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# Enhancing Urban Mobility: Exploring the Potential of Exclusive Motorcycle Lane Using VISSIM

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## Abstract

The proliferation of Mobility on Demand (MOD) services has ushered in a surge of ridesharing platforms, catalyzing the emergence of micro mobility solutions like motorcycle sharing. Consequently, motorcycles have witnessed unprecedented growth over recent decades. This proliferation, while offering convenience, has introduced challenges such as diminished road capacity, and compromised safety. This study advocates for the implementation of exclusive motorcycle lanes to mitigate the ensuing disorderliness using VISSIM microsimulation platform. Empirical data from a key corridor in Dhaka is harnessed to calibrate and simulate network performance scenarios—pre- and post-implementation of dedicated motorcycle lanes. The outcomes of our simulation experiments exhibit the implementation of dedicated motorcycle lanes leads to a reduction in vehicular throughput but improvement the flow of motorcycles. In addition, Surrogate Safety Measures (SSMs) demonstrate the safety improvements through implementation of the treatment.

## Keywords

Motorcycle Lane, Traffic Simulation, Capacity, Safety

## 1. Introduction

The urban transportation landscape has undergone a remarkable transformation with the advent of Mobility on Demand (MOD) services, ushering in an era of dynamic ridesharing platforms that cater to the evolving mobility needs of cities. This paradigm shift has been particularly exemplified by the introduction of micro mobility services, such as bike, scooter, and motorcycle sharing, as a response to the growing demand for efficient and flexible urban transportation options.

Motorized and non-motorized two-wheelers have emerged as pivotal modes of transportation, and their significance is poised to persist over the coming decades for several compelling reasons [1]. First, their exceptional maneuverability renders them highly effective in negotiating the confined spaces of urban locales where road widths are often constrained. Second, the affordability of ownership, minimal financing, insurance, and maintenance costs compared to automobiles makes them an economical choice [2] [3]. Third, motorcycles demonstrate superior land utilization efficiency, occupying less road and parking space, with the potential for accommodating multiple motorcycles within a single car space [4].

As a consequence, motorcycles have experienced an unprecedented surge in adoption particularly among the lower socioeconomic strata over the past decades, leading to a significant reconfiguration of urban mobility patterns., motorcycles have gained popularity as a preferred mode of commuting.

While this proliferation of motorcycles has contributed to enhanced accessibility and convenience, it has also precipitated a series of complex challenges that warrant careful examination. On roadways characterized by heavy traffic volumes, conflicts often arise among vehicles. The coexistence of substantial commercial vehicles and high-speed cars with more vulnerable, slower-moving entities can lead to discord. The inherent instability of two-wheelers coupled with their propensity for indisciplined road behavior, including occupying sidewalks, accentuates their vulnerability. These challenges manifest in the form of reduced road capacity, an increase in crashes, and a decline in overall road safety.

In this context, addressing the disorderliness induced by the substantial increase in motorcycles emerges as a critical imperative to ensure sustainable urban mobility. To mitigate the adverse effects of motorcycle proliferation and promote safe and efficient transportation, the proposition of dedicated motorcycle lanes surfaces as a pragmatic solution [5]. While pedestrian and cyclist segregation from motorized traffic is not new, exclusive facilities for motorcycles remain relatively unexplored. The lack of commitment to safety strategies and financial constraints often impedes the implementation of such measures. By delineating a segregated space for motorcycles, the implementation of such lanes holds the promise of streamlining traffic flow, enhancing road safety, and ultimately contributing to the harmonious coexistence of diverse transportation modes. Two distinct approaches for segregating motorcycles from regular traffic have been identified in the literature: Exclusive Motorcycle Lane (EMCL) and non-exclusive motorcycle lane (NEMCL) [6] [7]. EMCL entails a separate paved road, entirely distinct from the carriageway, demanding substantial right-of-way. On the other hand, NEMCL integrates with the carriageway but reserves dedicated space for motorcycles. NEMCL can be further categorized into marked corridors and paved shoulders, each with its own attributes [8].

