CALIBRATION AND VALIDATION OF VISSIM SIMULATION: A CASE STUDY OF PRIORITY BUS LANE AT BATU UBAN, PULAU PINANG

CHONG JIA WEI

UNIVERSITI SAINS MALAYSIA

2021

CALIBRATION AND VALIDATION OF VISSIM SIMULATION: A CASE STUDY OF PRIORITY BUS LANE AT BATU UBAN, PULAU PINANG

by

CHONG JIA WEI

Thesis submitted in fulfilment of the requirements for the degree of Bachelor of Engineering (Hons.) (Civil Engineering)

July 2021

Appendix A8

UNIVERSITI SAINS MALAYSIA

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2020/2021

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title : Calibration and Validation of VISSIM Simulation: A Case Study of Priority Bus Lane at Batu Uban, Pulau Pinang.

Name of Student: CHONG JIA WEI

I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

Signature:

____

Date : 4TH AUGUST 2021

Endorsed by:

ASSOC. PROF. DR NUR SABAHIAH ABDUL SUKOR
SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA (ENGINEERING CAMPUS)
14300, NIBONG TEBAL, PULAU PINANG
Tel: ...59561
Email:cesabahiah@usm.my; sabahiah@gmail.com

____

(Signature of Supervisor)

Name of Supervisor:

Date: 5.8.2021

Approved by:

____

(Signature of Examiner)

Name of Examiner: Prof Dr Ahmad Farhan Mohd Sadullah

Date: 5/8/2021

(Important Note: This form can only be forwarded to examiners for his/her approval after endorsement has been obtained from supervisor)

ACKNOWLEDGEMENT

First and foremost, I would like to express my greatest appreciation to my Final Year Project supervisor, Assoc. Prof. Dr. Nur Sabahiah Abdul Sukor for her patience and guidance throughout the project duration. Also, I would like to thank her for providing me the facilities and software such as PTV VISSIM simulation software to further completing my project. Undoubtedly, this dissertation will not be perfectly completed without her continuous assistance. The related knowledge, constructive critics and suggestions provided by her definitely helped me a lot in betterment of this dissertation.

In addition, I would like to express my gratitude to my faculty, School of Civil Engineering, Universiti Sains Malaysia for providing me a conducive learning space. They provided me a golden opportunity to gain the knowledge in Civil Engineering field especially the Highway and Traffic Engineering knowledge which basically aided me in completion of my project.

Last but not least, I am truly grateful to my family members for their unconditional care, love and moral support throughout the duration of this project. Furthermore, I would like to thank all those who have directly and indirectly helped me in the completion of this dissertation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

LIST OF ABBREVIATIONS

CBD	Central Business District
LOS	Level of Service
PCE	Passenger Car Equivalent
PCU	Passenger Car Unit

LIST OF APPENDICES

ABSTRAK

Pembangunan bandar, pertambahan bilangan penduduk dan peningkatan penggunaan kereta yang mendadak telah menyebabkan kesesakan lalu lintas yang memburukkan pencemaran udara dan pelepasan gas rumah hijau. Pulau Pinang sering mengalami kesesakan lalu lintas di jalan-jalan utama terutamanya di pusat bandar pada waktu puncak. Akibatnya, pengangkutan awam selalu mengalami kelewatan masa apabila masa perjalanan meningkat. Isu ini telah mengurangkan keminatan penduduk untuk menggunakan pengangkutan awam. Kajian ini bertujuan untuk mengkaji jumlah komposisi kenderaan di kawasan perhentian bas yang terpilih. Ciri-ciri lalu lintas akan disimulasikan menggunakan VISSIM. Dalam kajian ini, pengumpulan data dilakukan melalui penghitungan kenderaan dan kajian kelajuan kenderaan dari video yang telah dirakam untuk mendapatkan jumlah dan taburan kelajuan kenderaan. Seterusnya, proses verifikasi, kalibrasi dan validasi dilakukan untuk mengaji kemampuan VISSIM untuk mewakili ciri-ciri lalu lintas yang ditunjukkan dalam video tersebut. Model yang telah dikalibrasi digunakan untuk menilai kecekapan lorong keutamaan bas dalam mengurangkan kesesakan lalu lintas. Hasil verifikasi model menunjukkan bahawa kelajuan kenderaan yang disimulasikan tepat mewakili kelajuan satu kenderaan terpilih yang digambarkan dalam video. Hasil kalibrasi model simulasi terbukti dapat mengurangkan perbezaan model simulasi dari senario sebenar yang digambarkan dalam video. Simulasi membuktikan bahawa pengenalan lorong keutamaan bas tidak berkesan dalam kes ini. Oleh itu, kekerapan ketibaan bas di perhentian bas perlu dipertimbangkan sebagai faktor yang mempengaruhi kesesakan lalu lintas pada masa hadapan. Hasil kajian ini akan digunakan sebagai rujukan kepada kerajaan negeri untuk melaksanakan dasar pengangkutan awam untuk mengurangkan kesesakan lalu lintas di negeri Pulau Pinang.

