Evaluation of Impacts of Bus Priority Measures on Reliability of Bus Operation Using Micro Traffic Simulation - Case Study in Hanoi, Vietnam

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Abstract

In Asian cities, the serious traffic congestion has caused many problems, which have an adverse influence on buses such as delays of travel time, left-behind passenger and overcrowding. However, since the bus is still a dominant transport mode in the most of Asian cities, improving the bus operation in those cities is one of urgent tasks. Therefore, the purpose of this study is to evaluate the effects by introducing countermeasures for improving the bus operation from the viewpoints of reliability focusing on Hanoi city. So, in this study, firstly, literature review was conducted for selecting the indicators to assess the reliability of bus operation in Hanoi city, and several indicators based on reliability of travel time and headway were chosen in existing papers. Secondly, Chuong Duong Bridge area where are key routes from the suburbs to inner-city was selected as a case study area because chronic traffic jam causes some troubles on bus operation around this area. Thirdly, those selected indicators were applied to nominated routes based on the data from field survey, and evaluated the reliability of headway and travel time. Finally, the micro traffic simulation model was developed by using VISSIM for estimating the impacts on reliability with comparing among with/without the countermeasures which introduced the bus exclusive lane before Chuong Duong Bridge by decreasing the number of lanes from 3 to 2 lanes as bus priority operation. As the result, the evaluation of reliability of bus operation in Hanoi could be conducted from the perspective of headway and travel time.

Keywords: Bus, Reliability, Bus Priority Measures, Micro Traffic Simulation, VISSIM

1. Introduction

Even bus transport is still dominant transport mode in the most of Asian cities, level of service of bus operation is getting worse accordance with growth of a city. Especially, when the cities that rely primarily on non-motorized transport has been diverted to auto-dependent cities, bus operation used to be affected by serious traffic congestion and many negative impacts such as delays of travel time, left-behind passenger, overcrowding, etc. have been occurred. Such

deterioration of service level of bus operation might reduce the number of bus passengers. And this phenomenon increases another motorcycle and car users and make traffic congestion more serious. As a result, the reliability of bus operation becomes worse and again increases motorized vehicle users. To break out this negative loop, an improvement of bus operation is strongly required which might increase the reliability of bus operation. However, there are no existing researches that focus on evaluation of the impacts of improvement of bus operation in terms of reliability in Asian cities. Therefore, this study aims to evaluate impacts of the improvement measures of bus operation on its reliability.

To achieve aims of this study, we firstly selected the indictors represented reliability of bus operation based on literature reviews. Secondary, we selected countermeasures to apply nominated routes in Hanoi city. Then we developed a micro traffic simulation model to estimate impacts on reliability by comparing the estimated conditions with/without the countermeasures improving bus operation.

2. Literature Reviews

There are a lot of papers that evaluated the reliability of public transport operation from the viewpoints of passengers. For examples, Liu and Sinha[1)] evaluated the reliability of bus operation by employing three indicators such as travel time reliability proposed by Polus[2)] and Sterman and Schofer[3)], bus headway reliability proposed by Browman and Turnquist[4)] and passenger waiting time reliability that was utilized by TfL (Transport for London)[5)] and they examined the reliability of bus operation by calculating above indicators for the results of a micro traffic simulation in the case of York city, UK. They concluded that there is a strong relationship between passenger waiting time at bus stop and bus headway, and the increasing passenger demand make decrease the reliability of bus operation. Sorrantini[6)] also evaluated the reliability of bus operation at York city under 14 different scenarios reflected the change of passenger demand, overcrowding level, embarking and disembarking time using same indicators with Liu and Sinha[1)] and regularity indicator of bus service by van Oort and van Nes[7)] and recovery time.

Regarding the existing researches that focused on bus operation in Hanoi, for example, Anh et al.[8)] evaluated by using "performance indicator" after carrying out questionnaire survey and field survey for collecting the data concerning bus headway, passengers and characteristics of passengers on each line. This study evaluated the bus operation in Hanoi from the perspective of management in particular

Thus, there are few researches that evaluated the reliability of bus operation improvement measures in Hanoi.

