i. Reduction in turn-around time leading to increased vehicle utilization

ii. Size of operations increase

iii. Large size operations mean mobility improvement to many

iv. Extensions to the network possible

v. Flexible Operations

vi. Possible to operate BRTS as independent operation

a. Closed System Operations become viable

b. Private participation

c. Monitoring and regulating of services become less complex

Bottlenecks: In any network the bottlenecks such as frequent junctions, existence of level crossings, underpasses and flyover with 2/4 lanes would become problem areas. The details of these on each of the corridor have been presented below.

Environmental and Social Issues: Environmental aspects such as effects on air quality, issue of tree preservation and encroachment removal, road widening would have a bearing on the implementation of the project. As the proposed corridors under consideration utilize existing ROW, the project teams do not anticipate any major environmental or social issues. A detailed analysis of the same is proposed during DPR stage.

Table 7-6: Bottlenecks on the Corridors

Corridor No	Name of Corridor	Road Length with RoW						Junctions					Bottlenecks				Score	Rank
		60m	40m	30-40m	30m	20-30m	>20m	3-arm	4-arm	Multiple	Major Junctions	Total Junctions	Level Crossings	Underpass	Flyover/RoB	Flyover/RoB (Proposed)		
1	VASNA-SABARMATI - NARODA-NAROL	26.5	8.2	7.0	3.9	1.3	0.4	16	34	2	31	52	1	1	3	6	5	1
2	VASNA-SABARMATI	2.1	12.9	0.0	0.0	0.0	0.0	8	16	0	15	24	0	1	2	3	3	3
3	NARODA-NAROL	18.0	0.0	0.0	0.0	0.0	0.0	6	15	1	11	22	1	0	1	4	5	1
4A	THALTHEJ TO KALUPUR	0.0	0.0	2.1	4.0	1.0	0.4	2	13	2	13	17	0	1	0	2	1	5
4B	SATTADHAR TO KALUPUR	0.0	0.0	2.1	5.7	1.3	0.4	2	10	5	14	17	1	1	0	1	1	5
5	GHATLODIA TO VADAJ	0.0	0.0	0.0	3.9	1.3	0.0	3	5	2	6	10	1	0	0	1	2	2
6	SABARMATI TO SARKHEJ VIA ASHRAM RD	3.3	3.8	2.5	7.6	0.7	0.0	7	16	2	19	25	1	0	1	1	3	3
7	ISKCON TO KALUPUR	0.5	2.7	0.0	7.2	0.7	0.0	3	17	1	17	21	0	1	0	2	1	5
8	ST TO NAROL TO LAMBHA	3.1	0.0	0.0	5.4	0.0	0.0	2	11	1	7	14	0	0	0	0	4	2
9	ST TO JASODANAGAR CROSSROAD TO HATHIJAN	7.6	0.0	0.0	3.1	2.2	0.0	3	10	2	10	15	1	0	0	0	4	2
10	KALUPUR TO ODHAV	0.0	0.0	0.0	9.5	0.0	0.0	2	8	0	7	10	0	0	1	0	4	2
11	KALUPUR TO NARODA	4.5	0.0	0.0	5.8	0.0	0.0	3	4	1	4	8	0	0	1	0	5	1
12	THALTHEJ TO NAROL TO LAMBHA (UNIV ROAD)	3.1	0.0	10.8	3.3	0.0	0.0	6	21	0	14	27	0	0	1	2	4	2
13	SARKHEJ TO GOTA	12.5	0.0	0.0	0.0	0.0	0.0	2	10	0	7	12	0	0	1	2	5	1
14	PALDI TO ST VIA JAMALPUR (OPTIONAL CONNECTION)	0.0	0.0	0.0	3.3	0.0	0.0	1	3	1	5	5	0	0	0	0	1	5
15	ISKCON TO VASNA VIA. NEHRU NAGAR CIRCLE	0.5	3.1	2.4	0.3	0.0	0.0	0	9	0	6	9	0	0	1	2	3	3
16	SABARMATI - KALUPUR	2.6	0.4	2.1	2.3	0.7	0.4	3	11	0	12	14	0	0	1	0	2	2
17	VADAJ-GOTA	0	0	0		0	0	0	3	1	4	6	1	0	0		5	1
18	SHIVRANJANI-KALUPUR VIA SHREYAS, NEW BRIDGE, ST	0.5	0.2	5.4	5.5	0.0	0.0	1	15	2	13	18	0	0	1	1	3	3

Detail corridor profile is presented in Annexure 7.1.

7.4.3 Systemwide Impact

Major effort of this kind intending to develop BRTS must aim to achieving the following:

1. Relieve congestion
2. Improve safety
3. Maximize the rider-ship; present and the potential
4. Have citywide impacts
5. Provide opportunities for Transit-Oriented Development/ Promote Compact City
6. Integrate with other modes and thus provide greater accessibility to amenities and opportunities for mobility
7. Serve the needs of the poor

Of course bus by nature, with use of CNG would ameliorate negative environmental impacts.

These factors have been broadly analyzed as system-wide impacts in terms of volume capacity ratio, accident ratio, population coverage, total transit trips and integration aspects with major facilities and amenities. The situation and results have been summarized below.

Table 7-7: System-wide Impacts

Corridor No	Name of Corridor	Peak Hour Traffic (PCU's)	Fatal Accidents Density(2002) Fatal Accidents/Km	Population	% EWS & LIG	Regional Transport Terminals(Railway St and ST Depot)	City Transport terminals(AMTS)	University/Colleges	Public Institutes	Hospitals	Public Spaces/Gardens/ Entertainment	Wholesale Markets	Stadiums	Heritage	Rank
															System Impact
1	VASNA-SABARMATI - NARODA-NAROL	7350	3.45	1713976	67	5	5	5	8	2	3	1	1	1	1
2	VASNA-SABARMATI	3354	0	379303	59.1	2	3	3	0	2	0	1	0	1	9
3	NARODA-NAROL	6221	2.6	807015	69.2	2	2	1	2	0	1	0	1	0	2
4A	THALTHEJ TO KALUPUR	6405	1.1	319187	51	1	2	6	4	2	1	1	1	1	6
4B	SATTADHAR TO KALUPUR	6405	1.1	327888	63	1	2	4	2	0	1	1	1	1	5
5	GHATLODIA TO VADAJ	2809	0.9	309360	54	0	2	0	0	0	0	0	0	0	12
6	SABARMATI TO SARKHEJ VIA ASHRAM RD	6012	4.7	433826	49	2	2	6	3	1	1	0	1	2	3
7	ISKCON TO KALUPUR	8190	0.31	316087	61	2	2	3	4	1	4	1	0	1	4
8	ST TO NAROL TO LAMBHA	3586	1.6	281244	77	3	0	1	0	0	0	0	0	0	7
9	ST TO JASODANAGAR CROSSROAD TO HATHIJAN	4861	1.6	466781	81	2	0	1	0	0	0	0	0	0	8
10	KALUPUR TO ODHAV	7913	0.4	364771	83	1	2	0	0	1	0	1	1	1	5
11	KALUPUR TO NARODA	2509	0	676590	80	2	2	0	1	1	0	1	0	1	7
12	THALTHEJ TO NAROL TO LAMBHA (UNIV ROAD)	3586	1.6	496002	52	2	1	6	0	2	0	0	1	0	8
13	SARKHEJ TO GOTA	4004	0	248150	53	0	0	0	1	0	3	0	0	1	11
14	PALDI TO ST VIA JAMALPUR (OPTIONAL CONNECTION)	3604	0	225777	74	1	0	1	0	0	0	1	0	0	9
15	ISKCON TO VASNA VIA. NEHRU NAGAR CIRCLE	1741	0	274616	51	0	1	1	1	0	3	0	0	0	13
16	SABARMATI - KALUPUR	5458	1	325595	78	3	1	0	0	0	1	1	1	1	6
17	VADAJ-GOTA	2809	0	324333	64	1	1	0	0	0	0	0	0	0	10
18	SHIVRANJANI-KALUPUR VIA SHREYAS, NEW BRIDGE, ST	8190	1.6	408688	63	3	2	1	0	0	0	1	0	0	5

7.5 Corridor Selection

The performance of corridors with regard to three broad criteria has been presented table 7.9.

The circular corridor VASNA-SABARMATI – NARODA-NAROL emerges as top ranking corridor. While the corridor scores high on system-wide impacts and technical feasibility, density of travel demand is not high. This is mainly because east-west section has very little travel potential (air port, water works etc.,) Innovative route structuring strategies can enhance the travel demand. These are being analyzed further.

The north-south corridor SABARMATI TO SARKHEJ VIA ASHRAM RD and THALTHEJ TO KALUPUR east-west corridors got second rank. Both the corridors have been included as Metro corridors. Hence these have not been included for Exclusive Bus Lane treatment. However BRTS mixed services should operate on these til the time Metro becomes operational. In fact this would build traffic for metro in the long run. The corridor Naroda-Narol also got second rank.

The corridor VASNA-SABARMATI along 132 feet ring road emerged as major transit demand corridor. The corridor envisaged as part of circular corridor, together with ISKCON TO KALUPUR and SATTADHAR TO KALUPUR ranked number three in the overall ranking.

SHIVRANJANI-KALUPUR VIA SHREYAS, NEW BRIDGE, ST got fourth rank. The fifth ranked corridor Naroda – Narol competes with regional rail and hence not considered. Thaltej to Lamba with sixth rank largely mixes with other options and hence not considered further. To balance the overall transit network the seventh ranked Kalupur to Odhav (Sonini Chali) has been recommended for inclusion in the list of corridors for exclusive lane treatment. An extension to Maninagar, a major railway station has also been recommended.

