# BUS RAPID TRANSIT AT ISOLATED VEHICLE ACTUATED JUNCTION USING RECALL AND GREEN EXTENSION BUS PRIORITY STRATEGY

INTAN NURFAUZIRAH SHAFIQAH BINTI HAMZANI

A project report submitted in partial fulfilment of the

requirements for the award of the degree of

Master of Engineering (Transportation)

School of Civil Engineering

Faculty of Engineering

Universiti Teknologi Malaysia

JANUARY 2019

## DEDICATION

Specially dedicated to my parents, Hamzani bin Zainudin and Fauziah binti Elias, who have supported me throughout my master's journey.

## ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to my supervisor, Dr Sitti Asmah binti Hassan of Universiti Teknologi Malaysia from School of Civil Engineering for her advices, guidance as well as her suggestions throughout the completion of this project. I would also like to express my gratitude to the Information Technology Unit staffs of School of Civil Engineering Laboratory especially Mrs. Nurhayati binti Azhar and Mr Abdul Khalil bin Abdollah for his cooperation as well as his assistance during my simulation work in the computer laboratory.

I would also like to thank my course mate Ramzi for his help and support in completing this project. Besides that, I would also like to express my gratitude to my family members especially my parents, Hamzani bin Zainudin and Fauziah binti Elias for their moral support and encouragement during the completion of this project.

Last but not least, I would like to convey my greatest appreciation to others who have helped and contributed directly and indirectly in the successful completion of this project.

## ABSTRACT

The mode split of public transportation usage in Johor Bahru has been disappointingly low. This research highlights the concept of public transport implementation to reduce the number of private vehicles on the road in Jalan Bukit Impian, Johor Bahru. Therefore, Bus Rapid Transit (BRT) had been suggested as the alternative to improve public transportation as public transportation is well-known to have high quality of service. The objectives of this study were to determine performance of BRT as well as the financial benefit of different BRT scenarios. Three different BRT scenarios with varying modal split created where scenario 2,3 and 4 consists of 16:84, 38:62 and 46:54 ratio of public transportation to private transportation. The research implements the use of exclusive bus lane and bus priority strategy by recall and green extension method. Average delay time and average travel time was used to assess the performance of the network and the total delay cost is used to assess the financial benefits of BRT implementation. The results. The results were compared between the base case and the BRT scenarios. It was discovered that the implementation of BRT in the study area has no benefits in terms of average delay and travel time. However, in terms of total delay costs, Scenario 4 with 46% public transportation and 54% private transportation has the lowest total delay cost, which is up to 20.43% of savings. It can be concluded that, the objectives of the research in determining the performance and financial benefits of implementing BRT had been fulfilled.

# ABSTRAK

Mod pecahan penggunaan pengangkutan awam di Johor Bahru adalah sangat rendah. Kajian ini mengetengahkan konsep pelaksanaan pengangkutan awam untuk mengurangkan bilangan kenderaan persendirian di jalan raya di Jalan Bukit Impian, Johor Bahru. Oleh itu, Transit Aliran Bas (BRT) telah dicadangkan sebagai alternatif untuk memperbaiki penggunaan pengangkutan awam kerana ia merupakan pengangkutan awam terkenal dengan kualiti perkhidmatannya yang tinggi. Objektif kajian ini adalah untuk menentukan prestasi BRT serta faedah kewangan yang diperolehi dengan pelaksanaan BRT. Tiga BRT berbeza senario dengan pelbagai mod pecahan yang diwujudkan di mana senario 2,3 dan 4 terdiri daripada nisbah 16:84, 38:62 dan 46:54 pengangkutan awam dengan kenderaan persendirian. Penyelidikan ini melaksanakan penggunaan lorong bas eksklusif dan strategi keutamaan bas seperti panggilan semula dan kaedah sambungan hijau. Purata kelewatan masa perjalanan dan purata masa perjalanan telah digunakan untuk menilai prestasi rangkaian dan jumlah kos kelewatan digunakan untuk mentaksir manfaat kewangan pelaksanaan BRT. Hasil perbandingan keputusan antara model keadaan semasa dan senario BRT telah mendapati bahawa pelaksanaan BRT di kawasan kajian tidak mempunyai manfaat segi purata kelewatan dan masa perjalanan. Walau bagaimanapun, dari segi kos jumlah kelewatan, senario 4 yang terdiri daripada 46% pengangkutan awam dan 54% kenderaan persendirian mempunyai kos jumlah kelewatan keseluruhan paling rendah dengan pengurangan kos sehingga 20.43%. Maka dapat disimpulkan bahawa objektif kajian dalam menentukan prestasi dan manfaat kewangan untuk melaksanakan BRT sudah dipenuhi.

