BUS RAPID TRANSIT USING COMPENSATION METHOD AS BUS PRIORITY SYSTEM AT ISOLATED THREE-ARM JUNCTION

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DEDICATION

I dedicate this to my mom, Rasidah binti Janaidi and my aunt, Masamah binti Janaidi for their continuous support throughout my life.

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ABSTRACT

Current nature of Malaysia society and lifestyle creates various needs of travel. Nowadays, there are more affordable cars than it was for the last decades. People choose to invest in buying themselves a car rather than using public transportation that leads to congestion on the road. Johor Bahru is also one of the cities in Malaysia that suffers traffic congestion due to the rapid increase in transit needs and population density. Perbadanan Pengangkutan Awam Johor planned to introduce Bus Rapid Transit (BRT) system to help solve the problem regarding the traffic congestion. In this paper, the implementation of BRT system in an unsignalised junction were assessed using four scenarios of mode split to determine the performance of the BRT system before and after implementation. The four scenarios of mode split involved are base scenario, 84%:16%, 62%:38% and 46%:54% of private vehicles user against public transit user respectively. Microscopic traffic simulations of PTV VISSIM was used to carried out the assessment of BRT system and compensation method was used as the bus priority system at the junction. The costs of congestion were calculated based on the results from the VISSIM simulations. The level of service for the junction were compared between the scenarios. Further analysis showed that the mode split of 46% private vehicle users and 54% public transit users are more beneficial compared to other scenarios in term of travel time and cost of delay. The level of service had improved at some of the approaches at the junction.

ABSTRAK

Gaya hidup masyarakat Malaysia pada zaman sekarang telah mencipta pelbagai keperluan dari segi pengangkutan dan perjalanan. Selain itu, terdapat lebih banyak kereta yang berharga berpatutan di pasaran tempatan berbanding sedekad yang lalu. Ini membuatkan rakyat Malaysia memilih untuk membeli kenderaan sendiri daripada menggunakan pengangkutan awam yang sedia ada dan secara tidak langsung menyebabkan kesesakan di jalan raya. Johor Bahru merupakan salah satu daripada bandaraya yang sibuk di Malaysia dan sering mengalami kesesakan lalu lintas yang disebabkan peningkatan dalam keperluan transit dan kepadatan penduduk. Perbadanan Pengangkutan Awam Johor merancang untuk memperkenalkan sistem Bus Rapid Transit (BRT) untuk membantu menyelesaikan masalah kesesakan lalu lintas di dalam negeri tersebut. Dalam penyelidikan ini, pelaksanaan sistem BRT di persimpangan dalam Kawasan penyelidikan dinilai menggunakan empat senario pecahan mod untuk menentukan prestasi sistem BRT sebelum dan selepas pelaksanaan. Empat senario pecahan mod yang terlibat adalah senario asas, 84%: 16%, 62%: 38% dan 46%: 54% nisbah pengguna kenderaan persendirian dan pengguna transit awam. Perisian simulasi lalu lintas mikroskopik PTV VISSIM digunakan untuk melakukan penilaian sistem BRT dan kaedah pampasan digunakan sebagai sistem yang mengutamakan bas di persimpangan tersebut. Kos kelewatan juga dinilai berdasarkan hasil daripada simulasi VISSIM. Tahap perkhidmatan (LOS) untuk persimpangan telah dibandingkan antara senario. Analisis lanjut menunjukkan bahawa pecahan mod 46% pengguna kenderaan persendirian dan 54% pengguna transit awam lebih bermanfaat berbanding dengan senario lain dari segi masa perjalanan dan kos kelewatan. Tahap perkhidmatan telah bertambah baik pada beberapa jalan di persimpangan tersebut

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LIST OF ABBREVIATIONS

BRT	Bus Rapid Transit
LOS	Level of Service
PAJ	Pengangkutan Awam Johor
ITS	Intelligent Transport System
AVL	Automatic Vehicle Location
ATC	Automatic Traffic Counter
VAP	Vehicle Actuated Program
JKR	Jabatan Kerja Raya (Malaysian Public Works Department)

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CHAPTER 1

INTRODUCTION

1.0 General

Vehicles are very important for human to travels from one destination to another destination. It is just matter of choosing the transportation mode for their trips. In the last decades, the levels of mobility have increased significantly in Malaysia. These can be seen in the amount of traffic congestion during peak hours or festive season in any major roads. This creates concern about the increase in the use of car and the implications in terms of congestion and pollution. Furthermore, the current nature of society and lifestyle of people in Malaysia create varieties of travel needs. There are more affordable cars nowadays than it was few years ago. That is why more people choose to invest themselves in buying the car rather than using public transport.