ABSTRACT

Urban sprawl, rapid growth in population and increasing usage of cars have caused higher traffic volumes, leading to traffic congestion which has worsened air pollution and the greenhouse gas emissions. Penang has experienced traffic congestion on many main roads especially in the central business district (CBD) during weekday peak hours. As a result, delays and travel times of public transport have increased which has discouraged the public to use the public transport. This study aims to examine the traffic volume at the selected bus stop area. The traffic characteristics will be simulated using VISSIM. In this study, data collection was conducted through video recording for traffic counting and spot speed study to obtain the number and speed distribution of the vehicle. The data collected was input into VISSIM microscopic simulation software for further simulation. Then, verification, calibration and validation were performed to observe the ability of VISSIM simulation software to represent the traffic characteristics portrayed in the recorded video. The calibrated model was used to simulate and evaluate the efficiency of the introduction of priority bus lane to the original road network. The results of verification show that the simulated average speed of the vehicle accurately represents the speed of one vehicle as identified from the spot speed study. The results of calibration of the simulated model showed minimum deviation of the simulated model from the real scenario portrayed in the provided video. The simulation results prove that the introduction of priority bus lane is not effective for this case study. Therefore, the future study should consider the frequency of the bus arrival on the particular bus stop as a more determinant factor influencing the traffic condition. The findings in this study will be used as a reference for state government to implement public transport policy in reducing state traffic congestion.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The rising number of car ownership has resulted in car dependency and the owner's use of the vehicle. Travel demand is expected to surge at a similar rate with the speed of urbanisation, this has caused transportation issues especially in developing countries (Ashraf, 2013). Between 1960 and 2010, the number of private cars surged from nearly 100 million to over 700 million globally (Davis et al., 2016). Urban sprawl, rapid growth in population and cars have caused higher traffic volumes and surge in vehicular use, leading to traffic congestion which worsens air pollution and greenhouse gas emissions (Alotaibi & Potoglou, 2018).

State	Private Vehicles		Public Service Vehicles (PSV)	Goods Vehicles	Others	Total
	Motorcycles	Cars				
Perlis	84500	26510	385	2007	1365	114767
Kedah	954751	341197	7273	40710	20104	1364035
Penang	1408528	1130601	9586	80254	26710	2655679
Perak	1359771	772591	9534	75638	42708	2260242
Selangor	1423821	1157268	24273	194390	104724	2904476
Federal Territories	1863260	3987468	78752	268340	122509	6320329
Negeri Sembilan	557482	343007	4635	50160	7845	963129
Melaka	472701	344459	3425	28486	8830	857901
Johor	1873005	1498587	20365	153471	66183	3611611
Pahang	600470	392200	4310	45640	14663	1057283
Terengganu	393228	211124	2159	22172	6015	634698
Kelantan	549363	309663	3928	29689	7264	899907
Sabah	402237	697541	9574	116292	65807	1291451
Sarawak	798227	813569	5834	95373	71782	1784785
Business Partner Portals	191698	1263012	1002	3122	2076	1460910
Total	**12933042**	**13288797**	**185035**	**1205744**	**568585**	**28181203**

Table 1.1 Registered motor vehicles by type & state (Malaysia Automotive Association, 2017)

In Malaysia, Penang has the fourth highest number of registered vehicles. Over the last few years, traffic congestion has become much worse. Despite its limited land capacity, as according to the statistic shown in Table 1.1, Penang had the fourth largest number of registered vehicles in Malaysia (2,655,679 vehicles) in 2017, which ranked after the Federal Territories of Kuala Lumpur, Putrajaya and Labuan (6,320,329 vehicles), Johor (3,611,611 vehicles) and Selangor (2,904,476 vehicles) (Lee, 2017).

The number of new registered motor vehicles by type for Penang in 2017 shows that private vehicles have the greatest number of new registrations, which recorded 1,408,528 units for motorcycles and 1,130,601 units for cars. This may prove that the growing number of private vehicles is a direct and primary cause of traffic congestion in Penang (Lee, 2017).

In order to achieve a sustainable transportation goal, the local government must regard this car dependency situation seriously. This is because the majority of Penangites use their vehicles for every trip and destination on a daily basis. Since car owners are reliant on their vehicles and the capacity of roads are limited, traffic congestion will occur. Penang has experienced traffic congestion on certain main roads, particularly in the central business district (CBD), and also on inter-urban roads, during weekday peak hours. As a result of the congestion, delays and travel times have increased (Caisarina, 2008).

According to previous studies, indiscipline behaviours such as distraction increase the likelihood of being involved in an accident that could result in significant traffic congestion. Furthermore, the age group and gender of those who are most prone to engage in such behaviour while driving have been discovered (Simposium et al., 2012).

One of the modes of sustainable transportation is public transport, also known as mass transportation. When compared to private vehicles, it allows for a greater number of passengers to be transported. Bus, rail, and tram are examples of this mode of transportation. With rising fuel prices and air pollution, public transit can help alleviate issues such as traffic congestion and carbon emissions. Congestion not only raises the fuel consumption, but it also raises the level of pollution, endangering the public and the environment (Bagde et al., 2021).

Despite frequent efforts by the authorities and bus operators in Penang, low public transportation usage persists. The current public transportation policy appears to be ineffective, at least in terms of attracting road users to use public transportation instead of private transportation. The majority of respondents are unsatisfied with the general quality of Penang's bus service. A total of 276 people, or 69.35 %, are dissatisfied, and 36.23 % of them use public transportation (Chee & Fernandez, 2013).

The number of buses available for service is insufficient; capacity is limited; reliability is bad; the quality of public transportation facilities is poor; time scheduling is inconsistent; and route coverage is inadequate. The bus stops are also in poor condition (Caisarina, 2008).

Transportation is vital for tourist attraction in Penang. During weekends and festival seasons, the number of tourists will be higher. Congestion occurs when the number of vehicles on a road network exceeds its carrying capacity, which can occur for a variety of causes including poor driving habits and parking on the side of the road (Zainol, 2017).

The traffic congestion is reported to affect the operation of the bus. Typically, assessment of passenger on public transport services is based on their punctuality and availability. Traffic congestion will reduce the vehicle travel speed and increase in travel time, which increase the waiting time at bus stops and will affect the punctuality and reliability of the bus. This will definitely impact the perception of passengers on public transport service (Gierszewski & Koźlak, 2019).

The assessment indicates that many streets covered by buses in Penang are inappropriate for the development of physical bus priority measures, such as bus lanes or high-occupancy vehicle lanes, since the lanes are too narrow. Moreover, motorists' compliance with bus lane near the bus stop affects the number of buses running along these lanes (Aziz & Mohamad, 2020).

