

**STRATEGIES FOR ENHANCING THE OPERATIONAL
PERFORMANCE OF TRANSJAKARTA BUS RAPID TRANSIT
SYSTEM**

YUDHANTO MAHARUTO

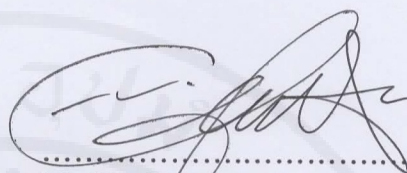
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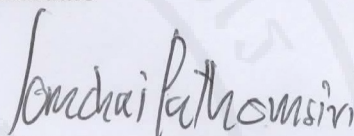
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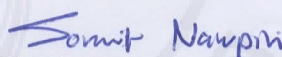
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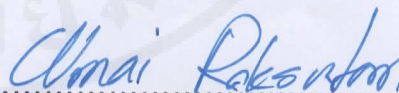
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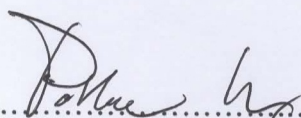
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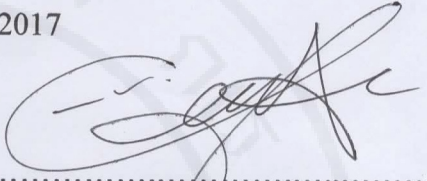


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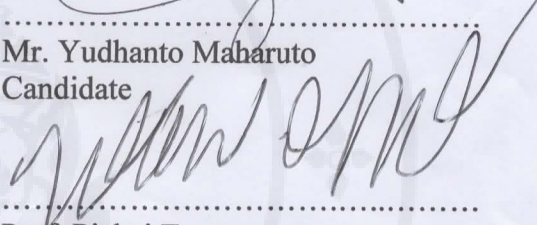
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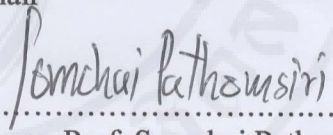
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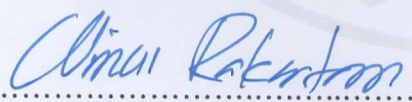
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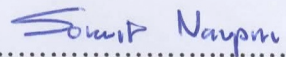
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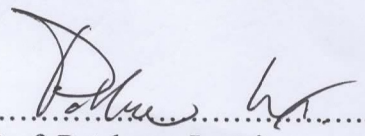
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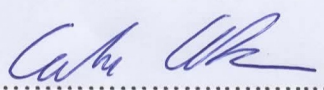
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STRATEGIES FOR ENHANCING THE OPERATIONAL PERFORMANCE OF TRANSJAKARTA BUS RAPID TRANSIT SYSTEM

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ABSTRACT

Bus Rapid Transit (BRT) system is one of the great innovations in public transit system due to its low cost and high performance. Jakarta, a capital city of Indonesia has implemented a BRT system, so-called TransJakarta since 2004. Now, it is the world's largest BRT system consisting of 12 corridors, 211 kilometers total length, and 482 buses carrying about 350,000 passengers daily. This research is aimed to understand the physical and operational characteristics of TransJakarta and also compared with Bangkok BRT. In addition, the study evaluated its performance, identified the problem, and proposed the strategies to enhance the operational performance. The ultimate goal was to improve the performance and service reliability of the TransJakarta as a rapid transit system. The field survey was conducted in January – March 2016 in Jakarta. The analysis results showed the details of problems by corridor from the aspects of operation, network, and infrastructure. The proposed strategies related to individual aspects such as the installation of a segregated lane, extra platform, passing lane, lane separation for BRT and the combination of them were assessed by using VISSIM simulation models. It is found that under the current demand pattern and system configuration it is almost impossible to achieve the desirable 25 kilometers/hour of average speed. In general, the most cost-effective enhancement strategy is the installation of a segregated lane. The significant time savings of approximately 50% were found in corridors 1, 2, and 3 from strategy combination 1, strategy combination and strategy combination, respectively. The remaining corridors may be able to realize the time savings between 22% and 35%.

KEY WORDS: BUS RAPID TRANSIT / TRANSJAKARTA / BANGKOK BRT / BRT
CHARACTERISTICS / BRT PERFORMANCE / SIMULATION

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CHAPTER I

INTRODUCTION

1.1 Background

Many cities and metropolitan areas face the problem of traffic congestion and its negative impact. In these cases, city government develops urban public transportation, known as transit, as the critical element in achieving balanced transportation system (Vuchic, 2007). The development and innovation of public transit system have been popularly discussed among the city government and experts around the world in the recent decades. One of the great innovations is the high quality bus service system called Bus Rapid Transit (BRT). BRT system has proved itself as the low cost and high performance mass transportation alternative. Hence, the expansion of BRT has been running fast both in developed and developing cities. BRT system has been implemented throughout Europe, North America, Latin America, South East Asia, China, Australia, and now increasingly in India, Africa, and Pakistan.

Jakarta as the major metropolitan city in Indonesia has been implementing these systems since 2004. As the big evolution in public transport, Jakarta city has a Bus Rapid Transit (BRT) system called TransJakarta. It is the BRT operator company under the regional government of Jakarta. TransJakarta has been in operation since 2004. It was the first BRT system launched in the Southern and Southeast Asia. The recent data from TransJakarta Company shows the daily demand of approximately 350,000 passengers which are served by 482 units of buses at the time of this research. TransJakarta has segregated lanes (width 3 m to 6 m) with physically separated by curbs on both sides. The total route length of TransJakarta is about 211 kilometers of which 14 kilometers are mixed traffic portions, mostly because of bridge and flyover. The system provides bus services on 12 corridors including on 10 direct routes around Jakarta City.

As the metropolitan city that faces high concentration of population, the congestion becomes the common problem in the traffic network. The congestion hardly affects the movement of BRT fleets. The delay, low punctuality of schedule, and irregular headway become the daily problem of the system which are felt by the users. The passengers complain about uncertain waiting time at several corridors. The average waiting time is more than 30 minutes during peak hours. However, during the last eleven years, the level service of TransJakarta has not been changed (Kompas, 2015). Note that, following Wright & Hook (2007), the benchmark of waiting time for transit service system is 1-5 minutes during peak period, and 5-10 minutes during off-peak period.

Over the recent study period, TransJakarta has been facing other problems beside delay; i.e., overcrowded both in vehicle and at stations that lead to inconvenience for the passengers. In addition, traffic problem such as interrupted bus way, delay at intersection and mixed traffic caused lower level of service. Please take a look at **Figure 1.1**. (Kompas, 2015)



Figure 1.1 Crowd of passengers, traffic congestion, and delay during rush hour operation

The expansion of BRT system in Jakarta through the increasing the number of corridors and the number of fleets has been carried out by the government. At its commencement in 2004, there was only one corridor. Then as of February 2013, the 12th corridor has been in operation. As of August 2015, the government added 500 more units of buses. The expansion of TransJakarta service tends to increase the number of users. Most corridors even operate 24 hours daily. Despite the severe problems facing it, TransJakarta is still the best bus service system in Jakarta Metropolitan City. Hence, the TransJakarta becomes the favorite public transport system in Jakarta. Furthermore, the relationship between the user's loyalty and image is not significant. It means that the users of TransJakarta are patronage its service, regardless of the image and the fact related to their experiences (Joewono et al., 2012). As a result, BRT should be the low cost, and high performance mass transportation alternative with rapid implementation. However, there has been no significant development of the BRT system in Jakarta over the last eleven years. The author realized that the study about enhancing of BRT system in Jakarta Metropolitan City is necessary. The performance evaluation also needs to be included in order to become the base of establishing the system and comparing performance of the proposed strategies. In order to improve the depth of the study, this research also analyzes and compares the performance of BRT systems in Jakarta and Bangkok, where there is only one corridor operated since 2007. Both cities have several similarities. They are the capital city experiencing chronic traffic congestion over many years.

1.2 Research objectives

Based on background and problem statement above, the following research objectives are set up.

- 1) To study the physical and operational characteristics of Bus Rapid Transit System in Jakarta Metropolitan City, and compare with Bangkok BRT.
- 2) To analyze and propose the strategies in order to improve the performance of Jakarta BRT.

1.3 Research questions

In order to achieve the research objectives, the following research questions have to be analyzed.

- 1) Is the recent Bus Rapid Transit system in Jakarta sufficient to accommodate the recent demand?
- 2) Is the Bus Rapid Transit performance in Jakarta in line with the performance standard as the reliable bus service system?
- 3) What kinds of operational strategies are suitable to enhance the performance of BRT system in congested and developing cities in general and the city of Jakarta in particular?

1.4 Scope of study

The study scope is in the service area of TransJakarta. It consists of 12 corridors. The total length of network is 211 km. The simulation also involves the mixed traffic volume on several links and intersections. The route map of corridors along Jakarta road network can be seen in **Figure 1.2**.

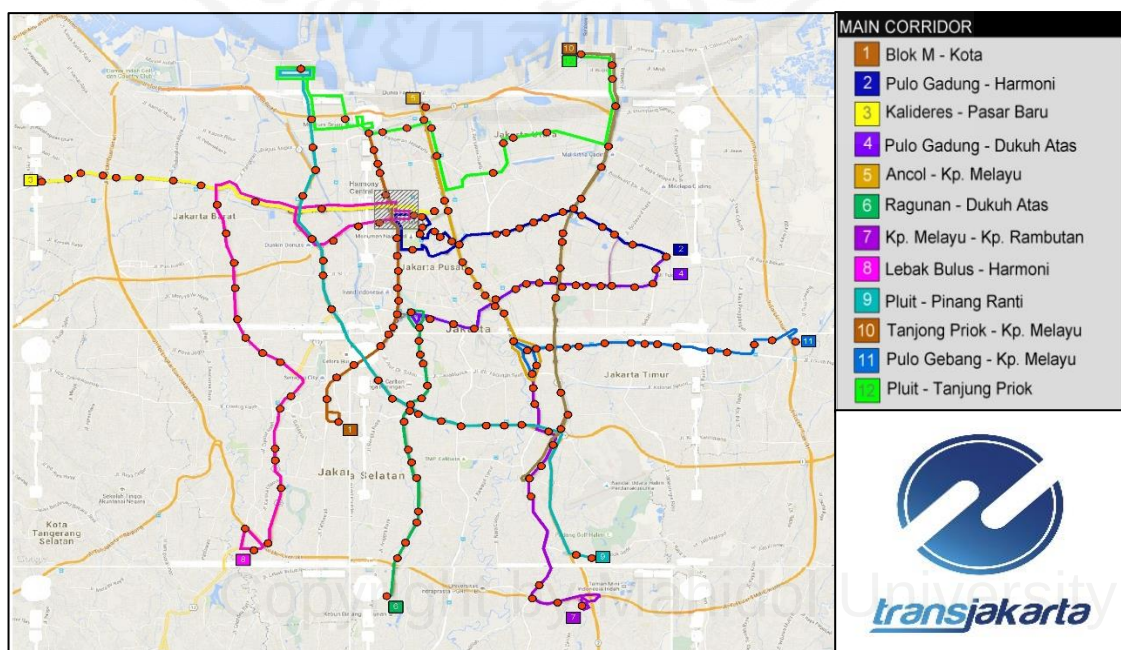


Figure 1.2 TransJakarta's route network map

CHAPTER II

LITERATURE REVIEW

The aim of this chapter is to review literature related to the bus rapid transit (BRT) system as well as the performance of BRT based on the view points of the operator, government, and passengers. The problems that BRT system has been facing and the improvement are also covered. This chapter focuses on several aspects of bus rapid transit system including policy, planning, implementation, and enhancement. All the information is based on existing studies, literatures, and knowledge related to the BRT system.

2.1 Definitions and characteristics of bus rapid transit system

Bus Rapid Transit (BRT) system is a great evolution of urban transit. The system takes the advantages between rail-based and rubber-tired transport. The bus provides nearly door to door service at lower cost than the heavy investment rail system like LRT (Light Rail Transportation). Hence, BRT system was designed in order to fill the gap between bus system and LRT. The system is typically close to modern-rail based transit system at more efficient cost of development. BRT system costs less than a light rail transit (LRT) system, it is 4 to 20 times cheaper (Wright & Hook, 2007). On the other hand, BRT gives positive impact on land development. Because of BRT, people are willing to travel further, then the economic activities along the road do not get the bad impact like in the case of LRT. In many cases, the development of rail track has given the bad impact to economic society along the track (Deng & Nelson, 2010). There are several definitions for BRT from different experts, including,

“BRT is a high-quality bus-based transit system which offers speed, convenience, and cost-effective urban mobility through the resolution of segregated busway infrastructure, rapid transit, and frequent operations, and superior in marketing and customer service.”

(Wright & Hook, 2007, p. 11)

“BRT is a flexible, rubber-tired rapid transit mode which combines stations, vehicles, services, running ways, and Intelligent Transportation System with positive and unique image.”

(Levinson et al., 2002, p. 2)

“BRT is bus transit designed as an integrated system of distinct buses and a separate infrastructure with considerable independence from other traffic, allowing higher speed, reliability, and safety.”

(Vuchic, 2007, p. 256)

The terms of definitions might be varying among the experts, but the same basic concepts were followed. They are high-quality service of mode and dedicated way of movement. In the recent time, the attributes of BRT are about dedicated lane or busway, special stations typically aligned to the center of the road, off-board fare collection, fast, and frequent operations.

For the first time, BRT was officially commenced in Curitiba, Brazil in 1974. Starting in 2000s, many cities were inspired to follow that system known as Bus Rapid Transit System. Since then, it has been operating around the world, BRT has proved itself as the public mode that can give the good performance and impact in terms of commercial speed, capacity, and productivity. As compared with the regular bus, BRT is more reliable in terms of passenger demand, user satisfaction, travel time, reliability, and externality such as air pollutant, carbon emission, and crash (Hidalgo and Gutierrez, 2012). More BRT has been implemented because of the following perspectives.

- BRT can be completed quickly at low to moderate cost and potentially self-financing. BRT has strong ability to reduce implementation time and cost compared with rail-based systems (Deng et al., 2013).

- BRT provides efficient and near door-to-door service than rail-based system (Raj et al., 2013). It offers rail transit-based system performance, but more closely to door-to-door service. BRT becomes a more advanced transportation than rail-based system in terms of urban transit.
- BRT offers low cost of operation and development, rapid implementation and high performance as an urban transit system. (Hidalgo & Gutierrez, 2012).

Based on Wright & Hook (2007), in order to be considered as BRT, it should be operated for a significant part of their journey within a fully dedicated right of way (busway) to avoid traffic congestion. In addition, a true BRT system requires most of the following attributes; alignment in the center of the road to avoid typical curb-side delays; stations with off-board fare collection to reduce boarding and alighting delay related to payment method; certain level of platforms which is equal to the bus floor to reduce boarding and alighting delay caused by steps at station; and bus priority (Wright & Hook, 2007).

2.2 BRT performance evaluation and parameters

BRT performance in transit operations has been receiving increasing attention as agencies faced with more immediate problem of providing credible service, while attempting to reduce operating cost (Ceder, 2007). In UK, a practical-transit guide reports that the perception of local bus passengers about the service is interpreted in the following ranking of importance by scores that add up to 100; i.e., reliability (34), frequency (17), vehicles (14), driver behavior (12), routes (11), fares (7), and information (5). Reliability aspect has the highest score that most people care about. There are three points of view regarding reliability attributes from the passenger's and operator's perspectives and exogenous attributes, all of which depend on circumstances; i.e., reliability attributes of concern to passengers, reliability attributes of concern to the operator, and reliability of exogenous attributes (Ceder, 2007). Until recent decades, many studies have been conducted regarding bus service reliability as well as performance and the factors influencing BRT performances.

The study by Deng et al. (2013) evaluated the physical characteristics, technical performance, and operational issues associated with BRT systems implemented in 13 Chinese cities. The study used SWOT approach to identify the key internal (strengths and weaknesses) and external factors (opportunities and threats) of developing BRT systems in China. They categorized the strengths as the advantages of the BRT systems consisting of low capital cost, self-finance, high passenger volume, low labor, short construction time, and considerable flexibility. Meanwhile, the weakness as the disadvantages, consists of less permanent than rail systems, road space occupation, negative image and impact on urban fabric. On the other hand, the study also discussed about the public policy support as the best opportunities. However, high demand for private cars is the threats of the BRT systems. The study evaluated BRT performance in terms of technical performance consisting of corridor demand, commercial speed, frequency, user fare, infrastructure costs, and BRT operators. The study founded that the low speed of buses become the common problem in the cities of China.

The qualitative parameters of BRT performance were also conducted by Currie and Delbosc (2014). The study reviewed about the performance of Australasian BRT and identified factors that can be the best factors needed to improve performance. The performance factors analyzed in this study are categorized by ridership perspective focusing on load of buses on route and in vehicle, then operation perspective focusing only on the average speed. The study founded the factors as the principal-influencing ridership performance of Australasia's BRT system; i.e., high service level, low speed, shorter stop spacing, segregated lane, accessible vehicle, lower fare, integration system, and pre-boarding ticketing.

The researchers conducted quantitative parameters mostly by using micro simulation in their work. One of studies has been conducted by Raj et al. (2013). The study analyzed the quantitative performance using micro simulation technique for the opening BRT system in New Delhi which has bus lane mixed with other types of vehicles. Delhi BRT faced several problems consisting of difficult access to bus platform and longer traffic signal cycle times. The study focused on speed, delay performance, and travel time in the network. Then, a quantitative performance

approach using micro-simulation technique has been formulated to evaluate the open BRT system's corridor functioning in Delhi. Micro simulation based on traffic flow models was developed for corridors. Another study with quantitative parameters of BRT performances was conducted by Yang et al. (2013). This study mainly investigated two advanced-control strategies; i.e., signal priority using advanced detection and transit speed control. The comparative performances between two proposed scenarios were based on several indicators including delay, travel speed, bus reliability, and average delay.

One of the reliable and practical benchmark of the BRT performance at the international level is called operational key performance indicators (KPIs). The work of Aziz et al. (2014) used various KPI parameters as the BRT performance indicators. The study analyzed BRT system in Lahore based on operational key performance indicators (KPI). The method evaluated by using various performance measurements or KPI which are accepted and practiced internationally by several institutions, such as FTA (2004), APTA (2010) and World Bank (2006). The framework for evaluation used the following 4 indicators.

- 1) Travel time savings; it means the saving resulting from the current BRT system as compared with the previous systems without the BRT. This indicator ensures that the advantages of BRT in terms of time travel deserve to replace the previous system at the same stage of network.
- 2) Service reliability; it consists of :
 - a. Trip realization means to measure the number of trips completed based on assigned trips in a given period of time.
 - b. Punctuality means to measure the on-time performance of the started trips.
 - c. Travel time reliability means to measure the on-time performance of the completed trips.
 - d. Schedule adherence or on-time performance shows how far the fleet follows the time table.

- e. Headway regularity shows how far the operation buses follow the planned headway.
 - f. Waiting time reliability observes the waiting time based on planned waiting time or acceptable waiting time.
- 3) Safety counts the number of accidents against fleet's kilometers.
 - 4) Capacity and comfort are measured by load factor, of which 85% is the benchmark of comfort.

There have been so many chosen aspects by experts to measure the performance of BRT. Overall, there are 3 main aspects that they usually considered; i.e., infrastructure aspect, operation aspect, and externalities. The performance parameters have been summarized in the Table 2.1.

Table 2.1 Summary of BRT performance aspects

Aspect	Indicator	Description	Authors
Infrastructure	Lane	-	Wright & Hook (2007), Hongyang (2005)
	Facility	-	Wright & Hook (2007) Hongyang (2005)
	Station/Bus stop	-	Wright & Hook (2007) Hongyang (2005), Liu et al. (2012)
	Priority	-	Hongyang (2005)
Operation	Travel speed	-	Wright & Hook (2007) Aziz et al. (2014), Deng et al. (2013), Currie & Delbosc (2014), Raj et al. (2013), Yang et al. (2013)
	Travel time	-	Wright & Hook (2007), Aziz et al. (2014), Raj et al. (2013), Yang et al. (2013)
	Service reliability	trip punctuality schedule headway waiting time safety load factor	Aziz et al. (2014), Raj et al. (2013), Yang et al. (2013), Hongyang (2005), Chunjiao et al. (2008), Liu et al. (2012), Tao et al. (2014)
	Ridership performance	passenger/ route-km passenger/vehicle-km	Currie & Delbosc (2014)
Externalities	Economic impact	-	Hongyang (2005)
	Environmental	-	Hongyang (2005)
	Social impact	-	Hongyang (2005)

The indicators of performance system are basically used to ensure the safety, mobility, convenience, and reliability. The measurements maybe both quantitative and qualitative performances. The recent study is using quantitative performance in operation aspect to compare the performance between existing system and enhanced system. The performance of operation aspects is interpreted by the simulation.

2.3 The issues of bus rapid transit

As mentioned before, BRT is the combination system between road-based and rail-based transportation. Furthermore, BRT offers lower cost, rapid implementation, and high performance than LRT. The advantages of BRT system could not always be fully exploited. The systems are basically the same among several cities that have been implementing BRT, but they faced different problems or issues because of various conditions and traffic behaviors. These factors impacted the operation and made BRT become inefficient. Base on the operational efficiency, The Institute for Transportation and Development Policy (ITDP) separates the BRT into two kinds; i.e., full BRT and standard BRT. The concept of full BRT system is the one with the following minimum characteristics (Wright & Hook, 2007).

- Segregated busway or dedicated lane or bus-only roadways must be the majority of the route length;
- Location of the busways is in the median of the roadway rather than in the side;
- Routes and corridors are integrated;
- Enhanced stations which are comfortable, convenient, secure, and weather-protected;
- Certain level access between the platform and vehicle floor;
- Special stations to facilitate physical integration between trunk routes, feeder service, or even with other mass transit systems;
- Pre-board or off-board fare collection;
- Physical- and fare-integration between routes, corridors, and feeder services;

- Entry to system restricted to prescribed operators under a reformed business and administrative structure (closed system);
- Distinctive marketing identity for system.

Following the above characteristics, the Institute of Transportation Development and Policy (ITDP) claimed that there are only two cities which have been implementing full BRT system because of the high political commitment towards quality public transport. They are Bogota (Colombia) and Curitiba (Brazil). The rest of the systems are standard BRT. Several existing BRT systems are closely to the full BRT. The limited-corridor systems in Leon and Mexico City (Mexico), Pereira (Colombia), and Guayaquil (Ecuador), if expanded into complete network; then, these system will qualify as the full BRT (Wright & Hook, 2007). In Brisbane (Australia), the system must be implemented by using the off-board fare collection, then it will be qualified as the full BRT. Then, in Jakarta (Indonesia), it has to make its feeder services more fully integrated with trunk services, then the system will be closely qualified as the full BRT (Wright & Hook, 2007).

Many planners believe that the BRT system in Bogota called TransMilenio is the great example. The complete features can be seen in the Table 2.2. Many studies have been conducted regarding BRT system in Bogota. The work of Pena and Moreno (2014) discussed the delay at bus stop of TransMilenio that affects service reliability. The study found TransMilenio shows capacity comparable to those obtained in systems with higher level of transport infrastructure. However, its capacity is limited by stop capacity. Then, a dwell-time model at bus stop based on Transit Capacity and Quality of Service Manual (TCQSM) was proposed to obtain satisfactory capacity regarding bus stop delay. In line with the capacity, the study of Hidalgo et al. (2012) examined the actual capacity of Bus Rapid Transit in Bogota at 43,000 passengers per hour per direction. Meanwhile, transit textbooks and engineering manual indicates that the capacity of Bus Rapid Transit system does not exceed 20,000 passengers per hour per direction.

The highly successful BRT in Bogota and Curitiba are not always followed by other cities, in particular for developing cities such as Mexico City, Santiago, Sao Paulo, Shanghai, Pune, Bangkok, and Jakarta, even though the systems

quite satisfied the citizen. They are fighting with switching private vehicle option into public transport option. In developing countries, usually the image of public transport is poor quality, inconvenience, crime potential, lack of safety, slower service than private vehicle, and overloading (Wright & Hook, 2007). Hence, those developing cities implemented BRT as the development of public transport. In fact, they faced various problems because of system failure. For example, the lack of headway regularity and schedule adherence are the major weaknesses of the BRT in Lahore. Furthermore, there are delays due to traffic congestion on the mixed traffic section (Aziz et al., 2014). Chinese cities are facing traffic problems caused by excessive concentration of population, rapid motorization, and inadequate transit services (Deng et al., 2013). These conditions are also experienced in Jakarta. The over load factor occurred on BRT fleets on various corridors due to the high concentration of population zones. Then, BRT in Australasia faced the delay caused by fare collection problem (Currie & Delbosc, 2014). In Ahmedabad, Janmarg BRT has the inconvenient problem because it lacks the information system, low floor section, and no-disable's facility (Bhuva, 2012). In summary, several BRT systems in developing cities become ineffective in operation because of the following factors (Hidalgo & Carrigan, 2010).

- Rushed implementation;
- Early deterioration of infrastructure;
- Occupancy level tends to push very high over expected capacity at 6-7 standees per m² which is not comfortable for the user;
- Delayed implementation caused failure such as fare collection system;
- Very tight financial planning for the systems which do not receive operational subsidies;
- Insufficient user education for implementation and system changes;

TransJakarta is the biggest BRT system in the world. Even though the government has big commitments towards the public transport in Jakarta City, TransJakarta has been facing several operational problems. In developing and congested city, the unacceptable waiting time and delay seem to be the common problem of any public transport even for BRT which is expected to be the high quality bus service. Most systems in highly populated cities and developing cities, such as in

Delhi, Bangkok, Jakarta, and Chinese cities face the congestion problem in mixed traffic section. Furthermore, prohibited movement by another type of vehicles into the right of busway pushes the severe problem into the operation system. On the other hand, intersections generally cause the most delay for BRT (Deng et al., 2013).

2.4 The development of bus rapid transit

Although, there are many problems with BRT operation, the growth of BRT as the great transit system is still exploding in other cities around the world. Based on survey data from EMBARQ (2011), there are about 120 cities with total of 280 bus corridors, 4,300 km of busway, 6,700 stations and about 30,000 buses serving around 28 million passengers per day. Those numbers could be more in the recent time if they conduct the new survey for updating. In certain regions of Asia, there are 27 cities which implemented BRT. Totally, 71 corridors have been operated with total 766 km of busway. In overview, the BRT system in Asia can be summarized in Table 2.2. Obviously, TransJakarta is the biggest system in the world. There are 12 main corridors with total 211 km of bus way, and serving around 313,000 passengers per day.

Table 2.2 BRT systems in Asia.

City	Name	Year Commenced	Number of Corridors	General Lane Type	Route Length (km)	Visualization
Jakarta, Indonesia	TransJakarta	2004	12	segregated (curb)	211	
Kuala Lumpur, Malaysia	Sunway Line	2015	1	segregated (guided)	5.4	
Bangkok, Thailand	Bangkok BRT	2010	1	mix (curb, mark)	15.1	
Ahmedabad, India	Janmarg	2009	13	segregated (fence)	87	

City	Name	Year Commenced	Number of Corridors	General Lane Type	Route Length (km)	Visualization
Pune, India	Pune BRT	2008	2	open	32.5	
Delhi, India	Delhi BRT	2008	1	mixed	-	
Chiayi, Taiwan	Chiayi BRT	2008	1	mixed (curb, mark)	29.65	
Nagoya, Japan	Yutorito Line	2001	1	segregated (guided)	6.7	
Beijing, China	Beijing BRT	2005	5	segregated	79	
Chang Zhou, China	Changzhou BRT	2008	2	segregated	56	
Chengdu, China	Chengdu BRT	2013	1	segregated	28.8	
Changde, China	Changde BRT	2012	1	segregated	18.9	
Guangzhou, China	Guangzhou BRT	2010	1	segregated	22.5	
Hangzhou, China	Hangzhou BRT	2006	3	mixed	55.4	
Heifei, China	Heifei BRT	2010	1	segregated	7.2	
Jinan, China	Jinan BRT	2008	5	segregated	41.6	

City	Name	Year Commenced	Number of Corridors	General Lane Type	Route Length (km)	Visualization
Lanzhou, China	Lanzhou BRT	2013	1	segregated	9.1	
Lianyungang, China	Lianyungang BRT	2012	1	segregated	34	
Shaoxing, China	Shaoxing BRT	2013	1	mixed	19	
Xiamen, China	Xiamen BRT	2008	3	segregated	51	
Yancheng, China	Yancheng BRT	2010	2	segregated	16	
Yichang, China	Yichang BRT	2015	1	mixed	23	
Yinchuan, China	Yinchuan BRT	2012	1	segregated	17	
Zaozhuang, China	Zaozhuang BRT	2010	6	mixed	133	
Zhengzhou, China	Zhengzhou BRT	2009	2	segregated	74.5	
Zhongshan, China	Zhongshan BRT	2014	1	segregated	13	
Zhoushan, China	Zhoushan BRT	2013	1	segregated	27	

Source: ITDP (2015b)

The growth of BRT is still increasing. As of August, 2015, several planning of BRT projects have been conducted in some cities. The project of Karachi

BRT called Metrobus, is planned for Karachi, Sindh, Pakistan with total route length of 109 km. The expected daily ridership would be 350,000 passengers (ITDP, 2015a). There will be four lines. They are the green line with 26 km of route length, the blue line with 30 km of route length, the yellow line with 26 km of route length, and the red line with 27 km of route length. The Karachi BRT has been planned and financed by the city government in cooperation with the Asian Development Bank. The development of Karachi BRT is expected to be finished in 2017.

Another project has been carried out in Cebu, Philippines. The Cebu Bus Rapid Transit System is a planned mass transit system for Cebu City located within the greater Cebu Metropolitan Area. It is expected to become the first operational bus rapid transit project in the Philippines (Lopez, 2010). TransCebu is the proposed name for the BRT line. Single deck non-articulated buses which hold between 85 and 110 passengers will be used. A running speed of 25 km/hr is proposed with a peak frequency of 75 buses per hour on the core route to every direction as the branch routes (IBRD, 2015). This operation is expected to carry 330,000 passengers daily for all directions. Another BRT project has also been conducted in Ashland, State of Chicago, USA. The Ashland Bus Rapid Transit is one of the planned bus rapid transit corridors in Chicago. The service will run on a route with approximately 17 miles in length. Buses will be operated using an exclusive lane in the center of the street, with bus platforms located in the median (Fried, 2013).

2.4 The enhancement of bus rapid transit

The studies to enhance the operation system of BRT are not as many as the evaluation and assessment studies. As of the recent study period, there have been some studies about the enhancement of the operation of BRT. The work of Chunjiao et al. (2008) optimized the BRT operation in Chinese cities by the combination scheduling; i.e., normal scheduling, zone scheduling, and express scheduling. This paper combined these kinds of scheduling using linear program in operations research. The model was developed by minimizing waiting time, in-vehicle time, and vehicle operation. The work of Bhuva (2012) with Ahmedabad BRT system as the field study believed that the success of the BRT system was due in part to the technological superiority. The

enhancement of BRT in this study is in the bus management system including the installation of a GPS unit on each bus. This allows the system performance to be evaluated in real-time, then passengers can receive accurate information of arrival time.

The enhancement of BRT by integration has been analyzed by Rahman et al. (2012). The aim of the study was to enhance the BRT system by integrating with non-motorized public transport called Rickshaws in one of Indian cities. The aim of the study is to develop integrated plans among rickshaws, high-quality public transport as well as BRT system. The result can justify only two possible locations for integrating with rickshaw service. The work of Liu & Teng (2014) analyzed and optimized the bottleneck capacity of elevated Bus Rapid Transit system in Chinese cities. The work of Zhongyi & Guanchuan (2013) improved the operation of BRT in Chinese cities by prioritizing traffic signal at the intersections. It used active transit signal priority to minimize control delay for buses at signalized intersection and consequently improve the operational performance of BRT. Two components were required for the implementation; i.e., detector and communication system for detecting a bus at upstream of the intersection stop line, and traffic signal priority (TSP) strategies which mainly include green extension and green recall. However, the higher priority of system BRT brings additional delay to the non-prioritized vehicles. The work of Yang et al. (2013) aimed to improve the BRT efficiency by using advanced traffic control strategies. The study offered five scenarios evaluated by simulation using VISSIM program. The scenarios are base case scenario, adding exclusive bus lane scenario, conventional active transit signal priority scenario, transit signal priority using advanced detection scenario, and transit speed control scenario. The results showed that the transit signal priority using advanced detection provided the best positive impact towards bus efficiency and reliability. Based on Wright and Hook (2007), Table 2.3 shows the feature's comparison of BRT system in several cities.

Table 2.3 Comparison of BRT Features in 4 cities

No	BRT Feature			
1	Segregated busways	✓	✓	✓
2	Existence of an integrated "network" of routes and corridors	✓	✓	Progressing
3	Enhanced station environment	✓	✓	✓
4	Special stations and terminals to facilitate transfers	✓	✓	Progressing
5	Overtaking lanes at stations	✓	-	-
6	Improvements to nearby public space	✓	p	-
7	High average commercial space	✓	✓	✓
8	Actual peak ridership over 8,000 passengers per hour per direction	✓	✓	✓
9	Pre-board fare collection and fare verification	✓	✓	✓
10	At-level boarding and alighting	✓	✓	✓
11	Fare-and physical-integration between routes and feeder services	✓	✓	✓
12	Entry to system restricted to prescribed operators under a reformed business (closed system)	✓	✓	✓
13	Competitively-bid and transparent contracts and concessions	✓	-	-
14	No need for operational subsidies	✓	✓	-
15	Independently operated and managed fare collection system	✓	✓	✓
16	Quality control oversight from an independent entity/agency	✓	✓	Progressing
17	Low-emission vehicle technology (Euro III or higher)	Progressing	-	-
18	Automated fare collection and fare verification system	✓	Progressing	✓
19	System management through centralized control center, utilizing vehicle location system	✓	-	-
20	Signal priority or grade separation at intersections	Progressing	-	✓
21	Distinctive marketing identity for system	✓	✓	✓
22	High-quality customer information (e.g., clear maps, signage, real-time information displays)	✓	✓	✓
23	Modal integration at stations (e.g., bicycle parking, taxi stations, easy transfer)	Progressing	Progressing	✓
24	Supporting car-restriction measures (e.g., road pricing)	✓	-	Progressing

Source: Wright and Hook (2007)

Planners and experts are thinking about special design features, level of segregation, intersection priorities, platform, vehicle, number of entrance, boarding level, payment method, and opportunity of overtaking, and information technology (Hidalgo and Gutierrez, 2012). Overall, the enhancement of BRT is a strategy for facing the challenging issues as well as improving travel performance, operating efficiency, and also institutional management. Related with the recent study, the enhancement of BRT leads to the improvement of service performance regarding both physical and operational. The assessment of the proposed strategies will be evaluated by using simulation approach. As mentioned before, the improvement in travel performance and operating efficiency are the factors that can be simulated.

By understanding the literatures about BRT system including characteristics, performance evaluations, challenging issues, developments, and the enhancements proposed by the experts; then, the author realized that the advantages of BRT system in Jakarta needs to be exploited more by improving performance in line with the standard. As widely known, the development of BRT in Jakarta has been going so well that it has become the largest BRT system in the world. However, the development system in size is not accompanied by improving performances. Hence, the author decided that the enhancement needs to be studied with the focus on technical aspects; i.e., operation, network, and infrastructure. The performance evaluation will be conducted by quantitatively analyzing the technical parameters that can be simulated by a computer program. All of research methods will be described in detail in the next chapter.

CHAPTER III

RESEARCH METHODOLOGY

The aim of this chapter is to discuss about the research methodology for reaching the objectives of the research. This chapter is separated into four sections. The first section discusses about primary data and secondary data as well as collection methods. The second section is research framework and data analysis. The third section is about analytical tools. Finally, the last section of this chapter discusses about the research procedure.

3.1 Data

In the case of this study, the data are necessary in order to evaluate the BRT's performance and to develop microsimulation model of BRT for assessing the proposed strategies. Basically, the data are distinguished into two kinds; i.e., the BRT data and mixed traffic data. The BRT data are the qualitative and quantitative information about characteristics and operation of TransJakarta. The study needs to collect also the mixed traffic data on the road along busway of TransJakarta and all intersections which are passed by TransJakarta's fleets for microsimulation purpose. Every data and collecting method are discussed in more details next.

3.1.1 The BRT data

The qualitative and quantitative data about characteristics of TransJakarta are needed to evaluate the performance of Bus Rapid Transit in Jakarta Metropolitan City. The performance parameters have been set as the base and indicator of proposed strategies. They will be discussed more in the data analysis section. The following kinds of data and the way to collect them are discussed one by one next.

1) General and operational characteristics of TransJakarta

Operational characteristics of TransJakarta are necessary for understanding the problem regarding the performance in operation. The general characteristics consist of corridor information including route-length on every corridor, infrastructure information including stations and busways, vehicle information, and other attributes if any. The operational characteristics consist of operation hours, number of buses including capacities by vehicle type, payment and fare collection, planned frequency and headway. The information about general characteristics and operation characteristics as the secondary data can be gained from the operation division of TransJakarta Operator Company. The observation and inventory survey on the spot are also needed to be conducted to obtain the actual operational condition, then the problem can be determined.

2) Demand data (passenger)

Demand characteristics is necessary in performance analysis and system development. Demand data are the number of passengers at individual corridors and individual stations. The total number of passengers at each corridor and the number of on-board passengers at each station can be gained from the operation division of TransJakarta Operator Company. However, there is no information about the number of off-board passengers at each station because there is no system device such as counter barrier to count. Hence, the number of off-board passengers must be collected by dynamic (in-vehicle) survey.

3) Average speed (km/hour) and travel time (minute)

Average speed and travel time are necessary as the main performance indicator that needs to be collected directly on the spot. Even though, speed and travel time can be gained from the calculation and simulation. Instead of that, the average speed is necessary to develop the system into microsimulation in order to assess the proposed strategies. The actual data are also used for calibrating the microsimulation model developed by the computer program named PTV VISSIM. The real speed and travel time data can be gained by conducting a dynamic in-vehicle survey. The dynamic survey is discussed in the next section of this chapter.

4) Observed arrival and departure times (O'clock)

The arrival and departure times must be set up to schedule the operation. However, the actual arrival and departure times need to be observed for evaluation of the punctuality and on- time performance. Arrival time is also used for calculating the real headway. Punctuality and on-time performance are explained in the data analysis section. Recording the arrival and departure time at every corridor can be done by the static survey on stations.

5) Waiting time on stations (minute)

Waiting time is one of performance parameters that can be gained directly by field survey or simulation. In this research, the static survey is conducted to obtain the waiting time data.

6) The dwelling time on stations (second)

It is the time for the bus to stop at the station. It consists of boarding time, alighting time, and dead time at the station. Dwelling time is one important factor that affects the performance parameters. The dwelling time can be recorded by conducting the static survey at stations.

3.1.2 Mixed traffic data

The mixed traffic data are necessary to develop the microsimulation model of BRT system by using VISSIM program. The mixed traffic data are classified traffic volume both on links and at intersections. In this study, the mixed traffic data consist of traffic volume on the links which are side by side the busways and at intersections which are troughed by TransJakarta's fleets. There are 107 roads and 132 intersections covered by the operation of TransJakarta. They are summarized in Tables 3.1 and 3.2.

Table 3.1 The links side by side TransJakarta's routes

Link No	Road Name	Corridors Involved	Link No	Road Name	Corridors Involved
1	Singamangaraja	1	55	Letjen M. T. Haryono	9A , 9
2	Jend. Sudirman	1 , 2A , 6A	56	Suryo Pranoto	8
3	M.H Thamrin	1 , 2A , 6A	57	Kyai Caringin	8 , 8A
4	Medan Merdeka	1 , 2 , 3A	58	Balikipapan	8 , 8A
5	Gajah Mada	1 , 8 , 2B , 3A	59	Tomang Raya	8 , 8A
6	Pintu Besar Selatan	1	60	Pondok Gede	9
7	Perintis Kemerdekaan	2 , 2A , 4	61	Danau Sunter Barat	12 , 9
8	Letjen R. Suprpto	2 , 2A	62	Eggano	10 , 12
9	Senen raya	2 , 2B	63	Sulawesi Raya	10 , 12
10	Kwini II	2 , 2B	64	Wiyoto Wiyono	10 , 12
11	Abdul Rahman Saleh	2 , 2B	65	Laksmana Yos Sudarso	10 , 12
12	Pejambon	2 , 2B	66	Jenderal Ahmad Yani	10
13	Medan Merdeka Timur	2 , 2B	67	D. I. Panjaitan	10 , 9
14	Perwira	2 , 2B	68	Sentra Primer	11
15	Banteng Barat	2 , 2B	69	Dr. Sumarmo	11
16	Veteran	2 , 8 , 3	70	Raya Penggilingan	11
17	Medan Merdeka Selatan	2 , 2A	71	I Gusti Ngurah Rai	11
18	Daan Mogot	3 , 8 , 3A	72	Bekasi Timur Raya	11
19	Kyai Tapa	3 , 8 , 3A	73	Raya Bekasi Barat	11
20	KH. Hasyim Anshari	3 , 8 , 3A	74	Danau Sunter Utara	12
21	Raya Bekasi	4 , 6B	75	Prapatan	2A , 2
22	Pemuda	4 , 6B	76	Ridwan Rais	2A , 2
23	Pramuka	4 , 6B	77	Mangga Dua Raya	12
24	Matraman	4 , 6B	78	Jembatan Batu	12
25	Tambak	4 , 6B	79	Pintu Besar Utara	12
26	Sultan Agung	4 , 6B	80	Bank	12
27	Galunggung	4 , 6B	81	Kali Besar Barat	12
28	Gunung Sahari Raya	5 , 12 , 7B ,	82	Kopi	12
29	St. Senen	5 , 7A	83	Gedong Panjang	12
30	Kramat Raya	5 , 7A	84	Pluit Selatan Raya	12
31	Salemba Raya	5 , 7A , 7B	85	Bandengan Utara	12
32	Matraman Raya	5 , 7A	86	Bandengan Selatan	12
33	Jatinegara Timur	5 , 7A , 11	87	Jembatan Tiga	12 , 9
34	Jatinegara Barat	5 , 7A	88	Pluit Putra Putri Edan	12 , 9
35	RM. Harsono	6 , 6A	89	Pluit Indah Raya	12 , 9
36	Warung Jati Barat	6 , 6A	90	Pluit Barat Raya	12 , 9
37	Buncit Raya	6 , 6A	91	Pluit Permai	12 , 9
38	Mampang Prapatan	6 , 6A	92	Pluit Timur Raya	12 , 9
39	H. R. Rasuna Said	6 , 4 , 6B	93	Jembatan dua	9
40	T.B. Simatupang	7 , 8	94	Katedral	2 , 2B , 5A
41	Raya Bogor	7 , 9	95	Pos	3 , 5A
42	Mayjen Sutoyo	7 , 9A , 7A , 9	96	Gedung Kesenian	3 , 5A
43	Letjen M. T. Haryono	7 , 9A , 7B	97	Budi Utomo	3 , 5A
44	Otto Iskandardinata	7 , 7A	98	Majapahit	1 , 2 , 3A
45	Pondok Pinang Raya	8	99	Roa Malaka Utara	12
46	Lebak Bulus Raya	8	100	Tiang Bendera	12
47	Metro Pondok Indah	8	101	Kunir	12
48	Sultan Iskandar Muda	8	102	Kemukur	12
49	Teuku Nyak Arif	8	103	Ketumbar	12
50	Arteri permata Hijau	8	104	Lada	12
51	Panjang Raya	8	105	Kayu Putih Raya	4
52	rof. Dr. Latumenten	8A , 9	106	HBR Motik	12
53	Letjen S. Parman	8A , 9A , 8	107	Underpass Angkasa	12
54	Jenderal Gatot Subroto	9A , 9			

Table 3.2 The nodes passed by TransJakarta's routes

Node No.	Type of Intersection	Corridors Involved	Node No.	Type of Intersection	Corridors Involved	Node No.	Type of Intersection	Corridors Involved
1	3-way	1	45	4-way	6, 6A, 6B	89	4-way	9, 12
2	3-way	1	46	4-way	6, 61, 6B, 9, 9A	90	4-way	9, 12
3	Boundary	1, 2A, 3A	47	4-way	6, 6A, 6B	91	3-way	9, 12
4	4-way	1, 9, 2A, 3A, 9A	48	4-way	7	92	4-way	9, 12
5	4-way	1, 2A, 3A	49	3-way	7, 9	93	3-way	9, 12
6	Boundary	1, 2A, 3A, 6A	50	3-way	7, 9	94	3-way	9, 12
7	Boundary	1, 2A, 3A	51	4-way	7, 10, 7A, 7B, 9A	95	3-way	9, 12
8	4-way	1, 2, 3, 8, 2B, 3A	52	3-way	7, 9, 10, 7A, 7B, 9A	96	4-way	10, 12
9	3-way	1, 3, 8, 2B, 3A	53	3-way	7, 9, 10, 7A, 7B, 9A	97	4-way	10, 12
10	4-way	1, 12	54	4-way	7, 9, 10, 7A, 7B, 9A	98	3-way	10, 12
11	4-way	2, 2A, 2B	55	4-way	7, 9, 7A, 7B, 9A	99	4-way	10
12	4-way	2, 2A, 2B	56	4-way	7, 5, 7A, 7B	100	4-way	10
13	4-way	2, 5, 2A, 2B, 7A, 7B	57	4-way	7, 5, 11, 7A, 7B	101	4-way	10
14	4-way	2, 2B	58	4-way	8, 11	102	4-way	10, 11
15	4-way	3, 2B, 3A	59	4-way	8	103	4-way	10
16	4-way	3, 8, 2B, 3A	60	4-way	8	104	4-way	10
17	4-way	3, 8, 9, 2B, 3A, 9A, 8A	61	4-way	8	105	4-way	10
18	4-way	3, 8, 2B, 3A	62	Boundary	8	106	4-way	11
19	4-way	3, 8, 2B, 3A	63	4-way	8	107	4-way	11
20	4-way	3, 8, 2B, 3A	64	4-way	8	108	3-way	11
21	4-way	4, 6B	65	3-way	8	109	4-way	11
22	4-way	4, 6B	66	4-way	8	110	4-way	11
23	4-way	4, 10, 6B	67	4-way	8	111	3-way	11
24	4-way	4, 5, 6B, 7A, 7B	68	4-way	8	112	3-way	11
25	4-way	4, 6B	69	4-way	8	113	3-way	12
26	3-way	4, 6B	70	4-way	8	114	4-way	12
27	3-way	4, 6B	71	4-way	8	115	4-way	12
28	Boundary	4, 6A, 6B	72	3-way	8	116	3-way	12
29	Boundary	4, 6B	73	3-way	8	117	3-way	12
30	4-way	5, 5A, 7B	74	4-way	8	118	4-way	12
31	3-way	5, 12, 6A, 7B	75	4-way	8	119	4-way	12
32	3-way	5, 12, 5A, 7B	76	4-way	8, 8A	120	Boundary	12
33	4-way	5, 12, 5A, 7B	77	4-way	8, 8A	121	4-way	12
34	4-way	5, 5A, 7B	78	4-way	8, 8A	122	4-way	12
35	3-way	5, 5A, 7A, 7B	79	4-way	8, 9, 8A, 9A	123	4-way	12
36	3-way	5, 7A, 7B	80	4-way	9	124	4-way	12
37	3-way	5, 7A, 7B	81	4-way	9, 9A	125	3-way	12
38	4-way	5, 7A, 7B	82	3-way	9, 9A	126	4-way	12
39	3-way	5, 7A, 7B	83	4-way	9, 9A	127	4-way	12
40	4-way	6, 6A, 6B	84	4-way	9, 9A	128	4-way	12
41	4-way	6, 6A, 6B	85	4-way	9	129	3-way	12
42	4-way	6, 6A, 6B	86	4-way	9, 12	130	4-way	3A, 2A, 6A
43	4-way	6, 6A, 6B	87	4-way	9, 12	131	4-way	3A, 2A, 6A
44	4-way	6, 6A, 6B	88	4-way	9, 12	132	Boundary	3A, 2A, 6A

1) Traffic volume (unit)

Traffic volume on the links which are side by side busways can be gained by conducting the *traffic counting* (TC) survey. The traffic volume at intersections which are passed by TransJakarta's fleets can be gained by conducting the *car turning movement counting* (CTMC) survey. These two surveys are explained in the next section of this chapter.

2) Travel speed (km/hour)

In order to develop the simulation model by VISSIM, travel speed in the network need to be collected. Travel speed is the average speed by all vehicle types

including motorcycle, car, truck and other conventional buses, if any. Travel speed data can be gained by conducting the *moving car observer* (MCO).

3) Signal phasing data

Signal phasing data including the green time, amber time, clearance time, and red time need to be collected at all intersections which are passed by BRT routes. The signal plan on intersection can be gained from the local transportation department of Jakarta Metropolitan City. Otherwise, the field observation must be conducted in each time shift. The signal phasing affects the delay performance of the traffic, in particular for the BRT operation system. The signal phasing data is not necessary for the intersection with the fly over management, merging, diverging, and priority system.

3.1.3 Data collection method

Some BRT data and mixed traffic data need to be collected by the field survey. There are several kinds of surveys in this research; i.e., *inventory survey*, *static survey* (on-station), *dynamic survey* (in-vehicle), *traffic counting* (TC), *car turning movement counting* (CTMC), and *moving car observer* (MCO). The details of these kinds of survey are explained one by one as follows.

1) Secondary data collection

The secondary data in this survey are the data that were collected by company and government institution. The following data can be gained from the company and institution concerned.

a) Data from TransJakarta operator company :

- Corridor information, such as the number of corridors, the routes, route-length, station locations, and distance between stations.
- Infrastructures and facilities information, such as the type of the lane and type of separator.
- Vehicle information, such as vehicle type, capacity, in-vehicle facilities, number of operation buses and non-operation buses.

- Operation information, such as, the time table, shift, operation hours, fare and payment collection.
- b) Data from the local transportation department :
 - The traffic data on every road which is troughed by TransJakarta fleets, such as the traffic volume, speed, road capacity, and road dimension.
 - The traffic data on every intersection which is troughed by TransJakarta fleets, such as traffic volume, degree of saturation, queue-length, and signal phasing plan.

In the case there is no updated information above, the survey has to be taken in order to get the needed data.

2) Inventory survey

The aim of this survey is to identify the infrastructure and the attribute of TransJakarta, such as type of bus lane, type of vehicle, capacity, facilities at the stations, facilities in lanes, dimension of vehicle, lane and station, and the condition of existing infrastructures and existing facilities that can affect the operation and performance of TransJakarta service system. The following equipment need to be prepared for conducting the inventory survey.

- Camera
- Stationery

Another aim of inventory survey is to observe the general characteristics of infrastructures, facilities, BRT attributes, and the problem of operation that can be identified by visualization, if any. Observation, capturing, recording, and measurement are the activities in this survey.

3) Static survey (at station)

Static survey in this research is conducted at every station of TransJakarta. The data that can be gained from this survey are the average of arrival and departure time for buses, average waiting time at stations, and average dwelling time at stations. The surveys are carried out during 4 periods; i.e., morning peak, 1st off-peak, evening peak, and 2nd off-peak. The survey cannot be conducted at all stations of TransJakarta because there is limitation on time and resource. Hence, the surveys are conducted at

no more than 3 stations for every corridor; i.e., the first station, the last station and the busiest stations along the corridor. The following equipment need to be prepared for conducting the survey.

- Form
- Stationery
- Watch and stop watch

The aim of this survey is to collect the data related to frequency, bus headway, and service operation at stations. There is at least one surveyor to handle one station. The following activities have to be done by the surveyor.

- First, record the departure and arrival time of buses at station concerned.
- Second, choose one passenger subject, record his waiting time until he gets aboard, choosing another one as well after the former subject has been aboard.
- Third, record the dwelling time of every bus that arrives at station concerned.

The survey form can be seen in **Figure 3.1**.

STATIC FORM 1			SURVEYOR NAME			
CORRIDOR NO. :			CORRIDOR NO. :			
STATION NO. :			STATION NO. :			
DATE :			DATE :			
DURATION TIME : -			DURATION TIME : -			
PAX NO.	ARRIVAL TIME (O'CLOCK)	BOARDING TIME (O'CLOCK)	BUS NO.	ARRIVAL TIME (O'CLOCK)	DEPARTURE TIME (O'CLOCK)	DWELLING TIME (SECONDS)

Figure 3.1 Static survey form 1 (for passenger) and 2 (for bus)

4) Dynamic survey (in-vehicle)

The dynamic survey is the survey inside the vehicle. The data that can be gained by this survey are the number of off-board and on-board passengers at every station for each corridor, travel time, travel speed, arrival time, and dwelling time at every station. The conflict area and other problem that affect the operation of buses at every corridor can be also known by this survey. The surveys are carried out during 4 periods; i.e., morning peak, 1st off-peak, evening peak, and 2nd off-peak. The surveys are carried out by two different directions (A to B and B to A) in every corridor. The following equipment are needed.

- Form
- Stationery
- Camera
- GPS
- Watch
- Stop watch

The aim of this survey is to get the data related to the service performance and load factor, and also to identify the problems occurred during the movement of operation bus. There is at least one surveyor for every bus that has been chosen as the sample. The following activities must be conducted by the surveyor.

- First, record the time when the bus arrives at every station.
- Second, record the time when bus departs from every station.
- Third, counts the number of off-board passengers and on-board passengers.
- Fourth, identify every problem and conflict area that are faced by bus during operation, capturing by camera for visualization and recording the location by GPS.

The survey form can be seen in **Figure 3.2**.

DYNAMIC FORM			SURVEYOR NAME	
CORRIDOR NO. :		DURATION TIME : -		
DATE :		DIRECTION : (A to B)/(B to A)		
STATION NO.	ARRIVAL TIME	DWELLING TIME	NUMBER OF PAX	
	(O'CLOCK)	(SECONDS)	OFF	ON

Figure 3.2 Dynamic survey form

5) Traffic counting (TC) survey

In the case there is no updated data about traffic volume on the needed roads from the local transport department; then, the traffic counting needs to be conducted in order to get the traffic volume data. Determining the survey spot and preparing the equipment need to be done before conducting the traffic counting. The survey locations are on every road which is side by side with busway. The surveys are carried on during 4 periods; i.e., morning peak hour, 1st off-peak hour, evening peak hour, 2nd off-peak hour. Because of the limitation on time and resources, the survey cannot be conducted 24 hours. The duration of surveys are 2 hours in peak period, and 1 hour in off-peak period. The following equipment are needed to be prepared.

- Camera recording
- Survey form
- Stationery

- Counter
- Watch

The aim of the survey is to count the classified traffic volume on the roads within a certain time by direct observation in the field. The first step of this survey is recording the traffic fluctuation within 2 hours during peak period and 1 hour during off-peak period. The second step is to count the traffic volume by using a counter, then fill the form. The traffic volume are classified by the type of vehicle; i.e., car, pick up, three-wheel, motorcycle, public-minivan, big bus (≥ 12 m in length), medium bus (≤ 12 m in length), big truck (≥ 8 in tonnage), medium truck (≤ 8 tonnage), and non-motorized vehicle. The survey form can be seen in **Figure 3.3**.

CLASSIFIED TRAFFIC COUNTING											SURVEYOR NAME	
ROAD NAME :					DATE :							
					DURATION TIME :							
					WEATHER :							
WAKTU	PV		PT					HV			UM	
	MC	CAR	PICK UP	VAN	BUS (< 8 M in length)	BUS (8 M in length)	BUS (12 M in length)	TRUK (< 8 M in length)	TRUK (8 M in length)	TRUK (12 M in length)	BICYCLE	OTHERS
	1	2	3	4	6	7	8	9	10	11	12	13
12.00 - 12.15												
12.15 - 12.30												
12.30 - 12.45												
12.45 - 13.00												
13.00 - 13.15												
13.15 - 13.30												
13.30 - 13.45												
13.45 - 14.00												

Figure 3.3 Traffic counting (TC) survey form

6) Car turning movement counting (CTMC) survey

In the case there is no information about the traffic turning movement volume data on every intersection needed from the Local Transport Department. Then, the CTMC survey needs to be conducted. The collection of traffic movement data has to be done in order to know the level of saturation at the intersection. The surveys are carried on during 4 periods; i.e., morning peak hour, 1st off-peak hour, evening peak hour, 2nd off-peak hour. As mentioned before about the limitation of time and

resource, the survey cannot be conducted 24 hours. The duration of surveys are 2 hours for peak period, and 1 hour for off-peak period. The following equipment are needed to be prepared.