7.5.1 BRTS Corridor Phasing

In addition to the rakings, in this decision process, following principles have been followed.

1. Metro Phase-1 Proposals (2 Corridors) have been taken as given.
2. Similarly Regional Rail Proposals are taken as given
3. The corridor on which Metro is proposed during phase-1 BRTS exclusive lane is not proposed. However it is recommended that on these corridors AMTS-BRTS mixed services should be operated. These services are expected to maintain certain quality – quantity standards.
4. On the same line exclusive bus lanes would not be implemented on corridors parallel to regional rail proposal only mixed services should be provided till the rail project materializes.

Table 7-8: Final Ranking Of Corridors and Recommendations

Corridor No.	Name of Corridor	Rank as per respective considerations			Cumulative Rank (equal weight)	Final Rank	Recommendations
		Transit Demand	Technical Feasibility	System Impact			
1	VASNA-SABARMATI – NARODA-NAROL	7	1	1	9	1	Exclusive BRTS Corridor and Closed System Operation
2	VASNA-SABARMATI	1	3	9	13	4	Part of C- 1
3	NARODA-NAROL	6	1	2	9	1	Part of C-1
4A	THALTHEJ TO KALUPUR	2	5	6	13	4	METRO Proposed – 1st Phase. AMTS-BRTS Mixed Service
4B	SATTADHAR TO KALUPUR	2	5	5	12	3	Parallel to Metro Line ***AMTS-BRTS Mixed Service***
5	GHATLODIA TO VADAJ	6	2	12	20	8	No BRTS
6	SABARMATI TO SARKHEJ VIA ASHRAM RD	5	3	3	11	2	METRO Proposed – 1st Phase. AMTS-BRTS Mixed Service
7	ISKCON TO KALUPUR	2	5	4	11	2	***Partly included in C-1*** Phase-2 ***AMTS-BRTS Mixed Service***
8	ST TO NAROL TO LAMBHA	7	2	7	16	6	Part of several corridors- no specific suggestion.
9	ST TO JASODANAGAR CROSSROAD TO HATHIJAN	8	2	8	18	7	Parallel to Regional Rail Line AMTS-BRTS Mixed Service
10	KALUPUR TO ODHAV	7	2	5	14	5	Exclusive Bus Lane Phase-1.b AMTS-BRTS Mixed Service
11	KALUPUR TO NARODA	4	1	7	12	3	Parallel to Regional Rail Line AMTS-BRTS Mixed Service
12	THALTHEJ TO NAROL TO LAMBHA (UNIV ROAD)	6	2	8	16	6	Part of other corridors
13	SARKHEJ TO GOTA	9	1	11	21	9	Phase-3
14	PALDI TO ST VIA JAMALPUR (OPTIONAL CONNECTION)	6	5	9	20	8	Part of C1 AMTS-BRTS Mixed Service
15	ISKCON TO VASNA VIA. NEHRU NAGAR CIRCLE	6	3	13	22	10	Part of C1 AMTS-BRTS Mixed Service
16	SABARMATI – KALUPUR	3	2	6	11	4	AMTS-BRTS Mixed Service
17	VADAJ-GOTA	5	1	10	16	8	Phase-2
18	SHIVRANJANI-KALUPUR VIA SHREYAS, NEW BRIDGE, ST	4	3	5	12	4	Exclusive Bus lane (part C1) & part phase-1 b

7.5.2 BRTS and AMTS Operations in Ahmedabad

The fleet requirement to achieve the desired level of public transport patronize has been presented in chapter 6 and have also been summarized in Chapter 8. It is envisaged that there will be three types of bus services in Ahmedabad in future:

1. BRTS Closed System Operations

   On all the corridors with exclusive corridor Closed System operations are recommended. On this corridor only BRTS buses will provide transit service.

2. AMTS-BRTS Mixed Operations

On rest of the corridors identified above, AMTS-BRTS mixed operations will be providing service. Here both system will run in a competitive environment. It is likely that private operators under AMTS may be asked to operate on these routes.

3. AMTS Operations

The AMTS will continue to own and run its own fleet. It is generally suggested that at least 25% of total PT fleet under AMTS ownership and operate on all routes other than BRTS Exclusive Corridor. (Indicative)

Modal share will increase from the present 7% to 20% by 2007, 30% by 2010, 35% by 2012 and 40% by 2014/15 and continue to maintain that level. To achieve this level fleet augmentation is required. Ideas on the mix of services and fleet ownership are being developed as below.

An initial thought is presented below.

Table 7-9: Service Types and Fleet Requirement

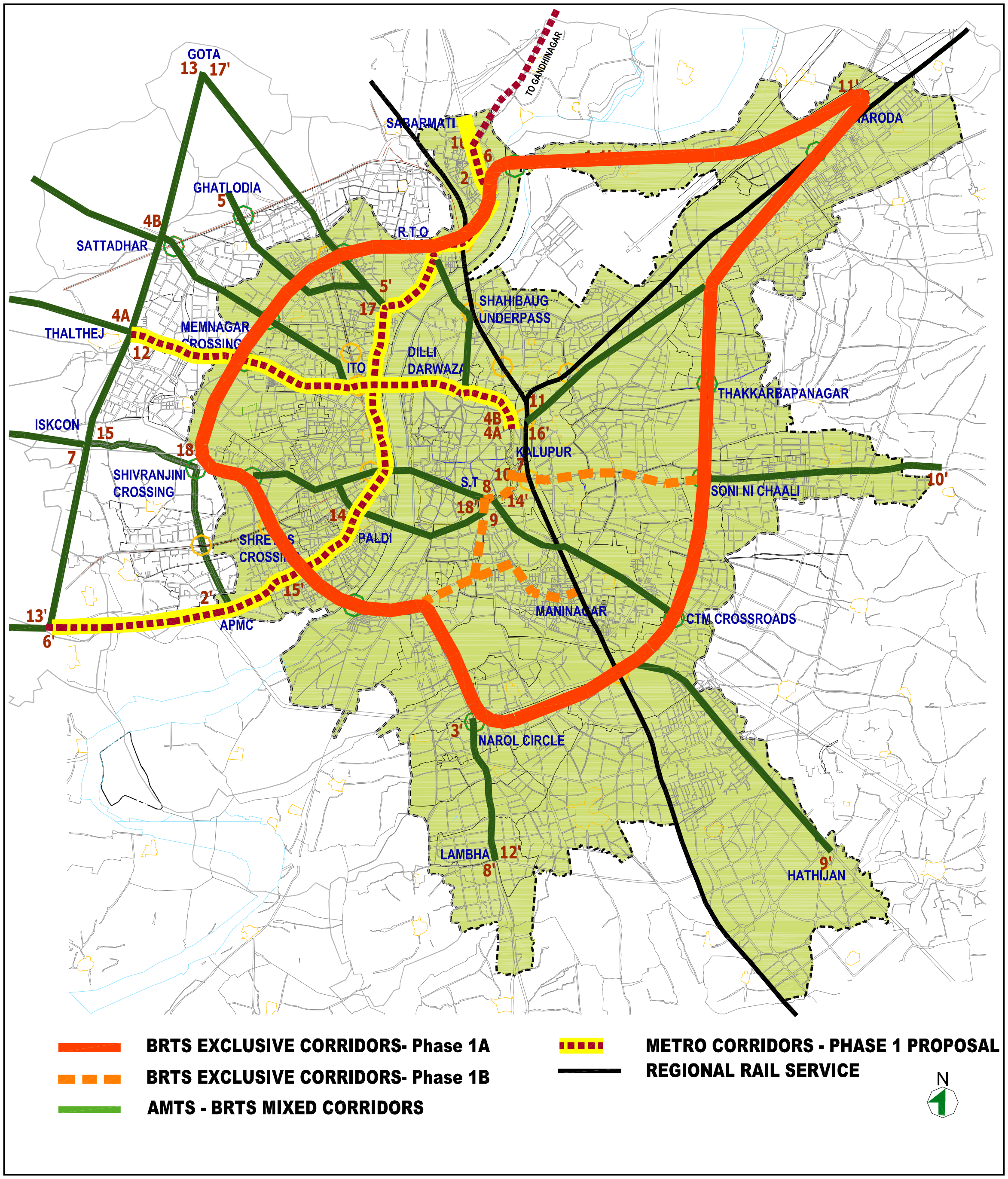
Year	AMTS		BRTS		Total
	OWN	Private	Feeder	Exclusive	
2005	506	94	0	0	600
2006	336	200	0	0	536
2007	200	300	200	100	800
2008	300	300	350	150	1100
2009	300	300	400	200	1200
2010	400	400	400	250	1450
2011	400	500	450	250	1600
2012	600	500	500	300	1900
2013	600	500	500	400	2000
2014	600	550	550	500	2200
2015	600	550	600	600	2350

It is important that a restructured AMTS will continue to maintain present fleet strength and in fact double with private participation. It is assumed that BRTS will have about 50% of the fleet strength.

