BUS RAPID TRANSIT SYSTEM: A MILESTONE FOR SUSTAINABLE TRANSPORT: A CASE STUDY OF JANMARG BRTS, AHMEDABAD, INDIA

Anuj Jaiswal [a], K. K. Dhote [b], R. Yadu Krishnan [c], Devansh Jain [d]
[a b c d] Department of Architecture & Planning, MANIT, Bhopal, India
[a] Corresponding author: jaiswalanuj@indiatimes.com

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Abstract: A sustainable transport system should provide mobility and accessibility to every urban neighbourhood in a safe, sound and environment-friendly way of transport. There is increase in the use of personal transport in the urban area. The rapid growth in the number of motor vehicles has resulted in severe traffic congestion and air pollution in many cities of the country.

One of the most important technical innovations in the transportation field has nothing to do with vehicle technology or alternative fuels. Rather, they involve the way bus services are operated and infrastructure is used to optimize their speed, comfort, and capacity. The U.S. Federal Transit Administration (FTA) has helped to popularize a term for such measures: Bus Rapid Transit, or BRT.

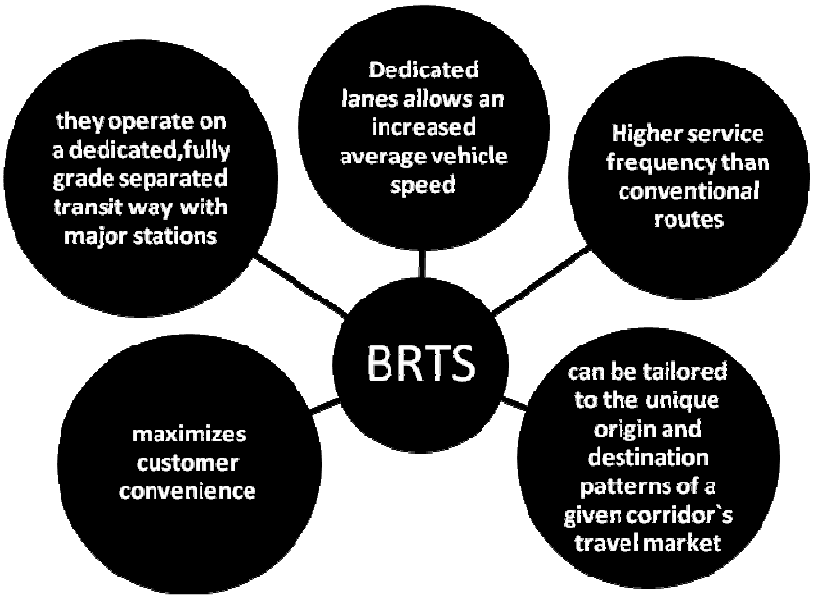
Bus rapid transit (BRT) is a term applied to a variety of public transportation systems using buses to provide faster, more efficient service than an ordinary bus line. The goal of these systems is to approach the service quality of rail transit while still enjoying the cost savings and flexibility of bus transit.

Ahmadabad has become the first city in South Asia to receive award for sustainable transport system. It has bagged for successful implementation of Bus Rapid Transit (BRT) system. This Paper examines the impact of BRT System on Ahmadabad's transport sector and the changes that can be brought about by introduction of BRT System in other cities. BRTS Ahmadabad has improved access for local riders and advanced public transportation systems while reducing the environmental impacts of transportation. Moving people quickly, at a low cost, with reduced greenhouse gases and air pollutants helps cities grappling with rapid growth, congestion and environmental concerns.

Keywords**:** *Bus Rapid Transit, Janmarg, Sustainable Transport, Advanced Public Transportation Systems.*

I. INTRODUCTION

Most of the million plus cities are faced with serious problem of congestion and pollution; they are looking for cost effective, efficient and sustainable means of public transport solutions. BRTS are increasingly being recognized as



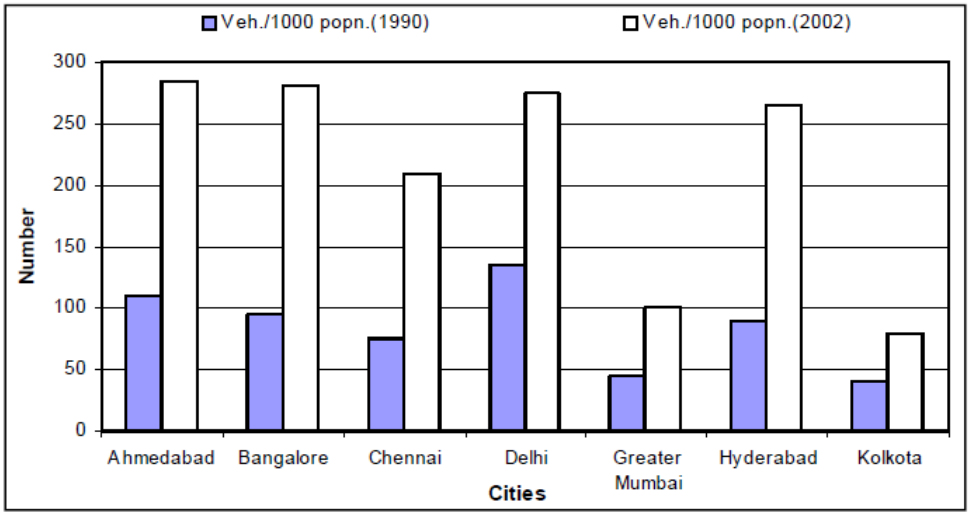


Figure 1: Comparative analysis of vehicular growth rates

amongst most effective solution for providing a cost effective and high quality public transport service in urban areas for both the developed and the developing world.

Bus Rapid Transit involves coordinated improvements in a transit system's infrastructure, equipment, operations, and technology that give preferential treatment to buses on urban roadways. Bus Rapid Transit encompasses a variety of approaches, including high capacity buses using exclusive busways or HOV lanes with other vehicles, and improving bus service on city arterial streets.

Bus Rapid Transit on busways or HOV lanes is sometimes characterized by the addition of extensive park and ride facilities along with entrance and exit access for these lanes. Bus Rapid Transit systems using arterial streets may include lanes reserved for the exclusive use of buses and street enhancements that speed buses and improve service, BRT, FTA report [1]. When public transit service is frequent and reliable, more people use it in place of their cars. The

study includes concept of BRTS, BRT system characteristics, and technologies and also study of the BRT system worldwide.

1.1 Characteristic of BRT System

As we look at the length, area and population of cities, as it increases the type of BRT and level of BRT changes from a basic bus service to a Full BRT service. The other factors that affect the type of BRT system may include local preferences and culture, population density, distribution of trips, climate, geography, topography, available financial resources, local technical capacity and knowledge, existing business and institutional structures, and, perhaps most importantly, the degree of existing political will to implement a high-quality system [1].