- Camera recording
- Survey form
- Stationery
- Counter
- Watch

The aim of the survey is to count the classified traffic turning movement volume on the roads within a certain time by direct observation in the field. The first step of this survey is to record the traffic fluctuation in the suitable angle on intersection within 2 hours for peak period and 1 hour for off-peak period. The second step is to count the traffic volume for each movement direction (left, straight, right) at all intersections by using counters, then fill the form. The traffic volume are classified by the type of vehicle; i.e., car, pick up, three-wheel, motorcycle, public-minivan, big bus (≥ 12 m in length), medium bus (≤ 12 m in length), big truck (≥ 8 in tonnage), medium truck (≤ 8 tonnage), and non-motorized vehicle. The survey form can be seen in **Figure 3.4**.

CAR TURNING MOVEMENT COUNTING FORM														SURVEYOR NAME		
INTERSECTION NAME		DATE														
FEET SIDE		DURATION TIME														
		WEATHER														
TIME	DIR.	CAR	PV	MC	PT/VAN	PICKUP	PT	BUS (<8M in length)	BUS (8M in length)	BUS (12M in length)	Truck (<8M in length)	Truck (8M in length)	Truck (12M in length)	BICYCLE	UNMOTORIZED VEHICLE	OTHERS
12.00 - 12.15	LEFT	1		2	3	4	5	6	7	8	9	10	11	12		
	STR															
	RIGHT															
12.15 - 12.30	LEFT															
	STR															
	RIGHT															
12.30 - 12.45	LEFT															
	STR															
	RIGHT															
12.45 - 13.00	LEFT															
	STR															
	RIGHT															
13.00 - 13.15	LEFT															
	STR															
	RIGHT															

Figure 3.4 Car turning movement counting (CTMC) survey form

7) Moving car observer (MCO) survey

In the case, there is no updated information about the average speed on the road needed; then, the MCO survey need to be conducted. In addition to speed, the road length and travel time can be also known by this survey. The surveys are carried out by two different directions (A to B and B to A) on every road. The survey time is also carried out during four time periods; i.e., morning peak hour, 1st off-peak hour, evening peak hour, 2nd off-peak hour. The following equipment need to be prepared.

- Car
- Form
- Stationery
- Stop watch

The aim of this survey is to know the travel speed and travel time for passing through the road from the starting point to the ending point of the road during the survey periods. There are at least two people for conducting the MCO survey. One as the driver and the other one as the surveyor. The car is driven through the road from the starting point to the ending point. The surveyor determines the travel speed based on travel time and travel distance. The survey form can be seen in **Figure 3.5**.

MCO FORM			SURVEYOR NAME
ROAD NAME :		DURATION TIME : -	
DATE :		WEATHER :	
DIRECTION : A to B			
ROAD LENGTH	START TIME	FINISH TIME	OBSTACLE
DIRECTION : B to A			
ROAD LENGTH	START TIME	FINISH TIME	OBSTACLE

Figure 3.5 Moving car observer (MCO) survey form

3.2 Data analysis

Capacity, speed and frequency are the critical elements of bus rapid transit system. The capacity must be sufficient to handle expected passenger demand. The service speed must be reliable to minimize travel times. The frequency must be efficient to minimize waiting times. Furthermore, the system should satisfy the three general objectives below (Wright & Hook, 2007).

- 1) The system should handle the current and projected demand;
- 2) The system should provide the service speeds of 25 kph or higher;
- 3) The system can be nearly door to door service by minimizing travel time.

In this research, the system capacity is represented by the corridor capacity, while the service speed and travel time are included as the pack of performance evaluation including the service reliability. The justification based on the system capacity and performance evaluation will lead the proposed strategies to improve the performance of BRT. The proposed strategies will be simulated using the computer program called VISSIM. The comparison of scenarios including the existing condition will be the final analysis of this research.

Overall, the data analysis is carried out in several stages; i.e., the analysis of system capacity of BRT, the performance evaluation method, the enhancing method, and the simulation approach. Every stage is explained in detail here.

3.2.1 The system capacity

The system's capacity is expressed by the corridor capacity. It needs to be calculated in order to identify the maximum number of passengers that can be handled by the current BRT system. The capacity is analyzed at each corridor per hour per direction. The basic calculation of corridor capacity is taken from Wright & Hook (2007) for the Institute of Transportation and Development Policy, as shown in equation (3.1).

$$CC = Cb \times LF \times F \times Nsp \quad (3.1)$$

Where, **CC** is corridor capacity in terms of passenger number per peak hour per direction (pphpd), **Cb** is vehicle capacity (passengers), **LF** is the expected load factor, **F** is service frequency (vehicles/hour), and **Nsp** is the number of stopping bays (platform).

The route network of TransJakarta is integrated with more than one corridor. In such case, there are several overlapped segments of more than one route. It means that there are number of stations and lanes which serve more than one corridor. In this case, calculating the saturation level is necessary. In this research, saturation level refers to the congestion of vehicle in the number of stations functioned as transfer station with more than one corridor served. The station's saturation level shows the percentage of time that a stopping bay (platform) is used by vehicle for boarding and alighting during a peak hour. Several studies put the different optimum level of station saturation. Following Wright & Hook (2007), the saturation level above 0.60 tends to be the congestion and the system can be broken down. Overall, the capacity analysis can be based on the proposed strategy in terms of the infrastructure development, such as the optimum number of buses, stopping bays, passing lanes, and the efficiency of operation.

3.2.2 Performance evaluation

The existing performance needs to be analyzed as the benchmarked parameter of the BRT in Jakarta Metropolitan City. As mentioned before, BRT service should be frequent and fast; hence, there is one main indicator of performance that users care about; namely, travel time. Travel time is a matter of travel speed and trip length. Travel time as the main indicator in this research is included in the pack of performance evaluation. Overall, there are several performance indicators in operation aspects that need to be concerned. They include travel time and service reliability.

1) Travel time

Travel time is the main performance indicator of public transport. BRT offers shorter travel time than other road public transportation modes between the same pair of origin and destination. Travel time is the matter of travel speed and trip length. For the safety reason, the spot speed cannot be more than 60 kph. However, if we discuss about travel speed as the average speed between origin and destination, the benchmark of 25 kph is the acceptable speed of BRT, following Wright & Hook (2007). The 25 kph of travel speed is discussed in ITDP as the minimum travel speed of BRT that can be accepted. Lower than that, they are closely similar to the conventional bus service. Hence, the travel speed of 25 kph becomes the consideration of this research. On the other hand, travel time is usually affecting the waiting time in the delay problem.

The travel time and travel speed for existing operation of TransJakarta are gained by the dynamic survey. With the dynamic survey, the conflict which interrupts the bus acceleration can also be known, such as the bottleneck problem, mixed traffic problem, etc. The improvement of travel speed by the proposed strategy can be identified by the simulation approach. Travel time can be calculated after the travel speed is gained with the basic formula.

2) Service reliability

The high level of service is one characteristic that BRT must have besides travel time. The service must be reliable in terms of punctuality, convenience, and ease. There are several indicators for service reliability that are considered in this research. They are waiting time reliability, trip realization, punctuality, travel time reliability, schedule adherence, headway regularity, safety reliability, and comfort. These indicators are following Aziz et al. (2014), based on Key Performance Indicator (KPI) which is internationally accepted by FTA (2004), APTA (2010), and World Bank (2006).

- *Waiting time reliability*

Waiting time is one of the performance indicators that users always care about. Most experts believe that the benchmark of waiting time for BRT as the rapid transit service must be 1 to 5 minutes during peak period and 5 to 10 minutes during off-peak period (Wright & Hook, 2007). The benchmark of 1 to 10 minutes of waiting time becomes the consideration of this research. The long waiting time happened mostly because of delay in the road network, insufficient frequency in operation, and high saturation at station. The existing waiting time will be calculated by using the equation (3.2) to observe the waiting time reliability.

$$\textbf{Waiting time reliability} (\%) = \frac{\Sigma \text{waiting time within } X \text{ mins}}{\text{total observations}} \times 100\% \quad (3.2)$$

Where, X minutes is the acceptable waiting time as the benchmark; i.e., 5 minutes during peak period and 10 minutes during off-peak period. The benchmark expects at least of 85% of passengers are supposed to wait within acceptable waiting time before aboard. Because of the limitation of resource, the observation of waiting time is conducted at the starting, ending, and the most congested station in each corridor.

- *Trip realization*

Trip realization is calculated in order to observe the realization of assigned trips in a given period time. The frequency depends on the trip assignment by the planner. Usually the planner assigns the bus trip based on the demand or demand oriented. The trip assignment with the acceptable load factor become the consideration of this research. The acceptable load factor is discussed as another performance indicator. To calculate trip realization refers to the equation (3.3).

$$\textbf{Trip realization} (\%) = \frac{\text{total number of trips executed}}{\text{total number of trips assigned}} \times 100\% \quad (3.3)$$

Following the KPI, the benchmark for BRT is 98%. The missed realization of trip assignment is usually because of the delays in the network. The missed trip realization can lead to the system failure.

- *Punctuality*

The punctuality needs to be identified as one of the parameters of service reliability for users. The low punctuality on schedule can be the indicator of the system failure. The punctuality in this research is related to the on time start and on time complete, as shown in equation (3.4) and equation (3.5).

$$\textbf{Punctuality at the start (\%)} = \frac{\textbf{number of trips started on time}}{\textbf{number of trips executed}} \times 100\% \quad (3.4)$$

$$\textbf{Punctuality at the complete (\%)} = \frac{\textbf{number of trips completed on time}}{\textbf{number of total trips executed}} \times 100\% \quad (3.5)$$

On-time start level is the matter of departure time in a given period time, during a particular peak hours. The low punctuality might be caused by the operation problem. Meanwhile, the on-time complete is the matter of travel time reliability. Following APTA (2010), the punctuality should be at least 85%. The delay problem in the network leads to the missed punctuality for bus to complete the trip by the schedule.

- *Headway regularity*

The planned headway should be set up by the operator with respect to the demand on every shift of time schedule. One of the KPI standards puts the headway regularity as one major of performance parameters. In order to know the headway reliability, the adherence of actual headways with the planned headway needs to be observed. The calculation refers to equation (3.6).

$$\textbf{Headway regularity(\%)} = \frac{\textbf{Number of arriving buses within headway}}{\textbf{total observations}} \times 100\% \quad (3.6)$$

Based on KPI, the benchmark is 85% for headway adherence (APTA, 2014). The low level adherence of headway is usually caused by the delay and operation problem.

- *Comfort and load factor*

The high occupancy is desirable for the operator company. In order to get high number of passengers or become the traffic user's choice in urban transportation, public transport service must be comfort. BRT, as he innovative bus service in urban public transport, is expected to compete healthily against the private vehicle; then, the traffic congestion can be reduced. As mentioned before, besides speed and time, the convenience is usually in the passenger's expectation. The in-vehicle convenience is always the matter of load factor. The load factor more than 85% is leading to the inconvenience for the passengers (Wright & Hook, 2007). The level of comfort is calculated with the equation (3.7) below.

$$\text{Level of comfort (\%)} = \frac{\text{number of buses which has } < 85\% \text{ of LF}}{\text{total observations}} \times 100\% \quad (3.7)$$

The high load factor (> 85%) is indicated inconvenience for passengers. That is caused by the insufficient frequency of service during the certain periods, particularly peak hour. The delay in the network and the lack of infrastructure also contribute to the inconvenience.

- *Safety reliability*

Every public transport must have the high level of safety. In the case of BRT, as the rapid system offering the high on-time service, also needs to consider about safety in operation. The safety reliability in this research is observed by the proportion of accidents in the whole system of BRT in Jakarta Metropolitan City. Based on KPI, the safety reliability is calculated as the number of accidents in kilometers of trips. The calculation refers to equation (3.8) below.

$$\text{Level of accident (\%)} = \frac{\text{total number of accidents}}{\text{total trip – kilometers}} \times 100\% \quad (3.8)$$

Based on the benchmark of 85% of total trip-kilometers should have no accident (Aziz et al., 2014). It means that the level accident must be no more than 15%. The low safety reliability might be caused by the infrastructure condition and human error.

3.2.3 The framework for enhancing BRT service

The enhancement to improve the performance of BRT operation in Jakarta Metropolitan City is analyzed based on the existing performance evaluation at the time of the study. The enhancement will be in the form of proposed strategies which are simulated by using simulation program; namely, VISSIM 8.00. The simulation approach is discussed in the next section in this chapter. Concerning about the delay in the network, it is mostly due to the delays on links and/or at intersections. For public transport in particular, the station is involved as well.

Link, intersection, and station are the main components of the public transport system, no exception for Bus Rapid Transit. The lagged performance on each of these components has different approach to handle.

- The failure on links for BRT is regarding with the lack of travel time performance due to delays. To handle, the restricted lane especially on mixed traffic (on the bridge, opened lane, fly over etc.), management of bottleneck, and contra flow have been mostly taken by the experts.
- The failure at the intersection affects the travel speed due to the long phasing signal and crossing conflict. The traffic priority system, real-time signalization system, and fly over have been mostly taken by the experts.
- The failure at the station is indicated by the high level of station saturation (greater than 0.6) and unacceptable waiting time. It is usually due to the delay and low capacity. Increasing the service frequency and upgrading the station's capacity are the suitable strategies.

As mentioned before, in order to determine the suitable strategy, the performance index must be analyzed in advance. The framework to determine the suitable strategies based on the results of capacity and performance evaluation is arranged and shown in **Figure 3.6**.

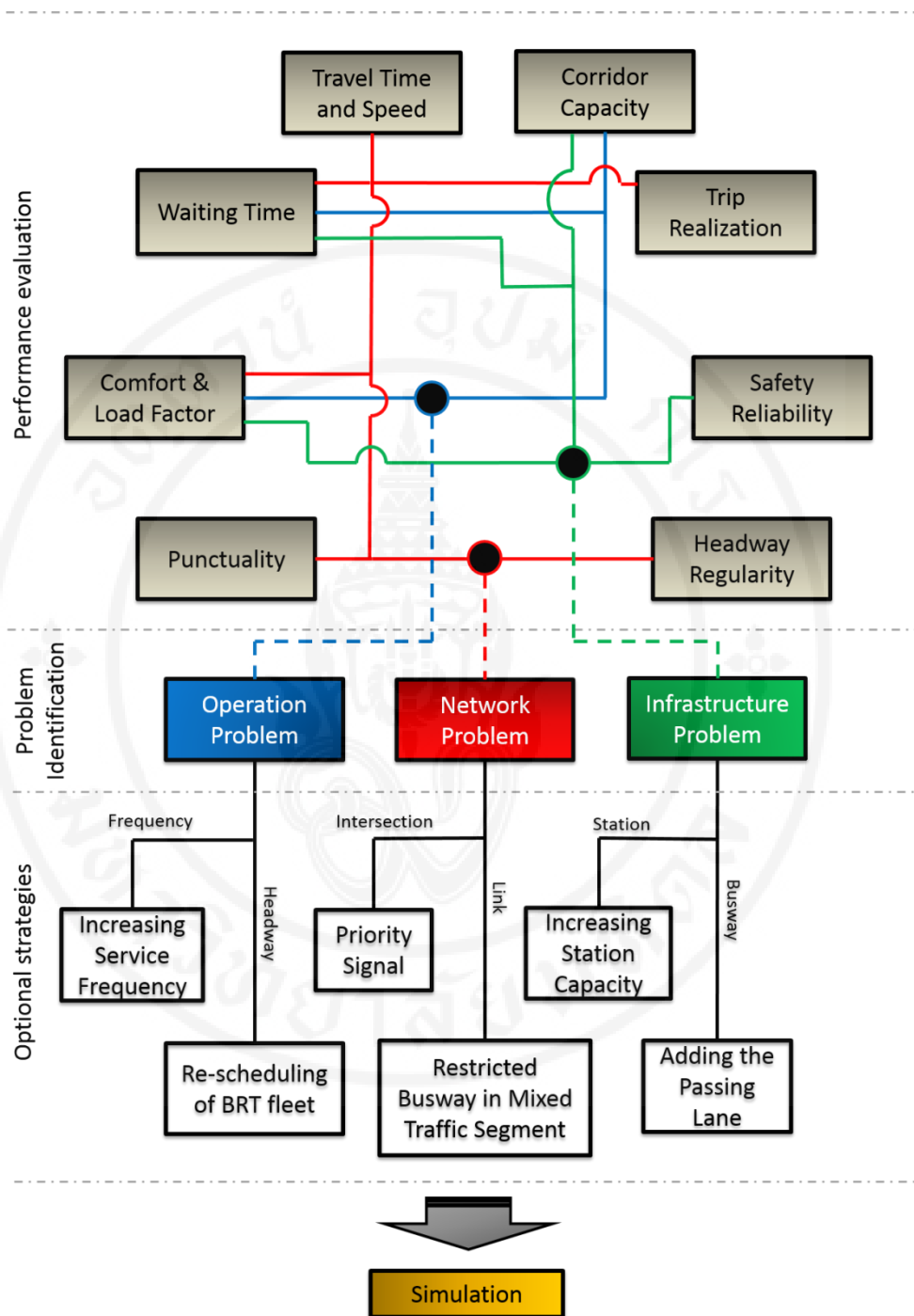


Figure 3.6 The framework to determine the optional strategies based on performance evaluation

Figure 3.6 shows the framework to determine the suitable strategy based on performance evaluation in this research. Basically, it consists of four processes. They are the performance evaluation, problem identification, determination of the proposed strategies, and the simulation.

1) Identification of performance evaluation

All performance indicators are evaluated in order to identify the failure indicator which is below the performance standard of rapid service. The cause of the failure performance is identified and categorized into three groups of problem; i.e., operation problem (blue line), network problem (red line), and infrastructure problem (green line). They are connected based on the indication of problem. It means if one performance is down, it affects another. For example, delay in the network causes the failure in travel time, it affects the waiting time, trip realization, punctuality, headway adherence, and causes high load factor. They are connected by the red line which is the problem in the network. Three indicators can be caused by more than one category of the problem. For example, the failure of waiting time can be occurred because of the lack of operation in frequency or headway which is connected with others by the blue line, or because of delay in the network which is connected with others by the red line, or because of the lack of capacity in infrastructure or facility which is connected with others by the green line. The causes of respective indicators above are explained as follows.

- *Travel time and speed*

The failure in travel speed is mainly caused by the delay in the road network both on the link and at the intersection.

- *Corridor capacity*

The insufficient capacity in the system is due to both the operation and the network problem. The operation problem is resulted from the under expected frequency and headway. While, the delay in the network can also push the system capacity down.

- *Waiting Time*

All kinds of the problem can affect the waiting time into suffer. In operation aspect, the lower frequency than expected demand tends to increase the waiting time for passengers. Meanwhile, in the network aspect, the delay of the bus's acceleration causes the long waiting time. In the case of infrastructure, the low

capacity and the limited number of platform at the station tend to contribute to the queue of the passengers and buses, then the waiting time is increasing.

- *Trip realization*

As mentioned before trip realization is related to the planned trip assignment. The actual number of trips completed could not be in accordance with the planned schedule because of the delay in the network.

- *Punctuality*

Low punctuality is mainly caused by the delay in the network.

- *Headway regularity*

The failure of headway regularity is mainly caused by the delay in the network.

- *Comfort and load factor*

In line with the waiting time indicator, all kinds of problems can affect the load factor. The low frequency and miss-target of headway in operation tend to create the congestion in the vehicle or crushed capacity. Meanwhile, the delay in the network affects the failure of the distribution of the passenger's loading; then, the load factor becomes uneven in vehicles. In the case of infrastructure, the low capacity and limited number of platforms or stopping bays tend to create congestion and queue.

- *Safety reliability*

Basically, safety is caused by three things; i.e., human error, nature, and infrastructure. This research only considers about technical aspect.

2) Problem identification

Basically, there are three kinds of technical problems which are concerned, in particular for this research. They are problems in operation, problem in the network, and problem in the infrastructure.

- *Operation problem*

The first problem is about operation. In **Figure 3.6**, the indicators which are affected by the operation problem are connected by the blue line. The operation

problem basically relates to service frequency and headway. The lack of service is caused by the insufficient trip frequency. The insufficient frequency is related to the number of buses which are provided by the operator. In the case of headway, the missed target of planned headway is caused by the failure in bus scheduling. Overall, the operation problem can affect the corridor capacity, waiting time and comfort. Corridor capacity is definitely related to the frequency and headway. Waiting time can be suffered if the service frequency cannot satisfy the demand. While, the load factor can be suffered because of the lack of capacity. The inconvenience for passenger is due to the crushed capacity (Wright & Hook, 2007).

- *Network problem*

The second problem is about network. The performance indicators which are affected by the network problem are connected by the red line in **Figure 3.6**. The network problem is mostly related to delay. Delay causes the suffer on travel time and waiting time, then tends to crush load factor. Delay also causes the failure of trip realization, punctuality, and headway regularity. The network basically consists of links and intersections. The failure of BRT's acceleration in the route network is always coming from those parts of the network. In the case of the problem on link, the mixed traffic lane in BRT's route mostly becomes the main reason of delay. It is usually occurred on the bridge, fly over, tunnel, and opened busway. Aside from that, the several segments of segregated BRT's lane is interrupted by the prohibited vehicle both by through from the intersection and by through the physical separator along the segregated lane. Then, the case of problem in intersection is due to the delay regarding the phasing signal and conflict point. The intersection is the place where the BRT's fleet is making contact in maneuver with other kinds of vehicles.

- *Infrastructure problem*

The third problem is about infrastructure. The indicators which are affected by the infrastructure problem are connected by the green line in **Figure 3.6**. They are corridor capacity, waiting time, load factor, and safety reliability. In case of BRT, the main and crucial infrastructure is the station and busway. The corridor capacity is also strongly depending on the infrastructure. The lack of capacity at the station also causes the station saturation becomes unacceptable. As mentioned before,

the unacceptable station saturation (>0.85) tends to create inconvenience for the passengers. The capacity of station is also related to the number of stopping bays. Meanwhile, several stations might handle more than one corridor because BRT route must be integrated. The limited number of bays at the station (usually one stopping bay per direction) push the buses to wait in queue before alighting. The queue of buses usually suffers from congested station, increasing the dwelling time, then affects the waiting time of passengers. In the case of busway infrastructure, the problem is usually caused by the mixed traffic lane and the limited number of passing lanes especially at the station which has more than one stopping bay. Safety reason also must be concerned in the infrastructure aspect.

3) Optional strategies

The optional strategies which is showed in **Figure 3.6** may be implemented conditionally. The strategy which will be proposed is the necessary strategy depending on the result of the problem identification process. There can be more than one strategy, if necessary. The consideration for each optional strategy is explained below.

- *Increasing service frequency*

The first optional strategy is the increment of service frequency. As shown in **Figure 3.6**, it has been included in the operational aspect which deals with frequency. In other words, increasing trip frequency is necessary to be implemented if the demand in the certain period cannot be satisfied. The best way to increase trip frequency is to add more buses. The number of buses is directly related also to the corridor capacity. On the other hand, frequency is related also to the headway. Shorter headway leads to more frequency. In the case of adding bus to increase service frequency, the fleet size can be determined by equation (3.9) (Wright and Hook, 2007).

$$Fo = \frac{D \times Tc}{Cb}$$

Where, **Fo** is the operational fleet size for corridor; **D** is the demand in corridor (in terms of passengers per peak hour per direction or pphpd); **Tc** is the travel time to complete cycle with expected travel speed (hours); and **Cb** is bus capacity.

- *Re-scheduling*

The second optional strategy is to re-schedule the BRT's fleet. The operation problem in the headway is the consideration of this optional strategy. In other words, if the supply still can be optimized by re-analyzing the planned headway; then, re-scheduling of BRT for each corridor is necessary. Besides, the re-scheduling busway needs to be conducted also if the service frequency is increased. The condition to implement this strategy is the current number of buses which must be sufficient to get the optimum headway. In the certain condition, it may be necessary for both the increment of frequency and re-scheduling, if the operation problem involves both frequency and headway. Basically, if the frequency increment is implemented by adding more buses, then re-scheduling is necessary also to be implemented with updated number of buses in order for the suitable time table to be established. However the bus assignment needs to be analyzed in advance. The minimum fleet size with acceptable load factor becomes the base to determine the assigned headway.

- *Priority signal*

The third optional strategy is priority signal. As mentioned before, the intersection is one of the major delay points that no vehicle in the road network can avoid. However, the priority management of traffic signal for BRT can reduce the delay at intersections. The philosophy is that BRT as the more efficient public transport mode deserves the top priority at the intersection. This strategy can be implemented at intersections with phasing signal management. The priority signal will be simulated by using VISSIM program.

- *Restricted busway in mixed traffic segment*

The fourth strategy still deals with the network aspect; i.e., restricted busway in mixed traffic segment. The mixed traffic that mentioned is the segment in BRT's route which is mixed with the other vehicles. As mentioned before, BRT should be dedicated in acceleration with segregated lane, but it is usually not 100% dedicated in practice, especially on the bridge, fly over, and several segments which are opened lanes without physical separator. The scenario of this strategy is to reduce the length of mixed traffic lane on crucial segments or all segments, if possible. On the

other hand, the link may have severe problem potentially from prohibited vehicles which passed through the BRT's lane both in an opened segment and in the segregated segment. Note that the physical separator of TransJakarta is the curb which can be passed by many kinds of vehicles such as jeep, motorcycle and big-tired vehicle. The lane also can be accessed at the intersection. Under certain condition; i.e., more than 50% of route length for the corridor is interrupted by prohibited vehicles, then the contra flow system is an efficient way to avoid the potential interference. This strategy can be simulated to evaluate the advantages.

- *Increasing station capacity*

The fifth strategy is dealing with the infrastructure; i.e., increasing station capacity. The highly congested station is usually occurred at the integrated station which handle more than one route or corridor. When more corridors are commonly handled by one station; then, the higher saturation occurs at the station which impacts the convenience, dwelling time, and safety. Increasing capacity is not only dealing with the dimension of the station, but also dealing with the number of stopping bays or platforms. Adding the stopping bay at station can minimize the dwelling time of buses for boarding and alighting the passengers at the station. It also distributes the queue of passengers to their preferred corridor. For example, when three corridors are stopping at the same station, then the perfect number of stopping bays is three. The multiple stopping bays is proved to increase the corridor capacity as compared with the success story in Bogota shown in **Figure 3.7** (Wright & Hook, 2007).



Figure 3.7 The multiple stopping bays (platforms) in Bogota's BRT

The use of multiple stopping bays has been one of the principal reasons for Bogota to achieve very high passenger capacity. As of 2012, Transmilenio achieves a peak capacity of 43,000 passengers per hour per direction (pphpd) (Hidalgo et al., 2012). The saturation level of stopping bay can be calculated by equation (3.13) proposed by Wright and Hook (2007).

$$X = T_d * F + [(P_b * T_b) + (P_a * T_a)] \quad (3.10)$$

Where, X is the saturation level at a stopping bay; T_d is dwell time (second); F is frequency (vehicles/second); P_b is total number of boarding passengers (passengers), T_b is average boarding time per passenger (second); P_a is the total number of passengers alighting; and T_a is the average alighting time per passengers (second).

- *Adding the passing lane*

As the compensation of the station with multiple stopping bays or platforms, the passing lane right at the station should be installed. As shown in **Figure 3.7**, the passing lane needs to be established at the station where there are multiple stopping bays. Adding the passing lane on the busway is the sixth optional strategy in this research. The passing lane is also necessary especially for the busway which lies along the integrated station. The queue of buses can be minimized by having the passing lane. The passing lane on certain segment also can be helpful in the emergency situation for safety reason. **Figure 3.8** shows the concept of passing lane at the station where there are multiple stopping bays in the median of the road.

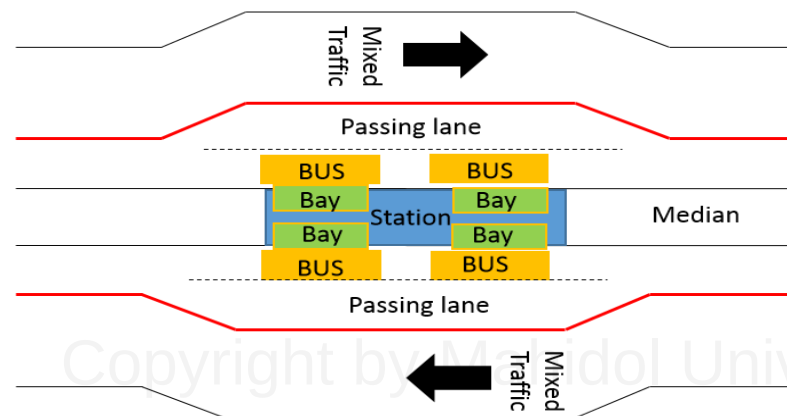


Figure 3.8 Passing lane concept at the station with multiple stopping bays

3.2.4 Simulation approach

The performance evaluation of the proposed strategies is carried in the traffic simulation program, VISSIM. Evaluating the impact on transport system generally includes three sets; i.e., impacts on the bus efficiency and reliability, impacts on private vehicle traffic, and overall impacts on the network (Yang et al., 2013). In the case of this study, the impact evaluation of the proposed strategies concerns with the impact on bus efficiency and reliability. The micro-simulations are run on several scenarios. The first scenario is the existing condition without any change on the system. The remaining scenarios are the proposed strategies which are determined by existing performance evaluation in advance. Overall, the simulation approach is conducted through three processes; i.e., simulation preparation, simulation calibration, and simulation with scenarios.

1) Simulation preparation

The simulation preparation is to develop the simulation model based on the BRT's attributes and field conditions. There are two kinds of traffic that must be considered in the simulation. They are mixed traffic and BRT route. Regarding the BRT's attributes, three main aspects need to be developed in the simulation by using VISSIM; i.e., public transport vehicle (PT-Vehicle), public transport stop (PT-Stop), and public transport line (PT-Line). Take a look at **Figure 3.9** for illustration.

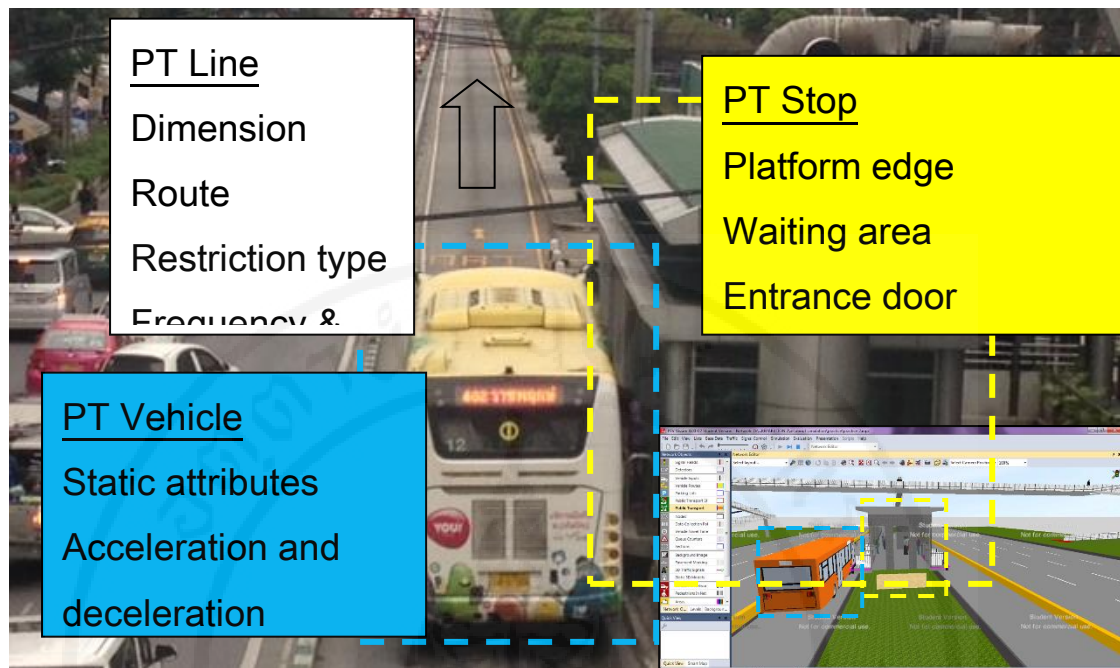


Figure 3.9 Illustration of BRT's attributes in simulation

Firstly, the PT-Vehicle in this case is the modelling of BRT's fleet in the simulation. In PT-Vehicle function, the following aspects need to be concerned to get the suitable model of PT-Vehicle as compared with the real vehicle's attributes.

- *Static aspect*; it consists of the vehicle category, physical display, and dimension. In this research, the vehicle in PT-lane is categorized as bus. Its dimension modelled according to the BRT's specifications.
- *Acceleration and deceleration aspect*; acceleration and deceleration are distinguished into two distributions; i.e., desired and maximum. Basically, there are default values in VISSIM with respect to the maximum acceleration, desired acceleration, maximum deceleration, and maximum deceleration based on the type and weight of vehicle.
- *PT parameters*; it consists of alighting and boarding time, clearance time, and capacity. As the public transport, the alighting time (sec/passenger) from vehicle, the boarding time (sec/passenger) to vehicle need to be modelled as compared with the average time of passenger for alighting and boarding in real situation. Meanwhile, the clearance time in PT parameter is modelled as compared with the dead time, such as closing door time before the bus accelerates to depart.

The capacity value is also inputted in this function tab, as shown in **Figure 3.10**.

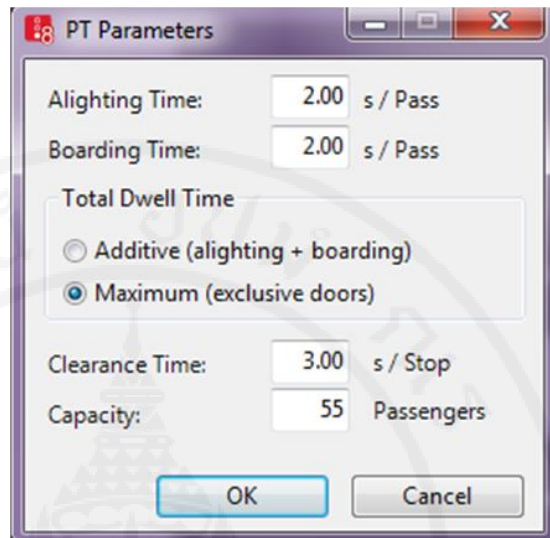


Figure 3.10 PT parameters on VISSIM

- *Entrance door*, entrance door of PT-Vehicle function is the matter of width. The number of doors is modelled in PT-stop function.

Secondly, it is the modelling of PT-Stop. In VISSIM, PT-Stop is represented with three area functions; i.e., PT-Stop on link, platform edge, and waiting area. The dwelling time must be modelled in advance as preceding decision before model other attributes.

- *Dwelling time* is the total amount of stopping times per vehicle which consists of boarding time, alighting time, and dead time on the station. Dwelling time of less than 21 seconds is categorized as the good performance of BRT (Wright and Hook, 2007). *The dwelling time* in VISSIM basically can be modelled in three methods. The first method is *dwell time distribution*, where the stop time is obtained from the selected dwell time distribution. The second method is to calculate dwell time according to *advanced passenger model*, where the stop dwell time is calculated on the basis of PT parameters by the vehicle type. The third method is to calculate *dwell time with PTV-VISWALK*, where the calculation of dwell time is estimated by microscopic pedestrian simulation using PTV-VISWALK program. In this research,

the decision of dwelling time is simulated using *advanced passenger model*. The calculated dwelling time is based on the following parameters in VISSIM (PTV AG, 2015).

- Number of alighting passengers = number of passengers x % alighting passengers
 - Number of boarding passengers = number of all passengers waiting that can be filled in the capacity of departed bus.
 - Total alighting time = number of alighting passengers x average alighting time
 - Total boarding time = number of boarding passengers x average boarding time
 - Passenger service time = clearance time + alighting time + boarding time.
- *PT-Stop in link* is the area where the bus is in the dwelling time condition. The station characteristics are modeled in this function. The distance and the position must be scaled as closely as the real condition. Related to the PT-line, the alighting distribution, boarding distribution, and alighting percentage are modelled by editing *PT Line (n) PT Stop (n) Pass (n)*. Please take a look at **Figure 3.11**.

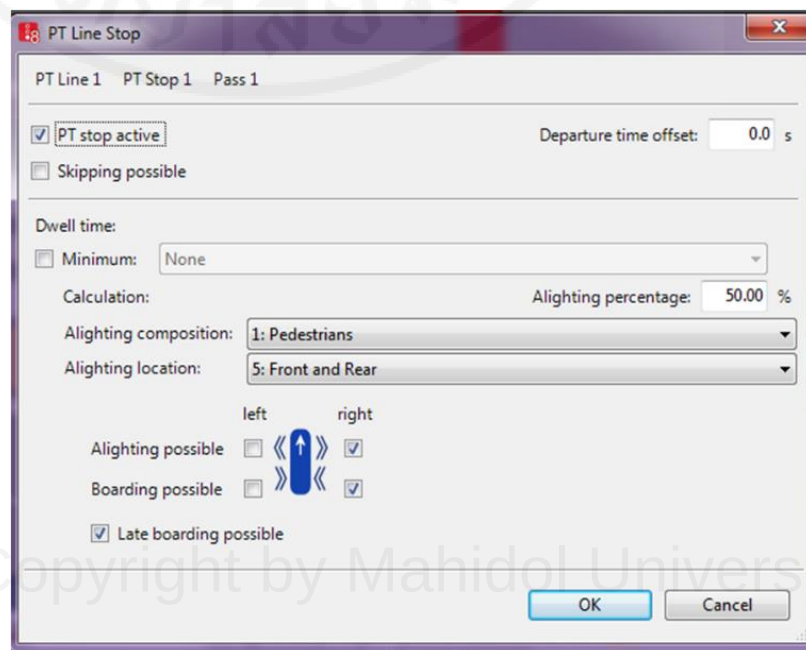


Figure 3.11 PT Line - Stop in VISSIM

- *Platform edge* is the area for alighting and boarding passengers. Dimension, height of platform, and public transport usage are modelled in this function. Platform is considered as the pedestrian area, but with special attributes as the passengers of public transport. Please take a look at **Figure 3.12**.

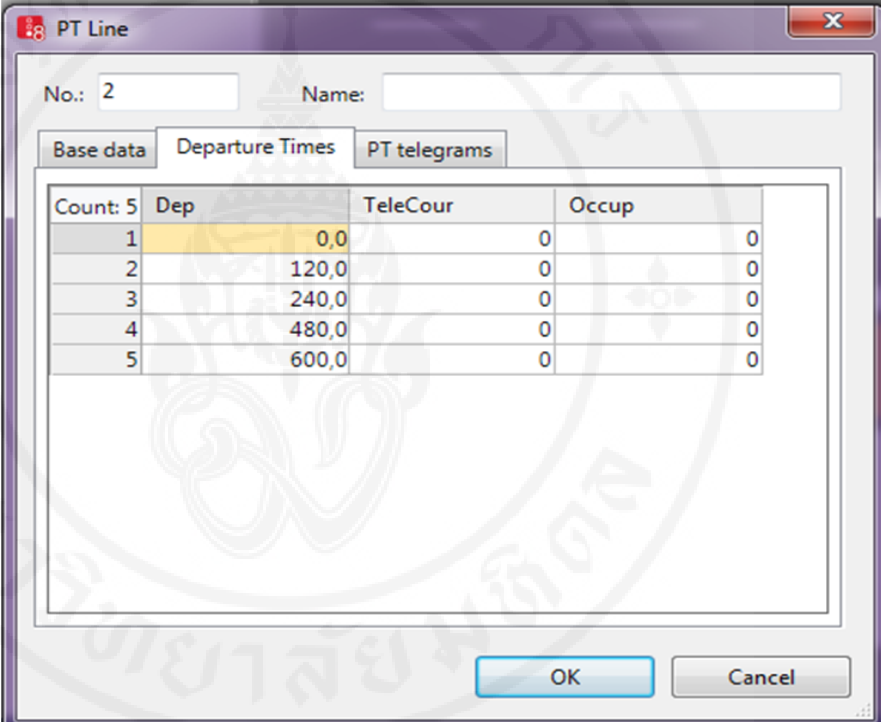
The screenshot shows the 'Pedestrian Area' configuration window in VISSIM. The 'No.' is set to 5, and the 'Name' is 'Platform edge PT stop 1 (right)'. The 'Level' is set to '1: Base', 'Z-Offset' is 1.300 m, 'Thickness (3D)' is 0.000 m, and 'Display type' is '1: Road gray'. In the 'Visualization' section, 'Individual pedestrians', 'Pedestrian record active', 'Show classified values', and 'Show label' are checked, while 'Always use as origin area' and 'Always use as destination area' are unchecked. The 'Public Transport Usage' section is active, showing 'Public transport usage' as 'Platform edge', 'for PT stop(s)' as 1, 'Boarding location' as 'Nearest door', and 'PT waiting behavior' as 'Wait at fixed location'. 'OK' and 'Cancel' buttons are at the bottom.

Figure 3.12 Modeling pedestrian area as platform edge in VISSIM

- *Waiting area* for passengers before boarding needs to be modelled as well as platform edge. The waiting area is defined by setting public transport usage at **Figure 3.12**.

Thirdly, it is the modelling of the PT-Line. PT-line is the overall moving of fleets from station to station until the end of the route. In PT-Line function, the following attributes need to be modelled.

- Base data of PT-Line, it consists of:
 - fleet type;
 - distribution of the desired speed for individual vehicles which run through the lane;
 - offset time regarding the time for buses to get into network;
- Departure time, where the trip frequency and headway can be inputted in this menu tab. Please take a look at **Figure 3.13**.



PT Line

No.: 2 Name:

Base data Departure Times PT telegrams

Count: 5	Dep	TeleCour	Occup
1	0,0	0	0
2	120,0	0	0
3	240,0	0	0
4	480,0	0	0
5	600,0	0	0

OK Cancel

Figure 3.13 Data input for departure time of PT in VISSIM

Overall, the simulation preparation according to the attributes of BRT must be done first before applying to run either existing condition or proposed strategies. The example of illustrative models in 2D and 3D which is adjusted with the real condition of a TransJakarta's station can be seen in **Figures 3.14 and 3.15**.

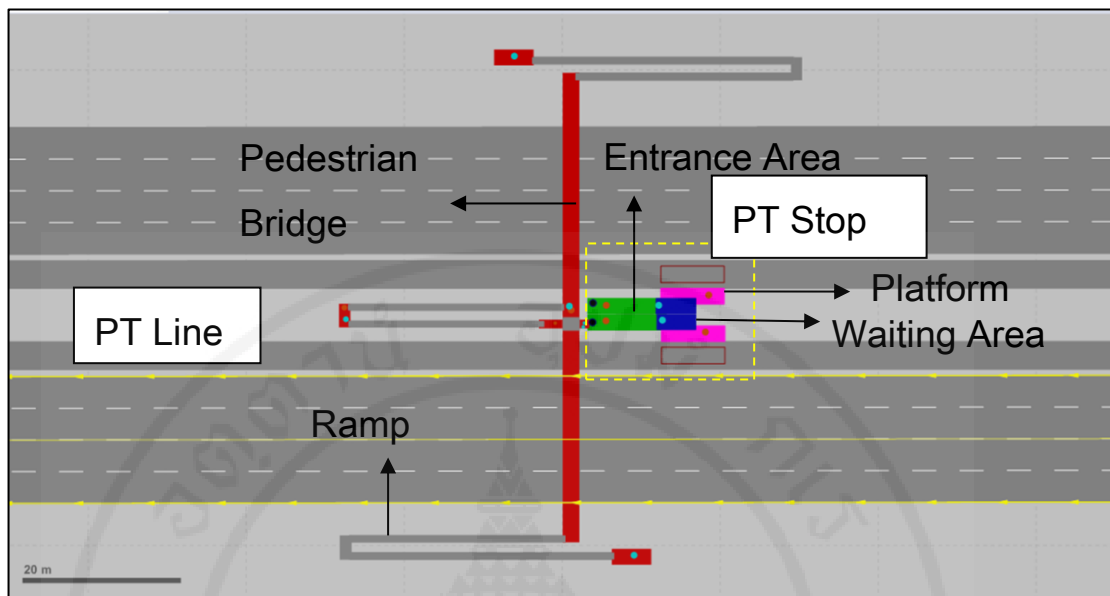


Figure 3.14 Visualization and description of 2D Network Editor in VISSIM for modelling BRT with segregated lane and enhanced station in the median.



Figure 3.15 Example of running 3D network in VISSIM for modelling BRT with segregated lane and enhanced station in the median of the roadway.

The simulation model in **Figures 3.14** and **3.15** is an example for one station in the BRT's network with segregated lane and enhanced station in median of the roadway. The middle station and lane type are practiced also by TransJakarta and Bangkok BRT.

2) Simulation calibration

In order to make sure that the BRT's simulation model represents as closely as possible the real situation, the calibration needs to be analyzed carefully. The other objective of calibration is to examine the applicability of the simulation model to predict the traffic condition. Traffic condition in this research means the mixed traffic at intersection, bridge and opened lane of BRT. The suitable simulation preparation is very important for model calibration. Besides, the following factors need to be examined.

- *Traffic flow data input*

Traffic flow data are used as the input to the traffic simulation model in VISSIM. The data need to be collected from the field. Flow and capacity both on link and at intersection are expressed in car units per hour. Each type of vehicles is calculated separately as heterogeneous traffic proportion. Vehicle type and travel speed data in mixed traffic condition are also inputted in VISSIM.

- *Driving behavior*

Driving behavior is related directly to car following model. VISSIM is projecting car following model using *wiedemann's* approach. In urban area with high congestion like Jakarta and Bangkok, it is appropriate to design using *wiedemann 74* by considering the safety distance between vehicles and standstill distance. This model is an improved version of *wiedemann's 1974* by considering the following parameters.

Table 3.3 Parameters according to Wiedemann 74

Parameters	Description
Average standstill distance	(αx) : defines the average desired distance between two cars. The tolerance lies between -1.0 m and +1.0 m which is normally distributed at around 0.0m with a standard deviation of 0.3 m. The default value is 2.0
Additive part of safety distance	(bx_{add}) : value used for the computation of the desired safety distance d . Allows to adjust the time requirement values. The default value is 2.0.
Multiplicative part of safety distance	(bx_{mult}) : value used for the computation of the desired safety distance d . Allows to adjust the time requirement values. Greater value = greater distribution (standard deviation) of safety distance. The default value is 3.0.

Source: PTV AG (2015)

Then, the desired distance d is calculated from:

$$d = \alpha x + bx$$

where:

αx : average standstill distance (meter)

Z : is a value of range [0,1]

v : vehicle speed (meters/second)

$$bx = (bx_{add} + bx_{mult} * Z) * v^{-2}$$

Using driving behavior function in VISSIM, the suitable condition can be designed as compared with the field study. Please take a look at **Figure 3.16** for the captured computer screen showing driving behavior function in VISSIM.

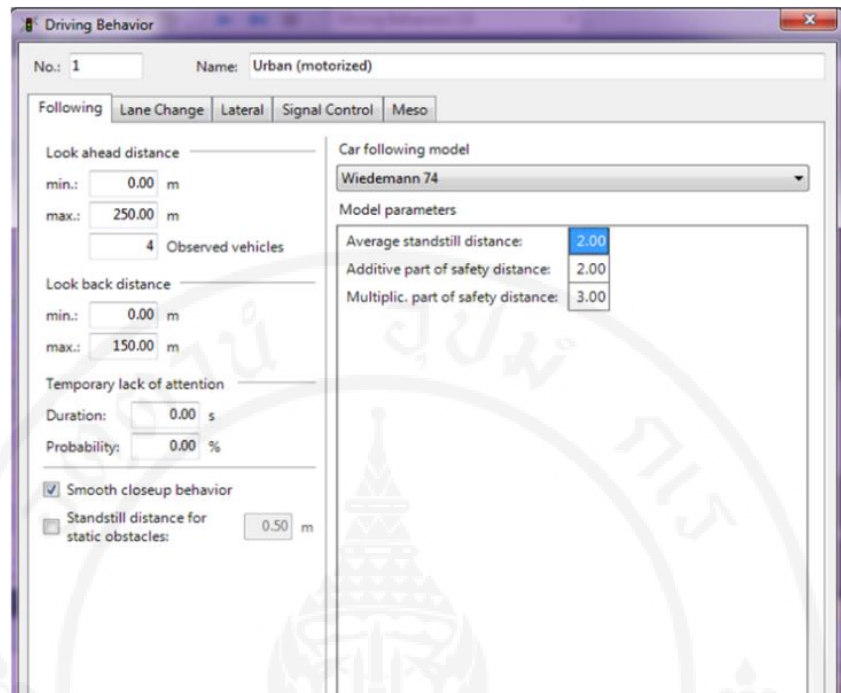


Figure 3.16 Driving behavior function in VISSIM

- *PT parameters*

In order to calibrate the model, the existing (do nothing) scenario has to be simulated and compared results with observed values from field condition. The non-parametric statistical method, namely, Wilcoxon Signed-Rank test is used to check if simulation results are significantly different from the observed values. The testing parameters are travel time and travel speed. Wilcoxon Signed-Rank test proceeds as follows (the Kenkel, 1995);

- a) The null hypothesis is that two populations are identical:

$$H_0: O_i = E_i$$

$$H_1: O_i \neq E_i$$

Where, O_i : observed values; E_i : simulation results

- b) Determine the significant level:

The significant level of 5% is adopted.

Where, significant level $\alpha = 0.05$

n = the total n observations – ties (identical paired-sample)

T_p = the number of samples with positive rank

T_n = the number of samples with negative rank

- c) When n is large ($n \geq 15$), then T value is approximately normally distributed with the mean of probability distribution (μ_T);

$$\mu_T = \frac{n(n+1)}{4} \quad (3.11)$$

and variance of probability distribution (σ_T^2);

$$\sigma_T^2 = \frac{n(n+1)(2n+1)}{24} \quad (3.12)$$

and also the random variable (Z):

$$Z = \frac{T - \mu_T}{\sigma_T} \quad (3.13)$$

Z is approximately as a standard normal. Where, the alternative hypothesis is two-sided, as shown in **Figure 3.17**.

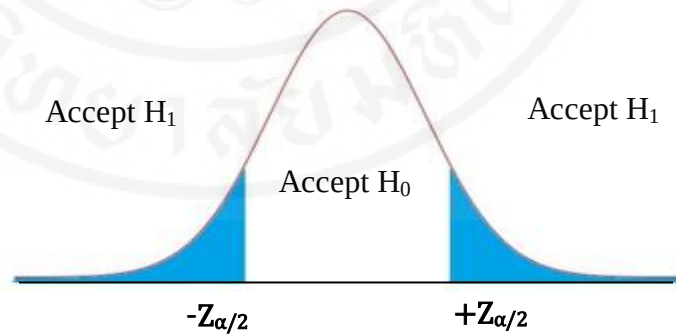


Figure 3.17 Normal distribution

- d) When n is small ($n \leq 15$), the normal distribution doesn't necessarily provide a good approximation to the distribution of " Z ". For a small sample, distribution tables for " T " are available.

The existing scenario in simulation is calibrated until the travel time and travel speed are in line with the observed condition. After the simulation model is validated, then prepare the scenario to simulate the proposed strategies. The proposed strategies become alternative scenarios beside the existing scenario.

3) Running simulation

The simulation model is ready to run after the preparation and validation have been done. The simulation will be run on several scenarios. The number of scenarios depends on the number of proposed strategies. The parameters such as PT travel speed, PT waiting time, and delay can be evaluated as the results or outputs of the simulation. Please take a look at **Figure 3.18** below.

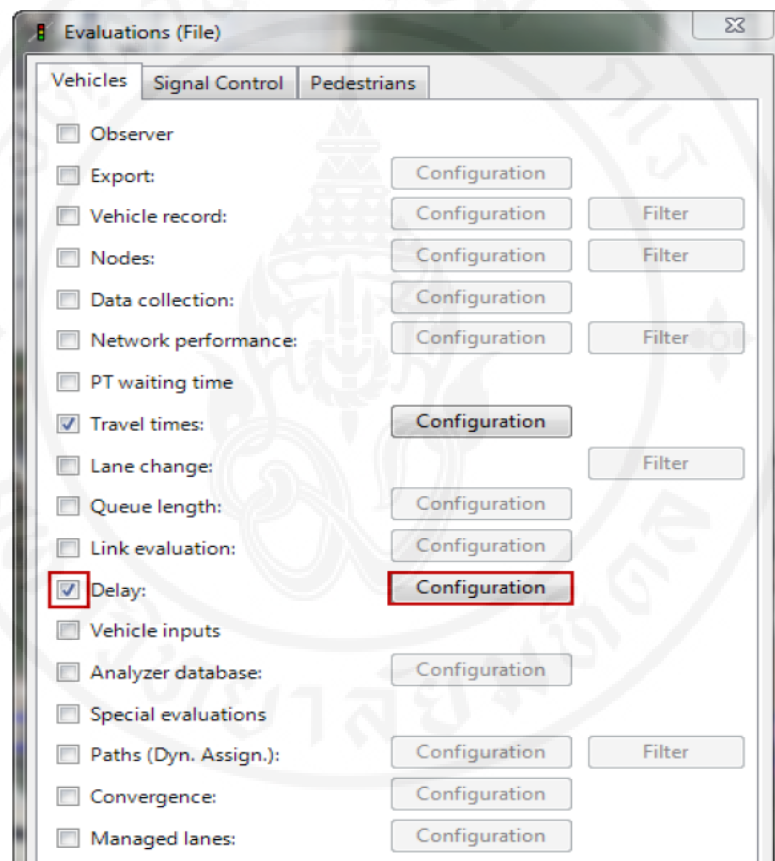


Figure 3.18 Evaluation configuration in VISSIM

The resulting performance parameters from the simulation can be used to make the decision whether the proposed strategy is suitable to be implemented. The combined scenarios maybe run to get better performance of BRT service.

3.3. Analytical tools

Regarding the analytical tools in this research, they are categorized into hardware and software.

3.2.1 Hardware

Hardware used in this research consists of computer, GPS, DSLR camera, and video camera. The specifications of these hardware are explained below.

1) Computer

Two kinds of computers are used in this research. They are computer hardware provided by T-LEX (Transportation, Traffic, and Logistics Expert Center) in the Department of Civil and Environmental Engineering, Faculty of Engineering, Mahidol University and the personal laptop computer. The specifications of both computers are showed below.

a) Desktop Computer

- Manufacturer and model: HP ProDesk 600 G1 TWR
- Processor: Intel Core i5 – 5470 CPU @ 3.20 GHz 3.20 GHz
- RAM: 4.00 GB
- System type: 32-bit Operating System
- OS: Windows 7 Home Premium

b) Laptop

- Manufacturer and model: ASUS K40iN
- Processor: Intel Core 2 Duo
- RAM: 2.00 GB
- System type: 32-bit Operating System
- OS: Windows 7 Home Premium

The desktop computer is used to run VISSIM program. Meanwhile, using laptop gives the mobile capability beside of working in the T-LEX laboratory.

2) GPS

GPS is used in the activities such as mapping, routing, and tracking location in the field study. The GPS which is used in this study is Google Maps mobile version installed in mobile phone (i Phone 4S) and Google Earth installed in laptop and desktop.

3) DSLR Camera

The DSLR camera is used to capture the actual image conditions while collecting the data. The camera has the following specifications.

- Manufacturer and model: Nikon D3000
- Lens: Kit lens and zoom lens 70-300
- Color filter type: RGBG
- Aspect ratio: 3:2

4) Video Camera

Video camera is used to record traffic characteristics such as traffic flow, and conflict point etc. The video camera has the following specifications.

- Manufacturer and model: Samsung HMX-H300
- Pixel: 5 MP
- Resolution: 1920 x 1080- Full HD
- Optical Zoom: 30x
- Digital Zoom: 300x

3.2.1 Software

Several software are used in this research. They include Microsoft Office 2013, VISSIM 9.0, AutoCAD 2013, and LINDO 6.1. These software are explained more detail below.

1) Microsoft Office 2013

The applicable parts of Microsoft office software are Excel, Words, and Power Point. The Microsoft Excel is used for calculating and creating table. Microsoft Words is used for writing purpose. The presentation will be arranged in Microsoft Power Point.