Currently, there are little awareness about sustainable transportation in our country that leads to improper transportation planning in the cities. The public transit service become unreliable to some of the citizen. Developing more reliable public transportation services can encourage the people to shift from using their own private vehicle into using the public transportation services. Although, changing people's mind is a difficult task to do because human behaviours are unpredictable. They may accept or reject the proposed changes. People choose to use their own private vehicle because of the flexibility of daily trips, more privacy and comfortable. Thus, attractive services and facilities of the public transportation is important in influencing all those factors. Most of the citizen also preferred to use private car instead of using public transportation because to them owning a private vehicle is far more convenient instead of using the current public transit services. Public transport was always being the second mode of transport for the people because of few reasons. Some of the public transports are not reliable when it comes to time, there will always be delays. Other

than that, most people are not comfortable in sharing spaces with strangers. Figure 1.1 shows the current modal split of travel in Johor Bahru.

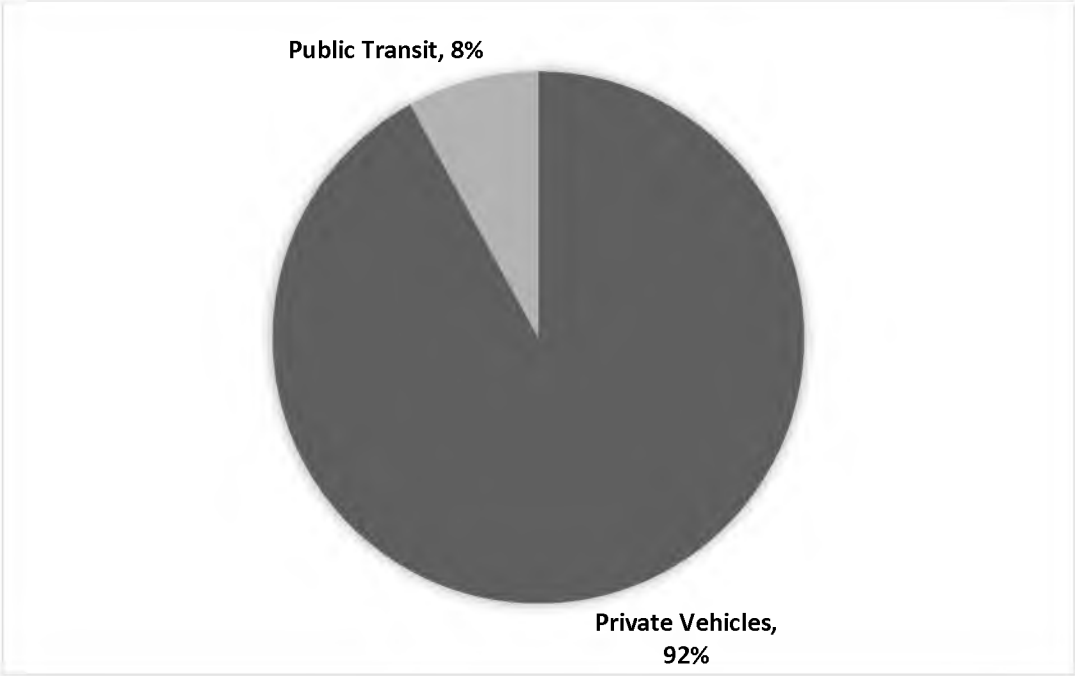

Figure 1.1: Current mode split of travel in Johor Bahru (Perbadanan Pengangkutan Awam Johor, 2016).