Surrogate Safety Measures (SSMs) represent a powerful methodology for evaluating the safety of a transportation corridor [9] [10] [11]. These measures provide an indirect assessment of safety by quantifying aspects of traffic behavior that correlate with the likelihood of accidents. Unlike traditional safety analyses that rely solely on historical accident data, SSMs offer a proactive approach by identifying potential safety concerns before actual collisions occur. SSMs encompass various traffic variables and behaviors that reflect potential hazards. For instance, parameters such as Time to Collision (TTC), Post Encroachment Time (PET), lane change frequency are commonly used SSMs [12] [13] [14].

Allocating existing lane width for motorcycles comes at the cost of a reduction in the capacity of other users of the road. While a detailed review of existing studies on the implementation of exclusive motorcycle lanes has been conducted in [15], to date, no study has investigated the impact of motorcycle lanes on both mobility and safety, specifically through SSMs. To fill this gap in literature, the scope of this study is as follows:

- To thoroughly assess the feasibility of dedicated motorcycle lanes in urban networks using microsimulation
- To understand the trade-off between the improvement of mobility of motorcycles and the reduction in capacity of other vehicles
- To quantify the passive safety benefits of introducing exclusive right of way for motorcycle users

To contribute to the existing literature, this study employs microsimulation using real-world data on a corridor with non-lane based heterogenous traffic flow. Results show that the implementation of a dedicated motorcycle lane leads to a reduction in flow of vehicles but an improvement in the overall flow of motorcycle as well as improvement in roadway safety. Furthermore, improvements in TTC, PET, and average lane change frequency show the impact of the exclusive motorcycle lanes on reducing potential conflicts and improving overall safety within the corridor.

The remainder of this paper is organized as follows. The next section provides an overview of the proposed method and the collected data. This is followed by the simulation setup used to calibrate and validate the network. Then, the results of the experiments are presented, including a comparative analysis between the pre and post implementation of the motorcycle lane treatment. The last section concludes the paper by highlighting the important findings and suggesting potential directions for future research.

## 2. Methodology

This section delineates the approach utilized in this study to assess the impact of an exclusive motorcycle lane on urban traffic dynamics. The subsequent subsections detail the data collection procedure, simulation framework, calibration, validation, and the comparative analysis conducted.

## 2.1. Data Collection

Selecting the right location for data collection was crucial, and we opted for a busy corridor in Dhaka, Bangladesh. This decision was driven by Dhaka's large population and the rapid increase in bike-sharing services. The number of registered motorcycles in Bangladesh is reported as 406,897 units in 2019, which has increased significantly from 395,603 units in 2018. With an average growth rate of roughly 60% as of 2017, this trend is expected to carry through 2019 and into the foreseeable future [16] [17]. By concentrating on this active urban setting, we aimed to understand how the introduction of an exclusive motorcycle lane affects safety and movement, taking into account the high population density and the growing popularity of bike-sharing services.

In order to achieve the specific objectives of this study a busy corridor along Mirpur Road was selected. The selected intersection constitutes Mirpur Road along the N-S direction and Kalabagan road in the E-W direction. Mirpur road corridor was selected as a pilot for the exclusive motorcycle lane as there are 3 wide lanes in each direction and Non-Motorized Vehicle (NMV) movement is restricted. NMV movement is permitted however, on the E-W approaches.

Heterogeneous non-lane based traffic conditions prevalent in developing countries require modeling a mix of different vehicle types and the lack of lane discipline [18] [19] [20]. For this study, a traffic survey was conducted to determine the peak flow period which was found to be between 05:00 pm to 08:00 pm. Manual traffic survey data at 15-minute interval was conducted to determine the peak hour traffic flow. The collected data include vehicle composition, vehicle classification, vehicle speed and detailed network geometry. In this study, the timing parameters for signal control were obtained through field observations of average cycle times. While fixed-time signal controllers were not present at the Kalabagan Intersection, manual cycle times were recorded and input to recreate the signal control in the simulation.