2) VISSIM 9.0

As mentioned before, the modelling scenarios related to proposed strategies uses VISSIM version 9.0 released in 2016. The licensed of VISSIM belongs to T-LEX in the Department of Civil and Environmental Engineering, Faculty of Engineering, Mahidol University. PTV VISSIM is the microscopic simulation program for modeling multimodal transport operation. VISSIM can create the conditions to test different traffic scenarios before their realization (PTV AG, 2015). In this study, VISSIM is used to test the proposed strategies related to the enhancement of Bus Rapid Transit.

3) AutoCAD 2013

The AutoCAD a product of Autodesk, is the software to draw the 2D and 3D technical image. It is used to draw the detailed map and display images. The AutoCAD 2013 license belongs to Mahidol University.

4) SPSS Statistics 17.0

The SPSS a software product of IBM, is used to perform the statistical analyses during the model validation stage. The SPSS 17.0 license belongs to Mahidol University.

5) LINDO 6.1

LINDO is the comprehensive software to build and solve the linear optimization model. This study conditionally uses LINDO if the optional strategy of *re-scheduling BRT* is chosen as the proposed strategy.

3.4 Research procedure

The steps to accomplish the research are as follows;

- 1) The research procedure starts with the literature review about Bus Rapid System and simulation approach. The definitions of BRT, issues of BRT, the development of BRT around the world, and simulation approach are reviewed as the base of the research.

2) The second step is to collect data needed to evaluate the performance of BRT and data needed to conduct the simulation. The data consist of BRT data and mixed traffic data.

3) The third step is the performance evaluation. It is conducted to identify the problems in the operation, network, and infrastructure aspects. Performance evaluation in this process is based on existing condition.

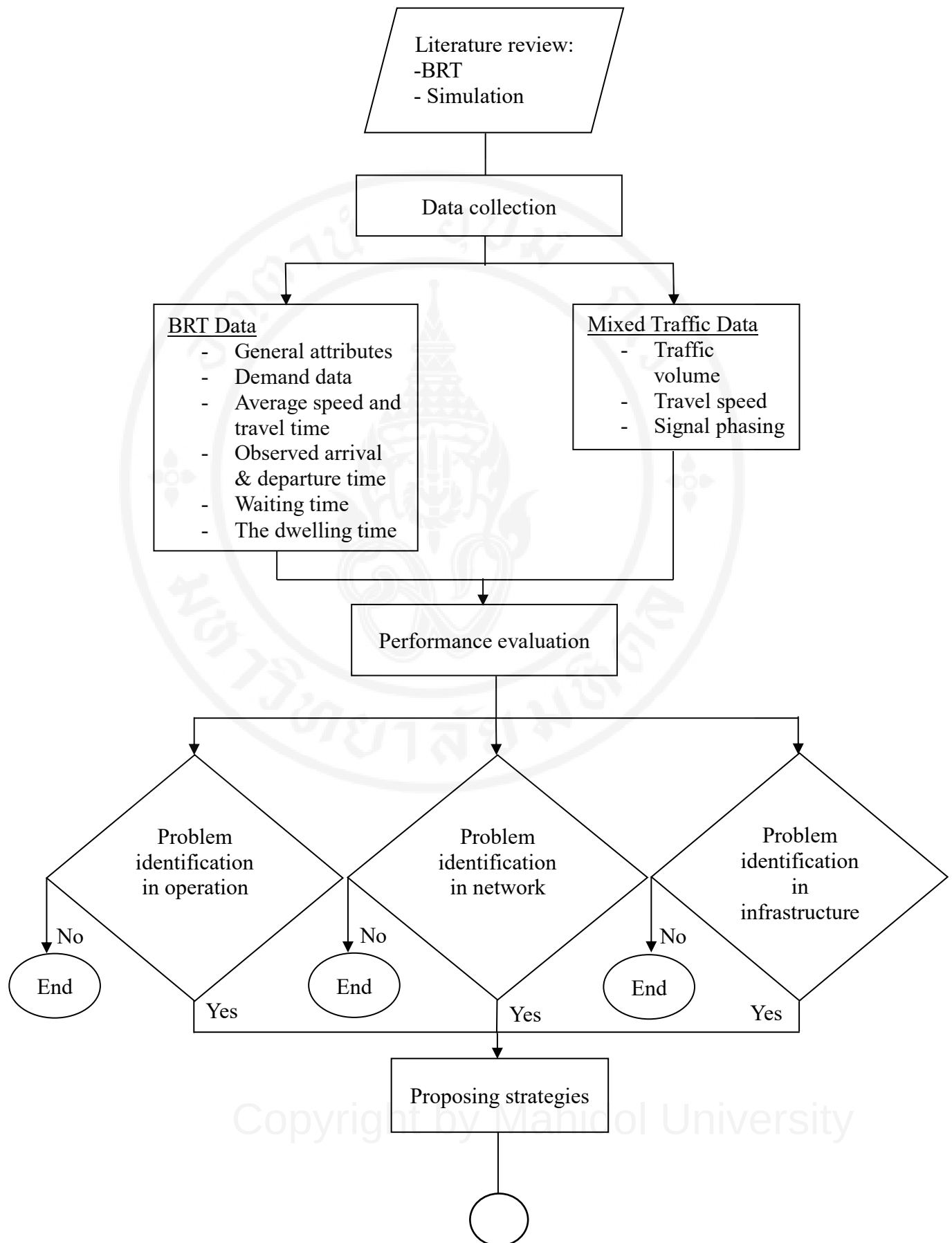
4) The fourth step is problem identification based on the performance evaluation. The problem is categorized into three aspects; i.e., problem in the operation, problem in the network, and problem in infrastructure. The justification to select optional strategy is based on the problem identification.

5) The fifth step is about proposing strategies. The optional strategies are prepared conditionally based on the problem identification. Then, the proposed strategies are developed and simulated to test the scenarios before realization.

6) The sixth is the comparison of performance impact among the scenarios as the results of simulation. The best scenario or combined scenarios is determined as the output of this process.

7) Finally, the research are closed with the conclusion to fulfill the objectives of this research.

Overall, the research is conducted following the flowchart shown in **Figure 3.19**.



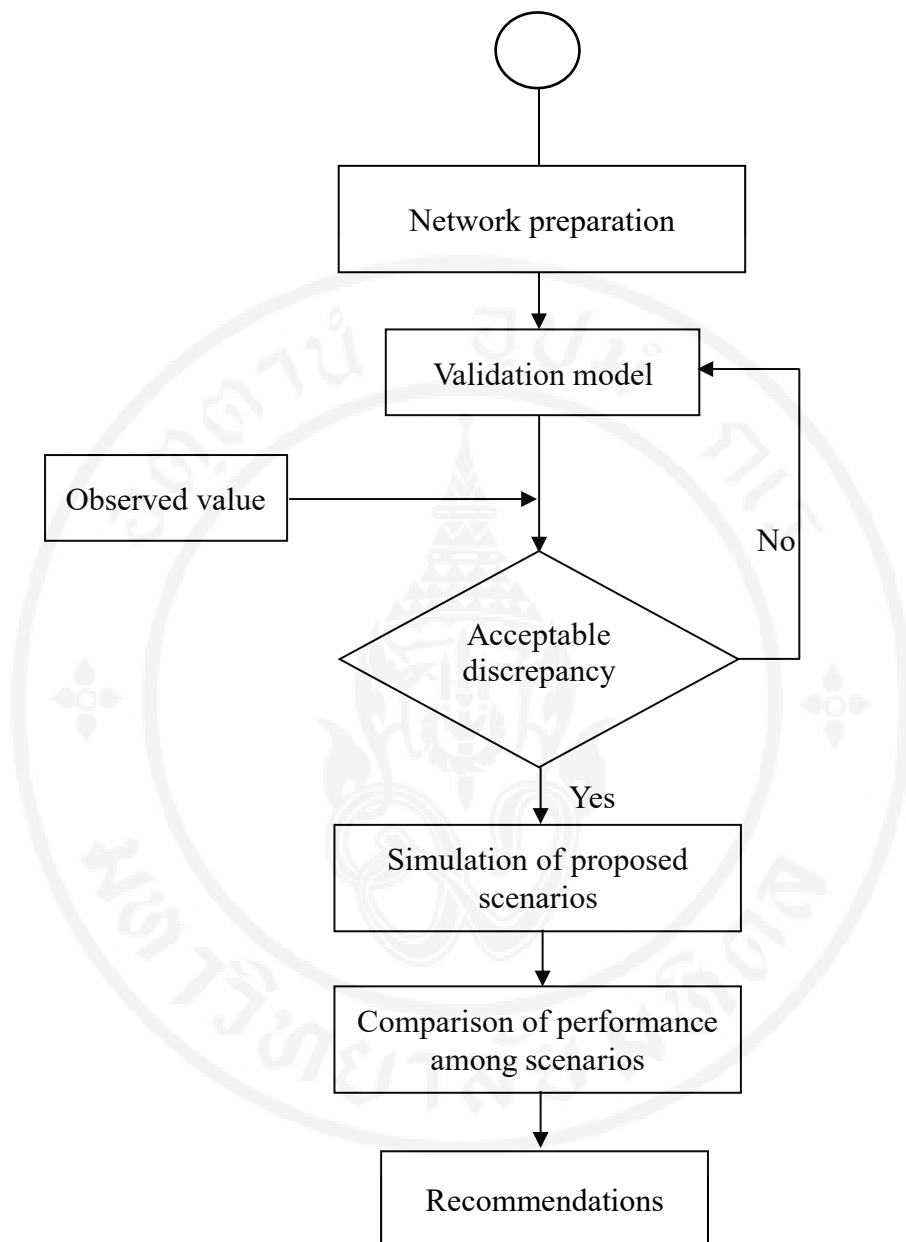


Figure 3.19 The research procedure

CHAPTER IV

RESULTS AND DISCUSSIONS

4.1 Data collection

Several kinds of data from both TransJakarta and Bangkok BRT are obtained by the surveys. The remaining data are gained from the related institutions; i.e., the Ministry of Transportation, the Local Transportation Department, and TransJakarta Operator Company. They consist of general characteristics, demand data, dynamic data, static data, and inventory data. They are described in this chapter.

4.1.1 General characteristics of TransJakarta

TransJakarta has segregated lane (width 3 m to 6 m) physically separated by curbs. The total route length of TransJakarta is 211 kilometers of which 14 kilometers of route is mixed traffic portions. The system provides bus services on 12 regular routes and 10 direct routes around Jakarta City, as shown in **Figure 4.1**.

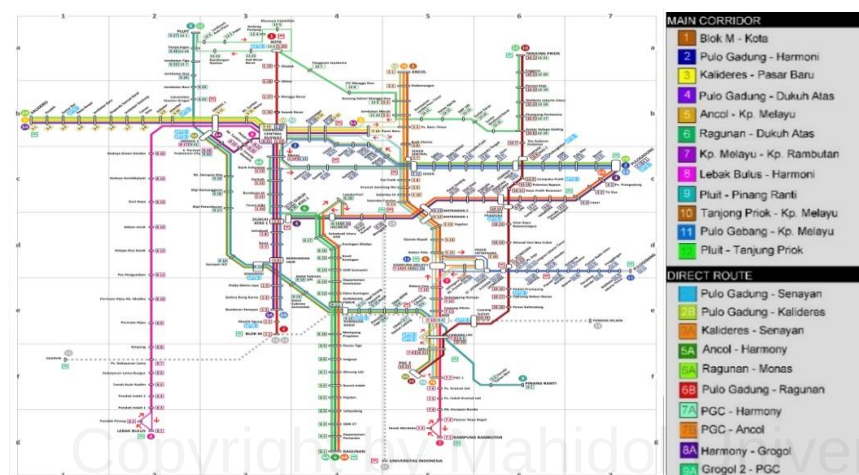


Figure 4.1 TransJakarta line service map

Source: TransJakarta (2015)

These routes are served by 208 units of articulated buses and 236 units of regular buses with standing and seating capacity up to 85 and 140 passengers, respectively. All buses are standard BRT bus. They can accommodate high-floor platform. NGV buses which are environmental friendly are used by TransJakarta. There are 2 entrance doors for regular bus and 3 entrance doors for articulated bus. The visualization of TransJakarta's buses is shown in **Figure 4.2**.



Figure 4.2 Articulated bus and regular bus operated by TransJakarta

The route and vehicle information can be seen in Table 4.1.

Table 4.1 Route length and number of buses operated on each corridor

Corridor Number	Route Length (m)	15-m Articulated Bus		12-m Single Bus		Total Number of Buses
		Units	Capacity	Units	Capacity	
1	13,619	51	140	0	85	51
2	13,591	13	140	20	85	33
3	14,974	11	140	22	85	33
4	11,980	0	140	33	85	33
5	11,780	23	140	0	85	23
6	14,921	2	140	70	85	72
7	12,372	9	140	40	85	49
8	26,477	14	140	23	85	37
9	28,918	31	140	19	85	50
10	19,376	25	140	4	85	29
11	13,070	16	140	1	85	17
12	29,560	13	140	4	85	17
Total	210,638	208		236		444

Source: Operation Division of TransJakarta Operator Company (2015)

The in-vehicle facility consists of information system, seats for disabled, and safety system. The in-vehicle information system is isolated or offline. It shows the next or arriving station with both visualizations on the screen and yelling from the conductor.

In the master plan issued by the Transportation department of Jakarta, for operation movement, the ideal speed for TransJakarta bus is below 50 km/hr, with the maximum headway of 5 to 10 minutes on each corridor.

Regarding the payment and fare collection, in line with the regional policy about priority of public transport, the government also gives the subsidy of 40% fare for users of TransJakarta (MOT, 2015). Until now in 2016, the fare is 3,500 rupiahs (0.35 USD) for all corridors. The price is flat for all destinations. There are two kinds of tickets; i.e., single-trip ticket (get on the spot at any station) and smart card (multiple trips) which can be topped up any time at every market or bank. Every station has at least one gate for smart card user. The payment for single trip ticket is manually done by the crew inside the ticket booth.



Figure 4.3 a) & b) Smart card of ticketing system c) & d) Single-trip ticket payment

Source: TransJakarta (2015)

4.1.2 Demand characteristics of TransJakarta

Based on the information from TransJakarta Company, the system serves 350,000 passengers per day (Operation Division, 2015). The daily demand on each corridor can be seen in Table 4.2. The last data updated was on August 17th, 2015.

Table 4.2. The daily demand on each main corridor

Corridor Number	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5	Shift 6	Shift 7	Total
	00:00-04:59	05:00-06:59	7:00-09:59	10:00-15:59	16:00-19:59	20:00-21:59	22:00-23:59	
1	377	6,124	13,000	20,237	25,882	6,143	1,485	73,248
2	42	3,862	4,024	6,042	4,973	1,370	247	20,560
3	100	4,690	5,402	7,033	5,168	1,456	325	24,174
4	-	3,777	4,973	6,046	5,788	1,249	223	22,057
5	39	2,852	4,124	8,711	9,502	2,225	423	27,876
6	-	4,999	6,236	6,911	9,021	2,140	243	29,550
7	71	5,550	4,940	5,848	3,759	942	198	21,308
8	87	3,958	5,863	6,966	7,881	2,291	816	27,862
9	151	6,965	8,860	12,375	12,613	3,367	815	45,146
10	27	2,071	2,784	4,296	4,339	985	260	14,762
11	-	1,727	2,052	2,461	1,484	364	39	8,127
12	-	652	846	1,425	1,462	296	-	4,681
Total	895	47,227	63,104	88,351	91,872	22,828	5,074	319,351

Source: Operation Division of TransJakarta Operator Company (2015)

Based on the updated data, the most congested corridor is the corridor 1 with 73,248 passengers per day. The lowest number of daily passengers is on corridor 12. The number of daily passengers by station by corridor can be seen in Tables 4.3 to 4.14

Table 4.3 The number of daily passengers along corridor 1 by station by shift

No	Corridor 1 Station	Shift 1				Shift 2				Shift 3				Shift 4								Shift 5								Shift 6				Shift 7 23:00-23:59	Total
		00:00-00:59 01:00-01:59	01:00-01:59 02:00-02:59	02:00-02:59 03:00-03:59	03:00-03:59 04:00-04:59	05:00-05:59 06:00-06:59	06:00-06:59 07:00-07:59	07:00-07:59 08:00-08:59	08:00-08:59 09:00-09:59	09:00-09:59 10:00-10:59	10:00-10:59 11:00-11:59	11:00-11:59 12:00-12:59	12:00-12:59 13:00-13:59	13:00-13:59 14:00-14:59	14:00-14:59 15:00-15:59	15:00-15:59 16:00-16:59	16:00-16:59 17:00-17:59	17:00-17:59 18:00-18:59	18:00-18:59 19:00-19:59	19:00-19:59 20:00-20:59	20:00-20:59 21:00-21:59	21:00-21:59 22:00-22:59	22:00-22:59 23:00-23:59												
1	Blok M	12	10	11	4	16	407	974	968	767	536	473	426	475	510	447	499	663	730	754	590	524	308	119	43					10,286					
2	Masjid Agung Arah Kota	0	0	0	0	1	72	301	347	230	110	48	59	61	96	87	93	202	130	103	61	51	24	0	0					2,076					
3	Bundaran Senayan	19	4	1	0	4	46	152	206	210	93	117	120	153	169	192	199	418	617	537	445	310	152	185	36					4,385					
4	Gelora	0	0	0	0	0	25	77	147	113	86	100	133	232	296	358	370	373	434	357	266	204	190	0	0					3,761					
5	Polda	0	0	0	0	0	48	110	139	106	87	104	120	159	138	136	195	237	379	393	224	151	126	0	0					2,852					
6	Bendungan Hilir	3	6	4	0	3	50	212	311	269	182	179	181	248	247	258	308	375	554	482	387	306	230	116	18					4,929					
7	Karet	4	0	3	1	4	58	235	380	328	185	131	166	194	174	164	261	350	699	567	350	275	155	60	10					4,754					
8	Dukuh Atas 1	4	2	1	0	2	28	186	213	229	142	128	126	193	148	176	153	253	520	448	258	154	86	41	16					3,507					
9	Tosari	8	3	4	16	16	62	192	299	278	147	159	162	172	182	189	260	342	600	505	362	280	216	227	48					4,729					
10	Sarinah	22	6	11	4	7	54	158	233	184	165	141	191	206	256	291	343	442	628	495	367	343	250	157	29					4,983					
11	Bank Indonesia	0	0	0	0	0	13	90	100	73	52	59	74	88	74	84	114	262	397	303	212	124	69	0	0					2,188					
12	Monas	0	0	2	0	0	25	90	89	63	72	98	107	127	138	169	228	422	343	183	139	114	63	14	3					2,489					
13	Harmoni	17	3	11	9	11	103	251	297	217	151	151	165	195	193	244	329	516	917	542	346	286	163	126	46					5,289					
14	Sawah Besar	0	0	0	0	0	115	363	389	292	190	157	134	187	187	159	162	238	392	233	173	160	135	2	0					3,668					
15	Mangga Besar	11	9	6	11	6	111	301	303	230	145	121	100	95	144	100	97	110	154	106	99	72	60	42	25					2,458					
16	Olino	0	0	0	0	0	89	230	290	191	117	102	118	105	75	64	94	147	178	133	83	87	43	0	0					2,146					
17	Glodok	0	0	0	0	2	54	166	235	166	109	113	138	152	158	188	215	278	279	142	62	50	16	0	0					2,523					
18	Stasiun Kota	15	22	4	4	18	154	520	736	462	334	355	330	304	262	294	316	365	515	418	263	204	159	80	42					6,176					
19	Masjid Agung Arah Blok M	0	0	0	0	0	0	2	0	3	4	3	3	2	5	2	7	4	1	7	3	2	1	0	0					49					
TOTAL		115	65	58	49	90	1,514	4,610	5,682	4,411	2,907	2,739	2,853	3,348	3,452	3,602	4,243	6,017	8,467	6,708	4,690	3,697	2,446	1,169	316					73,248					

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.4 The number of daily passengers along corridor 2 by station by shift

No	Corridor 2 Station	Shift 1						Shift 2		Shift 3		Shift 4						Shift 5						Shift 6				Shift 7	Total
		00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59				
1	Pulo Gadung	1	0	2	6	9	642	594	412	272	255	232	217	192	171	134	159	201	166	152	147	62	68	43	9	4,146			
2	Bermis	0	0	0	0	0	101	177	83	68	58	27	36	24	19	30	22	36	54	45	27	15	10	1	0	833			
3	Pulo Mas	2	0	1	3	4	106	190	118	100	79	78	57	49	52	58	61	82	118	99	64	61	52	45	2	1,481			
4	ASMI	0	0	0	0	0	39	59	44	44	29	28	27	25	30	33	54	49	51	36	33	28	15	0	0	624			
5	Pedongkelan	0	0	0	0	0	38	39	31	16	7	8	15	3	13	16	1	11	8	5	3	5	1	0	0	220			
6	Cempaka Timur	1	2	1	0	2	84	109	91	74	117	92	90	104	102	102	150	175	253	187	267	232	72	41	6	2,354			
7	RS Islam	0	0	0	1	0	75	121	91	67	51	55	35	49	47	84	74	90	74	57	47	40	32	11	1	1,102			
8	Cempaka Tengah	0	0	0	0	0	48	68	35	34	39	22	27	37	70	32	51	47	58	39	20	17	12	0	0	656			
9	PsCempaka	0	0	0	0	0	48	67	35	54	40	25	39	29	46	29	37	40	27	28	14	13	8	0	0	579			
10	Rawa Selatan	0	0	0	1	1	106	121	59	75	52	46	54	49	53	25	28	49	30	23	26	22	17	8	0	845			
11	Galur	0	0	0	0	0	132	119	73	61	61	42	44	51	43	35	35	40	52	28	35	13	2	0	0	894			
12	Atrium	0	0	0	0	0	6	11	19	19	15	19	11	29	26	22	27	40	39	37	24	29	27	0	0	400			
13	RSPAD	0	0	0	0	0	9	9	15	12	18	15	17	14	30	29	48	21	9	11	4	10	15	1	0	287			
14	Depluar Negri	0	0	0	0	0	4	10	4	4	1	5	10	6	15	17	12	34	15	6	5	6	1	0	0	155			
15	Gambir 1	2	1	0	0	2	29	17	16	21	35	41	32	36	38	81	52	80	37	30	25	46	33	14	17	685			
16	Istiqal	0	0	0	0	0	2	4	2	0	3	4	7	1	12	6	30	17	7	11	2	0	0	0	0	108			
17	Juanda	0	0	0	0	0	84	377	323	280	189	153	104	129	119	99	128	155	167	134	147	107	67	33	2	2,797			
18	Pecenongan	0	0	0	0	0	14	55	51	38	35	43	48	49	49	67	66	153	134	108	64	41	38	5	0	1,058			
19	Balai Kota	0	0	0	0	0	5	10	6	11	9	7	10	14	11	23	14	21	44	23	9	16	16	0	0	249			
20	Gambir 2	0	0	0	0	0	20	46	38	25	20	26	34	28	71	73	66	65	43	37	38	39	26	2	0	697			
21	Kwitang	0	0	0	0	0	21	46	29	32	29	8	15	17	31	18	26	31	27	21	12	19	4	2	2	390			
TOTAL		6	3	4	11	18	1,613	2,249	1,575	1,307	1,142	976	929	935	1,048	1,013	1,141	1,437	1,413	1,117	1,006	843	527	208	39	20,560			

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.5 The number of daily passengers along corridor 3 by station by shift

No	Corridor 3 Station		Shift 1				Shift 2				Shift 3				Shift 4								Shift 5				Shift 6		Shift 7 23:00- 23:59	Total
			00:00- 00:59	01:00- 01:59	02:00- 02:59	03:00- 03:59	04:00- 04:59	05:00- 05:59	06:00- 06:59	07:00- 07:59	08:00- 08:59	09:00- 09:59	10:00- 10:59	11:00- 11:59	12:00- 12:59	13:00- 13:59	14:00- 14:59	15:00- 15:59	16:00- 16:59	17:00- 17:59	18:00- 18:59	19:00- 19:59	20:00- 20:59	21:00- 21:59	22:00- 22:59					
1	Kalideres	9	4	9	4	17	624	995	552	492	415	291	301	253	256	193	242	245	287	262	147	104	95	42	22	5,861				
2	Pesakih	1	0	1	1	1	75	143	87	65	29	53	34	32	40	40	35	39	51	34	25	11	33	16	5	851				
3	Sumur Bor	0	0	0	0	0	135	255	152	128	93	78	75	45	57	54	69	63	50	53	33	33	13	0	0	1,386				
4	Rawa Buaya	3	0	4	2	7	225	349	226	185	152	126	126	98	95	95	82	109	161	146	97	69	60	36	4	2,454				
5	Jembatan Baru	3	0	1	0	2	135	224	126	128	80	85	66	62	62	41	51	51	64	35	30	37	23	15	2	1,323				
6	Taman Kota	0	0	0	0	0	116	189	100	122	105	81	57	48	82	57	64	83	66	54	41	26	21	0	0	1,312				
7	Indosiar	4	1	2	0	2	99	164	179	143	77	75	67	64	80	63	87	115	122	98	70	57	40	14	17	1,640				
8	Jelambar	1	1	0	2	1	61	168	179	133	90	66	72	81	101	151	137	154	157	130	104	84	95	62	7	2,037				
9	Grogol 1	1	1	1	2	3	71	245	260	186	134	128	107	163	184	192	262	229	187	172	119	188	121	26	9	2,991				
10	RS Sumber Waras	4	0	1	0	4	85	269	310	221	138	117	139	159	162	168	187	198	270	182	148	141	120	41	7	3,071				
11	Pasar Baru	0	0	0	0	0	15	48	51	31	30	46	38	67	113	97	140	133	153	81	120	53	32	0	0	1,248				
TOTAL		26	7	19	11	37	1,641	3,049	2,222	1,834	1,346	1,140	1,082	1,072	1,232	1,151	1,356	1,419	1,568	1,247	934	803	653	252	73	24,174				

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.6 The number of daily passengers along corridor 4 by station by shift

No	Corridor 4 Station		Shift 1				Shift 2				Shift 3				Shift 4								Shift 5				Shift 6				Shift 7	Total
			00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59						
1			0	0	0	0	0	0	0	0	263	332	192	134	89	68	69	70	64	34	77	69	108	71	57	35	31	17	0	1,780		
2			0	0	0	0	0	0	3	10	3	10	2	2	27	2	0	3	2	3	3	3	1	4	0	0	0	0	0	70		
3			0	0	0	0	0	0	95	177	77	77	77	45	40	37	82	31	20	26	24	74	83	44	21	12	6	4	0	837		
4			0	0	0	0	0	0	61	128	93	104	97	104	97	85	82	44	64	83	94	64	89	64	33	47	4	0	0	1,236		
5			0	0	0	0	0	0	112	155	112	97	56	71	52	54	54	63	63	65	79	130	92	61	73	73	22	0	0	1,430		
6			0	0	0	0	0	0	26	77	42	40	46	38	34	34	25	51	34	61	67	106	73	40	23	14	0	0	0	797		
7			0	0	0	0	0	0	111	196	116	118	104	72	65	61	49	71	68	96	110	109	73	69	63	17	1	1	1,569			
8			0	0	0	0	0	0	73	155	102	63	75	136	109	134	231	265	271	400	193	226	134	77	25	0	0	0	2,669			
9			0	0	0	0	0	0	1	24	42	33	22	16	17	8	9	6	11	25	17	42	18	13	14	6	9	0	0	333		
10			0	0	0	0	0	0	35	56	56	33	30	30	28	26	34	38	23	62	89	50	40	29	3	0	0	0	662			
11			0	0	0	0	0	0	52	83	46	34	32	16	16	16	19	19	8	16	31	25	22	6	16	13	1	0	455			
12			0	0	0	0	0	0	80	116	97	89	85	75	54	56	63	38	65	65	68	69	22	31	18	7	1	1,099				
13			0	0	0	0	0	0	76	88	72	44	40	36	36	39	43	56	49	80	66	51	50	34	38	19	0	0	917			
14			0	0	0	0	0	0	156	330	323	268	169	172	106	105	125	107	87	94	147	114	91	89	59	44	1	2,587				
15			0	0	0	0	0	0	90	110	100	88	53	45	39	34	42	39	27	39	54	61	43	32	14	0	0	0	910			
16			0	0	0	0	0	0	15	49	67	45	31	44	24	39	41	77	73	75	93	68	48	23	21	0	0	0	833			
17			0	0	0	0	0	0	52	349	520	454	253	144	129	97	98	100	144	284	398	297	221	148	105	77	3	3,873				
TOTAL			0	0	0	0	0	0	1	1,324	2,453	2,050	1,680	1,243	1,088	873	846	1,015	1,053	1,171	1,599	1,803	1,432	954	756	493	217	6	22,057			

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.7 The number of daily passengers along corridor 5 by station by shift

No	Corridor 5 Station	Shift 1				Shift 2				Shift 3				Shift 4				Shift 5				Shift 6				Shift 7		
		00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59	Total		
1	Kampung Melayu	1	0	0	0	0	2	300	385	305	310	225	201	193	215	237	190	266	331	357	350	313	251	220	118	9	4,779	
2	PsJatinegara	0	1	0	0	0	0	12	38	36	29	36	71	62	67	69	78	79	81	66	19	22	9	8	5	1	789	
3	Kebon Pala	0	0	0	0	0	0	81	106	85	73	59	27	32	32	31	40	29	46	41	30	41	18	11	0	0	782	
4	Slamet Riyadi	0	0	0	0	0	0	66	111	76	62	40	48	41	28	40	39	85	46	34	36	18	22	6	4	1	803	
5	Tegalan	0	0	0	0	0	0	53	113	84	61	58	47	46	67	51	76	92	87	76	77	79	54	39	2	0	1,162	
6	Matraman I	1	1	0	0	0	1	38	77	90	72	56	57	30	50	63	61	45	72	91	82	53	47	39	18	2	1,046	
7	Salemba Carolus	0	0	0	0	0	0	36	103	80	47	63	62	73	120	157	216	184	159	137	108	90	85	67	3	0	1,790	
8	Salemba UI	0	0	0	0	0	0	91	152	161	121	117	117	136	150	188	220	254	343	234	141	95	116	106	33	5	2,780	
9	Kramat Sentiong	1	1	0	1	0	0	99	148	120	132	92	76	88	81	92	103	113	202	160	121	84	77	43	19	1	1,854	
10	Pal Putih	0	0	0	0	0	0	54	80	92	78	63	89	51	58	60	67	84	116	109	74	71	82	48	2	0	1,278	
11	Senen Sentral	0	0	0	0	4	10	67	99	86	107	108	129	166	180	178	250	292	227	339	211	188	195	171	107	10	3,124	
12	Budi Utomo	0	0	0	0	0	0	6	23	26	16	9	22	15	27	55	35	33	60	72	34	24	8	4	0	0	469	
13	PsBaru Timur	0	1	0	0	0	0	23	42	49	56	36	30	36	43	47	45	66	98	118	91	48	60	43	26	2	960	
14	Jembatan Merah	1	3	0	0	0	2	48	85	82	66	48	38	34	39	43	40	69	115	190	91	53	38	26	12	4	1,127	
15	GnSahari MgDua	3	0	0	0	0	0	52	147	96	111	87	96	72	80	78	63	97	110	140	127	94	104	62	18	9	1,646	
16	Pademangan	1	1	0	0	0	0	30	54	70	44	48	39	31	37	50	48	74	94	174	128	63	27	19	1	1	1,034	
17	Ancol	1	0	1	0	1	0	1	7	26	22	14	20	19	28	37	55	49	122	233	414	782	492	98	22	10	0	2,453
TOTAL		9	8	1	5	16	1,063	1,789	1,560	1,399	1,165	1,168	1,134	1,311	1,494	1,620	1,984	2,420	2,752	2,502	1,828	1,291	934	378	45	27,876		

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.8 The number of daily passengers along corridor 6 by station by shift

No	Corridor 6 Station	Shift 1				Shift 2				Shift 3				Shift 4				Shift 5				Shift 6				Shift 7				Total
		00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59					
1	Ragunan	0	0	0	0	0	0	620	1,247	740	578	370	175	101	95	129	119	122	130	87	32	17	8	11	6	0	0	0	0	4,587
2	DeptPertanian	0	0	0	0	0	0	264	292	214	149	157	99	78	89	101	46	49	92	83	85	60	48	21	12	1	0	0	0	1,940
3	SMK 57	0	0	0	0	0	0	134	265	192	164	98	100	67	80	78	51	30	58	62	57	37	26	11	0	0	0	0	0	1,510
4	Jati Padang	0	0	0	0	0	0	113	200	142	111	81	58	54	40	40	19	24	19	49	39	22	26	15	4	0	0	0	0	1,056
5	Pejaten	0	0	0	0	0	0	38	134	105	70	59	53	60	81	62	42	56	67	86	88	63	58	57	25	0	0	0	0	1,204
6	Buncit Indah	0	0	0	0	0	0	41	125	103	58	43	35	39	34	28	17	22	26	66	38	40	23	8	0	0	0	0	0	746
7	Warung Jati	0	0	0	0	0	0	75	165	155	101	80	47	39	37	40	35	30	53	91	50	29	24	15	0	0	0	0	0	1,066
8	Imigrasi	0	0	0	0	0	0	32	70	63	57	50	59	32	27	43	39	35	48	46	49	21	19	16	0	0	0	0	0	706
9	Duren Tiga	0	0	0	0	0	0	126	267	181	140	116	96	37	62	50	70	57	81	97	80	77	36	26	5	0	0	0	0	1,604
10	Mampang Prapatan	0	0	0	0	0	0	82	157	210	148	92	68	71	72	69	52	66	96	184	193	131	99	73	17	0	0	0	0	1,880
11	Kuningan Timur	0	0	0	0	0	0	9	21	27	39	18	17	25	37	37	31	53	147	136	134	76	63	28	27	0	0	0	0	925
12	Patra Kuningan	0	0	0	0	0	0	10	27	25	39	23	30	29	28	42	53	75	154	236	181	122	87	75	14	0	0	0	0	1,250
13	Depkes	0	0	0	0	0	0	25	78	63	61	52	58	60	78	81	102	99	268	242	257	209	132	70	0	0	0	0	0	1,935
14	GOR Sumantri	0	0	0	0	0	0	40	138	165	166	99	108	144	97	170	213	252	369	317	316	238	267	219	95	0	0	0	0	3,413
15	Karet Kuningan	0	0	0	0	0	0	18	67	99	83	64	52	95	106	128	104	187	287	347	287	225	173	100	0	0	0	0	0	2,422
16	Kuningan Madya	0	0	0	0	0	0	15	60	105	80	61	55	51	79	76	71	121	235	331	268	220	135	73	37	0	0	0	0	2,073
17	Setia Budi Aini	0	0	0	0	0	0	11	29	46	58	28	22	40	25	35	43	72	104	223	179	90	58	30	0	0	0	0	0	1,093
18	Latuharhari	0	0	0	0	0	0	0	4	5	0	3	0	2	2	5	7	8	22	29	28	15	5	5	0	0	0	0	0	140
TOTAL		0	0	0	0	0	0	1,653	3,346	2,640	2,102	1,494	1,132	1,024	1,069	1,214	1,114	1,358	2,256	2,712	2,361	1,692	1,287	853	242	1	1	1	1	29,550

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.9 The number of daily passengers along corridor 7 by station by shift

No	Corridor 7 Station	Shift 1				Shift 2				Shift 3				Shift 4				Shift 5				Shift 6				Shift 7	
		00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59	Total	
1	Bidara Cina	0	0	0	0	0	57	84	46	49	51	47	46	27	30	40	40	40	48	27	18	16	8	4	2	691	
2	Gelanggang Remaja	0	0	0	0	0	36	75	53	39	34	30	29	30	39	41	44	44	42	40	21	9	4	0	0	605	
3	Cawang Otista	0	0	0	0	2	63	98	94	56	41	57	37	29	23	26	39	42	77	77	49	24	18	9	0	861	
4	BNN	5	4	0	2	3	245	333	201	185	159	108	72	81	65	84	86	118	139	120	112	74	51	20	16	2,283	
5	Cawang UKI	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	
6	BKN	0	0	0	0	0	3	156	319	163	133	113	92	85	62	82	70	46	112	69	47	55	25	11	13	1,701	
7	PGC 1	0	0	0	0	0	0	409	526	320	313	257	160	131	157	120	124	131	131	132	102	98	87	43	5	0	3,246
8	Pasar Kramat Jati	0	0	0	0	0	0	4	22	18	16	18	15	21	17	11	16	15	23	17	12	14	5	0	0	249	
9	Pasar Induk	0	0	0	0	0	0	48	42	15	12	18	15	13	18	15	17	17	17	16	9	13	9	6	0	0	300
10	RsHarapan Bunda	0	0	0	0	0	0	62	58	36	55	47	39	22	43	35	28	28	37	33	25	14	10	8	4	0	584
11	Makro	0	0	0	0	0	0	288	185	136	170	147	112	128	94	86	72	62	86	86	78	67	64	52	17	0	1,930
12	Tanah Merdeka	0	0	0	0	0	0	171	127	79	99	72	65	60	80	54	58	61	59	64	89	27	13	10	4	0	1,192
13	Kampung Rambutan	0	0	0	0	0	0	252	232	151	171	175	128	103	113	109	75	69	84	86	66	91	56	38	15	0	2,014
14	PGC 2	5	4	1	3	30	653	1,005	516	377	305	304	297	290	235	204	188	206	282	219	179	164	98	55	23	5,643	
TOTAL		16	11	1	5	38	2,444	3,106	1,828	1,675	1,437	1,176	1,045	1,060	901	843	823	999	1,091	911	758	576	366	144	54	54	21,308

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.10 The number of daily passengers along corridor 8 by station by shift

No	Corridor 8 Station	Shift 1				Shift 2				Shift 3				Shift 4				Shift 5				Shift 6				Shift 7		Total
		00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59			
1	Terminal Lebak Bulus	2	0	0	0	3	0	232	369	236	201	142	89	82	97	92	95	110	116	145	127	73	58	18	6	2,421		
2	Pondok Pinang	0	0	0	0	0	0	155	182	119	135	95	86	115	68	73	87	77	105	102	71	56	36	18	0	1,580		
3	Pondok Indah I	0	0	0	0	1	2	23	70	47	42	30	32	23	27	27	28	30	43	97	86	70	34	27	31	5	775	
4	Pondok Indah II	3	0	0	0	0	0	7	38	35	33	34	21	22	36	53	56	62	88	149	114	90	68	108	81	5	1,103	
5	Tanah Kusir Kodim	0	0	0	0	0	0	36	78	56	40	32	20	27	22	17	20	13	23	31	26	14	15	8	0	0	478	
6	Kebayoran Lama Bungur	0	0	0	0	0	0	30	62	51	44	21	12	13	15	25	20	8	28	31	32	22	13	13	0	0	440	
7	Pskebayoran Lama	0	0	0	0	1	4	70	203	242	229	104	74	58	64	57	42	43	83	145	110	82	62	40	32	6	1,751	
8	Simprug	0	0	0	0	0	0	6	16	21	28	19	6	5	9	9	8	25	27	40	32	20	9	9	2	1	292	
9	Permata Hijau	0	0	0	0	0	1	13	43	53	41	30	22	19	37	44	55	76	80	143	147	90	109	70	31	1	1,105	
10	Permata Hijau Rs Merdeka	0	0	0	0	0	1	57	118	115	68	44	37	36	45	29	34	22	61	74	46	23	21	19	9	1	860	
11	Pos Pengumben	0	0	0	0	0	0	38	84	49	33	23	27	17	10	14	10	6	10	22	6	2	3	4	0	0	358	
12	Kelapa Dua Sasak	0	0	0	0	0	0	56	156	151	120	55	58	56	53	40	42	59	54	63	89	47	32	20	0	0	1,151	
13	Kebon Jeruk	1	0	0	0	0	0	69	182	192	128	91	59	60	48	53	67	73	113	151	135	90	67	58	38	3	1,678	
14	Duri Kepa	0	0	0	0	0	1	63	207	151	131	110	95	73	68	81	79	97	91	235	147	98	72	42	17	3	1,861	
15	Kedoya Assidiqiyah	0	0	0	0	0	0	20	68	43	44	31	23	20	26	27	27	30	35	62	36	32	16	17	0	0	557	
16	Kedoya Green Garden	0	0	0	0	1	1	67	188	180	101	73	70	77	49	57	37	59	76	146	197	128	58	40	15	4	1,624	
17	Grogol II	12	3	6	5	12	88	241	310	190	130	88	88	108	146	162	266	238	259	227	201	171	127	135	83	21	3,229	
18	Central Park arah Pluit	2	3	2	1	0	27	62	72	57	64	49	70	57	59	83	84	101	161	198	148	141	117	117	14	1,689		
19	Tomang Mandala	0	0	0	0	0	0	17	67	30	24	31	34	29	23	15	14	16	33	61	26	19	16	9	0	0	464	
20	RS Tarakan	0	0	0	0	0	0	4	28	25	26	24	28	30	19	35	33	30	60	35	25	18	6	0	0	0	459	
21	Petojo	0	0	0	0	0	0	9	23	14	8	7	24	10	11	19	9	28	32	26	8	10	6	0	0	0	244	
22	Central Park arah PRanti	10	1	1	1	6	145	241	323	241	194	120	125	124	144	138	192	202	325	224	237	226	251	238	34	3,743		
TOTAL		30	7	9	13	28	1,232	2,726	2,515	1,964	1,384	1,074	1,075	1,054	1,132	1,250	1,381	1,690	2,496	2,093	1,602	1,222	1,069	712	104	27,862		

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.11 The number of daily passengers along corridor 9 by station by shift

No	Corridor 9 Station	Shift 1				Shift 2				Shift 3				Shift 4								Shift 5				Shift 6				Shift 7		Total
		00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59							
1	Terminal Pinang Ranti	0	0	0	0	0	1,236	774	449	438	379	317	254	217	179	129	97	111	132	121	90	58	28	0	0	5,009						
2	Garuda Taman Mini	0	0	0	0	0	329	226	117	156	116	93	106	134	96	82	85	88	94	82	77	49	28	0	0	1,958						
3	Cawang Ciliwung arah Pluit	0	0	0	0	0	0	55	97	66	49	27	37	19	15	18	19	15	18	55	28	24	16	7	0	0	565					
4	Cawang Ciliwung arah PRanti	0	0	0	0	0	7	11	9	18	12	9	12	12	18	18	22	29	37	32	20	9	13	0	0	288						
5	Cikoko Stawang arah Pluit	0	0	0	0	1	211	369	355	322	187	140	109	132	88	80	60	65	73	60	63	43	47	13	8	2,426						
6	Cikoko Stawang arah PRanti	0	0	0	0	3	39	103	95	83	61	54	45	54	48	55	75	105	111	118	85	99	48	32	2	1,315						
7	Tebet BKPM arah Pluit	0	0	0	0	0	32	107	78	48	49	32	40	37	27	25	35	43	85	73	34	21	12	0	0	778						
8	Tebet BKPM arah PRanti	0	0	0	0	0	5	35	33	23	19	23	29	26	25	37	45	73	89	72	30	26	22	0	0	612						
9	Pancoran Tugu	9	8	0	0	14	107	179	214	166	129	124	113	109	128	149	161	250	328	278	167	146	116	71	16	2,982						
10	Pancoran Barat arah Pluit	0	0	0	0	0	42	79	58	42	37	39	30	23	22	28	46	50	49	53	33	17	9	0	0	657						
11	Pancoran Barat arah PRanti	0	0	0	0	0	26	41	47	33	18	19	18	27	23	25	83	74	105	80	70	40	26	0	0	755						
12	Tegal Parang arah Pluit	0	0	0	0	0	19	44	41	37	28	19	36	20	19	34	31	51	56	46	35	16	39	0	0	571						
13	Tegal Parang arah PRanti	0	0	0	0	0	9	22	26	36	30	25	25	31	31	38	55	133	99	101	51	34	57	0	0	803						
14	Kuningan Barat	16	3	2	0	5	20	55	56	41	24	23	34	37	42	35	76	145	172	181	92	63	48	57	17	1,244						
15	Jamsostek GSubroto arah Pluit	1	2	0	0	3	23	72	65	58	38	46	41	47	24	56	73	93	186	170	113	98	51	50	2	1,312						
16	Jamsostek GSubroto arah PRanti	2	0	1	1	5	11	35	45	28	35	34	73	66	70	91	117	207	302	220	160	128	88	29	7	1,755						
17	LPI GSubroto arah Pluit	0	0	0	0	0	9	40	34	25	25	26	20	23	22	28	34	77	167	85	66	53	44	0	0	778						
18	LPI GSubroto arah PRanti	0	0	0	0	0	7	24	34	36	35	43	45	33	34	57	107	148	117	66	65	52	40	2	0	945						
19	Senanggi	8	7	3	3	7	39	118	103	75	75	96	105	120	133	172	228	209	256	229	217	218	225	159	26	2,831						
20	JCC Senayan arah Pluit	0	0	0	0	0	5	28	17	18	14	10	9	16	29	32	26	13	29	19	25	14	1	0	0	305						
21	JCC Senayan arah PRanti	0	0	0	0	0	16	30	31	33	27	16	17	24	34	67	72	75	50	25	36	25	27	0	0	605						
22	Silpi Pertamburan	5	6	0	3	5	206	394	371	343	254	241	218	214	205	204	282	324	348	311	200	140	117	58	17	4,466						
23	Silpi Kemangisan arah Pluit	3	0	0	0	1	29	102	106	72	46	69	50	54	73	51	45	54	146	122	72	39	42	2	8	1,186						
24	Silpi Kemangisan arah PRanti	3	1	0	3	1	107	289	342	286	174	140	138	107	109	97	143	114	165	132	108	92	63	16	5	2,635						
25	RSharapan kita arah Pluit	0	0	1	0	2	14	39	29	22	21	28	35	21	30	8	32	34	52	47	33	16	8	2	3	477						
26	RSharapan kita arah PRanti	0	0	0	0	2	35	108	101	71	61	51	56	61	76	97	102	104	114	61	38	30	54	11	5	1,238						
27	Latumenten St KA arah Pluit	0	0	0	0	0	23	39	48	18	22	19	16	12	10	9	13	10	19	9	2	2	6	0	0	277						
28	Latumenten St KA arah PRanti	0	0	0	0	0	7	12	16	5	3	11	14	9	6	4	3	4	9	2	3	0	1	0	0	109						
29	Jembatan Besi	0	0	0	0	0	66	153	167	98	100	68	46	49	66	61	51	50	55	59	43	61	52	18	0	1,263						
30	Jembatan Dua	0	0	0	0	0	28	69	74	66	24	25	39	33	25	16	27	34	30	22	17	5	15	0	0	549						
31	Jembatan Tiga	0	0	0	0	0	25	53	73	40	23	27	24	20	12	21	22	39	59	16	16	15	9	0	0	494						
32	Penjaringan	2	0	2	0	2	55	168	176	115	78	66	71	87	116	136	149	155	266	158	131	123	78	105	18	2,257						
33	Pluit	2	0	0	1	2	34	174	171	81	60	49	54	64	79	83	108	136	179	98	72	104	94	46	10	1,701						
TOTAL		51	27	9	11	53	2,876	4,089	3,647	2,982	2,231	2,019	1,941	1,934	1,917	2,044	2,520	3,115	4,034	3,176	2,288	1,852	1,515	671	144	45,146						

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.12 The number of daily passengers along corridor 10 by station by shift

No	Corridor 10 Station	Shift 1				Shift 2				Shift 3				Shift 4				Shift 5				Shift 6				Shift 7		Total
		00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59			
1	Cawang Soetoyo	1	2	0	0	0	0	11	40	30	26	23	11	17	8	8	9	21	25	41	40	23	20	19	10	3		388
2	Penas Kalimalang	0	0	0	0	0	1	67	115	58	40	36	46	45	29	45	27	23	46	40	51	33	23	19	8	1		753
3	Cipinang KbrNanas	0	0	0	0	0	0	20	48	64	33	32	22	32	39	31	27	39	40	29	35	24	16	6	0	0		537
4	Pedati Prumpung	0	0	0	0	0	0	41	75	55	42	41	24	31	41	26	25	11	26	60	33	14	12	10	0	0		567
5	Bea Cukai AYani	0	0	0	0	0	0	44	77	69	61	41	31	29	38	25	24	25	24	56	25	34	12	16	2	0		633
6	Utan Kayu Rawamangun	1	0	0	0	0	1	13	55	57	44	18	39	20	40	32	51	65	77	51	56	35	23	17	22	8		725
7	Kayu Putih Rawasari	1	0	0	0	0	0	68	120	106	66	48	67	43	63	63	35	65	68	110	51	43	42	28	9	4		1,100
8	Pulomas ByPass	0	0	0	0	0	0	22	40	43	27	12	19	24	44	51	67	70	106	122	86	44	41	30	10	2		860
9	Cempaka Putih	0	0	0	0	0	0	2	11	11	13	6	20	9	16	14	17	49	58	36	34	7	20	3	0	0		326
10	Yos Sudarso Kodamar	0	0	0	0	0	2	48	83	62	49	42	34	29	40	44	43	58	107	109	91	74	48	36	32	3		1,034
11	Sunter kelapa Gading	1	0	1	0	0	0	48	113	94	90	96	67	88	67	81	80	138	273	418	259	154	151	120	97	8		2,444
12	Walikota Jakarta Utara arah Cililitan	0	0	0	0	0	2	15	31	37	33	40	28	17	21	30	19	18	42	33	23	16	3	3	0	0		411
13	Walikota Jakarta Utara arah TjPriuk	0	0	0	0	0	0	1	0	1	1	2	1	2	2	1	0	1	8	1	7	0	0	0	0	0		28
14	Permai Koja	0	0	0	0	1	2	96	170	116	105	113	77	87	86	56	64	73	83	52	54	45	39	52	9	6		1,386
15	Eggano	1	1	0	0	0	1	113	133	62	68	59	62	54	44	46	55	53	80	58	55	24	21	20	7	1		1,018
16	Terminal TjPriuk	0	1	1	0	0	6	129	222	221	197	194	143	142	92	150	154	157	160	208	109	113	80	55	9	9		2,552
TOTAL		5	4	2	1	15	738	1,333	1,086	895	803	691	669	670	703	697	866	1,223	1,424	1,009	683	551	434	215	45	14,762		

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.13 The number of daily passengers along corridor 11 by station by shift

No	Corridor 11 Station	Shift 1					Shift 2		Shift 3		Shift 4					Shift 5					Shift 6			Shift 7	Total	
		00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59			22:00-22:59
1	Walikota Jakarta Timur	0	0	0	0	0	231	206	142	145	146	178	114	65	68	55	69	94	69	53	33	36	11	4	0	1,719
2	Penggilingan	0	0	0	0	0	88	53	33	45	38	31	30	22	19	14	12	17	17	6	5	10	4	0	444	
3	Perumnas Klender	0	0	0	0	0	163	157	144	111	133	102	81	63	64	51	44	57	49	44	20	21	11	8	0	1,323
4	Flyover Raden Inten	0	0	0	0	0	86	122	69	77	64	52	27	25	18	29	36	33	49	27	29	27	33	6	0	809
5	Buaran	0	0	0	0	0	25	31	22	25	16	21	13	12	8	6	8	18	18	14	1	10	3	0	0	251
6	Kampung Sumur	0	0	0	0	0	25	48	35	31	19	18	18	7	8	9	12	16	13	5	4	12	1	0	0	281
7	Flyover Klender	0	0	0	0	0	20	44	31	22	24	37	14	16	7	6	17	36	19	17	9	12	14	2	0	347
8	Stasiun Klender	0	0	0	0	0	34	53	57	22	24	21	15	18	22	14	12	18	31	7	7	4	0	0	0	359
9	Cipinang	0	0	0	0	0	22	43	53	29	19	13	15	17	8	11	11	16	16	9	5	3	3	1	0	294
10	Imigrasi Jakarta Timur	0	0	0	0	0	11	34	37	27	28	28	39	25	14	28	38	22	19	7	1	4	3	0	0	365
11	Pasar Enjo	0	0	0	0	0	14	28	34	24	22	17	16	8	8	19	8	15	9	9	10	3	6	0	0	250
12	Flyover Jatinegara	0	0	0	0	0	41	80	83	61	26	37	22	43	44	25	22	41	47	54	35	28	24	11	3	727
13	Stasiun Jatinegara Timur	0	0	0	0	0	17	10	11	20	19	36	26	10	31	34	37	50	42	41	44	16	13	4	0	461
14	Jatinegara RS Premier	0	0	0	0	0	8	33	26	35	23	23	25	29	28	32	26	42	50	33	32	24	28	0	0	497
TOTAL		0	0	0	0	0	785	942	777	674	601	614	455	360	347	333	352	475	448	326	235	210	154	36	3	8,127

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

Table 4.14 The number of daily passengers along corridor 12 by station by shift

No	Corridor 12 Station	Shift 1					Shift 2					Shift 3					Shift 4					Shift 5					Shift 6					Shift 7	Total
		00:00-00:59	01:00-01:59	02:00-02:59	03:00-03:59	04:00-04:59	05:00-05:59	06:00-06:59	07:00-07:59	08:00-08:59	09:00-09:59	10:00-10:59	11:00-11:59	12:00-12:59	13:00-13:59	14:00-14:59	15:00-15:59	16:00-16:59	17:00-17:59	18:00-18:59	19:00-19:59	20:00-20:59	21:00-21:59	22:00-22:59	23:00-23:59								
1	Simpang Biv klip gading	0	0	0	0	0	22	35	26	17	20	18	25	31	29	42	47	67	135	53	46	43	19	0	0	675							
2	Mall Sunter	0	0	0	0	0	39	62	58	53	77	60	42	61	57	64	75	83	111	75	56	48	38	0	0	1.059							
3	SMP 140	0	0	0	0	0	36	61	52	35	38	33	25	25	17	20	13	41	55	33	21	27	19	0	0	551							
4	Danau Agung	0	0	0	0	0	17	27	19	13	12	7	4	6	9	6	10	29	22	10	2	3	4	0	0	200							
5	Landas Pacu Timur	0	0	0	0	0	22	56	42	46	27	26	18	20	19	24	27	20	44	26	18	14	12	0	0	461							
6	Mangga Dua/ITC	0	0	0	0	0	3	13	8	18	13	28	43	29	34	65	45	82	101	48	17	11	7	0	0	565							
7	Jayakarta	0	0	0	0	0	5	10	4	7	2	8	7	4	4	9	4	5	4	5	5	2	1	0	0	86							
8	Kali Besar Selatan	0	0	0	0	0	1	0	0	2	1	2	0	0	2	3	0	4	5	2	1	1	0	0	0	24							
9	Pekojan	0	0	0	0	0	1	6	2	3	7	3	5	2	2	6	2	2	8	3	1	2	0	0	0	55							
10	Fatahillah	0	0	0	0	0	11	29	16	7	4	15	4	5	5	7	17	19	23	15	3	8	5	0	0	193							
11	Gedung Panjiang 1	0	0	0	0	0	14	57	41	16	13	8	11	13	7	8	10	13	18	2	5	2	0	0	0	246							
12	Pakin	0	0	0	0	0	27	53	30	22	25	15	21	15	10	10	14	22	11	10	4	6	5	0	0	300							
13	Pluit Selatan	0	0	0	0	0	4	41	37	17	16	10	9	7	12	21	6	25	25	14	8	12	2	0	0	266							
	TOTAL	0	0	0	0	0	202	450	335	256	255	233	214	218	207	285	268	409	557	312	184	182	114	0	0	0	4.681						

Source : Operation Division of Transjakarta Operator Company (updated on August 17th, 2015)

4.1.3 Inventory data of TransJakarta

In the case of this study, the inventory data is the physical aspects of infrastructure, facilities, and BRT attributes. The inventory surveys have been conducted during Feb 13th to 19th, 2016. In this section, every section is given the number in order to identify easily. The roman numeral indicates the corridor number, then the next number is the station number. There are several stations which are involved by more than one corridor as the transfer point. Table 4.15 to Table 4.26 show the information about station and busway attributes by corridor.