In 2015, the total population of Johor Bahru are about 1.6 million and expected to grow to 4.7 million by the year of 2045 (Perbadanan Pengangkutan Awam Johor, 2016). Rapid increase of transit needs and population density in certain areas of Johor Bahru cause congestions on the road uncontrollable and sometimes unexpected if any accident occurs on the road. Introducing Bus Rapid Transit (BRT) can help to solve the problem regarding the congestion on the road. The exclusive lane in BRT system help to reduce travel time and delay for buses by prohibiting other vehicles on the exclusive lane. Thus, the aims of implementing BRT system in a densely populated areas are improving the speeds by reducing the delays, increasing the reliability, comforts and capacity of the transit services (Merkert & Mulley, 2015; Wan, Kamga, Liu, Sugiura, & Beaton, 2016). These aims help to attract more people into using public transportation more than using their own private vehicle and leads to the change in modal split of people using the private vehicle with using bus for their daily trips.

1.1 Problem Statement

Malaysian government and the town planners always faced issues in the quality of the public transportation services. The rapid growth of the population in Malaysia causing difficulties in providing a good quality of public transportation especially in urban areas. Other than that, limited space and capital funding also contribute to the difficulties in developing proper public transit in developing area. On the basis of broad literature review, the impact for the implementation of bus priority system at an junction that are originally unsignalised junction had rarely been reported.

1.2 Aim and Objectives

The main aim of this study is to investigate the impact of different BRT scenarios at isolated vehicle actuated signalized junction. The following objectives were set up to achieve the aim of this study:

1. To identify the effect of BRT implementation in study area.
2. To examine the Level of Service of the junction before and after implementation of BRT.
3. To determine the financial benefits of developing BRT system in the study area.

1.3 Scope of Study

Due to practical constraints, this report cannot provide a comprehensive review on the application to whole route networks in Johor Bahru. Other than that, land use in the study area may limit the proposed additional exclusive lane for BRT system.

The study comprises of site investigation, microscopic simulation models and financial benefit analysis of the BRT implementation. An isolated unsignalised junction that passing through one of the routes for the proposed BRT corridors in Johor Bahru. The performance of the BRT system is analyse using microscopic simulation model based on different scenarios. The first scenarios is the base scenario or also

called the "do nothing" scenario. Three of other scenarios are after the implementation of BRT system with different model split from the base scenario. Visual inspection and traffic count survey were conducted on study area to obtain the required data for simulation. The microscopic simulation models were modelled using the PTV VISSIM.

1.4 Significance of Research

This research will provide comprehensive analysis on the improvement in term of quality for unsignalised junction from the implementation of BRT system. Changing the modal split of daily transportation mode can lead to reduction in the use of private vehicles on the road. Air pollution can also be reduced with the decreasing number of private vehicles. Other than that, the risk of accidents occurring will be lower and provide a safer road to travel.

1.5 Report Outline

This report is divided into 5 chapters by focusing on the study of BRT implementation in a densely populated area.

Chapter 1 outlines the background of the study, aims and objectives by highlighting on the problem statement and the importance of implementing BRT system in the densely populated area.

Chapter 2 reviews the literature regarding the BRT system and the case study involved in implementing the BRT system all over the world.

Chapter 3 describes the methodology used in achieving the objective of the study. Flow chart is made to show the sequence of tasks to be achieves such as identifying the area, to assess the severity of the study area, data collection, developing microscopic simulation model and result analysis.

Chapter 4 emphasizes on the analysis of results and data collected from the simulation conducted. The results were evaluated and the end products of the analysis were discussed.

Chapter 5 sums up all the reports by showing the conclusion and the recommendation of the studies conducted. This chapter will also highlight the end product of the study and provide helpful recommendations for future studies in the same area.

REFERENCES

Abdallah, T. (2017). Future Challenges and Sustainability Opportunities. In Sustainable Mass Transit (p. 230). https://doi.org/10.1016/B978-0-12-811299-1.00007-1

Akcelik. (2018). What Is Sidra Intersection? Retrieved July 24, 2018, from http://www.sidrasolutions.com/Software/intersection/Introduction

Ali, M. S., Adnan, M., Noman, S. M., & Baqueri, S. F. A. (2014). Estimation of traffic congestion cost - A case study of a major arterial in Karachi. Procedia Engineering, 77, 37–44. https://doi.org/10.1016/j.proeng.2014.07.030

Almselati, A. S., O. K. Rahmat, R. b., Jaafar, O., & Yahia, H. A. (2015). Using spike model to reduce traffic congestion and improve public transportation in Malaysia. Transportation Research Part D, 59-66.

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

Cvitanic, D., Breski, D., & Lovric, I. (2012). Possibility Of Microsimulation Models Calibration – Case Study In The City Of Split. Science in Traffic and Transport, 24(3), 231–242.

