CALIBRATION AND VALIDATION OF VISSIM MODEL FOR HETEROGENEOUS TRAFFIC IN BANGLADESH

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ABSTRACT

Dhaka, one of the world's most congested megacities, has a population of over 23 million, highlighting a highly heterogeneous traffic environment with private vehicles, motorcycles, public buses, CNG auto rickshaws, and nonmotorized rickshaws. Widely adopted microsimulation tools like VISSIM are not readily equipped to capture these dynamics, as they are generally calibrated for homogeneous, lane based traffic in developed countries. This study presents the calibration and validation of a VISSIM microsimulation model of urban traffic in Dhaka, both motorized and nonmotorized. Pedal rickshaws, handcarts have a significant effect on the functioning of traffic by reducing the mean speeds that affect the traffic flow, influence road capacity, and road safety issues, increasing the points of interaction and conflict, and bring in lateral mobility especially at signalized intersections. In existing current simulation studies, pedal rickshaws and CNG autorickshaws are often overlooked. Incorporating these vehicle types with custom 3D object models and behavior parameters, making the calibration process context sensitive and more reflective of the actual traffic mix in Dhaka. For modeling, a 340 meter segment was chosen on Bir Uttam Samsul Alam Sarak in central Dhaka. Field data, including traffic composition, directional volumes, travel times, and speed profiles, were collected using mobile devices. The corridor experienced peak directional flows of up to 2,676 vehicles/hour, with travel speeds varying significantly between directions. The model uses Wiedemann 99 car following logic, which was systematically adjusted to reflect complex lane changing behavior, variable headways, lateral movement, and reduced lane discipline, key features of Dhaka's traffic behavior. Calibration results achieved GEH statistics below 3, and simulation travel times differed from observed values by only 1.1% (Kakrail to Motijheel) and 7.0% (Motijheel to Kakrail). Validation on an independent dataset further confirmed model accuracy. The final calibrated VISSIM model of the selected corridor successfully replicates the traffic operational characteristics of Dhaka's complex traffic environment. Calibrated VISSIM network models serve as a reliable foundation for future simulation based analyses and decision making in similarly complex traffic environments.

Keywords: *traffic simulation, mixed traffic, driving behaviour, vissim, model calibration*

1. INTRODUCTION

Rapid urbanization, unplanned transport infrastructure, and the heterogeneous traffic on roads are causing Dhaka's traffic congestion to become worse. With a population of over 23 million (World Bank, 2025), Dhaka suffers from an intense transportation problem due to overpopulation. The city's traffic is characterized by nonlane based, heterogeneous traffic comprising both motorized and nonmotorized vehicles as well as high pedestrian intrusion and poor enforcement of lane discipline.

In order to streamline operations and planning interventions in traffic, it is essential to initially create a virtual environment where various strategies can be tested, assessed and improved without interfering with the real time traffic on the road. Microscopic traffic simulation tools in this regard are very useful. These tools allow planners to replicate and analyze the impacts of many different traffic conditions, such as timing of signals, lane layouts, and modal interactions, by modeling individual vehicle behavior in fine detail. One of the most popular of these tools is VISSIM, which offers the most flexibility, models the behavior of drivers in detail, and can be used to provide a simulation of both the public and the private transport infrastructure. It works on a stochastic and timestep based framework, and it uses fundamental theories of car following, lane changing, and gap acceptance to simulate vehicle dynamics with high realism (Chawla and Khare, 2024). However, the default settings of VISSIM are specifically oriented towards the structured and lanebased traffic systems, which are common to the developed countries. Consequently, it makes the direct application of VISSIM to developing cities in South Asia, where traffic is generally nonlane based and highly heterogeneous highly customized in terms of both vehicle definition and behavioral parameters (Alam et al., 2018). In the absence of appropriate localisation, the results of simulation may not be representative of real traffic. The heterogeneity of vehicles, unprofessional driving patterns, and the lack of strict adherence to rules of proper following lead to difficulties in simulation, which requires major manual modifications in model parameters, object profiles, and behavioral logic. An example is that pedal rickshaws have extremely unpredictable speeds and sideways movement patterns that are not native to most microsimulation software (Arkatkar et al., 2015).

A number of studies in South Asia have attempted to customize traffic microsimulation models to reflect more accurate representation of local features of local traffic systems. As an example, Arkatkar et al. (2015) and Alam et al. (2018) emphasized the significance of applying nonlane based driver behavior and paratransit to simulation settings. Chawla and Khare (2024) showed that sensitivity-based calibration enhances the applicability of VISSIM to Indian traffic, and Siddique et al. (2019) investigated the behavioral parameters on the mixed flow traffic based on the empirical datasets conducted in Bangladesh. Abbas et al. (2021) also dwell on the importance of localized parameters in the precise simulation of intersections of modal heterogeneity.