The launch of Rapid Penang on 31st July 2007 has resulted in a huge increase in bus usage. The operator took a number of initiatives to improve riders' experiences and the quality of service, including installing air conditioning on buses, maintaining bus hygiene and comfort, and providing Wi-Fi service on selected buses. Regular riders were given incentives in the form of cheap season passes and special fares for students and senior citizens. A headway analysis revealed that Rapid Penang is able to offer bus service on most routes according to schedule, demonstrating the increase in bus service quality. The launch of Rapid Penang led to a noticeable increase in bus ridership, where the bus operator planned to buy another 80 buses to add to its fleet of 150 buses which already dominated major routes in Penang to accommodate the increased bus ridership. Nonetheless, Penang traffic still remains extremely congested. The duration of traffic congestion is also rising, with delays starting as early as 7 a.m. and continuing before 4 p.m. in the afternoon (Chee & Fernandez, 2013).

Bus lanes are key element of bus rapid transit (BRT) systems and can improve traffic operations by separating bus traffic from the mainstream of the traffic. As a result, the operation of BRT systems with dedicated bus lanes is expected to reduce energy consumption and produce less impacts to the environment (Kim et al., 2019).

The introduction of priority bus lane will reduce the duration of the trip, the bus will not be stuck in a traffic jam, and the bus will arrive to the next stop on time. This will encourage people to make the bus as their primary mode of transportation and activity as they become more reliable (Caisarina, 2008).

Bus lanes bring various benefits such as bus operating efficiencies, passenger time savings, increased fare revenues, vehicle travel reduction benefits, for instance, reduced traffic congestion, facility cost savings, traffic safety, energy conservation and vehicle emission reductions (Litman, 2016).

Traffic simulation is an indispensable instrument for transport planners and traffic engineers. VISSIM is a behaviour-based multi-purpose traffic simulation that analyses and optimises traffic patterns at a microscopic level. It integrates public and private transportation to provide a wide range of urban and highway applications. Realistic traffic models are used to show complex traffic conditions in highest level of detail (Wilson et al., 2003).

The previous study demonstrated how simulation tools like PTV VISSIM may be used to simulate and analyse shared space as a potential solution to traffic congestion issues. The planner or engineer can repeat similar efforts by utilising built-in functions inside the existing PTV software package to examine unique shared space concepts. While previous studies have proven the efficiency and safety improvements for pedestrians, this study is one of the first to evaluate the potential congestion benefits of shared space (Frosch et al., 2019).

VISSIM also enables for comprehensive evaluations of these important areas in complicated settings, which often produce results that differ from the Highway Capacity Manual's generalised approach. Various inputs should be calibrated to local conditions in order to produce valid findings. Basic calibration factors for the simulation of traffic situations in an urban freeway merge or diverge scenario were examined in this study. Specific calibration variables for use in VISSIM were produced by gathering and analysing urban freeway traffic data from numerous sources (Dong et al., 2015).

Therefore, this thesis is to verify, validate and calibrate VISSIM based on the traffic congestion at Batu Uban bus stop, Penang. These methods can facilitate the understanding of how the traffic congestion affects the bus service at the bus stop.

1.2 Problem Statement

Penang state has the second highest population density in Malaysia. Georgetown is the major urban centre on the island as the administrative centre, and Butterworth and Bukit Mertajam on the mainland. Being one of the earliest most establish urban centres in Malaysia Penang has grown and on the 21st century remains a thriving commercial and industrial centre.

The number of cars in Penang is increasingly every year. Once a household own a car, the intention to use it for their mobility will be the top priority rather than to use the bus. Frequently their mobility is to work, take and drop the children for school, shopping, leisure, sport and so on. Many road users in Penang still do not prefer public transport as their main mode of transportation due to the long waiting time and travel time of public transport, which is time consuming as compared to private vehicle. With more people using their own private cars, there will be an increase in the rate of traffic congestion and worsen the traffic condition in Penang.

Public service transport is essential in order to overcome the worsening traffic condition in Penang. This is because public transport is able to carry many more passengers or road users as compared to private vehicle. This will definitely reduce the number of vehicles thus reducing the traffic congestion on the road in Penang.

Besides, the introduction of priority bus lane will definitely improve the bus service by shortening the travel time and waiting time of the bus. This is because the priority bus lane allows the bus to travel without the interruption of the other vehicles especially during the traffic congestion. The priority bus lane will also improve the safety of the bus service where the bus is free to stop at the bus stop without blocking the following traffic, the passengers are free to board and alight from the bus without the interruption of the other vehicles.

Consequently, the traffic congestion will cause the bunching of vehicle around the area of the bus stop or along the bus service line. This will definitely cause the delay of bus service. This will definitely impact the bus passengers especially those from the lower income group who depends much on the bus service.

Therefore, traffic simulation is crucial to portray the traffic condition on the desired location. Traffic simulation is an essential instrument for transport planners and traffic engineers to plan the transportation system precisely. Before the use of traffic simulation software, verification, calibration and validation is vital to ensure the software shows the accurate simulation close to the actual condition of the desired location.

In short, this study will focus on verification, calibration and validation of VISSIM microscopic simulation software to observe the traffic characteristics at the bus stop area. Also, the inclusion of priority bus lane to the road network will be considered to observe the influence of the priority bus lane on the traffic flow.

1.3 Objectives

1. To examine the traffic volume at the selected bus stop area.
2. To verify, calibrate and validate the VISSIM software towards the real condition at the selected bus stop area.
3. To simulate the addition of priority bus lane at the selected bus stop area.

1.4 Scope of Work

The scope of work of this study is to utilise the secondary data of traffic flow at the selected bus stop area which located at Jalan Sultan Azlan Shah, Batu Uban, Pulau Pinang in 2018. The time period of data collection is from 6:30 a.m. to 9:30 a.m. for morning peak hour and from 5:30 p.m. to 7:00 p.m. for evening peak hour for one selected day. The data collection will be conducted by video counting and spot speed study from the recorded video. The data collected will be input into VISSIM microscopic simulation software for further simulation. Then, verification, calibration and validation will be performed to observe the ability of VISSIM simulation software to represent the real life scenario presented in the recorded video.