## 2.2. Simulation Framework

VISSIM ("Verkehr In Städten-SIMulationsmodell") in German which means "Traffic in cities—simulation model" is a versatile, behavior-driven microscopic traffic simulation software, capable of representing diverse transport modes, including vehicles, pedestrians, cyclists, and autonomous vehicles, in realistic scenarios [18]. Its user-friendly interface and robust customization options make it an ideal choice for this study. VISSIM's adaptability to non-lane-based, heterogeneous traffic flow was pivotal in simulating the complex urban environment of Dhaka, ensuring accurate representation of the traffic dynamics.

Detailed, geometric data was overlaid over the Google Map background of the intersection into VISSIM graphical user interface to obtain the Kalabagan intersection network. **Figure 1(a)** shows the existing geometric features of the target

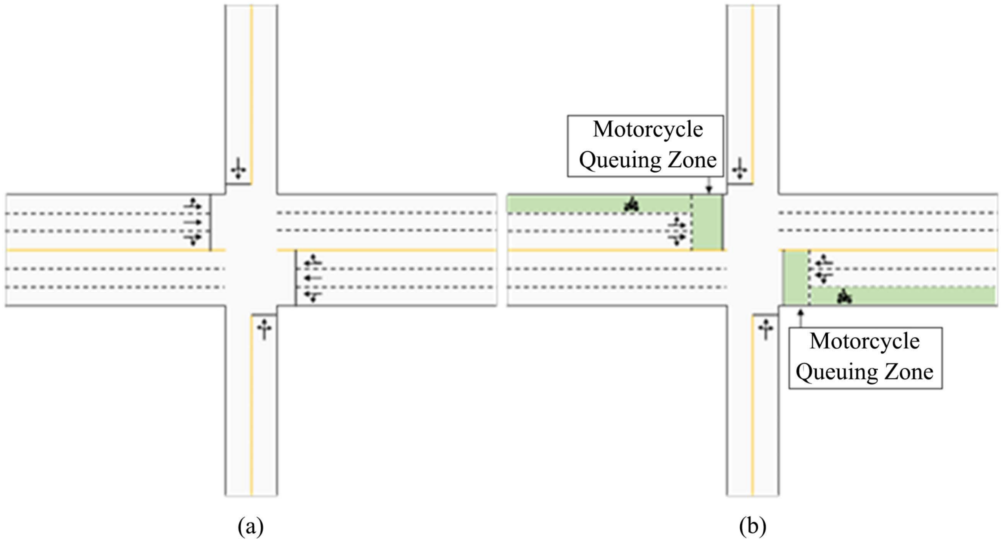


**Figure 1.** Schematic diagram of target corridor and intersection: (a) before implementation of exclusive motorcycle lane, (b) after implementation of exclusive motorcycle lane.

intersection the simulation was enriched with NMV and local motorized vehicle models like three-wheelers, autorickshaws and converted shuttle vans. Custom vehicle classes were established for each types involving tailored speed, weight, and dimension attributes to mirror real-world scenarios. Vehicle data, encompassing routes, types, and composition, was input based on a traffic survey. Signal heads were positioned at the intersection, their control parameters adjusted using average manual cycle times for simulated signal control. Given the complex, non-lane-based traffic flow of the city, the Wiedemann 99 car following model was employed for calibration. The signal heads were strategically placed along the intersection's four legs, replicating their real-world locations. Average manual cycle times were applied to establish the signal control cycle in the simulation, ensuring that the traffic dynamics closely resembled actual conditions. The Intersection selected for this study is shown in **Figure 1**.

The calibration process involved modifying VISSIM parameters including Standstill Distance, Headway time, Following variation, and more. These adjustments were continually fine-tuned to ensure the model's alignment with real-world characteristics. Data collection points and travel time sections were integrated to acquire simulation data for model validation.

