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Microsimulation Study of Bus Priority Performance Impact at Intersection

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Abstract: Traffic planning should concentrate on the advancement of public transport to ensure sustainability. One of the key reasons for the decline in the usage of buses in urban India is poor service quality. Buses play a vital role in providing secure and reliable travel in congested areas because it makes efficient use of limited road space, transporting much more passengers per unit of road space than a personal vehicle. Bus Priority Measures are techniques used to give buses priority over general. However, just a few research studies on bus priority systems in developing nations like India have been documented in the literature. This study aimed to assess travel time savings, various traffic performance indicators, and liability benefits to address transportation challenges such as delays by systematically simulating the impacts of various bus priority measures with respect to existing conditions. The results of the VISSIM simulation studies and comparisons with field traffic behavior indicated that the created models accurately depict the actual nature of traffic with a margin of error of less than 10%. The simulation model of bus priority measure result showed that priority measures reduced bus delays at an intersection and some of the measures can easily develop with less investment. The impact of offering a bus priority method for the signalized intersection was evaluated using the micro-simulation tool VISSIM in this study. According to the study, bus priority measure is projected to be effective even in a heterogeneous traffic condition like that seen in India. Transportation planners should focus on methods to minimize delays, enhance service management, and dependability since they are low-cost and provide highly efficient traffic management, preserving buses moving and enhancing mobility in congested locations.

***Index Terms* – Bus Priority, Public Transport, VISSIM, Software Calibration & Validation.**

I. INTRODUCTION

In many cities of India, there is an increasing gap between demand and supply of transportation which arise a problem like a delay, congestion and pollution. Mixed traffic exists in India's cities, and the road space must be shared by all types of vehicles 2-wheeler, 3-wheeler, 4-wheeler, Bus, LCV, HCV and non-motorized vehicles. The rapid urbanization of Indian cities has resulted in a massive volume of traffic during peak hours. This massive volume of traffic is the primary cause of traffic congestion on the metropolitan road network, particularly at an intersection. So, to reduce that problem and to improve the level of service for travelling in urban areas, several work strategies and policies are formed by various departments to reduce traffic congestion and improve transit mobility.

Congestion can be reduced by using various traffic management and operational tactics to improve the performance of the traffic infrastructure. The proposed mitigation techniques' effectiveness is tested in carefully prepared trials on a real roadway stretch with genuine demand scenarios. Furthermore, using microscopic modelling and refined validation, the behavior of proposed experimental mitigation techniques is analyzed and evaluated. [1] Intersections are one of the most common reasons for bus delays on major roads. As a result, bus priority treatments at traffic signals have proven to be effective in reducing overall bus journey time by reducing both bus travel time delay and delay variability. As a result, the quality and efficiency of bus operations have increased in terms of eliminating bus bunching, servicing longer routes for the same travel time, deploying fewer buses without compromising demand during peak periods, and so on.

Microsimulation models represent the actual and real representation of traffic behavior and network performance as these tool models are most useful to examine this complex traffic problem. Traffic simulation software is used to create microsimulation models to estimate the effectiveness of new bus priority changes. One of the main goals of traffic simulation is to examine the impact of background traffic on the operation of bus priority measures and to compare alternative bus priority scenarios. Models of microscopic simulation can be employed in a variety of transportation applications. They can, for example, be used to assess various traffic timing plans and geometric setup adjustments before putting any design approach into action in the field. Bus ridership may increase if buses were made more efficient by making their travel times equal to those of private vehicles and other public transportation modes on the road. [2] The development of network and intersection simulation models using microsimulation tools, along with validation of the models is studied. The validated microscopic simulation models can be utilized for further evaluation of various traffic operational conditions, such as bus priority measures for improving bus service performance. [3]

The successful implementation of bus QJL with pre-signal is also expected to encourage practitioners to apply similar bus priority treatment in other Indian cities as well as in other cities in emerging countries with analogous traffic operations.[4] The model developed reflects that with the reduction of overall vehicle volume, the delay reduces. This reduction in the delay is observed to be non-linear. This illustrates the constancy of the volume effect on delay in all scenarios across all intersections. Delay to buses, delay to autos, and average vehicle delay are the variables that have been measured. The QJL's efficacy is mostly determined by factors such as intersection shape, traffic volume, bus sharing, and so on.[5]

Simulating the impacts of various bus priority measures with respect to existing conditions by evaluating travel time savings, various traffic performance indicators and reliability benefits to address transportation challenges such as delays. The simulation model for the current scenario and priority measures, as well as the extracted traffic parameters from the result directory, were designed to allow comparisons across the models, including rating the alternatives based on the result attributes.[6]

Various studies have been conducted in the past and recent years with traffic microsimulation tools to evaluate the effectiveness of various engineering setups. However, there is still a need for additional investigation of a consistent and practical strategy for constructing a simulation model using a multimodal traffic micro-simulation tool to explore alternative bus priority treatments & the evaluation and ranking of the impacts of the various bus priority measures with respect to their attributes on delay parameters and other traffic flow elements.