## TABLE OF CONTENTS


| | TITLE | PAGE |
|---|---|---|
| | **DECLARATION** | **iii** |
| | **DEDICATION** | **v** |
| | **ACKNOWLEDGEMENT** | **vi** |
| | **ABSTRACT** | **vii** |
| | **ABSTRAK** | **viii** |
| | **TABLE OF CONTENTS** | **ix** |
| | **LIST OF TABLES** | **xvii** |
| | **LIST OF FIGURES** | **xx** |
| | **LIST OF ABBREVIATIONS** | **xxiii** |
| | **LIST OF APPENDIX** | **xxiv** |
| **CHAPTER 1** | **INTRODUCTION** | **1** |
| 1.1 | General | 1 |
| 1.2 | Problem statement | 2 |
| 1.3 | Research questions | 3 |
| 1.4 | Aims and Objectives | 3 |
| 1.5 | Scope of Work | 4 |
| 1.6 | Importance of study | 5 |
| 1.7 | Limitations of study | 5 |
| 1.8 | Report Outline | 5 |
| **CHAPTER 2** | **LITERATURE REVIEW** | **7** |
| 2.1 | Introduction | 7 |

2.2 Transportation in Johor Bahru 7

2.3 Public Transport System Characteristics 9

2.4 What is BRT? 10

2.5 Characteristics of Bus Rapid Transit 11

2.5.1 Dedicated running ways 12

2.5.2 Stations 12

2.5.3 Vehicles 13

2.5.4 Off-vehicle fare collection 14

2.5.5 Frequent all-day service 14

2.5.6 ITS Applications 14

2.6 Bus Priority at Intersection 15

2.6.1 Passive priority 15

2.6.2 Active priority 15

2.7 Bus Priority Methods 15

2.7.1 Extension and Recall Methods 16

2.7.2 Stage Re-ordering 16

2.7.3 Stage skipping 16

2.8 Traffic Control Strategies 17

2.8.1 Pretimed control (fixed time) 17

2.8.2 Vehicle Actuated 17

2.8.2.1 Fully-actuated control 18

2.8.2.2 Semi-actuated control 19

2.9 Detectors 19

2.9.1 Inductive loop detectors 19

2.9.2 Magnetic detector 20

2.10 Microsimulation Software 20

2.10.1 PTV VISSIM 21

2.10.2 PARAMICS (Parallel Microscopic Simulation) 21

2.10.3 CORSIM (Corridor Simulation) 22

2.10.4 VisVAP 24

2.11 Measure of effectiveness 25

2.11.1 Delays 25

2.11.2 Economic Assessment 26

2.11.3 Total Delay Cost- Relative Value of Time 28

2.12 Case studies 29

2.12.1 Australasian 29

2.12.2 Guangzhou, China 30

2.12.3 Bogota, Colombia 30

2.13 Summary 31

**CHAPTER 3 METHODOLOGY 33**

3.1 Introduction 33

3.2 Site Selection 34

3.3 Data collection on-field 36

3.3.1 Traffic Volume Data 36

3.3.1.1 Total Traffic Volume 36

3.3.1.2 Intersection Peak Hour Volume 37

3.3.1.3 Peak Hour by Approach 37

3.3.2 Vehicle Composition 37

3.3.3 Speed 37

3.4 Data Preparation 38

3.4.1 Traffic Volume 38

3.4.2 Desired Speed Distribution 38

3.4.3 Vehicle Composition 39

3.4.4 Signal Phasing Data 39

3.4.5 VisVAP coding 40

3.4.6 Vehicle Following Characteristics 41

3.4.7 Lane change behaviour 41

3.4.8 Simulation runs 42

3.5 Base case model development 42

3.5.1 Model Error Checking 43

3.5.2 Calibration and Validation 43

3.5.2.1 Traffic Flow 45

3.5.2.2 Speed 46

3.6 Alternative Scenarios 46

3.6.1 BRT Layout 46

3.6.2 Road user modal split and vehicle composition 47

3.6.2.1 Scenario 2 47

3.6.2.2 Scenario 3 47

3.6.2.3 Scenario 4 48

3.6.3 Traffic Signal Data 48

3.6.4 VisVAP coding 49

3.7 Evaluation 49

3.7.1 Vehicle Delay 49

3.7.2 Average Travel Time 50

3.7.3 Level of Service (LOS) 50

3.7.4 Economic Evaluation 51

3.7.5 Relative Value of Time 51

3.8 Summary 52

**CHAPTER 4 RESULT AND DISCUSSION 53**

4.1 Introduction 53

4.2 Site Selection 53

4.3 Data Collected on-Field 55

4.3.1 Traffic Volume Data 55

4.3.1.1 Total Traffic Volume 55

4.3.1.2 Intersection Peak Hour Volume 56

4.3.1.3 Peak Hour by Approach 57

4.3.2 Vehicle composition 61

4.3.3 Speed 61

4.4 Initial Modelling: Base Case Model 62

4.4.1 Traffic Volume for VISSIM Input 62

4.4.2 Vehicle Composition 64

4.4.3 Desired Speed Distribution 65

4.4.4 Traffic Signal Data 67

4.4.5 VisVAP flow chart 68

4.4.6 Vehicle Following Characteristics 69

4.4.7 Lane change behaviour 70

4.4.8 Simulation Runs 71