## 2.3. Validation of Simulation Model

The calibrated model was independently validated against field data, affirming its accuracy beyond the calibration dataset. This comprehensive approach ensured that the simulation accurately reflected the intricacies of the traffic dynamics being studied. The simulated intersection was validated using parameters such as Traffic Flow, GEH and Speed. The Geoffrey E. Havers (GEH) Statistic is a formula used in traffic engineering, traffic forecasting, and traffic modelling to compare two sets of traffic volumes which can be calculated as [21]

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

Here, $M$ represents the hourly traffic volume from the traffic model (or new count), while $C$ signifies the real-world hourly traffic count (or the old count). As per validation standards, $GEH$ values under 5 denote a satisfactory fit, values between 5 and 10 warrant further scrutiny, and values exceeding 10 indicate a poor match [22] [23] [24] [25].

To check the difference between the actual and simulated speed for each vehicle type, a t-test was performed using the actual and simulation data. The t-test is a statistical test that compares the means of two groups and determines if they are significantly different from each other. It also gives a p-value, which is the probability of obtaining the observed difference by chance.

### 2.4. Simulation of Treatment

After validation of the model, a subsequent simulation was designed to evaluate the impact of implementing an exclusive motorcycle lane along the corridor. Literature highlights motorcycle lane widths ranging from 2 m to 3.5 m. Given that motorcycles constitute a large portion of total vehicle composition, a lane width of 3.5 m was adopted for this analysis. In this simulation, specific modifications were introduced to the leftmost lane (Lane-03) along both Link 1 and Link 8 shown in Figure 1(b). All vehicle classes, excluding motorcycles, were restricted from utilizing this lane, thus establishing an exclusive zone for motorcycle movement. Subsequent to applying the Exclusive Motorcycle Lane treatment, data collection was undertaken through simulation runs to generate new datasets for comparison with the prior information. This comparative analysis would enable a comprehensive evaluation of the treatment's impact on traffic flow, safety, and overall corridor performance.

## 3. Results

### 3.1. Validation Results

The GEH values for the actual and simulated vehicle flows were meticulously computed for each of the four approaches at the intersection, as detailed in Table 1. These GEH values exhibited a range from 3.36 to 5.03. Notably, while a single value surpassed the GEH limit of 5.0 by a mere 0.03, the remaining values comfortably resided within this range. This pattern collectively suggests a favorable fit and, potentially, the successful validation of the model. Discrepancies in GEH values can be attributed, in part, to manual signal controls and their associated nuances. To ensure robust validation, an array of simulation runs was conducted to generate the model.

To further validate the vehicle speeds, Table 2 shows the results of the t-test performed. It is evident that, there is no significant difference between the actual and simulated speed for cars, buses, and 3-wheelers, as their p-values are all

**Table 1.** GEH values at different approaches using actual and simulated traffic flows.

| Approach | Actual flow veh/hr | Simulated flow veh/hr | Difference veh/hr | % Difference | GEH |
|---|---|---|---|---|---|
| N-S | 3570 | 3372 | 198 | 5.55 | 3.36 |
| S-N | 3105 | 2874 | 231 | 7.44 | 4.22 |
| E-W | 790 | 690 | 100 | 12.66 | 3.68 |
| W-E | 610 | 492 | 118 | 19.34 | 5.03 |

**Table 2.** Speed comparison between actual and simulated observations.

| Vehicle type | Actual mean speed (km/h) | Simulated mean speed (km/h) | t-statistic | p-value |
|---|---|---|---|---|
| Car | 10.31 | 10.92 | −1.23 | 0.22 |
| Bus | 7.52 | 7.1 | 0.85 | 0.4 |
| 3-wheeler | 11.75 | 10.92 | 1.67 | 0.1 |
| Motorcycle | 26.89 | 25.6 | 2.59 | 0.01 |

greater than 0.05. However, there is a significant difference between the actual and simulated speed for motorcycles, as their p-value is $0.01 < 0.05$. This means that the simulation significantly underestimates the speed of motorcycles.