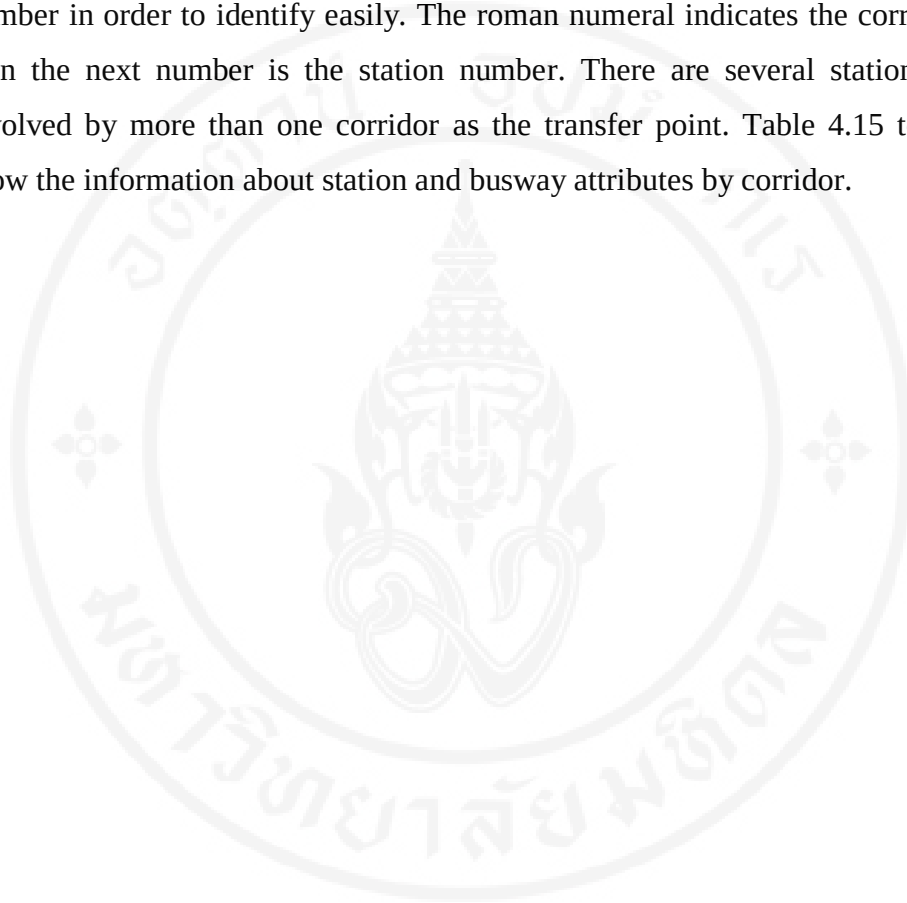


Table 4.15 Inventory data of corridor 1 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
I-1	Blok M	A-B , B-A	1	2	no	closed	open	yes
I-2	Masjid Agung	A-B , B-A	1	3	no	open	open	yes
I-3	Bundaran Senayan	A-B , B-A	1	3	no	closed	closed	no
I-4	Gelora Bung Karno	A-B , B-A	1	3	no	closed	open	yes
I-5	Polda Metro jaya	A-B , B-A	1	3	no	closed	open	yes
I-6	Bendungan Hilir	A-B , B-A	1	3	no	closed	closed	no
I-7	Karet	A-B , B-A	close duo to MRT construction by the time of this survey					
I-8	Setiabudi	A-B , B-A	close duo to MRT construction by the time of this survey					
I-9	Dukuh Atas	A-B , B-A	1	3	no	closed	closed	no
I-10	Tosari	A-B , B-A	1	3	no	closed	closed	no
I-11	Bundaran HI	A-B , B-A	1	3	no	closed	closed	no
I-12	Sarinah	A-B , B-A	1	3	no	closed	closed	no
I-13	Bank Indonesia	A-B , B-A	1	3	no	closed	closed	no
I-14	Monas	A-B , B-A	1	3	no	closed	closed	no
I-15	Harmoni	A-B , B-A	3	9	yes	closed	closed	no
I-16	Sawah Besar	A-B , B-A	1	3	no	closed	closed	no
I-17	Mangga Besar	A-B , B-A	1	3	no	closed	closed	no
I-18	Olimo	A-B , B-A	1	3	no	closed	closed	no
I-19	Glodok	A-B , B-A	1	3	no	closed	closed	no
I-20	Kota	A-B , B-A	1	2	no	closed	closed	no

Survey date; Feb 13th, 2016

Table 4.16 Inventory data of corridor 2 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
II-1	Pulo Gadung	A-B , B-A	2	4	no	closed	open	yes
II-2	Bermis	A-B , B-A	1	6	yes	closed	closed	no
II-3	Pulomas	A-B , B-A	1	6	yes	closed	closed	no
II-4	ASMI	A-B , B-A	1	6	yes	closed	closed	no
II-5	Pedongkelan	A-B , B-A	1	3	no	closed	closed	no
II-6	Cempaka Timur	A-B , B-A	1	5	no	closed	closed	no
II-7	RS Islam	A-B , B-A	1	3	no	closed	closed	no
II-8	Cempaka Tengah	A-B , B-A	1	3	no	closed	closed	no
II-9	Pasar Cempaka Putih	A-B , B-A	1	3	no	closed	closed	no
II-10	Rawa Selatan	A-B , B-A	1	3	no	closed	closed	no
II-11	Galur	A-B , B-A	1	3	no	closed	open	yes
II-12	Senen	A-B , B-A	1	3	no	closed	closed	no
II-13	Atrium	A-B	1	3	no	closed	open	yes
II-14	RSPAD	A-B	1	2	no	closed	open	yes
II-15	DEPLU	A-B	1	2	no	closed	open	yes
II-16	Gambir 1	A-B	1	2	yes	closed	open	yes
II-16b	Gambir 2	B-A	1	1	no	closed	open	yes
II-17	Istiqlal	A-B	1	2	no	closed	open	yes
II-18	Juanda	A-B	1	6	no	closed	open	yes
II-19	Pacenongan	A-B	1	1	no	closed	closed	no
II-20	Harmoni	A-B , B-A	3	9	yes	closed	closed	no
II-a	Monas	B-A	1	3	no	closed	closed	no
II-b	Balai Kota	B-A	1	1	no	closed	open	yes
II-c	Kwitang	B-A	1	1	no	closed	open	yes

Survey date; Feb 13th, 2016

Table 4.17 Inventory data of corridor 3 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
III-1	Kalideres	A-B , B-A	1	3	no	closed	closed	yes
III-2	Pesakih	A-B , B-A	1	3	no	closed	closed	no
III-3	Sumur Bor	A-B , B-A	1	6	no	closed	closed	no
III-4	Rawa Buaya	A-B , B-A	1	6	no	closed	closed	no
III-5	Jembatan Baru	A-B , B-A	1	6	no	closed	closed	no
III-6	Dispenda	A-B , B-A	1	3	no	open (A-B)	open	yes
III-7	Jembatan Gantung	A-B , B-A	1	3	no	open	open	yes
III-8	Taman Kota	A-B , B-A	1	3	no	closed	open	yes
III-9	Indosiar	A-B , B-A	1	6	no	open	open	yes
III-10	Jelambar	A-B , B-A	1	6	no	closed	open	yes
III-11	Grogol Trisakti	A-B , B-A	1	3	no	closed	closed	no
III-12	RS. Sumber Waras	A-B , B-A	1	6	no	closed	closed	yes
III-13	Harmoni	A-B , B-A	3	9	yes	closed	closed	no
III-14	Pecenongan	A-B , B-A	1	2	no	closed	closed	no
III-15	Juanda	A-B , B-A	2	4	no	closed	open	yes
III-16	Pasar Baru	A-B , B-A	1	2	no	closed	open	yes

Survey date; Feb 14th, 2016

Table 4.18 Inventory data of corridor 4 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
IV-1	Pulo Gadung	A-B , B-A	2	2	4	no	closed	yes
IV-2	Pasar Pulo Gadung	A-B , B-A	1	1	3	no	closed	no
IV-3	Tugas	A-B , B-A	1	2	6	no	closed	no
IV-4	Layur	A-B , B-A	1	2	6	no	closed	no
IV-5	Pemuda Rawamangun	A-B , B-A	1	1	3	no	closed	no
IV-6	Velodrome	A-B , B-A	1	2	6	no	closed	no
IV-7	Sunan Giri	A-B , B-A	1	1	2	no	closed	no
IV-8	UNJ	A-B , B-A	1	2	6	no	closed	no
IV-9	Pramuka BPKP	A-B , B-A	1	1	3	no	closed	no
IV-10	Pramuka LIA	A-B , B-A	1	1	2	no	closed	no
IV-11	Utan Kayu	A-B , B-A	1	1	2	no	closed	no
IV-12	Pasar Genjing	A-B , B-A	1	1	2	no	closed	no
IV-13	Matraman	A-B , B-A	1	1	2	no	open (A-B)	yes
IV-14	Manggarai	A-B , B-A	1	1	3	no	closed	yes
IV-15	Pasar Rumpit	A-B , B-A	1	1	2	no	closed	no
IV-16	Halimun	A-B , B-A	2	2	4	no	closed	no
IV-17	Dukuh Atas 2	A-B , B-A	1	2	4	no	closed	no

Survey date; Feb 13th, 2016

Table 4.19 Inventory data of corridor 5 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
V-1	Kampung Melayu (departure)	A-B , B-A	2	6	no	closed	closed	yes
V-2	Kebon Pala	A-B , B-A	1	3	no	closed	closed	no
V-3	Slamet Riyadi	A-B , B-A	1	3	no	closed	closed	0
V-4	Tegalan	A-B , B-A	1	3	no	closed	closed	0
V-5	Matraman 1	A-B , B-A	1	3	no	closed	closed	0
V-6	Salemba Carolus	A-B , B-A	1	6	no	closed	closed	0
V-7	Salemba UI	A-B , B-A	1	6	no	closed	closed	0
V-8	Kramat Sentiong	A-B , B-A	1	6	no	closed	closed	0
V-9	Pal Putih	A-B , B-A	1	3	no	closed	closed	yes
V-10	Sentral Senen	A-B , B-A	1	3	no	closed	closed	0
V-11	Budi Utomo	A-B , B-A	1	3	no	closed	closed	0
V-12	Pasar Baru Timur	A-B , B-A	1	3	no	closed	closed	0
V-13	Jembatan Merah	A-B , B-A	1	3	no	closed	closed	0
V-14	Gunung Sahari Mangga Dua	A-B , B-A	1	3	no	closed	closed	0
V-15	Pademangan	A-B , B-A	1	3	no	closed	open	yes
V-16	Ancol	A-B , B-A	1	3	no	closed	closed	0
V-a	Pasar Jatinegara	B-A	1	3	no	closed	closed	no
V-b	RS Premier Jatinegara	B-A	1	3	no	closed	closed	no

Survey date; Feb 15th, 2016

Table 4.20 Inventory data of corridor 6 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
VI-1	Ragunan	A-B, B-A	2	4	yes	closed	open	yes
VI-2	Departemen Pertanian	A-B, B-A	1	4	no	closed	closed	yes
VI-3	SMK 57	A-B, B-A	1	6	no	closed	closed	no
VI-4	Jati Padang	A-B, B-A	1	6	no	closed	closed	no
VI-5	Pejaten	A-B, B-A	1	2	no	closed	closed	no
VI-6	Buncit Indah	A-B, B-A	1	2	no	closed	closed	no
VI-7	Warung Jati	A-B, B-A	1	2	no	closed	closed	no
VI-8	Imigrasi	A-B, B-A	1	2	no	closed	closed	no
VI-9	Duren Tiga	A-B, B-A	1	4	no	closed	closed	no
VI-10	Mampang Prapatan	A-B, B-A	1	5	no	closed	closed	no
VI-11	Kuningan Timur	A-B, B-A	1	2	no	closed	closed	no
VI-12	Patra Kuningan	A-B, B-A	1	2	no	closed	closed	no
VI-13	Depkes	A-B, B-A	1	2	no	closed	closed	no
VI-14	GOR Sumantri	A-B, B-A	1	6	no	closed	closed	no
VI-15	Karet Kuningan	A-B, B-A	1	2	no	closed	closed	no
VI-16	Kuningan Madya	A-B, B-A	1	2	no	closed	closed	no
VI-17	Setiabudi Utara	A-B, B-A	1	2	no	closed	closed	no
VI-18	Latuharhari (A-B)	A-B	1	2	no	closed	closed	no
VI-19	Halimun (A-B)	A-B	2	4	no	closed	closed	no
VI-20	Dukuh Atas 2	A-B, B-A	1	3	no	closed	closed	no

Survey date; Feb 16th, 2016

Table 4.21 Inventory data of corridor 7 by station

No	Station	Involved Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
VII-1	Kp. Rambutan	A-B, B-A	2	4	yes	open	open	yes
VII-2	Tanah Merdeka	A-B	1	2	no	closed	open	yes
VII-3	Fly Over Raya Bogor	A-B, B-A	1	2	no	open	open	yes
VII-4	RS. Harapan Bunda	A-B, B-A	1	2	no	open	open	yes
VII-5	Pasar Induk	A-B, B-A	1	2	no	open	open	yes
VII-6	Pasar Kramat Jati	A-B, B-A	1	2	no	open	open	yes
VII-7	PGC/Cililitan	A-B, B-A	1	2	no	closed	closed	yes
VII-8	BKN	A-B, B-A	1	5	no	closed	closed	no
VII-9	Cawang UKI	A-B, B-A	2	6	no	closed	closed (A- B)	yes
VII-10	BNN	A-B, B-A	1	5	no	closed	open	yes
VII-11	Cawang Otista	A-B, B-A	1	2	no	closed	closed	no
VII-12	Gelanggang Remaja	A-B, B-A	1	2	no	closed	closed	no
VII-13	Bidara Cina	A-B, B-A	1	2	no	closed	closed	no
VII-14	Kp. Melayu	A-B, B-A	2	6	no	closed	closed	yes

Survey date; Feb 15th, 2016

Table 4.22 Inventory data of corridor 8 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
VIII-1	Teminal Lebak Bulus	A-B, B-A	2	6	no	closed	open	yes
VIII-2	Pondok Pinang	A-B	1	3	no	open	open	yes
VIII-3	Pondok Indah 1	A-B, B-A	1	3	no	open	open	yes
VIII-4	Pondok Indah 2	A-B, B-A	1	3	no	open	open	yes
VIII-5	Tanah Kusir Kodam	A-B, B-A	1	3	no	closed	closed	no
VIII-6	Keb. Lama Bungur	A-B, B-A	1	3	no	closed	closed	no
VIII-7	Ps. Kebayoran Lama	A-B, B-A	1	6	no	open	open	yes
VIII-8	Simprug	A-B, B-A	1	3	no	closed	closed	no
VIII-9	Permata Hijau	A-B, B-A	1	3	no	closed	closed	no
VIII-10	RS. Permata Hijau	A-B, B-A	1	3	no	closed	closed	no
VIII-11	Pos Pengumben	A-B, B-A	1	3	no	closed	closed	no
VIII-12	Kelapa Dua Sasak	A-B, B-A	1	3	no	closed	closed	no
VIII-13	Kebon Jeruk	A-B, B-A	1	3	no	closed	closed	no
VIII-14	Duri Kepa	A-B, B-A	1	3	no	closed	closed	no
VIII-15	Kedoya Raya	A-B, B-A	1	3	no	closed	closed	yes
VIII-16	Kedoya Green Garden	A-B, B-A	1	3	no	closed	closed	yes
VIII-17	Indosiar (Kor 3)	A-B, B-A	1	6	no	closed	open	yes
VIII-18	Jelambar (Kor 3)	A-B, B-A	1	6	no	closed	open	yes
VIII-19	Grogol 2	A-B, B-A	1	3	no	closed	closed	no
VIII-20	Sumber Waras	A-B	1	3	no	closed	closed	no

Survey date; Feb 17th, 2016

Table 4.22 Inventory data of corridor 8 by station (Continue)

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
VIII-21	Harmoni	A-B, B-A	3	9	yes	closed	closed	no
VIII-a	Tomang Mandala	B-A	1	3	no	closed	closed	no
VIII-b	RS. Tarakan	B-A	1	3	no	closed	closed	no
VIII-b	Petojo	B-A	1	3	no	closed	closed	no
VIII-d	S. Parman	B-A	1	3	no	closed	open	no

Survey date; Feb 17th, 2016

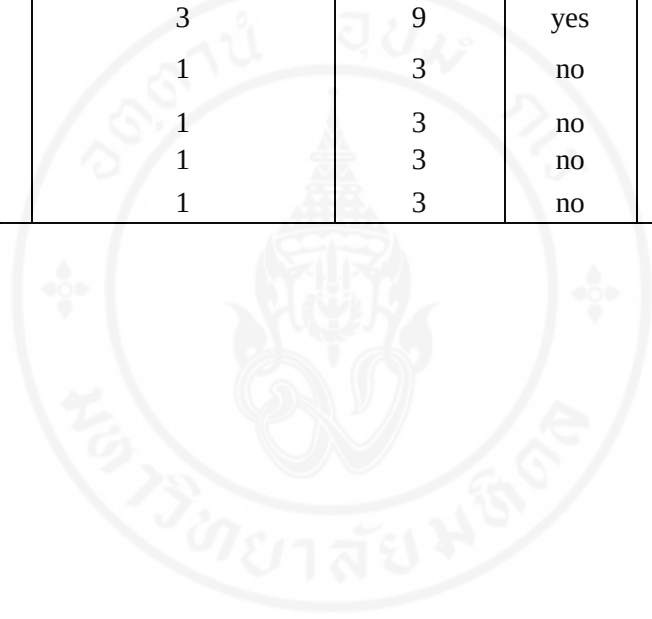


Table 4.23 Inventory data of corridor 9 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
IX-1	Pinang Ranti (departure)	A-B, B-A	2	4	no	closed	open	yes
IX-2	Taman Mini	A-B, B-A	1	3	no	open	open	yes
IX-3	Cawang UKI	A-B, B-A	2	6	no	closed	closed (A-B)	yes
IX-4	BNN	A-B, B-A	1	2	no	closed	open	yes
IX-5	Cawang Ciliwung	A-B, B-A	1	3	no	closed	closed	no
IX-6	Stasiun Cawang Cikoko	A-B, B-A	1	3	no	closed	closed	no
IX-7	Tebet BKPM	A-B, B-A	1	3	no	closed	closed	no
IX-8	Pancoran Tugu	A-B, B-A	1	2	no	open	closed	no
IX-9	Pancoran Barat	A-B, B-A	1	3	no	closed	closed	no
IX-10	Tegal Parang	A-B, B-A	1	3	no	closed	closed	no
IX-11	Kuningan Barat	A-B, B-A	1	2	no	closed	closed	no
IX-12	Jamsostek Gt. Subroto	A-B, B-A	1	3	no	closed	closed	no
IX-13	Lipi Gt. Subroto	A-B, B-A	1	3	no	closed	closed	no
IX-14	Semanggi	A-B, B-A	1	3	no	closed	closed	no
IX-15	JCC Senayan	A-B, B-A	1	3	no	closed	open	no
IX-16	Slipi Petamburan	A-B, B-A	1	2	no	closed	open	no
IX-17	Slipi Kemanggisan	A-B, B-A	1	3	no	closed	open	no
IX-18	RS. Harapan Kita	A-B, B-A	1	3	no	open	open	yes
IX-19	Parman Podomoro	A-B, B-A	1	2	no	open	closed	yes
IX-20	Grogol 2	A-B, B-A	1	3	no	closed	closed	no

Survey date; Feb 17th, 2016

Table 4.23 Inventory data of corridor 9 by station (Continue)

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
IX-21	Stasiun Grogol Latumenten	A-B, B-A	1	2	no	open	closed	no
IX-22	Jembatan Besi	A-B, B-A	1	3	no	closed	closed	no
IX-23	Jembatan Dua	A-B, B-A	1	3	no	open	closed	no
IX-24	Jembatan Tiga	A-B, B-A	1	3	no	closed	closed	no
IX-25	Penjaringan	A-B, B-A	1	3	no	open	open	yes
IX-26	Pluit	A-B, B-A	1	3	no	closed	closed	no

Survey date; Feb 17th, 2016

Table 4.24 Inventory data of corridor 10 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
X-1	Tanjung Priok Station	A-B, B-A	2	6	yes	closed	open	yes
X-2	Enggano	A-B, B-A	1	3	no	closed	open	yes
X-3	Permai Koja	A-B, B-A	1	3	no	closed	open	yes
X-4	Walikota Jakarta Utara	A-B, B-A	1	3	no	closed	open	yes
X-5	Plumpang Pertamina	A-B, B-A	1	3	no	closed	open	yes
X-6	Sunter Kelapa Gading	A-B, B-A	1	3	no	closed	open	yes
X-7	Yos Sudarso Kodamar	A-B, B-A	1	3	no	closed	closed	no
X-8	Cempaka Mas	A-B, B-A	1	3	no	closed	closed	no
X-9	Cempaka Putih	A-B, B-A	2	6	no	closed	closed	no
X-10	Pulomas By Pass	A-B, B-A	1	3	no	closed	closed	no
X-11	Kayu Putih Rawasari	A-B, B-A	1	3	no	closed	closed	no
X-12	Pemuda Pramuka	A-B, B-A	2	6	no	closed	closed	no
X-13	U. Kayu Rawamangun	A-B, B-A	1	3	no	closed	closed	no
X-14	Bea Cukai	A-B, B-A	1	3	no	closed	closed	no
X-15	Stasiun Jatinegara	A-B, B-A	1	3	no	closed	closed	no
X-16	Pedati	A-B, B-A	1	3	no	closed	closed	no
X-17	Cipinang Kebon Nanas	A-B, B-A	1	3	no	closed	open	yes
X-18	Penas Kali Malang	A-B, B-A	1	3	no	closed	open	yes
X-19	Cawang Sutoyo	A-B, B-A	1	3	no	closed	open	yes
X-20	Cawang UKI	A-B, B-A	2	6	no	closed	closed(A-B)	yes
X-21	BKN	A-B, B-A	1	2	no	closed	closed	no
X-22	PGC 2 (Cililitan)	A-B, B-A	1	3	no	closed	closed	yes

Survey date; Feb 18th, 2016

Table 4.25 Inventory data of corridor 11 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interrupti on lane
XI-1	Pulogebug	A-B, B-A	2	4	yes	closed	closed	yes
XI-2	Walikota Jakarta Timur	A-B, B-A	1	3	no	closed	closed	no
XI-3	Penggilingan	A-B, B-A	1	3	no	closed	open	yes
XI-4	Perumnas Klender	A-B, B-A	1	3	no	closed	open	yes
XI-5	Fly Over Radin Inten	A-B, B-A	1	3	no	closed	open	yes
XI-6	Buaran	A-B, B-A	1	3	no	closed	closed(B-A)	yes
XI-7	Kampung Sumur	A-B, B-A	1	3	no	closed	closed(B-A)	yes
XI-8	Fly Over Klender	A-B, B-A	1	3	no	closed	closed(B-A)	yes
XI-9	Stasiun Klender	A-B, B-A	1	3	no	closed	closed(B-A)	yes
XI-10	Cipinang	A-B, B-A	1	3	no	closed	open	yes
XI-11	Imigrasi Jakarta Timur	A-B, B-A	1	3	no	closed	closed	no
XI-12	Pasar Enjo	A-B, B-A	1	3	no	closed	closed	no
XI-13	Fly Over Jatinegara	A-B, B-A	1	3	no	closed	closed	no
XI-14	Stasiun Jatinegara 2	A-B, B-A	1	3	no	closed	closed	no
XI-15	Kp. Melayu	A-B, B-A	2	6	no	closed	closed	yes
XI-16	RS Premier Jatinegara	A-B	1	3	no	closed	closed	no

Survey date; Feb 20th, 2016

Table 4.26 Inventory data of corridor 12 by station

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
XII-1	Pluit	A-B, B-A	1	3	no	closed	closed	no
XII-2	Pluit Auto Plaza Landmark	A-B	1	3	no	open	open	yes
XII-3	Pakin	A-B	1	3	no	open	open	yes
XII-4	Gedong Panjang	A-B	1	3	no	closed	closed	no
XII-5	Fatahillah	A-B	1	3	no	open	open	yes
XII-6	Kota	A-B, B-A	1	2	no	closed	close	no
XII-7	Pangeran Jayakarta	A-B, B-A	1	3	no	closed	closed	no
XII-8	Mangga Dua ITC	A-B, B-A	1	3	no	closed	closed	no
XII-9	Gunung Sahari Mangga Dua	A-B, B-A	1	3	no	closed	closed	no
XII-10	Jembatan Merah	A-B, B-A	1	3	no	closed	closed	no
XII-11	Landasan Pacu Timur	A-B, B-A	1	3	no	open	open	yes
XII-12	Sunter SMP 140	A-B, B-A	1	3	no	open	open	yes
XII-13	Karya	A-B, B-A	1	3	no	open	open	yes
XII-14	Sunter Kelapa Gading	A-B, B-A	1	3	no	closed	open	yes
XII-15	Sunter Boulevard	A-B	1	3	no	closed	closed	no
XII-16	Plumpang Pertamina	A-B, B-A	1	3	no	closed	open	yes
XII-17	Walikota Jakarta Utara	A-B, B-A	1	3	no	open	open	yes
XII-18	Permai Koja	A-B, B-A	1	3	no	open	open	yes
XII-19	Enggano	A-B, B-A	1	3	no	open	open	yes
XII-20	Tanjung Priok (departure)	A-B, B-A	2	6	yes	closed	open	yes
XII-a	Danau Agung	B-A	1	3	no	open	open	yes

Survey date; Feb 19th, 2016

Table 4.26 Inventory data of corridor 12 by station (Continue)

No	Station	Direction (A-B/B-A)	Number of platforms @ direction	Number of gates	Passing lane	Lane on station	Lane after station	Interruption lane
XII-b	Kali Besar Barat	B-A	1	3	no	closed	open	yes
XII-c	Bandengan selatan	B-A	1	3	no	closed	closed	yes
XII-d	Jembatan Tiga	B-A	1	3	no	closed	closed	no
XII-e	Penjaringan	B-A	1	3	no	open	open	yes

Survey date; Feb 19th, 2016

4.1.4 Static data of TransJakarta

The static data is obtained by conducting the static survey. They consist of arrival and departure times of buses and the waiting time at the first and last terminal on each direction. The static surveys have been conducted between February 10th and March 4th, 2016. The static data is necessary to perform the analyses of waiting time reliability, trip realization, headway regularity, and punctuality. The arrival and departure times of TransJakarta can be seen at the Tables 4.27 to 4.37.

Table 4.27 Arrival and departure times of corridor 1 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number I-1									
1	7:07		7:01		1	17:18		17:15	
2	7:09	0:02	7:05	0:04	2	17:21	0:03	17:20	0:05
3	7:15	0:06	7:10	0:05	3	17:27	0:06	17:25	0:05
4	7:18	0:03	7:15	0:05	4	17:30	0:03	17:30	0:05
5	7:23	0:05	7:21	0:06	5	17:37	0:07	17:35	0:05
6	7:33	0:10	7:25	0:04	6	17:41	0:04	17:42	0:07
7	7:38	0:05	7:31	0:06	7	17:44	0:03	17:46	0:04
8	7:42	0:04	7:36	0:05	8	17:50	0:06	17:50	0:04
9	7:51	0:09	7:40	0:04	9	17:55	0:05	17:55	0:05
10	7:53	0:02	7:45	0:05	10	18:02	0:07	18:00	0:05
11	7:58	0:05	7:50	0:05	11	18:10	0:08	18:05	0:05
12	8:01	0:03	7:55	0:05	12	18:14	0:04	18:10	0:05
13	-	-	8:00	0:05	13	18:17	0:03	18:18	0:08
Station number I-20									
1	7:16		7:21		1	17:22		17:24	
2	7:21	0:05	7:26	0:05	2	17:28	0:06	17:32	0:08
3	7:22	0:01	7:28	0:02	3	17:31	0:03	17:35	0:03
4	7:26	0:04	7:35	0:07	4	17:39	0:08	17:41	0:06
5	7:33	0:07	7:38	0:03	5	17:47	0:08	17:50	0:09
6	7:43	0:10	7:48	0:10	6	17:50	0:03	17:53	0:03
7	7:46	0:03	7:50	0:02	7	17:56	0:06	17:58	0:05
8	7:54	0:08	8:00	0:10	8	18:02	0:06	18:04	0:06
9	7:59	0:05	8:04	0:04	9	18:12	0:10	18:14	0:10
10	8:08	0:09	8:13	0:09	10	18:15	0:03	18:18	0:04
-	-	-	-	-	11	18:24	0:09	18:26	0:08

survey date; Feb 10th, 2016

Table 4.28 Arrival and departure times of corridor 2 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number II-1									
1	6:40		6:47		1	16:44		16:46	
2	6:43	0:03	6:55	0:08	2	16:46	0:02	16:50	0:04
3	6:48	0:05	7:00	0:05	3	16:50	0:04	16:55	0:05
4	6:55	0:07	7:05	0:05	4	16:52	0:02	17:02	0:07
5	7:12	0:17	7:15	0:10	5	17:00	0:08	17:10	0:08
6	7:15	0:03	7:20	0:05	6	17:11	0:11	17:15	0:05
7	7:18	0:03	7:25	0:05	7	17:15	0:04	17:20	0:05
8	7:31	0:13	7:33	0:08	8	17:21	0:06	17:24	0:04
9	7:37	0:06	7:40	0:07	9	17:25	0:04	17:30	0:06
-	-	-	-	-	10	17:33	0:08	17:35	0:05
-	-	-	-	-	11	17:40	0:07	17:42	0:07
Station number II-20									
1	6:51		6:30		1	16:43		16:46	
2	7:02	0:11	6:35	0:05	2	16:51	0:08	16:56	0:10
3	7:24	0:22	6:53	0:18	3	16:55	0:04	16:59	0:03
4	7:30	0:06	7:05	0:12	4	17:00	0:05	17:05	0:06
5	7:34	0:04	7:25	0:20	5	17:18	0:18	17:24	0:19
6	7:41	0:07	7:32	0:07	6	17:26	0:08	17:30	0:06
7	7:51	0:10	7:40	0:08	7	17:36	0:10	17:37	0:07
8	-	-	7:45	0:05	8	17:40	0:04	17:44	0:07
-	-	-	-	-	9	17:42	0:02	17:48	0:04

survey date; Feb 11th, 2016

Table 4.29 Arrival and departure times of corridor 3 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number III-1									
1	7:05		7:01		1	17:11		17:10	
2	7:06	0:01	7:05	0:04	2	17:16	0:05	17:15	0:05
3	7:15	0:09	7:10	0:05	3	17:20	0:04	17:20	0:05
4	7:17	0:02	7:15	0:05	4	17:22	0:02	17:25	0:05
5	7:20	0:03	7:20	0:05	5	17:30	0:08	17:30	0:05
6	7:27	0:07	7:25	0:05	6	17:41	0:11	17:35	0:05
7	7:35	0:08	7:30	0:05	7	17:45	0:04	17:41	0:06
8	7:40	0:05	7:35	0:05	8	17:51	0:06	17:46	0:05
9	7:50	0:10	7:40	0:05	9	17:58	0:07	17:50	0:04
10	7:58	0:08	7:45	0:05	10	18:03	0:05	17:55	0:05
11	8:03	0:05	7:50	0:05	11	18:07	0:04	18:00	0:05
12	-	-	7:55	0:05	12	18:12	0:05	18:05	0:05
13	-	-	8:00	0:05	13	-	-	18:10	0:05
Station number III-16									
1	6:28		6:28		1	17:23		17:27	
2	6:32	0:04	6:32	0:04	2	17:35	0:12	17:31	0:04
3	6:33	0:01	6:33	0:01	3	17:39	0:04	17:42	0:11
4	6:37	0:04	6:37	0:04	4	17:44	0:05	17:45	0:03
5	6:41	0:04	6:41	0:04	5	17:51	0:07	17:53	0:08
6	6:53	0:12	6:53	0:12	6	17:58	0:07	18:01	0:08
7	7:20	0:27	7:20	0:27	7	18:07	0:09	18:04	0:03
8	7:25	0:05	7:25	0:05	8	18:14	0:07	18:19	0:15
9	7:28	0:03	7:28	0:03	9	18:22	0:08	18:28	0:09

survey date; Feb 12th, 2016

Table 4.30 Arrival and departure times of corridor 4 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number IV-1									
1	6:54		6:57		1	17:02		17:10	
2	6:58	0:04	7:05	0:08	2	17:05	0:03	17:17	0:07
3	7:06	0:08	7:10	0:05	3	17:15	0:10	17:20	0:03
4	7:13	0:07	7:15	0:05	4	17:18	0:03	17:25	0:05
5	7:16	0:03	7:20	0:05	5	17:27	0:09	17:30	0:05
6	7:28	0:12	7:30	0:10	6	17:35	0:08	17:38	0:08
7	7:30	0:02	7:35	0:05	7	17:37	0:02	17:43	0:05
8	7:36	0:06	7:40	0:05	8	17:40	0:03	17:50	0:07
9	7:40	0:04	7:45	0:05	9	17:43	0:03	17:55	0:05
10	7:47	0:07	7:50	0:05	10	17:50	0:07	18:00	0:05
11	7:51	0:04	7:56	0:06	11	18:02	0:12	18:05	0:05
12	7:57	0:06	8:00	0:04	12	18:07	0:05	18:11	0:06
Station number IV-17									
1	6:50		6:52		1	17:21		17:23	
2	6:58	0:08	7:00	0:08	2	17:27	0:06	17:30	0:07
3	7:05	0:07	7:07	0:07	3	17:32	0:05	17:35	0:05
4	7:09	0:04	7:12	0:05	4	17:38	0:06	17:41	0:06
5	7:16	0:07	7:18	0:06	5	17:46	0:08	17:48	0:07
6	7:21	0:05	7:22	0:04	6	17:54	0:08	17:55	0:07
7	7:30	0:09	7:32	0:10	7	18:05	0:11	18:07	0:12
8	7:34	0:04	7:36	0:04	8	18:10	0:05	18:11	0:04
9	7:40	0:06	7:42	0:06	9	18:16	0:06	18:17	0:06
10	7:48	0:08	7:50	0:08	10	18:23	0:07	18:24	0:07

survey date; Feb 17th, 2016

Table 4.31 Arrival and departure times of corridor 5 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number V-1									
1	6:51		6:53		1	17:13		17:14	
2	7:00	0:09	7:01	0:08	2	17:24	0:11	17:25	0:11
3	7:08	0:08	7:10	0:09	3	17:30	0:06	17:33	0:08
4	7:27	0:19	7:30	0:20	4	17:37	0:07	17:38	0:05
5	7:36	0:09	7:38	0:08	5	17:41	0:04	17:43	0:05
6	7:42	0:06	7:43	0:05	6	17:50	0:09	17:51	0:08
7	7:47	0:05	7:48	0:05	7	17:54	0:04	17:56	0:05
8	8:00	0:13	8:01	0:13	8	18:01	0:07	18:02	0:06
-	-	-	-	-	9	18:05	0:04	18:08	0:06
-	-	-	-	-	10	18:14	0:09	18:15	0:07
Station number V-16									
1	6:58		7:00		1	17:11		17:15	
2	7:00	0:02	7:05	0:05	2	17:15	0:04	17:20	0:05
3	7:01	0:01	7:10	0:05	3	17:23	0:08	17:25	0:05
4	7:10	0:09	7:15	0:05	4	17:25	0:02	17:30	0:05
5	7:18	0:08	7:20	0:05	5	17:30	0:05	17:35	0:05
6	7:19	0:01	7:25	0:05	6	17:34	0:04	17:40	0:05
7	7:22	0:03	7:30	0:05	7	17:40	0:06	17:45	0:05
8	7:29	0:07	7:35	0:05	8	17:46	0:06	17:51	0:06
9	7:31	0:02	7:40	0:05	9	17:50	0:04	17:55	0:04
10	7:46	0:15	7:47	0:07	10	17:59	0:09	18:02	0:07
11	7:48	0:02	7:55	0:08	11	18:07	0:08	18:05	0:03
12	7:51	0:03	8:00	0:05	12	18:13	0:06	18:10	0:05

survey date; Feb 18th, 2016

Table 4.32 The arrival time and departure time of corridor 6 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number VI-1									
1	7:40		7:44		1	17:11		17:15	
2	7:40	0:00	7:49	0:05	2	17:15	0:04	17:18	0:03
3	7:45	0:05	7:53	0:04	3	17:20	0:05	17:25	0:07
4	7:47	0:02	8:00	0:07	4	17:28	0:08	17:30	0:05
5	7:48	0:01	8:05	0:05	5	17:32	0:04	17:37	0:07
6	7:50	0:02	8:10	0:05	6	17:36	0:04	17:42	0:05
7	7:54	0:04	8:14	0:04	7	17:40	0:04	17:46	0:04
8	7:56	0:02	8:21	0:07	8	17:44	0:04	17:50	0:04
9	7:58	0:02	8:25	0:04	9	17:47	0:03	17:56	0:06
10	8:04	0:06	8:30	0:05	10	17:56	0:09	18:00	0:04
11	8:10	0:06	8:36	0:06	11	18:00	0:04	18:05	0:05
12	8:17	0:07	8:41	0:05	12	18:02	0:02	18:10	0:05
13	8:20	0:03	-	-	13	18:11	0:09	18:15	0:05
14	8:32	0:12	-	-	-	-	-	-	-
Station number VI-20									
1	6:48		6:50		1	17:18		17:20	
2	6:50	0:02	6:52	0:02	2	17:23	0:02	17:26	0:06
3	6:58	0:08	7:00	0:08	3	17:29	0:08	17:31	0:05
4	7:02	0:04	7:03	0:03	4	17:34	0:04	17:35	0:04
5	7:11	0:09	7:12	0:09	5	17:41	0:09	17:43	0:08
6	7:15	0:04	7:18	0:06	6	17:45	0:04	17:47	0:04
7	7:19	0:04	7:20	0:02	7	17:49	0:04	17:50	0:03
8	7:22	0:03	7:23	0:03	8	17:55	0:03	17:58	0:08
9	7:31	0:09	7:32	0:09	9	17:58	0:09	18:04	0:06
10	7:38	0:07	7:39	0:07	10	18:00	0:07	18:07	0:03
11	7:40	0:02	7:41	0:02	11	18:10	0:02	18:12	0:05
12	7:43	0:03	7:44	0:03	12	18:19	0:03	18:20	0:08
13	7:48	0:05	7:49	0:05	-	-	-	-	-

survey date; Feb 19th, 2016

Table 4.33 Arrival and departure times of corridor 7 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number VII-1									
1	7:15		7:18		1	17:11		17:15	
2	7:20	0:05	7:23	0:05	2	17:15	0:04	17:20	0:05
3	7:23	0:03	7:28	0:05	3	17:22	0:07	17:25	0:05
4	7:25	0:02	7:33	0:05	4	17:26	0:04	17:30	0:05
5	7:30	0:05	7:38	0:05	5	17:30	0:04	17:37	0:07
6	7:32	0:02	7:43	0:05	6	17:36	0:06	17:42	0:05
7	7:35	0:03	7:48	0:05	7	17:45	0:09	17:46	0:04
8	7:47	0:12	7:53	0:05	8	17:48	0:03	17:50	0:04
9	7:56	0:09	8:00	0:07	9	17:50	0:02	17:55	0:05
10	8:00	0:04	8:05	0:05	10	17:53	0:03	18:00	0:05
11	8:07	0:07	8:10	0:05	11	18:05	0:12	18:06	0:06
12	8:08	0:01	8:15	0:05	12	18:08	0:03	18:11	0:05
13	8:13	0:05	8:20	0:05	13	18:15	0:07	18:17	0:06
Station number VII-14									
1	7:10		7:13		1	17:21		17:25	
2	7:19	0:09	7:15	0:02	2	17:26	0:05	17:30	0:05
3	7:26	0:07	7:20	0:05	3	17:35	0:09	17:36	0:06
4	7:28	0:02	7:25	0:05	4	17:39	0:04	17:39	0:03
5	7:30	0:02	7:29	0:04	5	17:43	0:04	17:45	0:06
6	7:31	0:01	7:35	0:06	6	17:47	0:04	17:50	0:05
7	7:37	0:06	7:40	0:05	7	17:49	0:02	17:55	0:05
8	7:41	0:04	7:45	0:05	8	17:54	0:05	18:00	0:05
9	7:50	0:09	7:50	0:05	9	17:59	0:05	18:05	0:05
10	7:56	0:06	7:55	0:05	10	18:03	0:04	18:11	0:06
11	7:58	0:02	8:00	0:05	11	18:10	0:07	18:15	0:04
12	8:05	0:07	8:06	0:06	12	18:13	0:03	18:20	0:05
13	8:11	0:06	8:11	0:05	0:00	18:18	0:05	18:25	0:05

survey date; Feb 23th, 2016

Table 4.34 Arrival and departure times of corridor 8 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number VIII-1									
1	6:38		6:35		1	17:18		17:10	
2	6:39	0:01	6:44	0:09	2	17:20	0:02	17:15	0:05
3	6:43	0:04	6:55	0:11	3	17:26	0:06	17:23	0:08
4	6:48	0:05	7:02	0:07	4	17:31	0:05	17:27	0:04
5	6:50	0:02	7:07	0:05	5	17:40	0:09	17:34	0:07
6	6:56	0:06	7:12	0:05	6	17:41	0:01	17:40	0:06
7	6:59	0:03	7:18	0:06	7	17:47	0:06	17:45	0:05
8	7:09	0:10	7:23	0:05	8	17:51	0:04	17:52	0:07
9	7:23	0:14	7:28	0:05	9	17:59	0:08	17:57	0:05
10	7:25	0:02	7:35	0:07	10	18:06	0:07	18:05	0:08
11	7:28	0:03	-	-	11	18:11	0:05	18:10	0:05
12	7:32	0:04	-	-	12	18:16	0:05	-	-
Station number VIII-21									
1	7:09		7:11		1	18:30		18:34	
2	7:15	0:06	7:18	0:07	2	18:41	0:11	18:45	0:11
3	7:21	0:06	7:25	0:07	3	18:50	0:09	18:55	0:10
4	7:30	0:09	7:35	0:10	4	18:57	0:07	19:02	0:07
5	7:41	0:11	7:45	0:10	5	19:07	0:10	19:11	0:09
6	7:50	0:09	7:52	0:07	6	19:12	0:05	19:17	0:06
7	8:02	0:12	8:05	0:13	7	19:20	0:08	19:25	0:08
8	8:10	0:08	8:13	0:08	8	19:27	0:07	19:30	0:05
-	-	-	-	-	9	19:33	0:06	19:37	0:07

survey date; Feb 25th, 2016

Table 4.35 Arrival and departure times of corridor 9 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number IX-1									
1	6:25		6:30		1	17:11		17:00	
2	6:30	0:05	6:40	0:10	2	17:18	0:07	17:10	0:10
3	6:45	0:15	6:50	0:10	3	17:31	0:13	17:18	0:08
4	6:53	0:08	7:00	0:10	4	17:43	0:12	17:30	0:12
5	7:05	0:12	7:12	0:12	5	17:51	0:08	17:40	0:10
6	7:20	0:15	7:22	0:10	6	18:10	0:19	17:50	0:10
7	7:30	0:10	7:32	0:10	7	-	-	18:00	0:10
Station number IX-26									
1	6:24		6:30		1	17:22		17:25	
2	6:30	0:06	6:40	0:10	2	17:35	0:13	17:35	0:10
3	6:45	0:15	6:50	0:10	3	17:47	0:12	17:46	0:11
4	6:53	0:08	7:00	0:10	4	17:56	0:09	17:56	0:10
5	7:05	0:12	7:10	0:10	5	18:06	0:10	18:05	0:09
6	7:16	0:11	7:20	0:10	6	18:19	0:13	18:15	0:10
7	7:25	0:09	7:30	0:10	7	18:26	0:07	18:24	0:09

survey date; Feb 29th, 2016

Table 4.36 Arrival and departure times of corridor 10 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number X-1									
1	7:35		7:21		1	17:14		17:00	
2	7:40	0:05	7:25	0:04	2	17:17	0:03	17:05	0:05
3	7:43	0:03	7:31	0:06	3	17:25	0:08	17:11	0:06
4	7:45	0:02	7:35	0:04	4	17:29	0:04	17:15	0:04
5	7:50	0:05	7:40	0:05	5	17:34	0:05	17:21	0:06
6	7:52	0:02	7:45	0:05	6	17:44	0:10	17:26	0:05
7	7:55	0:03	7:50	0:05	7	17:51	0:07	17:30	0:04
8	8:00	0:05	7:55	0:05	8	17:54	0:03	17:35	0:05
9	8:13	0:13	8:00	0:05	9	17:59	0:05	17:40	0:05
10	8:19	0:06	8:05	0:05	10	18:12	0:13	17:45	0:05
11	8:27	0:08	8:10	0:05	11	-	-	17:50	0:05
12	8:30	0:03	8:15	0:05	12	-	-	17:55	0:05
13	8:33	0:03	8:20	0:05	13	-	-	18:00	0:05
Station number X-22									
1	7:21		7:32		1	17:14		17:00	
2	7:30	0:09	7:36	0:04	2	17:17	0:03	17:05	0:05
3	7:35	0:05	7:40	0:04	3	17:25	0:08	17:11	0:06
4	7:39	0:04	7:47	0:07	4	17:29	0:04	17:15	0:04
5	7:41	0:02	7:56	0:09	5	17:34	0:05	17:21	0:06
6	7:42	0:01	8:13	0:17	6	17:44	0:10	17:26	0:05
7	7:48	0:06	8:16	0:03	7	17:51	0:07	17:30	0:04
8	7:52	0:04	8:20	0:04	8	17:54	0:03	17:35	0:05
9	8:00	0:08	8:25	0:05	9	17:59	0:05	17:40	0:05
10	8:07	0:07	8:29	0:04	10	18:12	0:13	17:45	0:05
11	8:09	0:02	8:40	0:11	11	-	-	17:50	0:05
12	8:16	0:07	-	-	12	-	-	17:55	0:05
13	8:22	0:06	-	-	13	-	-	18:00	0:05

survey date; Mar 1st, 2016

Table 4.37 Arrival and departure times of corridor 11 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number XI-2									
1	7:36		7:36		1	17:10		17:06	
2	7:39	0:03	7:40	0:04	2	17:16	0:06	17:10	0:04
3	7:41	0:02	7:45	0:05	3	17:21	0:05	17:15	0:05
4	7:46	0:05	7:50	0:05	4	17:26	0:05	17:20	0:05
5	7:54	0:08	7:55	0:05	5	17:33	0:07	17:26	0:06
6	7:58	0:04	8:00	0:05	6	17:40	0:07	17:30	0:04
7	8:10	0:12	8:05	0:05	7	17:43	0:03	17:35	0:05
8	8:13	0:03	8:11	0:06	8	17:48	0:05	17:40	0:05
9	8:17	0:04	8:15	0:04	9	17:52	0:04	17:45	0:05
10	8:20	0:03	8:20	0:05	10	17:59	0:07	17:50	0:05
11	8:24	0:04	8:25	0:05	11	18:07	0:08	17:55	0:05
12	8:31	0:07	8:30	0:05	12	18:11	0:04	18:01	0:06
13	8:37	0:06	8:35	0:05	13	-	-	18:05	0:04
Station number XI-16									
1	7:27		7:29		1	17:15		17:16	
2	7:29	0:02	7:32	0:03	2	17:17	0:02	17:20	0:04
3	7:37	0:08	7:40	0:08	3	17:20	0:03	17:23	0:03
4	7:40	0:03	7:43	0:03	4	17:22	0:02	17:25	0:02
5	7:43	0:03	7:46	0:03	5	17:26	0:04	17:28	0:03
6	7:51	0:08	7:53	0:07	6	17:31	0:05	17:33	0:05
7	7:56	0:05	7:58	0:05	7	17:38	0:07	17:40	0:07
8	8:00	0:04	8:02	0:04	8	17:42	0:04	17:44	0:04
9	8:02	0:02	8:05	0:03	9	17:45	0:03	17:48	0:04
10	8:12	0:10	8:14	0:09	10	17:50	0:05	17:53	0:05
11	8:14	0:02	8:16	0:02	11	17:58	0:08	17:59	0:06
12	8:18	0:04	8:20	0:04	12	18:03	0:05	18:05	0:06
13	8:21	0:03	8:23	0:03	13	18:08	0:05	18:10	0:05
14	8:26	0:05	8:29	0:06	14	18:10	0:02	18:13	0:03
-	-	-	-	-	15	18:15	0:05	18:19	0:06

survey date; Mar 2nd, 2016

Table 4.38 Arrival and departure times of corridor 12 by bus at 2 peak periods

Bus No.	Morning Peak				Bus No.	Evening Peak			
	Arrival Time	h (mins)	Departure Time	h (mins)		Arrival Time	h (mins)	Departure Time	h (mins)
Station number XII-1									
1	6:32		6:38		1	16:59		16:56	
2	6:36	0:04	6:45	0:07	2	17:04	0:05	17:01	0:05
3	6:40	0:04	6:50	0:05	3	17:08	0:04	17:07	0:06
4	6:52	0:12	6:55	0:05	4	17:11	0:03	17:11	0:04
5	7:03	0:11	7:00	0:05	6	17:16	0:05	17:15	0:04
6	7:10	0:07	7:05	0:05	7	17:24	0:08	17:20	0:05
7	7:15	0:05	7:12	0:07	8	17:29	0:05	17:28	0:08
8	7:21	0:06	7:22	0:10	9	17:35	0:06	17:33	0:05
9	7:30	0:09	7:32	0:10	10	17:40	0:05	17:41	0:08
-	-	-	-	-	11	17:46	0:06	17:46	0:05
-	-	-	-	-	12	17:53	0:07	17:52	0:06
Station number XII-20									
1	7:02		7:14		1	17:33		17:41	
2	7:10	0:08	7:20	0:06	2	17:39	0:06	17:47	0:06
3	7:43	0:33	7:25	0:05	3	17:46	0:07	17:52	0:05
4	7:45	0:02	7:31	0:06	4	17:51	0:05	17:58	0:06
5	7:50	0:05	7:36	0:05	5	17:56	0:05	18:05	0:07
6	7:52	0:02	7:41	0:05	6	18:04	0:08	18:10	0:05
7	7:55	0:03	7:47	0:06	7	18:11	0:07	18:17	0:07
8	8:00	0:05	7:51	0:04	8	18:19	0:08	18:23	0:06
9	8:13	0:13	7:56	0:05	9	18:24	0:05	18:28	0:05
10	8:19	0:06	8:00	0:04	10	18:32	0:08	18:32	0:04
11	8:27	0:08	8:06	0:06	11	18:40	0:08	18:37	0:05
12	8:30	0:03	8:15	0:09	12	-	-	18:43	0:06

survey date; Mar 4th, 2016

The further analysis related with the arrival time and departure time are described in the next section of this chapter. Meanwhile, the waiting time at the first and last stations on each direction can be seen at the Tables 4.39 to 4.50.