4.5 Base case model development 71

4.5.1 Acceleration Pattern 71

4.5.2 Calibration and Validation 73

4.5.2.1 Traffic Flow 73

4.5.2.2 Speed 74

4.6 Alternative Scenario 75

4.6.1 BRT Layout 75

4.6.2 Road user mode split and vehicle composition 76

4.6.2.1 Scenario 2 76

4.6.2.2 Scenario 3 77

4.6.2.2 Scenario 4 79

4.6.3 Traffic Signal Data 80

4.6.4 VisVAP coding 81

4.7 Results 82

4.7.1 Vehicle Delay 82

4.6.2 Vehicles affected by delay 85

4.6.3 Average Travel Time 86

4.6.4 Level of Service (LOS) 89

4.5.5 Economic Evaluation 92

4.5.6 Total Delay Cost- Relative Value of Time 92

4.6 Summary 93

**CHAPTER 5 CONCLUSION 95**

5.1 Introduction 95

5.2 Significant Findings 95

5.2.1 Objective 1: To determine the effects of BRT on vehicle delay and travel time 95

5.2.2 Objective 2: To evaluate the economic effect of implementing BRT 96

5.3 Recommendation for future study 97

**REFERENCES** **99**

**APPENDIX** **105**

Appendix A Traffic Flow 105

Appendix B Base case VisVAP flow chart and coding 117

Appendix C Base case data collection 121

Appendix D Traffic Flow of BRT scenarios 135

Appendix E Vehicle volume and traffic composition of BRT scenarios 141

Appendix F BRT scenarios VisVAP flow chart and coding 147

Appendix G Delay results 155

Appendix H Travel time results 161

Appendix I Level of service (LOS) results 167

## LIST OF TABLES


| TABLE NO. | TITLE | PAGE |
|---|---|---|
| Table 2.1 | Desired condition for urban transit development | 9 |
| Table 2.2 | Urban Running Ways | 12 |
| Table 2.3 | Summary of Microscopic Program features | 22 |
| Table 2.4 | Relative value of time for various modes | 28 |
| Table 3.1 | Validation Threshold of traffic flow | 45 |
| Table 3.2 | Speed validation threshold | 46 |
| Table 3.3 | Level of Service (LOS) criteria | 50 |
| Table 3.4 | The value of time and price cost per litre fuel | 51 |
| Table 3.5 | Relative values of time for various mode | 51 |
| Table 4.1 | Total volume of vehicle per day and total volume per week | 55 |
| Table 4.2 | Summary of peak hour for morning and evening of intersection | 56 |
| Table 4.3 | Peak hour volume of the intersection | 57 |
| Table 4.4 | Summary of morning and evening peak for each approach | 58 |
| Table 4.5 | Highest flow in morning and evening in each approach junction | 59 |
| Table 4.6 | Total volume during peak hour | 60 |
| Table 4.7 | Total vehicle composition | 61 |
| Table 4.8 | Speed characteristics of vehicle classes during peak hour | 62 |
| Table 4.9 | Volume by time interval used for VISSIM simulation | 63 |

| | | |
|---|---|---|
| Table 4.10 | Total vehicle composition on each approach and turning movement | 64 |
| Table 4.11 | Signal stage data | 68 |
| Table 4.12 | Intersection interstage details | 68 |
| Table 4.13 | Parameters of driving behaviour | 70 |
| Table 4.14 | Wiedemann 99 parameters | 70 |
| Table 4.15 | Lane changing behaviour | 70 |
| Table 4.16 | Default and modified simulation parameters | 71 |
| Table 4.17 | Result of volume validation | 74 |
| Table 4.18 | Result of speed validation | 74 |
| Table 4.19 | Road user mode split | 76 |
| Table 4.20 | Volume of private and public vehicles in scenario 2 | 77 |
| Table 4.21 | Vehicle composition for scenario 2 | 77 |
| Table 4.22 | Volume of private and public vehicles in scenario 3 | 78 |
| Table 4.23 | Vehicle composition for scenario 3 | 78 |
| Table 4.24 | Volume of private and public vehicles in scenario 4 | 79 |
| Table 4.25 | Vehicle Composition for each scenario 4 | 79 |
| Table 4.26 | Signal stage data | 81 |
| Table 4.27 | Intersection interstage details | 81 |
| Table 4.28 | Average vehicle delay | 84 |
| Table 4.29 | Vehicles affected by delay | 85 |