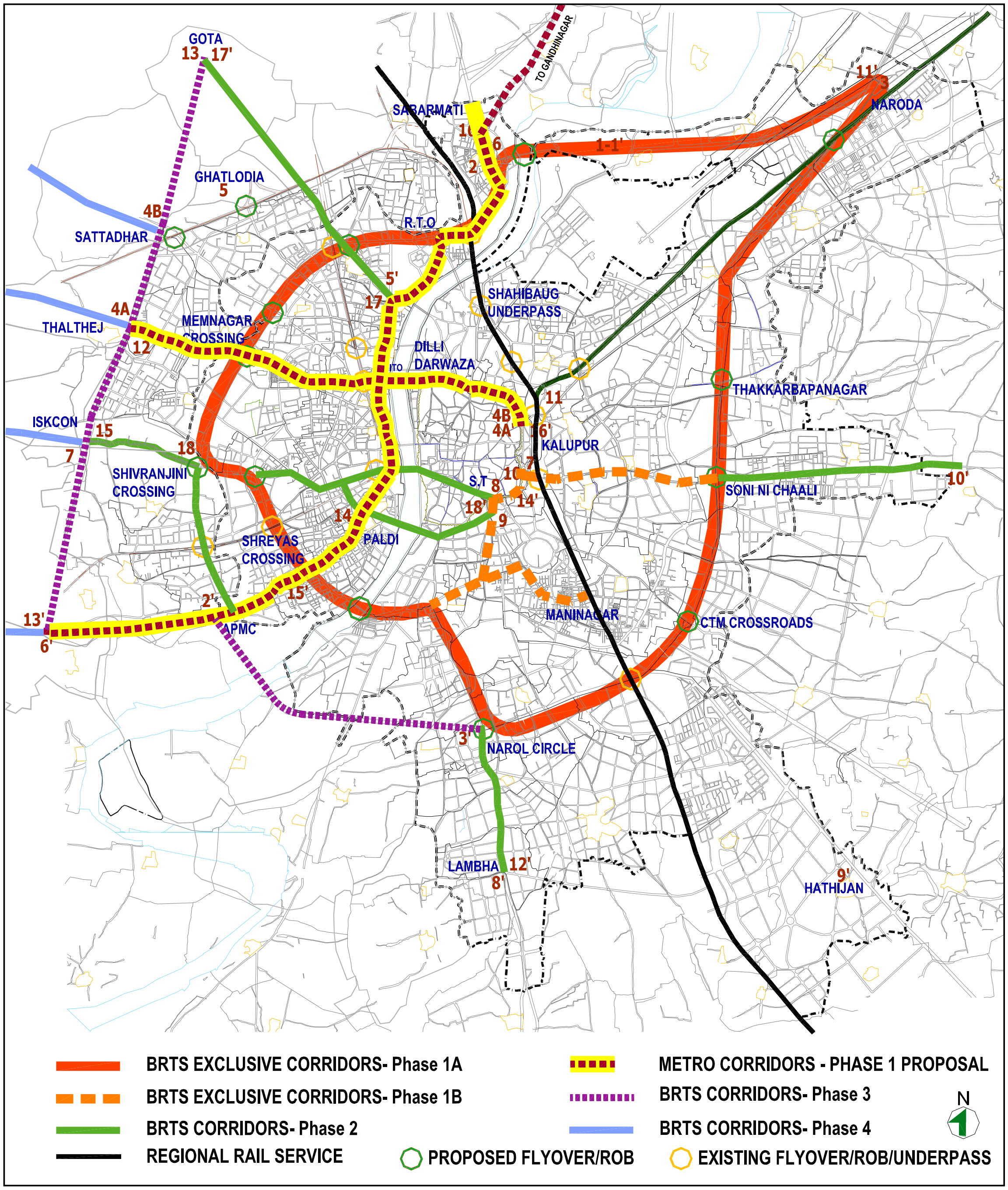
7.6 Summary

Eighteen corridors have been identified on which opportunities for developing BRTS were explored. The corridor 1 (Vasna-Sabarmati-Naroda-Narol) has been prioritized for implementation based on the ranking, results of which along with the recommendation are shown in Table 7-9. In addition, a link has also been proposed joining Danilimda with Maninagar and Kalupur and Kalupur to Odhav to be implemented in the later part of the first phase as a mixed BRTS corridor. This would enhance the connectivity of the core of the city with all other areas through an integrated transportation network of rail and bus corridors.

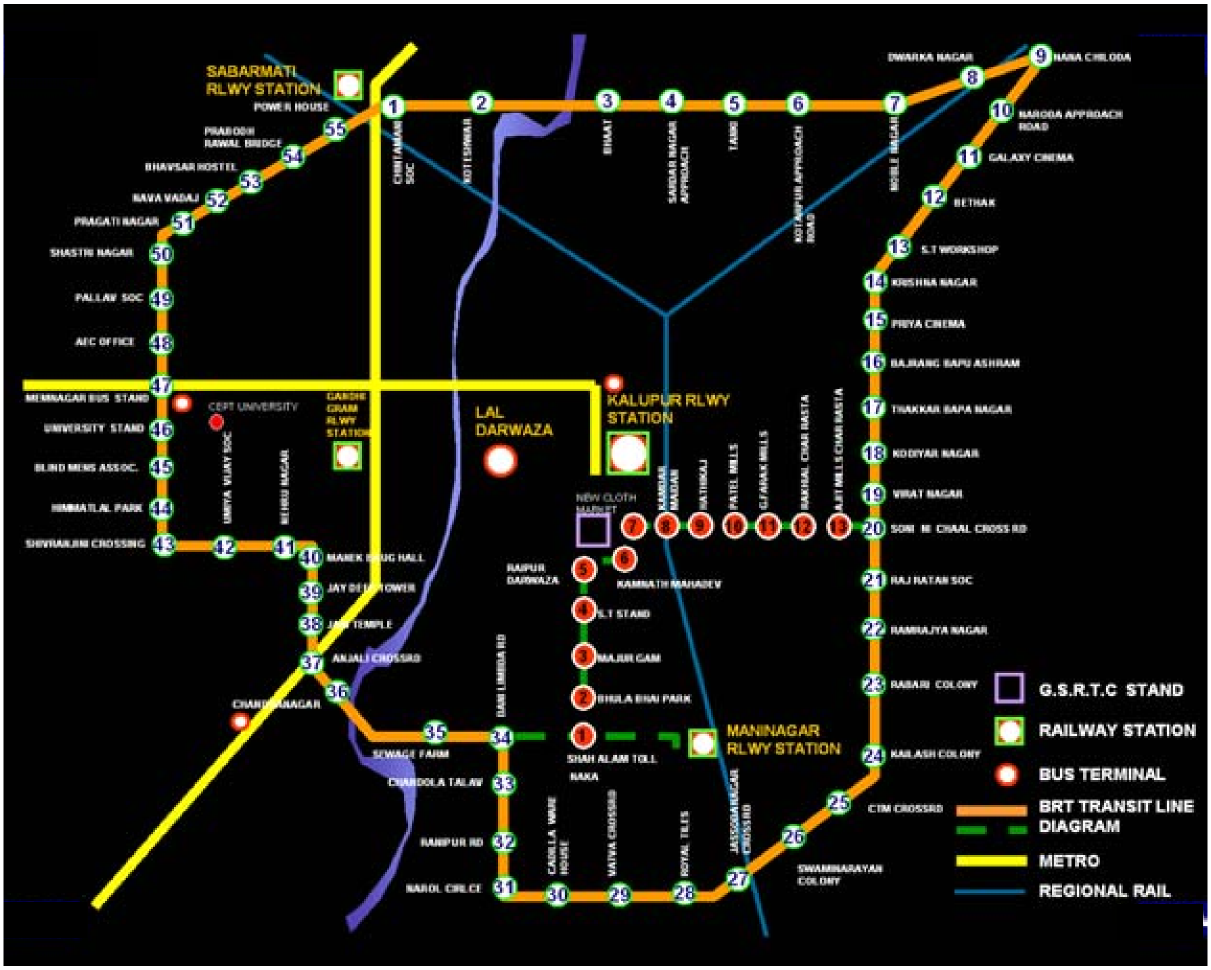
Map 7.4 BRTS Network



Map 7.5 BRTS Phasing and Integration



Map 7. 6 BRTS Transit Line Diagram



Chapter 8 THE BUS RAPID TRANSIT SYSTEM DESIGN

8. THE BUS RAPID TRANSIT SYSTEM DESIGN

8.1 Introduction

The proposed Bus Rapid Transit System will be a high quality, ultra-modern and passenger oriented rapid transit system to deliver fast, comfortable, economical and eco-friendly mobility to urban dwellers. By introducing the BRT system, the overall traffic flow will improve as significant shift from privatized modes towards BRT system is expected. Having identified BRT system corridors, this chapter discusses the policy and planning issues related with the development of BRT system as a whole. This chapter further discusses design and operational issues of the BRT System. At the end, based on the design recommendations, block cost estimates has been presented. It is recommended to develop a BRTS of around 50 km in phase-I comprising six road sections of varying length and ROW having dedicated road width for BRT. In addition there would be corridors on which BRT buses will run with other service (AMTS) acting as feeder service to the primary corridor.

8.2 Policy Issues

8.2.1 Median versus Side Lanes

Exclusive bus lanes are proposed to be mostly at grade, segregated from the existing volume of traffic by means of a physical separation. These exclusive bus lanes could be strategically placed either at the centre of the road (Median Bus lanes) or at the side (Side Bus lanes). Given below is a comparison of both types of bus ways:

SIDE LANE	MEDIAN LANE
Compatible with conventional bus door configuration on curb side (left side).	Easy to integrate bus flow with other flow at intersection
Easier accessibility from the pedestrian pathway.	Optimum road width for both direction movements.
Total road width occupied for bus lane is double.	Infrastructure created can be utilized even if BRTS withdrawn.
Capacity will remain under utilized.	Traditional bus door configuration on left side of travel can be retained by providing bus stops on left side.
Cost intensive treatment at junctions would have to be carried out as free left turn for regular traffic would be cut off.	Slight diversion to other traffic when a bulge is provided to accommodate the bus stops.
Example: Quito	Examples: Bogotá, Curituba, Cambridge

Experiences worldwide suggest having BRT system in the central verge (median lane) of the roadway is better option than curb lanes. For the city of Ahmedabad, given the constraints of road widths, encroachments, cattle menace and traffic disorder the median lane option for BRT is recommended.