3. Overview of Traffic Situation in Hanoi

3.1 Current Situation and Plan of Public Transport

Since the tram was abolished in the late 1980s, the number of bus passengers also was decreased. However, the bus services have never improved during the 1990s. In 2002, the "Model Bus" policy that introduced new bus routes, new vehicle fleet, and new bus shelters have been started. As the result, the share of bus has become about 5.6% in 2005 and 9.4% in 2012.

Currently, there are 60 buses operated routes in Hanoi city. The main transportation modes are motorcycles, passenger cars, buses and taxi, it is predicted that the number of passenger cars will increase due to economic development[9)]. The modal share of motorcycle is around 80%, but the share of bus is around 10% only. In addition, the road ratio is also very low (around 1.9% only) comparing with other cities in Asian countries.

Although five urban railways have been planned by and Bus Rapid Transit (BRT) have been planned by The World Bank, it is necessary to promote increasing the bus passengers due to taking long time for open. According to the result[8) 9)] from questionnaire surveys to citizens, it cannot be said bus service level is high in Hanoi.

3.2 Overview of JICA Project for Improving Bus Operation

The Project for Improving Public Transportation Hanoi (TRAHUD Ⅱ) is one of ongoing projects by Hanoi Department of Transportation under technical cooperation by Japan International Cooperation Agency (JICA). This project team examines feasibility of bus operation improvement measures with Hanoi Department of Transportation. One of candidate route is planed around along Ngo Gia Tu - Chuong Duong Bridge. Since this bridge is spanned the Song-Hong River, and key routes from the suburbs

to inner-city, the chronic traffic jam occurs around the bridge from the suburbs to inner-city during morning peak time, as the result, it causes the some troubles on bus operation. Therefore, changing the one of lanes in front of its bridge to bus priority lane have been planned as one of countermeasures.

The other location for pilot project will be National Highway No.1 crossing South-North in Hanoi city. The lanes separate based on the type of vehicle, but the intricate situation among buses and motorcycles cause not only adverse impacts on bus operation but also dangerous situation. The various bus priority measures are still being considerate.

Therefore, this study focused on Chuong Duong Bridge as a case study route (Fig.1). The image of current situation around Chuong Duong Bridge is shown Fig.2. In this route, 11 major bus routes are operated, and Bus transport volume on this Bridge is approximately 2,400 (veh./day).

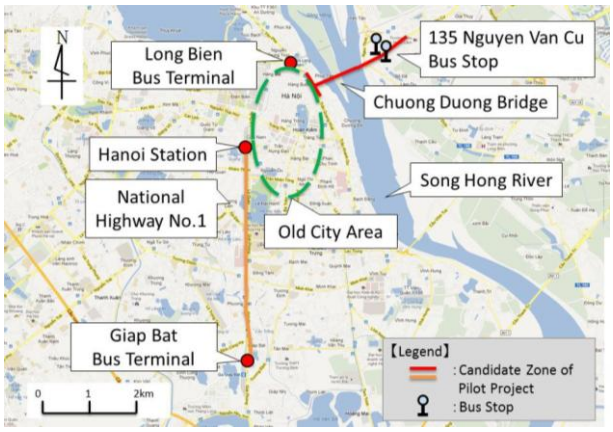

Fig. 1 Target Route in This Study

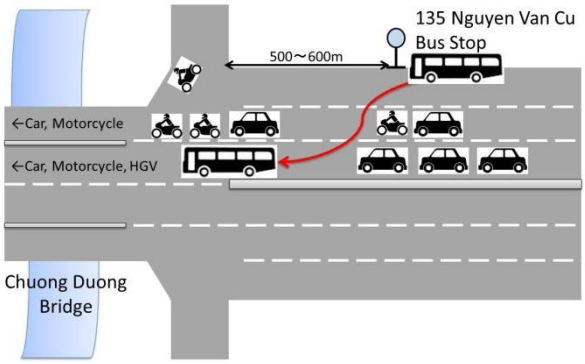

Fig. 2 Image of Traffic Situation along Chuong Duong Bridge (East Side)