## 3.2. Network Performance Evaluation

Two distinct simulation models were conducted to assess the impact of an exclusive motorcycle lane along the N-S approach of the intersection. Table 3 delineates the capacity variations observed across the four intersection approaches between simulations involving and excluding the exclusive motorcycle lane. The findings unveiled a significant reduction in the overall capacity of the N-S approaches, while the Dhanmondi-Kalabagan corridor, serving as the east-west connection, exhibited improvements although negligible. This phenomenon could be attributed to the dedicated motorcycle lane's appropriation of the leftmost lane, leading to a narrowing of the roadway. Conversely, motorcycles, known for their agile maneuvering capabilities and efficient use of inter-vehicular spaces, facilitated denser road space utilization, ultimately resulting in an augmented road capacity.

Table 4 shows the vehicle class-wise comparison of capacity with and without the installation of exclusive motorcycle lane. A significant reduction in flow of every vehicle class is evident whereas the flow of motorcycles improves. Cars experienced a significant reduction in flow, suggesting potential congestion or adjustments in driving behavior due to lane reallocation. The reduction in flow can be owed to the reduction of one lane thus dropping the overall capacity. Interestingly, buses exhibited a minimal change in flow, indicating a relatively lesser sensitivity to the motorcycle lane treatment. This might reflect the inherent

**Table 3.** Approach capacity comparison after implementation of dedicated motorcycle lane.

| Approach | Simulated mean flow without Motorcycle Lane (veh/hr) | Simulated mean flow with Motorcycle Lane (veh/hr) | Difference | t-statistic | Significance |
|---|---|---|---|---|---|
| N-S | 3372 | 2952 | −420 | 9.576 | Yes |
| S-N | 2874 | 2653 | −221 | 5.936 | Yes |
| E-W | 690 | 703 | 13 | −0.56 | No |
| W-E | 492 | 502 | 10 | −0.477 | No |

**Table 4.** Vehicle class capacity comparison after implementation of dedicated motorcycle lane.

| Vehicle class | Simulated mean flow without Motorcycle Lane (veh/hr) | Simulated mean flow with Motorcycle Lane (veh/hr) | Difference | t-value | Significance |
|---|---|---|---|---|---|
| Car | 1224 | 1026 | −198 | −5.207 | Yes |
| Bus | 240 | 216 | −24 | −1.365 | No |
| 3-wheeler | 408 | 348 | −60 | −3.165 | Yes |
| Motorcycle | 1308 | 1362 | 54 | 2.371 | Yes |

differences in bus movement patterns and their interactions with other vehicles. Moreover, the non-significant change in bus flow could also be attributed to the spatial distribution of motorcycle lanes along the studied corridors. Meanwhile, motorcycles benefited from the dedicated lanes, leading to enhanced flow and improved mobility.

A final comparison of the average vehicle speed between simulations with and without exclusive motorcycle lanes was performed (**Table 5**). The results collectively indicate that introducing the motorcycle lane led to significant changes in mean speeds across all vehicle types. Cars, buses, and 3-wheelers experienced decreased speeds, potentially due to shared road space and adjustments in traffic dynamics. On the other hand, motorcycles exhibited improved speeds, emphasizing the positive impact of the dedicated lane. Overall, the results indicate that the introduction of exclusive motorcycle lanes hurts the mobility of all vehicle modes due to a reduction of capacity. Therefore, the justification of introducing motorcycle lanes can be made from additional benefits in safety.