1.5 Significance of Study

The significance of this study is to demonstrate the relationship between the reduction in traffic and the bus operation around the bus stop area in Penang Island by using VISSIM. Nowadays, the growing population in Penang leads to the increase in number of private vehicles. Nonetheless, the restricted area in Penang has restrained the development of road network, causing the growing capacity of the road network unable to feed the rapid growth of the number of road users and private vehicles in Penang. Therefore, there is a need to propose a solution to reduce the usage of private vehicles, hence increase the service reliability of the bus service by reducing the traffic volume especially around the bus stop area, for instance, the provision of priority bus lane. Thus, this will encourage more mode shift from private vehicles to public transport. Moreover, the other significance of this study is to prove the efficiency for calibrating and validating the VISSIM model.

1.6 Dissertation Outline

This study report consists of five chapters. Chapter 1 is the introduction including background of study, problem statements, objectives, scope of work and significance of study. Chapter 2 is literature review focusing on traffic simulation using VISSIM, factors affecting the operation of the bus and other related studies. This chapter will provide relevant information for research background, methodology and discussion. Chapter 3 is the methodology which explains the procedures for data collection and analysis. Chapter 4 is result and discussion section that presents the data analysis through simulation using VISSIM software. Last but not least, Chapter 5 concludes the findings and recommendations from this study. This research is expected to obtain the number and percentage distribution of each class of the vehicle, the minimal percentage error of the simulated model as compared to the field values and the average speed of the traffic flow at the bus stop area after the introduction of priority bus lane.

CHAPTER 2

LITERATURE REVIEW

2.1 PTV VISSIM

PTV VISSIM is a microscopic simulation program for modelling multimodal transport operations and belongs to the Vision Traffic Suite software. PTV VISSIM is realistic and accurate in every detail by creating the best conditions to simulate and test different traffic scenarios before their realization in the real world. PTV VISSIM is now being widely used by the public sector, consulting firms and universities globally (PTV AG, 2021).

PTV VISSIM is a microscopic, time step oriented, and behaviour-based simulation tool for modelling urban and rural traffic including pedestrian flows. Besides private transportation, rail and road based public transportation may also be modelled. The traffic flow is simulated under various constraints of lane distribution, vehicle composition, signal control and the recording of private and public transportation (PTV AG, 2021).

2.2 Factors Affecting the Operation of the Bus

2.2.1 Traffic Congestion

The traffic congestion is reported to affect the operation of the bus. Traffic congestion will increase the waiting time at bus stops which will affect the punctuality and reliability of the bus. There is a direct relationship between operating speeds and patronage: a 10% reduction in speeds will decrease the patronage by minimum of 10%. The increased congestion will cause a rise in average headway, leading to bunching of buses. The impact on headway reliability was more significant with the higher level (10%) of congestion (A, 2009). The traffic congestion also affects the operation of the bus in many ways, such as raising the bus operating costs and higher fares and higher in-vehicle time (Begg, 2016).

The previous analysis shows that both bus stream and non-motorised stream have significant effects on car delay (Xiaobao et al., 2013). Congestion is unavoidable when the number of vehicles surpasses the capacity of a road, this is due to illegal roadside parking and bad driving habits (Zainol, 2017). Congestion and high passengers' demand can reduce bus service's reliability and availability. For instance, the assessment indicates that many streets covered by buses in Penang are inappropriate for the development of physical bus priority measures, such as bus lanes or high-occupancy vehicle lanes, since the lanes are too narrow. Moreover, motorists' compliance with bus lane near the bus stop affects the number of buses running along these lanes (Aziz & Mohamad, 2020).

2.2.2 The Design of the Bus Stop

The design of the bus stop will also affect the operations of multitype road users. The bus stop which contains the shared vehicle and bus lane has the highest reduction on vehicle speed, since the arrival of bus at the bus stop occupies the vehicle travel lane, blocking the incoming traffic. The average vehicle speed is reduced by 6.82 km/h. Nonetheless, this type of bus stop has reduced bus's stopping and leaving time since the bus can stop and merge into the traffic in the shortest time, and less affected by other road users (Zhang et al., 2018).

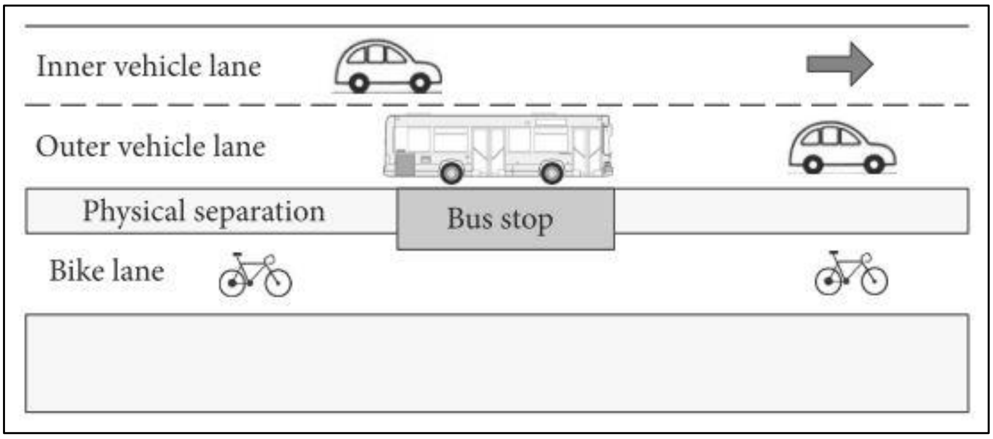

Figure 2.1 Bus Stop Which Contains the Shared Vehicle and Bus Lane (Zhang et al., 2018)