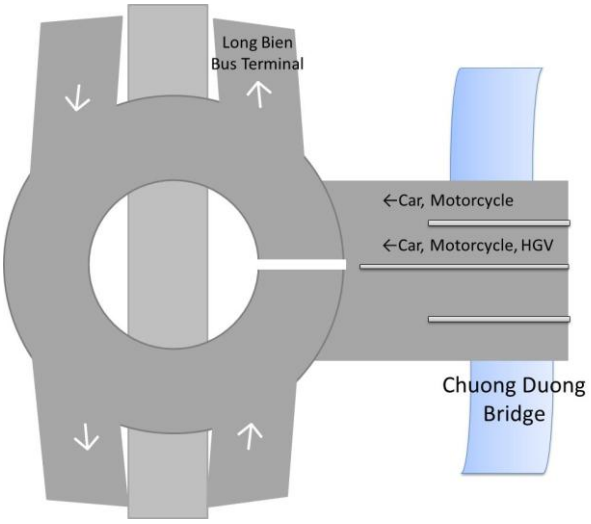

Fig. 3 Image of Traffic Situation along Chuong Duong Bridge (West Side)

4. Methodology

4.1 Flow of Analysis

Basic approach in this study is shown in Figure-4. Firstly, the current traffic situation was represented around the Chuong Duong Bridge using micro traffic simulation (VISSIM) after collecting data through field survey, and applied the existing indicators for assessing the reliability from the viewpoints of headway and travel time. Secondly, the simulation that introduced bus priority lane was represented and compared with those evaluations results.

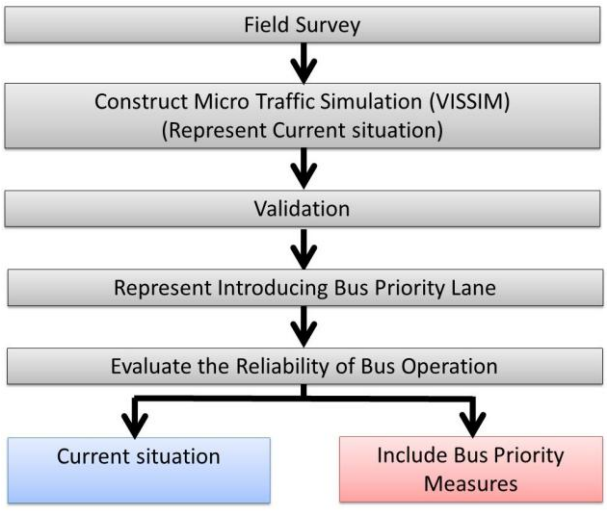

Fig. 4 Basic Approach in this Study

4.2 Outline of Field Survey

The field survey was conducted with 6 students of University of Transport and Communications, Hanoi to investigate the current traffic situation and to collect the data for evaluating the reliability around the Chuong Duong Bridge from 6:00a.m. to 9:00a.m. including morning peak time from 15th July to 22th, 2012. The summary of field survey is shown below.

- Day : 15th July - 22th, 2012.
- Time : Morning peak time at weekday (6:00a.m. - 9:00a.m.)
- Target Route : Along the Chuong Duong Bridge, Hanoi
- Investigator: 6 Students of University of Transport and Communications
- Survey Items

a) Travel time survey (3 kinds of vehicle… Bus, Passenger car (Taxi), Motorcycle)
b) Bus headway time survey at bus stop
c) Passenger count survey at bus stop
d) Bus stoppage time survey at bus stop
e) Video survey

4.3 Indicators for Evaluating Reliability

For evaluating the reliability of bus operation around the Chuong Duong Bridge, the indicators proposed by Polus[2] and Browman and Turnquist[4] for assessing reliability based on travel time and headway was applied in this study.

Regarding the evaluation of headway, there are 2 main evaluation methods. One is the calculated by standard deviation of headway, and the other one is evaluated by the time gap between bus timetable and arrival time such as Browman et al.[3]. Since there is no bus timetable in Hanoi, the indicators proposed by Browman and Turnquist [4] were applied in this study. The equation of indicator of headway reliability is shown below. It is possible to show the variability of headway by dividing standard deviation of headway by fixed average headway.