8.2.2 Open versus Closed System

Open System: BRT system lane is kept open for all existing bus operators. The benefit of dedicated infrastructure is distributed to all operators.

Closed System: BRT system lane is restricted only for BRT buses. BRT operators remain the only beneficiaries and hence responsible for efficiency and maintenance.

It is recommended to have a "Closed System" on the corridors where exclusive BRT system lane is proposed to be developed. The exclusive BRT lanes must be physically separated from the rest of the traffic by a physical barrier. ***However, considering the criticality of services, it is recommended that Fire Brigade and Ambulances will be allowed on the BRTS Lane.***

8.2.3 Exclusive/Dedicated versus Mixed Corridor

The presence of other bus service such as AMTS in the mixed traffic lanes would not only undermine the rider ship and hence profitability of the new system (BRT) under consideration; it will also congest the already reduced lanes for other traffic. Therefore it is recommended that the BRT corridors having dedicated BRT system lanes shall have only BRT system bus service running. No other service shall be allowed to compete with BRT system. However, BRTS buses will share other feeder routes with AMTS where there is no provision of dedicated bus lanes. Such a facility is referred as mixed corridor. BRT system buses, other buses and other traffic will share the available right of way.

8.2.4 Land Ownership of the corridor

One of the corridors under consideration for BRT system is part of National Highway 8 currently under the ownership of the National Highway Authority of India (NHAI). This highway may be handed over to Ahmedabad Municipal Corporation (AMC) once bypass to this is open to the traffic. Effort to develop BRT system on this corridor therefore should be coordinated with NHAI.

8.2.5 Bus Technology/Size Issue

The following are the vehicle types which can be used in the proposed BRT system with varying capacity.

Table 8-1: Vehicle Capacity

Vehicle type	Typical Number of Passenger	Typical Vehicle Length (m)
Vans	10-16	3
Mini Buses	25-35	6
Standard Buses (low floor)	60-80	12
Articulated Buses	120-170	18
Bi-Articulated Buss	240-270	24

However, to start with, we recommend using Standard buses having capacity between 60 and 70 passengers at a time.

The buses operating in the BRT system could be Indian buses, manufactured in India and eventually assembled in Ahmedabad. Clean bus technology to reduce emissions is essential. In this regard, we recommend exploring possibilities of having standard buses with required modification in floor height, seating arrangements etc. running on Compressed Natural Gas (CNG).

8.2.6 Advance Technology

The use of advanced technologies (or Intelligent Transportation Systems) to improve customer convenience, speed, reliability, and safety will be explored. Examples include systems that provide traffic signal preference for buses at intersections and cross streets, as well as Global Positioning Systems (GPS) to provide passenger information including real-time bus arrival information.

8.2.7 Fare Policy

Fare structure for the BRT system will be as competitive as possible.

8.3 Design Consideration

8.3.1 Geometric Design

The geometric design standards set for the project have been given in the below.

Sr. No.	Description	Design Standards
	ROW	
1.	*ROW*	40 - 60m
2.	*Set back between building line & road boundary*	3 - 6m
	Design Speed	
3.	*Design Speed*	80 kmph
	Geometric Design	
4.	*Cross-sectional elements* i.Lane widths a. Median Bus Lanes b. Carriageway c. Parking For Trucks d. Parking For Cars e. Service Lane f. Cycle Path	 7.0m 7.0m 3.0m 2.25m 6.0m 2.5/2.0m

Sr. No.	Description	Design Standards
	g. Pedestrian Pathway	2.0m
	ii.Cross Slope	
	a. Median Bus Lanes	2.0%
	b. Carriageway	2.0%
	c. Parking For Trucks	2.0%
	d. Parking	1.5%
	e. Service Lane	1.5%
	f. Cycle Path	1.5%
	g. Pedestrian Pathway	1.5%
5.	*Shyness strip* @ Median side	0.25m
6.	*Safe Stopping Sight distance*	120m
7.	*Horizontal Alignment*	
	i.Requiring no super elevation	1400m
	ii.Desirable requiring 4% super elevation	265m
	iii.Absolute minimum requiring 7% super elevation	230m
8.	*Vertical Alignment*	
	Minimum distance between PVI	150m
	Minimum length of vertical curve	50m
	Minimum "K" value	
	For – Sag curve	30
	For – Crest curve	35
9.	*Gradient*	
	Maximum	4%
	Desirable	2%
	Minimum	0.5%
	In kerbed sections	
	Desirable Minimum	0.5%
	Absolute Minimum	0.3%
	Desirable Maximum for Pedestrian Ramps	10%
	Desirable Maximum for Cycle tracks	3%
10.	*Maximum grade change not requiring a vertical curve*	0.6%
11.	*Minimum vertical clearance to road bridge over road*	5.5m
12.	*Minimum vertical clearance to road bridge over rail*	6.75m
13.	*Super elevation*	
	Maximum	7%
	Desirable	4%
14.	*Rate of change of super elevation*	1 in 150
15.	*Median*	
	i.Width of Median / Bus Shelter (raised)	2.5m
	ii.Transition in Median	1 in 15 to 1 in 20
	Pavement Design	
16.	i.For BRT Bus lanes & Carriageway	Thickness
	a. Bituminous Concrete (BC) or AC	40mm
	b. Dense Graded Bituminous Macadam (DBM)	160mm
	c. Wet Mix Macadam (WMM)	300mm
	d. Granular Subbase (GSB)	420mm
	e. Subgrade (SG)	500mm (min)
	ii.For Service lane	Thickness

Sr. No.	Description	Design Standards
	a. Bituminous Concrete (BC) or AC b. Dense Graded Bituminous Macadam (DBM) c. Wet Mix Macadam (WMM) d. Granular Subbase (GSB) e. Subgrade (SG)	40mm 60mm 200mm 400mm 500mm (min)
	Intersection Design	
17.	*Intersections* i. Length of storage lane (including 50m taper) for right turning ii. Minimum length of acceleration lane (including 80m taper) iii. Minimum length of deceleration lane (including 80m taper) iv. Maximum radius for left turn v. Minimum radius for right turn vi. Width of turning lane (inner radius of 30 m) vii. Rate of taper (minimum) viii. Minimum size of channelising island ix. Offset of island from vehicle path x. Desirable angle of intersection arm	 130m 180m 120m 30m 15m 5.5m 1 in 15 4.5sqm 0.3 – 0.6m 60 – 90 degrees
	Drainage Design	
18.	*Drain*	
	i. Minimum longitudinal gradient ii. Minimum width of drain iii. Minimum diameter of drain	0.3% 0.25m 0.45m
19.	*Manholes*	
	i. Spacing ii. Minimum inside dimension iii. Minimum allowable width (in case of shallow manholes upto 1.40m) iv. Opening for entry	10 – 20m 120cm X 90cm 75cm 50cm clear
	Safety Measures	
20.	*Traffic signals*	IRC : 93 – 1985 and better experiences
21.	*Pedestrian crossings & pathways*	IRC : 103 – 1988 and better experiences
	Road Furniture	
22.	*Road signage*	IRC : 67 – 1977 and better experiences
23.	*Pavement markings*	IRC : 35 – 1997 and better experiences
24.	*Delineators*	IRC : 79 - 1981 and better experiences
	Utilities	
25.	*Maximum depth of laying for Utility Lines*	
	i. Trunk sewer line ii. Water supply line a. Service line b. Trunk line iii. Electric cable a. LT cable b. HT cable	2 – 6m 0.6 – 1m 1 – 1.5m 0.6 – 1m 1.5 – 2m

Sr. No.	Description	Design Standards
	iv. Telecommunication cable a. Directly laid b. Laid in ducts v. Gas mains & lines	 0.6 – 1m 2 – 3m 2 – 3m
26.	*Minimum cover over the top of service line*	0.650m
27.	*Clearance for Utility Lines (Minimum)*	
	Horizontal i. Poles erected for various purpose of Street lighting, electric power, telecommunication lines in urban area a. For roads with raised kerbs • Minimum (from the edge of raised kerb) • Desirable (from the edge of raised kerb) b. For roads without raised kerbs Minimum (from the edge of carriageway) Vertical i. For ordinary wires and lines carrying very low voltage upto and including 110 volts e.g telecommunication lines ii. For electric power lines carrying voltage upto and including 650 volts iii. For electric power lines carrying voltage exceeding 650 volts	 300mm 600mm 1.5m 5.5m 6.0m 6.5m

8.3.2 Pavement Design & Drainage Arrangement

The BRT corridors are recommended to be developed for the running of standard buses customized to suit specific requirements along with high capacity urban buses. The pavement design requirement therefore would not be different from existing practices in a mixed traffic condition. There will be three types of pavement design requirements for developing BRT corridors.

Bus Lane

- The existing median portion will be dismantled and all the kerbs etc. will be removed. Excavation will be done up to the required depth and length. Over this cut surface, Wet Mix Macadam (WMM) of 30 cm thickness (in two layers 15 cm each) will be placed over a layer of Granular Sub Base (GSB) of 42 cm thickness (GSB in two layers, 20 cm and 22 cm thick respectively). Then 16 cm of Dense Bituminous Macadam (DBM) will be placed in two layers (8 cm each) on the top of WMM. Prime and Tack coats will be provided over existing road surface and finished DBM.
- The total width of the BRT lane (7.0 m) including the old median portion will be provided with 40 mm thick Ashphalt Concrete (AC) as a top layer for strengthening and providing proper camber, slope correction over the existing road surface.
- Implementing alternate pavement color through colored asphalt or concrete can reinforce the notion that a particular lane is reserved for BRT use, thereby improving aesthetics.