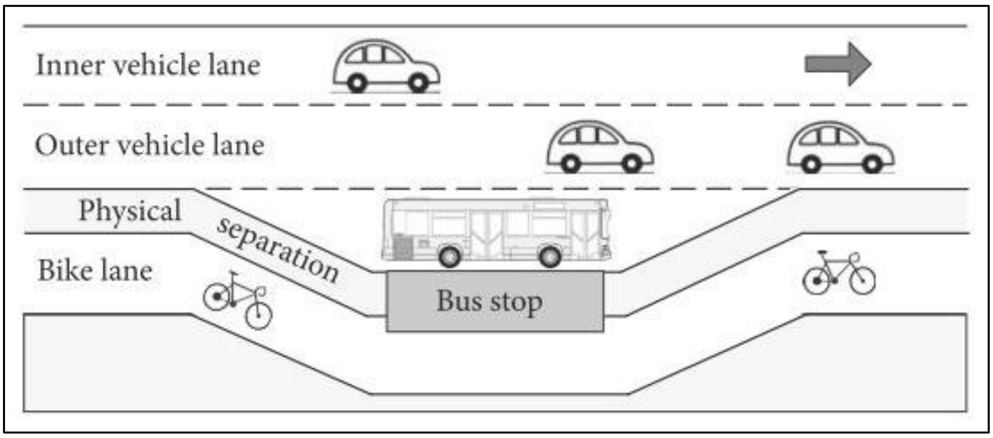

Figure 2.2 Bus Stop Which Contains a Bay Design (Zhang et al., 2018)

Whereas, for the bus stop which contains a bay design. The stop only reduces the vehicle speed by 2.19 km/h which is much smaller. The bus can stop easily at this type of bus stop, but having problems merging into the traffic lane (Zhang et al., 2018).

Also, another study suggests that obstructing exit of the bus stop is the main impact on delays at bus stop, especially when a bus is trying to merge into traffic lane from a bus stop (with bus bay) and due to the operation of a traffic signal in the same lane of bus stop (without bus bay) (Fernandez & Tyler, 2005). The other study recommends that at bus volumes above 200 vehicles per hour, the bus stop (without bus bay) is unreasonable because of the long car delays. Hence, bus bay design should be considered (Xiaobao et al., 2013).

2.2.3 The Design of the Road Near the Bus Stop

The mixed traffic flow between urban cars and bus impacts the operation status of bus near the bus stop. Therefore, the design of bus lanes and bus bay stops will minimize road traffic volume on bus stop influence zone (Pan et al., 2019). A study had suggested that an efficient bus service should consist of accessible bus route network which have a short travel distance (Hamid & Noh, 2015). While the other study suggested that public bus service is efficient and sustainable when the highway is 6 lanes, the road consisted of 2 lanes of 2 ways and there is bus and taxi lane on the road. This is because these factors will affect bus reliability (Bachok et al., 2018).

Besides, the introduction of transit lanes to the road will free up roads used by buses. Thus, the travel time of the buses will be greatly reduced. Also, these transit lanes will encourage private vehicle users to switch to buses when the lanes are dedicated for buses and motorcycles only and only one lane for cars. This will indirectly reduce the number of private vehicles within that particular area (Tan, 2019).

2.3 Verification

Verification is defined as the "process of determining that a calculation method implementation accurately represents the developer's conceptual description of the calculation method and the solution to the calculation method" (International Standards Organization, 2008). Another study defines verification as the process of ensuring that the model design has been transformed into a computer model with sufficient accuracy, in other words, building the model right (Carson, 2002).

Verification of a simulation model should be done before validation because the verification process is not connected to data. The validation process must consist of the results from verification and therefore come after verification. The process of verification checks how close the code output is to the true solution of the mathematical equation (Sankararaman & Mahadevan, 2015).

Verification is concerned with detecting and removing errors in the model by comparing numerical solutions to analytical or highly accurate benchmark solutions. This is important to identify and eliminate programming and implementation errors within the software (software quality assurance) and to verify the correctness of the numerical algorithms that are implemented in the code (Thacker et al., 2004).

Model verification deals with the detection and elimination of errors in the model by comparing simulation model outcomes to practical solutions from the real-world situation. Thus, the purpose of model verification processes, which deal with logical relationships within, and simulation specifications associated with the model, can be seen as being to ensure the simulation model is complete and correct (Yin & McKay, 2018).

2.4 Calibration

Calibration is defined as the "process of adjusting modelling parameters in a computational model for the purpose of improving agreement with experimental data" (International Standards Organization, 2008). Another study defines calibration consists of determining the physical and operational characteristics of an existing system and determining the data when input to the computer model will yield realistic results (Thacker et al., 2004).

Previous study recommended a seven-step general calibration procedure as follows: first, identification of the intended use of the model, determination of initial estimates of the model parameters, collection of calibration data, evaluation of the model results; , macro-level calibration, sensitivity analysis and micro-level calibration (Sanz & Software, 2014). Calibration is important to generate better agreement between the experiment and the model (Thacker et al., 2004).

2.4.1 Calibration of VISSIM for Bus Rapid Transit Systems in Beijing Using GPS Data

The previous study has presented an approach for calibrating the microscopic simulation model VISSIM for bus rapid transit systems using GPS data. The Sum of Squared Error (SSE) of the collected and the simulated vehicle speeds at the cross-sections was well-defined as the evaluation index. The calibration is to find the best combination of the parameters to minimize the SSE, and a Genetic Algorithm is to optimise the search process. A computer program is utilised to integrate the MATLAB, Visual Basic, and VISSIM to improve the calibration. The proposed approach is proven efficient for calibrating the VISSIM model (Yu et al., 2006).