Nonetheless, the majority of simulation models continue to ignore the presence of pedal rickshaws and CNG auto-rickshaws that constitute more than 30% of the traffic during the peak hours in Dhaka (BUET, 2024). Like previous studies which have successfully utilized the Wiedman 99 car following model for calibrating VISSIM in heterogeneous traffic scenarios, this study adopts the same methodology to collect data and modeling. One of the 340 meter sections of Bir Uttam Samsul Alam Sarak was modeled, which is based on the field information collected in detail, directional volumes, vehicle composition and travel times, and generated a context sensitive simulation. The main behavioral parameters (desired speeds, headways, standstill distances, and lane changing aggressiveness) were manually tuned to be a representation of the local driving behavior. The fidelity to calibration was determined with the GEH statistic with values below 5 (advocated by the UK Highway Agency) representing a good correlation between the simulated and observed conditions. The discrepancy between standard parameters and parameters required to simulate Dhaka traffic indicates the necessity of localized calibration procedures in South Asian cities.

2. METHODOLOGY

This section outlines the methodology used to model Dhaka's heterogeneous, nonlane based traffic conditions of the study location using PTV VISSIM. This includes study area selection, field data collection(FHWA guidelines), modeling, defining vehicle types, and parameter calibration and validation. The aim of the methodology followed was to replicate the traffic pattern observed by adjusting vehicle behaviour and model parameters. Every step was carefully completed following empirical observations to ensure model accuracy.

2.1 Study Area & Data Collection

The study area is a 340 meter stretch of Bir Uttam Samsul Alam Sarak, which is a critical arterial road in central Dhaka, Bangladesh. It is a typical urban street with high density transport mix and a significant amount of both motorized vehicles (cars, buses, trucks, CNG autorickshaws) and non motorized vehicles (pedal rickshaws, bicycles). The traffic in the locality is also further complicated by the common interference of pedestrians, the lack of discipline among lanes and lack of protection of traffic laws, which is the norm in South Asian urban environments. The strategic importance is also indicated in the high traffic flow of the road, which connects the two main areas as a result of commuting and trade with each other, hence increasing traffic congestion during peak periods.

The selection of the study corridor (Bir Uttam Samsul Alam Sarak, Figure 1) is conditioned by such qualities as nonlane based traffic circulation which are extremely problematic regarding the use of traditional traffic modeling methods, such as VISSIM. The corridor was chosen to avoid the influence of intersections, signals, and turning movements, allowing the analysis to focus solely on car-following and lateral interaction behavior. The segment is fit for the purpose of the simulation of the traffic patterns where the various traffic management strategies may be experimented with virtually.

This simulation model and calibration were based on data acquired over a two peak hour period (7:00 AM to 9:00 AM and 5:00 PM to 7:00 PM) which reflects the maximum amount of traffic on this corridor. Data were collected in clear weather conditions during daylight hours, ensuring good visibility and with no influence of adverse weather. A second day was used as the other set of data to validate the model. In the collection of the data, both the manual count and video based observations were used to make sure that there was precision in the classification of the vehicles and the travel time recorded.

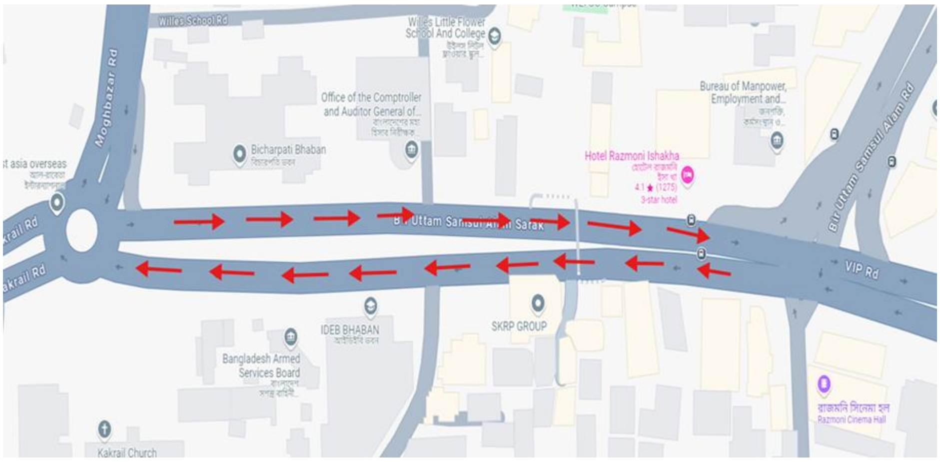

Figure 1: Bir Uttam Samsul Alam Sarak on Google Map

2.1.1 Traffic Volumes and Composition

The vehicle composition data were taken in four strategic locations on the 340 meter length using the smartphone camera. The directional distribution obtained was 43% for Kakrail to Motijheel direction and 57% for the other direction. The car types that were observed were cars, buses, trucks, and nonmotorized vehicles (NMVs), such as rickshaws and bicycles. The vehicle counts were done in every 600 seconds and the counting done during the most operational hours (Figure 2) and these were to be amalgamated to be utilized in VISSIM input later. Turning movement counts were also extracted through manual field observation, where two observers were positioned at opposite ends of the segment. Each observer independently recorded the number of vehicles entering and exiting the study section. The Mixed traffic interactions were documented through direct field observation and video recordings along the study corridor.