Mixed Lane (existing bituminous carriageway)

- It is proposed to have two lanes (7.0 m) on each side for the mixed traffic. If the existing carriageway width is not sufficient to accommodate, widening has to be done in the same line of existing median portion. Prime and Tack coats will be provided over existing road surface and finished DBM. Thereafter, a common Ashphalt Concrete (AC) layer of 40 mm thick will be put for the entire width (Mixed Lane) for strengthening and providing proper camber slope correction over the existing road surface.

Service Lane

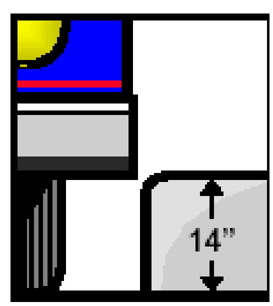
- Baring few sections, service lanes are not very well defined along the proposed BRT corridor. It is proposed to construct a fresh pavement comprising 40 cm thick GSB (in two layers, 20 cm each), 20 cm thick WMM and then 60 mm thick DBM over the finished WMM surface. Prime and Tack coats will be provided over finished DBM. Over this a layer of 40 mm thick Ashphalt Concrete (AC) will be placed.

Drainage Arrangement

The existing storm water drains will be dismantled if not at the outer side of the roadway width. The storm water drain is proposed to be underneath the proposed footpath adjacent to the service lanes. It will be a box type concrete drain with manholes at regular interval. The manholes shall be covered with airtight inspection covers. There will be a provision of duct to accommodate other utility lines within the same. There would also be a provision for drain inlets at appropriate spacing. Physical separators between BRT lane/Mixed lane and Mixed Lane/service lane will also have provision for surface water to flow towards main storm drain running parallel to the corridor.

8.3.3 Location of Bus Stop/Bus shelter

Bus stops to be generally provided before intersections in the direction of travel to utilize the stoppage time wherever practicable/possible. Average spacing between two bus stops should be 800 m. Bus stations can have more than one loading platform depending upon the demand at given locations. 55 bus stop locations have been identified along phase 1 BRTS network (circular one). Bus stops will be on the left side (in the direction of travel). Hence, the doors of the buses will also be on left side (standard practice in India). However, there should always be a provision for two boarding/alighting platforms per stop on each side.



At mid-block, bus shelter should be staggered by at least 50 m (c/c) to facilitate overtaking of the buses and pedestrian flow.

Other design details of a bus stop/shelter are as follows:

- To achieve a safe, easy, and efficient means of passenger boarding and alighting, platforms level with BRT vehicle floors (approximately 35 cm above the pavement for low floor vehicles) are the preferred station platform treatment. The level station boarding and alighting platforms will create a seamless transition between the station and the vehicle.

- Raised verges between BRT lane and mixed lane will be made friendly to the physically challenged persons near bus stops and intersections by providing a gentle slope with different surface treatment.
- 3 m wide and 12 m long bus box (marking), two on each side.
- Extended shelter to accommodate more waiting passenger and at least two platforms.

8.3.4 Access to Bus Stop

Adequate provision in design should be made to ensure safe and convenient movements of passengers to/from BRT bus stops. At mid-block bus stops, a pedestrian phase signal to be provided to enable safe crossing of the urban dwellers guided through zebra crossings. The maximum number of mixed traffic lanes the pedestrians would need to cross is only two at a time, which can generally be negotiated safely.

At high-volume bus stops, a pedestrian subway will be provided to facilitate unrestricted crossing of BRT system users and other urban dwellers.

The bus stop near intersections shall be accessed using zebra crossings provided at intersection and then 2.0 m footpath between BRT lane and mixed traffic lane.

8.3.5 Treatment of Intersections

We recommend a grade-separated facility along the BRT system corridor at major intersections. Grade-separators should have six lanes. Two at the middle should be dedicated for BRT service and two lanes on each side for mixed traffic other than BRT buses. However, on flyover section, the physical separator between BRT lane and Mixed traffic lane can be reduced to 0.5 m width gradually before take off point of the flyover. By doing this we will be able to have extra width/lane near intersections underneath the flyover. This shall partly be utilized in accommodating counter fort wall for the flyovers.

The junctions recommended to have flyover/ROB by AMC/AUDA are:

1. Naroda Railway Crossing (ROB: Old NH8 and Ahmedabad - Himmat Nagar BG)
2. Thakkarbapa Nagar Intersection (Old NH8 and Nikol Road)
3. Soni Ni Chal Intersection (Old NH 8 and Odhav Road)
4. CTM Cross Road Junction (on Old NH 8)
5. Memnagar Bus Depot Intersection (Drive in Road and 132’ Ring Road)
6. Shivranjani Crossroads (Satellite Road and 132’ Ring Road)

7. AEC Cross Road Intersection (132' Ring Road and Sattadhar Road)
8. Shreyas Crossing (ROB: Old NH8 and Ahmedabad - Rajkot BG)

In view of the proposed BRT corridor, all these proposed flyovers/ROB should be a six-lane facility. In addition, following are the locations where we recommend having grade-separated flyovers.

9. Akbar Nagar Circle
10. Nehru Nagar Circle
11. Narol Circle

All remaining intersections along BRT system corridor will be signalized at grade. The design should be done with a view to minimize conflicts and improving traffic flow with preference to BRT buses. All movements at the intersections should be controlled through signalized phasing. The present free left turning movements too would be regulated through traffic signals to provide safe pedestrian crossing. Since traffic is segregated into BRT bus lane, mixed lane, service lane (on few corridors), cycle tracks (on some corridors), each of these lanes will have their unique signal posts which may have overlapping or staggered phases for different lane movements from the same arm. Wherever sufficient Right of-Way is available, an additional storage lane should be provided.

8.3.6 Parking Provision

The corridors having Right-of-Way equal to or more than 40 m should be provided with a parking lane (3 m) on both sides to accommodate existing parking demand. Parking lane should be integrated with proposed service lanes and physically separated from mixed traffic lanes. However, parking will not be allowed on parking lanes, 50 m before and after any intersections. Instead, these lanes will be utilized for providing additional storage lanes at intersections. So will be the case in front of mid-block bus stops, 100 m of this parking lane should be designated only for auto/taxi parking. Also, off-street parking will be provided underneath the flyover wherever recommended.

8.3.7 Bicycle Tracks

Looking at the existing share of bicycle traffic volume on the corridors under consideration for BRT system, we recommend having cycle tracks with a minimum width of 2.0 m on both sides of the road adjacent to the footpath. Generally, cycle tracks are separated by physical barrier (verge or berm) from the main carriageway, but we recommend here to separate cycle track by level difference (20 cm) with a mild slope (1:1). By doing this, we will be able to save approximately 0.5 m on both sides.

8.3.8 Pedestrian Facilities

A footpath with a minimum width of 2.0 m should be provided for each side along the BRT system corridor. This would facilitate longitudinal movement of urban dwellers. The level of footpath shall be higher by 20 cm than cycle track with a mild slope (1:1). The pedestrians other than BRT system users will also use the subways provided at selected mid-block bus stops for crossing the entire roadway. For pedestrian crossings, a 3-5 m wide zebra crossing is recommended across all arms at intersections.

8.3.9 Street Lighting

Street lighting design of the proposed BRT corridor assumes special significance as it has to cater to various lighting requirement such as BRT buses plying on BRT lane, other motorized traffic on mixed lane, slow moving and motorized traffic on service lanes and pedestrian on footpath. The lighting design therefore should cater to all these users simultaneously taking care of the basic design parameters of luminous intensity, the contrast, glare, light uniformity over the pavements and aesthetic. Various alternatives could be explored in detail design stage. However, the following guiding parameters should be adopted in the lighting design.

	Average Illumination (lux)	Minimum Illumination at any point of the road (lux)	Uniformity Ratio (E avg/E min)
BRT Lane	35	17	3.0
Mixed Lane	35	17	3.0
Service Lane	25	20	4.0
Footpath	25	-	-
Crosswalk	35	-	-
Cycle Track	25	20	-
Junctions	35	-	-

Lighting Type for Varying ROW sections –

- Carriage Way (Mixed Lane) & BRT Bus lane lighting with poles being installed on the footpath separating the two with double bracket lights to cover the carriage way and bus lane and parking.
- In case of 60 m ROW, parallel parking, cycle track and footpath etc. individual poles / bollards can be installed at the slope between cycle track and pedestrian for illuminating the service lane.
- Spacing, height and wattage should be decided to satisfy the basic requirement of lighting given in the table above.

8.3.10 Street Furniture

Adequate attention will be paid towards development of the corridor as a model road corridor, which not only satisfies the requirement of moving traffic in BRT system but also addresses the needs of all users of the urban road. In this regard, adequate attention to be paid towards providing adequate furniture along the road such as:

- Traffic signs
- Road markings

- Traffic signals
- Railings/guard rails
- Channelisers
- Planters
- Tree guards
- Landscaping of untreated areas
- Roadside toilets
- Auto/taxi stand
- Garbage dumps

8.3.11 Relocation of Existing Services/Utilities

The existing overhead and underground utilities such as telephone poles, electric poles, transformers, underground cables, water drains, sewage pipelines etc. will be shifted appropriately and efficiently at proposed locations.

8.4 Operational Issues

1. System Capacity: is a function of the capacity of the vehicle, the load factor, the frequency of the vehicles and average speed of the vehicle. Based on our rider-ship estimate, we have fixed the following parameters which in turn effect the operational requirement in terms of number of depots, terminals, and fueling stations etc.