1.2 Advantages of BRT over other Transit Systems

BRT has generally the following advantages:
a) BRT having more flexibility than Light Rail, It can able to phase in service rather than having to wait for an entire system to be built, and it can also be used as an interim system until Light Rail is built.

b) Bus Rapid Transit routes can also be adjusted and rerouted over time to serve new developments and dispersed employment centres that may have because of development outside the city centre, there are now eight employment centres that need to be considered in its transit analysis.

c) Bus Rapid Transit can respond to changes in employment, land-use, and community patterns.

d) On the other hand, Light Rail Transit lines are fixed and cannot easily change to adjust to new patterns of housing and employment.

e) Compared to other mass transit alternatives, the BRT is by far the most cost-effective means of providing rapid transit service—about 10-20 percent of the cost of light rail and 1-10 percent of Metro.

f) Although Bus Rapid Transit sometimes uses rail-style park-and-ride lots, Bus Rapid Transit routes can also collect riders in neighbourhoods and then provide rapid long distance service by entering a bus way or HOV (high occupancy vehicle) facility. Transit agencies have considerable flexibility to provide long distance service without requiring a transfer between vehicles. This is a significant.

g) In performance of transit system, two elements are ridership and system speed. While ridership varied considerably, the largest ridership on Bus Rapid Transit and Light Rail systems were quite similar. Speed varied but that Bus Rapid Transit projects were generally faster. This was likely due to the nature of the Bus Rapid Transit systems; express bus operations or operations with longer stop spacing have higher speeds.

h) Ridership on Bus Rapid Transit and Light Rail systems varies widely and depends, in part, on frequency of service, number of stops, hours of operation, and customer demand. For example, ridership on 4 bus ways ranged from 7,000 riders per day to about 30,000 per day and averaged about 15,600 riders per day. For 13 bus lines on HOV lanes, ridership ranged from 1,000 to about 25,000 riders per day, with an average ridership of about 8,100. In addition, the ridership on the two arterial street Bus Rapid Transit lines in Los Angeles was about 9,000 to 56,000 per day, with an average of 32,500 per day. In addition, ridership can vary greatly with vehicle sizes and passenger capacity between Light Rail and bus vehicles, which can affect vehicle based comparisons as mentioned in feasibility report by RITES and TRIP Delhi [2].

i) Distance Speeds generally depends on the characteristics such as distance between stops, fare-collection methods, the degree to which the tracks or roadway are exclusive to transit vehicles or share right-of-way with cars and other vehicular traffic, type of the intersection and geometric design of the road.

1.3 Proposed BRT System in Indian Cities, their Length and Population

In India, it is started first in Pune city then in Delhi partial corridor is started from 21st April 2008, and also proposed in other cities as described below.
BRT is being implemented in Indian cities of Ahmadabad, Surat, Rajkot, Bhopal, Indore Pune - Pimpri Chinchwad, Vijayawada, Vishakhapatnam, Jaipur and Delhi. The BRT projects in these cities are sanctioned under JNNURM and in Delhi it is funded by Govt. of Delhi. Table shows Indian cities under plan to be implemented BRT system in near future mentioned in BRT developments in India [3] .

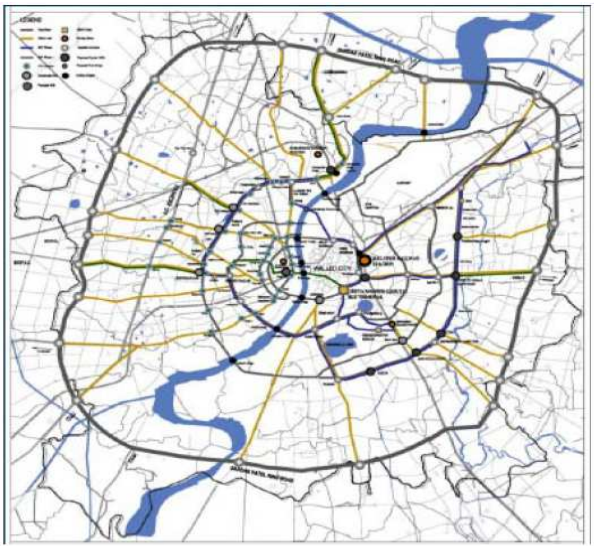


Figure 2 Ahmadabad city map showing redial pattern

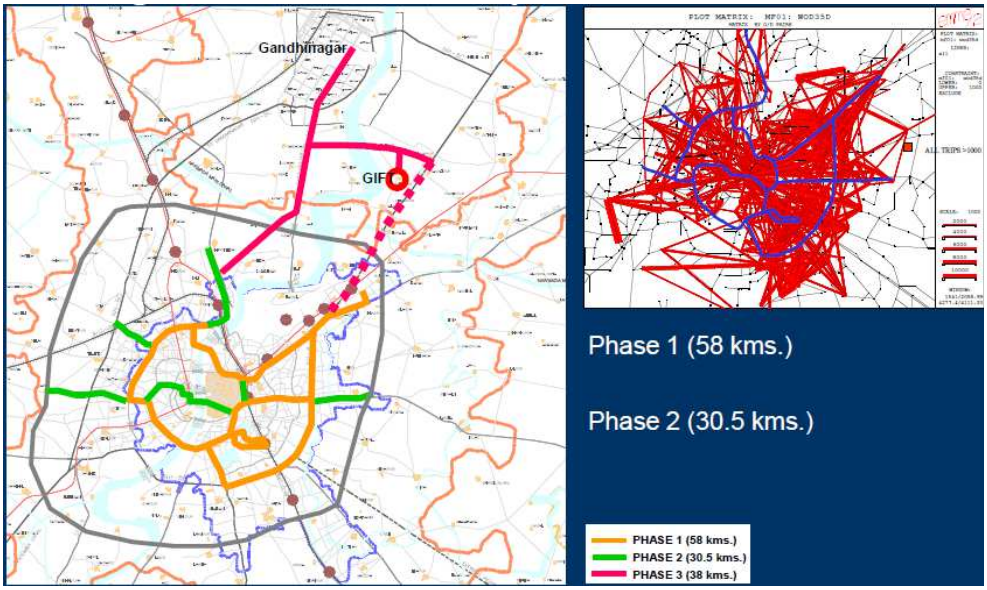


Figure 3: Map Showing the Selection of corridors along with DL diagram

The comparative data of vehicular growth rates in all major metro cities in India. Ahmadabad, Bangalore Hyderabad and Chennai have recorded a higher growth rate than Delhi, Mumbai and Calcutta. In the year 2002 Ahmadabad has recorded the highest per capita motor vehicles in India.

2. 'JANMARG': AN APPRECIATION

In the city of Ahmadabad, AMTS has been providing public transport facilities since 1947. The peak performance of AMTS was observed in 1997 when it recorded about 8 lakh boarding with a fleet size of 820 operating over 164 routes. Due to inherent constraints of public sector body, the agency started suffering a great deal as discussed in