2.4.2 Calibration of VISSIM for Shanghai Expressway Using Genetic Algorithm

The previous study explains the methodology and results of the calibration of a model of an 8.4 km segment of the North-South Shanghai Expressway. The calibration is performed with the reference of field data from the Traffic Information Collecting System in Shanghai. The parameters for calibration are chosen corresponding to the characteristics of traffic flow of expressway and experiences. The chosen parameters for calibration are desired lane change distance, waiting time before diffusion, average desired distance between stopped cars, headway time as a function of speed and safety distance allowed before the driver moves closer to the vehicle ahead. The validation of the calibrated models is performed using vehicle speeds. The results from runs utilizing the default parameter values, optimized parameter values and the actual field data are compared at 8 different data collection sites. The absolute average difference between measured and simulated speeds before and after calibration are 1.86 % with root mean square (RMS) error of 3.88 and 0.84 % with RMS error of 2.09, respectively. This indicates that the calibration using the genetic algorithm can generate more accurate results than the default VISSIM parameter values (Zhizhou et al., 2005).

2.4.3 Microscopic Simulation Model Calibration and Validation, Case Study of VISSIM Simulation Model for a Coordinated Actuated Signal System

The previous study introduces 9 main processes for calibration and validation of a simulation model from a 12-intersection section of highway in Fairfax, Virginia with an actuated signal system, which are measure of effectiveness selection, data collection, calibration parameter identification, experimental design, simulation runs, surface function development, candidate parameter set generations, evaluation, and validation through new data collection. The adjustments of parameters during calibration should follow field-measured conditions and user's justification. The 7 parameters decided for calibration are emergency stopping distance, lane-change distance, desired speed distribution, number of observed preceding vehicles, average standstill distance, waiting time before diffusion and minimum headway. The selected parameter sets maximum queue length at an intersection for validation and compared to the obtained field data. It was observed that the field maximum queue length was within the top 10% of the simulated distribution. This calibration method used was proven more effective in imitating the field conditions than the default values (Park & Schneeberger, 2003).

2.4.4 Calibration and Validation of VISSIM Model of an Intersection with Modified Driving Behavior Parameters

The previous study suggested a procedure for microscopic simulation model calibration and validation. The proposed procedure is effective in the calibration and validation for VISSIM for signalized intersections. Two key matters were encountered during the implementation of calibration and validation procedure. The first issue dealt with statistical testing when claiming the calibrated model was equal to the field data. The second issue was the importance of visualization in the calibrations process. The study only utilized a single day of data collection and two measures of performance (Dey et al., 2018).

2.5 Validation

Validation is defined as the "process of determining the degree to which a calculation method is an accurate representation of the real world from the perspective of the intended uses of the calculation method" (International Standards Organization, 2008). Another study defines verification as the process of ensuring that the model is sufficiently accurate for the purpose at hand in other words, building the right model (Carson, 2002).

After the verification process, the model simulation must be validated. The validation process requires a comparison between simulation results and experimental results. To quantify the model form uncertainty during the validation process (Roy & Oberkampf, 2011).

Model validation evaluates how accurate the simulation model is as a depiction of a real-world system for the purpose of simulation. Model validation processes quantify the accuracy of the model by comparing simulation results to experimental or operational outcomes (Yin & McKay, 2018).

Validation deals with the physics associated with the model. Validation is crucial to quantify confidence in the predictive capability of the model by comparison with experimental data. Validation are done to produce high-quality data to assess the precision of a model prediction (Thacker et al., 2004).

The previous study evaluated the calibrated models with a new set of data under untried conditions, including the input volumes, traffic composition, and other required data. The Geoffrey E. Heaver (GEH) statistic is adopted to compare field traffic volumes with those taken from simulation data (Dey et al., 2018).

The previous study had established method for calibration based on neural network model on urban road network in the city of Osijek, Croatia and validated on the urban road network of another city, city of Rijeka which has very different characteristics due to specific geographical and topographical conditions and different driver behaviour as well. Results of travel time modelling with calibrated model demonstrate great level of compatibility with results measured in situ both for route used for calibration (direct route) as well as for the route used for validation (indirect route). The fact proves that calibration process was successful, and that applied calibration method can be applied also for other urban road network (Otković et al., 2020).

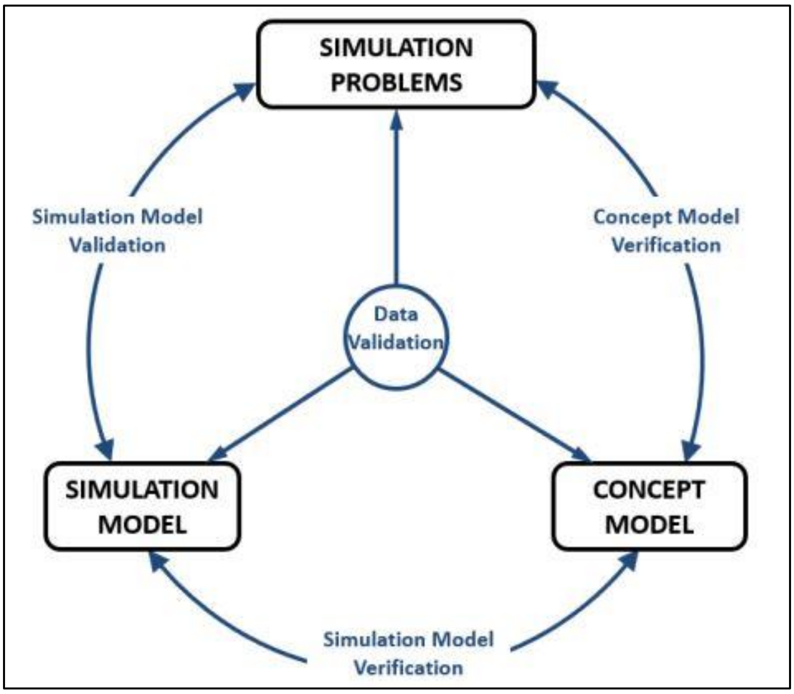

Figure 2.3 Model verification and validation architecture (Yin & McKay, 2018)

2.6 Traffic Simulation Using VISSIM

Previous study utilizes VISSIM simulation software to assess the common influence of bus arrival frequency and nonmotor vehicle traffic volume on traffic flow in bus stop area. Three types of stations are chosen for simulation research. They are the linear type stop located next to the nonmotor vehicle lanes, the linear type stop that the nonmotor vehicle lane bypasses after the platform and the harbour type stop located next to the nonmotor vehicle lane. Finally, a suitable station type optimization plan is proposed according to the simulation results (Pan et al, 2018).