- Capacity of the bus: 60-70
- Load Factor: 0.6
- Frequency Peak: 2 minute
- Frequency Off-Peak: 4 minute
- Dwell Time: 20-40 sec.
- Average Journey Speed: 30 kmph

It is recommended to have 50 buses to start with plying on one circular corridor covering around 50 km of length in a closed system. Another 100 buses will run on 5-6 radial corridors identified as feeder in a “mixed system”. The total fleet size can be gradually increased to 1,000 in next ten years with increase in demand.

The first phase would be to build as “closed system” on one circular corridors. In addition, there would be feeder corridors on which BRT buses would be plying in a mixed system with other service such as AMTS. In subsequent phases some of these corridors could be converted into BRT exclusive “closed system” corridor. In all phases for better integration, there would be “transfer stations” that would allow free transfer for passenger using BRT buses in mixed/open situation probably on radial roads.

2. System Operation: In the first phase, to start with, there would be only ‘local service’ which stops at all bus stops. Subsequently ‘express service’ would be introduced which will not stop at all bus stops. Based on the performance of the system and specific demand, other services like 'Ladies only', and 'AC service' could also be considered in future.

3. Fare Collection System: A BRT system design should consider fare collection policy in terms of its impact on both bus dwell time and passenger convenience. From the point of view of the speed and capacity of the BRT system alone, the current manual collection method with an independent collector inside the bus could be very efficient. Passengers board fast from all doors without the restrictions of turnstiles. However, there are always some merits in collecting fare outside the bus at bus stops too. Hence, in case of BRT system Ahmedabd we recommend having hybrid system. At high-volume stops where many passengers board at the same time, the external collection system should be placed. The use of prepaid tickets, tokens, passes, or smart card can be encouraged by fare policy or developing an enclosed monitored paid-fare area. External fare collection system also allows boarding passenger demand to be more evenly distributed between doors, rather than being concentrated at the front door.

The cash fare can be higher with discounts offered for purchasing multi-trip tickets or cards. This policy has the potential to reduce dwell time. In addition, it is a form of price differentiation, which has been successfully used in other countries to increase both revenue and ridership.

The BRT operator should consider various alternatives and select an appropriate system only after the basic design of the system and institutional arrangement is clearly established.

4. Basic Infrastructure: the basic infrastructure of a BRT system such as number and location of bus depots, bus terminals and fuel station etc. will be created suitably.

5. Integration: Four types of the system could run on various corridors in the city of Ahmedabad. These could be:

- Only BRT buses: closed system
- Mixed BRTS System/ AMTS: open system
- AMTS: open system
- Rail based system (in future)

In the larger interest of public transport users, an integrated policy should be devised to provide efficient transfer between different systems on different corridors including creating physical infrastructure for transfer.

8.5 Evolving Alternative cross sections

The identified corridors for BRT system have varying right-of way. The available ROW of the identified corridors is given below:

BRT System Corridor 1 considered in Phase 1: **Sabarmati** – Acher – Sardar Nagar – Airport – Kotarpur – Naroda Industrial Estate – ST Workshop – AMC West Zone Office - Soni Ni Chal (Phase I) – CTM Cross Road – Jasoda Nagar Cross Road – Narol Circle – Chandola Lake – - Dani Limda - Sewage Farm – Anjali Cross Road – Sreyas Cross Road – Nehru Nagar Circle – Shivranjani Cross Road – IIM/University – Mem Nagar Cross Road – Akabar Nagar Circle - RTO – **Sabarmati**

Road Section	Length (km)	Service Proposed	RoW (m)	Proposed Cross Section
Shivranjani Cross Road – IIM/University – Mem Nagar Cross Road – Akabar Nagar Circle - **RTO**	8.0	Closed system	40	**CS: B-B**
RTO - Sabarmati	2.7	Closed system	60	**CS: A-A**
Sabarmati – Acher – **Sardar Nagar**	3.3	Closed system	24	**Proposed Road (partly existing) ROW to be improved to suit CS: D-D**
Sardar Nagar – Airport – Kotarpur – Naroda Industrial Estate – ST Workshop – Soni Ni Chal – CTM Cross Road – Jasoda Nagar Cross Road – **Narol Circle**	24.0	Closed system	60	**CS: A-A**
Narol Circle – Chandola Lake	2.0	Closed system	30	**CS: D-D**
Chandola Lake – Dani Limda - Anjali Cross Road– Nehru Nagar Circle – **Shivranjani Cross Road**	7.5	Closed system	35	**CS: C-C**
BRT System Corridor 2 (Dani Limda – ST – Sarangpur/Kalupur - Odhav) considered in Phase 1				
Dani Limda - ST		Open system	35	
ST – Sarnagpur/Kalupur		Open system	30	
Sarnagpur/Kalupur - Odhav		Open system	30	
BRT System Corridor 3 (Dani Limda – Mani Nagar) considered in Phase 1				
Dani Limda – Mani Nagar		Open system	30	

Conceptualizing cross-sections is the essence for any kind of corridor development for a system. Various alternative cross-sections at initial stage with and without cycle track, varying width of mixed lane and footpaths for each RoW category (Annexure 8.1). The recommended cross-sections not only considers the requirement of BRT buses but also accommodate the need of other users of the corridor such as motorized traffic other than BRT bus, cycles, pedestrians etc.. We believe the

proposed improvement over full roadway width shall ensure better mobility level on the corridor as a whole. The cross-sections are:

(a) 60 m RoW:

Two central bus lanes – each of 3.5 m width, one for each direction of travel will replace the existing median. These will be abutted by a 2.5 m wide footpath–cum- bus stop/shelter/platform on each side. There will be two motorized lane for mixed traffic, a 7.0 m wide for each direction of travel. The mixed lane will be separated by adjacent service/parking lane by a 0.75 m wide median. A 11.25 m wide service lane on both sides will accommodate truck parking on the right side and car/two wheeler parking on the left side. The parking lanes would be demarcated by paint and not by any kind of physical barrier. At the outer side, there would be a 2.5 m wide cycle track and 2.0 m wide footpath for pedestrians for each direction of travel. Wherever extra width is available at mid-block sections or at intersections, it is recommended to be utilized for providing emergency/refuge/storage lanes, garbage dumps, pubic toilets and general landscaping. Access to abutting properties and minor roads will be restricted to service lane. The traffic from these will join the motorized lane (Mixed lane) at intersections or specified locations. The proposed cross-section is presented in Figure 8.1.

The purpose of having 2.5 m wide footpath throughout, adjacent to the BRT lane is to accommodate bus stops without bulging and in future create three lane BRT system by taking 1.5 m from both sides without disturbing the whole cross section of the road. The staggered bus stops would ensure overtaking at bus stop locations.

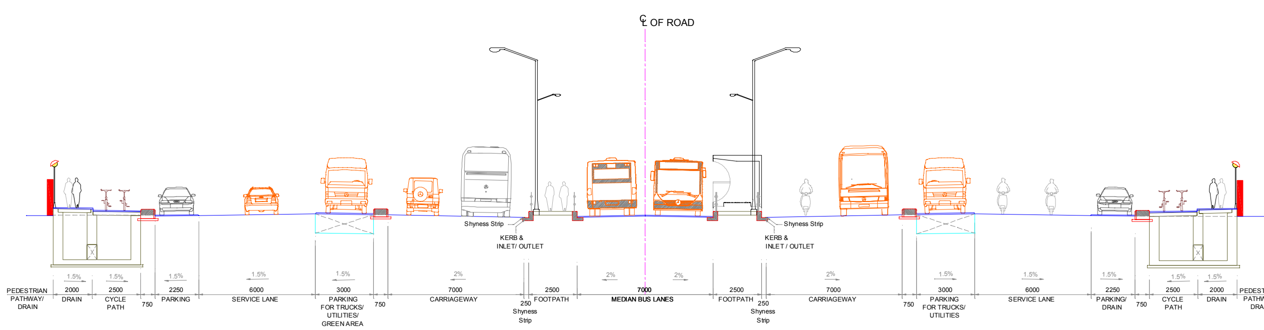


Figure 8.1: **CS: A-A:** BRT system Cross-section at Bus Station (total 60 m)

(b) 40 m RoW:

Two central bus lanes – each of 3.5 m width, one for each direction of travel will replace the existing median. These will be abutted by a 2.5 m wide footpath–cum- bus stop/shelter/platform on each side. There will be two motorized lanes for mixed traffic, 7.0 m wide for each direction of travel. The mixed lane will be abutted by a 2.5 wide parking lane (parallel) for each direction of travel. The parking lane will be followed by a slightly elevated cycle track (2.0 m wide) and then a footpath (2.0 m wide) on each direction of travel. There would be storm water drain below the footpath.

Wherever extra width is available at mid-block sections or at intersections, is recommended to be utilized for providing emergency/refuge/storage lanes, garbage dumps, pubic toilets and with general landscaping. Access to abutting properties and minor roads will be directly motorized lane. Parking would be restricted at such locations. The proposed cross-section is presented in Figure 8.2.