### 3.3. Network Safety Evaluation

To analyze the safety performance of implementing a motorcycle lane, surrogate safety measures were evaluated and shown in **Table 6**. TTC is the time required for two vehicles to collide if they continue at their present speed and direction. A

**Table 5.** Vehicle class speed comparison after implementation of dedicated motorcycle lane.

| Vehicle class | Simulated mean speed (km/h) (without motorcycle lane) | Simulated mean speed (km/h) (with motorcycle lane) | Difference | t-value | Significance |
|---|---|---|---|---|---|
| **Car** | 10.92 | 9.1 | −1.82 | 44.318 | Yes |
| **Bus** | 7.1 | 6.8 | −0.3 | 9.583 | Yes |
| **3-wheeler** | 10.92 | 9.1 | −1.82 | 44.318 | Yes |
| **Motorcycle** | 25.6 | 29.4 | 3.8 | −47.904 | Yes |

**Table 6.** Vehicle class speed comparison after implementation of dedicated motorcycle lane.

| Surrogate Safety Measure | Before Motorcycle Lane | After Motorcycle Lane | Change (%) |
|---|---|---|---|
| Average Time to Collision (TTC) | 2.5 seconds | 2.8 seconds | 12% |
| Average Post Encroachment Time (PET) | 1.1 seconds | 1.2 seconds | 9.00% |
| Average Lane Change Frequency | 0.9 changes/500m | 0.7 changes/500m | −22.20% |

lower TTC indicates a higher risk of collision. The results show that the TTC increases by 12% when adding motorcycle lane, which means that the risk of collision decreases. This may be because the motorcycle lane separates the motorcycles from other vehicles and reduces their interaction and conflict. PET is the time elapsed between the end of one vehicle's encroachment and the beginning of another vehicle's encroachment at the same location. A lower PET indicates a higher severity of conflict. The results show that the PET increases by 8.3% when adding motorcycle lane, which means that the severity of conflict increases. This may be because the motorcycle lane reduces the available space for other vehicles and increases their congestion and encroachment. Lane change frequency is the number of lane changes per unit distance. A higher lane change frequency indicates a higher complexity and instability of traffic flow. The results show that the lane change frequency decreases by 22.2% when adding motorcycle lane, which means that the traffic flow becomes more stable and smoother. This may be because the motorcycle lane reduces the need for motorcycles to change lanes and improves their flow efficiency.

## 4. Conclusions

This study investigated the impact of introducing a dedicated motorcycle lane on a busy corridor in Dhaka using microsimulation. The results revealed a complex interaction between different types of vehicles and the motorcycle lane implementation. The impact on network performance underscores a trade-off between vehicle classes. While cars, buses, and 3-wheelers experienced reduced flow, motorcycles demonstrated improved mobility due to the exclusive lane. The average vehicle speeds showcased a similar trend, with cars, buses, and 3-wheelers exhibiting decreased speeds, and motorcycles benefiting from the dedicated lane's enhanced flow. Regarding safety, the lower TTC values and higher PET values suggest improved collision risk management due to the motorcycle lane's segregation of traffic streams. The reduction in Lane Change Frequency implies enhanced traffic stability and reduced complexity. Collectively, these findings advocate for the motorcycle lane's positive influence on traffic efficiency and safety despite a drop in mobility of other modes of transportation.

Future work may further investigate the safety impact of implementing dedicated lanes by evaluating Crash Modification Factors (CMFs) using EB, cross-sectional methods, NB-Lindley models, etc. [11] [26]-[35]. Furthermore, in light of the growing emphasis on developing inclusive and multifunctional urban spaces, future research endeavors could explore the implementation of specialized lanes for additional modes of transportation, such as dedicated cycle lanes, exclusive e-scooter lanes, on-street parking etc. [35] [36] [37] [38]. This proactive approach aligns with the concept of road diets as part of the "complete streets," initiative. Finally, the identification of optimal locations to implement motorcycle lane facilities in an urban network is worth exploring as implementing in random locations may not always yield optimum benefits [39] [40] [41]. Using heuristics to determine optimal locations or implementation schedule is an interesting area that has gained interest in recent times [41] [42] [43] [44] [45].

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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