Figure 2: Traffic data collection

2.1.2 Travel Time and Speed Data

Measures of travel time of cars were taken at the entrance and exit positions of the study area. The data points were critical in validating the model. The mean speed of various vehicles was measured with the special consideration of the nonlane based vehicles such as peddle Rickshaw and CNG autorickshaw.

2.1.3 Signal Timing and Control Data

Signal timing data of the study area was measured at the end of the segments. This information is essential in setting the signal control parameters of the VISSIM model and it provides proper reckoning of the traffic flow under the signalized condition (Mathew & Radhakrishnan, 2010). The data of the signal that were collected was made in VISSIM simulation environment to imply the signal operations that were observed in a road. The distribution patterns of vehicles, arrival time and timing of every signal were scaled to coincide with field results..

2.2 VISSIM Network Modeling

The version of VISSIM that was used in this study is 2024.00-02, and the coding of the simulation model of the study area was done in a systematic manner that started with the creation of the new traffic model file, in which a suitable unit (metric) was selected according to the local situation. The background map of the study area was then scaled in such a way that the road network geometry reflected the actual physical layout that had a 340 meter long heterogeneous traffic flow. The model network was built by stipulating links and connectors that fitted the real road map such that the movement of vehicles could be simulated properly.

Next, vehicle inputs were given that consisted of motorized vehicles (cars, buses, trucks, motorcycles) and nonmotorized vehicles (pedal rickshaws, bicycles), and their respective turning movements and volumes at intersections. Signal groups and signal heads at the signalized intersection at the end of the corridor were configured based on peak hour field data.