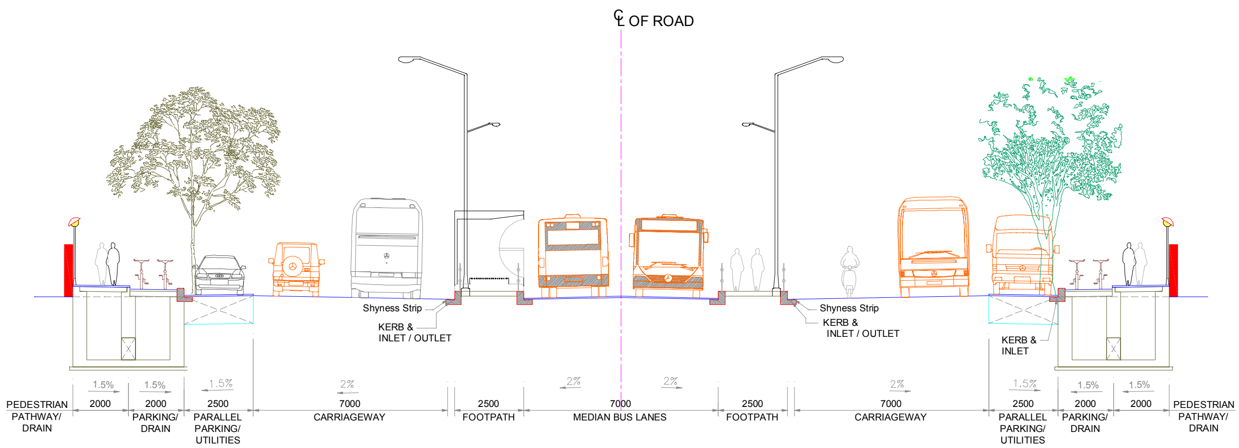


Figure 8.2: **CS: B-B:** BRT system Cross-section at Bus Station (total 40 m)

The purpose of having 2.5 m wide footpath throughout, adjacent to the BRT lane is to accommodate bus stops without bulging and in future create three lane BRT system by taking 1.5 m from both sides without disturbing the whole cross section of the road. The staggered bus stops would ensure overtaking at bus stop locations.

(c) 35 m RoW:

Two central bus lanes – each of 3.5 m width, one for each direction of travel will replace the existing median. These will be abutted by a 2.5 m wide footpath–cum- bus stop/shelter/platform on each side. There will be a motorized lane-cum-parking for mixed traffic, a 8.0 m wide for each direction of travel. The mixed-cum-parking lane will be followed by a slightly elevated cycle track (1.5 m wide) and then a footpath (1.5 m wide) on each direction of travel. The storm water drain will be beneath the footpath.

Wherever extra width is available at mid-block sections or at intersections, is recommended to be utilized for providing emergency/refuge/storage lanes, garbage dumps, pubic toilets and with general landscaping. Access to abutting properties and minor roads will be directly motorized lane. Parking would be restricted at such locations. The proposed cross-section is presented in Figure 8.3.

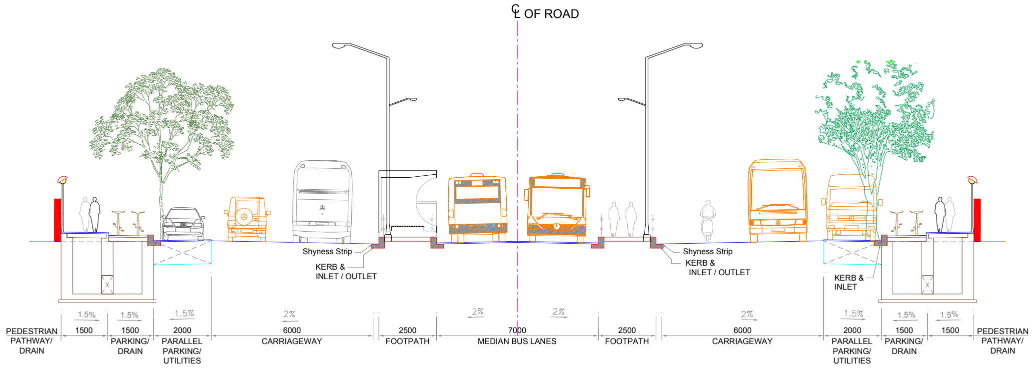


Figure 8.3: **CS: C-C:** BRT system Cross-section at Bus Station (total 35 m)

(d) 30 m RoW:

Two central bus lanes – each of 3.5 m width, one for each direction of travel will replace the existing median. These will be abutted by a 1.0 m wide physical separator on each side. There will be a motorized lane of 6.5 m wide for each direction of travel. The motorized lane will be followed by a cycle track (2.0 m wide) and then a footpath (2.0 m wide) on each direction of travel. Underneath the footpath, there would be storm water drain.

Wherever extra width is available at mid-block sections or at intersections, is recommended to be utilized for providing emergency/refuge/storage lanes, garbage dumps, pubic toilets and with general landscaping. Access to abutting properties and minor roads will be directly motorized lane. Parking would be restricted at such locations. The proposed cross-section is presented in Figure 8.4.

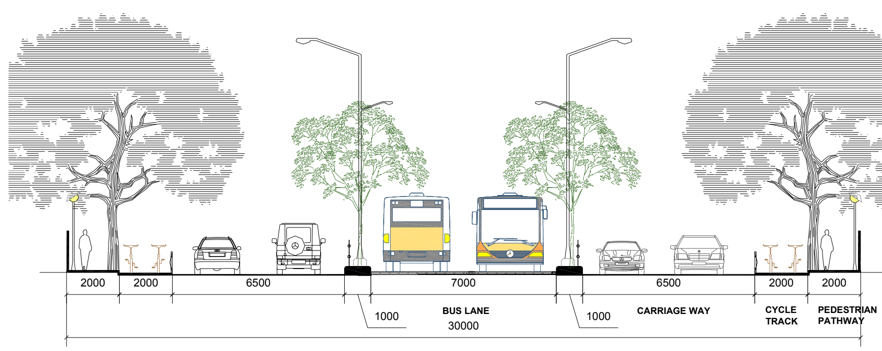


Figure 8.4: **CS: D-D:** BRT system Cross-section at Bus Station (total 30 m)

8.6 Plan/Profile for a Typical Section

Topographic survey was done on a typical section (near Soni ni Chal on NH 8, about 1.5 km) having RoW 60 m. Plan and profile have been prepared for that section which is presented in the following figure.

The plan and profile helped assessing realistic road improvement cost for a km, which was utilized estimating block cost for the entire corridor.

8.7 Block Cost Estimates

The cost estimate for the BRT corridor phase-I (Circular: Shivranjani – Sabrmati – Narol - Shivranjani) has been prepared, covering Dismantling, road work, paving and concrete, road marking/traffic signs, street furniture, landscaping, electrification, traffic signals etc. and miscellaneous items. Estimate of the quantity related to civil work is primarily based on the typical pavement design explained in earlier section. As regards other items such as bus shelters, subway, flyovers buses, depots, terminals etc. lumpsum provision have been made.

The table below shows the item wise capital cost for the corridor development.

Table 8-2: Cost Estimate

Road Section	Length (km)/No.	ROW (m)	Unit Rate (Rs.)	Total Cost (Rs. in lakh)
Shivranjani Cross Road – RTO	8	40	58,813,689	4,705
RTO - Sabarmati	2.7	60	79,968,779	2,159
Sabarmati – Sardar Nagar	3.3	24	40,881,863	1,349
Sardar Nagar – Narol Circle	24	60	79,968,779	19,193
Narol Circle – Chandola Lake	2	30	40,881,863	818
Chandola Lake – Shivranjani Cross Road	7.5	35	47,050,952	3,529
Bus Stop	(2X55)	n/a	300,000	330
Road Improvement Cost				***32,083***
Bus	100	n/a	3,000,000	3,000
External Ticketing System	Lump sum	n/a	10,000,000	100
Information System at Bus Stops	Lump sum	n/a	10,000,000	100
Depot-cum-Terminal	2	n/a	20,000,000	400
Terminal	2	n/a	5,000,000	100
System Operation Cost				***3,700***
Flyovers	11	n/a	200,000,000	22,000
Subways	5	Varying	20,000,000	1,000
				23,000
GRAND TOTAL (Rs. in lakh)				**58,782**

The cost of minor improvement/maintenance of the corridors proposed for BRT buses to run in open system is not considered.

8.8 Construction Sequence

We recommend all the construction works be done from one road junction to another junction to minimize disturbance to road traffic/road users. No rerouting of traffic would be required. Keeping this aspect in view, it is proposed to divide various construction works into the following phases so as to keep only portion of the available ROW closed for the construction activity and remaining open to traffic:

In the case of 60 m right-of-way the construction activity would be divided into three phases as follows:

Phase 1

- Shifting of utilities and removal of encroachments
- Widening of CD works to the full roadway width
- Construction of footpath, cycle track and service lanes
- Diversion of traffic into constructed service lanes
- Street lighting

Phase 2

- Construction/widening of motorized lane (Mixed lane) and adjacent footpath
- Diversion of Motorized traffic on the mixed lane
- Street lighting

Phase 3

- Removal of existing median
- Construction of BRT bus lanes and Bus stops
- Residual work

In the case of 40 m right-of-way the construction activity would be divided into two phases as follows:

Phase 1

- Shifting of utilities and removal of encroachments
- Removal of existing footpath
- Widening of CD works to the full roadway width
- Construction of footpath, cycle track
- Widening of the existing carriageway to the required width.
- Diversion of traffic into constructed service lanes

Phase 2

- Diversion of Motorized traffic on the widened carriageway
- Block the required width necessary for the construction of central BRT bus lane.
- Construction of footpath proposed adjacent to the BRT lane and guard rails
- Remove temporary barricades
- Removal of existing median
- Construction of BRT bus lane and bus stops
- Residual work

8.9 Summary

In order to ensure better mobility on the identified corridor as whole, separate lanes for cyclists and pedestrians, motorized traffic and BRT Buses have been provided. Various cross sections have been explored by incorporating segregated and mixed options for the cycle traffic as per the RoW availability. Bus stops have been strategically placed in a segregated manner to enable overtaking in the bus lane. A thumb rule capital cost for the development of the identified corridor has also been discussed in this chapter.

