Evaluation of Effect of Bus Rapid Transit System on Urban Road using Vissim

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Abstract

Urbanization and change in life standards along with socio economic up gradation resulted in rapid growth of private vehicle ownership and use. This causes stress on the existing urban transport system. In urban area road networks are with sharing of limited right of way by variety of modes in most of the cities of world. There is requirement of large size of road network and facilities in terms of infrastructure which leads to increase in urban boundaries. There are unmanageable problems like traffic congestion, accident, inadequate parking area, delay, inconvenience, uncomforting, environment and deterioration. To minimize or eliminate this kind of problems, proper traffic management by providing efficient road infrastructure facility and mobility. Mode shift from personalized vehicle to public transit vehicle is required. Bus Rapid Transit System (BRTS) is one of the most effective solutions for removal of congestion. Before implementation of any facility there is a need to study the effect of proposed facility and mobility on traffic. There is need to study effect of BRTS on urban corridor before implementation. This research work carried out on study area Jashodanagar to Hathijan road of Ahmedabad, Gujarat. The selected stretch is of 6.1 km length located in Vatva ward in south zone of Ahmedabad city. There is population of 1, 64,730 and 35,480 households in study area. Selected corridor is divided in to four segments to carry out micro level analysis. Stated preference survey is carried out up to 750 m width on both side along the selected corridor to collect information like Travel characteristics and rider type. Classified volume count survey at intersection and spot speed along midblock of the stretch is carried out. Vehicle occupancy survey is carried out to derive number of users and beneficiaries. Videography is carried out to estimate travel demand and traffic performance. Effect of BRTS is measured in terms of modal shift of private vehicle users to BRTS. Effect of BRTS is evaluated on mixed traffic performance using VISSIM software. Traffic projection is compared with BRTS and without BRTS scenario. Developed network model with and without BRTS in VISSIM is validated with error range of 0.84 % to 12.75 % which is less than the permissible error 20%.
Keyword- BRTS, Modal Shift, Traffic Congestion, Urban Road, VISSIM

I. INTRODUCTION

The global percentage of urban population has been steadily increasing in the 20th century. According to the World Bank, more than 60% of the world population will be living in urban areas in the year 2030.Due to rapid growth in Urbanization and industrialization there is increase in travel demand. With increase in urbanization the mobility facility and infrastructure also increase. Transportation has always been a critical part of human societies. Modern economic have been accompanied by a considerable rise in the need of transportation in past two hundred years.

In Ahmedabad city two wheelers ownership comprise more than 70 % of the total vehicles. The vehicle composition is 72 % of vehicles are two wheelers, 15% cars and 4% auto rickshaws [15]. It can be said that 90 % of trip can be done by private vehicles (either owned or hired) in Ahmedabad.Approximately10% of trips made by

Public transportation. Development of a transit-oriented urban transport system has been realized by developing countries and administrations as one of the most effective strategies to solve congestion and pollution problems.

The study has been carried out with the objective to evaluate effect of proposed BRTS on urban corridor. By using Vissim software traffic scenario with Proposed BRTS is generated during this study.

II. LITERATURE REVIEW

ThanedSteinnem et.al. (2016) [3] has worked on potential for model shift by passenger car and motorcycle user towards bus rapid transit system in Asian developing city. He concluded that the BRT (Bus Rapid Transit) could attract significantly private vehicle users to change mode choice. The shift proportion of motorcycle users is higher than that for passenger car users to change mode choice. Gautam Raj Godavarthi et.al. (2014) [2] had measured the performance of Bus rapid transit corridor based on volume by capacity ratio. Based on this study, they had concluded that a 0.688 V/C ratio is the optimal flow value for BRT corridors. This implies that up to0.688, both the Motorised Vehicle (MV) lane users and bus lane users will enjoy reasonable travel speeds and smaller delays. If the V/C ratio is exceeded on either BRT lane or MV lane, then the BRT system becomes untenable for the MV

lane and BRT users, creating traffic congestion. BhanuKireeti Chanda et.al (2014) [1] had analysis for introduction to corridor selection and assessment for Bus Rapid Transit System. They conclude that the current mode of transport is incomplete and suggested implementation of BRT or Light Rail Transit (LRT) to improve level of service. Dipti Thanki et.al. (2012) [8] had carried out study on the methodology on urban road network using VISSIM and it was concluded that the difference between actual delay and simulated delay is similar.