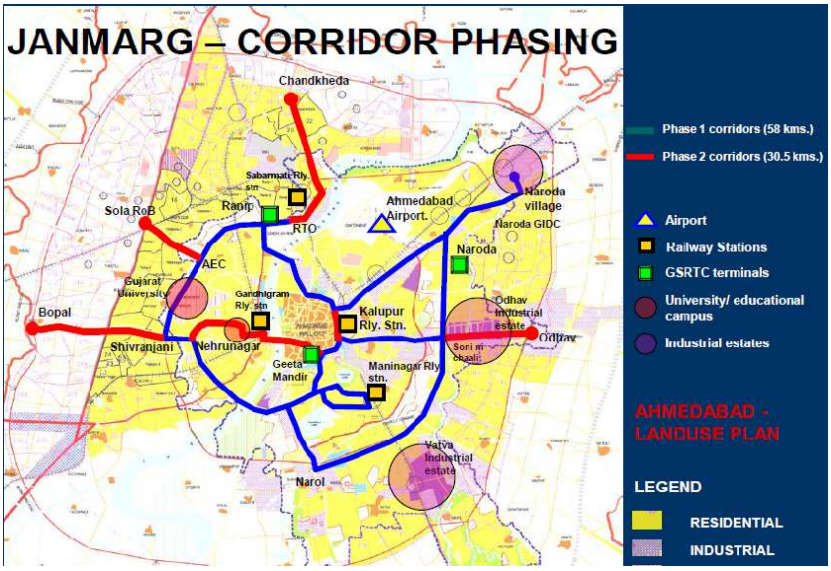


Figure 4: Corridor Phasing

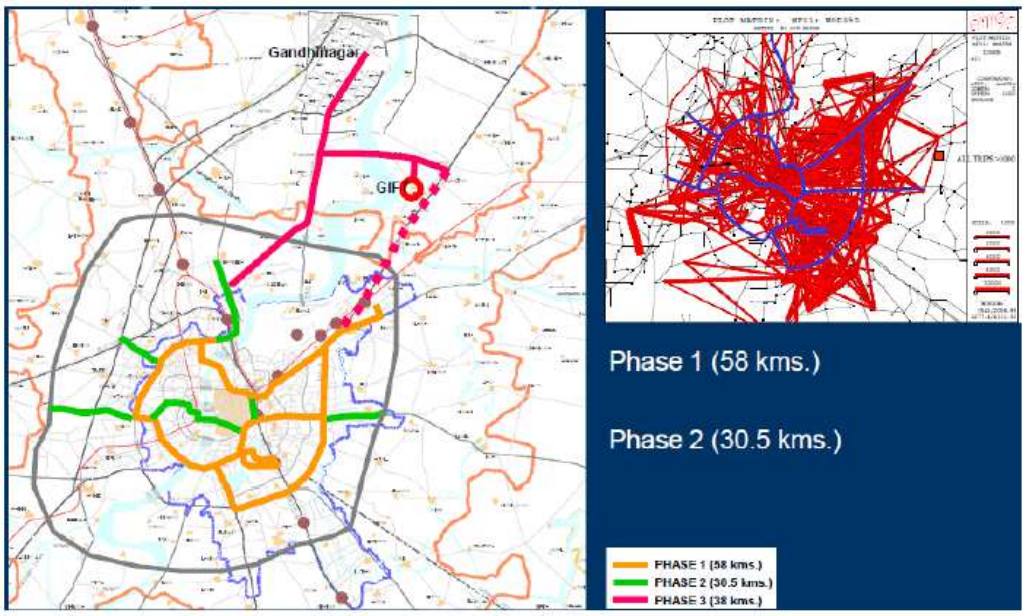


Figure 5: Map Showing the Selection of corridors along with DL diagram

Janmarg Report [4]. Excessive manpower, stagnant and aged fleet, poor maintenance, large overheads, non-responsive operations plan became the sources of inefficiency. The organization started to lose heavily. Fleet availability became uncertain forcing reduction in operations. Average daily ridership came down to 325,378 in the year 2004.

As a restructuring policy, to improve transit service, AMC invited private operators to participate in provision of public transport on a gross contract model (kilometre scheme). Since the AMTS was not able to meet the increasing demand of the fleet as well as increasing deficit, the private operators were asked to run the buses in 2005. As on Feb 2008, there are 538 buses operated by private operators and 484 by AMTS taking the total fleet to 1022. Daily passengers (daily boarding) have gone up to 936,886.

This is a clear indication of latent demand waiting to be serviced.

2.1 How relevant is BRT for Ahmadabad

a) Ahmadabad has a well developed ring-radial structure, high density development and dispersed travel pattern.
b) No Single mode is adequate to meet with the mobility needs in cities
c) Improvements in existing bus system alone are not adequate to bring about significant modal shifts.

2.2 Specifications and Route Selection

Specifications

a) Closed system –trunk and feeder services
b) Central bus lanes
c) Median bus stops
d) Closed' bus shelters
e) Distance based fare –smart cards
f) Integrated ticketing system –Trunk, feeder and AMTS
g) Automatic vehicle tracking system

Route Selection

a) Connectivity of important origin and destinations
b) Existing bus patronage and pattern of movement
c) Catalyst for area development -low income, low accessibility zones (old walled city)
d) Availability of right of way to build infrastructure
e) Formation of strong network for flexible route operations
f) Overall impact of transit on city
g) Connect 'busy places' but avoid 'busy roads'

The BRT phases proposed now is with the basic aim to link the major institutional and industrial pockets of Ahmadabad. This would help people to shift to the public transit from their private modes for their work and education trips. The first 2 phases are aimed at providing better connectivity inside the city and the third phase is aimed at connecting Gandhi Nagar and GIFT city to Ahmadabad. The first two phases are in operation now and the third phase is under construction.

2.3 'Janmarg' Route Plans

Both the phases of BRT are so designed, that they don't overlap the areas in which AMTS service is provided. *Janmarg* has also proper feeder systems which feed people for the running of BRT system. Orange coloured buses act as feeders for the BRT services. The AMSTS, BRTS and Feeder Network is shown in the map Figure 8.

Initially, trial runs started in the RTO to Pirana BRT corridor which is around 12 kms long to help passengers understand its system and its applications and no fares were collected. It was also to help the drivers for safe and comfortable ride and proper manoeuvring and docking at bus stations. It was to check the physical aspects and allow scope for rectifications before the system comes into operation. These trail runs would help us get a public feedback and opinions.
A new GIS road network was created since the city boundaries have expanded since it was coded the last time. All modelling work carried out to estimate demand on BRT network of Phase 1 and 2 was done on this new GIS road network using data collected through surveys as mentioned in the earlier section. Thematically, the BRT network chosen for Phase 1 is fairly accurate. But a good operations plan needs to assess the demand location by location on this network to structure a good routing plan with bus frequencies. EMME3, industry leading software for transit modelling has been employed.

The operations plan developed not only provides route structure for BRT operations but also the rationalised routing plan for AMTS operations. This is necessary so that the two systems complement each other rather than compete with each other.
Transit demand estimation would involve estimation of change in demand from the current users under various operating conditions, estimating shifts from transit-like (shared auto) services, estimating shifts from intermediary transit and personalised modes, generated traffic due to quality improvements in transit. In terms of routes following three types of routes are structured to operate transit services:

1. BRT Trunk Routes
2. Complementary Routes (AMTS)
3. BRT Feeder Routes

Scenarios have been developed with and without fare integration. Based on an assessment of the existing routes and travel desires, alternate set of BRT trunk routes, BRT feeder routes and Complimentary routes have been analysed. Of this following set has been adopted. In this set there are 10 BRT trunk routes, 21 BRT Feeder and 60 complimentary services have been identified for operation.