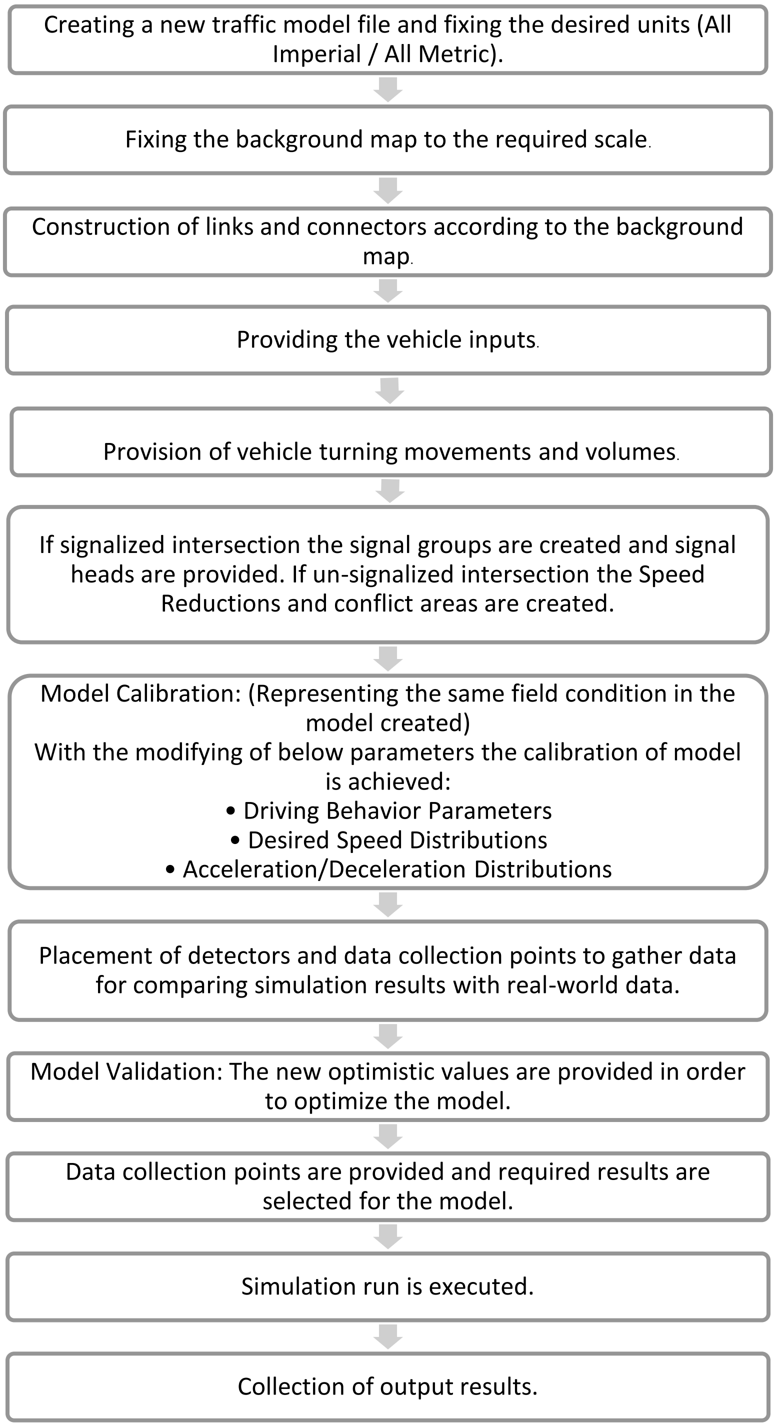

Figure 3: Steps of creating a VISSIM traffic network model

In contrast, the non signalized intersection at the other end was modeled by using speed reduction and defining the conflict areas, which are particularly important in the simulation of the special flow behaviour of the urban traffic in Dhaka. Calibration of the model was subsequently done by modifying parameters of those parameters to give the required field conditions. This was done by adjusting the driving behavior parameter using the Wiedmann 99 car following model, including headways, distribution of desired speeds and acceleration/deceleration profiles to reflect the traffic dynamics that were present in the field. Additionally, data collection points and data parameters were added to the link in model, which would be used to gather the traffic data in the simulation to be used in the calibration of collected data. These data were then compared with actual data collected in the real world to determine the accuracy of the model and other adjustments. The model was validated with optimistic values once it was calibrated and then verified. The validation was done by running the model with a new dataset of a different day (evening peak hour in this case) and comparing the results obtained through the simulation model with field data to measure the performance of the model. The flow data recorded to validate the model included 1892 vehicles/hour in Kakrail Motijheel direction and 2446 vehicles/hour in the Motijheel to Kakrail direction; from which only .9% and 3% respectively were NVMs of the total composition. The last simulation runs were conducted and the average results, the delay times, the queue lengths, and the vehicle throughput were gathered as the output of the calibrated model. The modeling process followed a systematic sequence, as outlined in the flowchart (Figure 3) of modeling steps.

2.3 Vehicle Types and Traffic Composition

Different vehicle classes in the simulation were defined by both their physical and behavioral parameters to accurately replicate observed traffic. The VISSIM model includes six distinct vehicle types: cars, motorcycles, buses, trucks, CNG autorickshaws, and pedal rickshaws. Some specifications were given which are specific to the vehicle length, acceleration/deceleration rates, desired speed distributions, and standstill distances, but only on the basis of the field collected data at the site of the research.

The inputs of CNGs and pedal rickshaws were done very meticulously because they do not operate in the same way as conventional motorized vehicles. These types of vehicles were not inherently in VISSIM and had to be added to the simulation manually as new classes of vehicles, with inputs made on all the relevant parameters, including dimensions calibration, speed distributions, headways, acceleration profiles, and lateral movement behaviour. To increase the visualization and interpretability of the simulation, rickshaws, CNGs, and motorcycles were also custom inputs with three dimensional (3D) models. These models were obtained to the open access library of SketchUp 3D Warehouse and allocated to its respective classes in VISSIM. While these enhancements do not affect simulation dynamics, they allow for a more intuitive understanding of spatial interactions. Snapshots of the integrated 3D models are presented in Figure 4. Vehicle routing decisions at junctions were based on observed turning ratios to prevent flow distortions during simulation and allow calibration with class-wise volume comparisons.

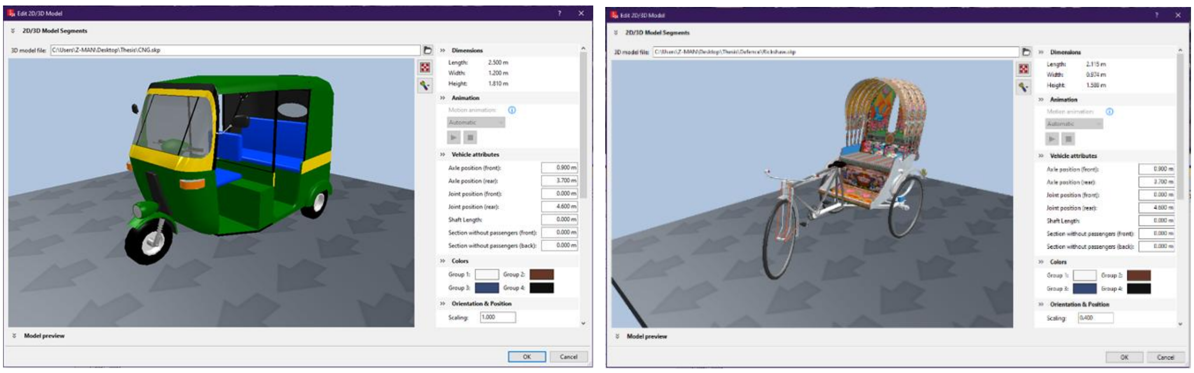

Figure 4: 3D models of CNG and Pedal Rickshaws input into VISSIM.