III. STUDY AREA

The study stretch located in Vatva, South zone of Ahmedabad city. Jashodanagar and hathijan gam, two nodes are located in vatva zone as shown in Figure 1. Selected stretch is of 6.1 km length. The population of Vatva -study area is 1, 64,730 [15].
Selected corridor is divided in to four segments to carry out micro level analysis.

1) Jashodanagar to Trikampura Approach
2) Trikampura to Ramol cross road Approach
3) Ramol to Hathijan Approach
4) Lalgebi circle to Hathijan Approach

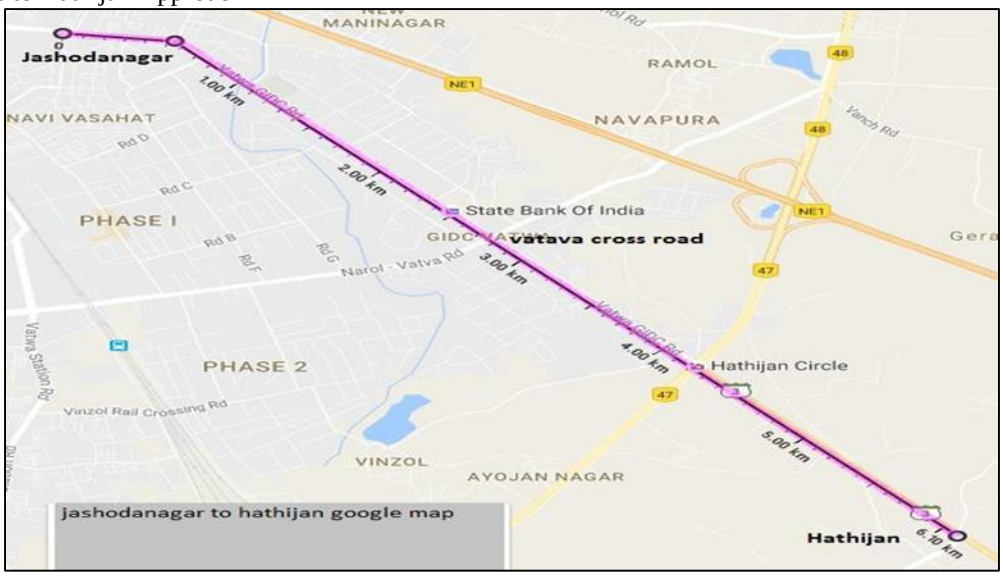


Fig. 1: study area geographic detail

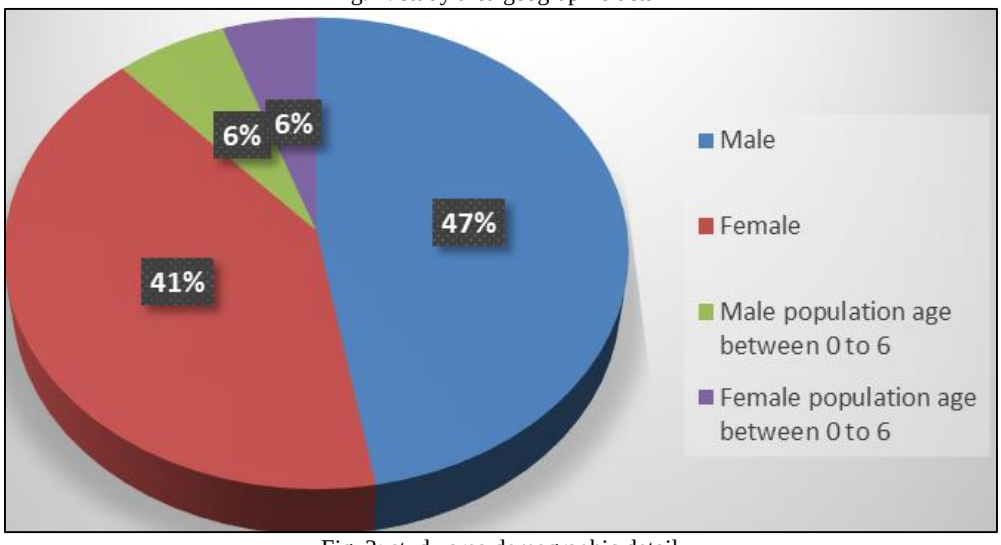


Fig. 2: study area demographic detail

Figure 2 shows demographic details of study area. There are 35,480 households in study area.

IV. DATA COLLECTION

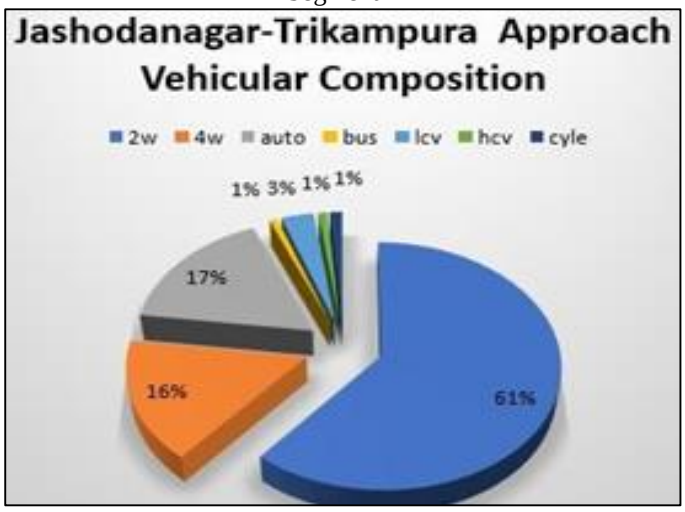