2.4 Business Model

Any business model would have to take into consideration the two basic costs involved in the project. The two basic costs involved are:
a) Installation Costs
b) Running Costs

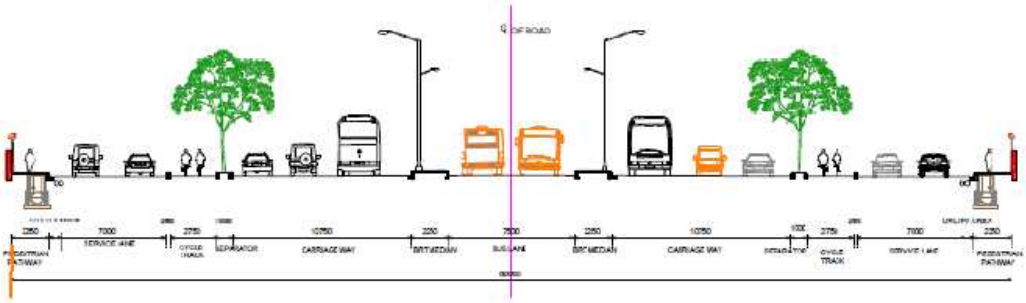


Figure 6: Road Cross Section 60m ROW

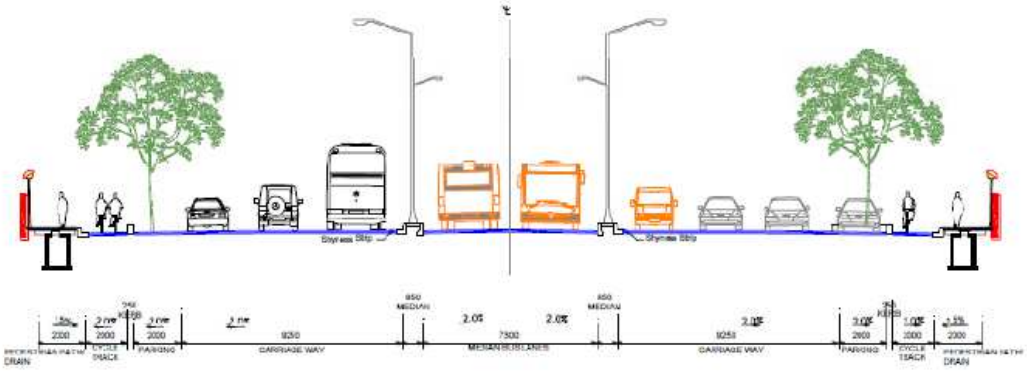


Figure 7: Road Cross Section 60m ROW

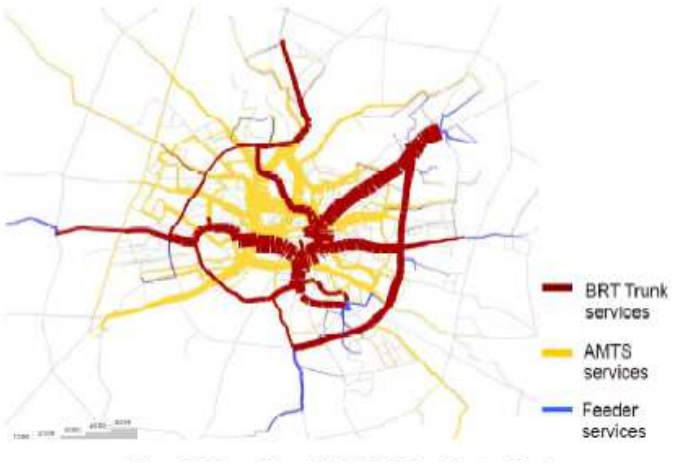


Figure 8: Route Plan of AMTS, BRTS and Feeder Services

Table 1 : Per Km Installation Cost of Various Systems around the World (in million USD)

Bagota trans Milenio	BRT	6
Sao Paula 9 De Julho	BRT	2
Porto Alegres Assis	BRT	2
Curitiba Eixo Sul	BRT	2
Trans Jakarta	BRT	1

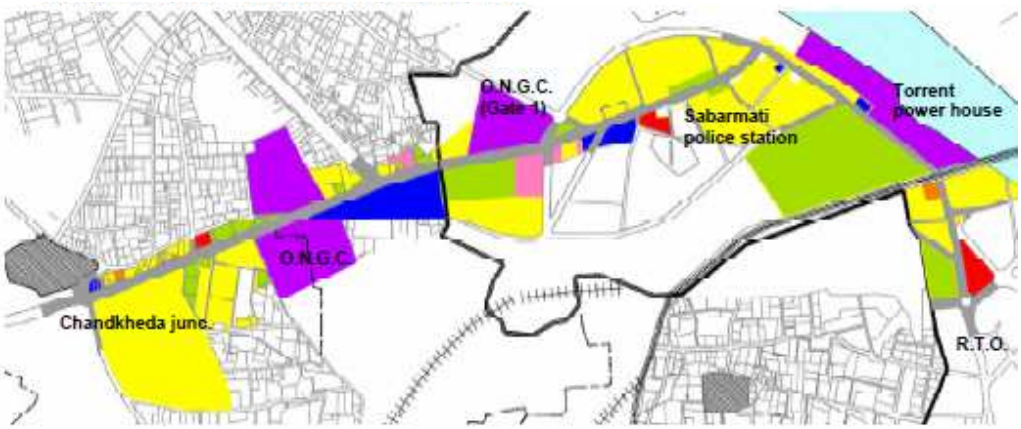


Figure 9: Map of corridor - 1

Installation Costs

As given in the Detailed Project Report the total installation cost of the project is 588 crores INR (Phase- I) and 430 crores INR (Phase-II). Therefore the total project cost is 1018 crores INR. The installation cost is found out in terms of per kilometre cost of installing the BRT system. Therefore dividing the total installation cost by the total system length of 88.5 Kms, we get the per km cost to be 11.50 crores INR per Km (2.5 million USD).

On comparison we find out that installation cost of ***'janmarg'*** is very much cheaper than the Bogota model is costlier than many of the other systems around the world.

Running Costs

Running cost analysis is made by comparing the running cost of BRT with other modes of transport mention in L. R. Kadiyali [5]. The average running cost of each mode is calculated with the help of average vehicle occupancy, the fuel cost and the vehicle average. This would help us derive per Km running cost and from which per person running cost can be calculated.

2 wheelers
Fuel Cost: 62 INR
Vehicle Average: 40 kms
Average Vehicle Occupancy: 1.5
Per Km Running Cost: 1.55 INR
Running Cost per Km per Person: 1.03 INR

4 wheelers
Fuel Cost: 52 INR (Average of petrol and diesel cost)
Vehicle Average: 10 kms
Average Vehicle Occupancy: 3
Per Km Running Cost: 5.2 INR
Running Cost per Km per Person: 1.73 INR

Janmarg
Per Km running Cost: 34 INR
Average Vehicle Occupancy: 40
Running Cost per Km per Person: 0.85 INR

3. SITE INTRODUCTION & DATA COLLECTION

'Janmarg' Phase-II

In Ahmadabad Pilot project of 5 corridors on phase-II is selected for case study. Data collection comprises of primary data and secondary data. Primary data was collected from primary surveys and secondary data is collected from various sources such as libraries,

internet websites, and from some of the organizations concerned with BRTS such as RITES, CEPT and CRRI etc.

3.1 Corridor Characteristics

3.1.1 Corridor 1: RTO to Chandkheda

This corridor starts from Ranip junction near RTO and extends up to Chandkheda. The ROW for this stretch is clear with no major encroachments. There is one existing four lane ROB that climbs over the railway line. After the railway line, the ROW is 60 m till Chandkheda.

The corridor is an upcoming residential neighbourhood. Major activities along the corridor are residential in nature including the O.N.G.C. Township at Chandkheda. The Torrent power house is located near the R.T.O. junction. About 1.5 km off the corridor is the Sardar Patel stadium at Motera.
The corridor is gradually developing as residential hub on par with the more affluent western suburbs of Ahmadabad. The area behind the Torrent plant is a dense low and middle income residential neighbourhood. Small commercial developments are gradually coming up along the edge of the road due to its upcoming demand.
This corridor acts as an extension of the RTO to Pirana corridor of phase 1 and improves the connectivity to the northern suburbs of Ahmedabad.

