Abstract

Name: Doan Hong Duc

Topic: **Measures of Bus Rapid Transit Signal Priorities at Signalized Intersections in Motorcycle Dependent Cities**

Supervisors: Prof. Dr.-Ing. Manfred Boltze
Dr.Eng.Vu Anh Tuan
M.Eng. Huynh Duc Nguyen
M.Sc. Wei Jiang

Bus Rapid Transit (BRT) is a new public transport mode that has been successfully implemented in both developing and developed countries. BRT is a cost-effective solution of providing a high-quality transport service and better air quality.

With the successful implementation in the world, some Vietnamese cities, Motorcycle dependent cities (MDCs), where the public transport operates with low quality, is now paying attention to BRT as well. According to the approved plan for transportation in MDCs to 2020, in the future, these cities will develop of an urban railway system. However, in the reality, these cities can only afford some subway lines, because the construction cost of this network is too costly. Thus, a different type of mass transit with a seen cheaper should be considered. Bus rapid transit becomes a great potential to improve the service level of public transport system in these cities, as a promising alternative compared with the construction costs of metro system. In addition, BRT is recommended to realize the low carbon society target for Asia development cities (e.g.: Thailand and Jakarta, Indonesia) since BRT would shift private vehicle users to a transport sector which emits lower CO_2 . However, it is difficult to introduce BRT to MDCs and also other Asia cities like Bangkok (Thailand). These cities are facing serious traffic problems due to their rapid urbanization such as urban sprawl, traffic congestion. Moreover, the oversaturated traffic flow at the signalized intersection in MDCs due to the high amount of motorcycle traffic mixing with other traffics.

The operation of bus is within the context of more congestion and disruption at signalized intersections. Although the advantages of the BRT system are obvious, such as: dedicated bus lane, heterogeneous traffic conditions will limit the efficiency of the implementation of exclusive bus lane. Transit signal priority (TSP) for BRT system in MDCs is not fully exploited. TSP is a strategy that supports the movement of transit vehicles through signalized intersections. With the emergence of BRT, TSP has been widely implemented at signalized intersections in the world and become a central component of bus system in order to improve the efficiency and reliability of bus operation. Therefore, the implementation TSP for BRT system is a challenging process in MDCs. The previous study on TSP has mostly focused on its effectiveness on improving bus efficiency and bus regularity, as well as the impacts on general traffics. However, the potential environmental impacts that could be caused by TSP control have not been studied, particularly on traffic emissions (CO_2, NO_x and PM_{10}). Consequently, this research focuses on the design and multi-objective simulation evaluation of signal priority for BRT under the condition of mixed traffic flows.

The thesis is divided into seven parts. The first part includes the introduction. The second and third parts present a comprehensive literature review. In the second chapter illustrates the overall of Bus Rapid Transit system development and performances in the world. BRT has achieved to increase bus ridership in

BRT corridors similar to other transit modes, such as LRT and metro systems. The attractiveness of a BRT system is that it can achieve these advantages with relatively lower investment and community disruption than metro systems. BRT has a potential solution for implementing in Motorcycle Dependent Cities that improving public transport services.

The third chapter summarizes the literature reviewed on various aspects of transit signal priority (TSP): concepts of TSP, the types of TSP strategies, the evaluation of these strategies. TSP strategies are most commonly categorized as passive priority (cycle length shortening, phase splitting, area-wide timing plans and metering vehicles), active priority (green extension, early green, actuated bus phase) and real-time priority. The evaluations of TSP strategies have been widely documented. The evaluation is categorized into three main streams: traffic performance evaluation, economic evaluation and environment evaluation. Traffic performance evaluation includes the assessment of bus performance, bus reliability , general traffic and cross street traffic performance, and overall traffic performance. Economic evaluation of TSP projects can assess a project based on cost-effectiveness analysis such as benefit to cost ratio or net benefit. Environment evaluation mentioned the emission impact of TSP, including total CO_2 emission and air pollutants (NO_x, PM_{10}).

In the next part, some major problems of bus service caused by many factors are identified in problem analysis, including urban transport problems, bus service, current air quality status, and Bus rapid transit implementation in MDCs. The fifth chapter, this thesis proposes an integrated simulation model to investigate the impact of TSP on traffic performance, as well as traffic emission under using different traffic and transit conditions using micro-simulation software, VISSIM with VAP and EnViVer modules, which are utilized to simulate different scenarios. A multi-objectives evaluation also is proposed to assess the TSP measures. This evaluation based on the four main goals of traffic management, including satisfaction of mobility needs, increase of traffic safety, reduction of environmental pollution, and improvement of economic efficiency. TSP implementation with multi-objectives evaluation need to be considered some major factors, this thesis could be categorized these factors into seven main areas: (1) road characteristics, (2) traffic characteristics, (3) vehicle characteristics, (4) pedestrian considerations, (5) transit characteristics, (6) traffic modeling, (7) emission modeling.

The experimental design is presented in chapter six, taken one signalized intersection with 03 lanes per direction on main-street of the potential BRT corridor in Ho Chi Minh City as a case study with different signal priority strategies, including fixed-time control, green extension, early green, actuated bus phase methods are developed for the isolated signalized intersection. Simulation results indicate that the BRT vehicle would typically benefit from signal priority with travel times savings and delay reduction as well as greater person delay reduction with the active signal priority strategy, including green extension, early green and actuated bus phase insertion, combines with exclusive bus lane. This thesis also found that the impact of active signal priority strategy on total traffic emissions is little higher than fixed-time signal control in mixed traffic flow with dominated motorcycle due to the negative impacts of TSP implementation on general traffics (e.g.: increase other vehicles delay, number of stops and queue length) and motorcycle fleet contributes the highest percentage of CO_2, PM_{10} pollutions and the second highest percentage of NO_x pollution at this case study.