As per methodology adopted to fulfill objectives of the study, following survey has been conducted.

- Road inventory survey

- Classified volume count survey is conducted at all intersections on study stretch.
- Vehicle occupancy survey is carried out to derive actual number of trip makers.
- Existing scenario of study area with characteristics of traffic is done by videography survey.
- Spot speed is measured along the midblock of selected stretches.
- Stated preference survey is carried out up to 750 m width on both side along the selected corridor to collect information like Travel characteristics and rider type.

As per Classified volume count survey analysis, the vehicle composition on segment 1, 2, 3, and 4 in percentage with pie chart as shown in Figure 3 below.

Segment 1



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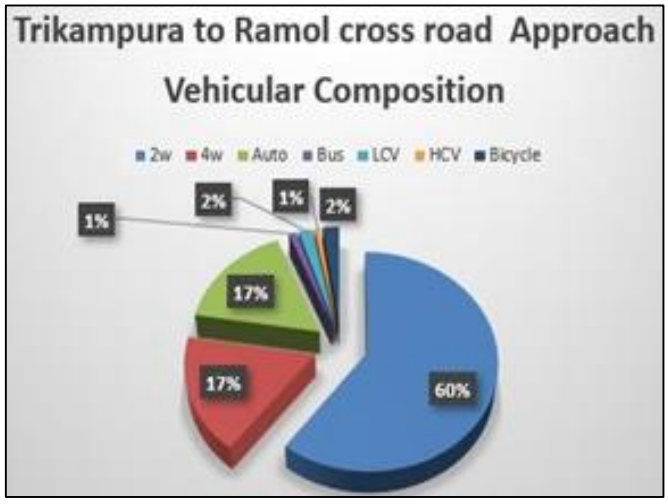