Deng, T., Ma, M., & Nelson, J. D. (2016). Measuring the impacts of Bus Rapid Transit on residential property values : The Beijing case. Research in Transportation Economics, 60, 54–61. https://doi.org/10.1016/j.retrec.2016.08.005

Deng, T., & Nelson, J. D. (2013). Bus Rapid Transit implementation in Beijing: An evaluation of performance and impacts. Research in Transportation Economics, 39(3), 108–113. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000150

Gardner, K., D'Souza, C., Hounsell, N., Shrestha, B., & Bretherton, D. (2009). Interaction of buses and signals at road crossings - review of bus priority at traffic signals around the world. UITP: Interaction of Buses and Signals at Road

Crossings, (01147024), 1–68. Retrieved from https://trid.trb.org/view/907320

Gettman, D., & Head, L. (2003). Surrogate Safety Measures From Traffic Simulation Models Final Report.

Greene, D., Jones, D., & Delucchi, M. (1997). The full costs and benefits of transportation - Contribution to theory. Berlin: Springer-Verlag

Hallenbeck, M. E., Selezneva, O. I., & Quinley, R. (2014). Verification, Refinement, and Applicability of Long-Term Pavement Performance Vehicle Classification Rules, (November).

Hebbert, M. (2012). Cities and Climate Change (Global Report on Human Settlements 2011)/Climate Change and Cities (First Assessment Report of the Urban Climate Change Research Network). The Town Planning Review (Vol. 83). https://doi.org/10.1787/9789264091375-en

Holst, M. (2018). Evaluation of the impact of Bus Rapid Transit on air pollution in Mexico City Germ, 63(November 2017), 209–220. https://doi.org/10.1016/j.tranpol.2018.01.001

Hounsell, N. B., McLeod, F. N., & Shrestha, B. P. (2004). Bus priority at traffic signals: investigating the options. Proceedings of 12th International Conference on Road Transport Information and Control, 287–294. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?isnumber=29563&arnumber=1341762&count=60&index=51

Hwang, M., Kemp, J., Lerner-Lam, E., Neuerburg, N., Okunieff, P., & Schiavone, J. (2006). Advanced Public Transportation Systems : the State of the Art Update 2006. Federal Transit Administration, 1–264. Retrieved from http://trid.trb.org/view.aspx?id=790604%5Cn http://ntl.bts.gov/lib/30000/30100/30101/APTS_State_of_the_Art.pdf

Jabatan Kerja Raya. (1987). A Guide to the Design of Traffic Signals. Arahan Teknik Jalan, 11/87, 1–107.

Jiang, Y., Christopher Zegras, P., & Mehndiratta, S. (2012). Walk the line: Station context, corridor type and bus rapid transit walk access in Jinan, China. Journal of Transport Geography, 20(1), 1–14.

https://doi.org/10.1016/j.jtrangeo.2011.09.007

Jorgenson, A. K., Rice, J., & Clark, B. (2010). Cities, slums, and energy consumption in less developed countries, 1990 to 2005. Organization and Environment, 23(2), 189–204. https://doi.org/10.1177/1086026610368376

Kasipillai, J., & Chan, P. (2008). Travel Demand Management: Lesson for Malaysia. J. Public Transport, 41-55.

Khasnabis, S., & Rudraraju, R. K. (n.d.). Optimum Bus Headway for Preemption. Transportation Research Record 1603, (970248), 128–136. https://doi.org/10.3141/1603-17

Levinson, H. S., Zimmerman, S., Clinger, J., & Gast, J. (2003). Bus Rapid Transit: Synthesis of Case Studies.

Levinson, H., Zimmerman, S., Clinger, J., & Rutherford, G. (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., Cracknell, J., & Soberman, R. (2003). Bus Rapid Transit, Volume 2: Implementation Guidelines (Vol. 2). https://doi.org/10.17226/21947

Lindau, L. A., Hidalgo, D., & de Almeida Lobo, A. (2014). Barriers to planning and implementing Bus Rapid Transit systems. Research in Transportation Economics, 48, 9–15. https://doi.org/10.1016/j.retrec.2014.09.026

Litman, T. (2017). Build for Comfort , Not Just Speed, (January 2008).