Table 4.30 Average Travel Time 88

Table 4.31 Savings with comparison of base case with BRT scenarios 94

## LIST OF FIGURES


| FIGURE NO. | TITLE | PAGE |
|---|---|---|
| Figure 1.1 | Proposed BRT corridors in in Johor Bahru | 4 |
| Figure 2.1 | Transportation mode split in Johor Bahru in 2015 | 8 |
| Figure 2.2 | Vehicle composition in Johor Bahru | 8 |
| Figure 2.3 | (a) Stations in Bogota, Colombia (b) Stations at Curitiba, Brazil | 13 |
| Figure 2.4 | BRT vehicle in Jakarta | 13 |
| Figure 2.5 | Inductive loop detector | 20 |
| Figure 2.6 | VisVAP flowchart | 25 |
| Figure 3.1 | Flow chart of study sequence | 34 |
| Figure 3.2 | Study area | 35 |
| Figure 3.3 | Layout of automatic traffic counter | 36 |
| Figure 3.4 | Run number and the corresponding seed value | 42 |
| Figure 3.5 | Model validation and calibration process | 44 |
| Figure 4.1 | T-junction at Taman Impian Emas | 53 |
| Figure 4.2 | Layout and movement at the intersection | 54 |
| Figure 4.3 | Total traffic volume per day | 56 |
| Figure 4.4 | Peak hour volume of intersection | 57 |
| Figure 4.5 | (a) Peak hour traffic from the North approach (b) Peak hour traffic from the South-West approach (c) Peak hour traffic from the North-East approach | 60 |

| | | |
|---|---|---|
| Figure 4.6 | Desired speed distribution for class 1 | 65 |
| Figure 4.7 | Desired speed distribution for class 2 | 65 |
| Figure 4.8 | Desired speed distribution for class 3 | 65 |
| Figure 4.9 | Desired speed distribution for class 5 | 65 |
| Figure 4.10 | Desired speed distribution for class 6 | 66 |
| Figure 4.11 | Desired speed distribution for class 7 | 66 |
| Figure 4.12 | Desired speed distribution for class 8 | 66 |
| Figure 4.13 | Desired speed distribution for class 9 | 66 |
| Figure 4.14 | Desired speed distribution for class 10 | 66 |
| Figure 4.15 | Desired speed distribution for class 11 | 66 |
| Figure 4.16 | Desired speed distribution for class 12 | 67 |
| Figure 4.17 | Desired speed distribution for class 13 | 67 |
| Figure 4.18 | Intersection stage diagram | 68 |
| Figure 4.19 | Acceleration pattern for North-East approach | 72 |
| Figure 4.20 | Acceleration pattern for North approach | 72 |
| Figure 4.21 | Acceleration approach for South-West approach | 73 |
| Figure 4.22 | Layout of intersection with BRT lanes | 75 |
| Figure 4.23 | Dimension of BRT lanes | 75 |
| Figure 4.24 | Intersection stage diagram | 80 |
| Figure 4.25 | Comparison of delays in different scenarios by approach | 84 |
| Figure 4.26 | Average delay time per vehicle in each scenario | 85 |

| | | |
|---|---|---|
| Figure 4.27 | Vehicles affected by delay | 86 |
| Figure 4.28 | Average Travel Time | 88 |
| Figure 4.29 | Average travel time per vehicle in each scenario | 89 |
| Figure 4.30 | Level of service (LOS) of base case | 90 |
| Figure 4.31 | Level of service (LOS) of scenario 2 | 90 |
| Figure 4.32 | Level of service (LOS) of scenario 3 | 91 |
| Figure 4.33 | Level of service (LOS) of scenario 4 | 91 |
| Figure 4.34 | Total delay cost | 92 |
| Figure 4.35 | Total delay cost with relative value of time | 93 |

## LIST OF ABBREVIATIONS

ATC- Automatic Traffic Counter

BRT – Bus Rapid Transit

LOS-Level of Service

RM-Ringgit Malaysia

RSMPE-Root Mean Squared Percent Error

MOE- Measure of Effectiveness

## LIST OF APPENDIX


| APPENDIX | TITLE | PAGE |
|---|---|---|
| Appendix A | Traffic Flow | 105 |
| Appendix B | Base case VisVAP flow chart and coding | 117 |
| Appendix C | Base case data collection | 121 |
| Appendix D | Traffic Flow of BRT scenarios | 135 |
| Appendix E | Vehicle volume and traffic composition of BRT scenarios | 141 |
| Appendix F | BRT scenarios VisVAP flow chart and coding | 147 |
| Appendix G | Delay results | 155 |
| Appendix H | Travel time results | 161 |
| Appendix I | Level of service (LOS) results | 167 |

# CHAPTER 1

# INTRODUCTION

## 1.1 General

This chapter presents the importance of transportation and transport problem faced by developing cities. This chapter also describe the research questions to be answered at the end of the study, aims and objectives, scope of work involved in this study and the thesis outline.