Table 4.39 Waiting time of corridor 1 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number I-1							
1	6:58	7:01	0:03	1	17:10	17:15	0:05
2	7:02	7:05	0:03	2	17:15	17:20	0:05
3	7:05	7:10	0:05	3	17:21	17:25	0:04
4	7:11	7:15	0:04	4	17:26	17:30	0:04
5	7:20	7:25	0:05	5	17:30	17:35	0:05
6	7:24	7:31	0:07	6	17:36	17:42	0:06
7	7:26	7:30	0:04	7	17:43	17:46	0:03
8	7:31	7:36	0:05	8	17:47	17:50	0:03
9	7:34	7:40	0:06	9	17:52	17:55	0:03
10	7:40	7:45	0:05	10	17:56	18:00	0:04
11	7:46	7:50	0:04	11	18:01	18:05	0:04
12	7:50	7:55	0:05	12	18:06	18:10	0:04
13	7:57	8:00	0:03	13	18:11	18:18	0:07
Station number I-20							
1	7:15	7:21	0:06	1	17:20	17:24	0:04
2	7:21	7:26	0:05	2	17:24	17:32	0:08
3	7:26	7:28	0:02	3	17:33	17:35	0:02
4	7:29	7:35	0:06	4	17:36	17:41	0:05
5	7:35	7:38	0:03	5	17:41	17:50	0:09
6	7:38	7:48	0:10	6	17:50	17:53	0:03
7	7:48	7:50	0:02	7	17:54	17:58	0:04
8	7:53	8:00	0:07	8	17:59	18:04	0:05
9	8:02	8:04	0:02	9	18:05	18:14	0:09
10	8:05	8:13	0:08	10	18:15	18:18	0:03
-	-	-	-	11	18:18	18:26	0:08

survey date; Feb 10th, 2016

Table 4.40 Waiting time of corridor 2 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number II-1							
1	6:36	6:47	0:11	1	16:42	16:46	0:04
2	6:47	6:55	0:08	2	16:47	16:50	0:03
3	6:50	6:55	0:05	3	16:52	16:55	0:03
4	6:56	7:00	0:04	4	16:57	17:02	0:05
5	7:00	7:05	0:05	5	17:04	17:10	0:06
6	7:01	7:15	0:14	6	17:11	17:15	0:04
7	7:15	7:20	0:05	7	17:16	17:20	0:04
8	7:22	7:25	0:03	8	17:21	17:24	0:03
9	7:26	7:33	0:07	9	17:25	17:30	0:05
10	7:33	7:40	0:07	10	17:30	17:35	0:05
Station number II-20							
1	6:30	6:35	0:05	1	16:34	16:46	0:12
2	6:35	6:53	0:18	2	16:46	16:56	0:10
3	6:55	7:05	0:10	3	16:57	16:59	0:02
4	7:08	7:25	0:17	4	17:00	17:05	0:05
5	7:27	7:32	0:05	5	17:07	17:24	0:17
6	7:34	7:40	0:06	6	17:25	17:30	0:05
7	7:40	7:45	0:05	7	17:31	17:37	0:06
-	-	-	-	8	17:39	17:44	0:05
-	-	-	-	9	17:45	17:48	0:03

survey date; Feb 11th, 2016

Table 4.41 Waiting time of corridor 3 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number III-1							
1	7:02	7:05	0:03	1	17:04	17:10	0:06
2	7:05	7:10	0:05	2	17:11	17:15	0:04
3	7:12	7:15	0:03	3	17:17	17:20	0:03
4	7:17	7:20	0:03	4	17:21	17:25	0:04
5	7:21	7:25	0:04	5	17:26	17:30	0:04
6	7:26	7:30	0:04	6	17:31	17:35	0:04
7	7:32	7:35	0:03	7	17:37	17:41	0:04
8	7:37	7:40	0:03	8	17:43	17:46	0:03
9	7:41	7:45	0:04	9	17:46	17:50	0:04
10	7:46	7:50	0:04	10	17:50	17:55	0:05
11	7:51	7:55	0:04	11	17:56	18:00	0:04
12	7:56	8:00	0:04	12	18:01	18:05	0:04
-	-	-	-	13	18:07	18:10	0:03
Station number III-16							
1	6:20	6:28	0:08	1	17:20	17:27	0:07
2	6:30	6:32	0:02	2	17:28	17:31	0:03
3	6:39	6:41	0:02	3	17:35	17:42	0:07
4	6:43	6:53	0:10	4	17:44	17:45	0:01
5	6:57	7:20	0:23	5	17:48	17:53	0:05
6	7:21	7:25	0:04	6	17:55	18:01	0:06
7	7:25	7:28	0:03	7	18:03	18:04	0:01
-	-	-	-	8	18:08	18:19	0:11
-	-	-	-	9	18:20	18:28	0:08

survey date; Feb 12th, 2016

Table 4.42 Waiting time of corridor 4 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number IV-1							
1	6:53	6:57	0:04	1	17:07	17:10	0:03
2	6:59	7:05	0:06	2	17:12	17:17	0:05
3	7:06	7:10	0:04	3	17:17	17:20	0:03
4	7:11	7:15	0:04	4	17:23	17:25	0:02
5	7:17	7:20	0:03	5	17:26	17:30	0:04
6	7:21	7:30	0:09	6	17:32	17:38	0:06
7	7:30	7:35	0:05	7	17:40	17:43	0:03
8	7:36	7:40	0:04	8	17:44	17:50	0:06
9	7:41	7:45	0:04	9	17:52	17:55	0:03
10	7:46	7:50	0:04	10	17:57	18:00	0:03
11	7:51	7:56	0:05	11	18:00	18:05	0:05
12	7:58	8:00	0:02	12	18:05	18:11	0:06
Station number IV-17							
1	6:50	6:52	0:02	1	17:20	17:23	0:03
2	6:53	7:00	0:07	2	17:24	17:30	0:06
3	7:01	7:07	0:06	3	17:31	17:35	0:04
4	7:08	7:12	0:04	4	17:37	17:41	0:04
5	7:13	7:18	0:05	5	17:41	17:48	0:07
6	7:18	7:22	0:04	6	17:48	17:55	0:07
7	7:22	7:32	0:10	7	17:56	18:07	0:11
8	7:33	7:36	0:03	8	18:08	18:11	0:03
9	7:37	7:42	0:05	9	18:11	18:17	0:06
10	7:43	7:50	0:07	10	18:17	18:24	0:07

survey date; Feb 17th, 2016

Table 4.43 Waiting time of corridor 5 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number V-1							
1	6:36	6:53	0:17	1	17:08	17:14	0:06
2	6:40	7:01	0:21	2	17:14	17:25	0:11
3	7:02	7:10	0:08	3	17:26	17:33	0:07
4	7:11	7:30	0:19	4	17:33	17:38	0:05
5	7:31	7:38	0:07	5	17:39	17:43	0:04
6	7:39	7:43	0:04	6	17:44	17:51	0:07
7	7:44	7:48	0:04	7	17:52	17:56	0:04
8	7:49	8:01	0:12	8	17:56	18:02	0:06
-	-	-	-	9	18:03	18:08	0:05
-	-	-	-	10	18:08	18:15	0:07
Station number V-16							
1	7:28	7:30	0:02	1	17:10	17:15	0:05
2	7:32	7:35	0:03	2	17:16	17:20	0:04
3	7:40	7:47	0:07	3	17:22	17:25	0:03
4	7:48	7:55	0:07	4	17:25	17:30	0:05
5	7:58	8:00	0:02	5	17:31	17:35	0:04
-	-	-	-	6	17:36	17:40	0:04
-	-	-	-	7	17:42	17:45	0:03
-	-	-	-	8	17:47	17:51	0:04
-	-	-	-	9	17:52	17:55	0:03
-	-	-	-	10	17:55	18:02	0:07
-	-	-	-	11	18:04	18:05	0:01
-	-	-	-	12	18:06	18:10	0:04

survey date; Feb 18th, 2016

Table 4.44 Waiting time of corridor 6 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number VI-1							
1	7:38	7:44	0:06	1	17:11	17:15	0:04
2	7:45	7:49	0:04	2	17:15	17:18	0:03
3	7:50	7:53	0:03	3	17:19	17:25	0:06
4	7:54	8:00	0:06	4	17:27	17:30	0:03
5	8:01	8:05	0:04	5	17:31	17:37	0:06
6	8:06	8:10	0:04	6	17:38	17:42	0:04
7	8:12	8:14	0:02	7	17:43	17:46	0:03
8	8:15	8:21	0:06	8	17:46	17:50	0:04
9	8:22	8:25	0:03	9	17:51	17:56	0:05
10	8:26	8:30	0:04	10	17:57	18:00	0:03
11	8:32	8:36	0:04	11	18:00	18:05	0:05
12	8:38	8:41	0:03	12	18:06	18:10	0:04
-	-	-	-	13	18:11	18:15	0:04
Station number VI-20							
1	6:34	6:50	0:16	1	17:05	17:20	0:15
2	6:52	7:03	0:11	2	17:20	17:31	0:11
3	7:04	7:12	0:08	3	17:26	17:35	0:09
4	7:12	7:20	0:08	4	17:32	17:43	0:11
5	7:20	7:32	0:12	5	17:38	17:47	0:09
6	7:33	7:44	0:11	6	17:45	17:58	0:13
7	7:45	7:56	0:11	7	17:55	18:04	0:09
-	-	-	-	8	18:00	18:07	0:07
-	-	-	-	9	18:08	18:12	0:04
-	-	-	-	10	18:15	18:20	0:05

survey date; Feb 19th, 2016

Table 4.45 Waiting time of corridor 7 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number VII-1							
1	7:15	7:18	0:03	1	17:10	17:15	0:05
2	7:18	7:23	0:05	2	17:17	17:20	0:03
3	7:24	7:28	0:04	3	17:22	17:25	0:03
4	7:29	7:33	0:04	4	17:25	17:30	0:05
5	7:34	7:38	0:04	5	17:31	17:37	0:06
6	7:39	7:43	0:04	6	17:39	17:42	0:03
7	7:44	7:48	0:04	7	17:44	17:46	0:02
8	7:50	7:53	0:03	8	17:47	17:50	0:03
9	7:54	8:00	0:06	9	17:50	17:55	0:05
10	8:00	8:05	0:05	10	17:57	18:00	0:03
11	8:05	8:10	0:05	11	18:00	18:06	0:06
12	8:11	8:15	0:04	12	18:07	18:11	0:04
13	8:16	8:20	0:04	13	18:12	18:17	0:05
Station number VII-14							
1	7:10	7:13	0:03	1	17:20	17:25	0:05
2	7:14	7:15	0:01	2	17:25	17:30	0:05
3	7:16	7:20	0:04	3	17:31	17:36	0:05
4	7:22	7:25	0:03	4	17:36	17:39	0:03
5	7:25	7:29	0:04	5	17:40	17:45	0:05
6	7:30	7:35	0:05	6	17:46	17:50	0:04
7	7:36	7:40	0:04	7	17:51	17:55	0:04
8	7:42	7:45	0:03	8	17:56	18:00	0:04
9	7:45	7:50	0:05	9	18:01	18:05	0:04
10	7:50	7:55	0:05	10	18:06	18:11	0:05
11	7:55	8:00	0:05	11	18:12	18:15	0:03
12	8:02	8:06	0:04	12	18:15	18:20	0:05
13	8:07	8:11	0:04	13	18:21	18:25	0:04

survey date; Feb 23th, 2016

Table 4.46 Waiting time of corridor 8 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number VIII-1							
1	6:30	6:35	0:05	1	17:05	17:10	0:05
2	6:36	6:44	0:08	2	17:11	17:15	0:04
3	6:45	6:55	0:10	3	17:16	17:23	0:07
4	6:55	7:02	0:07	4	17:25	17:27	0:02
5	7:03	7:07	0:04	5	17:29	17:34	0:05
6	7:08	7:12	0:04	6	17:35	17:40	0:05
7	7:14	7:18	0:04	7	17:40	17:45	0:05
8	7:19	7:23	0:04	8	17:47	17:52	0:05
9	7:24	7:28	0:04	9	17:54	17:57	0:03
10	7:30	7:35	0:05	10	17:58	18:05	0:07
-	-	-	-	11	18:07	18:10	0:03
Station number VIII-21							
1	7:10	7:25	0:15	1	18:30	18:34	0:04
2	7:26	7:35	0:09	2	18:34	18:45	0:11
3	7:35	7:52	0:17	3	18:45	18:55	0:10
4	7:52	8:05	0:13	4	18:55	19:02	0:07
5	8:06	8:19	0:13	5	19:03	19:11	0:08
-	-	-	-	6	19:12	19:17	0:05
-	-	-	-	7	19:17	19:25	0:08
-	-	-	-	8	19:25	19:30	0:05
-	-	-	-	9	19:30	19:37	0:07

survey date; Feb 25th, 2016

Table 4.47 Waiting time of corridor 9 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number IX-1							
1	6:15	6:30	0:15	1	16:05	17:00	0:55
2	6:30	6:40	0:10	2	17:01	17:10	0:09
3	6:31	6:40	0:09	3	17:13	17:18	0:05
4	6:41	7:00	0:19	4	17:23	17:30	0:07
5	6:42	7:00	0:18	5	17:31	17:40	0:09
6	7:00	7:22	0:22	6	17:41	17:50	0:09
7	7:01	7:22	0:21	7	17:51	18:00	0:09
8	7:23	7:32	0:09		-	-	-
Station number IX-26							
1	6:26	6:30	0:04	1	17:20	17:25	0:05
2	6:32	6:40	0:08	2	17:25	17:35	0:10
3	6:43	6:50	0:07	3	17:37	17:46	0:09
4	6:51	7:00	0:09	4	17:47	17:56	0:09
5	7:00	7:10	0:10	5	17:57	18:05	0:08
6	7:12	7:20	0:08	6	18:06	18:15	0:09
7	7:21	7:30	0:09	7	18:17	18:24	0:07

survey date; Feb 29th, 2016

Table 4.48 Waiting time of corridor 10 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number X-1							
1	7:17	7:21	0:04	1	16:56	17:00	0:04
2	7:22	7:25	0:03	2	17:00	17:05	0:05
3	7:25	7:31	0:06	3	17:06	17:11	0:05
4	7:31	7:35	0:04	4	17:12	17:15	0:03
5	7:35	7:40	0:05	5	17:17	17:21	0:04
6	7:41	7:45	0:04	6	17:22	17:26	0:04
7	7:45	7:50	0:05	7	17:26	17:30	0:04
8	7:52	7:55	0:03	8	17:30	17:35	0:05
9	7:55	8:00	0:05	9	17:36	17:40	0:04
10	8:01	8:05	0:04	10	17:41	17:45	0:04
11	8:07	8:10	0:03	11	17:46	17:50	0:04
12	8:12	8:15	0:03	12	17:51	17:55	0:04
13	8:15	8:20	0:05	13	17:57	18:00	0:03
Station number X-22							
1	7:30	7:32	0:02	1	17:35	17:44	0:09
2	7:35	7:36	0:01	2	17:45	17:48	0:03
3	7:36	7:40	0:04	3	17:50	17:54	0:04
4	7:43	7:47	0:04	4	17:56	18:00	0:04
5	7:50	7:56	0:06	5	18:01	18:07	0:06
6	7:57	8:13	0:16	6	18:10	18:17	0:07
7	8:15	8:16	0:01	7	18:18	18:23	0:05
8	8:17	8:20	0:03	8	18:25	18:30	0:05
9	8:24	8:25	0:01	9	18:33	18:35	0:02
10	8:25	8:29	0:04	10	18:38	18:41	0:03
11	8:29	8:40	0:11	-	-	-	-

survey date; Mar 1st, 2016

Table 4.49 Waiting time of corridor 11 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number XI-2							
1	7:31	7:36	0:05	1	17:02	17:06	0:04
2	7:37	7:40	0:03	2	17:08	17:10	0:02
3	7:40	7:45	0:05	3	17:12	17:15	0:03
4	7:46	7:50	0:04	4	17:18	17:20	0:02
5	7:53	7:55	0:02	5	17:22	17:26	0:04
6	7:57	8:00	0:03	6	17:28	17:30	0:02
7	8:02	8:05	0:03	7	17:30	17:35	0:05
8	8:06	8:11	0:05	8	17:36	17:40	0:04
9	8:11	8:15	0:04	9	17:43	17:45	0:02
10	8:16	8:20	0:04	10	17:49	17:50	0:01
11	8:21	8:25	0:04	11	17:54	17:55	0:01
12	8:25	8:30	0:05	12	17:56	18:01	0:05
13	8:31	8:35	0:04	13	18:03	18:05	0:02
Station number XI-16							
1	7:26	7:29	0:03	1	17:02	17:06	0:04
2	7:31	7:32	0:01	2	17:08	17:10	0:02
3	7:38	7:40	0:02	3	17:12	17:15	0:03
4	7:40	7:43	0:03	4	17:18	17:20	0:02
5	7:41	7:46	0:05	5	17:22	17:26	0:04
6	7:47	7:53	0:06	6	17:28	17:30	0:02
7	7:53	7:58	0:05	7	17:30	17:35	0:05
8	8:00	8:02	0:02	8	17:36	17:40	0:04
9	8:03	8:05	0:02	9	17:43	17:45	0:02
10	8:06	8:14	0:08	10	17:49	17:50	0:01
11	8:15	8:16	0:01	11	17:54	17:55	0:01
12	8:17	8:20	0:03	12	17:56	18:01	0:05
13	8:21	8:23	0:02	13	18:03	18:05	0:02
14	8:24	8:29	0:05	-	-	-	-

survey date; Mar 2nd, 2016

Table 4.50 Waiting time of corridor 12 by passenger during 2 peak periods

Pax No.	Morning Peak			Pax No.	Evening Peak		
	Arrival Time	Boarding Time	Waiting (mins)		Arrival Time	Boarding Time	Waiting (mins)
Station number XII-1							
1	6:10	6:38	0:28	1	16:57	17:01	0:04
2	6:40	6:45	0:05	2	17:03	17:07	0:04
3	6:47	6:50	0:03	3	17:09	17:11	0:02
4	6:53	6:55	0:02	4	17:11	17:15	0:04
5	6:55	7:00	0:05	5	17:16	17:20	0:04
6	7:00	7:05	0:05	6	17:21	17:28	0:07
7	7:06	7:12	0:06	7	17:29	17:33	0:04
8	7:13	7:22	0:09	8	17:34	17:41	0:07
9	7:24	7:32	0:08	9	17:41	17:46	0:05
-	-	-	-	10	17:46	17:52	0:06
Station number XII-20							
1	7:10	7:14	0:04	1	17:35	17:41	0:06
2	7:15	7:20	0:05	2	17:42	17:47	0:05
3	7:22	7:25	0:03	3	17:49	17:52	0:03
4	7:26	7:31	0:05	4	17:55	17:58	0:03
5	7:33	7:36	0:03	5	17:59	18:05	0:06
6	7:37	7:41	0:04	6	18:07	18:10	0:03
7	7:42	7:47	0:05	7	18:12	18:17	0:05
8	7:47	7:51	0:04	8	18:19	18:23	0:04
9	7:50	7:56	0:06	9	18:25	18:28	0:03
10	7:57	8:00	0:03	10	18:30	18:32	0:02
11	8:01	8:06	0:05	11	18:32	18:37	0:05
-	-	-	-	12	18:38	18:43	0:05

survey date; Mar 4th, 2016

4.1.5 Dynamic data of TransJakarta

The dynamic data is obtained by conducting the dynamic survey (in-vehicle survey). They consist of arrival time, number of alighting passengers and boarding passengers per direction at all stations. The dynamic surveys have been conducted between February 10th and March 4th, 2016 for all corridors. Because of the limitation on time and cost, the surveys for all corridors are conducted for 1 trip per direction during 2 peak periods; i.e., morning-peak and evening-peak. The most congested hour becomes the consideration to determine the survey time. Tables 4.51 to

4.62 show the dynamic data and load factor that can be determined by calculating the ratio between the number of passengers (pax) on the bus and the vehicle capacity.

Table 4.51 Arrival time and dynamic demand data at all stations of corridor 1

St. no	Station	Morning Peak					Evening Peak				
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time
Direction (A-B): stations I-1 to I-20											
I-1	Blok M	0	81	81	0.58	7:18		48	48	0.34	17:32
I-2	Masjid Agung	4	0	77	0.55	7:34	0	5	53	0.38	17:47
I-3	Bundaran Senayan	1	3	79	0.56	7:37	0	17	70	0.50	17:52
I-4	Gelora Bung Karno	1	1	79	0.56	7:39	0	18	88	0.63	17:54
I-5	Polda Metro jaya	1	3	81	0.58	7:40	5	17	100	0.71	17:58
I-6	Bendungan Hilir	8	8	81	0.58	7:42	38	39	101	0.72	18:00
I-9	Dukuh Atas	8	7	80	0.57	7:44	24	0	77	0.55	18:03
I-10	Tosari	10	1	71	0.51	7:46	29	6	54	0.39	18:05
I-11	Bundaran HI	12	1	60	0.43	7:47	12	35	77	0.55	18:07
I-12	Sarinah	7	1	54	0.39	7:50	16	18	79	0.56	18:09
I-13	Bank Indonesia	8	0	46	0.33	7:53	8	27	98	0.70	18:11
I-14	Monas	14	1	33	0.24	7:56	4	23	117	0.84	18:13
I-15	Harmoni	14	31	50	0.36	8:04	54	38	101	0.72	18:20
I-16	Sawah Besar	10	1	41	0.29	8:07	26	23	98	0.70	18:22
I-17	Mangga Besar	10	1	32	0.23	8:09	21	0	77	0.55	18:24
I-18	Olimo	0	0	32	0.23	8:10	7	0	70	0.50	18:25
I-19	Glodok	20	0	12	0.09	8:12	23	2	49	0.35	18:27
I-20	Kota	12	0	0		8:16	49	0	0		18:30
	Average Load Factor				0.42						0.57
Direction (B-A): stations I-20 to I-11											
I-20	Kota	0	66	66	0.47	8:35		68	68	0.49	18:45
I-19	Glodok	6	14	74	0.53	8:39	0	8	76	0.54	18:48
I-18	Olimo	0	9	83	0.59	8:40	1	5	80	0.57	18:49
I-17	Mangga Besar	0	15	98	0.70	8:41	0	15	95	0.68	18:50
I-16	Sawah Besar	0	21	119	0.85	8:43	6	23	112	0.80	18:52
I-15	Harmoni	24	50	145	1.04	8:46	42	47	117	0.84	18:54
I-14	Monas	12	0	133	0.95	8:54	16	0	101	0.72	19:03
I-13	Bank Indonesia	9	5	129	0.92	8:56	4	12	109	0.78	19:05
I-12	Sarinah	23	23	129	0.92	8:59	15	35	129	0.92	19:07
I-11	Bundaran HI	20	9	118	0.84	9:02	14	22	137	0.98	19:09
I-10	Tosari	17	51	152	1.09	9:04	13	32	156	1.11	19:10
I-9	Dukuh Atas	27	21	146	1.04	9:07	19	29	166	1.19	19:13
I-6	Bendungan Hilir	50	54	150	1.07	9:09	39	36	163	1.16	19:16
I-5	Polda Metro jaya	23	8	135	0.96	9:10	16	20	167	1.19	19:18
I-4	Gelora Bung Karno	23	0	112	0.80	9:12	22	0	145	1.04	19:20
I-3	Bundaran Senayan	59	0	53	0.38	9:14	35	0	110	0.79	19:22
I-2	Masjid Agung	29	0	24	0.17	9:17	21	0	89	0.64	19:27
I-1	Blok M	24	0	0	0.00	9:20	89	0	0	0.00	19:31
	Average Load Factor				0.74						0.80

Survey date; Feb 10th, 2016

Table 4.52 Arrival time and dynamic demand data at all stations of corridor 2

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations II-1 to II-20												
II-1	Pulo Gadung	0	70	70	0.50	6:47		20	20	0.14	17:32	
II-2	Bermis	1	6	75	0.54	6:53	2	2	20	0.14	17:40	
II-3	Pulomas	1	12	86	0.61	6:58	4	8	24	0.17	17:47	
II-4	ASMI	4	5	87	0.62	7:00	2	4	26	0.19	17:49	
II-5	Pedongkelan	0	1	88	0.63	7:02	4	0	22	0.16	17:51	
II-6	Cempaka Timur	10	17	95	0.68	7:06	7	39	54	0.39	17:58	
II-7	RS Islam	4	4	95	0.68	7:07	4	2	52	0.37	17:59	
II-8	Cempaka Tengah	4	5	96	0.69	7:09	1	4	55	0.39	18:00	
II-9	Pasar Cempaka Putih	4	6	98	0.70	7:10	5	2	52	0.37	18:01	
II-10	Rawa Selatan	4	10	104	0.74	7:12	2	2	52	0.37	18:03	
II-11	Galur	0	10	114	0.81	7:13	4	4	52	0.37	18:05	
II-12	Senen	16	4	102	0.73	7:31	10	2	44	0.31	18:18	
II-13	Atrium	1	1	102	0.73	7:33	4	4	44	0.31	18:20	
II-14	RSPAD	5	5	102	0.73	7:35	2	5	47	0.34	18:22	
II-15	DEPLU	1	5	106	0.76	7:36	2	7	52	0.37	18:23	
II-16	Gambir 1	6	5	105	0.75	7:40	8	11	55	0.39	18:27	
II-17	Istiqlal	0	0	105	0.75	7:41	3	0	52	0.37	18:29	
II-18	Juanda	7	0	98	0.70	7:43	11	0	41	0.29	18:31	
II-19	Pacenongan	4	0	94	0.67	7:44	2	0	39	0.28	18:32	
II-20	Harmoni	94	0	0		7:49	39	0	0	0.00	18:38	
	Average Load Factor				0.68						0.29	
Direction (A-B): stations II-20 to II-1												
II-20	Harmoni	0	81	81	0.58	7:58		66	66	0.47	18:45	
II-a	Monas	12	8	77	0.55	8:05	1	4	69	0.49	18:50	
II-b	Balai Kota	6	1	72	0.51	8:10	7	3	65	0.46	18:56	
II-16b	Gambir 2	2	2	72	0.51	8:11	6	4	63	0.45	18:57	
II-c	Kwitang	0	5	77	0.55	8:12	1	3	65	0.46	18:58	
II-12	Senen	36	8	49	0.35	8:25	24	4	45	0.32	19:09	
II-11	Galur	4	4	49	0.35	8:29	8	3	40	0.29	19:13	
II-10	Rawa Selatan	0	2	51	0.36	8:30	4	2	38	0.27	19:14	
II-9	Pasar Cempaka Putih	6	0	45	0.32	8:31	5	0	33	0.24	19:16	
II-8	Cempaka Tengah	4	2	43	0.31	8:33	3	2	32	0.23	19:18	
II-7	RS Islam	10	2	35	0.25	8:34	5	4	31	0.22	19:19	
II-6	Cempaka Timur	17	8	26	0.19	8:36	11	14	34	0.24	19:21	
II-5	Pedongkelan	0	0	26	0.19	8:39	8	0	26	0.19	19:24	
II-4	ASMI	16	5	15	0.11	8:41	7	3	22	0.16	19:26	
II-3	Pulomas	13	0	2	0.01	8:43	8	1	15	0.11	19:28	
II-2	Bermis	1	1	2	0.01	8:47	4	0	11	0.08	19:31	
II-1	Pulo Gadung	2	0	0	0.00	8:50	11	0	0	0.00	19:33	
	Average Load Factor				0.30						0.28	

Survey date; Feb 11th, 2016

Table 4.53 Arrival time and dynamic demand data at all stations of corridor 3

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations III-1 to III-16												
III-1	Kalideres	0	56	56	0.40	8:01	0	32	32	0.23	17:05	
III-2	Pesakih	0	5	61	0.44	8:14	0	4	36	0.26	17:17	
III-3	Sumur Bor	2	8	67	0.48	8:18	0	3	39	0.28	17:21	
III-4	Rawa Buaya	0	18	85	0.61	8:22	6	16	49	0.35	17:25	
III-5	Jembatan Baru	0	15	100	0.71	8:25	1	7	55	0.39	17:27	
III-6	Dispenda	4	17	113	0.81	8:28	5	17	67	0.48	17:30	
III-7	Jembatan Gantung	2	22	133	0.95	8:38	2	22	87	0.62	17:37	
III-8	Taman Kota	0	22	155	1.11	8:52	6	12	93	0.66	17:49	
III-9	Indosiar	10	0	145	1.04	9:05	9	0	84	0.60	18:01	
III-10	Jelambar	1	6	150	1.07	9:08	4	7	87	0.62	18:05	
III-11	Grogol Trisakti	28	6	128	0.91	9:10	19	6	74	0.53	18:07	
III-12	RS. Sumber Waras	10	0	118	0.84	9:12	4	0	70	0.50	18:09	
III-13	Harmoni	107	0	11	0.08	9:19	46	0	24	0.17	18:15	
III-14	Pecenongan	1	0	10	0.07	9:25	16	0	8	0.06	18:20	
III-15	Juanda	6	0	4	0.03	9:26	4	0	4	0.03	18:21	
III-16	Pasar Baru	4	0	0		9:27	4	0	0		18:23	
	Average Load Factor				0.64						0.39	
Direction (A-B): stations III-16 to III-1												
III-16	Pasar Baru	0	4	4	0.03	7:13	0	8	8	0.06	18:34	
III-15	Juanda	0	6	10	0.07	7:16	0	3	11	0.08	18:36	
III-14	Pecenongan	2	30	38	0.27	7:17	0	22	33	0.24	18:38	
III-13	Harmoni	6	73	105	0.75	7:24	3	58	88	0.63	18:44	
III-12	RS. Sumber Waras	12	10	103	0.74	7:32	8	7	87	0.62	18:53	
III-11	Grogol Trisakti	17	30	116	0.83	7:34	15	22	94	0.67	18:55	
III-10	Jelambar	6	2	112	0.80	7:37	7	2	89	0.64	18:58	
III-9	Indosiar	10	12	114	0.81	7:40	7	10	92	0.66	19:03	
III-8	Taman Kota	4	4	114	0.81	7:45	18	2	76	0.54	19:13	
III-7	Jembatan Gantung	7	4	111	0.79	7:47	23	4	57	0.41	19:18	
III-6	Dispenda	5	8	114	0.81	7:50	14	6	49	0.35	19:22	
III-5	Jembatan Baru	10	0	104	0.74	7:53	9	0	40	0.29	19:26	
III-4	Rawa Buaya	33	12	83	0.59	7:56	11	9	38	0.27	19:28	
III-3	Sumur Bor	11	10	82	0.59	7:58	10	3	31	0.22	19:31	
III-2	Pesakih	31	0	51	0.36	8:00	8	0	23	0.16	19:32	
III-1	Kalideres	51	0	0		8:04	23	0	0		19:36	
	Average Load Factor				0.60						0.39	

Survey date; Feb 12th, 2016

Table 4.54 Arrival time and dynamic demand data at all stations of corridor 4

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations IV-1 to IV-17												
IV-1	Pulo Gadung	0	19	19	0.22	7:07	0	12	12	0.14	17:02	
IV-2	Pasar Pulo Gadung	2	0	17	0.20	7:11	0	0	12	0.14	17:07	
IV-3	Tugas	0	13	30	0.35	7:13	0	13	25	0.29	17:10	
IV-4	Layur	4	15	41	0.48	7:15	3	14	36	0.42	17:12	
IV-5	Pemuda											
	Rawamangun	4	17	54	0.64	7:17	3	16	49	0.58	17:14	
IV-6	Velodrome	0	6	60	0.71	7:22	1	9	57	0.67	17:18	
IV-7	Sunan Giri	6	11	65	0.76	7:24	7	11	61	0.72	17:20	
IV-8	UNJ	9	15	71	0.84	7:25	6	22	77	0.91	17:21	
IV-9	Pramuka BPKP	15	13	69	0.81	7:28	12	17	82	0.96	17:23	
IV-10	Pramuka LIA	2	2	69	0.81	7:30	0	3	85	1.00	17:25	
IV-11	Utan Kayu	6	2	65	0.76	7:31	0	1	86	1.01	17:26	
IV-12	Pasar Genjing	9	11	67	0.79	7:33	4	8	90	1.06	17:28	
IV-13	Matraman	36	23	54	0.64	7:36	28	13	75	0.88	17:31	
IV-14	Manggarai	4	6	56	0.66	7:43	9	3	69	0.81	17:37	
IV-15	Pasar Rumput	9	8	55	0.65	7:45	4	4	69	0.81	17:39	
IV-16	Halimun	8	6	53	0.62	7:48	5	8	72	0.85	17:41	
IV-17	Dukuh Atas 2	53	0	0		7:50	72	0	0		17:45	
	Average Load Factor				0.62						0.70	
Direction (A-B): stations IV-17 to IV-1												
IV-17	Dukuh Atas 2	0	38	38	0.45	8:00	0	25	25	0.29	17:57	
IV-16	Halimun	2	2	38	0.45	8:04	2	3	26	0.31	18:01	
IV-15	Pasar Rumput	0	0	38	0.45	8:06	0	0	26	0.31	18:03	
IV-14	Manggarai	6	12	44	0.52	8:08	1	7	32	0.38	18:06	
IV-13	Matraman	6	6	44	0.52	8:18	13	8	27	0.32	18:15	
IV-12	Pasar Genjing	4	0	40	0.47	8:21	5	0	22	0.26	18:17	
IV-11	Utan Kayu	0	0	40	0.47	8:22	0	2	24	0.28	18:18	
IV-10	Pramuka LIA	8	0	32	0.38	8:23	0	3	27	0.32	18:19	
IV-9	Pramuka BPKP	6	4	30	0.35	8:25	10	9	26	0.31	18:21	
IV-8	UNJ	4	0	26	0.31	8:26	8	0	18	0.21	18:22	
IV-7	Sunan Giri	4	8	30	0.35	8:28	5	6	19	0.22	18:24	
IV-6	Velodrome	4	0	26	0.31	8:31	2	0	17	0.20	18:26	
IV-5	Pemuda											
	Rawamangun	6	2	22	0.26	8:33	5	5	17	0.20	18:28	
IV-4	Layur	6	0	16	0.19	8:35	6	1	12	0.14	18:30	
IV-3	Tugas	6	0	10	0.12	8:37	8	0	4	0.05	18:32	
IV-2	Pasar Pulo Gadung	6	0	4	0.05	8:39	3	0	1	0.01	18:34	
IV-1	Pulo Gadung	4		0		8:46	1	0	0		18:40	
	Average Load Factor				0.35						0.24	

Survey date; Feb 17th, 2016

Table 4.55 Arrival time and dynamic demand data at all stations of corridor 5

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations V-1 to V-16												
V-1	Kampung Melayu Bus Station (departure)	0	90	90	0.64	6:53	0	98	98	0.70	17:21	
V-2	Kebon Pala	4	8	94	0.67	6:58	0	4	102	0.73	17:27	
V-3	Slamet Riyadi	1	4	97	0.69	6:59	0	2	104	0.74	17:28	
V-4	Tegalan	0	3	100	0.71	7:00	1	2	105	0.75	17:29	
V-5	Matraman 1	10	5	95	0.68	7:03	13	5	97	0.69	17:31	
V-6	Salemba Carolus	4	4	95	0.68	7:09	2	7	102	0.73	17:35	
V-7	Salemba UI	10	1	86	0.61	7:12	8	2	96	0.69	17:38	
V-8	Kramat Sentiong	4	8	90	0.64	7:14	9	10	97	0.69	17:40	
V-9	Pal Putih	4	13	99	0.71	7:16	5	15	107	0.76	17:43	
V-10	Sentral Senen	32	10	77	0.55	7:22	47	39	99	0.71	17:48	
V-11	Budi Utomo	0	1	78	0.56	7:27	5	4	98	0.70	17:54	
V-12	Pasar Baru Timur	9	8	77	0.55	7:31	11	18	105	0.75	17:57	
V-13	Jembatan Merah	27	4	54	0.39	7:35	33	9	81	0.58	18:02	
V-14	Gunung Sahari Mangga Dua	26	1	29	0.21	7:40	31	2	52	0.37	18:03	
V-15	Pademangan	10	0	19	0.14	7:41	11	0	41	0.29	18:04	
V-16	Ancol	19	0	0		7:44	41		0	0.00	18:06	
	Average Load Factor				0.56						0.62	
Direction (A-B): stations V-16 to V-1												
V-16	Ancol	0	1	1	0.01	7:48	0	27	27	0.19	7:48	
V-15	Pademangan	0	1	2	0.01	7:50	1	2	28	0.20	7:50	
V-14	Gunung Sahari Mangga Dua	0	2	4	0.03	7:52	2	2	28	0.20	7:52	
V-13	Jembatan Merah	0	2	6	0.04	7:57	4	2	26	0.19	7:57	
V-12	Pasar Baru Timur	0	1	7	0.05	8:04	5	2	23	0.16	8:04	
V-11	Budi Utomo	0	1	8	0.06	8:07	0	1	24	0.17	8:07	
V-10	Sentral Senen	4	7	11	0.08	8:09	14	13	23	0.16	8:09	
V-9	Pal Putih	2	1	10	0.07	8:14	7	1	17	0.12	8:14	
V-8	Kramat Sentiong	0	2	12	0.09	8:16	3	2	16	0.11	8:16	
V-7	Salemba UI	0	2	14	0.10	8:17	2	2	16	0.11	8:17	
V-6	Salemba Carolus	1	0	13	0.09	8:19	2	0	14	0.10	8:19	
V-5	Matraman 1	1	8	20	0.14	8:22	3	7	18	0.13	8:22	
V-4	Tegalan	0	4	24	0.17	8:23	0	2	20	0.14	8:23	
V-3	Slamet Riyadi	0	0	24	0.17	8:25	2	0	18	0.13	8:25	
V-2	Kebon Pala	0	4	28	0.20	8:27	3	1	16	0.11	8:27	
V-a	Pasar Jatinegara	7	4	25	0.18	8:29	4	2	14	0.10	8:29	
V-b	RS Premier Jatinegara	1	1	25	0.18	8:31	1	2	15	0.11	8:31	
V-1	Kampung Melayu Bus Station (departure)	25	0	0		8:33	15	0	0	0.00	8:33	
	Average Load Factor				0.10						0.14	

Survey date; Feb 18th, 2016

Table 4.56 Arrival time and dynamic demand data at all stations of corridor 6

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations VI-1 to VI-20												
VI-1	Ragunan	0	47	47	0.55	7:49	0	16	16	0.19	17:15	
VI-2	Departemen Pertanian	0	7	54	0.64	7:52	1	1	16	0.19	17:20	
VI-3	SMK 57	0	26	80	0.94	7:57	0	4	20	0.24	17:23	
VI-4	Jati Padang	7	0	73	0.86	8:00	0	2	22	0.26	17:26	
VI-5	Pejaten	0	0	73	0.86	8:03	1	0	21	0.25	17:30	
VI-6	Buncit Indah	2	0	71	0.84	8:05	0	1	22	0.26	17:32	
VI-7	Warung Jati	0	2	73	0.86	8:08	0	3	25	0.29	17:35	
VI-8	Imigrasi	0	2	75	0.88	8:10	2	0	23	0.27	17:37	
VI-9	Duren Tiga	2	21	94	1.11	8:13	5	5	23	0.27	17:40	
VI-10	Mampang Prapatan	16	7	85	1.00	8:16	7	3	19	0.22	17:43	
VI-11	Kuningan Timur	9	28	104	1.22	8:19	11	42	50	0.59	17:46	
VI-12	Patra Kuningan	2	0	102	1.20	8:21	5	2	47	0.55	17:48	
VI-13	Depkes	16	0	86	1.01	8:22	7	8	48	0.56	17:50	
VI-14	GOR Sumantri	16	12	82	0.96	8:24	19	10	39	0.46	17:52	
VI-15	Karet Kuningan	9	0	73	0.86	8:27	2	0	37	0.44	17:53	
VI-16	Kuningan Madya	5	9	77	0.91	8:28	11	13	39	0.46	17:54	
VI-17	Setiabudi Utara	5	12	84	0.99	8:30	21	24	42	0.49	17:56	
VI-18	Latuharhari (A-B)	0	0	84	0.99	8:32	0	0	42	0.49	17:58	
VI-19	Halimun (A-B)	37	0	47	0.55	8:34	17	0	25	0.29	18:00	
VI-20	Dukuh Atas 2	47		0		8:38	25	0	0		18:05	
	Average Load Factor				0.91						0.36	
Direction (A-B): stations VI-20 to VI-1												
VI-20	Dukuh Atas 2	0	153	153	1.80	6:52	0	104	104	1.22	18:12	
VI-17	Setiabudi Utara	8	0	145	1.71	6:56	6	9	107	1.26	18:17	
VI-16	Kuningan Madya	16	2	131	1.54	6:58	27	3	83	0.98	18:18	
VI-15	Karet Kuningan	17	7	121	1.42	7:00	22	9	70	0.82	18:20	
VI-14	GOR Sumantri	11	4	114	1.34	7:01	15	4	59	0.69	18:21	
VI-13	Depkes	13	0	101	1.19	7:05	17	5	47	0.55	18:25	
VI-12	Patra Kuningan	15	0	86	1.01	7:07	14	2	35	0.41	18:27	
VI-11	Kuningan Timur	8	29	107	1.26	7:09	22	36	49	0.58	18:29	
VI-10	Mampang Prapatan	6	0	101	1.19	7:11	10	5	44	0.52	18:31	
VI-9	Duren Tiga	2	0	99	1.16	7:15	16	3	31	0.36	18:34	
VI-8	Imigrasi	4	0	95	1.12	7:17	6	6	31	0.36	18:36	
VI-7	Warung Jati	7	0	88	1.04	7:19	5	6	32	0.38	18:38	
VI-6	Buncit Indah	2	0	86	1.01	7:22	2	0	30	0.35	18:41	
VI-5	Pejaten	0	0	86	1.01	7:24	6	6	30	0.35	18:43	
VI-4	Jati Padang	1	0	85	1.00	7:26	0	0	30	0.35	18:45	
VI-3	SMK 57	3	0	82	0.96	7:30	5	4	29	0.34	18:50	
VI-2	Departemen Pertanian	8	0	74	0.87	7:35	13	0	16	0.19	18:53	
VI-1	Ragunan	74		0		7:40	16	0	0		18:56	
	Average Load Factor				1.21						0.57	

Survey date; Feb 19th, 2016

Table 4.57 Arrival time and dynamic demand data at all stations of corridor 7

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations VII-1 to VII-17												
VII-1	Kp. Rambutan	0	31	31	0.36	7:35	0	17	17	0.20	17:15	
VII-2	Tanah Merdeka (A-B)	3	22	50	0.59	7:38	0	18	35	0.41	17:18	
VII-3	Fly Over Raya Bogor	0	43	93	1.09	7:43	1	27	61	0.72	17:24	
VII-4	RS. Harapan Bunda	3	15	105	1.24	7:45	0	14	75	0.88	17:27	
VII-5	Pasar Induk	2	10	113	1.33	7:49	3	11	83	0.98	17:31	
VII-6	Pasar Kramat Jati	3	3	113	1.33	7:57	4	3	82	0.96	17:38	
VII-7	PGC/Cililitan	12	10	111	1.31	8:01	9	4	77	0.91	17:42	
VII-8	BKN	17	0	94	1.11	8:03	12	0	65	0.76	17:46	
VII-9	Cawang UKI	19	15	90	1.06	8:05	21	20	64	0.75	17:48	
VII-10	BNN	10	3	83	0.98	8:14	11	2	55	0.65	17:57	
VII-11	Cawang Otista	2	0	81	0.95	8:20	5	0	50	0.59	18:00	
VII-12	Gelanggang Remaja	0	0	81	0.95	8:22	4	0	46	0.54	18:02	
VII-13	Bidara Cina	0	0	81	0.95	8:23	10	0	36	0.42	18:03	
VII-14	Kp. Melayu	81	0	0	0.00	8:24	36	0	0	0.00	18:05	
	Average Load Factor				0.95						0.63	
Direction (A-B): stations VII-17 to VII-1												
VII-14	Kp. Melayu	0	43	43	0.51	6:33	0	49	49	0.58	18:11	
VII-13	Bidara Cina	0	7	50	0.59	6:34	0	7	56	0.66	18:12	
VII-12	Gelanggang Remaja	2	3	51	0.60	6:35	0	3	59	0.69	18:13	
VII-11	Cawang Otista	2	0	49	0.58	6:37	2	0	57	0.67	18:15	
VII-10	BNN	7	0	42	0.49	6:39	8	3	52	0.61	18:17	
VII-9	Cawang UKI	10	7	39	0.46	6:43	9	9	52	0.61	18:20	
VII-8	BKN	0	0	39	0.46	6:46	4	0	48	0.56	18:23	
VII-7	PGC/Cililitan	0	3	42	0.49	6:48	12	4	40	0.47	18:25	
VII-6	Pasar Kramat Jati	0	0	42	0.49	6:50	3	0	37	0.44	18:27	
VII-5	Pasar Induk	2	3	43	0.51	6:55	6	4	35	0.41	18:35	
VII-4	RS. Harapan Bunda	7	0	36	0.42	6:58	10	0	25	0.29	18:38	
VII-3	Fly Over Raya Bogor	24	0	12	0.14	7:00	18	0	7	0.08	18:40	
VII-2	Tanah Merdeka (A-B)	0	0	12	0.14	7:06	1	0	6	0.07	18:44	
VII-1	Kp. Rambutan	12	0	0	0.00	7:10	6	0	0	0.00	18:48	
	Average Load Factor				0.42						0.44	

Survey date; Feb 23rd, 2016

Table 4.58 Arrival time and dynamic demand data at all stations of corridor 8

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations VIII-1 to VII-21												
VIII-1	Teminal Lebak Bulus	0	46	46	0.33	7:45	0	28	28	0.20	17:00	
VIII-2	Pondok Pinang	0	23	69	0.49	7:53	0	20	48	0.34	17:10	
VIII-3	Pondok Indah 1	3	13	79	0.56	7:58	1	26	73	0.52	17:14	
VIII-4	Pondok Indah 2	3	5	81	0.58	8:03	2	22	93	0.66	17:20	
VIII-5	Tanah Kusir Kodam	0	13	94	0.67	8:08	2	7	98	0.70	17:24	
VIII-6	Keb. Lama Bungur	3	5	96	0.69	8:09	2	3	99	0.71	17:25	
VIII-7	Ps. Kebayoran Lama	10	23	109	0.78	8:12	4	14	109	0.78	17:28	
VIII-8	Simprug	3	0	106	0.76	8:17	3	0	106	0.76	17:32	
VIII-9	Permata Hijau	15	0	91	0.65	8:21	8	0	98	0.70	17:36	
VIII-10	RS. Medika Permata Hijau	0	3	94	0.67	8:23	3	2	97	0.69	17:39	
VIII-11	Pos Pengumben	0	3	97	0.69	8:25	0	1	98	0.70	17:42	
VIII-12	Kelapa Dua Sasak	5	10	102	0.73	8:27	0	4	102	0.73	17:44	
VIII-13	Kebon Jeruk	8	15	109	0.78	8:31	5	12	109	0.78	17:48	
VIII-14	Duri Kepa	3	0	106	0.76	8:37	6	0	103	0.74	17:53	
VIII-15	Kedoya Raya	10	0	96	0.69	8:39	6	0	97	0.69	17:56	
VIII-16	Kedoya Green Garden	8	0	88	0.63	8:44	2	0	95	0.68	18:02	
VIII-17	Indosiar (Kor 3)	13	5	80	0.57	8:53	8	3	90	0.64	18:09	
VIII-18	Jelambar (Kor 3)	0	3	83	0.59	8:56	4	2	88	0.63	18:12	
VIII-19	Grogol 1	25	20	78	0.56	8:59	28	0	60	0.43	18:15	
VIII-20	Sumber Waras	5	5	78	0.56	9:00	4	0	56	0.40	18:17	
VIII-21	Harmoni Central Busway	78	0	0		9:08	56	0	0		18:24	
	Average Load Factor				0.64						0.62	
Direction (A-B): stations VIII-21 to VIII-1												
VIII-21	Harmoni Central Busway	0	140	140	1.00	6:19	0	53	53	0.38	18:34	
VIII-a	Petojo	18	9	131	0.94	6:22	0	17	70	0.50	18:37	
VIII-b	Rs Tarakan	22	11	120	0.86	6:25	0	10	80	0.57	18:40	
VIII-c	Tomang Mandala	27	13	106	0.76	6:28	2	34	112	0.80	18:43	
VIII-d	S Parman	16	0	90	0.64	6:35	2	0	110	0.79	18:49	
VIII-18	Grogol 2	40	0	50	0.36	6:40	12	0	98	0.70	18:54	
VIII-17	Jelambar (Kor 3)	13	4	41	0.29	6:41	4	4	98	0.70	18:55	
VIII-16	Indosiar (Kor 3)	2	11	50	0.36	6:43	3	8	103	0.74	18:58	
VIII-15	Kedoya Green Garden	0	0	50	0.36	6:50	4	0	99	0.71	19:04	
VIII-14	Kedoya Raya	2	2	50	0.36	6:52	0	3	102	0.73	19:06	
VIII-13	Duri Kepa	0	2	52	0.37	6:55	4	3	101	0.72	19:09	
VIII-12	Kebon Jeruk	4	2	50	0.36	6:57	12	2	91	0.65	19:11	
VIII-11	Kelapa Dua Sasak	0	0	50	0.36	6:59	9	0	82	0.59	19:13	
VIII-10	Pos Pengumben	2	0	48	0.34	7:01	5	0	77	0.55	19:15	
VIII-9	RS. Medika Permata Hijau	0	0	48	0.34	7:04	1	0	76	0.54	19:18	
VIII-8	Permata Hijau	2	0	46	0.33	7:06	2	0	74	0.53	19:19	
VIII-7	Simprug	0	2	48	0.34	7:15	1	4	77	0.55	19:25	
VIII-6	Ps. Kebayoran Lama	0	0	48	0.34	7:18	11	0	66	0.47	19:29	
VIII-5	Keb. Lama Bungur	2	2	48	0.34	7:22	3	1	64	0.46	19:33	
VIII-4	Tanah Kusir Kodam	0	0	48	0.34	7:23	8	0	56	0.40	19:34	
VIII-3	Pondok Indah 2	7	2	43	0.31	7:25	14	10	52	0.37	19:36	
VIII-2	Pondok Indah 1	7	0	36	0.26	7:31	12	0	40	0.29	19:44	
VIII-1	Teminal Lebak Bulus	36	0	0		7:33	40	0	0		19:47	
	Average Load Factor				0.45						0.58	

Survey date; Feb 25th, 2016

Table 4.59 Arrival time and dynamic demand data at all stations of corridor 9

St. no	Station	Morning Peak					Evening Peak				
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time
Direction (A-B): stations IX-1 to IX-26											
IX-1	Pinang Ranti Station (departure)	0	171	171	1.22	6:25	0	59	59	0.42	17:18
IX-2	Taman Mini	0	20	191	1.36	6:27	0	8	67	0.48	17:21
IX-3	Cawang UKI	0	41	232	1.66	6:40	6	55	116	0.83	17:34
IX-4	BNN	2	6	236	1.69	6:52	5	3	114	0.81	17:44
IX-5	Cawang Ciliwung	3	3	236	1.69	7:08	2	2	114	0.81	17:58
IX-6	Stasiun Cawang Cikoko	3	15	248	1.77	7:11	3	3	114	0.81	18:01
IX-7	Tebet BKPM	9	4	243	1.74	7:13	10	4	108	0.77	18:03
IX-8	Pancoran Tugu	15	9	237	1.69	7:16	8	16	116	0.83	18:08
IX-9	Pancoran Barat	3	8	242	1.73	7:21	3	5	118	0.84	18:13
IX-10	Tegal Parang	9	2	235	1.68	7:23	16	3	105	0.75	18:15
IX-11	Kuningan Barat	28	11	218	1.56	7:25	11	35	129	0.92	18:17
IX-12	Jamsostek Gt. Subroto	13	7	212	1.51	7:31	18	17	128	0.91	18:23
IX-13	Lipi Gt. Subroto	20	2	194	1.39	7:33	16	9	121	0.86	18:25
IX-14	Semanggi	36	11	169	1.21	7:37	13	24	132	0.94	18:29
IX-15	JCC Senayan	7	2	164	1.17	7:38	10	2	124	0.89	18:31
IX-16	Slipi Petamburan	15	2	151	1.08	7:41	7	0	117	0.84	18:34
IX-17	Slipi Kemanggisian	19	3	135	0.96	7:43	5	5	117	0.84	18:36
IX-18	RS. Harapan Kita	15	2	122	0.87	7:49	11	6	112	0.80	18:40
IX-19	Parman Podomoro	28	8	102	0.73	7:52	26	4	90	0.64	18:44
IX-20	Grogol 2	35	4	71	0.51	7:55	21	5	74	0.53	18:47
IX-21	Stasiun Grogol Latumenten	6	0	65	0.46	8:00	15	3	62	0.44	18:52
IX-22	Jembatan Besi	2	1	64	0.46	8:03	1	0	61	0.44	18:55
IX-23	Jembatan Dua	6	0	58	0.41	8:05	3	0	58	0.42	18:57
IX-24	Jembatan Tiga	1	0	57	0.41	8:07	10	0	48	0.35	18:59
IX-25	Penjaringan	11	0	46	0.33	8:09	11	0	37	0.27	19:02
IX-26	Pluit	46	0	0		8:17	37	0	0		19:10
	Average Load Factor				1.17						0.70
Direction (A-B): stations IX-26 to IX-1											
IX-26	Pluit	0	28	28	0.20	8:23	0	38	38	0.27	19:15
IX-25	Penjaringan	0	41	69	0.49	8:29	3	36	71	0.51	19:20
IX-24	Jembatan Tiga	0	12	81	0.58	8:32	0	3	74	0.53	19:23
IX-23	Jembatan Dua	0	6	87	0.62	8:34	0	2	76	0.54	19:25
IX-22	Jembatan Besi	2	30	115	0.82	8:37	0	11	87	0.62	19:28
IX-21	Stasiun Grogol Latumenten	20	8	103	0.74	8:40	8	6	85	0.61	19:31
IX-20	Grogol 2	30	69	142	1.01	8:42	33	3	55	0.39	19:33
IX-19	Parman Podomoro	26	28	144	1.03	8:47	11	3	47	0.34	19:38
IX-18	RS. Harapan Kita	8	2	138	0.99	8:57	4	1	44	0.31	19:47
IX-17	Slipi Kemanggisian	8	6	136	0.97	8:59	7	2	39	0.28	19:49
IX-16	Slipi Petamburan	6	6	136	0.97	9:05	12	9	36	0.26	19:55
IX-15	JCC Senayan	6	2	132	0.94	9:08	6	2	32	0.23	19:58
IX-14	Semanggi	32	14	114	0.81	9:12	31	32	33	0.24	20:02
IX-13	Lipi Gt. Subroto	8	8	114	0.81	9:15	4	16	45	0.32	20:05
IX-12	Jamsostek Gt. Subroto	12	8	110	0.79	9:17	5	40	80	0.57	20:07
IX-11	Kuningan Barat	30	26	106	0.76	9:24	16	55	119	0.85	20:11
IX-10	Tegal Parang	16	6	96	0.69	9:26	11	24	132	0.94	20:13
IX-9	Pancoran Barat	4	6	98	0.70	9:27	5	10	137	0.98	20:14
IX-8	Pancoran Tugu	10	8	96	0.69	9:29	14	11	134	0.96	20:18
IX-7	Tebet BKPM	0	2	98	0.70	9:31	4	4	134	0.96	20:20
IX-6	Stasiun Cawang Cikoko	8	2	92	0.66	9:33	12	3	125	0.89	20:22
IX-5	Cawang Ciliwung	2	4	94	0.67	9:34	6	14	133	0.95	20:23
IX-4	BNN	18	8	84	0.60	9:37	15	5	123	0.88	20:26
IX-3	Cawang UKI	43	41	82	0.59	9:41	51	40	112	0.80	20:33
IX-2	Taman Mini	41	4	45	0.32	9:51	31	3	84	0.60	20:42
IX-1	Pinang Ranti Station (departure)	45		0		9:54	84	0	0		20:45
	Average Load Factor				0.73						0.59

Survey date; Feb 29th, 2016

Table 4.60 Arrival time and dynamic demand data at all stations of corridor 10

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations X-1 to X-22												
X-1	Tanjung Priok Station	0	43	43	0.31	7:15	0	40	40	0.29	17:00	
X-2	Enggano	0	12	55	0.39	7:19	0	5	45	0.32	17:05	
X-3	Permai Koja	0	34	89	0.64	7:24	0	10	55	0.39	17:09	
X-4	Walikota Jakarta Utara	0	6	95	0.68	7:26	0	6	61	0.44	17:12	
X-5	Plumpang Pertamina	0	8	103	0.74	7:30	1	2	62	0.44	17:16	
X-6	Sunter Kelapa Gading	0	2	105	0.75	7:34	9	8	61	0.44	17:21	
X-7	Yos Sudarso Kodamar	0	2	107	0.76	7:40	0	3	64	0.46	17:27	
X-8	Cempaka Mas	17	12	102	0.73	7:41	13	10	61	0.44	17:28	
X-9	Cempaka Putih	4	1	99	0.71	7:45	2	4	63	0.45	17:32	
X-10	Pulomas By Pass	1	8	106	0.76	7:46	3	24	84	0.60	17:33	
X-11	Kayu Putih Rawasari	7	3	102	0.73	7:48	1	5	88	0.63	17:35	
X-12	Pemuda Pramuka	21	6	87	0.62	7:50	18	9	79	0.56	17:37	
X-13	Utan Kayu Rawamangun	2	2	87	0.62	7:51	2	2	79	0.56	17:38	
X-14	Bea Cukai	1	2	88	0.63	7:53	5	2	76	0.54	17:40	
X-15	Stasiun Jatinegara	6	2	84	0.60	7:55	11	9	74	0.53	17:42	
X-16	Pedati	2	3	85	0.61	7:56	4	3	73	0.52	17:43	
X-17	Cipinang Kebon Nanas	0	3	88	0.63	8:00	0	2	75	0.54	17:48	
X-18	Penas Kali Malang	6	1	83	0.59	8:02	3	0	72	0.52	17:51	
X-19	Cawang Sutoyo	0	2	85	0.61	8:06	7	2	67	0.48	17:54	
X-20	Cawang UKI	44	3	44	0.31	8:07	34	3	36	0.26	17:56	
X-21	BKN	3	0	41	0.29	8:11	20	0	16	0.12	18:00	
X-22	PGC 2 (Cililitan)	41	0	0		8:14	16		0		18:03	
	Average Load Factor				0.60						0.45	
Direction (A-B): stations X-22 to X-1												
X-22	PGC 2 (Cililitan)	0	26	26	0.19	8:29	0	12	12	0.09	18:17	
X-21	BKN	0	21	47	0.34	8:31	0	14	26	0.19	18:19	
X-20	Cawang UKI	0	35	82	0.59	8:33	0	14	40	0.29	18:22	
X-19	Cawang Sutoyo	1	1	82	0.59	8:36	1	1	40	0.29	18:25	
X-18	Penas Kali Malang	3	4	83	0.59	8:38	3	3	40	0.29	18:28	
X-17	Cipinang Kebon Nanas	3	1	81	0.58	8:39	2	3	41	0.29	18:30	
X-16	Pedati	0	5	86	0.61	8:42	2	7	46	0.33	18:34	
X-15	Stasiun Jatinegara	4	4	86	0.61	8:43	4	3	45	0.32	18:35	
X-14	Bea Cukai	4	9	91	0.65	8:45	3	18	60	0.43	18:37	
X-13	Utan Kayu Rawamangun	10	1	82	0.59	8:47	8	3	55	0.39	18:39	
X-12	Pemuda Pramuka	8	13	87	0.62	8:49	12	8	51	0.36	18:41	
X-11	Kayu Putih Rawasari	4	3	86	0.61	8:53	5	2	48	0.34	18:45	
X-10	Pulomas By Pass	4	0	82	0.59	8:55	5	0	43	0.31	18:47	
X-9	Cempaka Putih	5	1	78	0.56	8:56	3	0	40	0.29	18:48	
X-8	Cempaka Mas	28	5	55	0.39	9:01	13	15	42	0.30	18:53	
X-7	Yos Sudarso Kodamar	3	1	53	0.38	9:03	7	1	36	0.26	18:55	
X-6	Sunter Kelapa Gading	26	1	28	0.20	9:07	15	1	22	0.16	18:59	
X-5	Plumpang Pertamina	9	0	19	0.14	9:11	3	0	19	0.14	19:04	
X-4	Walikota Jakarta Utara	1	0	18	0.13	9:13	2	0	17	0.12	19:07	
X-3	Permai Koja	10	0	8	0.06	9:15	4	0	13	0.10	19:08	
X-2	Enggano	5	0	3	0.02	9:17	8	0	5	0.04	19:10	
X-1	Tanjung Priok Station	3	0	0		9:20	5	0	0		19:14	
	Average Load Factor				0.43						0.25	

Survey date; Mar 1st, 2016

Table 4.61 Arrival time and dynamic demand data at all stations of corridor 11

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations XI-1 to XI-16												
XI-1	Pulogebang	0	7	7	0.05	7:35	0	4	4	0.03	17:10	
XI-3	Penggilingan	0	0	7	0.05	7:43	1	1	4	0.03	17:18	
XI-2	walikota timur	0	7	14	0.10	7:50	0	11	15	0.11	17:25	
XI-3	Penggilingan (single bus)	0	0	14	0.10	7:51	0	8	23	0.16	17:27	
XI-4	perumnas klender	0	11	25	0.18	7:54	0	4	27	0.19	17:30	
XI-5	raden inten	1	7	31	0.22	7:56	2	4	29	0.21	17:32	
XI-6	buaran	0	3	34	0.24	7:58	2	4	31	0.22	17:35	
XI-7	kampung sumur	0	1	35	0.25	8:02	0	1	32	0.23	17:38	
XI-8	fly over klender	0	0	35	0.25	8:04	3	1	30	0.21	17:41	
XI-9	klender	0	4	39	0.28	8:06	0	0	30	0.21	17:42	
XI-10	cipinang	0	1	40	0.29	8:08	2	2	30	0.21	17:46	
XI-11	imigrasi jakarta timur	0	4	44	0.31	8:10	0	4	34	0.24	17:48	
XI-12	pasar enjo	0	4	48	0.34	8:12	6	1	29	0.21	17:50	
XI-13	fly over jatinegara	8	3	43	0.31	8:14	6	2	25	0.18	17:52	
XI-14	stasiun jatinegara	3	10	50	0.36	8:16	7	12	30	0.21	17:54	
XI-15	rumah sakit primer	0	1	51	0.36	8:19	5	15	40	0.29	17:57	
XI-16	kampung melayu	51	0	0		8:20	40		0		17:58	
	Average Load Factor				0.23						0.18	
Direction (A-B): stations XI-16 to XI-1												
XI-16	kampung melayu	0	22	22	0.16	6:40	0	19	19	0.14	18:10	
XI-14	stasiun jatinegara	0	2	24	0.17	6:46	0	9	28	0.20	18:16	
XI-13	fly over jatinegara	2	5	27	0.19	6:47	2	3	29	0.21	18:17	
XI-12	pasar enjo	2	0	25	0.18	6:49	2	0	27	0.19	18:19	
XI-11	imigrasi jakarta timur	1	1	25	0.18	6:50	3	0	24	0.17	18:20	
XI-10	cipinang	1	1	25	0.18	6:53	0	0	24	0.17	18:22	
XI-9	klender	0	1	26	0.19	6:55	3	3	24	0.17	18:25	
XI-8	fly over klender	2	0	24	0.17	6:56	0	0	24	0.17	18:26	
XI-7	kampung sumur	1	0	23	0.16	6:58	0	2	26	0.19	18:28	
XI-6	buaran	0	0	23	0.16	6:59	4	0	22	0.16	18:29	
XI-5	raden inten	4	0	19	0.14	7:01	5	6	23	0.17	18:31	
XI-4	perumnas klender	2	1	18	0.13	7:02	8	4	19	0.14	18:33	
XI-3	Penggilingan (single bus)	0	0	18	0.13	7:05	0	0	19	0.14	18:38	
XI-2	walikota timur	7	0	11	0.08	7:07	16	0	3	0.02	18:41	
XI-1	Pulogebang	11		0		7:15	3	0	0		18:49	
	Average Load Factor				0.16						0.16	

Survey date; Mar 2nd, 2016

Table 4.62 Arrival time and dynamic demand data at all stations of corridor 12

St. no	Station	Morning Peak					Evening Peak					
		Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	Off-board (pax)	On-board (pax)	On-Bus (pax)	Load Factor	Arrival Time	
Direction (A-B): stations XII-1 to XII-20												
XII-1	Pluit	0	15	15	0.11	6:38	0	53	53	0.38	17:01	
XII-2	Pluit Auto Plaza Landmark	0	4	19	0.14	6:47	0	2	55	0.39	17:09	
XII-3	Pakin	0	6	25	0.18	6:49	0	7	62	0.44	17:10	
XII-4	Gedong Panjang	4	6	27	0.19	6:50	2	2	62	0.44	17:11	
XII-5	Fatahillah	6	6	27	0.19	6:52	0	2	64	0.46	17:13	
XII-6	Kota	8	55	74	0.53	6:55	34	57	87	0.62	17:15	
XII-7	Pangeran Jayakarta	10	4	68	0.49	6:58	6	7	88	0.63	17:17	
XII-8	Mangga Dua ITC	8	6	66	0.47	7:00	18	27	97	0.69	17:19	
XII-9	Gunung Sahari Mangga Dua	2	0	64	0.46	7:03	35	11	73	0.52	17:22	
XII-10	Jembatan Merah	2	17	79	0.56	7:08	15	19	77	0.55	17:27	
XII-11	Kemayoran	2	8	85	0.61	7:22	20	10	67	0.48	17:40	
XII-12	Sunter SMP 140	8	6	83	0.59	7:28	10	13	70	0.50	17:47	
XII-13	Karya	10	8	81	0.58	7:33	23	25	72	0.51	17:51	
XII-14	Sunter Boulevard	11	6	76	0.54	7:43	19	0	53	0.38	17:58	
XII-15	Sunter Kelapa Gading	15	0	61	0.44	7:45	11	2	44	0.31	18:00	
XII-16	Plumpang Pertamina	10	4	55	0.39	7:50	17	0	27	0.19	18:05	
XII-17	Walikota Jakarta Utara	4	0	51	0.36	7:53	5	3	25	0.18	18:08	
XII-18	Permai Koja	11	0	40	0.29	7:56	9	0	16	0.11	18:09	
XII-19	Enggano	5	0	35	0.25	7:59	1	0	15	0.11	18:10	
XII-20	Tanjung Priok Bus Station (departure)	35	0	0	0.00	8:02	15	0	0	0.00	18:13	
	Average Load Factor				0.37						0.40	
Direction (A-B): stations XII-20 to XII-1												
XII-20	Tanjung Priok Bus Station (departure)	0	25	25	0.18	8:18	0	20	20	0.14	18:20	
XII-19	Enggano	0	2	27	0.20	8:21	0	5	25	0.18	18:23	
XII-18	Permai Koja	2	17	42	0.30	8:25	0	13	38	0.27	18:25	
XII-17	Walikota Jakarta Utara	0	6	48	0.35	8:27	2	7	43	0.31	18:27	
XII-16	Plumpang Pertamina	2	23	69	0.50	8:30	3	15	55	0.39	18:30	
XII-15	Sunter Boulevard	2	21	88	0.63	8:35	6	20	69	0.49	18:35	
XII-14	Sunter Kelapa Gading	4	6	90	0.65	8:38	9	17	77	0.55	18:38	
XII-13	Karya	46	21	65	0.47	8:57	22	18	73	0.52	18:55	
XII-12	Sunter SMP 140	11	6	61	0.44	9:06	5	10	78	0.56	19:03	
XII-a	Danau Agung	2	0	59	0.42	9:09	5	5	78	0.56	19:06	
XII-10	Landasan Pacu Timur	6	17	69	0.50	9:17	10	9	77	0.55	19:14	
XII-9	Jembatan Merah	21	11	59	0.42	9:35	18	5	64	0.46	19:31	
XII-8	Gunung Sahari Mangga Dua	4	50	105	0.75	9:39	17	21	68	0.49	19:35	
XII-7	Mangga Dua ITC	25	13	92	0.66	9:42	30	15	53	0.38	19:38	
XII-6	Pangeran Jayakarta	2	0	90	0.65	9:44	6	6	53	0.38	19:40	
XII-5	Kota	65	32	57	0.41	9:50	35	19	37	0.26	19:45	
XII-b	Kali Besar Barat	0	0	57	0.41	9:54	1	0	36	0.26	19:49	
XII-c	Bandengan selatan	6	2	53	0.38	9:57	4	0	32	0.23	19:53	
XII-d	Jembatan Tiga			53	0.38	10:00	2	0	30	0.21	19:56	
XII-e	Penjaringan	38	61	76	0.54	10:04	27	3	6	0.04	20:00	
XII-1	Pluit	76	0	0	0.00	10:10	6		0	0.00	20:08	
	Average Load Factor				0.44						0.34	

Survey date; Mar 4th, 2016

4.1.6 General characteristics of Bangkok BRT

Bangkok BRT, Thailand is operated by the Bangkok Metropolitan Administration. It was officially launched in 2010 with only one corridor. Bangkok BRT interchanges with BTS skytrain at both start and end stations; i.e., Sathorn and Ratchapruk stations. There are 15,000 daily passengers being served by 20 units of operating buses (ITDP, 2015b). In order to understand the characteristics of Bangkok BRT, the field studies were conducted on September 4th, 2015 for preliminary survey and on September 14th, 2015 for dynamic survey. The total route length of Bangkok BRT is 15.1 kilometers of which 8.5 kilometers of route is mixed traffic portions. There are twelve stations located along the median of the road, as shown in **Figure 4.4**.