3.1.2 Corridor II: AEC Junction - S G Highway (Sola)

This corridor starting from AEC Junction leading to S.G. Highway has residential and mixed land use. The whole length of about 3.1 km has middle income and lower middle income group residential development. A park, petrol pump and other such small facilities are also found along the corridor.
ROW along the corridor is 24 m. The stretch acts as a major connection to S.G. Highway and the Sola village. Both S.G. Highway and Sola are emerging as a major activity zones. This corridor connects to the RTO to Pirana corridor of phase 1 at AEC junction and will act as a major contributor to the trunk network identified in phase 1. In future, this corridor can connect across the SG highway upto the Sardar Patel ring road at Science City.

3.1.3 Corridor III: Shivranjini- Iskcon -Bopal

The stretch of about 6.5 km has a variety of activities. The stretch can be divided into two parts taking land use into consideration. Commercial activities are seen along the corridor from Shivranjini to Jodhpur cross roads. Star India Bazaar is a major attraction along this edge. Further ahead, going till Ramdev cross roads gradual change in the land use from commercial to institutional can be identified. The Indian Space Research Organisation (ISRO) is located along the corridor. The corridor further ahead has again commercial activities with Fun republic, Big Bazaar and Iskcon Temple as major attractions. Land prices on this road are amongst the highest in Ahmadabad and this area has emerged as a preferred destination for big malls, hotels and restaurants and multiplexes.

The other side of the Sarkhej Gandhinagar highway is abutted by open plots and scattered residences. At the end of the road is Bopal. Bopal is a thriving satellite suburb of Ahmedabad and will add demand to the corridor. The area is one of the fastest developing residential areas. The RoW varies along the corridor. The average RoW till S.G. Highway is about 40m. RoW from Iskcon to Bopal is 60 m along the whole length. This corridor acts as a radial feeding into the corridor from phase 1 at Shivranjini. Looking at the overall network, it forms a major east west link that will cut across the city and link the suburbs of western Ahmedabad with the educational and commercial areas of central Ahmedabad before continuing onto major transport hubs in the walled city and ending at the industrial suburb of Odhav in eastern Ahmadabad.

3.1.4 Corridor IV: Nehru Nagar Gulbai Tekra/University CG Road Law Garden Ellis Bridge Geeta Mandir

This corridor starts from near the Nehru nagar and continues to the University (500M away) and ends at Geeta Mandir, which is a major intercity bus terminal. The length of this corridor is 6.2 km with varying land use pattern with major commercial and recreational destinations like C.G.Road and Law garden. This corridor cuts across the central areas of the city and eventually connects to the phase 1 corridor at Nehru Nagar and Geeta Mandir junctions.
The corridor connects the University area consisting of major institutions like Physical Research laboratory, Gujarat university, CEPT University, MG Science College, LM Pharmacy, LD college of Arts and L.D. college of engineering and technology. The Gulbai tekra stretch has a major low income residential zone followed by C.G.Road, which is a major commercial hub. Further ahead Law garden is a major recreational and commercial hub. As we cross the Ellis Bridge and enter the old city mixed land use can be found along the length. Thus this corridor links all the varying major destinations of the city like C.G. Road, Law Garden and old city and finally connects to the major S.T Terminal of Geeta mandir.

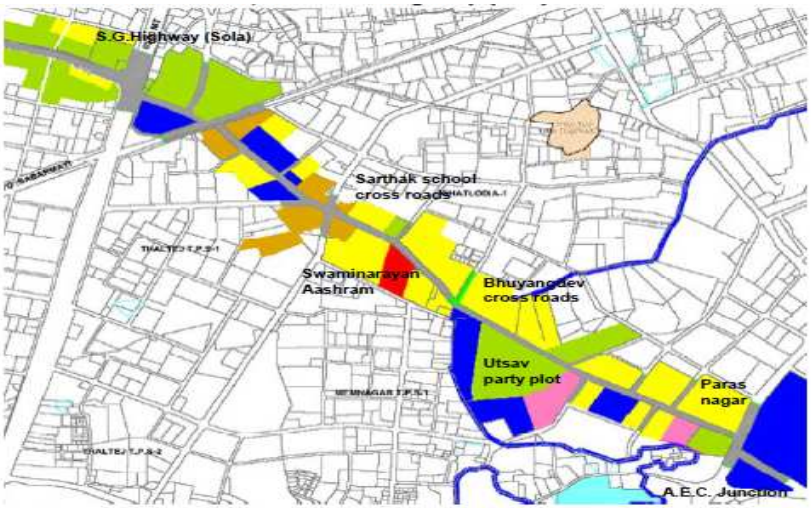


Figure 10: Map of Corridor- II

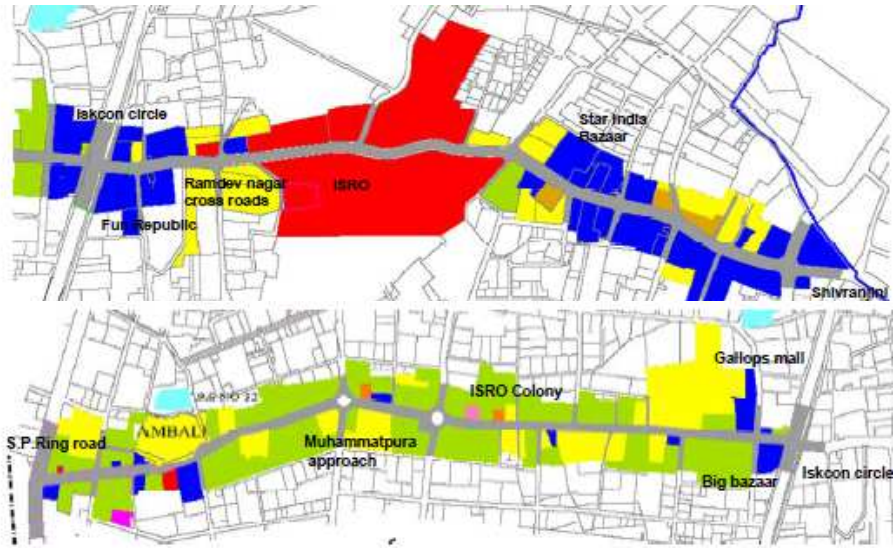


Figure 11: Map showing corridor III

Figure 12: Map showing corridor IV

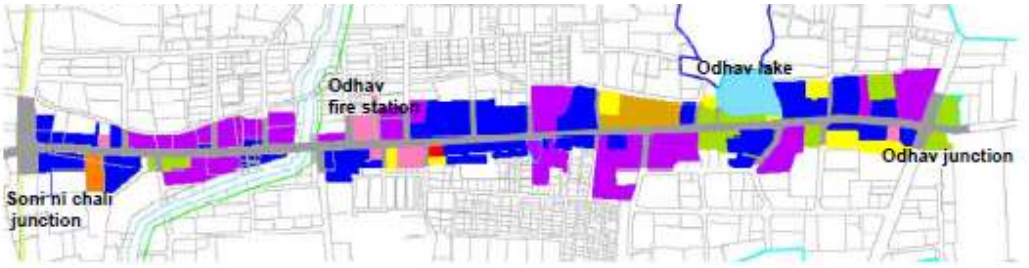


Figure 13: Map showing corridor V

This corridor connects the educational area and then to the Geeta mandir which is part of phase 1. From then on, this corridor connects the Kalupur and further east to the Soni ni chawl and Odhav. The ROW between Ellis Bridge and Geeta mandir has recently being widened entire corridor has clear ROW.