Land transportation such as buses is the main mode of transportation in Malaysia. The use of public transportation such as buses are reducing and resulting in the rising use of private transportation. Due to the increasing dependency on private transport, it resulted to the rising in congestion levels. Road users need to confront the peak hour traffic, road accidents, air pollution and driving stress which results in the increasing numbers of social, economic and environmental problems.

According to Malaysian Institute of Road Safety Research (2017), the number of registered vehicles in Malaysia has increased from 8 million in 1997 to more than 27 million in 2016, representing an increase of more than 300% in 19 years while the population only has an increase of 146% in the last 19 years. High car ownerships have been a trend in urban agglomerations in Malaysia and only a small percentage of urban travel by public transportation. It has been a common scene during the recent years where middle to high income households to own more than one car (Minhans & Moghaddasi, 2013). In 2011, car ownership in Johor is expected to grow from 500 cars per 1000 population to more than 800 by 2025 (Iskandar Regional Development

Authority, 2011). Increase in car ownership will lead to increasing number of vehicles on the road.

According to Kamba et al. (2007), public transportation in Malaysia requires more travel time, does not cover most of the desirable routes and also has infrequent services. Besides that, high traffic congestion and delay experienced by public transportation also makes public transportation undesirable. Less satisfying quality of public transportation will lead to more road users shifting to private transportation and will result to higher level of road congestion. This will affect the productivity and quality of life of road users as they would need to spend more time on the road for to reach their destination. In order to decrease the use of private transportation, improvements need to be done to public transportation. To promote modal shift of private vehicle users to public transportation, car users prefers improvements in punctuality, more accessible routes and low fares.

Bus Rapid Transit (BRT) is constructed to provide improved level of service for bus transportation modes. Bus rapid transits aim to reach railroad level of service but at a much lower development cost and greater operating flexibility as compared with rail transit. Bus Rapid Transit is not only beneficial to the current users of bus transport and users who shift to use bus transport mode but also to private transportation users as they will experience less congestion due to less number of vehicles on the road (Papageorgiou & Ioannou, 2009).

## 1.2 Problem statement

Johor Bahru is considered the second largest urban city in Malaysia after Kuala Lumpur. Due to the increasing development of the city, similar to many developing Asian cities, they are faced with the challenge of providing efficient urban public bus transportation. Intracity public transportation availble in Johor Bahru is limited to buses and buses are always considered to be unreliable by passengers. Buses punctuality are usually depending on the traffic condition where these types of

conditions are not always predictable. Uncoordinated and unrganized movement of buses also makes it difficult for road users as they need to change buses to reach their final destination. These are the few reasons why buses are unattractive to passengers.

In order to promote improvements in public transport in Johor Bahru area, one of the alternatives is to implement BRT as BRT has higher quality of service compared to the common buses. Comprehensive planning and decision making to provide better transportation service to avoid congestion in urban and main residential areas in the state due to increasing in dependency to private vehicles and overall increase in the number of vehicles in the future.

The residents in urban areas needs a reliable transportation facility to commute daily which is the responsibility of the public authorities to accommodate the public needs (Gautam et al., 2013). In order to test the reliability of the BRT, the analysis of delay and travel time of proposed BRT system will be conducted in this study based on microsimulation modelling.

## 1.3 Research questions

Considering the problem statements as mentioned in the previous section, the following questions can be answered:

1) Is there improvement on the delay and travel time by the implementation of BRT?
2) What is the monetary value and financial benefits gained from implementation of BRT?