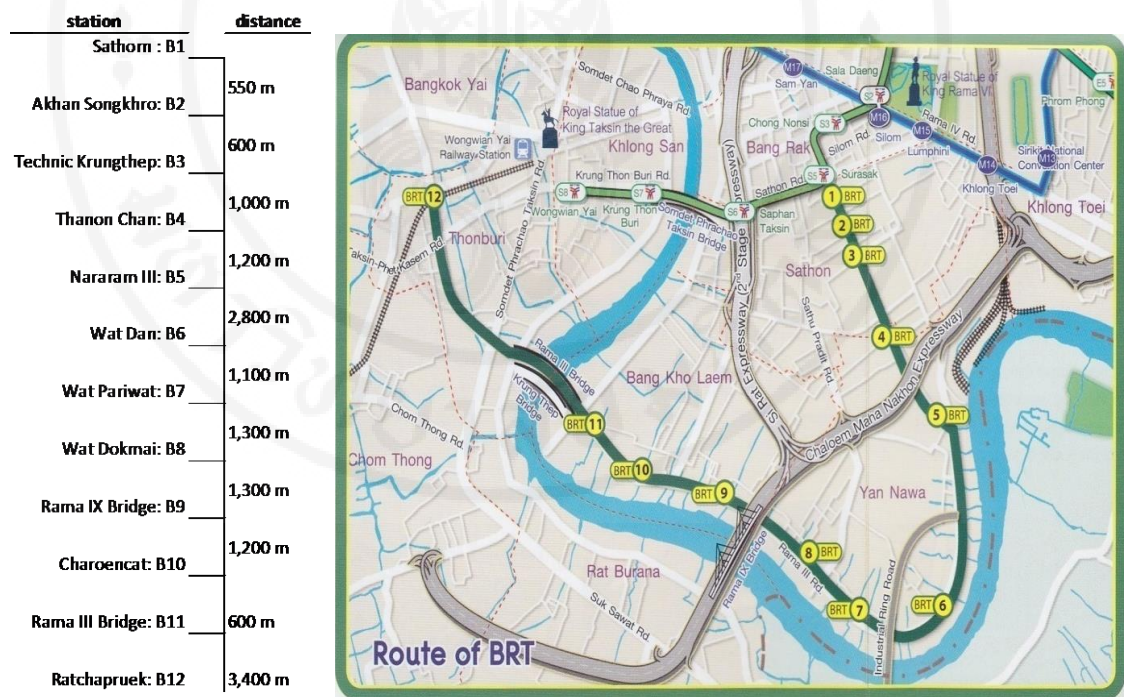


Figure 4.4 Bangkok BRT route map and distance between stations

Source: Thaibis (2010)

The system is served by medium air-conditioned buses with 20 seating capacity and 34 standing capacity each that provide single door access to the right hand side of the buses. Bangkok BRT uses NGV buses which are environmentally friendly. The on-board information system is online showing the arriving station with

both visualization on the screen and announcement from the speaker. The BRT system provides one exclusive seat for disabled people and space for wheelchair. The visualization of facilities can be seen in **Figure 4.5**.



Figure 4.5 a) Bangkok's NGV bus, b) One entrance-door, c) Interior, d) LCD screen

Bangkok BRT system is using high-floor of platform with two types of stations; i.e., protected platform with automatic sliding glass door and opened platform. The arrival section for all stations is opened platform, but only in Sathorn and Ratchapruek station are using protected platform in the departure section. The stations are accessible for wheelchair and disabled people, as shown in **Figure 4.6**.



Figure 4.6 Bangkok BRT's station, a) & b) Opened platform, c) Protected platform, d) Information screen at the station, e) Direction sign, f) Handicapped facility

Bangkok BRT uses off-board fare collection method in the form of smart card. The smart card can be obtained through ticketing machine for single-trip.

Bangkok BRT provides also the personal card for multiple trips that can be obtained and topped up through the counter at the stations. The fare is flat at 12 to 20 Baht per trip, it depends on the distance. The visualization can be seen in **Figure 4.7**.

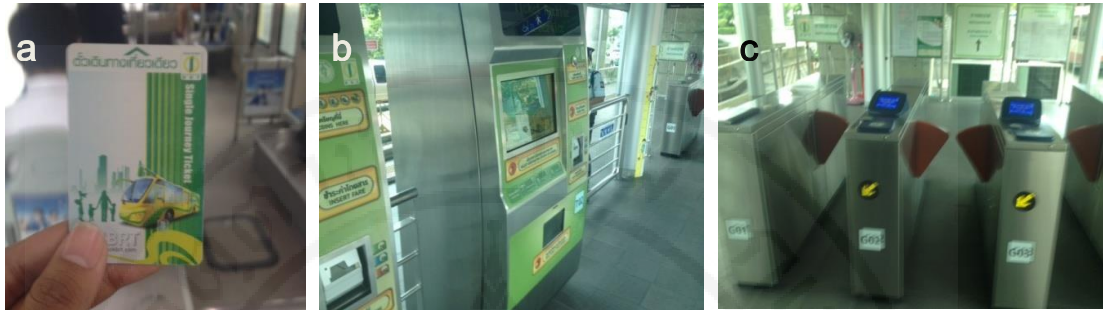


Figure 4.7 a) Smart-card ticket, b) Ticketing machine, c) Barrier at the station

4.2 Comparison study of BRT in Jakarta and Bangkok

4.2.1 Comparison study of physical and operational aspects

Having studied about BRT in Jakarta and Bangkok, the comparison for physical and operational aspects can be analyzed. However, the comparison study based on standard features of BRT are analyzed. Both TransJakarta and Bangkok BRT are qualified as standard BRT. How far they are from being full BRT can be compared with the minimum features of full BRT system given in Wright & Hook (2007). The comparison of BRT based on standard features is shown in Table 4.63.

Table 4.63 The comparison results between TransJakarta and Bangkok BRT with respect to standard BRT features

No	Standard BRT Features	TransJakarta	Bangkok BRT
1	Segregated busways or bus-only lane	✓	✓
2	Integrated of routes and corridors	✓	x
3	Enhanced station with special level of platform	✓	✓
4	Special stations and terminals to facilitate transfer	✓	I
5	Passing lane at station	✓	x
6	High average travel speeds (>20 km/h)	x	✓
7	Actual peak ridership over 8,000 passengers per hour per direction (pphpd)	✓	x
8	Pre-board fare collection	✓	✓
9	Physical- and fare- integration between routes, corridors and feeder services	✓	✓
10	Self-financing or no need operational subsidies	x	x
11	Low-emission vehicle technology (Euro III or higher)	✓	✓
12	Automated fare collection and verification system	✓	✓
13	Utilizing automatic vehicle location system or GPS	x	✓
14	Signal priority or grade separation at intersections	x	x
15	High-quality customer information (e.g., clear maps, real-time information displays)	✓	✓
16	Modal integration at stations (e.g., bicycle parking, taxi stations, easy transfer between public transport systems)	✓	✓
17	Facility for disabled people	x	✓

Note: ✓ =yes; x=no; I=insufficient network

For TransJakarta, 5 features of full BRT are not fulfilled by the current system. These features are standard travel speed, self-financing, automatic vehicle location system, signal priority or grade separation at intersections, and facility for the disabled. Meanwhile, for Bangkok BRT, 4 standard features are not fulfilled by the current system. They are passing lane at the station, actual peak ridership, self-financing, and signal priority or grade separation at intersections features. There are

two features; i.e., special station to facilitate transfer and integrated corridors features that are not possible to be fulfilled because only one corridor is operated.

Furthermore, the qualitative data are identified in order to get the physical characteristics, including structures and infrastructures of TransJakarta and Bangkok BRT. The comparison of BRT features regarding physical aspects can be seen in Table 4.64.

Table 4.64 The comparison between TransJakarta and Bangkok BRT based on physical aspect

No	Physical aspects	TransJakarta	Bangkok BRT
1	Location of busways	Median	Median
2	Location of entrance doors	Front, middle, & rear (right side)	Middle (right side)
3	Type of surface material on runways	Asphalt	Asphalt
4	Type of surface material on runways at stations	Concrete	Concrete
5	Type of vehicles	Articulated (18m) and regular (12m) buses	Regular (8m) bus
6	Fuel type used by vehicles	CNG	CNG

In terms of physical characteristics, the difference between the two systems is about the type of vehicle and entrance door. TransJakarta can accommodate the large number of demand due to the high capacity of buses. However, the operation and performance characteristics affect also the system capacity, not just the fleet size.

In terms of operation, the system operation must be frequent. Many features must be arranged to make sure the frequency of BRT operation. The comparison of operational characteristics between TransJakarta and Bangkok BRT can be seen in Table 4.65.

Table 4.65 The comparison between TransJakarta and Bangkok BRT based on operational aspect

No	Operation aspect	TransJakarta	Bangkok BRT
1	Year system commenced	2004	2010
2	Number of existing corridors	12	1
3	Number of corridors with the existence of direct routes	-	-
4	Total length of existing corridors	211 km	15.1 km
5	Percentage of segregated lanes	93.4%	33.6%
6	Percentage of opened lanes (%)	6.6%	66.4%
7	Number of stations	465	12
8	Average distance between stations	909 m	1,368 m
9	Number of stations with passing lanes	6	0
10	Type of fare collection / verification technology	Smart card	Smart card
11	Number of intersection with priority signal control	-	-
12	Number of grade-separated intersections	-	-
13	Fare (USD)	3,500 Rupiahs (0.35 USD)	12 Baht (0.34 USD)

Based on the observation of operation, TransJakarta's fleet movement is more protected. Over the total route length of 211 km, 196 km of bus lanes are protected by curb and 15 km of lanes are mixed traffic. For Bangkok BRT, the total route length is 15 km with around 5 km of bus lanes are protected and 10 km of lanes are mixed traffic. In the case of priority signal at intersection, both systems are not given.

4.2.2 Comparison study of performance aspect

The basic operational performance indicators; i.e., travel speed and load factor are analyzed. For safety reason, the spot speed cannot be more than 60 kph. However, if we discuss about travel speed as the average speed between origin and destination, the benchmark of 25 kph is the acceptable minimum speed of BRT. Having speed lower than 25 kph makes it closely similar to the conventional bus service. The performance analysis was carried out based on the data from dynamic and static surveys during two peak periods. Beside speed and time, the convenience is

usually in the passenger's expectation. The in-vehicle level of convenience may be measured by load factor (volume per capacity). The load factor of more than 0.85 is leading to the inconvenience for passengers. The comparison of basic performance characteristics is summarized in Table 4.66.

Table 4.66 The comparison between TransJakarta and Bangkok BRT based on travel speed and load factor

BRTS	Morning peak		Evening peak	
	Average load factor	Travel speed (km/hr)	Average load factor	Travel speed (km/hr)
<i>TransJakarta</i>				
Corridor 1	0.58	16	0.69	16
Corridor 2	0.50	13	0.30	13
Corridor 3	0.62	14	0.39	13
Corridor 4	0.49	16	0.47	17
Corridor 5	0.33	15	0.38	17
Corridor 6	1.06	17	0.46	18
Corridor 7	0.68	18	0.53	17
Corridor 8	0.54	19	0.60	19
Corridor 9	0.95	17	0.65	17
Corridor 10	0.52	21	0.35	19
Corridor 11	0.19	20	0.17	19
Corridor 12	0.40	17	0.37	19
<i>Bangkok BRT</i>				
Bangkok BRT	0.34	28	0.39	26

In terms of travel speed, TransJakarta can only reach 17 kph on average in the morning-peak period and also 17 kph in the evening-peak period. Overall, for TransJakarta the travel speed becomes a big problem due to lower than 25 kph benchmark. Among 12 corridors, only corridor 10 can closely reach the standard travel speed of rapid system. On the other side, Bangkok BRT can perform better with travel speed of 28 kph and 26 kph in the morning-peak and evening-peak, respectively. Bangkok BRT can perform above the 25 kph benchmark.

In terms of load factor, there are two corridors with suffered load factor (>0.85) in the morning-peak period. They are corridor 6 and corridor 9 with severe load factors of 1.06 and 0.91 respectively. On the other side, the lone corridor of

Bangkok BRT has no problem with the average load factor during both peak periods. Overall the general performance characteristics that represented the whole system are summarized in Table 4.67.

Table 4.67 The comparison between TransJakarta and Bangkok BRT based on general performance aspect

No	Performance aspect	TransJakarta	Bangkok BRT
1	Average daily demand (passengers)	350,000	15,000
2	the percentage of daily traveler using BRT (BRT's daily demand/daily traffic volume)	0.66%	0.06%
3	Average load factor	0.5	0.37
4	Average travel speed (km/h)	18 km/h	27 km/h
5	Average peak headway (minutes)	5 mins	5 mins
6	Average non-peak headways (minutes)	10 mins	10 mins
7	Average dwell time at stations (seconds)	26 sec	15 sec

Overall, the Bangkok BRT tends to be a more convenient system with acceptable load factor and faster travel speed. However, the system has only one corridor that serves about 15,000 passengers per day. The level of interest for using BRT system is still low. As compared with the amount of 25 million person-trips per day in Bangkok Metropolitan Region (Bangkok + Patumthani + Nonthaburi), the percentage of daily travelers using BRT mode is up to 0.06% only. The low level of mode choice for BRT is due to the small service area. The current role of Bangkok BRT's system is just the feeder service to the rail-based mass transit at Chongnonsee and Wongwian Yai stations.

The different condition is experienced by TransJakarta. The travel speed and load factor for several corridors tend to be the failure. This condition shows that there are many constraints in the movement of operation bus of TransJakarta. Even though more 90% of its lanes are protected, the external factors from mixed traffic seem to strongly affect the operation of BRT in Jakarta. On the other hand, Jakarta has high traffic volume during weekdays because it is both a major origin and destination of people from other nearby cities; i.e., Bogor, Depok, Tangerang, and Bekasi. These cities are considered as agglomeration area called Jabodetabek. Hence, TransJakarta has a very large service area that serves about 350,000 passengers daily. As compared

with the estimated travel demand of 53 million person-trips per day, the percentage of daily travelers using BRT is up to 0.66%. As mentioned before, TransJakarta system role is the core public transportation system which integrated directly and indirectly with the commuter line (rail system), bus stations, and the central business districts in Jakarta.

4.3 Performance evaluation, problem identification, and proposed strategies for TransJakarta

Following the framework in **Figure 3.6**, the performance evaluation process must be taken to identify the problem, then the suitable strategies are proposed based on the problem identification. The analysis is done for every corridor. They are described on by one below.

4.3.1 Corridor 1

Corridor 1 is the most congested corridor among the other corridors. The route passes through 20 stations in both directions. The total distance network is 13.6 km. The route of corridor 1 and the station points are shown in **Figure 4.8**.

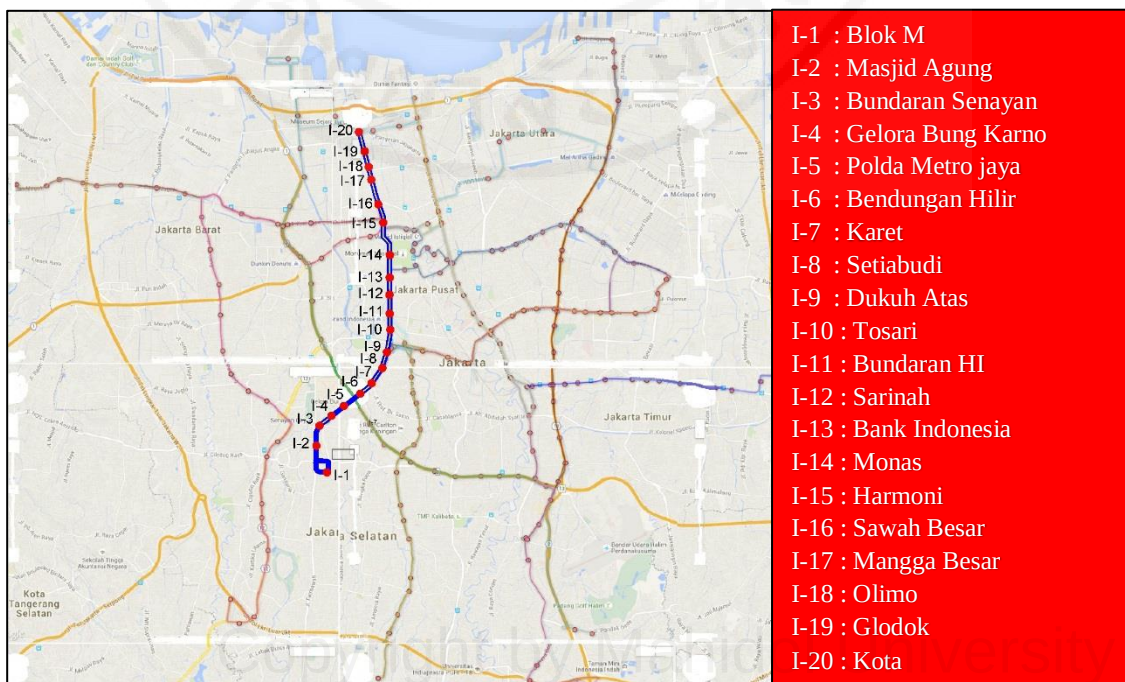


Figure 4.8. The route map of corridor 1

The performance evaluation has been done for corridor 1. As mentioned before, there are 8 parameters which are grouped into three aspects; i.e., travel time, system capacity, and service reliability.

1) Travel time and travel speed

Travel time is the main performance indicator of BRT as the rapid system. Travel time is a function of travel speed and trip length. **Figure 4.9** shows the average of travel time and travel speed between stations and also the average of travel time and travel speed from start to finish stations.

Direction (A-B) Morning Peak	
Station:	I-1 I-2 I-3 I-4 I-5 I-6 I-7 I-8 I-9 I-10 I-11 I-12 I-13 I-14 I-15 I-16 I-17 I-18 I-19 I-20
Distance:	1,401 987 573 519 798 432 569 541 795 577 626 585 746 1,277 581 941 325 510 836 meters Total: 13,619 meters
Travel speed	5 20 17 31 24 46 24 35 13 12 15 10 12 28 20 15 13 km/hr Total: 14.1 km/hr
TT:	16 3 2 1 2 2 2 2 2 1 3 3 3 8 3 2 1 2 4 mins Total: 58 mins
Direction (A-B) Evening Peak	
Station:	I-1 I-2 I-3 I-4 I-5 I-6 I-7 I-8 I-9 I-10 I-11 I-12 I-13 I-14 I-15 I-16 I-17 I-18 I-19 I-20
Distance:	1,401 987 573 519 798 432 569 541 795 577 626 585 746 1,277 581 941 325 510 836 meters Total: 13,619 meters
Travel speed	6 12 17 8 24 31 24 17 19 18 22 11 17 28 20 15 17 km/hr Total: 14.1 km/hr
TT:	15 5 2 4 2 3 2 2 2 2 2 7 2 2 1 2 3 mins Total: 58 mins
Direction (B-A) Morning Peak	
Station:	I-20 I-19 I-18 I-17 I-16 I-15 I-14 I-13 I-12 I-11 I-10 I-9 I-8 I-7 I-6 I-5 I-4 I-3 I-2 I-1
Distance:	836 510 325 941 581 1,277 746 585 626 577 795 541 569 432 798 519 573 987 1,401 meters Total: 13,619 meters
Travel speed	13 31 20 28 12 10 22 12 13 17 16 46 48 16 17 20 28 km/hr Total: 18.2 km/hr
TT:	4 1 1 2 3 8 2 3 3 2 3 2 1 2 2 2 3 3 mins Total: 45 mins
Direction (B-A) Evening peak	
Station:	I-20 I-19 I-18 I-17 I-16 I-15 I-14 I-13 I-12 I-11 I-10 I-9 I-8 I-7 I-6 I-5 I-4 I-3 I-2 I-1
Distance:	836 510 325 941 581 1,277 746 585 626 577 795 541 569 432 798 519 573 987 1,401 meters Total: 13,619 meters
Travel speed	17 31 20 28 17 9 22 18 19 35 16 31 24 16 17 12 21 km/hr Total: 17.8 km/hr
TT:	3 1 1 2 2 9 2 2 2 1 3 3 2 2 2 5 4 mins Total: 46 mins

Figure 4.9. Travel time, travel speed, and distance between stations of corridor 1

Based on the segmental-travel speed between stations (failure travel speed expressed by red numbers), the delay occurred on 84% of all segments in the first direction (A-B) and 76% of all segments in the second direction (B-A). Overall, the average travel speed of corridor 1 reaches 14 km/hour during the morning-peak period and 18 km/hour during the evening-peak period. It means that the travel speed is below the standard of 25 km/hour. More segments got delayed during evening-peak period, but lower speed during morning-peak period. As a result, the travel time of corridor 1 is failure in both directions as the rapid transit system.

2) System capacity

System capacity is very crucial in terms of passenger satisfaction. There are 51 units of articulated bus (140 of passenger capacity) which serve the corridor 1. There are 19 stations with single platform and 1 integrated stations with triple platforms. From the equation (3.1), the system capacity of corridor 1 is 1,428 pphpd (passenger per peak-hour per direction) or 2,856 passengers/hour with the trip frequency of 12 vehicles/hour. The number of passengers in the rush hour (between 17:00 and 18:00 o'clock) is 8,467. As the result, the system capacity of corridor 1 cannot accommodate the actual daily demand. **Figure 4.10** shows the picture of passenger's crowd at Station I-1 and station I-21.



Figure 4.10. The passenger's crowd at station I-1 (left) and station I-21 (right)

The lack in corridor capacity is because of the lack in trip frequency and infrastructure mostly due to the station has single platform in this very congested corridor.

3) Service reliability

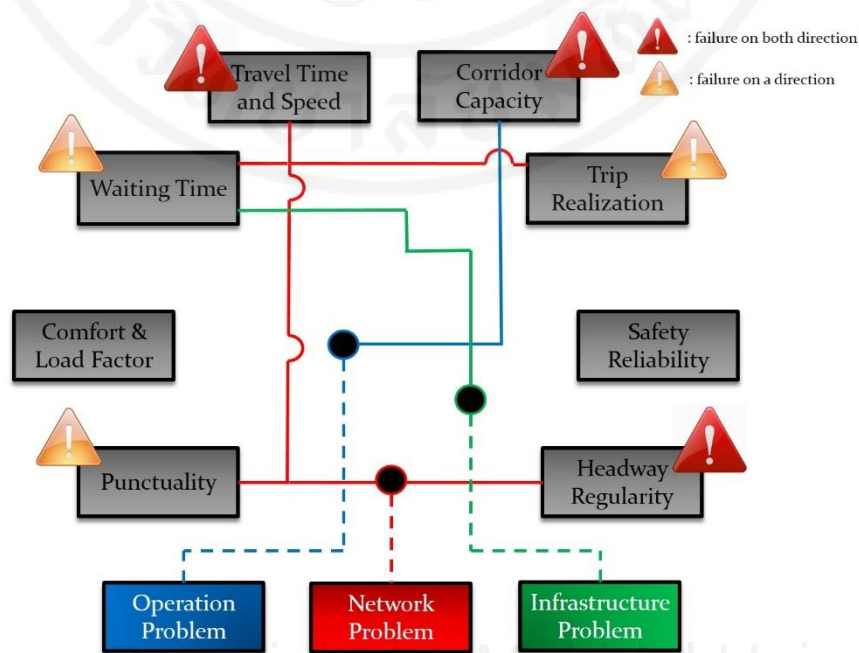
Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 1 is summarized in Table 4.68 below.

Table 4.68 Service reliability of corridor 1

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	85%	62%
Trip realization	98%	100%	81%
Punctuality at the start	85%	73%	14%
Punctuality at the complete	85%	38%	62%
Headway regularity	85%	88%	62%
Comfort and load factor	0.85	0.49	0.77

The failure in waiting time is found in the second direction (B-A). There is 62% of passengers has waiting time within 5 minutes during peak-hour as a benchmark, but it is still below the standard of 85%. The second direction (B-A) also failed to execute all the assigned-trip frequency during peak hour. The failure in punctuality is found in both directions. The irregular headway of arrival time occurred in the second direction (B-A). In terms of average load factor, both directions have load factors below 0.85. These are acceptable for convenience of passengers.

Based on the performance evaluation, the problem identification and strategy determination is expressed in **Figure 4.11**.

**Figure 4.11.** The problem identification of corridor 1

As shown in **Figure 4.11**, corridor 1 faces the problem in three aspects; i.e., operational, network, and infrastructure. The following strategies are considered.

1) Operational aspect

According to the framework in **Figure 3.6**, operational problem deals with the frequency and headway. In case of the corridor 1 with normal-average travel time of 29 minutes, there are 3,979 pphd (passenger per peak hour per direction) for the first direction (A-B) and 4,488 pphpd for the second direction (B-A) which are served by articulated bus with 140 passengers of capacity. Then, the calculation by equation (3.9) found that 17 units per peak hour is the minimum number of buses, then the headway is 212 seconds to satisfy the demand, on the other hand the allocated bus for corridor 1 is 51 units (operation and non-operation). It means that the availability of buses is sufficient. In this case increasing trip frequency by decreasing headway from 5 minutes to 3 minutes 32 seconds becomes the second scenario. By increasing the frequency, the all demands can be accommodated within the acceptable load factor and waiting time.

2) Network aspect

Network problem deals with the link and the node. In the case of corridor 1, there are 12 junctions with phasing signal management along the route and there are 4 segments with mixed traffic along the route. The mixed-traffic restriction and priority signal strategies are simulated directly in the simulation by considering the space and another possibility. These strategies form the package for third scenario. By giving the priority to BRT fleet's movement, the delay can be minimized.

3) Infrastructure aspect

According to the framework in **Figure 3.6**, Infrastructure problem deals with the station and busway. The conflict usually occurs at the station which involves more than one corridor, it is called integrated station. In the case of corridor 1, there is 1 of the 3 integrated stations with extra platform and passing lane; i.e., station I-15. While, it also the largest and most congested station of TransJakarta with triple platforms per direction, it is also installed with the passing lane. While, there is still

bus queues for dwelling at the other integrated station, the **Figure 4.12** shows the bus queue at the station I-14.



Figure 4.12. The buses take a queue for dwelling at Monas station (station I-14)

The installation of extra platform and passing lane at station I-15 become the package of the fourth scenario for corridor 1. By installing more platform on the integrated stations, the queue of dwelling time can be avoided.

4.3.2 Corridor 2

The route of corridor 2 passes through 20 stations along the first direction (A-B) and 17 stations along the second direction (B-A). There are 24 stations which are located on this corridor. The total distance network is 12.96 km for the first direction (A-B) and 11.8 km for the second direction. The route of corridor 2 and the station points are shown in **Figure 4.13**.

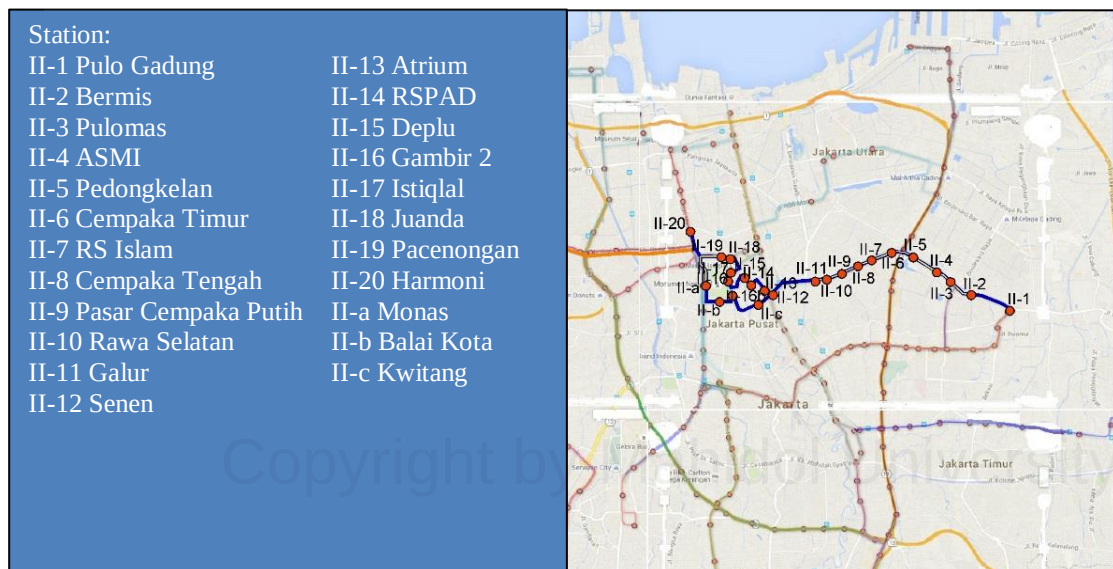


Figure 4.13. The route map of corridor 2

The eight parameters which are distinguished into 3 aspects of performance; i.e., travel time, system capacity, and service reliability are described next.

1) Travel time and travel speed

The travel time and travel speed of corridor 2 are shown in **Figure 4.14**. It shows the overall and segmental travel time and travel speed between stations.

Direction (A-B) Morning Peak	
Station:	II-1 II-2 II-3 II-4 II-5 II-6 II-7 II-8 II-9 II-10 II-11 II-12 II-13 II-14 II-15 II-16 II-17 II-18 II-19 II-20
Distance:	1,480 778 548 802 767 664 471 500 529 372 1,508 259 649 349 862 321 776 289 1,045 meters Total: 12,969 meters
Travel speed	15 9 16 24 12 40 14 30 16 22 5 8 19 21 13 19 23 17 13 km/hr Total: 12.6 km/hr
TT:	6 5 2 2 4 1 2 1 2 1 18 2 2 1 4 1 2 1 5 mins Total: 62 mins
Direction (A-B) Evening Peak	
Station:	II-1 II-2 II-3 II-4 II-5 II-6 II-7 II-8 II-9 II-10 II-11 II-12 II-13 II-14 II-15 II-16 II-17 II-18 II-19 II-20
Distance:	1,480 778 548 802 767 664 471 500 529 372 1,508 259 649 349 862 321 776 289 1,045 meters Total: 12,969 meters
Travel speed	11 7 16 24 7 40 28 30 16 11 7 8 19 21 13 10 23 17 10 km/hr Total: 11.8 km/hr
TT:	8 7 2 2 7 1 1 1 2 2 13 2 2 1 4 2 2 1 6 mins Total: 66 mins
Direction B-A Morning Peak	
Station:	II-20 II-a II-b II-16 II-c II-12 II-11 II-10 II-9 II-8 II-7 II-6 II-5 II-4 II-3 II-2 II-1
Distance:	980 1,205 634 115 556 1,497 370 524 504 472 667 765 807 549 776 1,367 meters Total: 11,788 meters
Travel speed	8 14 38 7 3 22 22 31 15 28 20 15 24 16 12 27 km/hr Total: 13.6 km/hr
TT:	7 5 1 1 13 4 1 1 2 1 2 3 2 2 4 3 mins Total: 52 mins
Direction B-A Evening Peak	
Station:	II-20 II-a II-b II-16 II-c II-12 II-11 II-10 II-9 II-8 II-7 II-6 II-5 II-4 II-3 II-2 II-1
Distance:	980 1,205 634 115 556 1,497 370 524 504 472 667 765 807 549 776 1,367 meters Total: 11,788 meters
Travel speed	12 12 38 7 3 22 22 16 15 28 20 15 24 16 16 41 km/hr Total: 14.7 km/hr
TT:	5 6 1 1 11 4 1 2 2 1 2 3 2 2 3 2 mins Total: 48 mins

Figure 4.14. Travel time, travel speed, and distance between stations of corridor 2

There is only few segment along corridor 2 which has travel speed more than 25 km/hour. The delay occurred on 84% of all segments in the first direction (A-B) and 78% of all segments in the second direction (B-A). The average travel speed during both peak periods doesn't meet the required value. The average travel speed of corridor 2 is about 13 km/hour during both peak periods. As a result, the travel time of corridor 2 is failure in both directions as the rapid transit system.

2) System capacity

In terms of capacity, corridor 2 is served mostly by 13 units of articulated bus, also there are 20 units of regular bus which are allocated as the substitution. There

are 18 stations with single platform, 5 stations with double platforms, and 1 station with triple platforms. From the equation (3.1), the system capacity of corridor 2 is 1,547 pphpd (passengers per peak hour per direction) or 3,094 passengers/hour with the trip frequency of 13 vehicles/hour. The number of passengers in the rush hour (between 06:00 and 07:00 o'clock) is 2,249. As a result, the system capacity of corridor 2 still can accommodate the actual daily demand.

3) Service reliability

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 2 is summarized in Table 4.69 below.

Table 4.69 Service reliability of corridor 2

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	70%	50%
Trip realization	98%	77%	65%
Punctuality at the start	85%	70%	47%
Punctuality at the complete	85%	13%	50%
Headway regularity	85%	55%	38%
Comfort and load factor	0.85	0.51	0.29

Almost all parameters in corridor 2 in both directions are failed, except the load factor. The waiting time is worse in the second direction (B-A), it is only 50% of passengers in peak hour has waiting time within 5 minutes. The suffered waiting time on corridor 2 occurred because of the delaying in the network instead of operation. Both directions also failed for executing all assigned-trip frequency. The punctuality of both directions are also failed. In the first direction even only 13% the arrival time is on schedule. The headway of both directions are also unreliable. The low service reliability will discourage people to use BRT in corridor 2. While, the load factor of both directions are quite low.

Based on the performance evaluation, the framework to identify the problem and determine the strategy is expressed in **Figure 4.15**.

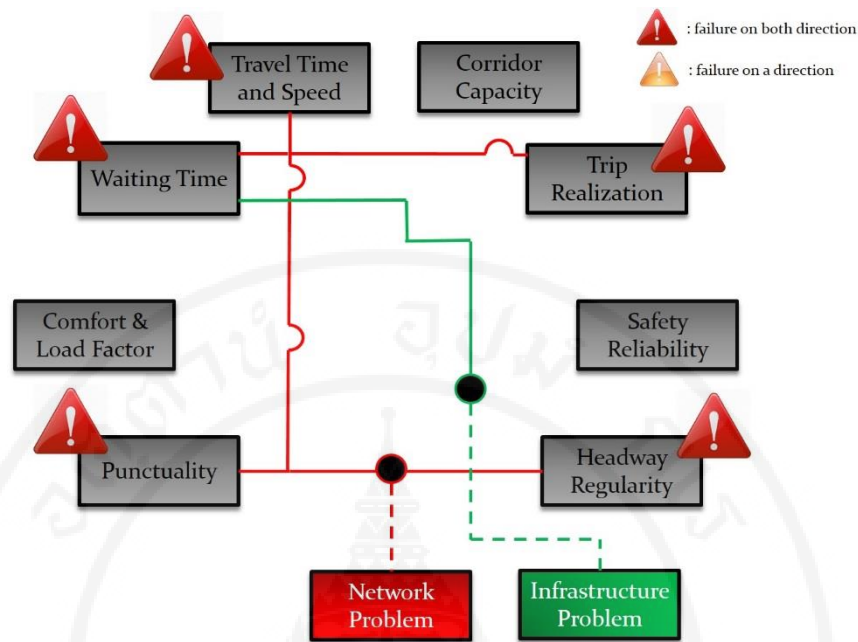


Figure 4.15. The problem identification of corridor 2

As shown in **Figure 4.15**, corridor 2 faces the problem in two aspects; i.e., network, and infrastructure. The following strategies are considered.

1) *Network aspect*

Network deals with the link and node. In the case of corridor 2, there are 12 signalized intersections and 3 intersections without phasing signal management along the route. There are 14 segments along the route which are still open lane. As the impact, there are many conflicts along the route of corridor 2 due to mixed traffic. The mixed-traffic restriction and priority signal might be the best strategies to enhance the travel speed of corridor 2. While, they are simulated directly in the simulation for assessment by considering the space and another possibility. These strategies form the package for second scenario. By giving the priority to BRT fleet's movement, the delay in the network can be minimized.

2) *Infrastructure aspect*

According to the framework in **Figure 3.6**, Infrastructure problem deals with the station and the busway. In the case of corridor 2, there are 4 corridors are involved in this corridor's network. While, there are 5 stations which are integrated with the other corridors. Among those integrated stations, there 2 stations have more

than 1 platform with passing lane, 1 station has double platforms without passing lane, and 2 station with only single platform. As for, the **Figure 4.12** above shows the queue between bus of corridor 1 and corridor 2. The enhancement considers the space and the other possibilities. As a decision, the strategies in term of infrastructure in order to enhance the corridor 2; i.e.:

- Installation of extra platform and passing lane at station II-a;
- Installation of passing lane at station II-18.

These strategies form the package for third scenario. By installing more platform on the integrated stations, the queue of dwelling time can be avoided.

4.3.3 Corridor 3

The corridor 3 connect the Kalideres and Pasarbaru districts. It passes through 16 stations in both directions. The total network is 14.97 km. The route of corridor 3 and the station points are shown in **Figure 4.16**.

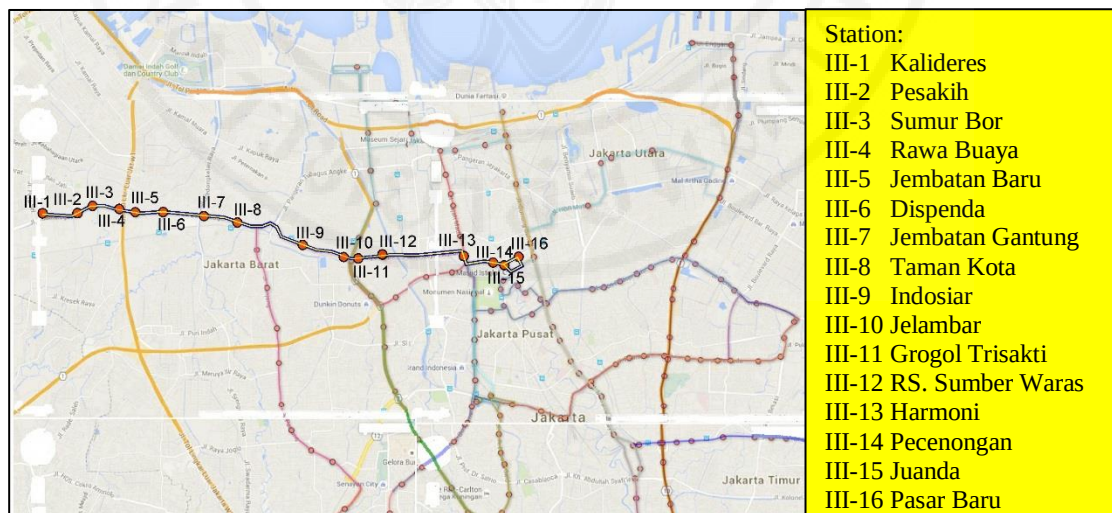


Figure 4.16. The route map of corridor 3

The performance evaluation has been done for corridor 3. As mentioned before, the 8 parameters are grouped into three aspects; i.e., travel time, system capacity, and service reliability. They are described one by one below.

1) Travel time and travel speed

Based on the data result, the travel speed and travel time are performed by segment and trip during 2 peak periods. As shown in **Figure 4.17**.

Direction A-B		Moring peak															
Station:	III-1	III-2	III-3	III-4	III-5	III-6	III-7	III-8	III-9	III-10	III-11	III-12	III-13	III-14	III-15	III-16	
Distance:	1,133	480	811	473	834	1,109	974	2,238	1,306	335	798	2,746	943	281	512	meters	Total: 14,973 meters
Travel speed:	5	7	12	9	17	7	4	10	26	10	24	24	9	17	31	km/hr	Total: 10.4 km/hr
TT:	13	4	4	3	3	10	14	13	3	2	2	7	6	1	1	mins	Total: 86 mins
Direction A-B		Evening peak															
Station:	III-1	III-2	III-3	III-4	III-5	III-6	III-7	III-8	III-9	III-10	III-11	III-12	III-13	III-14	III-15	III-16	
Distance:	1,133	480	811	473	834	1,109	974	2,238	1,306	335	798	2,746	943	281	512	meters	Total: 14,973 meters
Travel speed:	6	7	12	14	17	10	5	11	20	10	24	27	11	17	15	km/hr	Total: 11.5 km/hr
TT:	12	4	4	2	3	7	12	12	4	2	2	6	5	1	2	mins	Total: 78 mins
B-A		Moring peak															
Station:	III-16	III-15	III-14	III-13	III-12	III-11	III-10	III-9	III-8	III-7	III-6	III-5	III-4	III-3	III-2	III-1	
Distance:	512	281	943	2,746	798	335	1,306	2,238	974	1,109	834	473	811	480	1,133	meters	Total: 14,973 meters
Travel speed:	10	17	8	21	24	7	26	27	29	22	17	9	24	14	17	km/hr	Total: 17.6 km/hr
TT:	3	1	7	8	2	3	3	5	2	3	3	3	2	2	4	mins	Total: 51 mins
B-A		Evening peak															
Station:	III-16	III-15	III-14	III-13	III-12	III-11	III-10	III-9	III-8	III-7	III-6	III-5	III-4	III-3	III-2	III-1	
Distance:	512	281	943	2,746	798	335	1,306	2,238	974	1,109	834	473	811	480	1,133	meters	Total: 14,973 meters
Travel speed:	15	8	9	18	24	7	16	13	12	17	13	14	16	29	17	km/hr	Total: 14.5 km/hr
TT:	2	2	6	9	2	3	5	10	5	4	4	2	3	1	4	mins	Total: 62 mins

Figure 4.17. Travel time, travel speed, and distance between stations of corridor 3

Most segments have the average travel speed below 25 km/hour. The delay occurred on 90.6% of all segments in the first direction (A-B) and 87.5% of all segments in the second direction (B-A). The failures of travel speed occurred on the most segment between stations along the route. Overall, the travel speed of corridor 3 reach about 14 km/hour during morning-peak period and about 13 km/hour during evening-peak period. As a result, the travel time of corridor 3 is failure in both directions as the rapid transit system.

2) System capacity

System capacity is performed by corridor capacity. The 11 units of articulated bus (140 of capacity) and 22 units of regular bus (85 of capacity) serve the corridor 3. There are 8 stations with single platform, 7 stations with double platforms,

and 1 station with triple platforms. From the equation (3.1), the system capacity of corridor 1 is 2,320 pphpd (passenger per peak-hour per direction) or 4,641 passengers/hour with the trip frequency of 13 vehicles/hour. The number of passengers in the rush hour (between 06:00 and 07:00 o'clock) is 3,049. As a result, the system capacity of corridor 3 is sufficient to accommodate the actual daily demand.

3) Service reliability

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 3 is summarized in Table 4.70 below.

Table 4.70 Service reliability of corridor 3

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	96%	50%
Trip realization	98%	100%	69%
Punctuality at the start	85%	96%	28%
Punctuality at the complete	85%	44%	70%
Headway regularity	85%	96%	61%
Comfort and load factor	0.85	0.51	0.49

The failure in waiting time reliability occurred in the second direction (A-B), where there is 50% of passengers has waiting time within 5 minutes during peak hour. The second direction is also failed to perform the trip realization and the punctuality into the benchmark. The failure in headway regularity also occurred in the second direction. In terms of load factor, both directions have load factor below 0.85 which are acceptable for convenience of passengers. In this case, the second direction experienced the worse service reliability than the first direction.

Based on the performance evaluation and following the framework in **Figure 3.6**, the problem identification and strategy determination is expressed in **Figure 4.18**.

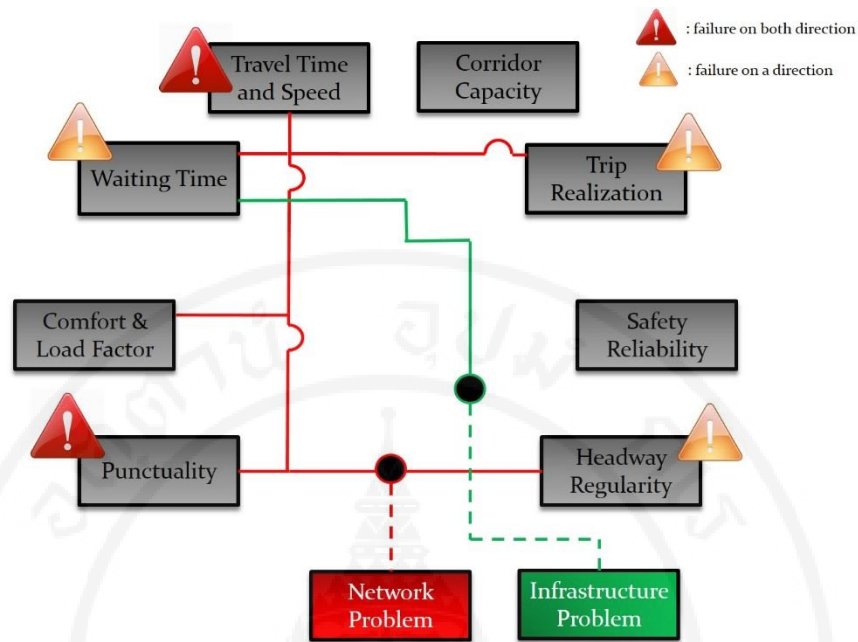


Figure 4.18. Problem identification of corridor 3

As shown in **Figure 4.18**, corridor 3 faces the problem in two aspects; i.e., network, and infrastructure. The following strategies are considered.

1) *Network aspect*

Network problem deals with the link and the node. In the case of corridor 3, there are 7 signalized intersections and 2 intersections without phasing signal management along the route. There are 5 links are still opened lane. Hence, the priority signal strategy is simulated directly in the simulation by considering the space and another possibility. This strategy forms the package for second scenario. By giving the priority to BRT fleet's movement, the delay can be minimized.

2) *Infrastructure aspect*

Strategy in infrastructure consider the improving at station. Among all stations, there are 7 integrated stations, where 1 station has triple platforms and passing lane, 4 stations have double platforms, and 2 stations have only a platform. Based on the observation, the queue found at these stations, such as at station III-15, as shown in the **Figure 4.19** below.



Figure 4.19. The bus queue for dwelling at Juanda station (station III-15)

As a decision, these are the following strategies to enhance the corridor 3 by considering the space and another possibility:

- Installation of extra platform and passing lane at station III-14;
- Installation of passing lane at station III-9, station III-10, station III-12, and station III-15.

These strategies form the package for third scenario of corridor 3. By installing extra platform and passing lane on the integrated stations, the queue of dwelling time can be avoided.

4.3.4 Corridor 4

Corridor 4 connects between Pulogadung bus terminal and Dukuh Atas district. There are 17 stations which are involved in both directions. The total network length is 11.9 km. The route map is shown in **Figure 4.20**.

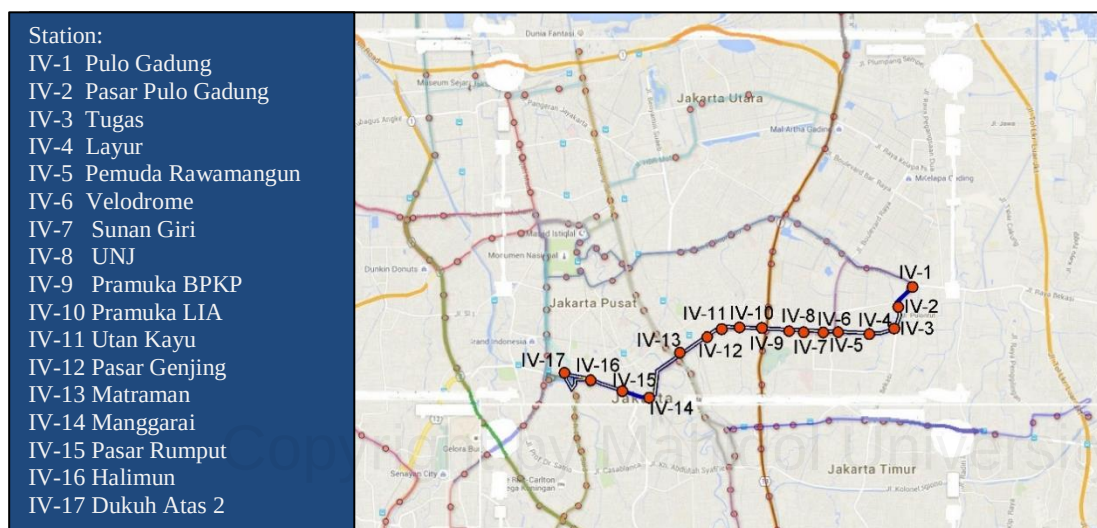


Figure 4.20. The route map of corridor 4

The performance evaluation of corridor 4 has been done. The evaluation in 3 aspects are described below.