II. STUDY AREA, DATA COLLECTION & METHODOLOGY

The study area is Umiya Hall intersection of Ahmedabad city. Latitude and Longitude coordinates are 23° 4' 27" N and 72° 33' 23" E. Actual field data on classified intersection volume at each turn of the legs by vehicle type, traffic signal cycle lengths, traffic composition, road geometry, and queue length on traffic operation were compiled for developing the simulation models in VISSIM.

To fulfil the study's goal, the suggested methodology includes many phases. The initial step in this process is to identify the problem. The scope and purpose of the investigation are then clarified by a literature review. The study region is then chosen as previously mentioned. Following that, videography was used to capture data for the goal of acquiring volume data. Manually obtained speed data, road geometry, queue length, and signal cycle length. Following that, data was extracted in order to create the base model in VISSIM software. Model calibration and validation used sensitivity analysis to reflect the actual field situation in software. Then, in software, construct simulation models for each priority measure. After the results are received, a comparison and ranking for the chosen study area will be conducted, followed by a suitable conclusion.

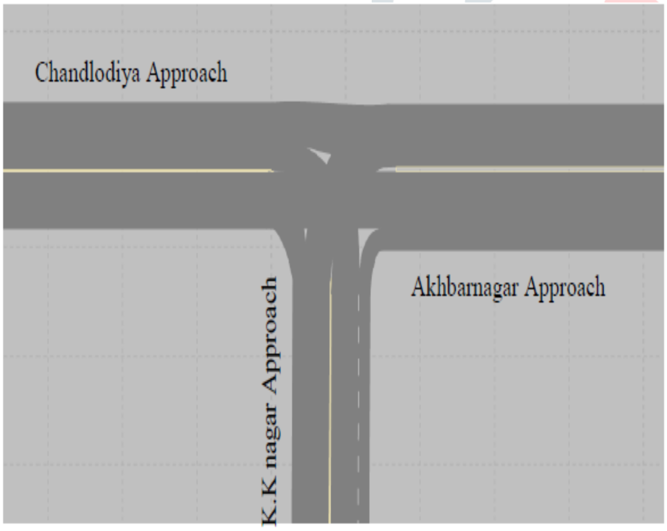

Fig 1: Snapshot of Existing Design Developed In VISSIM

Fig 2: Snapshot of Priority 1 Queue Jump Lane Developed In VISSIM

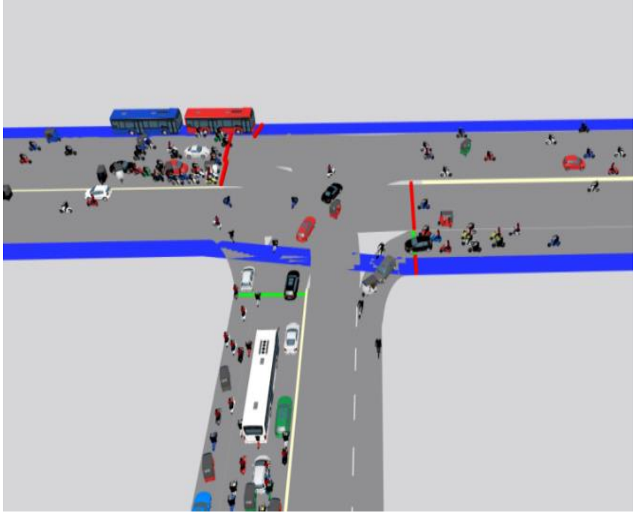

Fig 3: Snapshot of Priority 2 Exclusive Bus Lane Developed In VISSIM

Fig 4: Snapshot of Priority 3 Exclusive Bus Lane Followed by Special Turn Lane Developed In VISSIM

III. MODEL DEVELOPMENT: CALIBRATION AND VALIDATION

The Umiya Hall signalized T-intersection (3 legged) was studied for designing the traffic simulation for the base model, validation, and bus priority experiments. Before considering the various types of bus priority measures, a base model was created and tested to see whether the VISSIM model of the study intersection could accurately represent actual traffic behavior. Geometric data, traffic management, and traffic flow data for the intersections were all necessary for the model setup in VISSIM. The traffic micro-simulation software VISSIM (PTV, 2022 SP 03 VERSION) was used to represent traffic operations at the intersections in a micro-simulation framework.