2.4 Model Calibration

In order to perfectly recreate the observed traffic dynamics, a careful calibration was performed based on empirical data on the selected corridor. The behavioral model at VISSIM was customized to the Wiedemann 99 car following logic, which is among the commonly used schemes of simulating urban mixed traffic scenarios with the involvement of heterogeneous vehicles and irregular flow conditions (PTV Group, 2022). The model enables micro level interactions on vehicles to be adjusted by setting sensitivity levels on the spacing, acceleration, and oscillation of vehicles.

The driving behaviour parameters that have been adjusted during the calibration run included Wiedmann 99 car following model: lateral behaviour, decision to change lanes, rerouting logic, standstill distance (CC0), headway time (CC1), following distance (CC2), responsiveness parameters, including acceleration starting standstill (CC8), negative headway thresholds (CC4), etc. The previous similar studies have proven the flexibility to the Wiedemann 99 model in complex, heterogeneous traffic environments to justify its choice in this simulation. As an example, Raju et al. (2017) managed to reproduce nonlane based traffic behavior using the model on the Indian roads, whereas Hassan and Puan (2023) emphasized the ability of the model to reproduce various car interactions in the typical urban traffic in Southeast Asia.The parameters standstill distance, following distance oscillation, distance dependency of oscillation, oscillation acceleration, and waiting time before diffusion were selected because they are known to have a strong influence on car-following behavior under heterogeneous and non-lane-based traffic conditions like in Bangladesh. The results support the appropriateness of the model in the description of microdynamics of the subject road. Figure 5 shows the default values of parameters for the Wiedemann car following model in VISSIM and Table 1 shows the difference between adjusted and default values (Figure 5) to be used in the calculation of the value of calibration. All parameters adjusted were through an iterative trial and error method within realistic bounds until desired testing on the characteristics of observed traffic flows, and were adjusted to conform to observed traffic characteristics.