## 1.4 Aims and Objectives

The aim of this study is to investigate performance of BRT as well as the financial benefit of different BRT scenarios. The specific objectives of the study were as follows:

(1) To determine the effects of BRT on the vehicle delay and travel time

(2) To evaluate the economic effect of implementing BRT

## 1.5 Scope of Work

An intersection in one of the proposed BRT corridors as shown in Figure 1.1 is chosen based on the characteristic of intersections such as presence of traffic signal. The study is conducted to evaluate the performance of BRT with dedicated lane and traffic priority at isolated signalized intersection as well as evaluating the financial benefits in order to see if implementation of BRT is reasonable. Microsimulation models of base case (current condition without BRT) and different scenarios (with BRT) of varying mode split between public transportation (BRT) and private vehicles are evaluated to show the expected performance of road users shift to public transportation mode. Current condition data such as volume and speed data as well as signal phasing timing will be collected to model the current condition of the intersection and the data is also vital model calibration and validation. The microsimulation model were modelled using PTV VISSIM software.

Figure 1.1 Proposed BRT corridors in in Johor Bahru (Perbadanan Pengangkutan Awam Johor, 2016a)

## 1.6 Importance of study

Providing better public transportation will lead to better access to amenities such as health, education and social services. Better public transportation service will encourage road users to use public transportation on a daily basis hence reducing the number of private vehicles on the road. Less private vehicles on the road will also promote better environmental quality and also reduce fuel consumption.

## 1.7 Limitations of study

The study only utilizes the use of two validation parameters such as traffic flow and speed. According to Washington State Department of Transportation (WSDOT) (2014), traffic flow and speed is the minimum requirement of validation parameters. It is suggested that more calibration parameters such as the intersection delay and travel time are collected.

This study also does not consider the traffic growth factor in Johor Bahru. The changes in modal split were implemented in the base case model.

## 1.8 Report Outline

This report contains five chapters focusing on the modelling and analysis of BRT systems.

Chapter 1 presents the background of the study, aim and objectives to be achieved by highlighting the problem statement and the importance of the study on BRT systems implemented.

Chapter 2 discussed the literature review of BRT systems and the characteristics of BRT systems implemented in the study as well as case studies of

BRT systems in similar countries. Other than that, the important inputs for the modelling of the BRT system were also discussed in this chapter

Chapter 3 describes the methodology and the procedures used to conduct the data collection and the development of the BRT system in the VISSIM software. The equipment used for data collection is described in detail in this chapter.

Chapter 4 highlights the results and data generated by the software. The results were analysed and the outcomes and financial benefits were discussed

Chapter 5 summarizes the report by providing the conclusion and the possible recommendations for future studies. This chapter emphasizes the main outcomes of the study and provides helpful recommendations to be improved from the current study to help with future studies.

# REFERENCES


Ahmed, B. (2014). Exploring New Bus Priority Methods at Isolated Vehicle Actuated Junctions. *Transportation Research Procedia*, *4*, 391–406. https://doi.org/10.1016/j.trpro.2014.11.030

American Public Transportation Association. (2010). Designing Bus Rapid Transit Running Ways, 45.

Arkatkar, S. (2016). Calibration of vehicle following models using trajectory data under heterogeneous traffic conditions, 1–58.

Bloomberg, L., & Dale, J. (2000). Comparison of Vissim and Corsim Traffic Simulation Models on a Congested Network. *Transportation Research Record*, *1727*(August), 52–60. https://doi.org/10.3141/1727-07

Cervero, R. (2013). Bus Rapid Transit (BRT): An Efficient and Competitive Mode of Public Transport. *IURD Working Paper 2013-01*, (October), 1–36. Retrieved from http://escholarship.org/uc/item/4sn2f5wc.pdf

Dunn Engineering Associates. (2005). Traffic Control Systems Handbook, (October).

Fehr & Peers Transportation Consultants. (2005). Conceptual Bus Rapid Transit (BRT) Plan for South Placer County.

Fowkes, A. . (2001). *Values of time for road commercial vehicles*.

Garber, N. J., & Hoel, L. A. (2009). *Traffic and Highway FOURTH EDITION* (Fourth). CENGAGE Learning.

Gardner, K., Souza, C. D., & London, T. (2009). UITP WORKING GROUP : Interaction of buses and signals at road crossings Deliverable 1 Review of Bus Priority at Traffic Signals around the World. *Transportation Research*, (April).

Gautam, R. G., Sekhar, C. R., & Velmurugan, S. (2013). Micro simulation Based Performance Evaluation of Delhi Bus Rapid Transit Corridor. *Procedia - Social*

*and Behavioral Sciences*, *104*, 825–834. https://doi.org/10.1016/j.sbspro.2013.11.177

Gettman, D., & Head, L. (2003). Surrogate Safety Measures from Traffic Simulation Models. *Transportation Research Record*, *1840*(1), 104–115. https://doi.org/10.3141/1840-12

Haight, F. A. (1994). Problems in Estimating Comparative Costs of Safety and Mobility Problems in Estimating Comparative Costs of Safety and Mobility, *28*(1), 7–30.