1) Travel time and travel speed

The travel time and travel speed of corridor 2 in detail are shown in **Figure 4.21**. It shows also the average travel time and travel speed between stations.

Direction A-B		Morning peak																	
Station:	IV-1	IV-2	IV-3	IV-4	IV-5	IV-6	IV-7	IV-8	IV-9	IV-10	IV-11	IV-12	IV-13	IV-14	IV-15	IV-16	IV-17		
Distance:	1,138	624	695	805	381	498	385	692	598	445	445	861	1,482	738	898	1,297	meters	Total:	11,980 meters
Travel speed:	17	19	21	24	5	15	23	14	18	27	13	17	13	22	18	39	km/hr	Total:	16.7 km/hr
TT:	4	2	2	2	5	2	1	3	2	1	2	3	7	2	3	2	mins	Total:	43 mins
Direction A-B		Evening peak																	
Station:	IV-1	IV-2	IV-3	IV-4	IV-5	IV-6	IV-7	IV-8	IV-9	IV-10	IV-11	IV-12	IV-13	IV-14	IV-15	IV-16	IV-17		
Distance:	1,138	624	695	805	381	498	385	692	598	445	445	861	1,482	738	898	1,297	meters	Total:	11,980 meters
Travel speed:	14	12	21	24	6	15	23	21	18	27	13	17	15	22	27	19	km/hr	Total:	16.7 km/hr
TT:	5	3	2	2	4	2	1	2	2	1	2	3	6	2	2	4	mins	Total:	43 mins
Diretion B-A		Morning peak																	
Station:	IV-17	IV-16	IV-15	IV-14	IV-13	IV-12	IV-11	IV-10	IV-9	IV-8	IV-7	IV-6	IV-5	IV-4	IV-3	IV-2	IV-1		
Distance:	1,297	898	738	1,482	861	445	445	598	692	385	498	381	805	695	624	1,138	meters	Total:	11,980 meters
Travel speed	19	27	22	9	17	27	27	18	42	12	10	11	24	21	19	10	km/hr	Total:	15.6 km/hr
TT:	4	2	2	10	3	1	1	2	1	2	3	2	2	2	2	7	mins	Total:	46 mins
Direction B-A		Evening peak																	
Station:	IV-17	IV-16	IV-15	IV-14	IV-13	IV-12	IV-11	IV-10	IV-9	IV-8	IV-7	IV-6	IV-5	IV-4	IV-3	IV-2	IV-1		
Distance:	1,297	898	738	1,482	861	445	445	598	692	385	498	381	805	695	624	1,138	meters	Total:	11,980 meters
Travel speed	19	27	15	10	26	27	27	18	42	12	15	11	24	21	19	11	km/hr	Total:	16.7 km/hr
TT:	4	2	3	9	2	1	1	2	1	2	2	2	2	2	2	6	mins	Total:	43 mins

Figure 4.21. Travel time, travel speed, and distance between stations of corridor 4

There only 2 segments in the first direction have a good travel speed as follows the standard, the remaining segments of 87% has a low travel speed due to the delay. While, 71% of segmental-travel speed in the second direction (A-B) got delayed also. Both average travel speeds during peak periods are failure. The average travel speed of corridor 4 is 16 km/hour during morning-peak periods and 17 km/hour during evening-peak period. As a result, the travel time of corridor 4 is failure in both directions as the rapid transit system.

2) System capacity

System capacity is represented by the corridor capacity. The corridor 4 is served by 33 units of regular bus with 85 of passenger capacity. There are 10 stations

with single platform and 7 stations with double platforms. From the equation (3.1), the system capacity of corridor 4 is 939 pphpd (passengers per peak hour per direction) or 1,878 passengers/hour with the trip frequency of 13 vehicles/hour. The number of passengers in the rush hour (between 06:00 and 07:00 o'clock) is 2,453. As a result, the system capacity of corridor 4 is insufficient to accommodate the actual daily demand.

3) Service reliability

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 2 is summarized in Table 4.71 below.

Table 4.71 Service reliability of corridor 4

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	79%	50%
Trip realization	98%	92%	77%
Punctuality at the start	85%	75%	25%
Punctuality at the complete	85%	10%	17%
Headway regularity	85%	71%	35%
Comfort and load factor	0.85	0.66	0.29

The waiting time reliability of both directions are failed. In terms of trip realization, the second direction (B-A) can only execute 77% of assigned trips during peak hour. The lack of punctuality occurred in both directions. In the first direction even only 17% the arrival time is on schedule. The headway regularity of both directions are also failure. While, the load factor of both directions are still acceptable for convenience of passengers.

Based on the performance evaluation, the framework to identify the problem and determine the strategy is shown in **Figure 4.20**.

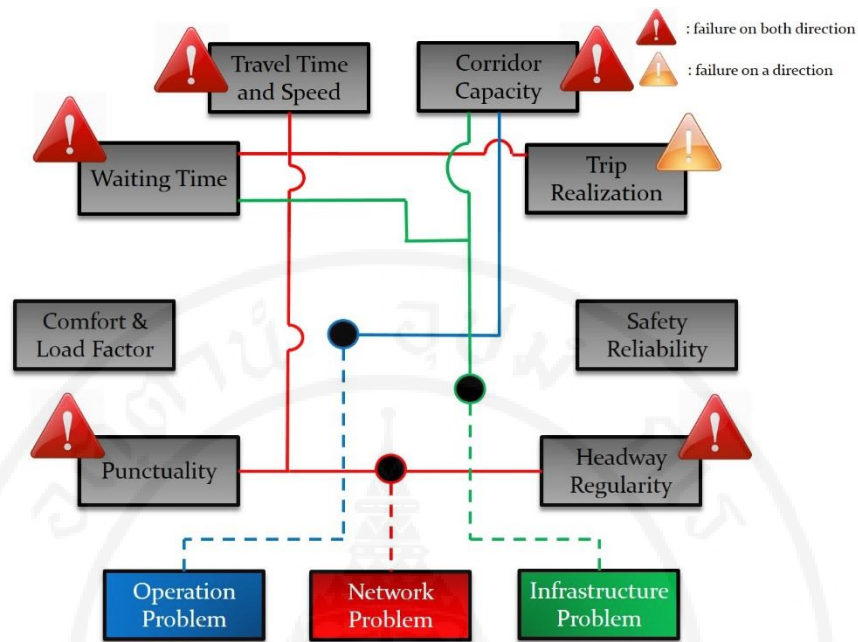


Figure 4.22. Problem identification of corridor 4

As shown in **Figure 4.22**, corridor 3 faces the problem in three aspects; i.e., network, and infrastructure. The following strategies are considered.

1) *Operational aspect*

Operational problem deals with the frequency and headway. In case of the corridor 4 with normal-average travel time of 31 minutes, there are 1,840 pphd (passenger per peak hour per direction) for the first direction (A-B) and 785 for the second direction (B-A) which are served by articulated bus with 85 passengers of capacity. Then, the calculating by equation (3.9) found that 14 units per peak hour is the minimum number of buses, then the headway is 257 seconds to satisfy the demand. On the other hand the allocated bus for corridor 4 is 33 units (operation and non-operation). It means that the availability of buses is sufficient. In this case increasing trip frequency by decreasing headway from 5 minutes to 4 minutes 17 seconds becomes the second scenario. By increasing the frequency, the all demands can be accommodated within the acceptable load factor and waiting time.

2) *Network aspect*

Network deals with the link and node. Along the route of Corridor 4 faces 10 signalized intersections and 6 un-signalized intersections. There are 3 links along

the route which are still opened lane. Hence, the mixed-traffic restriction and priority signal are the best strategies to enhance the travel speed of corridor 4 in the network. While, they are simulated directly in the simulation for assessment by the consideration of space and another possibility. These strategies form the package for third scenario. By giving the priority to BRT fleet's movement, the delay in the network can be minimized.

3) Infrastructure aspect

Infrastructure problem deals with the station and the busway. In the case of corridor 4, there are 2 integrated stations with double platforms and 1 station which is the station IV-1 at bus terminal with double platforms and passing lane. There is still found the bus queue at the station IV-18 as the last station, as shown in **Figure 4.23** below.



Figure 4.23. The bus queue for dwelling at Dukuh Atas station (station IV-18)

The bus queue occurred because the available platform for involved corridor at the integrated stations are not installed with the passing lane, it causes the bus have to wait the front bus to reach the allocated platform. Hence, the installation of passing lane at station IV-17 and IV-18 become the fourth scenario for corridor 4. By extending the passing lane, the unnecessary queue can be avoided.

4.3.5 Corridor 5

The corridor 5 connects between Kampung Melayu Bus terminal and Ancol district. The route passes through 16 stations in the first direction (A-B) and 18 stations in the second direction. The route and the station points are shown in **Figure 4.24**.

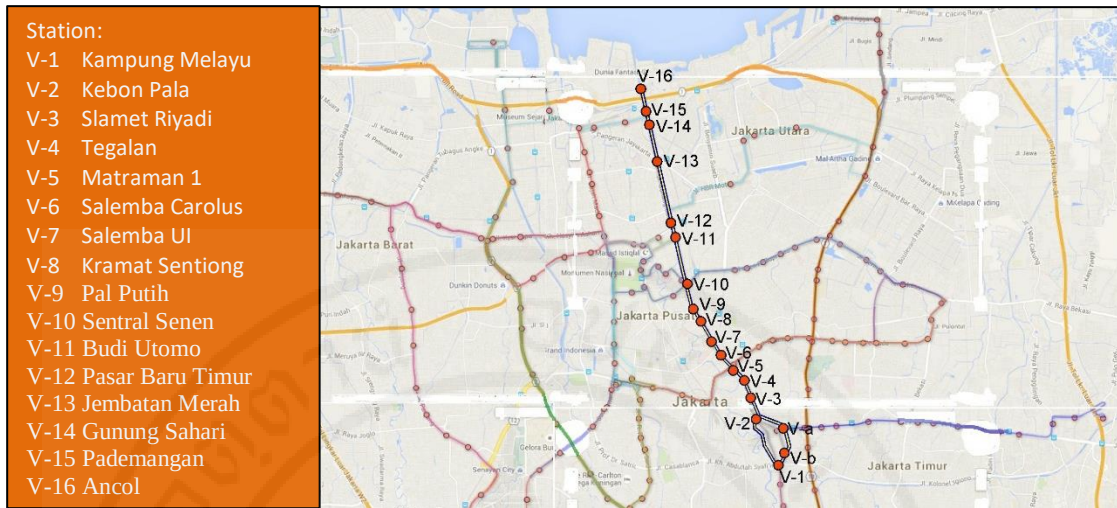


Figure 4.24. The route map of corridor 5

The performance evaluation has been done for corridor 5. As mentioned before, the 8 parameters are grouped into three aspects; i.e., travel time, system capacity, and service reliability.

1) Travel time and travel speed

Based on the data results, the travel speed and travel time are represented by segment and trip during 2 peak periods. As shown in **Figure 4.25**.

Direction A-B		Morning peak																	
Station:	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10	V-11	V-12	V-13	V-14	V-15	V-16			
Distance:		1,487	523	657	447	510	447	682	438	754	1,383	425	1,772	1,129	348	697	meters	Total: 11,699 meters	
Travel speed:		18	31	39	9	5	9	20	13	8	17	6	27	14	21	14	km/hr	Total: 13.8 km/hr	
TT:		5	1	1	3	6	3	2	2	6	5	4	4	5	1	3	mins	Total: 51 mins	
Direction A-B		Evening peak																	
Station:	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10	V-11	V-12	V-13	V-14	V-15	V-16			
Distance:		1,487	523	657	447	510	447	682	438	754	1,383	425	1,772	1,129	348	697	meters	Total: 11,699 meters	
Travel speed:		15	31	39	13	8	9	20	9	9	14	9	21	68	21	21	km/hr	Total: 15.6 km/hr	
TT:		6	1	1	2	4	3	2	3	5	6	3	5	1	1	2	mins	Total: 45 mins	
B-A		Morning peak																	
Station:	V-16	V-15	V-14	V-13	V-12	V-11	V-10	V-9	V-8	V-7	V-6	V-5	V-4	V-3	V-2	V-a	V-b	V-1	
Distance:		716	348	1,128	1,771	425	1,380	756	437	682	444	509	448	656	523	81	588	1,090 meters	Total: 11,982 meters
Travel speed:		21	10	14	15	8	41	9	13	41	13	10	27	20	16	2	18	33 km/hr	Total: 16.0 km/hr
TT:		2	2	5	7	3	2	5	2	1	2	3	1	2	2	2	2	mins	Total: 45 mins
B-A		Evening peak																	
Station:	V-16	V-15	V-14	V-13	V-12	V-11	V-10	V-9	V-8	V-7	V-6	V-5	V-4	V-3	V-2	V-a	V-b	V-1	
Distance:		716	348	1,128	1,771	425	1,380	756	437	682	444	509	448	656	523	81	588	1,090 meters	Total: 11,982 meters
Travel speed:		21	21	10	18	13	41	11	13	41	13	31	27	20	16	5	18	33 km/hr	Total: 18.0 km/hr
TT:		2	1	7	6	2	2	4	2	1	2	1	1	2	2	1	2	mins	Total: 40 mins

Figure 4.25. Travel time, travel speed, and distance between stations of corridor 5

Most segments between stations have the speed below 25 km/hour. The delay occurred on 80% of all segments in the first direction (A-B) and 73% of all segments in the second direction (B-A). Overall, the average travel speed of corridor 5 reaches 15 km/hour during morning-peak period and 17 km/hour during evening-peak period. The failures of travel speed occurred on the most segments between stations along the route. As a result, the travel time of corridor 5 is failure in both directions as the rapid transit system.

2) *System capacity*

The system capacity is represented by the corridor capacity. There are 23 units of articulated bus which are allocated to corridor 5. This corridor involves 17 stations with single platform and 1 station with double platforms. From the equation (3.1), the system capacity of corridor 5 is 1,547 pphpd (passenger per peak-hour per direction) or 3,094 passengers/hour with the trip frequency of 13 vehicles/hour. The number of passengers in the rush hour (between 17:00 and 18:00 o'clock) is 2,752. As a result, the system capacity of corridor 5 is sufficient to accommodate the actual daily demand.

3) *Service reliability*

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 5 is summarized in Table 4.72 below.

Table 4.72 Service reliability of corridor 5

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	33%	82%
Trip realization	98%	69%	92%
Punctuality at the start	85%	0%	88%
Punctuality at the complete	85%	79%	11%
Headway regularity	85%	39%	83%
Comfort and load factor	0.85	0.59	0.12

All parameters in service reliability are failure in both directions, except load factor. Both directions are failure in term of waiting time reliability, the reliability

is very low of 33% in the first direction during peak hour. While, the assigned trip cannot be executed at least 98% by both directions, but the trip realization of 92% by second direction (B-A) closes to the benchmark. The punctuality below standard is also found in both directions, in particular for the first direction (A-B). Both directions have load factor below 0.85 which are acceptable for convenience of passengers.

Based on the performance evaluation and following the framework in **Figure 3.6**, the problem identification and strategy determination are expressed in **Figure 4.26**.

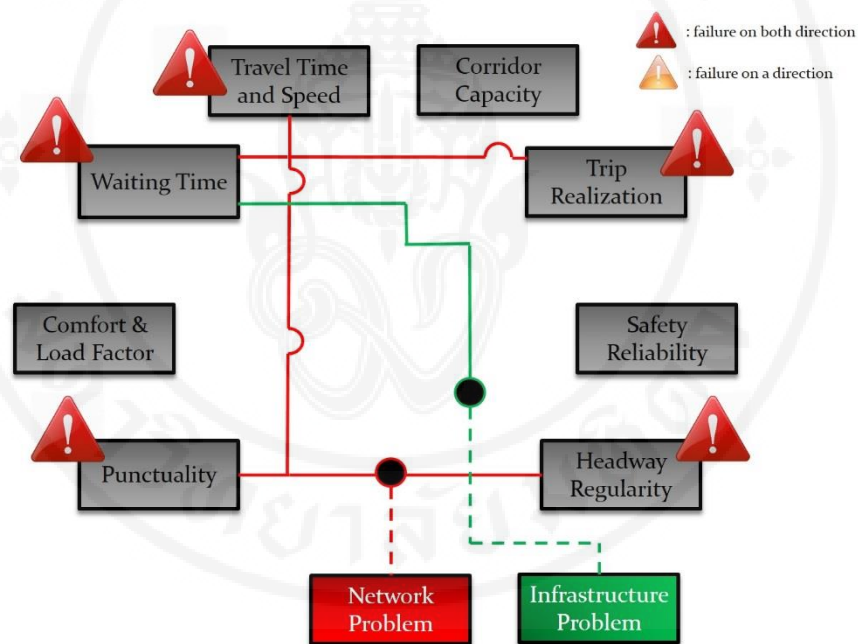


Figure 4.26. Problem identification of corridor 5

As shown in **Figure 4.17**, corridor 3 faces the problem in two aspects; i.e., network, and infrastructure. The following strategies are considered.

1) Network aspect

Network problem deals with the link and the node. In the case of corridor 5, there are 15 signalized intersections along the route. There is 1 segment with opened lane. Hence, the restricted lane and priority signal are simulated directly in the simulation by the consideration of space and another possibility. These strategies form

the package for second scenario. By giving the priority to BRT fleet's movement, the delay can be minimized.

2) Infrastructure aspect

Strategy in infrastructure consider the improving at integrated stations. There are 2 integrated stations with single platform and 1 integrated station with 6 platforms. Based on the consideration of space and another possibility, the strategy to enhance the corridor 5 in infrastructure aspect is installation of extra platform and passing lane at station V-13 and station V-14. It will avoid the unnecessary queue at the station. This strategy will be simulated as the third scenario.

4.3.6 Corridor 6

Corridor 6 connects between Ragunan district and Dukuh Atas district. The route passes through 20 stations. The total trip length is 14.9 km in both directions. The route of corridor 2 and the station points are shown in **Figure 4.27**.

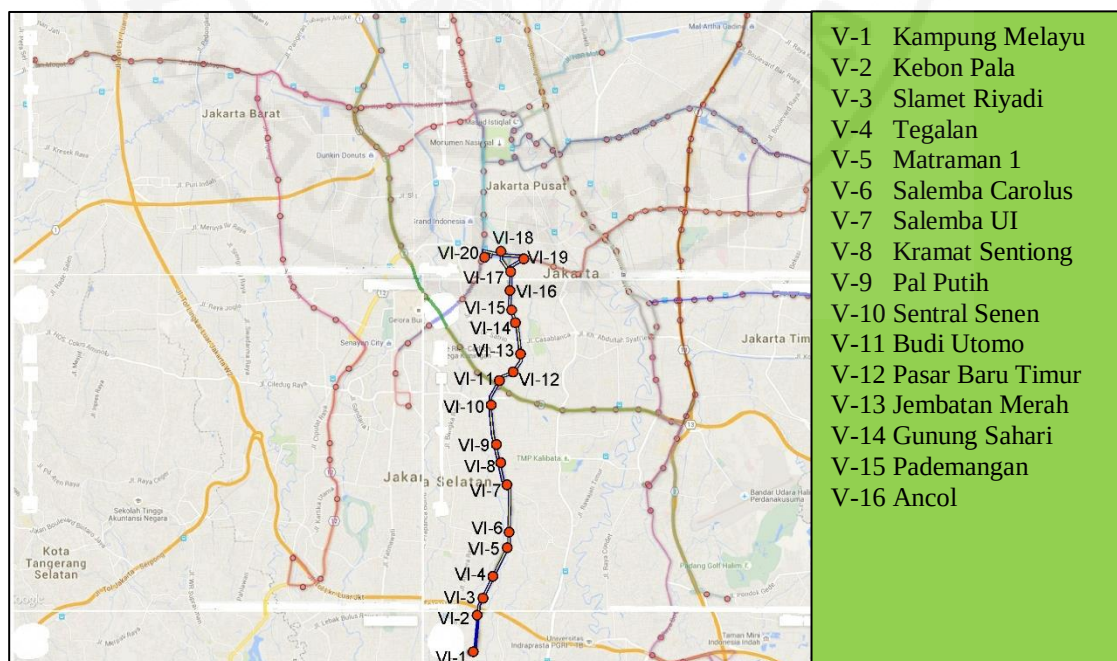


Figure 4.27. The route map of corridor 6

The eight parameters which are distinguished into 3 aspects of performance; i.e., travel time, system capacity, and service reliability are described below.

1) Travel time and travel speed

The travel time and travel speed of corridor 6 in detail are shown in **Figure 4.28**. It shows the average of segmental travel time and travel speed between stations.

Direction A-B

Morning peak

Station:	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VI-9	VI-10	VI-11	VI-12	VI-13	VI-14	VI-15	VI-16	VI-17	VI-18	VI-19	VI-20	
Distance:	1,551	423	683	885	467	1,387	631	531	1,174	720	469	585	920	356	555	479	895	899	1,310	meters	Total: 14,920 meters
Travel speed:	31	5	14	18	14	28	19	11	23	14	14	35	28	7	33	14	27	27	20	km/hr	Total: 18.3 km/hr
TT:	3	5	3	3	2	3	2	3	3	3	2	1	2	3	1	2	2	2	4	mins	Total: 49 mins

Direction A-B

Evening peak

Station:	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VI-9	VI-10	VI-11	VI-12	VI-13	VI-14	VI-15	VI-16	VI-17	VI-18	VI-19	VI-20		
Distance:	1,551	423	683	885	467	1,387	631	531	1,174	720	469	585	920	356	555	479	895	899	1,310	meters	Total: 14,920 meters	
Travel speed:	19	8	14	13	14	28	19	11	23	14	14	18	28	21	33	14	27	27	16	km/hr	Total: 17.9 km/hr	
TT:	5	3	3	4	2	3	2	3	3	3	2	2	2	2	1	1	2	2	2	5	mins	Total: 50 mins

Direction B-A

Morning peak

Station:	VI-20	VI-17	VI-16	VI-15	VI-14	VI-13	VI-12	VI-11	VI-10	VI-9	VI-8	VI-7	VI-6	VI-5	VI-4	VI-3	VI-2	VI-1			
Distance:	1,244	479	555	356	920	585	469	720	1,174	531	631	1,387	467	885	683	423	1,551	meters	Total: 13,060 meters		
Travel speed:	19	14	17	21	14	18	14	22	18	16	19	28	14	27	10	5	19	km/hr	Total: 16.3 km/hr		
TT:	4	2	2	1	4	2	2	2	4	2	2	3	2	2	4	5	5	mins	Total: 48 mins		

Direction B-A

Evening peak

Station:	VI-20	VI-17	VI-16	VI-15	VI-14	VI-13	VI-12	VI-11	VI-10	VI-9	VI-8	VI-7	VI-6	VI-5	VI-4	VI-3	VI-2	VI-1			
Distance:	1,244	479	555	356	920	585	469	720	1,174	531	631	1,387	467	885	683	423	1,551	meters	Total: 13,060 meters		
Travel speed:	15	29	17	21	14	18	14	22	23	16	19	28	14	27	8	8	31	km/hr	Total: 17.8 km/hr		
TT:	5	1	2	1	4	2	2	2	3	2	2	3	2	2	5	3	3	mins	Total: 44 mins		

Figure 4.28. Travel time, travel speed, and distance between stations of corridor 6

There is only fewer segment along corridor 6 which has travel speed more than 25 km/hour as compare with the speeds which are lower than standard. There is about 65% of all segmental-travel speeds in the first direction (A-B) and about 82% of all segmental-travel speeds in the second direction (B-A) which are lower than the standard of 25 km/hour. The average travel speed during morning-peak is 17 km/hour and the average travel speed during evening-peak hour is 18 km/hour. As a result, the travel time of corridor 6 is failure in both directions as the rapid transit system.

2) System capacity

In terms of capacity, corridor 6 is served by 70 units of regular bus and 2 units of articulated bus. There are 18 stations with single platform and 2 stations with double platforms. While, only station VI-1 has passing lane. From the equation (3.1), the system capacity of corridor 6 is 939 pphpd (passengers per peak hour per direction) or 1,876 passengers/hour with the trip frequency of 13 vehicles/hour. The

number of passengers in the rush hour (between 17:00 and 18:00 o'clock) is 3,346 passengers. As a result, the system capacity of corridor 6 is insufficient to accommodate the actual daily demand.

3) Service reliability

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 6 is summarized in Table 4.73 below.

Table 4.73 Service reliability of corridor 6

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	80%	12%
Trip realization	98%	96%	96%
Punctuality at the start	85%	48%	24%
Punctuality at the complete	85%	52%	89%
Headway regularity	85%	76%	60%
Comfort and load factor	0.85	0.63	0.89

As shown in Table 72 above, both directions have been failed in term of waiting time reliability. Meanwhile, the trip realization among them closes to the standard with the gap of 2%. Both directions are also failed in term of punctuality in departure time. The headway regularity is also failed in both directions. In terms of load factor, the overload occurred in the second direction (B-A), but the load factor is also very close to the standard of 0.85.

Based on the performance evaluation and following the framework in **Figure 3.6**, the problem identification and strategy determination are expressed in **Figure 4.29** below.

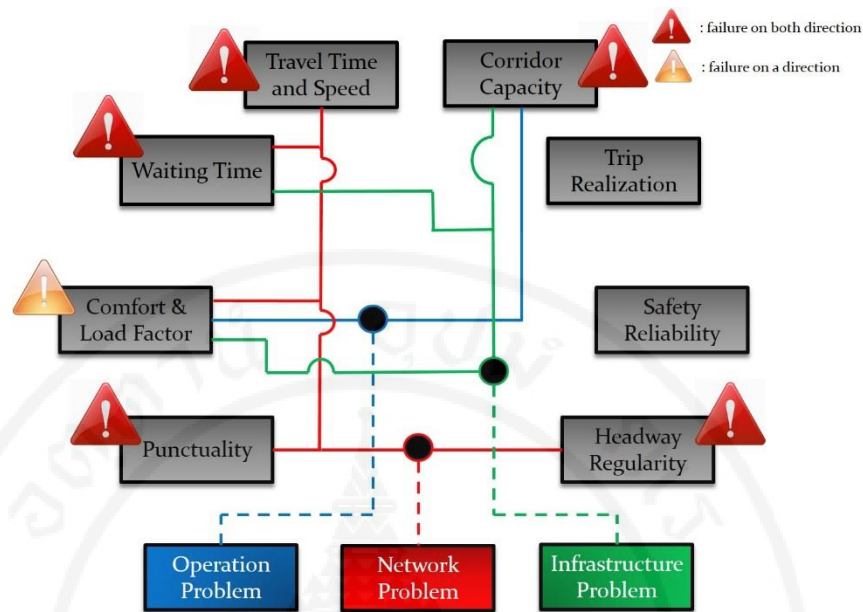


Figure 4.29. Problem identification of corridor 6

As shown in **Figure 4.29**, corridor 6 faces the problem in three aspects; i.e., operation, network, and infrastructure. The following strategies are considered.

1) *Operational aspect*

According to the framework in **Figure 3.6**, operational problem deals with the frequency and headway. In case of the corridor 6 with normal-average travel time of 32 minutes, there are 1,573 pphd (passenger per peak hour per direction) for the first direction (A-B) and 1,773 pphd for the second direction (B-A) which are mostly served by regular bus with 85 passengers of capacity. Then, the calculation by equation (3.9) found that 13 units per peak hour is the minimum number of buses, then the headway is 277 seconds to satisfy the demand. On the other hand, the allocated bus for corridor 6 is 72 units (operation and non-operation). It means that the availability of buses is sufficient. In this case increasing trip frequency by decreasing headway from 5 minutes to 4 minutes 37 seconds becomes the second scenario. By increasing the frequency, the all demands can be accommodated within acceptable load factor and waiting time.

2) *Network aspect*

Network problem deals with the link and the node. In the network of corridor 6, there are 11 signalized intersections and 5 un-signalized intersections.

While, there are 4 links which are opened lane. Then, the mixed-traffic restriction and priority signal are simulated directly in the simulation by the consideration of space and another possibility. These strategies form the package for third scenario. By giving the priority to BRT fleet's movement, the delay in the network can be minimized.

3) Infrastructure aspect

Infrastructure problem deals with the station and busway. The corridor 6 has only 1 integrated station that has double platforms without passing lane. The queue between the bus that belongs to corridor 6 and the bus that belongs to corridor 4 is shown in **Figure 4.23**. Hence, the installation of passing lane at the station VI-20 becomes the suitable strategy for corridor 6 in terms of infrastructure aspect. By providing the passing lane, the unnecessary bus queue can be avoided. This strategy becomes the fourth scenario in the simulation.

4.3.7 Corridor 7

Corridor 7 connects the Kampung Rambutan and Kampung Melayu bus terminals. The total network distance is about 12.3 km. The route of corridor 7 and the station points are shown in **Figure 4.30**.

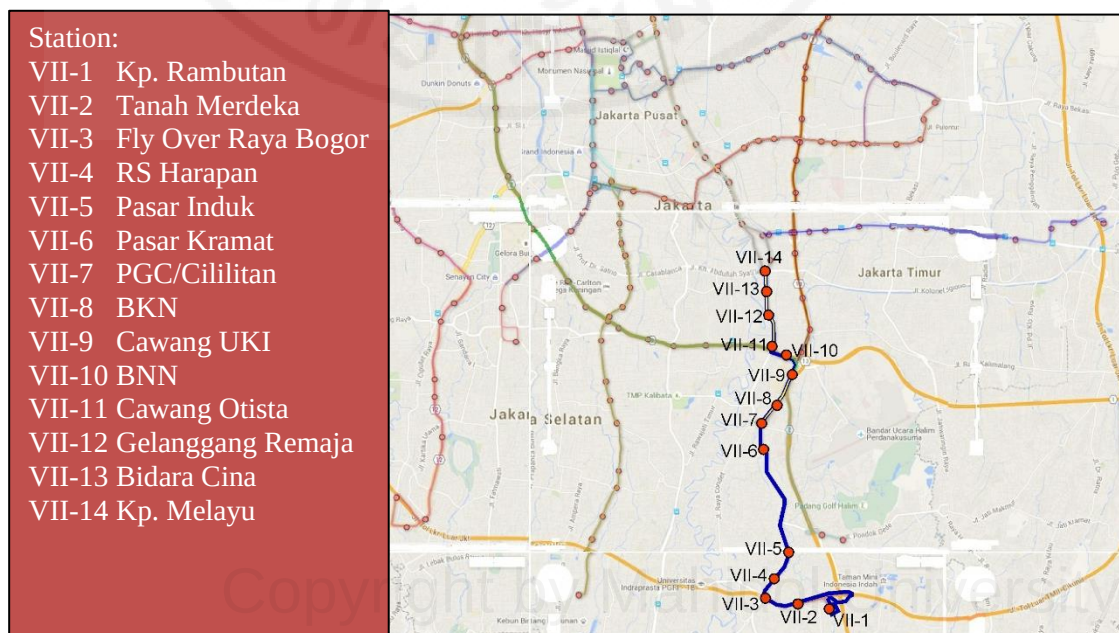


Figure 4.30. The route map of corridor 7

The performance evaluation has been done for corridor 1. As mentioned before, there are 8 parameters which are grouped into three aspects; i.e., travel time, system capacity, and service reliability.

1) Travel time and travel speed

Travel time is the main performance indicator of BRT as the rapid system. As mentioned before, travel time is the matter of travel speed and trip length. **Figure 4.31** shows the travel time and travel speed between stations and total from start to finish.

Direction A-B		Morning peak															
Station:	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8	VII-9	VII-10	VII-11	VII-12	VII-13	VII-14			
Distance:	1,006	1,001	644	982	3,020	739	648	913	654	583	933	642	608	meters	Total:	12,373	meters
Travel speed:	20	12	19	15	23	11	19	27	4	6	28	39	36	km/hr	Total:	15.2	km/hr
TT:	3	5	2	4	8	4	2	2	9	6	2	1	1	mins	Total:	49	mins

Direction A-B		Morning peak															
Station:	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8	VII-9	VII-10	VII-11	VII-12	VII-13	VII-14			
Distance:	1,006	1,001	644	982	3,020	739	648	913	654	583	933	642	608	meters	Total:	12,373	meters
Travel speed:	20	10	13	15	26	11	10	27	4	12	28	39	18	km/hr	Total:	14.8	km/hr
TT:	3	6	3	4	7	4	4	2	9	3	2	1	2	mins	Total:	50	mins

Direction B-A		Morning peak															
Station:	VII-14	VII-13	VII-12	VII-11	VII-10	VII-9	VII-8	VII-7	VII-6	VII-5	VII-4	VII-3	VII-2	VII-1			
Distance:	579	642	933	453	773	913	648	739	3,020	982	644	1,001	1,006	meters	Total:	12,333	meters
Travel speed:	35	39	28	14	12	18	19	22	36	20	19	10	15	km/hr	Total:	20.0	km/hr
TT:	1	1	2	2	4	3	2	2	5	3	2	6	4	mins	Total:	37	mins

Direction B-A		Morning peak															
Station:	VII-14	VII-13	VII-12	VII-11	VII-10	VII-9	VII-8	VII-7	VII-6	VII-5	VII-4	VII-3	VII-2	VII-1			
Distance:	579	642	933	453	773	913	648	739	3020	982	644	1001	1006	meters	Total:	12,333	meters
Travel speed:	35	39	28	14	15	18	19	22	23	20	19	12	15	km/hr	Total:	19.5	km/hr
TT:	1	1	2	2	3	3	2	2	8	3	2	5	4	mins	Total:	38	mins

Figure 4.31. Travel time, travel speed, and distance between stations of corridor 7

As shown in the **Figure 4.31** above, about 69% of the segmental-travel speed in the first direction (A-B) and about 73% of the segmental-travel speed in the second direction (B-A) are below the standard of 25 km/hour. Overall, corridor 7 can reach the average travel speed of 15 km/hour during the morning-peak period and 20

km/hour during the evening-peak period. It means that the travel speed is below the standard of 25 km/hr.

2) *System capacity*

System capacity is represented by corridor capacity. The corridor 7 is usually served by 40 units of regular bus. There are 10 stations with single platform and 4 stations with double platforms. From the equation (3.1), the system capacity of corridor 7 is 939 pphpd (passenger per peak-hour per direction) or 1,876 passengers/hour with the trip frequency of 13 vehicle/hour. The number of passengers in the rush hour (between 06:00 and 07:00 o'clock) is 3,106. As a result, the system capacity of corridor 3 is insufficient to accommodate the actual daily demand.

3) *Service reliability*

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 7 is summarized in Table 4.74 below.

Table 4.74 Service reliability of corridor 7

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	92%	100%
Trip realization	98%	100%	100%
Punctuality at the start	85%	46%	73%
Punctuality at the complete	85%	65%	73%
Headway regularity	85%	85%	81%
Comfort and load factor	0.85	0.79	0.43

The waiting time reliability in both directions is above the required percentage. The corridor 7 also successfully executed all of assigned trips in both directions. But it still faces the low punctuality in both directions. The headway regularity is failure in the second direction, but it closes to the required percentage. In terms of load factor, both directions have the load factor below 0.85, it means that the load factor of corridor 7 is still acceptable for inconvenience of passengers.

Based on the performance evaluation and following the framework in **Figure 3.6**, the problem identification and strategy determination are expressed in **Figure 4.32**.

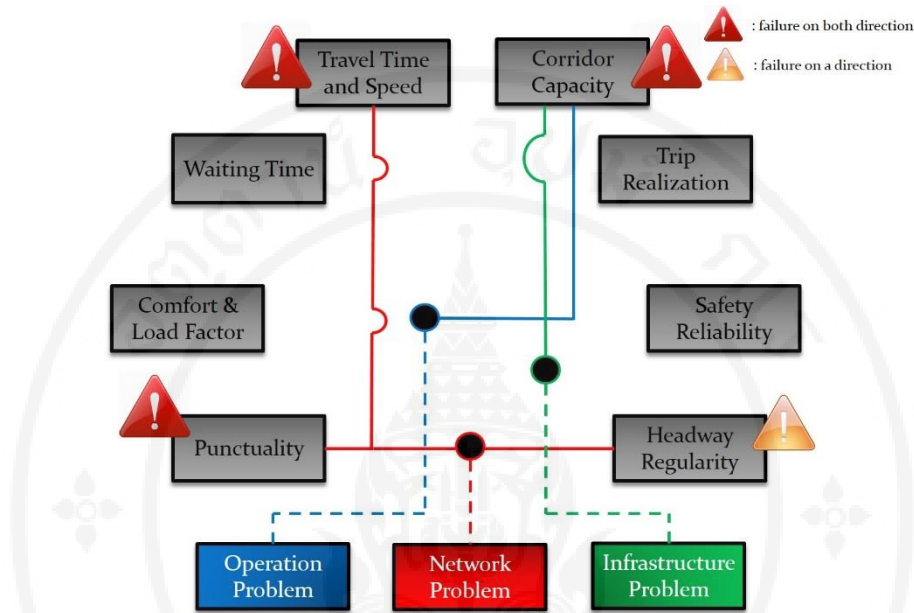


Figure 4.32. Problem identification of corridor 7

As shown in **Figure 4.32**, corridor 7 faces the problem in three aspects; i.e., operational, network, and infrastructure. The following strategies are considered.

1) Operational aspect

According to the framework in **Figure 3.6**, operational problem deals with the frequency and headway. In case of the corridor 7 with existing average travel time is 43.5 minutes, there are 2,174 pphd (passenger per peak hour per direction) for the first direction (A-B) and 932 pphd for the second direction (B-A) which are served by regular bus with 85 passengers of capacity. Then, the calculation by equation (3.9) found that 15 units per peak hour is the minimum fleet size, then the headway is 240 seconds to satisfy the demand. On the other hand, the allocated bus for corridor 7 is 49 units (operation and non-operation). It means that the availability of buses is sufficient. In this case increasing trip frequency by decreasing headway from 5 minutes to 4 minutes becomes the second scenario. By increasing the frequency, the daily demand can be accommodated within acceptable load factor and waiting time.

2) Network aspect

Network problem deals with the link and the node. In the case of corridor 7, there are 8 signalized intersections that are involved along the route of corridor 7. There are more opened lanes rather than close lane along the route. There are 8 links are still open along the route. The mixed-traffic restriction and priority signal strategies are simulated directly in the simulation by the consideration of space and another possibility. These strategies form the package for third scenario. By giving the priority to BRT fleet's movement, the delaying can be minimized.

3) Infrastructure aspect

Infrastructure aspect deals with the station and the busway. Based on the observation, there are 1 integrated station with single platform, 1 integrated stations that has double platform with passing lane, and 2 integrated stations that have double platform without passing lane. In terms of the busway, there are 6 stations which are not protected by segregated lane-on-station. It causes the dwelling time on station can be interrupted easily by mixed traffic. As shown in **Figure 4.33**.



Figure 4.33. The interrupted dwelling process at the opened lane-on-station VII-7

As the consideration of space and another possibilities, the strategies in term of infrastructures aspect in order to enhance the corridor 7; i.e.:

- Installation of passing lane at the station VII-8 and station VII-9;
- Installation of segregated lane-on-station at the station VII-3, station VII-4, station VII-5, station VII-6, and station VII-7, and VII-10.

These strategies form the package for fourth scenario in the simulation. By the installing extra platform and passing lane, the bus queue can be minimized. The protected busway on station gives the priority to bus for dwelling and alighting.

4.3.8 Corridor 8

The corridor 8 connects between Lebak Bulus bus terminal and Harmoni district. It passes through 21 stations in the first direction (A-B) and 23 stations in the second direction (B-A). The total network distance is about 25.2 km in the first direction and 25.5 km in the second direction. The route and the station points are shown in **Figure 4.34**.



Figure 4.34. The route map of corridor 8

The performance evaluation has been done for corridor 8. As mentioned before, the 8 parameters are grouped into three aspects; i.e., travel time, system capacity, and service reliability.

1) Travel time and travel speed

Travel time is the main performance indicator of BRT as the rapid system. As mentioned before, travel time is a function of travel speed and trip length. **Figure 4.35** shows the average of travel time and travel speed between stations and travel speed from start to finish.

Direction A-B		Morning peak																								
Station:	VIII-1	VIII-2	VIII-3	VIII-4	VIII-5	VIII-6	VIII-7	VIII-8	VIII-9	VIII-10	VIII-11	VIII-12	VIII-13	VIII-14	VIII-15	VIII-16	VIII-17	VIII-18	VIII-19	VIII-20	VIII-21					
Distance:		1,184	1,227	2,373	1,201	476	1,624	630	1,923	714	860	880	1,258	1,011	1,219	1,175	2,275	1,316	302	798	2,746	meters	Total:	25,192 meters		
Travel speed:		9	15	28	14	29	32	8	29	21	26	26	19	10	37	14	15	26	6	48	21	km/hr	Total:	18.2 km/hr		
TT:		8	5	5	5	1	3	5	4	2	2	2	4	6	2	5	9	3	3	1	8	mins	Total:	83 mins		
Direction A-B		Evening peak																								
Station:	VIII-1	VIII-2	VIII-3	VIII-4	VIII-5	VIII-6	VIII-7	VIII-8	VIII-9	VIII-10	VIII-11	VIII-12	VIII-13	VIII-14	VIII-15	VIII-16	VIII-17	VIII-18	VIII-19	VIII-20	VIII-21					
Distance:		1,184	1,227	2,373	1,201	476	1,624	630	1,923	714	860	880	1,258	1,011	1,219	1,175	2,275	1,316	302	798	2,746	meters	Total:	25,192 meters		
Travel speed:		7	18	24	18	29	32	9	29	14	17	26	19	12	24	12	20	26	6	24	24	km/hr	Total:	18.0 km/hr		
TT:		10	4	6	4	1	3	4	4	3	3	2	4	5	3	6	7	3	3	2	7	mins	Total:	84 mins		
Direction B-A		Morning peak																								
Station:	VII-21	VIII-a	VIII-b	VIII-c	VIII-d	VIII-18	VIII-17	VIII-16	VIII-15	VIII-14	VIII-13	VIII-12	VIII-11	VIII-10	VIII-9	VIII-8	VIII-7	VIII-6	VIII-5	VIII-4	VIII-3	VIII-2	VIII-1			
Distance:		606	2,332	1,167	468	1,600	636	1,932	705	850	868	1,241	1,003	1,225	1,165	2,291	1,318	169	1,096	1,177	1,259	751	1,655	meters	Total:	25,514 meters
Travel speed:		12	47	23	4	19	38	58	6	26	17	37	30	37	23	69	9	3	16	71	38	8	50	km/hr	Total:	20.7 km/hr
TT:		3	3	3	7	5	1	2	7	2	3	2	2	2	3	2	9	3	4	1	2	6	2	mins	Total:	74 mins
Direction B-A		Evening peak																								
Station:	VII-21	VIII-a	VIII-b	VIII-c	VIII-d	VIII-18	VIII-17	VIII-16	VIII-15	VIII-14	VIII-13	VIII-12	VIII-11	VIII-10	VIII-9	VIII-8	VIII-7	VIII-6	VIII-5	VIII-4	VIII-3	VIII-2	VIII-1			
Distance:		606	2,332	1,167	468	1,600	636	1,932	705	850	868	1,241	1,003	1,225	1,165	2,291	1,318	169	1,096	1,177	1,259	751	1,655	meters	Total:	25,514 meters
Travel speed:		12	47	23	5	19	38	39	7	26	17	37	30	37	23	137	13	3	16	71	38	6	33	km/hr	Total:	21.0 km/hr
TT:		3	3	3	6	5	1	3	6	2	3	2	2	2	3	1	6	4	4	1	2	8	3	mins	Total:	73 mins

Figure 4.35. Travel time, travel speed, and distance between stations of corridor 8

There 62.5 % of all segmental-travel speeds in the first direction (A-B) and 50% of all segmental-travel speeds in the second direction (B-A) are below the standard of 25 km/hour. The average travel speed is 19 km/hour during both peak periods. As a result, the travel time of corridor 7 is failure in both directions as the rapid transit system.

2) System capacity

The system capacity is represented by the corridor capacity. The corridor 8 is served by 14 units of articulated bus and 23 units of regular bus. There are 20 stations with single platform, 4 stations with double platforms, and 1 station with triple platforms. From the equation (3.1), the system capacity of corridor 8 is 1,547 pphpd (passenger per peak-hour per direction) or 3,094 passengers/hour with the trip frequency of 13 vehicle/hour which is mostly taken by articulated buses. The number of passengers in the rush hour (between 06:00 and 07:00 o'clock) is 2,726. As a result, the system capacity of corridor 8 is sufficient to accommodate the actual daily demand.

3) Service reliability

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway

regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 8 is summarized in Table 4.75 below.

Table 4.75 The service reliability of corridor 8

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	76%	21%
Trip realization	98%	81%	65%
Punctuality at the start	85%	43%	47%
Punctuality at the complete	85%	12%	71%
Headway regularity	85%	57%	18%
Comfort and load factor	0.85	0.63	0.52

All parameters in service reliability are failure, except load factor. The waiting time reliability of 21% in the second direction is far below the standard. Then, the punctuality of the arrival time of 12 % in the first direction is far below the standard. In terms of load factor, both directions have acceptable load factor.

Based on the performance evaluation and following the framework in **Figure 3.6**, the problem identification and strategy determination are expressed in **Figure 4.36**.

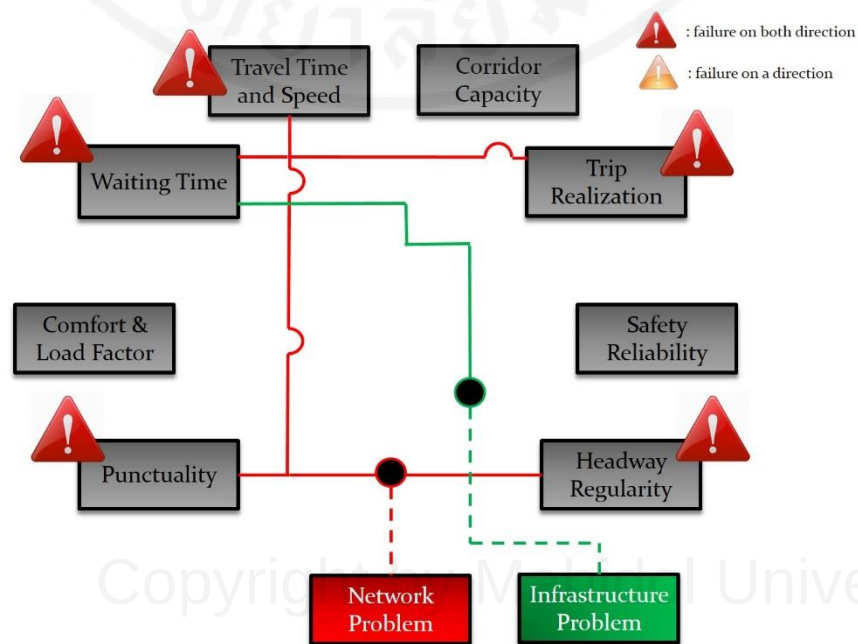


Figure 4.36. Problem identification of corridor 8

As shown in **Figure 4.36**, corridor 8 faces the problem in two aspects; i.e., network, and infrastructure. The following strategies are considered.

1) Network aspect

Network problem deals with the link and the node. There are 20 signalized intersections and 4 un-signalized intersections are involved along the route. The opened lanes are still exist on 9 segments of 23 segments between stations. Hence, the priority signal and the restricted lane strategies is simulated directly in the simulation as the second scenario. By giving the priority to BRT fleet's movement, the delay can be minimized.

2) Infrastructure aspects

In terms of infrastructure aspect, the strategy consider the improving station and busway. There are 1 integrated station with single platform, 2 integrated stations that have double platforms without passing lane, and 1 integrated station that has triple platforms with passing lane. Also, there are 5 un-protected stations that still exist along the route of corridor 8. As the consideration of space and another possibilities, the improving infrastructures in order to enhance the corridor 3; i.e.:

- Installation of the extra platform and passing lane at station VIII-19;
- Installation of the passing lane at station VIII-18 and station VIII-19;
- Installation of segregated lane-on-station at station VIII-2, station VIII-3, station VIII-4, station VIII-7, and station VIII-17.

These strategies form the package for third scenario in simulation. By installing the extra platform and passing lane, the bus queue can be minimized. The protected lane on station gives the priority to bus for dwelling and alighting.

4.3.9 Corridor 9

The corridor 9 is the second most congested corridor after corridor 1. It connects between Pinang Ranti and Pluit districts. The total network distance is 20.3 km, it is the second longest network after corridor 12. The Corridor 9 is also the corridor with the greatest number of stations among the all corridors. The route passes

through 26 stations in both directions. The route and the station points are shown in **Figure 4.37** below.

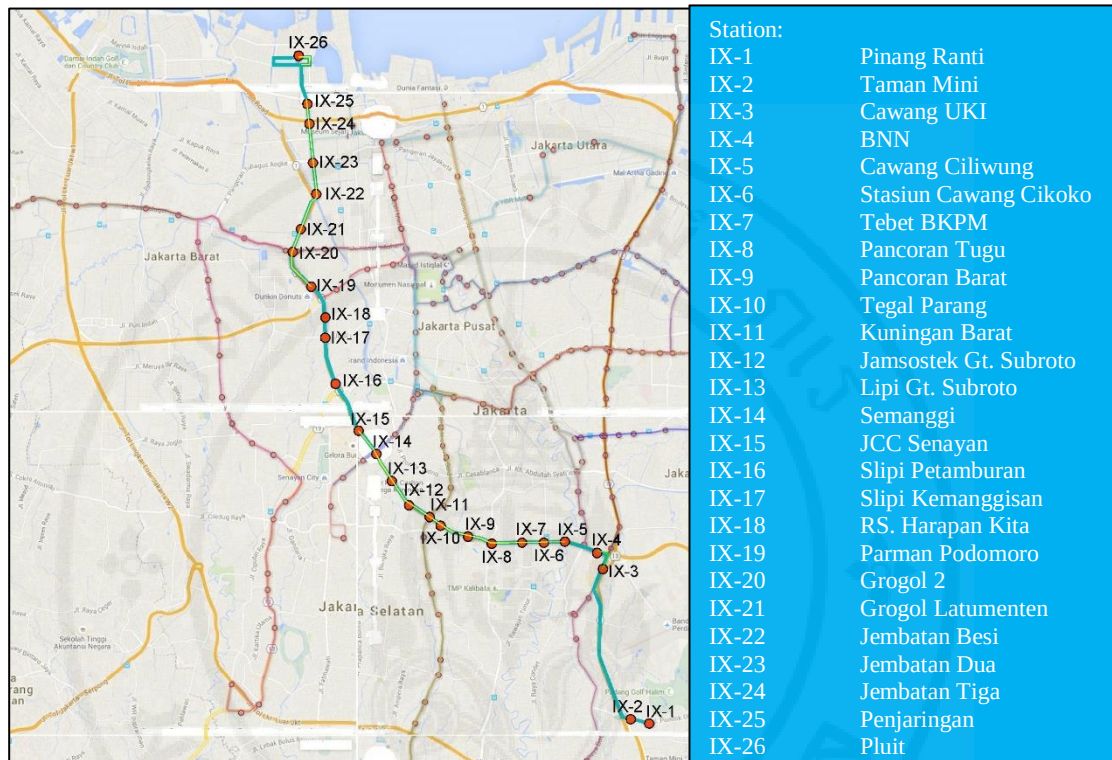


Figure 4.37. The route map of corridor 9

Then, the eight parameters are distinguished into 3 aspects of performance; i.e., travel time, system capacity, and service reliability.

1) *Travel time and travel speed*

Travel time is the main performance indicator of BRT as the rapid system. As mentioned before, travel time is a function of travel speed and trip length. **Figure 4.38** shows the travel time and travel speed between stations and also the travel speed from start to finish stations.

Direction A-B		Morning peak																									
Station:	IX-1	IX-2	IX-3	IX-4	IX-5	IX-6	IX-7	IX-8	IX-9	IX-10	IX-11	IX-12	IX-13	IX-14	IX-15	IX-16	IX-17	IX-18	IX-19	IX-20	IX-21	IX-22	IX-23	IX-24	IX-25	IX-26	
Distance:		597	5,300	654	1,004	601	667	913	739	843	294	784	828	924	897	1,630	1,392	595	1,400	1,100	755	1,169	972	1,108	789	2,538	meters
Travel speed:		18	24	3	4	12	20	18	9	25	9	8	12	14	54	33	42	6	28	22	9	23	29	33	24	19	km/hr
TT:		2	13	12	16	3	2	3	5	2	2	6	4	4	1	3	2	6	3	3	5	3	2	2	2	8	mins
																										Total:	20,337 meters
																										Total:	17.9 km/hr
																										Total:	68 mins

Direction A-B		Evening Peak																									
Station:	IX-1	IX-2	IX-3	IX-4	IX-5	IX-6	IX-7	IX-8	IX-9	IX-10	IX-11	IX-12	IX-13	IX-14	IX-15	IX-16	IX-17	IX-18	IX-19	IX-20	IX-21	IX-22	IX-23	IX-24	IX-25	IX-26	
Distance:		597	5,300	654	1,004	601	667	913	739	843	294	784	828	924	897	1,630	1,392	595	1,400	1,100	755	1,169	972	1,108	789	2,538	meters
Travel speed:		12	24	4	4	12	20	11	9	25	9	8	25	14	27	33	42	9	21	22	9	23	29	33	16	19	km/hr
TT:		3	13	10	14	3	2	5	5	2	2	6	2	4	2	3	2	4	4	3	5	3	2	2	3	8	mins
																										Total:	69 mins

Direction B-A		Morning peak																									
Station:	IX-26	IX-25	IX-24	IX-23	IX-22	IX-21	IX-20	IX-19	IX-18	IX-17	IX-16	IX-15	IX-14	IX-13	IX-12	IX-11	IX-10	IX-9	IX-8	IX-7	IX-6	IX-5	IX-4	IX-3	IX-2	IX-1	
Distance:		1,716	789	1,108	972	1,075	829	1,100	1,400	502	1,392	1,692	841	806	828	875	398	843	662	913	667	601	994	773	5,300	627	meters
Travel speed:		17	16	33	19	22	25	13	8	15	14	34	13	16	25	8	12	51	20	27	20	36	20	12	32	13	km/hr
TT:		6	3	2	3	3	2	5	10	2	6	3	4	3	2	7	2	1	2	2	2	1	3	4	10	3	mins
																										Total:	27,703 meters
																										Total:	18.3 km/hr
																										Total:	91 mins

Direction B-A		Evening peak																									
Station:	IX-26	IX-25	IX-24	IX-23	IX-22	IX-21	IX-20	IX-19	IX-18	IX-17	IX-16	IX-15	IX-14	IX-13	IX-12	IX-11	IX-10	IX-9	IX-8	IX-7	IX-6	IX-5	IX-4	IX-3	IX-2	IX-1	
Distance:		1,716	789	1,108	972	1,075	829	1,100	1,400	502	1,392	1,692	841	806	828	875	398	843	662	913	667	601	994	773	5,300	627	meters
Travel speed:		21	16	33	19	22	25	13	9	15	14	34	13	16	25	13	12	51	10	27	20	36	20	7	35	13	km/hr
TT:		5	3	2	3	3	2	5	9	2	6	3	4	3	2	4	2	1	4	2	2	1	3	7	9	3	mins
																										Total:	27,703 meters
																										Total:	18.5 km/hr
																										Total:	90 mins

Figure 4.38. Travel time, travel speed, and distance between stations of corridor 9

As shown in **Figure 4.38**, there are 74% of all segments in the first direction (A-B) and 68% of all segments in the second direction (B-A) that have the travel speed below the standard of 25 km/hour. Overall, the average travel speed is 18 km/hour during morning-peak and evening-peak periods. It means that the travel speed is below the standard of 25 km/hour. As a result, the travel time of corridor 9 is failure in both directions as the rapid transit system.

2) System capacity

System capacity is very crucial in terms of passenger satisfaction. The corridor 9 is served by 31 units of articulated bus and also the substitution buses of 19 units of regular bus. In terms of station, there are 22 stations with single platform and 4 stations with double platforms. From the equation (3.1), the system capacity of corridor 9 is 833 pphpd (passenger per peak-hour per direction) or 1,666 passengers/hour with the trip frequency of 7 vehicles/hour. This capacity is very low for second congested corridor. While, the number of passengers in the rush hour (between 06:00 and 7:00 o'clock) is 4,089. As the result, the system capacity of corridor 9 cannot accommodate the actual daily demand. **Figure 4.39** shows the crowd of passengers on the bus and at the station IX-1.