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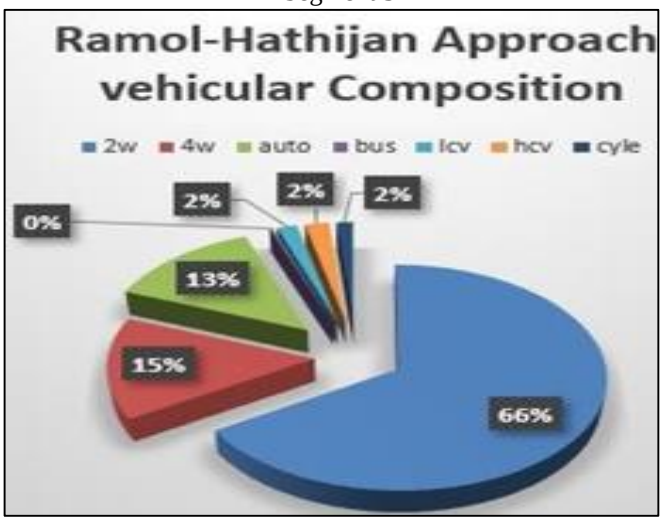

Segment 4

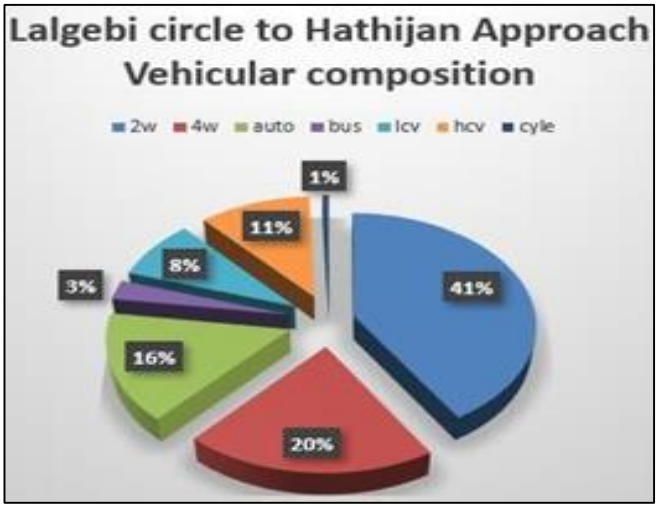

Fig. 3: vehicular composition

Vehicular volume in PCU/hr for all segments is as shown in Table 2. The number of vehicles counted is converted to PCU values as per Table 1. In order to convert the different vehicle classes to one class such as passenger car, conversion factors passenger car unit (PCU) are used.

Type of vehicle	*2W*	*4W*	*Auto*	*Bus*	*LCV*	*HCV*	*Bicycle*
PCU value	*0.75*	*1.0*	*1.2*	*2.2*	*1.4*	*2.2*	*0.4*

Table 1: PCU value to convert CVC data in PCU

All categories of vehicles are represented in PCU/hr in Table 2. As per IRC 106:1990 Design Hourly Volume (DHV) for four lane undivided arterial road is 3000 PCU/hr. and for 2 lanes it is 2400 PCU/hr. The PCU/hr values for segments will be use for V/C ratio and LOS calculation.

Volume (PCU/hr.)	*2W*	*4W*	*Auto*	*Bus*	*LCV*	*HCV*	*Bicycle*	*Total*
Segment 1	*1364*	*478*	*599*	*50*	*134*	*59*	*22*	*2706*
Segment 2	*1358*	*521*	*593*	*69*	*79*	*53*	*41*	*2714*
Segment 3	*1511*	*452*	*488*	*21*	*74*	*141*	*26*	*2713*
Segment 4	*701*	*348*	*267*	*49*	*144*	*185*	*10*	*1704*

Table 2: vehicular volume in PCU/hr

Space mean speed (SMS) in km/hr for various categories of the vehicles is as shown in Table:3

SMS (Km/hr.)	*2W*	*4W*	*Auto*	*Bus*	*LCV*	*HCV*	*Bicycle*
Segment 1	*33*	*29*	*24*	*30*	*30*	*26*	*14*
Segment 2	*33*	*31*	*28*	*27*	*27*	*23*	*12*
Segment 3	*26*	*37*	*26*	*26*	*30*	*23*	*13*
Segment 4	*41*	*52*	*29*	*44*	*37*	*41*	*15*

Table 3: SMS on segment 1,2,3 and 4 (Km/hr.)