3.1.5 Corridor V: Soni ni chawl-Odhav

This stretch of 3.6 km starts from Soni ni chawl junction on N.H. and leads to Odhav junction. The ROW on this stretch is 30 m. On street activities can be seen along the whole stretch. The major land use along the stretch is industrial. Later half of the stretch is more commercial and residential than industrial. This corridor acts as a major connection to the Odhav village. Major two-wheeler and bicycle movement can be seen along the entire stretch. At Soni ni chawl junction, this corridor connects to two corridors from phase 1 – the Narol Naroda corridor and the Soni ni chawl Sarangpur corridor.

3.2 Data collection comprises of two parts,

- Primary Data and
- Secondary data Primary data has been collected from primary surveys carried out on the pilot BRT corridor for pre BRT and post BRT situations. Secondary data such as literatures, maps, previous studies, various BRT studies carried out worldwide, from various literatures and international case studies from journals and internet are collected.

4. IDENTIFICATION OF IMPACT PARAMETERS

Impact parameters identified for the study are as follows:

Traffic Impact

a) Change in capacity utilization of bus lanes and non-bus lanes.

b) Change in speed -for all modes

Operational Impact

a) Exclusive lane for buses

Travel Impact

a) Change in route of private modes

b) Impact on travel time

c) Impact on travel distance

d) Impact of the BRT corridor development on the secondary road network of immediate influence area.

Safety Impact

a) Impact on Road Safety-Accessibility of Pedestrians-Children, Senior citizen, disables, etc.

5. DATA ANALYSIS

Introduction

Data analysis is a process of gathering, modelling, and transforming data with the goal of highlighting useful information, suggesting conclusions, and supporting decision making.

Primary data was collected from various traffic and travel surveys along the proposed pilot BRT corridor and analyzed with traffic engineering parameters.

Traffic impact parameters were identified in broad such as traffic characteristics, speed, travel characteristics, etc and analyzed as per traffic engineering techniques and compared at different sections of the corridor with the present and past study. Traffic impact parameters that were analyzed are,

Traffic Impact

a) Traffic composition

b) Peak hour traffic flow

c) Change in average speed in the corridor

Table 2: Difference in PCU values -Pre BRTS and Post BRTS

Name of Corridor	Name of location		Pre BRTS (PCU)	Post BRTS (PCU)	Remark (reduction)
CORRIDOR - I	ONGC	Total traffic	13890	11798	2092 PCU (15.06 %)
		Peak hour	3705	2763	942 PCU (27.78 %)
CORRIDOR - II	Ashram Rd	Total traffic	39688	32848	6840 PCU (17.25 %)
		Peak hour	5485	5104	381 PCU (6.95 %)
CORRIDOR - III	Shahjananda	Total traffic	33340	30232	3108 PCU (9.32 %)
		Peak hour	4204	3444	760 PCU (13.09)
CORRIDOR - IV	Law garden	Total traffic	17269	15941	1328 PCU (7.70 %)
		Peak hour	4405	3684	721 PCU (16.35 %)
CORRIDOR - V	CMC skylark	Total traffic	30107	23905	6202 PCU (20.6 %)
		Peak hour	4759	4174	585 PCU (11.52 %)

Table 3: Increase in average speed along the corridors

Name of Corridor	Pre BRTS AVG SPEED (KM/Hr)	POST BRTS AVG SPEED (KM/Hr)	Remark (total increase in KM/Hr)
CORRIDOR - I	27	32.5	5.5
CORRIDOR - II	12.5	16	3.5
CORRIDOR - III	22.5	29	6.5
CORRIDOR - IV	12.5	17	4.5
CORRIDOR - V	16	26	10

The above increase in speed is remarkable for the cities like Ahmadabad.

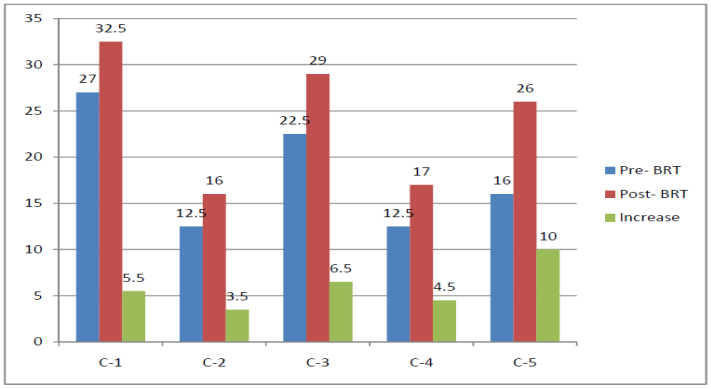


Figure 14: Showing increase in speed Pre BRT and Post BRT

Social Impacts

a) Impact on road safety
b) Accidents

Environmental Impacts

a) Impact on air quality in that area
b) Change in SPM, CO, NO levels

5.1 Study of traffic flow and congestion reduction along the Corridors

Traffic flow study is carried out to understand the efficiency level of the traffic system and to correlate with the proposed capacity. Here, traffic flow study was carried out for at five corridors of Phase- II. The surveys were conducted for 12 hours straight between 9:00am to 9:00pm and finally the numbers in peak hours are represented. Manual method of surveying was used, where a person sits at the site (as mentioned in the DPR of '*Janmarg'*) for 12 continuous hours and counts the number of vehicles passing through the particular road.

5.2 Study of Average Speed along the Corridors

This described in table 3.

5.3 Study of Accidents along the Corridors

It is observed, that there has been a rise in the number of accidents in the past three years. This study aims at checking the impact of BRT on the road safety. This study would give a brief on whether the BRT system installed has helped in reducing the road accidents which is improving day by day. The data required for this study is collected from the Detailed Project Report of '*Janmarg'* for the Pre- BRT situation and the current record is provided by the Police and traffic department. The comparison of both the data would give an idea on whether the road accidents have reduced considerably.

Pedestrian Safety

Safety for pedestrians is necessary in urban transport system. As pedestrians are the maximum no. in the model split of the traffic composition and the public transport users are also pedestrians in their access and dispersal trips.
In Ahmedabad the BRT corridor has been constructed in the aim of public transport priority and to make sustainable transport system. For efficient public transport system their access and dispersal modes i.e. pedestrians have to be facilitate. So, various pedestrian facilities also have been implemented.

5.4 Analysis of Air Composition along all the Corridors

It is observed, that there has been a constant rise in pollution and the pollutants contributing to it in the past three years. This study aims at checking the impact of BRT on the environment. This study would give a brief on whether the BRT system installed has helped in reducing the pollution which is increasing day by day. The data required for this study is collected from the Detailed Project Report of '*Janmarg'* for the Pre- BRT situation and the current record is provided by CEPT. The comparison of both the data would give an idea on whether the road accidents have reduced considerably. Comparing the 2007 data as well as the 2010 data would show us the impact of the BRT system on the safety of the corridor. The table below shows the cumulative level of pollutants along the 5 corridors. The 2007 data is as per given in the Detailed Project Report and the 2010 data is provided by CEPT.

The Table 5 data shows that the level of pollutant has reduced. The Carbon monoxide (CO) which is the major constituent of the vehicular emissions has reduced to considerable level. Even the drop in the Suspended Particulate Matter (SPM) is a bit appealing.