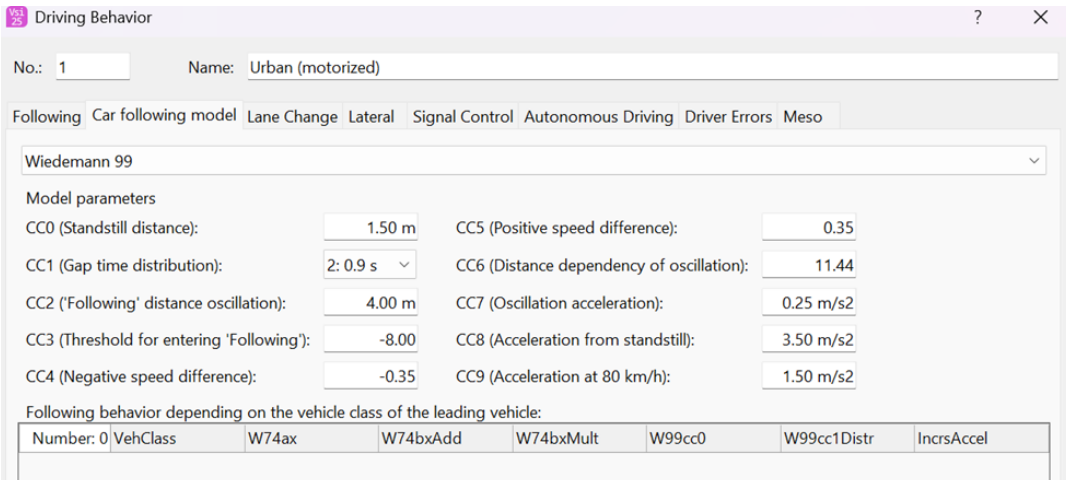

Figure 5: Default Values of Wiedmann 99 model in VISSIM

Table 1: Parameters Changed to Calibrate the Model

Parameter	Calibrated Value	Default value
Car Following		
Standstill Distance(m)	0.3	1.5
Headway Time(s)	.9	.9
Following distance oscillation(m)	1.5	4.0
Distance dependency of oscillation	1.00	11.44
Oscillation acceleration(m/s2)	3.00	0.25
Acceleration from standstill (m/s2)	2.00	3.50
Lane Changing		
Maximum deceleration(m/s2)	-5.00	-3.00
$-1m/s^2$ per distance(m)	70	100
Accepted deceleration(m)	-1.50	-1.00
Waiting time before diffusion(s)	20.00	60.00
Min. clearance(front/rear) (m)	0.3	0.5
Lateral		
Desired Position at Free Flow	Any	Allowed
Minimum Lateral Distance(m)		
Distance at 0Km/h	0.1	0.2
Distance at 50Km/h	1.00	1.00
Collision time gain(s)	5.00	2.00
Minimum longitudinal speed(km/h)	1.50	1.0
Overtake on Same Lane		
On Left	Allowed	Allowed
On Right	Allowed	Allowed

In the above table, the large reduction in standstill distance and following distance oscillation reflects the aggressive car-following behaviour and minimal spacing commonly observed in Dhaka traffic. Increased oscillation acceleration and reduced distance dependency were necessary to reproduce the rapid speed corrections, bumper to bumper following behavior, and frequent stop go oscillations observed in mixed traffic streams. Calibration was accepted only after achieving convergence across multiple criteria, reducing the likelihood of overfitting.

2.5 Model Validation

In order to determine whether the calibrated simulation model would be able to accurately model the behaviour of real-world traffic, a validation was performed using field flow data collected on a different day, as shown in the results section. These were the directional volumes of segments, turning movements, and observed journey time, all of which were not utilized in the calibration stage. It was aimed at finding out whether the model could be dependable in modeling traffic conditions with different demand and modal structures.

Quantitative validation was done by the use of the GEH statistic, a modified chi-squared formula that is common in traffic modeling in order to determine the quality of fit between developed and actual traffic volumes. GEH is especially appropriate to microsimulation because it is sensitive to both absolute and relative deviations. The GEH equation is defined as:

$$GEH = \sqrt{\frac{2(M-C)^2}{(M+C)}} \qquad (1)$$

In the equation of GEH (1), M represents the volume of traffic to be modelled and C represents the measured volume. GEH values of less than 5 are regarded to be a good model accuracy (Hellinga, 1998). The calibrated traffic flows must reach GEH calibration target values ≤ 5, which is in accordance with the UK Department for Transport requirements regarding model acceptance (Dowling et al., 2004; Beza, 2022). The calibration process was carried out using a trial-and-error approach within VISSIM until the deviations in volume, queue lengths, and speed were minimized. Table 2 shows a summary of the validation targets.

Table 2: Calibration Target

Criteria & Measures	Acceptability Targets
Hourly Flows, Model vs. Observed	
Individual Link Flows	
Within 15%, for 700 vph < Flow < 2700 vph	>85% of cases
Within 100 vph, for Flow < 700 vph	>85% of cases
Within 400 vph, for Flow > 2700 vph	>85% of cases
Total Link Flows	
Within 5%	All Accepting Links
GEH Statistics – Individual Link Flow	
GEH < 5	>85% of cases
GEH Statistics – Total Link Flow	
GEH < 4	All Accepting Links
Travel Times, Model vs. Observed	
Journey Times Network	
Within 15% (or one minute, if higher)	>85% of cases
Visual Audits	
Individual Link Speeds	
Visually acceptable Speed-Flow relationship	To analyst's satisfaction
Bottlenecks	
Visually acceptable Queuing	To analyst's satisfaction

To complement quantitative measures, qualitative validation was done with detailed visual inspections (Figure 6) within the VISSIM environment. Close consideration was given to the overtaking and weaving of pedal rickshaws and CNGs in nonlane sections, aligning with field observations. These inspections were helpful in the lateral behavior calibration and routing logic used in the development of a model.