The other study utilizes VISSIM to assess the environmental benefits of median bus lanes, the simulation will reveal environmental impacts incurred by smoother traffic flow in both the dedicated bus lanes and general-purpose lanes. The simulation results of the corridors with and without median bus lanes, revealing that the speeds of both transit buses and general-purpose lane vehicles increase significantly when median bus lanes are operated. To be specific, the speed increase for general-purpose lane vehicles is 50.2% (Kim et al., 2019).

There is another study which proposed the use of VISSIM with an additional logic script to evaluate the practicality of implementing the dynamic bus lane concept. In the mentioned study, three options were analysed, which were no bus lane, standard exclusive bus lane and dynamic bus lane. Simulation model parameters were calibrated using a genetic algorithm. The results indicate that the dynamic bus lane could bring the same benefits to public transport and slightly increase the travel times of private transport as compared to exclusive bus lane (Szarata et al., 2021).

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter will present and explain the methodology used in order to achieve the objectives of this study. The overall methodology of this study is summarised in the flow chart as follows:

LITERATURE REVIEW & BACKGROUND STUDY
• Understanding the characteristics of traffic condition in Penang. • Understanding the correlation between traffic congestion and bus service. • Verification, calibration and validation methods for simulation models using VISSIM. • Understanding the effects of priority bus lane on the traffic flow.

↓

DATA COLLECTION	
Area of study	**Time of data collection**
Three-lane road in front of the bus stop near pedestrian bridge at Jalan Sultan Azlan Shah, Batu Uban, Pulau Pinang	AM Peak : 6:30 a.m. to 9:30 a.m. PM Peak : 5:30 p.m. to 7:00 p.m.
Traffic volume determination	**Speed determination**
Counting the vehicles from the recorded videos.	Spot speed study from the recorded videos.

↓

DATA ANALYSIS
• Determination of the number and percentage distribution of each class of the vehicle. • Determination of the morning and evening peak hour. • Determination of the speed distribution of vehicle for specific direction and time frame.

↓

VERIFICATION, CALIBRATION AND VALIDATION OF MODEL		
Verification	**Calibration**	**Validation**
Results from the analysis were input into VISSIM and the comparison was made.	The parameters and settings in VISSIM were adjusted close to the results from the analysis.	Default setting and calibrated setting were compared in VISSIM.

↓

SIMULATION USING THE CALIBRATED MODELS
• Determination of the average speed for the specified case involving priority bus lane: – Replacing left lane of Direction A with priority bus lane. – Adding priority bus lane beside left lane of Direction A.

↓

PRESENTATION OF RESULT
• Statistics and results of the simulation from VISSIM were presented.

↓

CONCLUSION AND RECOMMENDATION

Figure 3.1 Flow chart of methodology

3.2 Area of Study

The area of study is a three-lane road situated in front of the bus stop which located near pedestrian bridge at Jalan Sultan Azlan Shah, Batu Uban, Pulau Pinang. The particular bus stop is a Rapid Penang bus service station which serves for 102, 301, 303, 304 and 401 service line. The mentioned bus stop is designed without bus bay and located beside a highway where vehicles travel at a relatively higher speed. Therefore, when the bus stops in front of the mentioned bus stop, the following vehicles must slow down and eventually stop to wait until the bus leaves. This may be dangerous to the vehicles especially vehicles on the highway. This study aims to investigate the feasibility of adding bus lanes to smoothen the traffic flow.

Figure 3.2 Location of three-lane road (area of study) (green), bus stop (red) and observation point where video was captured (orange) (Google Map)

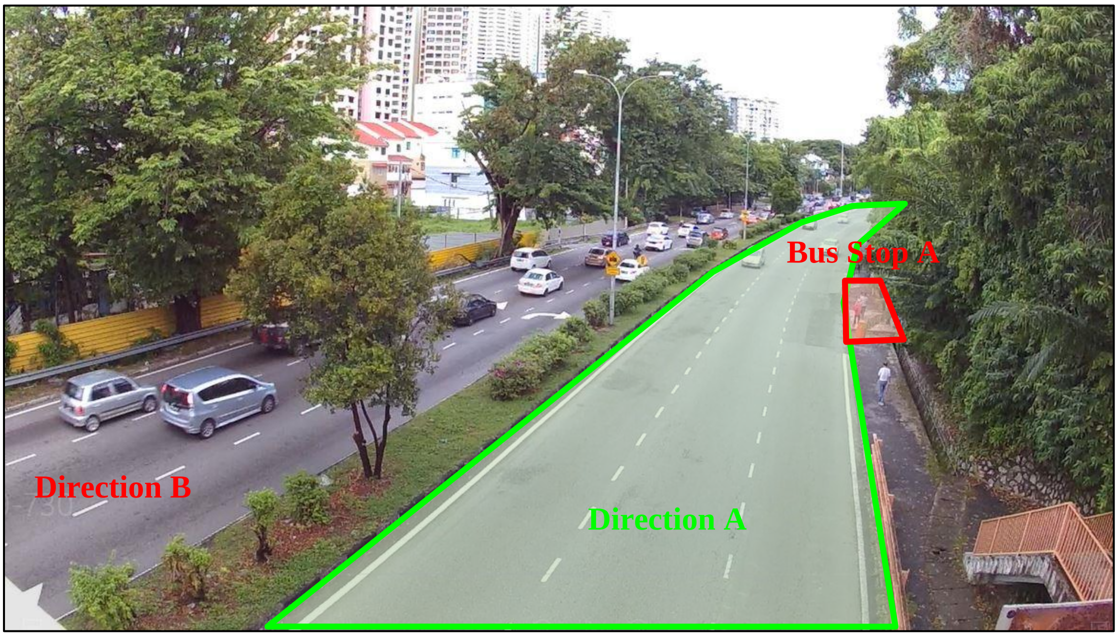

Figure 3.3 Location of three-lane road (area of study) (green) and bus stop (red) in the video