5.5 User's Rating Analysis

The user rating analysis shows that, the citizen who use the system are very much satisfied with the system and the general compliments of the public are as below:

- JANMARG's services are much more satisfactory than AMTS.
- JANMARG is an excellent service and a Service like this is a necessity for making Ahmadabad a metro. It is a simply great service for people.
- It is a very good facility for the people.
- Bus and bus-stops are very clean.
- Very good work.
- This system is wonderful. This bus system is very good.
- Bus system is really good. Please continue this service. It is like services in Europe-America.
- This Janmarg system is good and comfortable.
- Thank you for BRTS.
- Buses come on time and the frequency is very good, it makes the system special.
- JANMARG makes people reach their work and homes on time. Thank you so much.

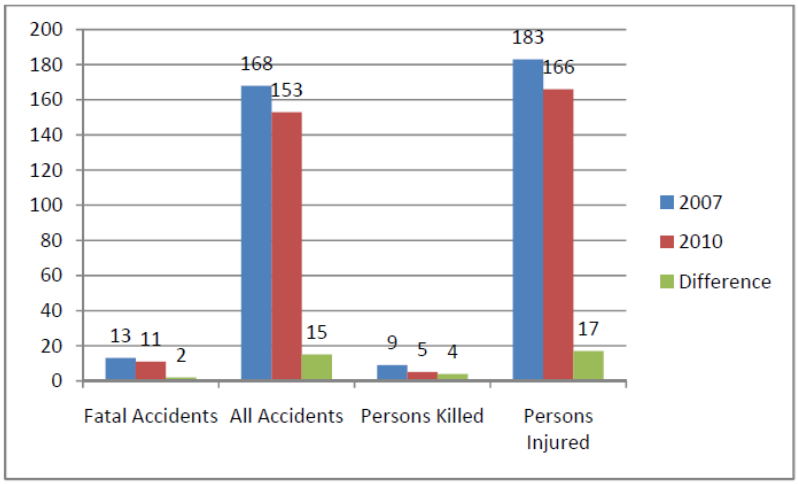


Figure 15: Figure showing the comparative analysis of both the years for Corridor-I

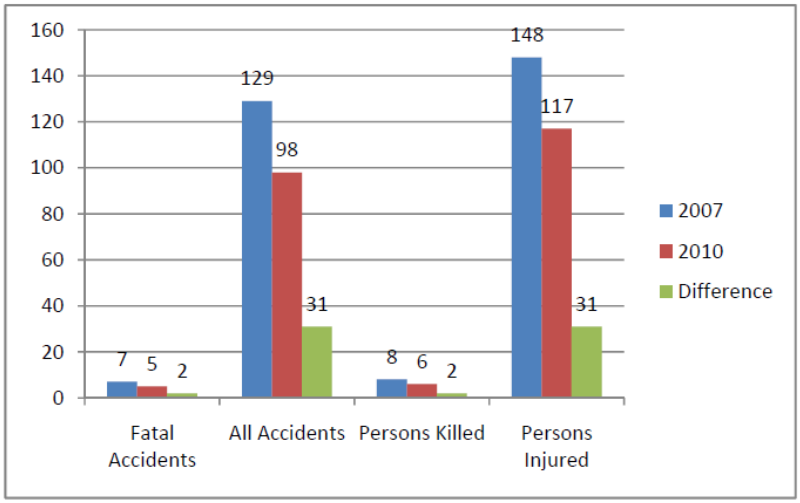


Figure 16: Figure showing the comparative analysis of both the years for Corridor-II

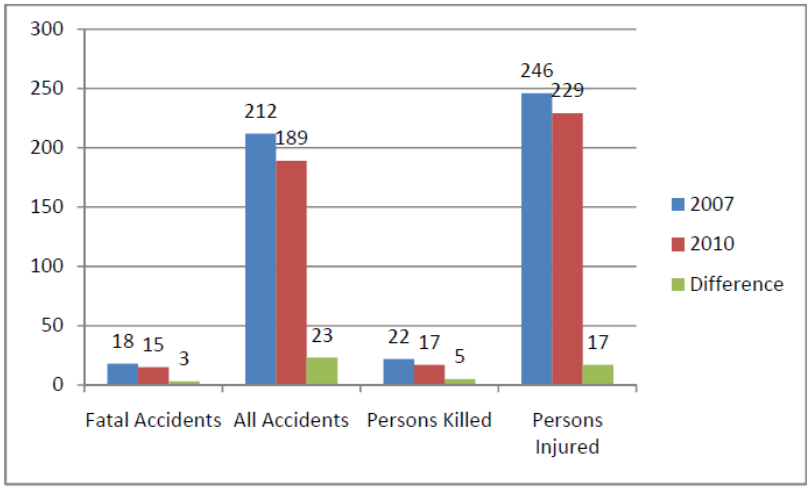


Figure 17: Figure showing the comparative analysis of both the years for Corridor-III

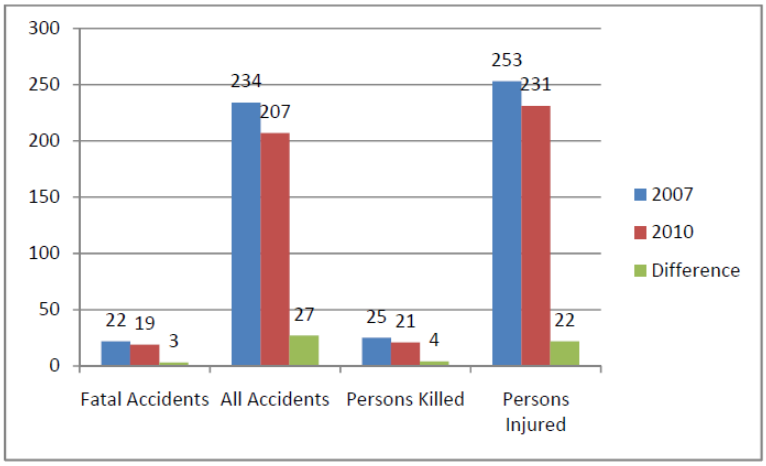


Figure 18: Figure showing the comparative analysis of both the years for Corridor-IV

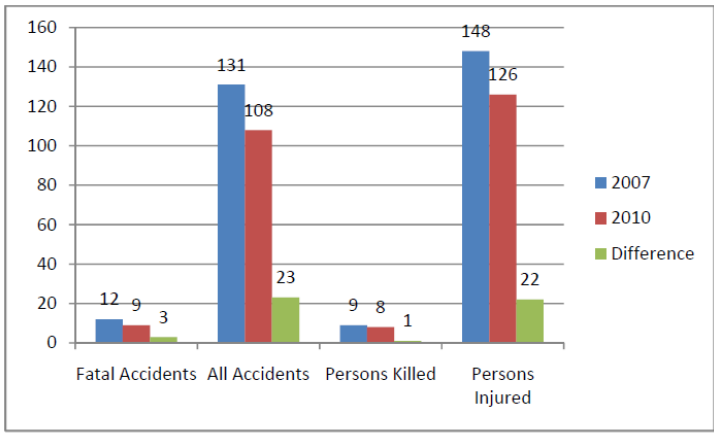


Figure 19: Figure showing the comparative analysis of both the years for Corridor-V