V. DATA ANALYSIS

A. Level of Service Analysis

As per IRC 106:1990 Design Hourly Volume (DHV) for four lane undivided arterial road is 3000 PCU/hr and for 2 lane road it is 2400 PCU/hr. The level of service analysis on each segment is as details given in table 4. It is found that on Segment 1, 2 and 3 level of service (LOS) is D and on segment 4 LOS B.

Segment no.	*Volume (PCU/hr)*	*DHV (PCU/hr)*	*V/C*	*LOS category*
Segment 1	*2706*	*3000*	*0.901*	*LOS D*
Segment 2	*2714*	*3000*	*0.904*	*LOS D*
Segment 3	*2713*	*3000*	*0.904*	*LOS D*
Segment 4	*1704*	*2400*	*0.71*	*LOS B*

Table 4: Level of service Analysis on all Segments

B. Travel Demand

Type of vehicle	*2w*	*4W*	*Auto*	*Bus*
Vehicle occupancy	*1.29*	*1.45*	*3.02*	*38.26*

Table 5: Vehicle occupancy on study stretch

Vehicle occupancy survey is conducted to derive actual number of roadusers as shown in Table 5. Passengers per hour per direction (PPHPD) are calculated by using classified volume and vehicle occupancy.

Type of vehicle	*2W*	*4W*	*Auto*	*Bus*	*Bicycle*
Segment 1	*2347*	*692*	*1507*	*864*	*36*
Segment 2	*2335*	*755*	*1493*	*1205*	*68*
Segment 3	*2598*	*654*	*1229*	*363*	*43*
Segment 4	*1205*	*507*	*672*	*693*	*17*

Table 6: Travel Demand (PPHPD)

C. Traffic Forecasting

Base year 2016 data is forecasted up to 2025 by considering 7.64% growth rate of vehicles per year in Ahmedabad city [15]. As per the generated future scenario traffic volume will reach beyond the capacity in year 2019.Table 7 shows the traffic volume data (before) without BRTS and (after implementation) with BRTS.

Year	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*
Without BRTS	*1833*	*2913*	*3136*	*3377*	*3636*	*3915*	*4216*	*4539*	*4887*	*5263*
With BRTS	*1623*	*1747*	*1881*	*2025*	*2181*	*2348*	*2528*	*2723*	*2931*	*3157*

Table 7: Year wise predicted traffic volume (PCU/hr.)

D. Rider Composition

As per stated preference (SP) survey the riders analyzed as per the availability of vehicle ownership. By data analysis they are categorized in Choice rider and Captive rider for Public transportation facility and personalized vehicle user to make travel. Figure 4 shows the rider composition along the corridor.

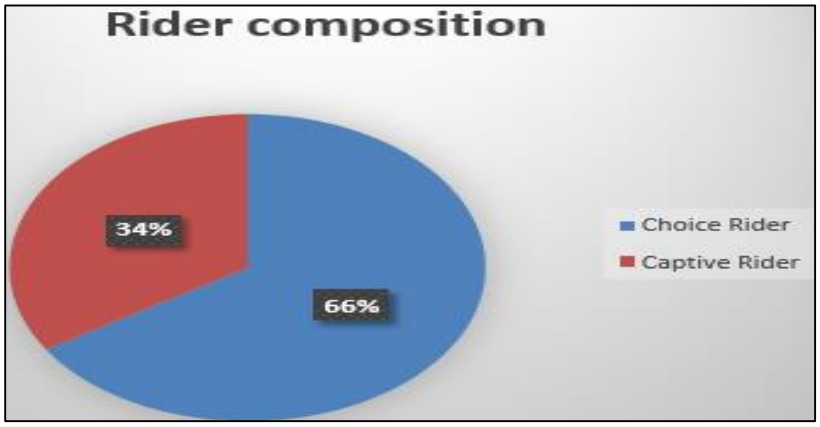

Fig. 4: Rider composition

E. Mode Shift to BRTS

Figure 5 shows the mode use after implementation of BRTS on selected study corridor. According to stated preference survey about 34 % passengers has shown willing to use BRTS if it has been provided.