Litman, T. (2018). Transport Cost and Benefit Analysis II - Travel Time Costs, (August), 1–26. Retrieved from www.vtpi.org/tca/tca0502.pdf

Mackenzie, J., Dower, R., & Chen, D. (1992). The Going Rate: What it Really Cost to Drive. Washington, DC: World Resource Institute.

MALAYSIA. (2014). M.M.S. Malaysia: Department of Statistics.

Mallqui, Y. Y. C., & Pojani, D. (2017). Barriers to successful Bus Rapid Transit expansion: Developed cities versus developing megacities. Case Studies on Transport Policy, 5(2), 254–266. https://doi.org/10.1016/j.cstp.2017.01.004

McLeod, F., & Hounsell, N. (2003). Bus Priority at Traffic Signals—Evaluating Strategy Options. Journal of Public Transportation, 6(3), 1–14. https://doi.org/10.5038/2375-0901.6.3.1

McTrans. (n.d.). TSIS-CORSIM™. Retrieved July 24, 2018, from https://mctrans.ce.ufl.edu/mct/index.php/tsis-corsim/

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

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(September), 75–88. https://doi.org/10.1016/j.tra.2017.09.010

Meyer, N., & Kent, J. (1998). Perverse Subsidies. Winnipeg, Manitoba: The International Institute for Sustainable Development.

Mulley, C., & Tsai, C. (Patrick). (2013). Mulley, Tsai - 2013 - How much does new transport infrastructure add to land values Evidence from the bus rapid transit system in Sydne_opt. Transport Policy, 51, 1–9. https://doi.org/10.1016/j.tranpol.2016.01.011

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

Prevedouros, P. D., & Wang, Y. (1999). Simulation of Large Freeway and Arterial Network with CORSIM, INTEGRATION, and WATSim. Transportation Research Record, 1678(1), 197–207. https://doi.org/10.3141/1678-24

PTV Group. (n.d.). PTV VISSIM. Retrieved July 24, 2018, from http://vision-traffic.ptvgroup.com/en-us/products/ptv-vissim/

Ratrout, N. T., & Rahman, S. M. (2009). A Comparative Analysis Of Currently Used Microscopic And Macroscopic Traffic. The Arabian Journal for Science and Engineering, 34(1), 121–133.

Salter, R. J. (1974). Highway Traffic Analysis and Design.

Schwanen, T., & Mokhtarian, P. L. (2005). What affects commute mode choice:

Neighborhood physical structure or preferences toward neighborhoods? Journal of Transport Geography, 13(1 SPEC. ISS.), 83–99. https://doi.org/10.1016/j.jtrangeo.2004.11.001

Siedler, C. E. (2014). Can bus rapid transit be a sustainable means of public transport in fast growing cities ? Empirical evidence in the case of Oslo, 1(2352), 109–120. https://doi.org/10.1016/j.trpro.2014.07.012

Steg, L. (2003). Can Public Transport Compete With The Private Car. Department of Psychology, University of Groningen, Netherlands, 27-35.

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

Traffic Engineering Operations & Safety Manual. (2018). Traffic Engineering , Operations & Safety Manual.

Trafficware. (n.d.). Synchro Studio. Retrieved July 23, 2018, from http://www.trafficware.com/synchro.html

Verghis, M. A., & Sander, F. (2015). Malaysia Economic Monitor : Transforming Urban Transport. The World Bank.

Wan, D., Kamga, C., Liu, J., Sugiura, A., & Beaton, E. B. (2016). Rider perception of a “light” Bus Rapid Transit system - The New York City Select Bus Service. Transport Policy, 49, 41–55. https://doi.org/10.1016/j.tranpol.2016.04.001

Wiedemann, R. (1974). Simulation des StrafJenverkehrsjlusses. Schtiftenreihe Des Instituts Fur Verkehrswesen Der Universitat Karlsri.The, (Heft 8).

Wiedemann, R. (1991). Modeling of RTI-Elements on multi-lane roads. Advanced Telematics in Road Transport, Vol. ll, 1001–1019.

Wijaya, S., Imran, M., & McNeill, J. (2017). Multi-level policy tensions in Bus Rapid Transit (BRT) development in low-income Asian cities. Transportation Research Procedia, 25, 5104–5120. https://doi.org/10.1016/j.trpro.2018.02.040