Hughes, C., & Zhu, X. (2011). Guangzhou, China, Bus Rapid Transit Emissions Impact Analysis, (May).

Iskandar Regional Development Authority. (2011). *Blueprint 2010 - 2030 for Iskandar Malaysia*. *Journal* (Vol. 1).

ITDP, Giz, ClimateWorks Foundation, Rockefeller Foundation, & ICCT. (2013). The BRT Standard 2013. *Report*, 1–50.

Jabatan Kerja Raya. (1987). A Guide to the Design of Traffic Signal, 1–83.

Jayasooriya, S. A. C. ., & Bandara, Y. M. M. . (2017). Measuring the Economic Costs of Urban Traffic Congestion. *Moratuwa Engineering Research Conference (MERCon)*, 141–146.

Kamba, A. N., Rahmat, R. A. O. K., & Ismail, A. (2007). Why Do People Use Their Cars: A Case Study In Malaysia. *Journal of Social Sciences*, *3*(3), 117–122. https://doi.org/10.3844/jssp.2007.117.122

Kili, K. A. (2017). Public housing on target - Metro News | The Star Online. Retrieved July 1, 2018, from https://www.thestar.com.my/metro/community/2017/08/26/public-housing-on-target-developer-to-build-444-townhouses-in-taman-impian-emas-for-johoreans/

Kon, T. (1998). Collision Warning and Avoidance System for Crest Vertical Curves.

*Vasa*, 51–92. Retrieved from etd-43098-201311

Land Public Transport Commission (SPAD). (2016). Land Public Transport Information-History, Aspirations and Challenges, 1–19. Retrieved from http://www.spad.gov.my/sites/default/files/chairman_speech-22april20161.pdf

Leal, M. T., & Bertini, R. L. (2003). Bus Rapid Transit: An Alternative for Developing Countries. *ResearchGate*, (November), 1–13.

Levinson, H., Adams, C., & Hoey, W. (1975). *TCRP Report 155: Bus Use of Highways Planning and Design Guidelines*. *National Research Council* (Vol. 155).

Levinson, H., Zimmerman, S., Clinger, J., & Rutherford, G. S. (2002). Bus Rapid Transit : An Overview. *Journal of Public Transportation*, *5*(2), 1–30. https://doi.org/10.5038/2375-0901.5.2.1

Levinson, H., Zimmerman, S., Clinger, J., Rutherford, S., Smith, R. L., Cracknell, J., & Soberman, R. (2003). *Bus Rapid Transit, Volume 1: Case Studies in Bus Rapid Transit. TCRP Report 90* (Vol. 1). https://doi.org/10.17226/23367

Lyons, G., Transport, C., & Urry, J. (2004). the Use and Value of Travel Time, 1–26.

Malaysian Institute of Road Safety Research. (2017). General Road Accident Data in Malaysia (1997 – 2016). *Department of Statistics Malaysia*, 2016. Retrieved from http://www.miros.gov.my/web/guest/road

Mathew, P. T. V. (2017). Lecture Notes in Transportation Systems Engineering Vehicle-Actuated Signals Basic Principles, 1–18.

Menneni, S. (2008). Pattern Recognition Based Microsimulation Calibration (Vissim Car-following Parameters). *University of Missouri-Columbia*, (December), 91–142. Retrieved from https://mospace.umsystem.edu/xmlui/handle/10355/9102

Menneni, S., & Sun, C. (n.d.). Analysis of Wiedemann 74 and 99 Driver Behaviour Parameters, (573).

Merkert, R., & Mulley, C. (2015). Determinants of Bus Rapid Transit (BRT) system yields and efficiency – A global benchmarking exercise. *14th Conference on Competition and Ownership in Land Transport Thredbo 14*, *106*, 75–88. https://doi.org/10.1016/j.tra.2017.09.010

Mimbela, L. E. Y. (2000). A Summary of Vehicle Detection and Surveillance Technologies used in IN INTELLIGENT TRANSPORTATION SYSTEMS.

Minhans, A., & Moghaddasi, A. (2013). Transport cost analysis of city bus and private car usage in Johor Bahru, Malaysia. *Jurnal Teknologi (Sciences and Engineering)*, *65*(3), 25–31. https://doi.org/10.11113/jt.v65.2143

Nithya, S., Nithyananthan, R., Semthurkumar, D., & Gunasekaran, K. (2012). Design of vehicle actuated signal for a major corridor in chennai using simulation. In *5th Urban Mobility India Conferecne & Expo 2012*.