Model calibration is defined as the process of selecting the best set of model input variables and adjusting or fine-tuning their default values in order to actually reflect the field-measured and observed local traffic conditions by selecting the best set of model input parameters and adjusting or really well their default values in order to accurately represent the field-measured and observed local traffic conditions. Identification of sensitive parameters, heuristic determination of selected parameter ranges, and adjustment of selected parameters using Sensitivity Analysis was all part of the calibration approach. The models were calibrated and verified utilizing volume, spot speed, and transit time as the Measure of Effectiveness (MOE) for heterogeneous traffic operations. The calibration procedure is carried out by using the sensitivity analysis process. [7,8]

Queue length and average travel time field values are the larger queue length of 50 m of Akhbarnagar leg and avg. travel time of all vehicles from Akhbarnagar to Chandlodiya is used for further calibration. The sensitivity analysis was carried out for the calibration of the model from a result of simulation output. The Major effective parameters selected for sensitivity analysis are Max. look ahead distance, Standstill distance, Additive part of safety distance, Multiple parts of safety distance Maximum deceleration, Acceptable deceleration, Wait time before diffusion, The minimum headway. Simulating the network with the default VISSIM value revealed that the performance measure did not meet the field observed effectiveness measure. These calibrated parameters were adjusted to field data by completing a number of iterations within the defined value ranges until the field values for travel time and queue length were similar to the VISSIM produced values. As a result, the set of calibrated parameters indicated in the table is also employed in the validation process.

Table 1 Driving Behavior Parameter Default Values & Calibrated Values

Sr no.	Parameter	Default Values	Calibrated Values
1	Max. look ahead distance (m)	250 m	30 m
2	Standstill distance (m)	2 m	1.50 m
3	Additive part of safety distance	2	1
4	Multiple parts of the safety distance	3	1.50
5	Maximum deceleration (m/s2)	-4 m/s2	-3 m/s2
6	Acceptable deceleration (m/s2)	-1 m/s2	-1.50 m/s2
7	Wait time before diffusion (s)	60	60
8	The minimum headway (m)	0.5 m	1 m

The model and its behaviour are compared to the real system during the validation phase. In general, the model of the present system is regarded as "valid" if two sets of output data compare favourably. The error produced between the simulated and actual data should not be larger than 10% for any validation to be accurate. To complete the validation, traffic parameters from the simulation results were carefully examined in order to match the specified effectiveness measures with the simulated outputs.

1) Validation of Volume & Travel time parameters for calibrated value

Table 2 Volume and travel time comparison

Sr no.	Approach & Direction	Actual Volume	Simulated Volume	GEH Value	Field Travel Time	Simulated Travel Time	Difference
1	CH to AK Straight	5068	4990	1.099	7.699	7.89	2.48%
2	CH to KK Right turn	1247	1228	0.292	12.06	13.07	8.37%
3	KK to AK Right turn	1549	1536	0.33	6.90	6.42	6.96%
4	KK to CH Left turn	1092	1089	0.091	11.68	12.56	7.53%
5	AK to CH Straight	2612	2549	1.24	11.69	12.07	3.25%
6	AK to KK Left turn	1344	1337	0.191	5.47	5.24	4.2%

A comparison of flow and travel time for various approaches is shown in the table. Each approach has been calibrated, and the GEH value is less than 5 and travel time percentage difference less than 10%, indicating a satisfactory fit between the simulated model and the actual field conditions.

2) Validation of Queue Length parameter for calibrated value

As shown in below table all percentage difference between actual and simulated queue length is less than 10 % indicating a satisfactory fit between the simulated model value and the observed value.

Table 3 Queue Length comparison

Sr no.	Approach & Direction	Field Queue Length	Simulated Queue Length	Difference
1	CH to KK Right turn	105	108.47	3.20 %
2	KK to AK Right turn	65	68.92	5.68 %
3	AK to CH Straight	50	53.51	6.56%

IV. Simulation Model Development for Each Bus Priority Measures

Priority 1 Queue jump lanes Buses spend a significant amount of time waiting at signalized intersections with other traffic, a dedicated lane in the form of a queue jump lane was suggested to avoid waits. Defining links and connectors based on field data, splining the links and connectors, constructing the queue jump lane, adding vehicle characteristics, and generating other fundamental model components are some of the basic steps in the modelling process. The model was then fed the vehicle parameters (vehicle type, vehicle composition, and total volume inputs). After that, the vehicle paths for each conceivable link movement were allocated, including the new queue jump lane. A Bus coming from Chandlodiya approach and Akhbarnagar approach are more comparatively with K.K nagar approach. So, the queue jump lane was designed only for that road approach. Because the normal queue length is substantially shorter than 105 meters, the special queue jump lane was designed on the curbside of the carriageway beginning about 100–150 meters before approaching the intersection. The new queue jump lane was designed to reduce bus delays and improve bus transit efficiency levels. New signal design created in VISSIM. (Figure 2)