Table 4: No. of accident along the corridors

Name of Corridor		Fatal accidents	All accidents	Person killed	Person injured
CORRIDOR - I	Pre BRTS	13	168	9	183
	Post BRTS	11	153	5	166
CORRIDOR – II	Pre BRTS	7	129	8	148
	Post BRTS	5	98	6	117
CORRIDOR – III	Pre BRTS	18	212	22	246
	Post BRTS)	15	189	17	229
CORRIDOR – IV	Pre BRTS	22	234	25	253
	Post BRTS	19	207	21	231
CORRIDOR - V	Pre BRTS	12	131	9	148
	Post BRTS	9	108	8	126

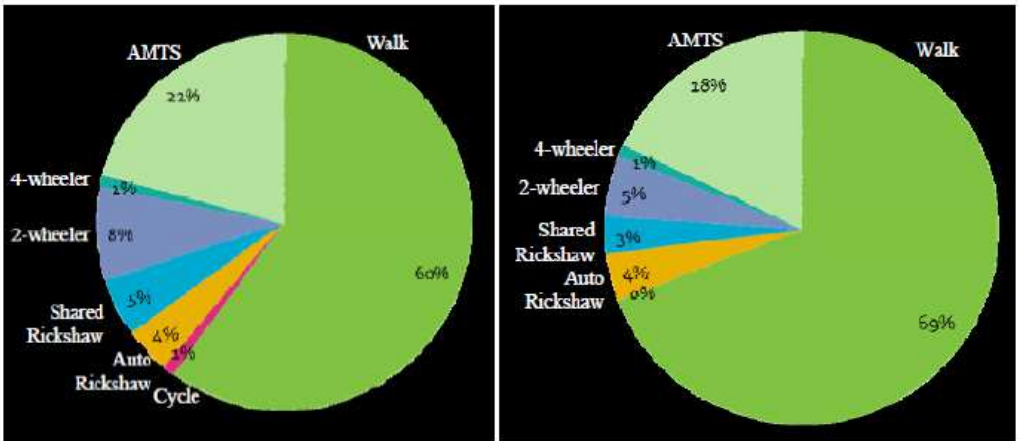


Figure 20: Figure showing graphics showing the access mode and Egress mode of users

Janmarg, Ahmadabad is a very sustainable system as the route selection is takes the passengers to a very close proximity to their work place or home. This is shown with the help of the graph Figure 20.

6. CONCLUSIONS

Bus Rapid Transit Plan for Ahmadabad is a multifaceted project which integrates landuse and transport, various forms of public transport services as well as other motorized and non-motorized modes through various physical, operational and policy interventions to achieve the objective of making Ahmadabad an accessible and competitive city. Given this multi-dimensional nature of the project, anticipated impacts are numerous, some measurable and some qualitative in nature. Significant benefits to road users are anticipated due to improvements as mentioned below.

The BRT project in Ahmadabad includes up-gradation of 217 kms of road network from the present partially developed divided / undivided carriageway, open for mixed traffic to a fully designed street with:

a) Physically segregated road space for buses, bicycles, pedestrians and for mixed traffic,
b) Adequate lighting and other roadway operational infrastructure,
c) Road user amenities such as toilets, kiosks, telephone, etc.,
d) Space for parking to be operated as paid parking facility.
The benefits are in the form of of savings in vehicle operating costs and travel time savings. In addition, following benefits are also expected.

Increased Public Transit Patronage: Under the 'Regular bus operations' the quality of bus services tends to deteriorate after certain level of operations. The operating costs tend to increase and with deterioration in quality, the patronage dwindles. As a result only the 'captive riders' are likely to continue using buses. The market situation is also such that the proportion of the 'captive riders' is on the decline. This is because of improved economic wellbeing of the people and easy availability of loans for procuring personalized vehicles. Low levels of patronage also mean high losses which discourages investments in procurement of buses pushing the whole system into a low level equilibrium trap. Only way out to make urban transport sustainable is to make the system attractive by qualitatively upgrading the services to match the technology advancements in the personalized mode. Possible improvements without BRT treatment would be limited and less likely to yield any significant benefit in the long run. The BRT, a rapid, safe, reliable, flexible, quality service with its own identity would have the ability to provide quality service which is close to (in the long run better than) the services offered by the personalized modes at a much lower cost. Hence achieving higher transit patronage is feasible under BRT conditions as mentioned in '*Urban Transport for Growing Citie's* Geetam Tiwari [6].

Efficient Public Transit Operations: Efficiency improvements in bus operations under BRTS arise due to time savings and rationalized operations. They are:
a. Increased vehicle utilization (Increase in speed, rapid boarding & alighting, reduced turnaround time)
b. Reduced manpower cost (Off-board ticketing and improved manpower efficiency because of fast service/speed)
c. Reduced operating costs (Fuel efficiency, less idle time, less wear and tear, longer Life of the bus)

Efficient Mixed Personalized Transit Operations: BRTS will also improve operating conditions for personalized vehicles. The various contributing factors towards this are: segregated traffic, improved road surface quality, better lighting, junction improvements (some elevated and others better regulated) and shifting a part of heavy traffic to outer ring road (through proposed 'Toll' for through traffic and the proposed Goods Terminal Act). Further, in Phase-II BRT plan, roads have been chosen such that negative impact on current user groups and abutting activities is minimum.

Reduction in Accidents: Some of the BRT corridors are presently highly accident prone. With traffic segregation, exclusive pedestrian and bicycle facilities, better illumination, effective regulation, training and public education, accidents on these roads are likely to come down by 75 to 90%.

Improved Air Quality: BRT benefits in terms of air quality improvements are anticipated due to shift from personalized and more polluting three wheelers to buses, cleaner fuel choice, and promotion of non-motorized mobility with facility integration for bicycles and pedestrians and overall travel reduction through land development intensification around BRT corridors.

Operations Efficiency: Efficiency in operations is anticipated due to private sector investments in bus procurement and operations. Thus overall traffic management in the city is likely to improve.
In view of the analysis carried out, the conclusions can be summarized into the following points:
a) Due to BRT being implemented congestion decreased on the BRT corridor as private vehicles are shifting towards the public transport mode.
b) Due to segregation of the lanes, the traffic is being managed well.
c) Road capacity utilization anywhere on the corridor for the Motorized vehicle lanes was a bit higher than the acceptable limit but has decreased significantly from pre to post BRT situations.
d) There is an increase in average speed along all the corridors.
e) There has been primarily a shift of people using 2 wheelers to BRT. There is only a very slight change of 4 wheeler users to BRT.
f) The Fatal as well as the other accident statistics have gone down after the implementation of BRT.
g) The number of deaths due to these accidents has also gone down.
h) There is also a slight decrease in the composition of the pollutants along all the corridors.
i) The above conclusions states application of BRT Corridor on this Phase has been successful.

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AUTHORS:

Name: Prof. Anuj Jaiswal
Mailing address: Department Of Architecture and Planning, MANIT, Bhopal, India
Tel: +91-9893051635
E-mail: jaiswalanuj@indiatimes.com

Name: Dr.K.K.Dhote
Mailing address: Department Of Architecture and Planning, MANIT ,Bhopal, India
Tel:+91-9406518194
E-mail: kkdhote@hotmail.com

Name: Y. Krishnan
Mailing address: Department Of Architecture and Planning, MANIT, Bhopal,India
Tel:+91- 8928241484
E-mail: krishnanyadhu.r@gmail.com

Name: Devansh Jain
Mailing address: E-4/65 Arera Colony, Bhopal, (M.P.), India
Tel: +91-9179744734
E-mail: devansh_jainbpl@yahoo.com