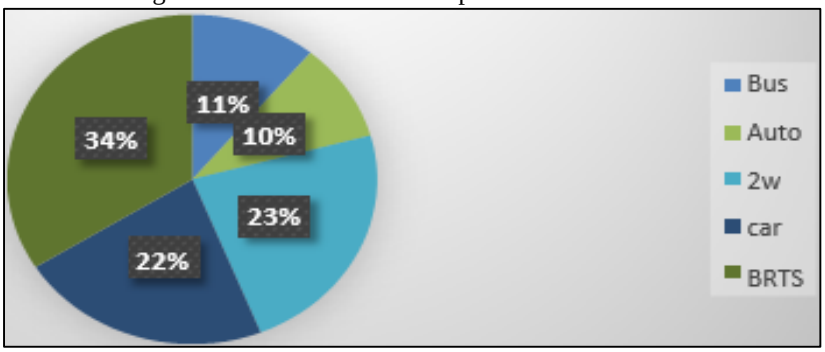

Fig. 5: Mode use Comparison after implementation BRTS

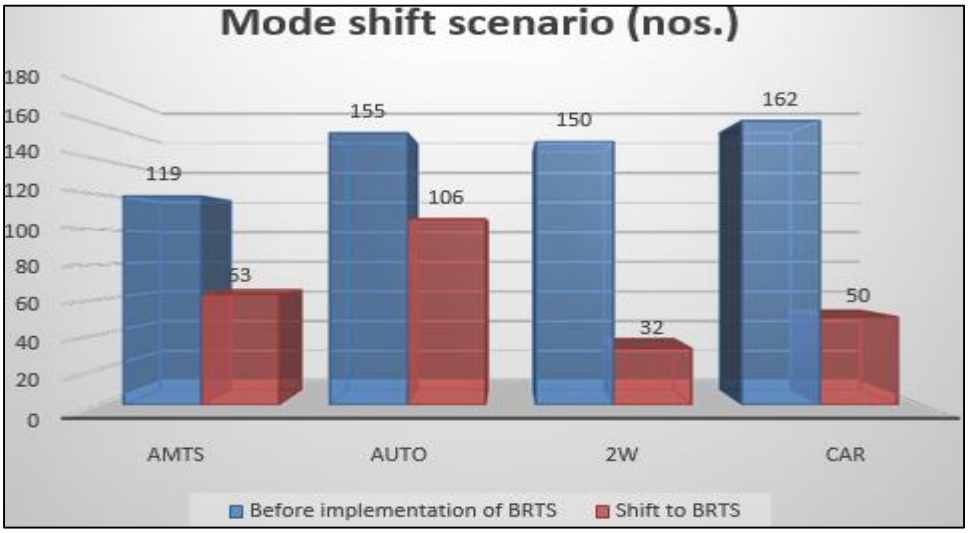

Fig. 6: Mode use comparison before and After Implementation

Figure 6 shows the mode use comparison before and after implementation of BRTS. Maximum number of passengers who change the mode and shift to BRTS is AUTO traveler. Less numbers of travelers are not willing to change mode of travel-2w and car.

VI. Simulation Analysis

A. Simulation Result on Segment 1

Table 8 shows Delay Result by Simulation, with and without BRTS on segment 1, 2,3 and 4 of the urban corridor. Stop delay and vehicle delay has been measured by simulation by using VISSIM software.