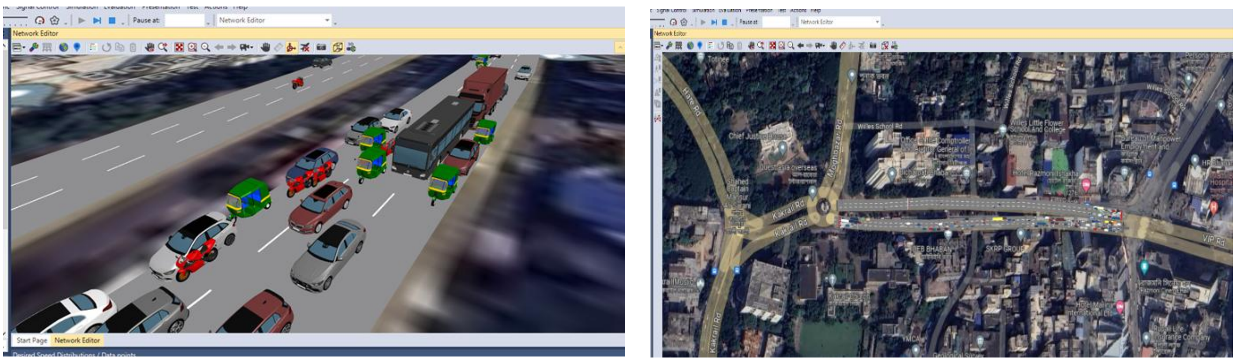

Figure 6: Visual inspection of the simulation environment

3. RESULTS

The VISSIM model was calibrated against various performance indicators, such as the volume of traffic, the travel time, and the graphical confirmation of the interaction between vehicles. The model was found to be consistent with the observed traffic patterns in the study area in Dhaka. The validation of flow was done by GEH statistic which is a popular measure of the accuracy of the model in modeling traffic volumes. Table 3 indicates that both segments of the route, Kakrail to Motijheel and Motijheel to Kakrail, had GEH values of 1.866 and 1.053, respectively, which are much lower than the 5 threshold of acceptability. Moreover, the rate of error in flow was not exceeded by 15% in both sections, which proved the high level of accuracy of simulation.

Table 3: Model Validation for Flow Using Different Day Data

Segment	Actual		Simulation	Difference (Actual-Simulation/hr)	% Error {Below 15% acceptable}	GEH
	Veh/hour	Veh/10mins	Veh/10mins	Veh/hour		
Kakrail - Motijheel	1892	315	349	202	10.68	1.866
Motijheel - Kakrail	2446	408	387	124	5.07	1.053

Travel time accuracy was assessed by comparing observed and simulated journey durations. The deviation in travel time was minimal, with absolute differences of 0.31 seconds and 8.76 seconds for the two routes, corresponding to percentage differences of 1.14% and 6.99% respectively (Table 4). These results fall well within the commonly accepted margin of ±15% for dynamic traffic modeling.

Table 4: Model Validation for Travel Time

Segment	Actual(Sec)	Simulation(Sec)	Difference(Sec)	%Difference
Kakrail-Motijheel	27.3	27.61	0.31	1.1355
Motijheel-Kakrail	125.3	134.06	8.76	6.9912

In addition Average Speed and Queue length were also compared as shown in Table 5. This table compares the average speed and queue length for both segments of the route. The model results show a minimal difference between the actual and simulated values for both speed and queue length, with percentage differences for speed ranging from 5.92% to 6.60%, and for queue length from 4.88% to 9.56%.

Table 5: Model Validation for Average Speed and Queue Length

Parameter	Segment	Actual	Simulation	% Difference
Arithmatic Average Speed(Km/hr)	Kakrail to Motijheel	53.53	50.36	5.92
	Motijheel to Kakrail	30.27	33.29	9.97
Queue Length(m)	Kakrail to Motijheel	11.54	14.22	23.23
	Motijheel to Kakrail	28.07	24.58	12.43

These outcomes support the fact that the manual tuning of the Wiedemann 99 parameters, and the inclusion of local vehicle classes, including rickshaws and CNGs, effectively simulated the dynamics of the Dhaka corridor. These findings were further corroborated visually on the simulation as vehicle interactions, queuing patterns and overtaking behavior were within the same level of observation in the field.

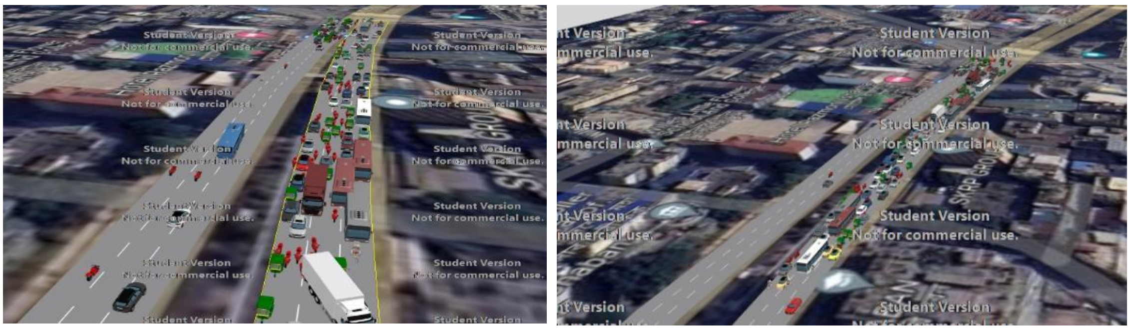

Figure 7: Simulation Screenshots

4. CONCLUSION

This paper has created and tested a microscopic model of traffic simulation of a section of Bir Uttam Samsul Alam Sarak in Dhaka in PTV VISSIM in a manner that has overcome the limitation of this tool in relation to nonlane based, heterogeneous traffic flow. The simulation obtained a high level of fidelity with real-world traffic data by factoring in localized vehicle classes (CNG autorickshaws and pedal rickshaws) not available as default models in VISSIM, as well as tuning parameters that control major behavioural aspects using the Wiedemann 99 car following model. The performance of the calibration strategy was validated by validation metrics such as GEH values of less than 2 and travel time error of less than 7% which ensured that the calibration was effective in reproducing the traffic conditions that were being captured.