Priority 2- Exclusive Bus Lane adding one extra lane on either side of the existing lanes, using the boarding and alighting space, was suggested for the exclusive bus lanes. In a similar manner to the description in Priority 1, link flows and other vehicle input attributes were included. The vehicle routes were also defined as the current conditions, including a new dedicated bus route on both sides of the road. Link flows and other vehicle input attributes were also added in a similar way as the discussions in the previous sections. For the Exclusive bus lane, a new signal design was created. In exclusive bus lane 1 only for right turning buses signal is created, straight going buses do not follow signal so stopped delay for straight going buses only occur when right-turning bus stand in red signal and straight going buses come behind that bus. (Figure 3)

Priority 3- Exclusive Bus Lane followed by Special Lane for Turning Buses Buses were given higher priority over other traffic under this technique, which might create significant delays for other traffic because buses occupied the majority of the lanes at the intersection. Two of the lanes were set aside for turning and through movements commencing roughly 150 meters before the intersection. Before feeding the vehicle inputs, the connections and connectors, as well as the vehicle routes for bus priority 3, were specified. Link flows and other vehicle input attributes were also added in a similar way as the discussions in the previous sections. Exclusive Bus Lane followed by a special lane for turning buses design developed in VISSIM. For Exclusive bus lane followed by special lane signal design same as exclusive bus lane created. In exclusive bus lane 1 only for right turning buses signal is created, for straight going buses extra lane is designed so no delay occurs for straight going buses. (Figure 4)

To evaluate and rank the impact of various bus priority measures on delay parameters based on their attributes excel files are created for results. Results attribute carried out for each bus priority measures. Result carried out from 1-hour simulation run for 1-hour field volume data.

V. Result and Discussion

Delays are critical performance factors for comparing the effectiveness and efficacy of proposed transportation development. The delays for each of the link flows were filtered from the result directory to compare the priority alternatives based on their influence on general traffic delay. The related average link delays for general traffic, as well as the overall average for all connections, are calculated, as shown in table 4. Table 5 shows the average bus delay for each approach.

Table 4 Average delay result Comparison For whole traffic Morning 10 to 11

Sr no.	Approach & Direction	Average Delay for the whole Traffic (in seconds)			
		Existing	Priority1	Priority2	Priority 3
1	CH to AK Straight	19.97	17.69	19.57	19.57
2	CH to KK Right turn	58.73	59.8	42.6	42.62
3	KK to AK Right turn	32.21	32.18	33.75	33.75
4	KK to CH Left turn	21.22	17.52	18.5	18.53
5	AK to CH Straight	30.31	28.9	30.24	30.24
6	AK to KK Left turn	2.71	16.79	14.98	15.04

Table 5 Average delay result Comparison For only buses Morning 10 to 11

Sr no.	Approach & Direction	Average Delay for only buses (in seconds)			
		Existing	Priority1	Priority2	Priority 3
1	CH to AK Straight	19.62	0.51	8.43	0
2	CH to KK Right turn	60.93	60.93	53.76	44.94
3	KK to AK Right turn	40.58	41.12	40.58	33.75
4	KK to CH Left turn	20.33	20.33	20.33	18.53
5	AK to CH Straight	32.29	22.75	13.18	13
6	AK to KK Left turn	1.74	1.74	5.53	0.32

Delay comparison for buses

For each priority choice, average bus delays were determined, and the average of the delays for the existing bus system was calculated by filtering the bus delays individually. Table 3 summarizes the values of the computed average percentage change in delay for the priority alternatives in comparison to the present state. The data in the table demonstrate that all priority alternatives reduce bus delays significantly.