Segment		Direction	Stop Delay	Vehicle Delay
1	without BRTS	jashodanagar to trikampura	76.082149	242.66967
		Trikampura to jashoda	69.315678	236.58934
	withBRTS	jashodanagar to Trikampura	21.082149	182.60927
		Trikampura to jashoda	19.067294	189.24867
		BRTS lane	46.005469	16.023648
2	without BRTS	Trikampura to Ramol	89.08215	309.4597
		Ramol to Trikampura	91.31568	296.7599
	with BRTS	Trikampura to Ramol	29.08215	139.455
2	with BRTS	Ramol to Trikampura	21.06729	121.2487
		BRTS lane	46.00547	16.02365
3	without BRTS	Ramol to Lalgebi circle	63.08215	186.7582
		Lalgebi circle to Ramol	71.31568	159.5261
	with BRTS	Ramol to lalgebi circle	18.14543	127.455
		Lalgebi circle to Ramol	17.05294	132.7985
		BRTS lane	23.56355	9.023648
4	without BRTS	Lalgebi circle to Hathijan	39.08215	106.7582
		Hathijan to Lalgebi circle	31.31568	109.5261
	with BRTS	1: Lalgebi circle to Hathijan	18.14543	78.1255
		2: Hathijan to Lalgebi circle	17.05294	72.89867

Table 8: Stop delay and vehicle delay

Table 9 shows the details of simulation results on segment 1, 2, 3 and 4 with and without BRT is for15 minutes and 0-900,900-1800,1800-2700,2700-3600 interval.

Segment		Vehicle passes	Speed (Km/hr.)
1	Without BRTS	2605	29.824538
	With BRTS	2296	31.538913
2	Without BRTS	2567	29.18204
	With BRTS	2059	37.10141
3	Without BRTS	2655	28.49454
	With BRTS	2134	32.4197
4	Without BRTS	1532	40.30704
	With BRTS	1263	49.09891

Table 9: Simulation Result on study stretch

B. Validation of Model

Table 10 shows the details of volume on each segment collected by simulation for validation. Error in Developed network without BRTS is in range between 0.84 to 12.75 percentages which is lesser than the permissible error 20 %

Segment	Conditions	Volume Without BRTS	Error (%)
1	Before simulation	2977	
	After simulation	2605	12.50
2	Before simulation	2893	
	After simulation	2567	11.27
3	Before simulation	3043	
	After simulation	2655	12.75
4	Before simulation	1545	
	After simulation	1532	0.84

Table 10: validation of Network Model without BRTS

Table11 shows the details of volume on each segment collected by simulation for validation. Error in Developed network with BRTS is in range between 1.33 to 7.78 percentages which is lesser than the permissible error 20 %.as per Vissim 9- Manual.

Segment	Conditions	With BRTS Delay	Error (%)
1	Before simulation	2355	2.51
	After simulation	2296	
2	Before simulation	2063	2.19
	After simulation	2059	
3	Before simulation	2314	7.78
	After simulation	2133	
4	Before simulation	78.1255	1.33
	After simulation	72.89867	

Table 11: validation network model with BRTS

VII. CONCLUSION

- Traffic composition along the corridor revels that major part of the vehicles are private users and dependent on para-transit (auto-rickshaw) while public transport is very less compare to private modes.
- Level of service on segment 1-3 (4.3 km.) is in category LOS D while on segment 4 (1.8 km) Level of service is B, as per volume by capacity ratio and speed.
- Demand in PPHPD on the corridor up to segment 1-3 is satisfied while on segment 4 is lower as compare to segment1-3.
- According to traffic forecasting the corridor is beyond capacity in 2019 without BRTS, and if BRTS is adopted it can be extended up to2023.
- Rider composition according to stated preference survey is 34 % are captive rider and 64% are the choice rider.
- Mode shift from private users to BRTS is 21-30 % while para transit user to BRTS is 68 % and from AMTS to BRTS is 59%.
- Developed Network model with and without BRTS in VISSIM is validated with error range between 0.84% to
- 12.75 % which is less than the permissible error 20% as per Vissim-9 Manual for user.
- According to simulation analysis reduction in delay on different segment varies in range of 16.75% to 54.94%.
- It can be concluded that implementation of BRTS gives positive impact on the corridor.

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