Reliability of Travel Time;

$$RT_i = \frac{\mu_{ti}}{\sigma_{ti}} \quad for \quad t_i \in \{t_{inm}\} \qquad (1)$$

μ_{ti} : Standard Deviation of Travel Time

σ_{ti} : Average of Travel Time

Reliability of Headway;

$$RH_i = \frac{\sigma_{hi}}{\mu_{hi}} \quad for \quad h \in \{t_{inms}\} \qquad (2)$$

σ_{hi} : Average of Headway

μ_{hi} : Standard Deviation of Headway

5. Results

Applying equation (2), the reliability of headway were calculated by the route and by the date conducted survey as shown in Table-1 to Table-4. For several routes, the reliability could not calculate because bus could not come to the bus stop during observation period.

The result shows average headways of buses were close to schedule headways at almost all bus routes. However, reliability of headway for several routes is not high.

Table 1 Result of Headway Reliability

19th July : Chuong Duong Bridge → Suburb

Bus Route Number	Headway (min)	Average Headway	Standard Deviation	Indicator of Headway Reliability
3	10 - 15	-	-	-
10	10 - 20	08:55	03:08	0.35
11	10 - 15 - 20	-	-	-
15	10 - 15	10:45	04:29	0.42
17	10 - 15	10:02	02:15	0.22
22	5 - 10	05:44	04:18	0.75
34	10 - 15	12:23	04:11	0.34
40	10 - 15 - 20 - 30	09:17	05:13	0.56
42	10 - 15	-	-	-
43	15 - 20	-	-	-
54	15 - 20	12:18	05:17	0.43

Table 2 Result of Headway Reliability

19th July : Suburb → Chuong Duong Bridge

Bus Route Number	Headway (min)	Average Headway	Standard Deviation	Indicator of Headway Reliability
3	10 - 15	09:52	01:52	0.19
10	10 - 20	13:00	38:00	0.61
11	10 - 15 - 20	10:45	04:36	0.43
15	10 - 15	10:15	07:16	0.71
17	10 - 15	11:42	03:54	0.33
22	5 - 10	05:45	01:54	0.33
34	10 - 15	10:16	01:47	0.17
40	10 - 15 - 20 - 30	08:24	05:09	0.61
42	10 - 15	13:01	06:05	0.47
43	15 - 20	16:24	04:01	0.24
54	15 - 20	13:29	06:06	0.45

Table 3 Result of Headway Reliability

20th July : Chuong Duong Bridge → Suburb

Bus Route Number	Headway (min)	Average Headway	Standard Deviation	Indicator of Headway Reliability
3	10 - 15	11:01	05:08	0.47
10	10 - 20	08:29	04:01	0.47
11	10 - 15 - 20	-	-	-
15	10 - 15	11:35	04:35	0.40
17	10 - 15	10:13	03:38	0.36
22	5 - 10	06:34	05:03	0.77
34	10 - 15	11:52	04:23	0.37
40	10 - 15 - 20 - 30	10:33	03:06	0.29
42	10 - 15	32:17	25:59	0.80
43	15 - 20	14:26	35:02	2.43
54	15 - 20	12:39	03:40	0.29

Table 4 Result of Headway Reliability

20th July : Suburb → Chuong Duong Bridge

Bus Route Number	Headway (min)	Average Headway	Standard Deviation	Indicator of Headway Reliability
3	10 - 15	10:23	02:38	0.25
10	10 - 20	09:03	06:57	0.77
11	10 - 15 - 20	10:35	05:29	0.52
15	10 - 15	10:52	08:12	0.75
17	10 - 15	13:21	07:21	0.55
22	5 - 10	06:20	02:45	0.43
34	10 - 15	11:46	04:55	0.42
40	10 - 15 - 20 - 30	11:01	05:16	0.48
42	10 - 15	13:25	05:21	0.40
43	15 - 20	19:10	11:14	0.59
54	15 - 20	13:05	06:15	0.48

6. Conclusion

In this study, the reliability of existing bus operation was evaluated using reliability indicators through a field survey. As the result, it was found that there was variability on headway at some bus routes. As one of reasons for that, it is considered that traffic congestion used to make bus bunching before the 135 Nguyen Van Cu bus stop and this affect to variability of headway. Thus, there is high possibility that the headway at next bus stop might be influenced its variability by traffic congestion occurred before Chuong Duong Bridge.

At present, it is under evaluation of travel time reliability on existing bus operation and representing the simulation model based on the data from field survey. For further study, the headway and travel introduced the improvement measures of bus operation will be evaluated and compared by using existing 2 indicators for assessing reliability.

Acknowledgment

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