Chapter 9 SUPPORT MECHANISM

9. SUPPORT MECHANISM

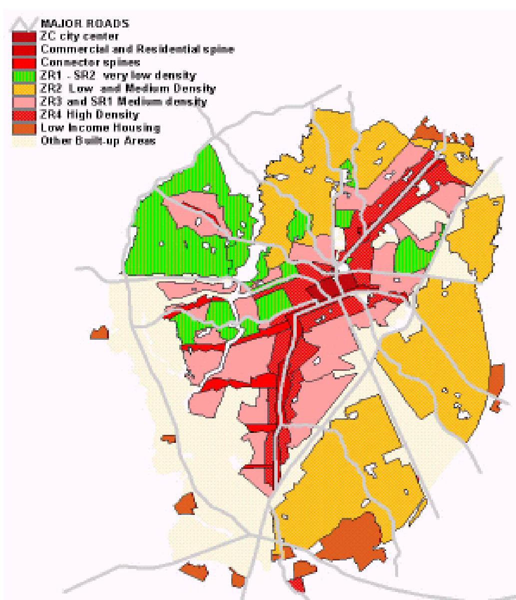
Transport projects are known to yield wide-ranging benefits to the individuals and also induce land-use changes resulting in increased land value. On the other side land-use changes help transit system to attract more Rider ship. Hence, the need is for land-use-transport integration. This chapter briefly dwells upon the support measures required to make transit oriented development and also explores possibilities of cost recovery.

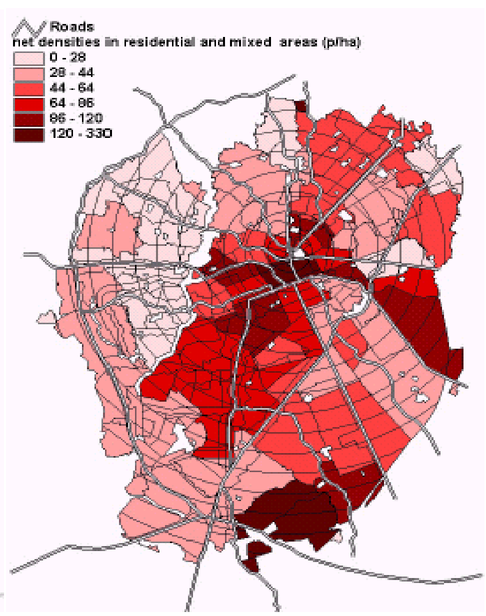
9.1 Transit Supportive Activities

While the efforts are to develop world-class integrated transit systems in Ahmedabad, policies and programmes to encourage use of public transport and at the same time restrain use of personal modes are required.

Box-1

A successful example is found the case of Curitiba where along with transit development, land use zoning and density norms were changed. In 20 years it is seen that ***40% of the entire city's population resides within three blocks of major transit arteries.***





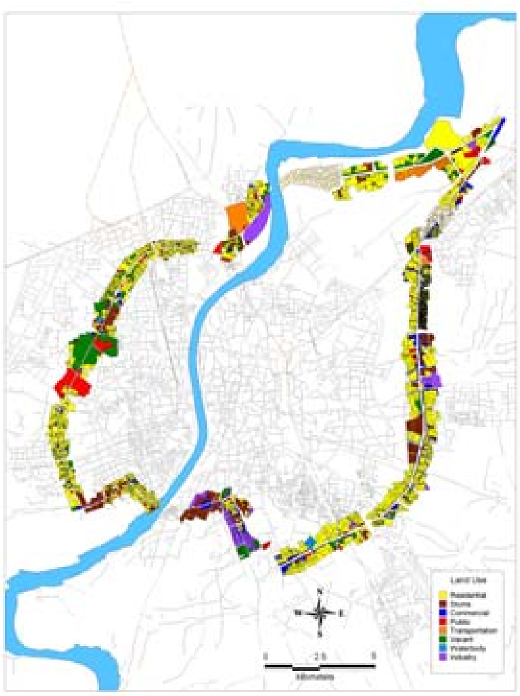
Map 9.1.a Curitiba: Use Zoning **Map 9.1.B Curitiba: Density**

The city of Ahmedabad is comparatively compact. Further intensification of corridors need consideration. Without land-use intensification along the corridor achieving transit demand in excess of 10,000 pphpd would be difficult. Hence, the need for increase in density/FSI along corridor is recommended.

A land use survey of the entire corridor stretch covering 250 meters or upto the immediate parallel road was undertaken to establish the land use potentials. The land-use along the corridor is presented below. (Table 9.1 &. Map 9.2)

Table 9-1: Land Use along Corridor

Land Use	**Area (Sq.Km)**	**%age**
Slums & Others	7.18	14.4
Public Institutions	4.62	9.3
Residential/Commercial	32.53	65.1
Vacant	5.60	11.2
Total	49.93	100.0



Map9.2: Land Use along the Corridor

Map9.3: FSI Utilisation along the Corridor

The total area is about 31 sq. kms. While the permissible FSI is 1.8, present utilization rate is only 0.68 which is quite low (Map 9.3). However, it is to be noted that much of the road was developed very recently. Hence full potential of development is yet to be exploited. The identified corridor for BRT system is very much in the developing part of the city. Ahmedabad having the culture of liner shopping and mixed-use development, the corridor has the potential to become a major commercial street. Mixed land use and linear shopping character appears help keep trip rates and length lower and hence to be encouraged. Legislative measures to utilize the full land use potential of the road are to be designed.

In addition, addressing other integration issue is also important. A comprehensive AMTS and BRTS integration plan, BRTS project implementation, developing a clear-cut parking policy are some of the issues to be tackled.

9.2 Resource Generation

Of the estimated cost of INR 588 Crores about Rs. 321 Crores is for basic infrastructure development. In addition on optional elements (Fly over, subways) another 230 Crores would be spent. Buses and depot/terminals would cost about 37 Crores.

It is expected that buses and bus operation related expenses would be borne by the private operators without any support from Government. Infrastructure development costs would have to be recovered through direct/indirect mechanisms.

In this regards, various options have been examined at a preliminary level. The likely yield and feasibility are summarized below.

9.2.1 Land Development

Land Development Option and Assumptions:

1. Total area likely to develop : 21 Sq. Km
2. 50% of Residential /commercial and vacant land will available for development.
3. The development will be staggered beyond 20 year time period and by 20th year 50% plot owners will use additional FSI
4. F.S.I to be provided: 3.5 on either side of the road for 250 meters and 500 mts along intersecting road
5. For the rate chargeable for additional F.S.I three scenarios have been developed
    a. Rs. 500
    b. Rs. 750
    c. Rs. 1000.

Table 9-2: Revenue Yield from sale of FSI

Year	End of 3rd Year	End of 5th Year	End of 10th Year	End of 15th Year	End of 20th Year	Total
Pace of restructuring (%)	5	15	25	30	50	
Land Developed	0.65	1.297184	1.2972	0.64859	1.2972	5.19
Amount Rs. Lakh @.500/ Sq. Mt	3242.96	6485.92	6485.92	3242.96	6485.92	25943.68
Amount Rs. Lakh @ Rs. 750 Sq. Mt	4864.44	9728.88	9728.88	4864.44	9728.88	38915.53
Amount Rs. Lakh @ Rs. 1000 Sq. Mt	6485.92	12971.84	12971.84	6485.92	12971.84	51887.37

However, direct cost recovery is generally not feasible in such cases. Recovery of costs through indirect methods needs examination.

9.2.2 Other Options

Of the other options pay and park facility and advertisement revenue are two important sources likely to yield revenue on regular basis. Their significance will grow with the development of area.

Other sources include adopting Benefit Cess model (Mumbai model), Parking Charge (Delhi model) Toll (Mumbai model) are examples tried out. However these have not been proved as sustainable sources. Initial estimates from these have been presented below.

BRTS Ahmedabad

Table 9-3: Revenue Options and Realization Potential: Preliminary Estimates

Sl. No	Description of Potential Revenue Generation Mechanism	Revenue Potential (Rs. Crores) Quick Estimate
1	Conventional Sources - Pay and Park Facility and Advertisement Revenue	15 / Year
2	Land Development / FSI With 150 Mts. either side along 132' ring road and Naroda Narol Highway over a total length of 30 kms. With an increase in FSI by **1** at Rate**:** a. Rs. 500 sq. Mt b. Rs. 1000 Sq. Mts	 259 518

Sl. No	Description of Potential Revenue Generation Mechanism	Revenue Potential (Rs. Crores) Quick Estimate
3	Road Improvement Benefit Cess (On the lines of Mumbai,s Sewerage Benefit Cess) on Property (Along with Property Tax) Rate of Cess on Property Tax - at 5% - AMC Area - at 5% - AUDA to charge similar to sewerage charge TOTAL - at 10% AMC Area - at 10% AUDA to charge similar to sewerage charge TOTAL Average amount per property at 5% Rs. 95/Year at10% Rs. 190/Year	7.53 1.88 **9.41 / Year** 15.05 03.76 **18.82 /Year**
4	Transport Improvement Cess (On the lines of earlier Mumbai's Cess on Fuel) @50 Ps per Litre sold	15.0 / Year
5	Addl Charge (Parking Charge as in Delhi) on New Vehicles one time on new vehicles @ Rs. 5000 for Cars & Trucks @ Rs. 1000 for 2 wheelers	20.0 / Year
6	Addl. Cess on Octroi at 5%	17.5 / Year

9.3 End Note

It is important to note here that the entire cost required to develop such BRT system is not only for BRT system as such but also to enhance overall mobility on the corridor. The support measures and mechanism discussed so far is primarily an initial thought. A detailed financial viability of the project based on the capital cost, operation & maintenance cost and revenue through fare box and other means needs to be done in the next step.

Building on the design concepts presented in this report towards finality, more robust travel demand data and system operations design are the next important steps. Working out institutional framework is a critical task.