Papageorgiou, G., & Ioannou, P. (2009). *Development and Evaluation of Bus Priority Scenarios via Microscopic Simulation Models*. *IFAC Proceedings Volumes* (Vol. 42). IFAC. https://doi.org/10.3182/20090902-3-US-2007.0098

Papageorgiou, G., & Maimaris, A. (2012). *Planning for Effective Bus Rapid Transit Systems : A scenario simulation modelling based approach*. *IFAC Proceedings Volumes* (Vol. 45). IFAC. https://doi.org/10.3182/20120912-3-BG-2031.00076

Park, B. B., & Qi, H. (2004). *Development and Evaluation of A Calibration and Validation Procedure for Microscopic Simulation Models*. Retrieved from https://trid.trb.org/view.aspx?id=740343

Park, B. B., Yun, I., & Choi, K. (2004). Evaluation of Microscopic Simulation Tools for Coordinated Signal System Deployment, *8*(2), 239–248.

Perbadanan Pengangkutan Awam Johor. (2016a). *Johor Public Transport Masterplan (2015-2045)*. Perbadanan Pengangkutan Awam Johor.

Perbadanan Pengangkutan Awam Johor. (2016b). *Johor Public Transport Masterplan (2015-2045)*. Perbadanan Pengangkutan Awam Johor.

Planung, P. T. V, & Verkehr, T. (2012). *Visvap 2.16 user manual.*

Ratrout, N. T., & Rahman, S. M. (2009). A Comparative Analysis of Currently Used Microscopic and Macroscopic Traffic. *Science*, *34*(1), 121–133.

Rrecaj, A. A., & Bombol, K. M. (2015). Calibration and Validation of the VISSIM Parameters - State of the Art. *Tem Journal-Technology Education Management Informatics*, *4*(3), 255–269. Retrieved from http://www.temjournal.com/content/43/05/TemJournalAugust2015_255_269.pdf

Saidallah, M., El Fergougui, A., & Elalaoui, A. E. (2016). A Comparative Study of Urban Road Traffic Simulators. *MATEC Web of Conferences*, *81*, 05002. https://doi.org/10.1051/matecconf/20168105002

Salter, R. . (1976). *Highway Traffic Analysis and Design*. Macmillan Publishers LTD.

Sandoval, E. E., & Hidalgo, D. (2004). TransMilenio: A High Capacity - Low Cost Bus Rapid Transit System Developed for Bogotá, Colombia. *Urban Public Transportation System*, 37–49. https://doi.org/10.1061/40717(148)4

SIAS. (2009). S-Paramics Principles. *Paramics Microsimulation SIAS Limited, Edinburgh, Www.Paramics-Support.Com*.

Taman Impian Emas - About Us. (n.d.). Retrieved from http://www.impianemas.my/abouts/1/About-Us

The World Bank. (2014). Cairo Traffic Congestion Study, (November), 0–12. Retrieved from http://www.worldbank.org/content/dam/Worldbank/TWB-Executive-Note-Eng.pdf

The World Bank. (2015). *Malaysia Economic Monitor Transforming Urban Transport*.

Transportation Research Board. (2000). *Highway capacity manual. Environmental Protection*. https://doi.org/10.1061/(ASCE)HY.1943-7900.0000746.

Vahid, S., Alavi, K., & Moahamd, M. S. (2011). Urban Public Bus Adequacy Evaluation Analysis : A Johor Bahru , Johor , Malaysian Case Study. *Urban Public Bus Adequacy Evaluation Analysis: A Johor Bahru, Johor, Malaysia Case Study Seyed*, 1–16.

VTATransit. (2007). Bus Rapid Transit Service Guidelines, 101.

Wallis, I., Associates, I. W., Rupp, L. K., Jacobs, R. A., & Ltd, N. (2015). *Travel time saving assessment*. Retrieved from http://www.nzta.govt.nz/assets/resources/research/reports/570/570.pdf

Wardman, M. (2004). Public transport values of time. *Transport Policy*, *11*(4), 363–377. https://doi.org/10.1016/j.tranpol.2004.05.001

Washington State Department of Transportation (WSDOT). (2014). Protocol for VISSIM Simulation. *Washington State Department of Transportation*, (September), 162. https://doi.org/10.1088/1748-9326/8/2/024010

Wisconsin Department of Transportation. (2018). Traffic Engineering, Operations & Safety Manual, 1–5.

Yarger, B. W. (1993). Fully Actuated Vs . Semi- Actuated Traffic Signal Systems.

Zaman, M., Sultan, Z., Fard, M., Siyaka, A., & Pung, J. C. (2017). An Assessment of Public Transport Facility in Johor Bahru: a case study in Taman Ungku Tun Aminah Area, Majlis Perbandaran Johor Bahru Tengah, Malaysia. *International Journal of Built Environment and Sustainability*, *4*(2), 71–80. https://doi.org/10.11113/ijbes.v4.n2.178