Despite these promising outcomes, the study was constrained by a limited corridor length, manual trial and error calibration, and a relatively narrow dataset. The applicability of these aspects may be limited. applicability of the findings to the more complex environments or bigger networks. Also, the manual analysis is a valuable tool but it is labor intensive and has analyst bias. Future research could explore using machine learning or optimization algorithms for automated calibration of behavioral parameters, reducing human bias and boosting efficiency. Moreover, to test the performance of VISSIM in light of the large variety of traffic present in Dhaka, it can prove helpful to take the simulation to a bigger city network. The introduction of real-time information. feeds (i.e. GPS or CCTV based vehicle tracking) may also be involved in making models responsive and support the dynamic traffic management planning within the cities with informal and mixed traffic systems.

In conclusion, this paper demonstrates that it is possible to adjust VISSIM to suitably reflect the complicated traffic flows. Casual customization and data-driven calibration makes the customization of a South Asian city a possibility. The procedure used in this paper provides a generalisable approach to simulation based planning and traffic control in other nonlane based cities.

5. DECLARATION OF USE OF AI

This study made limited use of artificial intelligence–based tools during the manuscript preparation stage. AI tools were utilized solely to assist with language refinement, grammatical correction, and improvement of sentence clarity to enhance the readability of the paper. The use of AI did not influence the research design, data collection, data analysis, interpretation of results, or the development of conclusions. All technical content, analyses, figures, and scientific judgments presented in this paper are entirely the work of the authors.

REFERENCES

Alam, Q. M., Sarker, B., Biswas, B., Zubayer, K. H., Tofa, T. R., Nurain, N., & Al Islam, A. B. M. (2018). Towards simulating non-lane based heterogeneous road traffic of less developed countries. EPiC Series in Computing, 52, 37–48.

Arkatkar, S., Velmurugan, S., Puvvala, R., Ponnu, B., & Narula, S. (2015). Methodology for simulating heterogeneous traffic on expressways in developing countries: A case study in India. Transportation Letters, 7(1), 1–11.

Beza, A. D. (2022). How PTV VISSIM has been calibrated for the simulation of automated vehicles. Advances in Civil Engineering, 2022, 1–13. https://doi.org/10.1155/2022/3049054

BUET. (2024). Urban transport study for Greater Dhaka. Bangladesh University of Engineering and Technology, Department of Civil Engineering.

Chawla, A., & Khare, M. (2024). Simulation of traffic flow under heterogeneous traffic conditions using VISSIM. Current Trends in Civil & Structural Engineering, 10(3). https://doi.org/10.33552/CTCSE.2024.10.000736

Dey, A. C., Roy, S., & Uddin, M. A. (2018). Calibration and validation of VISSIM model of an intersection with modified driving behavior parameters. International Journal of Advanced Research, 6(12), 107–112. https://doi.org/10.21474/IJAR01/8120

Dowling, R., Skabardonis, A., & Alexiadis, V. (2004). Traffic analysis toolbox: Volume III: Guidelines for applying traffic microsimulation modeling software. U.S. Department of Transportation, Federal Highway Administration. https://ops.fhwa.dot.gov/trafficanalysistools/tat_vol3/

Hassan, M., & Puan, O. C. (2023). Calibration methodologies of VISSIM-based microsimulation model for heterogeneous traffic conditions—A survey. Advances in Transportation Studies, International Journal. https://www.researchgate.net/publication/369037482

Hellinga, B. (1998). Requirement for the calibration of traffic simulation models. Proceedings of the Canadian Society for Civil Engineering Annual Conference, 1–10.

Mathew, T. V., & Radhakrishnan, P. (2010). Calibration of microsimulation models for non-lane-based heterogeneous traffic at signalized intersections. Journal of Urban Planning and Development, 136(1), 59–66. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000018

PTV Group. (2022). PTV VISSIM 2022 user manual. Karlsruhe, Germany: PTV Planung Transport Verkehr GmbH.

Raju, N., Kumar, P., Chepuri, A., & Arkatkar, S. S. (2017). Calibration of vehicle following models using trajectory data under heterogeneous traffic conditions. Transportation Research Board. https://www.researchgate.net/publication/318053564

World Bank. (2025, October 19). World development indicators: Population and urbanization. https://databank.worldbank.org/