Table 6 Average percentage change in bus delay result with respect to existing condition

Priority Measures' Relative Position Based on Delay Attributes

Delay Data	Priority 1	Priority 2	Priority 3	Average Delay for existing condition
Average delay for buses only (in seconds)	26.1	23.6	18.4	30.7
Average Percentage Change in Delay for the Priority options with respect to existing condition	-14.98%	-23.13%	-40.06%	

The effectiveness of each priority experiment was evaluated and ranked based on its delay reduction qualities based on the observed results. Overall, all of the priority measures were determined to help reduce traffic congestion and bus delays. As a result, the relative ranks of each priority measure revealed that when considering the overall average percentage reduction in general traffic delays Priority 1 is more effective other than priority 2 and priority 3. Priority 3 offers a great reduction in delays for buses, but overall vehicle delay increases because of the introduction of a Special signal for buses for the turning movements that increased the stopped delay of other vehicles. If we study and carry out the modal shift behavior then priority 2 and priority 3 may be effective for reducing the traffic delays. Also, if right-turning buses are more than priority 2 and priority 3 may be effective.

Given the significant expense, implementing Bus Priorities 2 and 3 over a city's highways may be difficult. Priority 1 might, on the other hand, be executed with less investment by making just minor changes to intersection locations to decrease delays. Priority 1 results revealed that a large decrease in bus delays could be accomplished, even if the overall traffic delay reduction was not significant. So according to characteristics of intersection and VISSIM delay result attributes the first rank is given to priority 1, the Second rank given to priority 3 and the third rank given to priority 2.

VI. Conclusion

The Bus Priority methods mentioned in this paper may have previously been applied in some regions of the world in some form or another. This time, though, these are shown in relation to Indian heterogeneous traffic situations. This measure might result in significant time savings and increased bus mobility. The simulation model for the present situation and priority measures, as well as the retrieved traffic parameters from the result directory, were configured, allowing comparisons across the models, including evaluating the alternatives based on their performance. With the use of VISSIM Simulation Software, these strategies are analysed and evaluated against the actual intersection. Calculated errors between the simulated model and the existing condition for several performance indicators were all within 10%, indicating that any simulated network is valid. Even if all of the priority methods analysed reduced delays significantly, implementing Bus Priority 1 needs relatively little cost. After studying and evaluating all of the proposed methods, we can observe that they are all effective in decreasing delays not just for buses but also for the whole traffic flow, particularly in circumstances of increased heterogeneous traffic flow.

VII. Acknowledgement

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References

[1] T.V. Arasan, P. Dadagiri, Microsimulation study of the effect of exclusive bus lanes on heterogeneous traffic flow, ASCE J. Urban Plan. Dev. 136 (1) (2010) 50.
[2] Robel Desta ∗, János Tóth, Simulating the performance of integrated bus priority setups with microscopic traffic mockup experiments. Scientific African 11 (2021) e00707.
[3] Robel Desta, Bikila Teklu, Mihret Dananto Simulation experiments and validation for considering bus priority treatments in small cites: The case of Hawassa city, Ethiopia. International Journal of Engineering, Science and Technology Vol. 10, No. 4, 2018, pp. 21-28
[4] Kinjal Bhattacharyya, Bhargab Maitra, and Manfred Boltze. Implementation of Bus Priority with Queue Jump Lane and Pre-Signal at Urban Intersections with Mixed Traffic Operations: Lessons Learned? Transportation Research Board 2019.
[5] Bhargab Maitra, Kinjal Bhattacharyya, Roshan Jose, Manfred Boltze4, Micro-simulation-based evaluation of Queue Jump Lane at isolated urban intersections**:** an experience in Kolkata. Journal of Transport Literature, 9(3), 10-14, Jul.
[6] Robel Desta, Bikila Teklu, Mihret Dananto Simulation experiments and validation for considering bus priority treatments in small cites: The case of Hawassa city, Ethiopia. International Journal of Engineering, Science and Technology Vol. 10, No. 4, 2018, pp. 21-28
[7] Prashanth.M, Nikhil T R, Yateen Lokesh & N S Chandanshree, Calibration and Validation of VISSIM Driving Behaviour Parameters for Signalized and UN-Signalized Intersections in Bangalore City. GIS Science Journal Volume 7, Issue 11, 2020.
[8] Mathew T V., Radhakrishnan P., Calibration of Microsimulation Models for Non-Lane-Based Heterogeneous Traffic at Signalized Intersections. *J Urban Plan Dev*. 2010; 136(1):59-66.
[9] V. Thamizh Arasan and P. Vedagiri, Simulating Heterogeneous Traffic Flow on Roads with and Without Bus Lanes. Journal of Infrastructure Systems © ASCE / December 2009.
[10] Kevin N. Balke, Conrad L. Dudek, and Thomas Urbanik II, Development and Evaluation of Intelligent Bus Priority Concept. Transportation Research Record 1727.
[11] Ihor Vikovych, Roman Zubachyk, Bus Lane within the Area of Intersection" Method for Buses Priority on the Intersections. Transport and Telecommunication, 2015, volume16, no. 4, 267–276.