3.3 Method of Data Collection

3.3.1 Traffic Counting

Traffic counting is a count of vehicular traffic, which is performed along a selected road, path or intersection. In this study, the traffic counting was performed through video counting, where manual counting was done by assigning a person to record the traffic flow as the vehicles passed through a particular section in the recorded video.

The recorded video was taken in 2018 from an observation point located on the pedestrian bridge. The view covered both directions of a two-way three-lane road which located in front of the selected bus stop as shown in Figure 3.4. The time frame of the video consisted of morning peak hour which started from 6:30 a.m. to 9:30 a.m. and evening peak hour which started from 5:30 p.m. to 7:00 p.m.

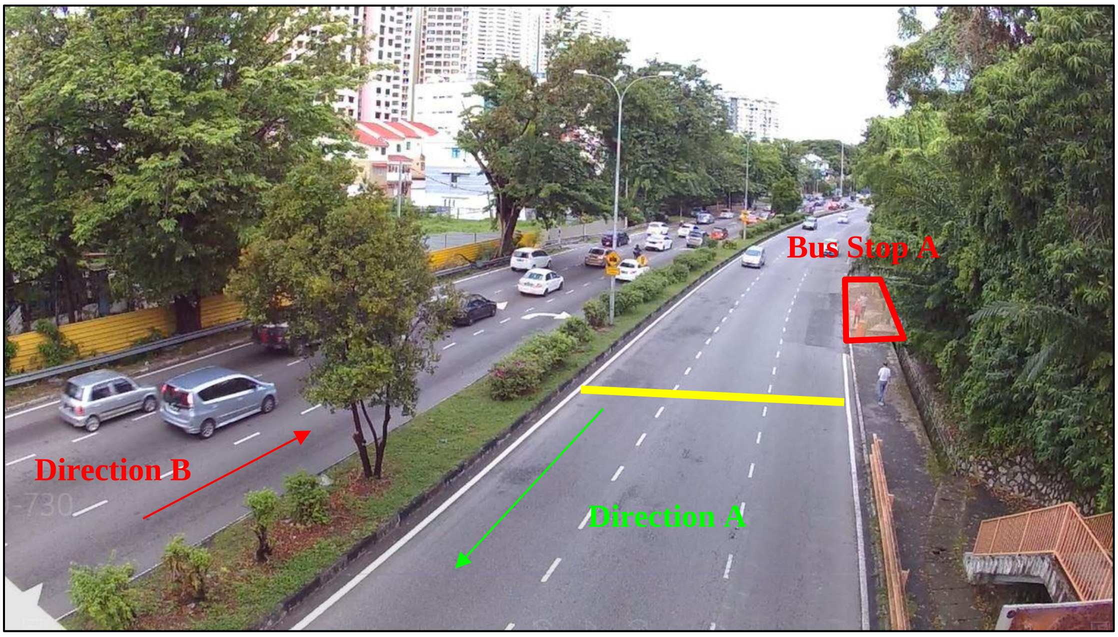

Figure 3.4 The view covered both directions in the provided video and reference line (yellow) for traffic counting

Nonetheless, the results for 9:00 a.m. to 9:15 a.m., 9:15 a.m. to 9:30 a.m., 6:30 p.m. to 6:45 p.m. and 6:45 p.m. to 7:00 p.m. were discarded since the videos provided were less than 15 minutes in these four intervals.

The video counting was performed by assuming a reference line across the road (Figure 3.4). Any vehicle passed by this reference line was counted as one unit of vehicle. In this study, the vehicles were classified into five classes as shown in Table 3.1. The total number of each class of the vehicle was recorded in 15 minutes interval.

Table 3.1 Classifications of vehicles

Vehicle Class	Type of Transport
1	Cars, Small Vans, Utilities
2	Large Vans, Lorries (with 2 axles)
3	Large Lorries, Trailers, Heavy Vehicles (with 3 axles and more)
4	Buses
5	Motorcycles

3.3.1.1 Determination of Morning Peak Hour and Evening Peak Hour

The results obtained from the traffic counting were calculated where each class of the vehicle was converted to Passenger Car Unit (PCU) using the Passenger Car Equivalent (PCE) as provided by Arahan Teknik (Jalan) 13/87 as shown in Table 3.2.

Table 3.2 PCE of each class of the vehicles (Source: Arahan Teknik (Jalan) 13/87)

Vehicle Class	PCE
1	1.00
2	1.75
3	2.25
4	2.25
5	0.33

The highest volume (in PCU) from the four preceding 15 minutes intervals was the peak hour for that particular section and time frame.

3.3.1.2 Percentage Distribution of Vehicles

The results obtained from the traffic counting were calculated where each class of the vehicle was divided by the total number of the vehicles that passed by the mentioned section to obtain the percentage distribution of each class of the vehicle.

3.3.2 Spot Speed Study

The speed of each class of the vehicle was determined through the spot speed study from the video provided. The objective of the spot speed study is to determine the speed distribution of a traffic flow at a specified time frame and location.

First, the location and distance desired for the spot speed study were outlined. The location chosen should be clear and easily spotted where the starting line and the finishing line were outlined clearly. The distance desired was 29.4 m which was the distance between the bus stop and the staircase of the pedestrian bridge. The 29.4 m