Figure 4.39. The crowd of passengers at the station IX-1 and on the bus

The lack of the corridor capacity is mainly because of the lack in trip frequency of this corridor.

3) Service reliability

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 9 is summarized in Table 4.76 below.

Table 4.76 Service reliability of corridor 9

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	7%	14%
Trip realization	98%	100%	100%
Punctuality at the start	85%	71%	79%
Punctuality at the complete	85%	29%	64%
Headway regularity	85%	86%	93%
Comfort and load factor	0.85	0.93	0.66

The waiting time reliability in both directions is very low because of low trip frequency, even the all assigned trips in both directions can be successfully executed. While, the punctuality of both directions doesn't meet the required percentage of 85% as the standard. Headway regularity reached the required percentage of at least 85% trip is within the planned headway as the standard. In terms of load factor, an unacceptable load factor is found in the first direction (A-B) of 0.93, while the second direction is close to 0.85 as the acceptable load factor.

Based on the performance evaluation and following the framework in **Figure 3.6**, the problem identification and strategy determination are expressed in **Figure 4.40**.

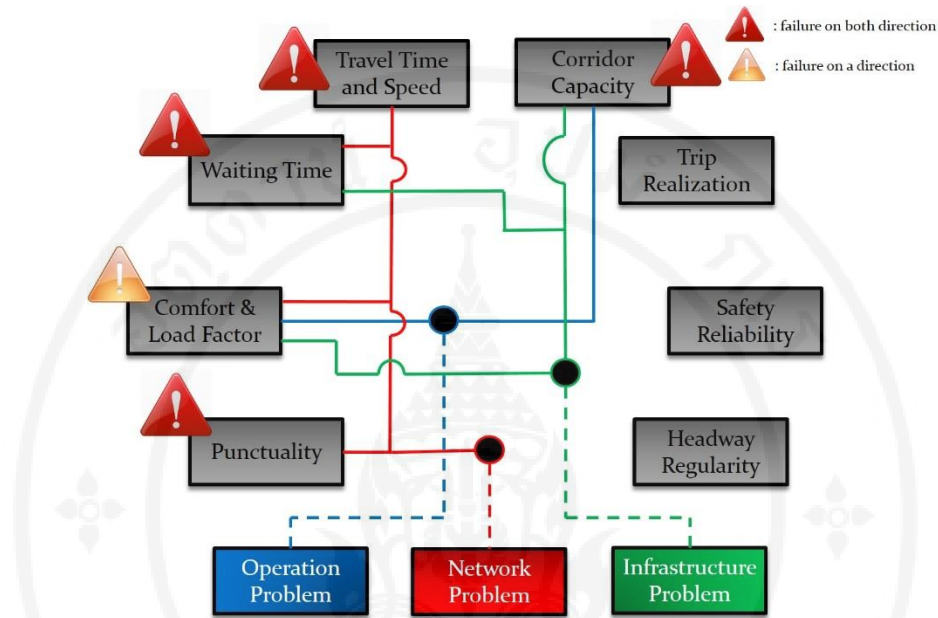


Figure 4.40. Problem identification of corridor 9

As shown in **Figure 4.40**, corridor 9 faces the problem in three aspects; i.e., operational, network, and infrastructure. The following strategies are considered.

1) Operational aspect

According to the framework in **Figure 3.6**, operational problem deals with the frequency and headway. In case of the corridor 9 with normal-average travel time of 59 minutes, there are 1,922 pphd (passenger per peak hour per direction) for the first direction (A-B) and 2,167 pphd for the second direction (B-A) which are served by articulated bus with 140 passengers of capacity. Then, the calculation by equation (3.9) found that 21 units per peak hour is the minimum fleet size, then the headway is 171 seconds to satisfy the demand. On the other hand, the allocated bus for corridor 9 is 50 units (operation and non-operation). In this case increasing trip frequency by decreasing headway from 8.5 minutes to 2 minutes 51 seconds becomes the second scenario. By increasing the frequency, the daily demand can be accommodated with acceptable load factor and waiting time.

2) *Network aspect*

Network aspect deals with the link and node. In the case of corridor 9, there are 23 signalized intersections are involved along the route of corridor 9. There are 10 links which are still opened lane and 1 link is closed in only 1 direction side. Hence, the mixed-traffic restriction and priority signal strategies are simulated directly in the simulation as the third scenario. By giving the priority to BRT fleet's movement, the delay can be minimized.

3) *Infrastructure aspect*

In the case of this study, the infrastructure aspect deals with the station and busway. There are 2 integrated stations that have single platform with opened lane-on-station, 1 integrated station that has double platforms with opened lane-on-station, and 2 integrated stations that have double platforms without passing lane. Also, there are other 6 stations without any protection on their lane-on-stations. The enhancement considers the space and another possibility. As a decision, the improvement infrastructure in order to enhance the corridor 9; i.e.:

- Installation of extra platform and passing lane at station IX-3, station IX-20 and station IX-25;
- Installation of passing lane at station IX-26;
- Installation of passing lane and segregated lane at station IX-2, station IX-8, and station IX-11.

By installing more platform and passing lane on the integrated stations, the queue of dwelling time can be avoided. Then, the segregated lane-on-station protects bus for dwelling and alighting. These strategies form the package for fourth scenario in simulation.

4.3.10 Corridor 10

The corridor 10 connects between Tanjung Priok bus terminal and Cililitan district. The total network distance is about 19 km in both directions. The route passes through the 22 stations in both directions. The route and the station points are shown in **Figure 4.41**.



Figure 4.41. The route map of corridor 10

The performance evaluation has been done for corridor 10. The eight parameters are grouped into 3 aspects of performance; i.e., travel time, system capacity, and service reliability.

1) Travel time and travel speed

The travel time and travel speed of corridor 10 in detail can be seen in **Figure 4.42**. It shows the overall and segmental travel time and travel speed.

Direction A-B		Morning peak																					
Station:	X-1	X-2	X-3	X-4	X-5	X-6	X-7	X-8	X-9	X-10	X-11	X-12	X-13	X-14	X-15	X-16	X-17	X-18	X-19	X-20	X-21	X-22	
Distance:	1,136	484	552	1,083	1,599	2,373	492	976	312	1,174	614	571	863	1,127	492	1,297	831	705	676	915	716	meters	Total: 18,988 meters
Travel speed:	17	6	17	16	24	24	30	15	19	35	18	34	26	34	30	19	25	11	41	14	14	km/hr	Total: 19.3 km/hr
TT:	4	5	2	4	4	6	1	4	1	2	2	1	2	2	1	4	2	4	1	4	3	mins	Total: 59 mins
Direction A-B		Evening peak																					
Station:	X-1	X-2	X-3	X-4	X-5	X-6	X-7	X-8	X-9	X-10	X-11	X-12	X-13	X-14	X-15	X-16	X-17	X-18	X-19	X-20	X-21	X-22	
Distance:	1,136	484	552	1,083	1,599	2,373	492	976	312	1,174	614	571	863	1,127	492	1,297	831	705	676	915	716	meters	Total: 18,988 meters
Travel speed:	14	7	11	16	19	24	30	15	19	35	18	34	26	34	30	16	17	14	20	14	14	km/hr	Total: 18.1 km/hr
TT:	5	4	3	4	5	6	1	4	1	2	2	1	2	2	1	5	3	3	2	4	3	mins	Total: 63 mins
Direction B-A		Morning peak																					
Station:	X-22	X-21	X-20	X-19	X-18	X-17	X-16	X-15	X-14	X-13	X-12	X-11	X-10	X-9	X-8	X-7	X-6	X-5	X-4	X-3	X-2	X-1	
Distance:	650	915	676	674	831	1,297	492	1,127	863	571	614	1,174	312	976	492	2,373	1,627	1,066	552	484	1,273	meters	Total: 19,039 meters
Travel speed:	20	27	14	20	50	26	30	34	26	17	9	35	19	12	15	36	24	32	17	15	25	km/hr	Total: 22.4 km/hr
TT:	2	2	3	2	1	3	1	2	2	2	4	2	1	5	2	4	4	2	2	2	3	mins	Total: 51 mins
Direction B-A		Evening peak																					
Station:	X-22	X-21	X-20	X-19	X-18	X-17	X-16	X-15	X-14	X-13	X-12	X-11	X-10	X-9	X-8	X-7	X-6	X-5	X-4	X-3	X-2	X-1	
Distance:	650	915	676	674	831	1,297	492	1,127	863	571	614	1,174	312	976	492	2,373	1,627	1,066	552	484	1,273	meters	Total: 19,039 meters
Travel speed:	20	18	14	13	25	19	30	34	26	17	9	35	19	12	15	36	20	21	33	15	19	km/hr	Total: 20.0 km/hr
TT:	2	3	3	3	2	4	1	2	2	2	4	2	1	5	2	4	5	3	1	2	4	mins	Total: 57 mins

Figure 4.42. Travel time, travel speed, and distance between stations of corridor 10

As shown in the **Figure 4.42** above, about 67% of the segmental-travel speeds in the first direction (A-B) and about 60% of the segmental-travel speeds in the second direction (B-A) are below the standard of 25 km/hour. Overall, corridor 10 can reach the average travel speed of 21 km/hour during the morning-peak period and 19 km/hour during the evening-peak period. Overall, the average travel speed of corridor 10 is below the standard of 25 km/hr.

2) *System capacity*

System capacity is represented by corridor capacity. The corridor 10 is served by 25 units of regular bus and 4 substitution units of regular bus. There are 16 stations with single platform and 4 stations with double platforms. From the equation (3.1), the capacity of corridor 10 is 1,547 pphpd (passenger per peak-hour per direction) or 3,094 passengers/hour with the trip frequency of 13 vehicles/hour. The number of passengers in the rush hour (between 17:00 and 18:00 o'clock) is 1,424. As a result, the system capacity of corridor 10 is insufficient to accommodate the actual daily demand.

3) *Service reliability*

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 10 is summarized in Table 4.77 below.

Table 4.77 Service reliability of corridor 10

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	96%	76%
Trip realization	98%	100%	81%
Punctuality at the start	85%	81%	33%
Punctuality at the complete	85%	43%	70%
Headway regularity	85%	92%	48%
Comfort and load factor	0.85	0.53	0.34

As shown in Table 4.76, the waiting time reliability is below the required percentage in the second direction, while the waiting time is reliable in the first direction. The second direction can only have executed 81% of all assigned trips

during peak period which is still below the required percentage. The unreliable punctuality occurred in both directions. The second direction has also been failure in terms of headway regularity. In terms of load factor, both directions have load factor below 0.85 which are acceptable for convenience of passengers.

Based on the performance evaluation and following the framework in **Figure 3.6**, the problem identification and strategy determination are expressed in **Figure 4.43**.

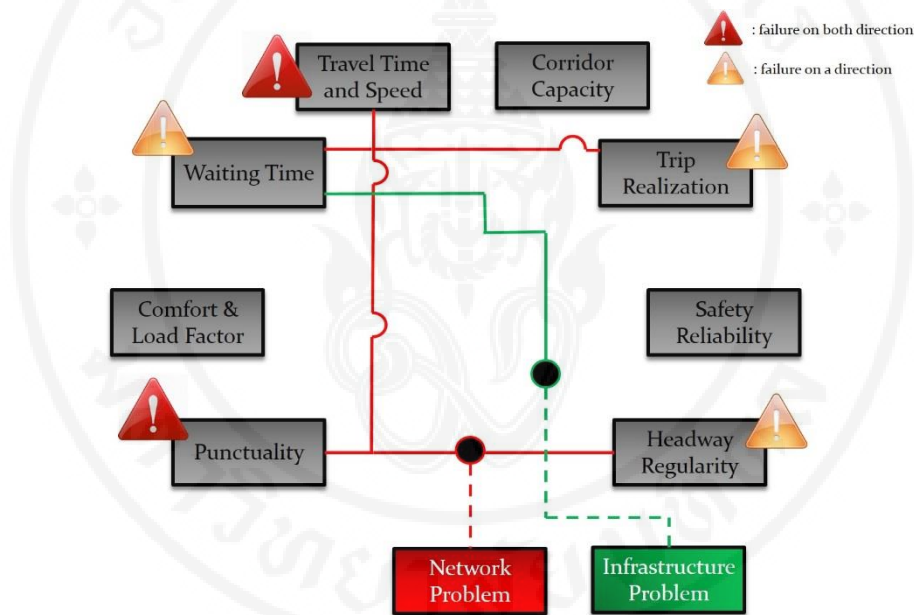


Figure 4.43. Problem identification of corridor 10

As shown in **Figure 4.43**, corridor 10 faces the problem in two aspects; i.e., network, and infrastructure. The following strategies are considered.

1) Network aspect

Network aspect deals with the link and the node. In the case of corridor 10, there are 11 signalized intersections and 3 un-signalized intersections that are involved along the route of corridor 10. There are 11 links from 21 links of the route are opened lane, also 1 link is closed only in 1 side. As a decision, the mixed-traffic restriction and priority signal strategies are simulated directly in the simulation by the consideration of space and another possibility. These strategies form the package for

third scenario. By giving the priority to BRT fleet's movement in the network, the delay can be minimized.

2) *Infrastructure aspect*

Infrastructure aspect deals with the station and the busway. Based on the observation along the route, there are 4 integrated stations with 1 platform, and 4 integrated stations with double platforms, and there no station has passing lane, except station X-1. In terms of busway, there are 5 stations which have no segregated lane-on-station, where those all stations are integrated station. It not only causes the unnecessary queue, but also causes the interrupted dwelling time by mixed-traffic. As a decision, the improvement infrastructure in order to enhance the corridor 10; i.e.:

- Installation of extra platform, segregated lane, and passing lane at station X-3, station X-4, station X-5, station X-6, and station X-20;
- Installation of segregated lane on station X-2, station X-7, station X-14, and station X-17
- Installation of passing lane at station X-21.

By installing more platform and passing lane on the integrated stations, the queue of dwelling time can be avoided. Then, the segregated lane-on-station protects bus for dwelling and alighting. These strategies form the package for third scenario in simulation.

4.2.11 Corridor 11

The corridor 11 connects between Pulogebang bus terminal and Kampung Melayu bus terminal. It passes through 16 stations in the first direction (A-B) and 15 stations in the second direction. The total network distance is about 13.7 km in the first direction (A-B) and 11.2 km in the second direction (B-A). Both directions have the different routes on several links due to one-way regulation. The route and the station points are shown in **Figure 4.44**.

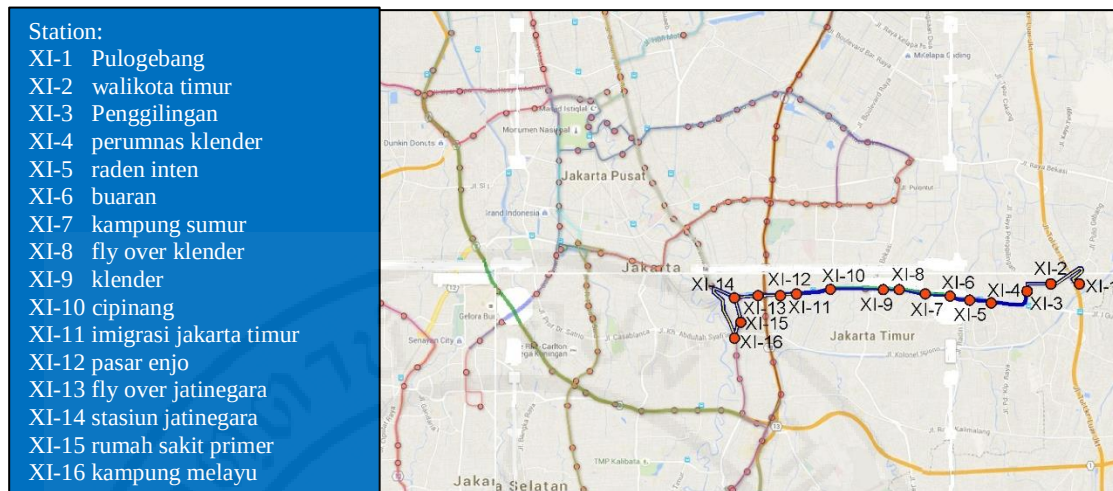


Figure 4.44. The route map of corridor 11

The performance evaluation has been done. They are described below.

1) *Travel speed and travel time*

Figure 4.45 shows the travel time and travel speed between stations and travel speed from start to finish stations.

Direction A-B		Morning peak																	
Station:	XI-1	XI-3	XI-2	XI-3	XI-4	XI-5	XI-6	XI-7	XI-8	XI-9	XI-10	XI-11	XI-12	XI-13	XI-14	XI-15	XI-16		
Distance:	2,594	786	763	1,344	690	742	656	987	484	1,017	804	447	533	610	862	437	meters	Total:	13,756 meters
Travel speed:	19	7	46	27	21	22	10	30	15	31	24	13	16	18	17	26	km/hr	Total:	18.3 km/hr
TT:	8	7	1	3	2	2	4	2	2	2	2	2	2	2	3	1	mins	Total:	45 mins
Direction A-B		Evening peak																	
Station:	XI-1	XI-3	XI-2	XI-3	XI-4	XI-5	XI-6	XI-7	XI-8	XI-9	XI-10	XI-11	XI-12	XI-13	XI-14	XI-15	XI-16		
Distance:	2,594	786	763	1,344	690	742	656	987	484	1,017	804	447	533	610	862	437	meters	Total:	13,756 meters
Travel speed:	19	7	23	27	21	15	13	20	29	15	24	13	16	18	17	26	km/hr	Total:	17.2 km/hr
TT:	8	7	2	3	2	3	3	3	1	4	2	2	2	2	3	1	mins	Total:	48 mins
Direction B-A		Morning peak																	
Station:	XI-16	XI-14	XI-13	XI-12	XI-11	XI-10	XI-9	XI-8	XI-7	XI-6	XI-5	XI-4	XI-3	XI-2	XI-1				
Distance:	2,164	610	533	447	804	1,017	484	987	656	742	690	1,344	786	1,807	meters	Total:	13,071 meters		
Travel speed:	22	37	16	27	16	31	29	30	39	22	41	27	24	14	km/hr	Total:	22.4 km/hr		
TT:	6	1	2	1	3	2	1	2	1	2	1	3	2	8	mins	Total:	35 mins		
Direction B-A		Evening peak																	
Station:	XI-16	XI-14	XI-13	XI-12	XI-11	XI-10	XI-9	XI-8	XI-7	XI-6	XI-5	XI-4	XI-3	XI-2	XI-1				
Distance:	2,164	610	533	447	804	1,017	484	987	656	742	690	1,344	786	1,807	meters	Total:	13,071 meters		
Travel speed:	22	37	16	27	24	20	29	30	39	22	21	16	16	14	km/hr	Total:	20.1 km/hr		
TT:	6	1	2	1	2	3	1	2	1	2	2	5	3	8	mins	Total:	39 mins		

Figure 4.45. Travel time, travel speed, and distance between stations of corridor 11

As shown in **Figure 4.44**, there are 73 % of all segments in the first direction (A-B) and 56% of all segments in the second direction (B-A) which have the travel speed below the standard of 25 km/hour. Overall, the average travel speed is 20 km/hour during morning-peak period and the average travel speed during evening-peak period is 19 km/hour. It means that the travel speed is below the standard of 25 km/hour. As a result, the travel time of corridor 11 is failure in both directions as the rapid transit system.

2) System capacity

System capacity is represented by corridor capacity. The corridor 11 is served by 16 units of articulated bus and 1 substitution unit of regular bus. In terms of station, there are 14 stations with single platform and 2 stations with double platforms. From the equation (3.1), the system capacity of corridor 11 is 1,547 pphpd (passenger per peak-hour per direction) or 3,094 passengers/hour with the trip frequency of 13 vehicles/hour. Furthermore, the rush hour (between 06:00 and 7:00 o'clock) is 942. As a result, the capacity of corridor 11 is sufficient to accommodate the actual daily demand.

3) Service reliability

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 11 is summarized in Table 4.78 below.

Table 4.78 Service reliability of corridor 11

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	100%	86%
Trip realization	98%	100%	112%
Punctuality at the start	85%	81%	34%
Punctuality at the complete	85%	97%	44%
Headway regularity	85%	88%	72%
Comfort and load factor	0.85	0.21	0.16

Overall, the corridor 11 is the most reliable in terms of service, as compare with the other corridors. Almost all parameters of service reliability reach the standard.

But in terms of departure time punctuality in both directions is below the required percentage of 85% as the standard. The headway regularity in the second direction (B-A) doesn't reach the required percentage of 85%.

Based on the performance evaluation and following the framework in **Figure 3.6**, the problem identification and strategy determination are expressed in **Figure 4.46** below.

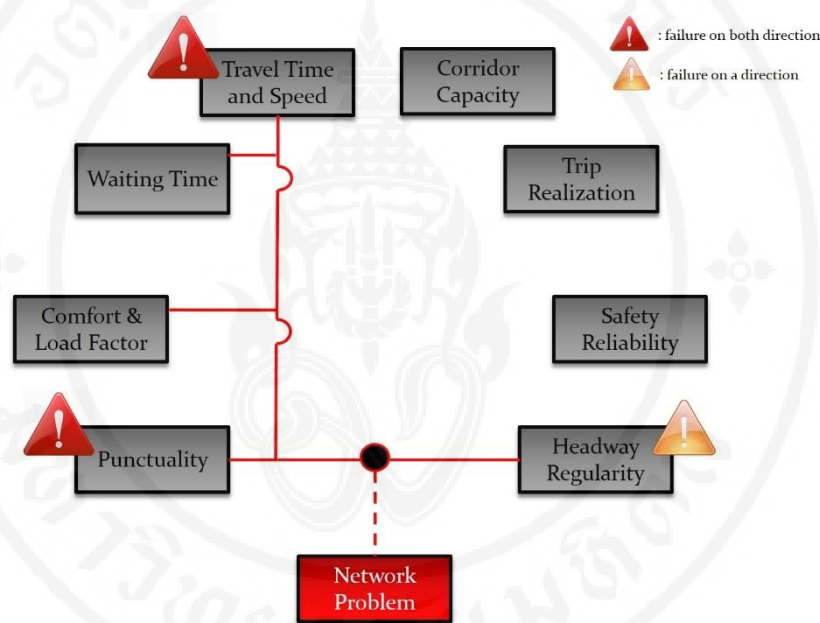


Figure 4.46. Problem identification of corridor 11

Even though, the corridor 11 has the best performance among the others, the framework still found the problem in the network aspect. The network aspect deals with the link and node. The corridor 1 involves 9 signalized intersections along its route. In terms of link, there are 4 links that are still open lanes and 4 links are closed for mixed traffic at only 1 direction side, the remaining of 8 links are closed for mixed traffic. Hence, the mixed-traffic restriction and priority signal strategies are simulated directly in the simulation as the third scenario. By giving the priority to BRT fleet's movement, the delay can be minimized.

4.2.12 Corridor 12

The corridor 12 connects between Pluit district and Tanjung Priok bus terminal. It passes through 20 stations in the first direction (A-B) and 21 stations in the second direction (B-A). The corridor 12 is the longest network among the other corridors, but it has the lowest daily demand among the others. The total network distance is 25.7 km in the first direction and 30.2 km in the second direction. The route and the station points are shown in **Figure 4.47**.

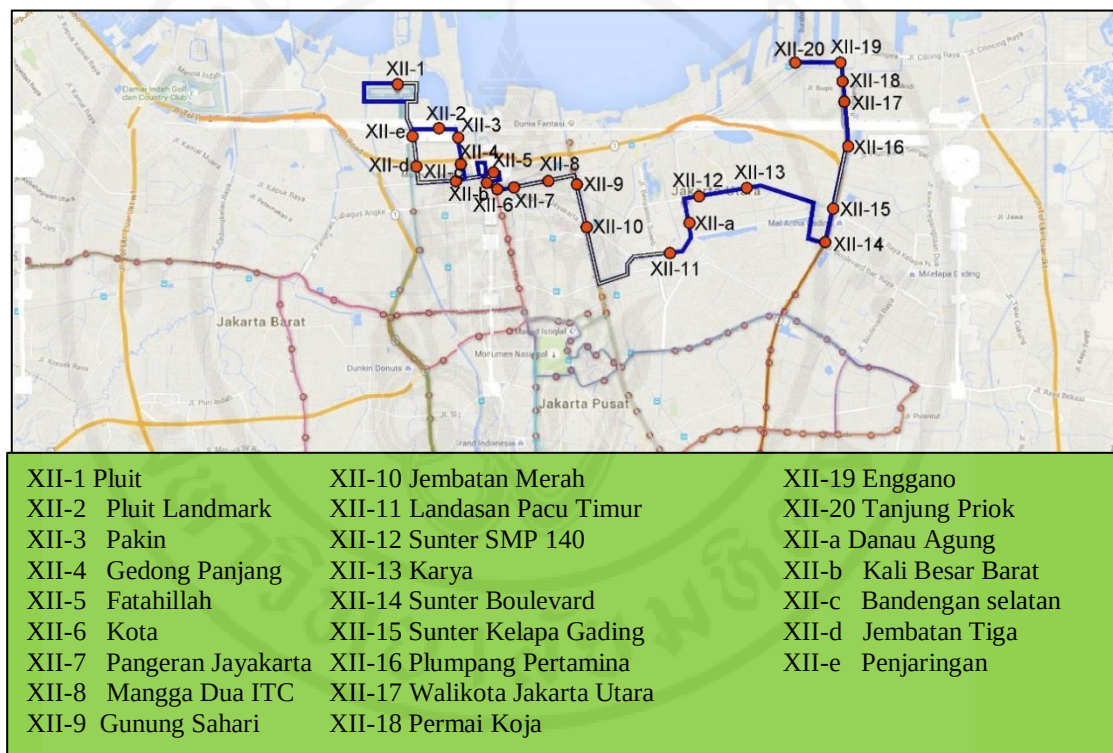


Figure 4.47. The route map of corridor 12

The performance evaluation has been done for corridor 8. As mentioned before, the 8 parameters are grouped into three aspects; i.e., travel time, system capacity, and service reliability.

1) Travel time and travel speed

Travel time is the main performance indicator of BRT as the rapid system. As mentioned before, travel time is the matter of travel speed and trip length. **Figure 4.48** shows the average of travel time and travel speed between stations and the travel speed from start to finish stations.

Direction A-B

Morning peak

Station:	XII-1	XII-2	XII-3	XII-4	XII-5	XII-6	XII-7	XII-8	XII-9	XII-10	XII-11	XII-12	XII-13	XII-14	XII-15	XII-16	XII-17	XII-18	XII-19	XII-20			
Distance:	2,441	730	593	1,591	867	475	891	858	1,135	3,629	1,857	1,305	3,338	870	1,882	805	545	802	1,127	meters	Total:	25,741	meters
Travel speed:	16	22	36	48	17	10	27	17	14	16	19	16	20	26	23	16	11	16	23	km/hr	Total:	18.4	km/hr
TT:	9	2	1	2	3	3	2	3	5	14	6	5	10	2	5	3	3	3	3	mins	Total:	84	mins

Direction A-B

Evening peak

Station:	XII-1	XII-2	XII-3	XII-4	XII-5	XII-6	XII-7	XII-8	XII-9	XII-10	XII-11	XII-12	XII-13	XII-14	XII-15	XII-16	XII-17	XII-18	XII-19	XII-20			
Distance:	2,441	730	593	1,591	867	475	891	858	1,135	3,629	1,857	1,305	3,338	870	1,882	805	545	802	1,127	meters	Total:	25,741	meters
Travel speed:	18	44	36	95	26	14	27	17	14	17	16	20	29	26	23	16	33	48	23	km/hr	Total:	21.8	km/hr
TT:	8	1	1	1	2	2	2	3	5	13	7	4	7	2	5	3	1	1	3	mins	Total:	71	mins

B-A

Morning peak

Station:	XII-20	XII-19	XII-18	XII-17	XII-16	XII-15	XII-14	XII-13	XII-12	XII-a	XII-10	XII-9	XII-8	XII-7	XII-6	XII-5	XII-b	XII-c	XII-d	XII-e	XII-1			
Distance:	1,127	543	497	1,882	2,752	870	2,301	1,322	965	893	4,532	1,135	858	900	558	468	1,036	1,424	791	5,317	meters	Total:	30,171	meters
Travel speed:	23	8	15	38	33	17	7	9	19	7	15	17	17	27	6	7	21	28	12	53	km/hr	Total:	16.2	km/hr
TT:	3	4	2	3	5	3	19	9	3	8	18	4	3	2	6	4	3	3	4	6	mins	Total:	112	mins

B-A

Evening peak

Station:	XII-20	XII-19	XII-18	XII-17	XII-16	XII-15	XII-14	XII-13	XII-12	XII-a	XII-10	XII-9	XII-8	XII-7	XII-6	XII-5	XII-b	XII-c	XII-d	XII-e	XII-1			
Distance:	1,127	543	497	1,882	2,752	870	2,301	1,322	965	893	4,532	1,135	858	900	558	468	1,036	1,424	791	5,317	meters	Total:	30,171	meters
Travel speed:	23	16	15	38	33	17	8	10	19	7	16	17	17	27	7	7	16	28	12	40	km/hr	Total:	16.8	km/hr
TT:	3	2	2	3	5	3	17	8	3	8	17	4	3	2	5	4	4	3	4	8	mins	Total:	108	mins

Figure 4.48. Travel time, travel speed, and distance between stations of corridor 12

There is 65.8 % of all segments in the first direction and 80% of all segments in the second direction that have travel speed below the standard of 25 km/hour. Overall, the average travel speed is 17 km/hour in the first direction and 19 km/hour in the second direction. As a result, the travel speed of corridor 12 is failure in both directions to meet with the standard of the rapid transit system.

2) System capacity

The system capacity is represented by the corridor capacity. The corridor 12 is served by 14 units of articulated bus and 4 units of regular bus. There are 23 stations with single platform and 2 stations with double platforms. From the equation (3.1), the system capacity of corridor 12 is 1,547 pphpd (passenger per peak-hour per direction) or 3,094 passengers/hour with the trip frequency of 13 vehicles/hour which is mostly taken by articulated buses. The number of passengers in the rush hour (between 17:00 and 18:00 o'clock) is 557. As a result, the system capacity of corridor 12 is sufficient to accommodate the actual daily demand.

3) Service reliability

Service reliability is expressed by 6 parameters; i.e., waiting time reliability, trip realization, starting punctuality, finishing punctuality, headway

regularity, and load factor. From the equations (3.2), (3.3), (3.4), (3.5), (3.6), (3.7), and (3.8), the service reliability of corridor 12 is summarized in Table 4.79 below.

Table 4.79 Service reliability of corridor 8

Parameters	Benchmark	Direction A-B	Direction B-A
Waiting time reliability	85%	63%	87%
Trip realization	98%	81%	92%
Punctuality at the start	85%	37%	22%
Punctuality at the complete	85%	8%	48%
Headway regularity	85%	62%	54%
Comfort and load factor	0.85	0.38	0.39

The waiting time reliability is failure in the first direction. Both directions are failed to execute all assigned trips. The punctuality and headway regularity in both directions are also failure. In terms of load factor, both direction have the load factor below 0.85 which are acceptable for inconvenience of passengers. The corridor 12 might be the longest network among all corridors, but it has the lowest number of daily passengers among all corridors.

Based on the performance evaluation, the problem identification and strategy determination are expressed in **Figure 4.49**.

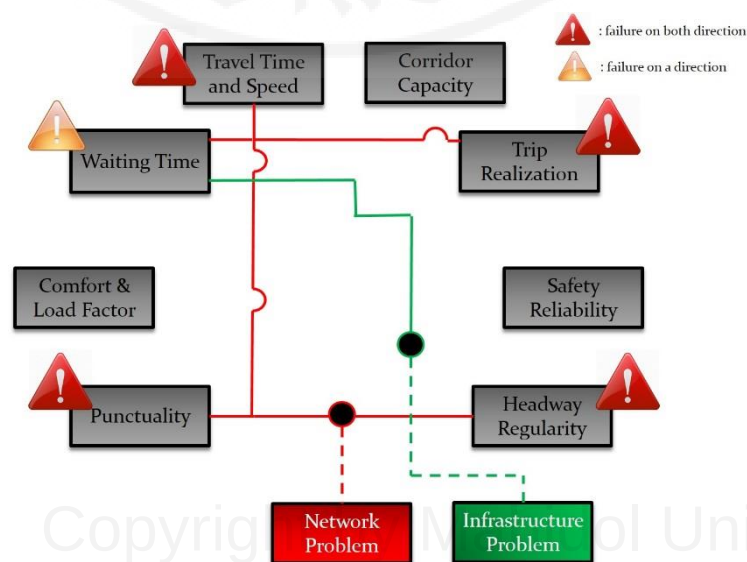


Figure 4.49. Problem identification of corridor 12

As shown in **Figure 4.48**, corridor 8 faces the problem in two aspects; i.e., network, and infrastructure. The following strategies are considered.

1) Network aspect

Network problem deals with the link and the node. The network of corridor 12 involves 15 signalized intersections and 10 un-signalized intersections. Then, there are 20 links which are opened lane and 9 links which are segregated lane. Hence, the priority signal and the mixed-traffic restriction strategies is simulated directly in the simulation as the second scenario. By giving the priority to BRT fleet's movement, the delay can be minimized.

2) Infrastructure aspect

In terms of infrastructure aspect, the strategy considers the improving station and busway. The corridor 12 has 8 integrated stations with single platform, 2 integrated stations that has double platforms without passing lane, and 1 integrated with double platforms and passing lane. Furthermore, there are 11 stations without segregated lane-on-station to protect the dwelling time for bus. The enhancement considers the space and another possibility. As a decision, the improving infrastructure in order to enhance the performance of corridor 12; i.e.:

- Installation of extra platform and passing lane at station XII-6, station XII-9, station XII-10, station XII-14, station XII-17, station XII-18, station XII-19, and station XII-e;
- Installation of passing lane at station XII-1 and station XII-16;
- Installation of segregated lane-on-station at station XII-2, station XII-3, station XII-5, station XII-11, station XII-12, station XII-13, station XII-17, station XII-19, and station XII-20.

These strategies form the package for third scenario in simulation. By installing the extra platform and passing lane, the bus queue can be minimized. The protected busway on station gives the priority to bus for dwelling and alighting.

4.4 Simulation approach for TransJakarta

The performance evaluation, problem identification, and proposing strategies have been accomplished for all corridors. The next step is the assessment of the proposed strategies by using the simulation approach, so that the best scenario can be determined by considering the travel time and travel speed improvements. The traffic simulation software; namely, VISSIM is used in this study. The entire network of 211 km is generated by corridor using VISSIM. The simulation model consists of PT-Line, PT-Stop, and PT-Vehicle. They have been done for all corridors. The simulation is performed separately by corridor. Then, the calibration model put every condition as real as possible by considering the mixed traffic and BRT traffic. In order to make sure that the model is calibrated well, the validation is done by comparing between the actual result and the model result. The travel time and travel speed are the parameters to compare between scenarios. The simulation approach of every corridor is explained by corridor.

4.4.1 Simulation results for corridor 1

In order to make it easy for identifying links and nodes in the network of corridor 1, **Figure A.1** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) *Model validation*

The development of simulation model for corridor 1 has been done, the visualization of a partial network is shown in **Figure 4.50**.

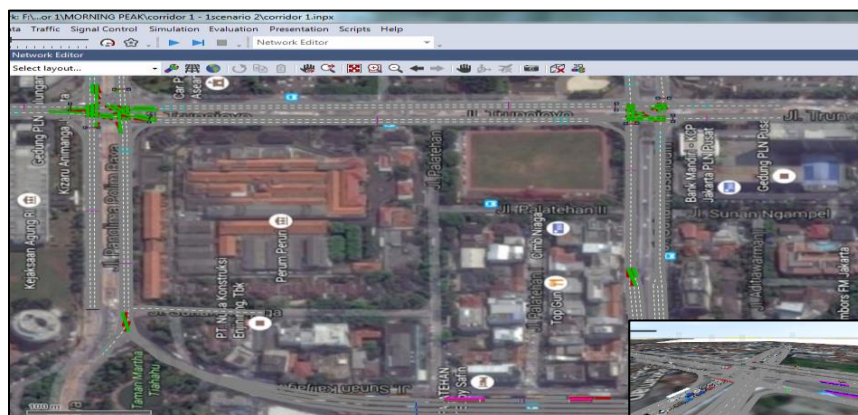


Figure 4.50. A part of simulated network of corridor 1

The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figures 4.51** and **4.52** show the comparison of arrival times during two peak periods.

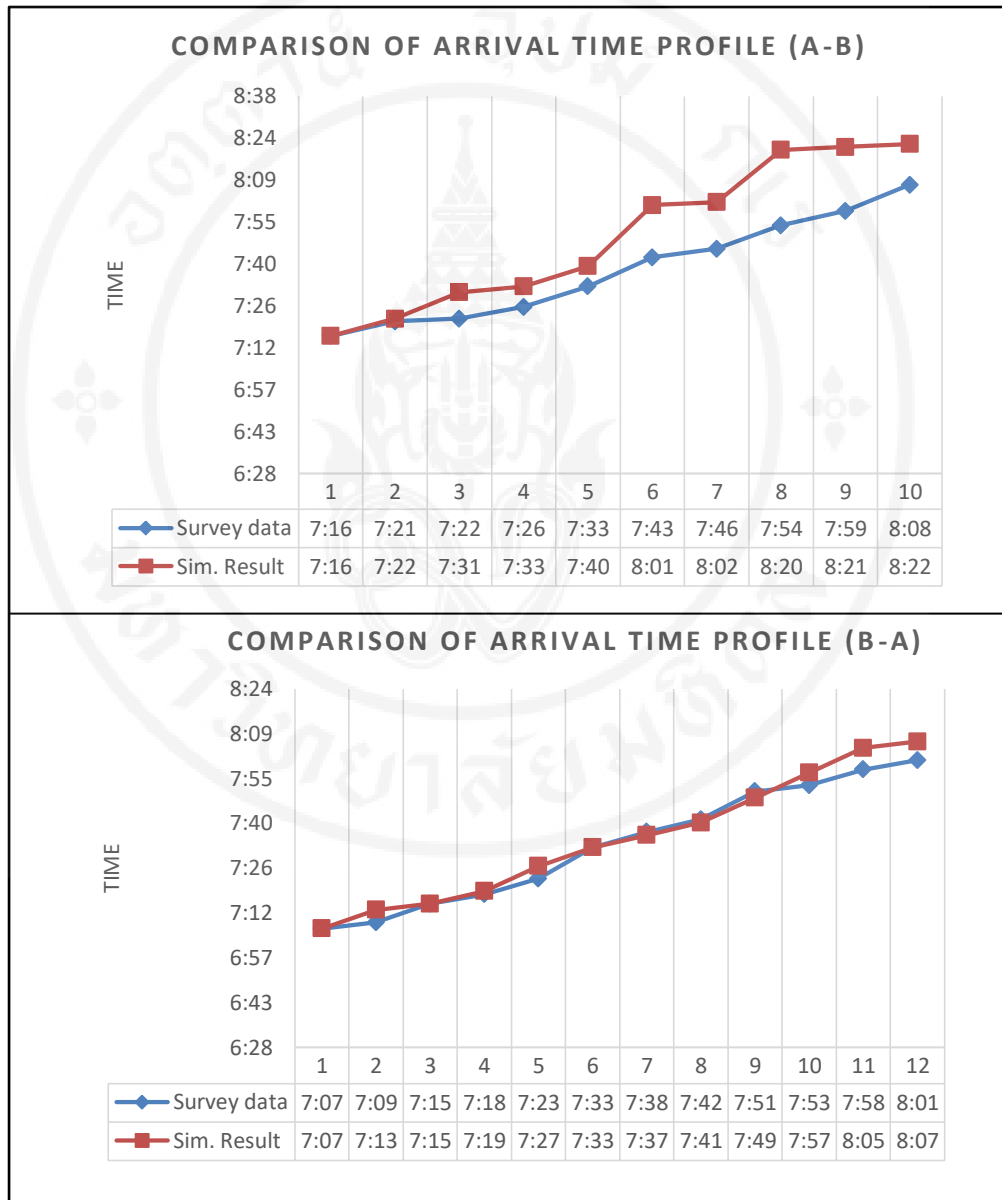


Figure 4.51 The comparison of arrival times for corridor 1 between actual and simulation results during morning-peak hour

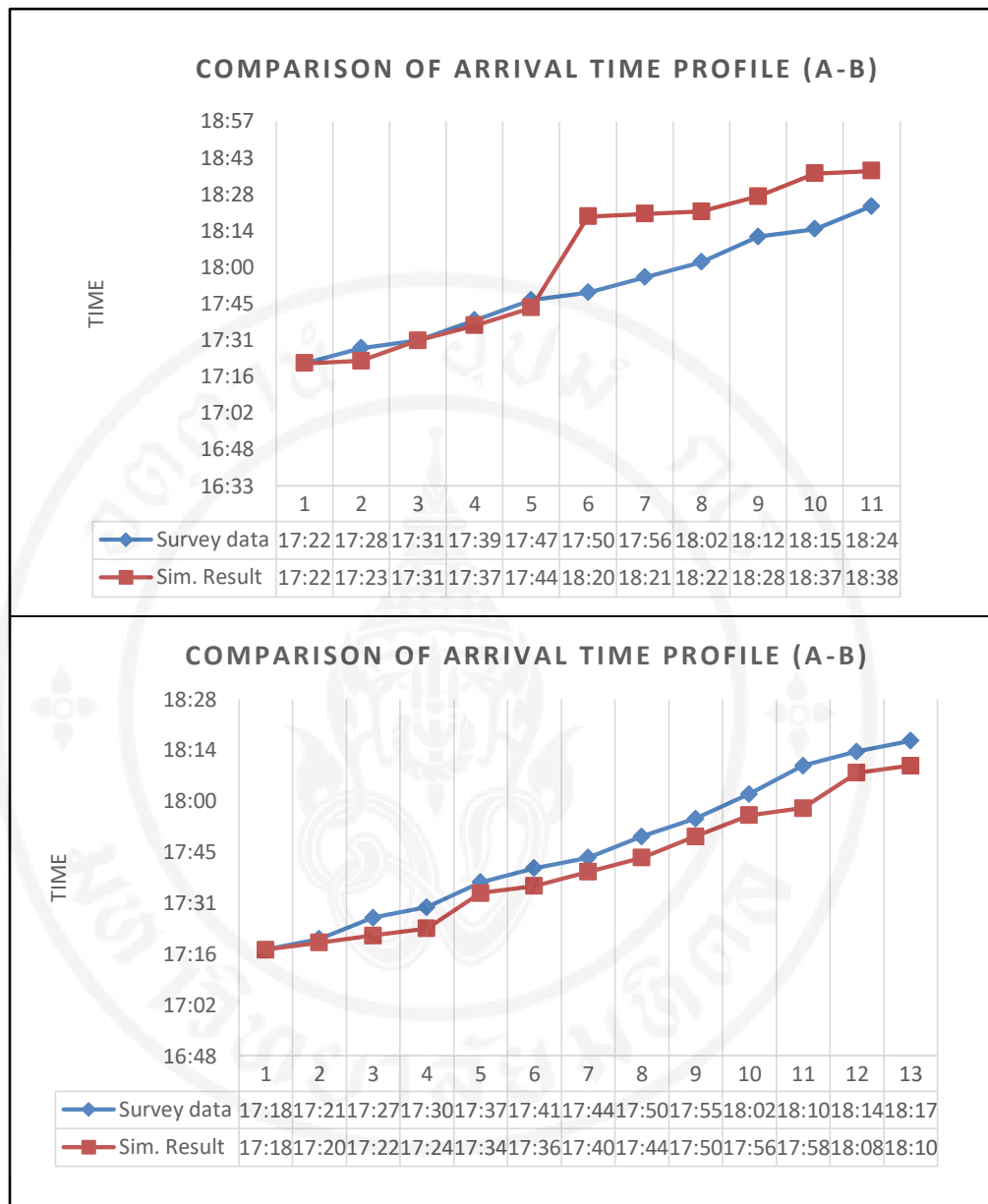


Figure 4.52 The comparison of arrival times for corridor 1 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.51** and **4.52** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 2 to 12 minutes during morning peak and 5 to 12 minutes during evening peak.

Figures 4.53 and **4.54** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.

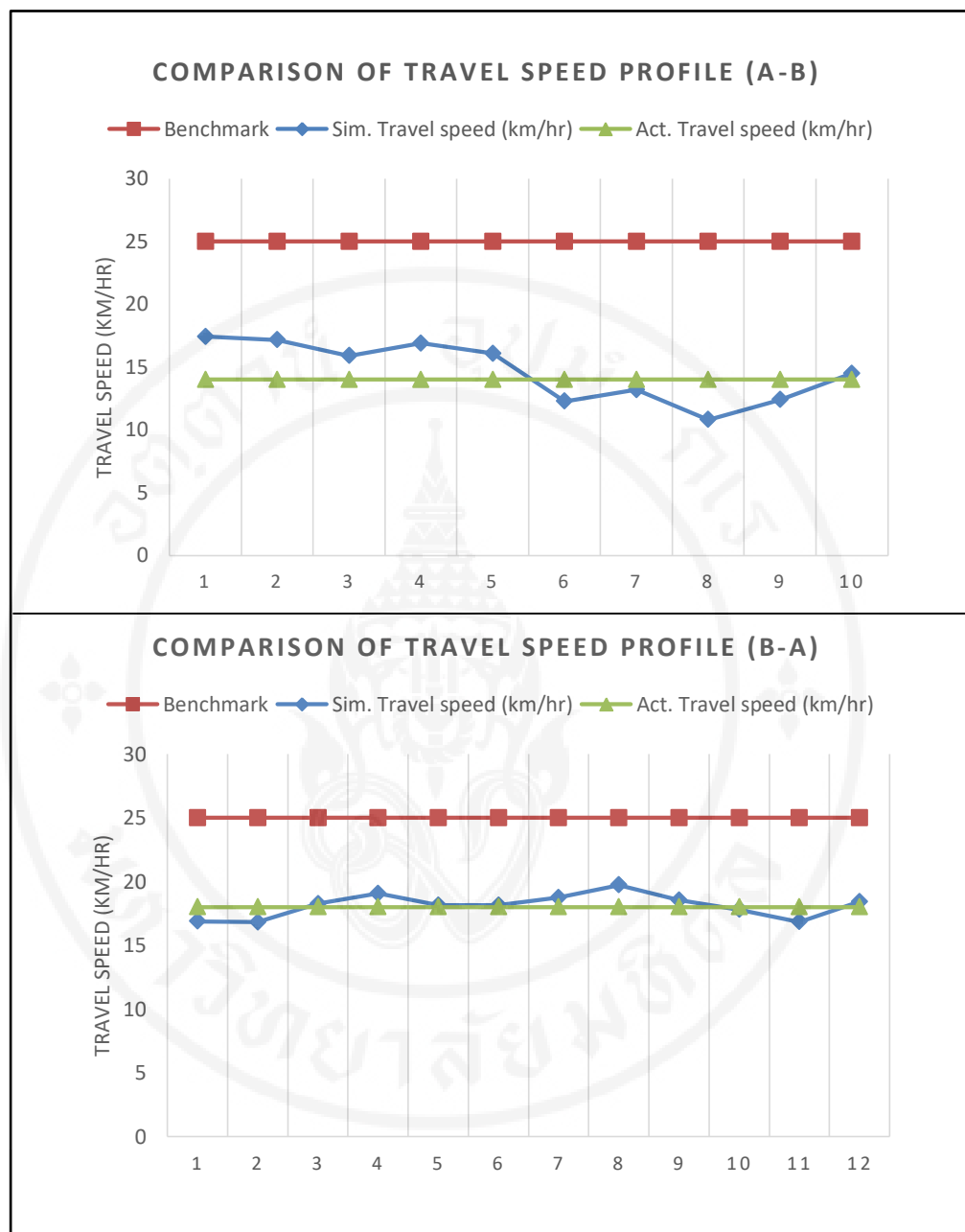


Figure 4.53 The comparison of travel speeds for corridor 1 between actual and simulation results, and the benchmark during morning-peak hour

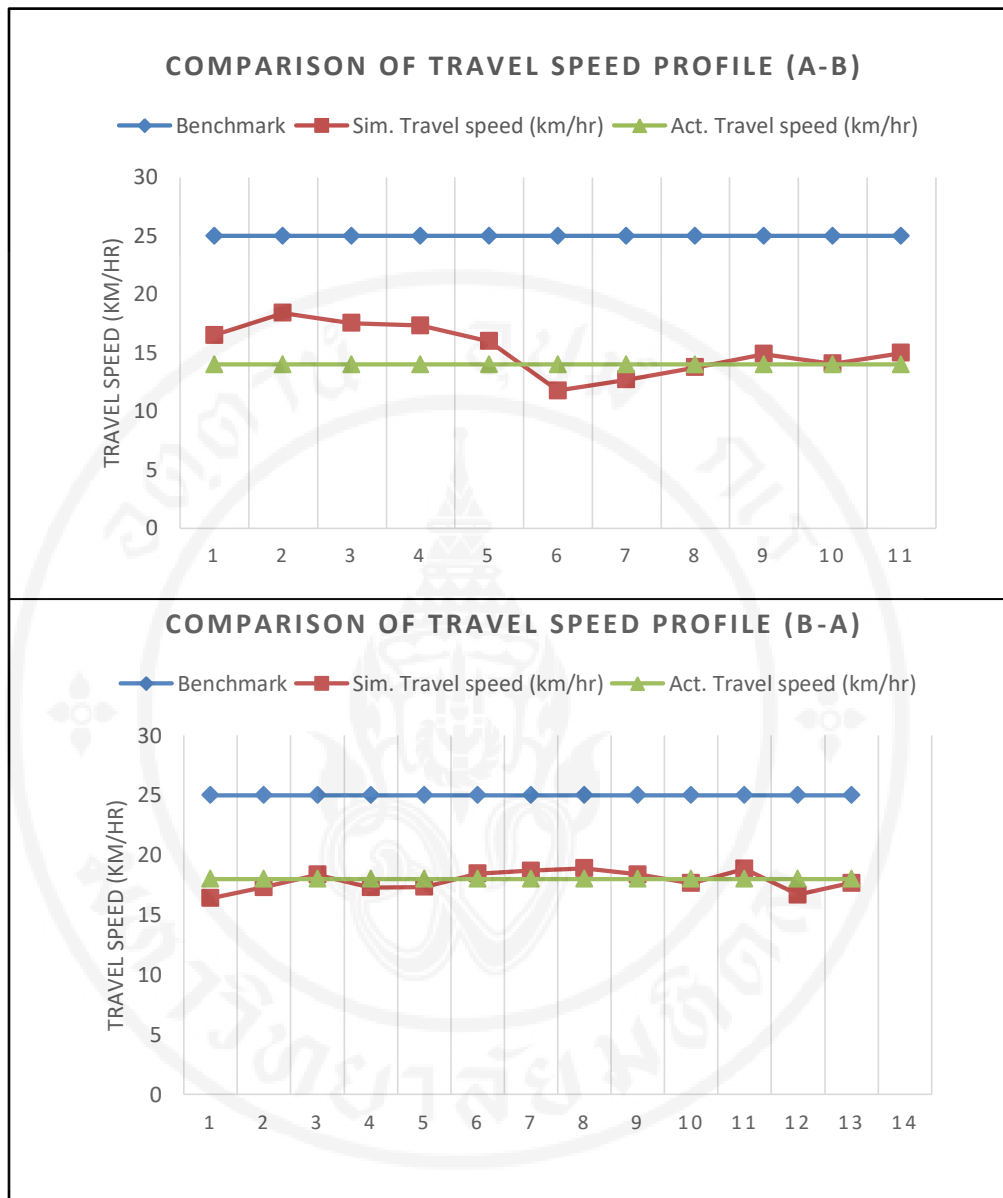


Figure 4.54 The comparison of travel speeds for corridor 1 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.53** and **4.54**, the final calibration shows 98% similarity of travel speeds during morning peak and 94% during evening peak between the simulation result and the actual result. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Tables 4.80 and 4.81. The difference between the average actual travel time and simulated travel time

is -2% for the first direction (A-B) and -2% for the second direction (B-A) during morning peak. Meanwhile, the difference during evening peak is -7% for the first direction (A-B) and -4% for the second direction (B-A).

Table 4.80 Percentage differences between actual and simulated travel times for corridor 1 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	58	47	-19	45	47	+4
2	58	47	-19	45	47	+4
3	58	51	-12	45	44	-2
4	58	48	-17	45	42	-7
5	58	50	-14	45	44	-2
6	58	66	+14	45	44	-2
7	58	61	+5	45	42	-7
8	58	75	+29	45	40	-11
9	58	65	+12	45	43	-4
10	58	56	-3	45	45	0
11	-	-	-	45	47	+4
12	-	-	-	45	43	-4
$\bar{X}$	58	57	-2	45	44	-2

Table 4.81 Percentage differences between actual and simulated travel times for corridor 1 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	58	49	-16	46	46	0
2	58	44	-24	46	43	-7
3	58	46	-21	46	43	-7
4	58	47	-19	46	42	-9
5	58	49	-16	46	43	-7
6	58	69	+19	46	45	-2
7	58	64	+10	46	42	-9
8	58	59	+2	46	48	+4
9	58	54	-7	46	45	-2
10	58	58	0	46	46	0
11	58	53	-9	46	42	-9
12	-	-	-	46	45	-2
13	-	-	-	46	41	-11
$\bar{X}$	58	54	-7	46	44	-4

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. Table 4.82 shows the positive ranks and negative ranks from the SPSS output.

Table 4.82 Wilcoxon Signed-Rank test for validating the simulation results of corridor 1

		N	Mean Rank	Sum of Ranks
Direction (A-B), morning peak				
sim_trav_time	Negative Ranks	6 ^a	5.67	34.00
-				
act_trav_time	Positive Ranks	4 ^b	5.25	21.00
	Ties	0 ^c		
	Total	10		
Direction (A-B), evening peak				
sim_trav_time	Negative Ranks	7 ^a	6.07	42.50
-				
act_trav_time	Positive Ranks	3 ^b	4.17	12.50
	Ties	1 ^c		
	Total	11		
Direction (B-A), morning peak				
sim_trav_time	Negative Ranks	8 ^a	6.00	48.00
-				
act_trav_time	Positive Ranks	3 ^b	6.00	18.00
	Ties	1 ^c		
	Total	12		
Direction (B-A), evening peak				
sim_trav_time	Negative Ranks	8 ^a	6.44	51.50
-				
act_trav_time	Positive Ranks	4 ^b	6.63	26.50
	Ties	2 ^c		
	Total	14		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak*: The sum of ranks for negative differences is $T_n = 34$; the sum of ranks for positive differences is $T_p = 21$. Thus, we have $t_0 = \min(T_p, T_n) = 21$. It shows that for $n = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 21$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak*: The sum of ranks for negative differences is $T_n = 42.5$; the sum of ranks for positive differences is $T_p = 12.5$. Thus, we have $t_0 = \min(T_p, T_n) = 12.5$. It shows that $(n - \text{ties}) = 10 - 1 = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 12.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak*: The sum of ranks for negative differences is $T_n = 48$; the sum of ranks for positive differences is $T_p = 18$. Thus, we have $t_0 = \min(T_p, T_n) = 18$. It shows that $(n - \text{ties}) = 12 - 1 = 11$ observations, the critical value of t_0 is $T = 11$ with $\alpha = 0.05$. Because the value $T = 18$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak*: The sum of ranks for negative differences is $T_n = 51.5$; the sum of ranks for positive differences is $T_p = 26.5$. Thus, we have $t_0 = \min(T_p, T_n) = 26.5$. It shows that $(n - \text{ties}) = 14 - 2 = 12$ observations, the critical value of t_0 is $T = 14$ with $\alpha = 0.05$. Because the value $T = 26.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 1, there are 8 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Increase trip frequency by decreasing headway from 5 minutes to 3 minutes 32 seconds
- Scenario 3: Implement priority signal and mixed-traffic restriction on links 1.2 and 1.3
- Scenario 4: Install the extra platform and passing lane at station I-14
- Combination 1: Conducting scenarios 2 and 3
- Combination 2: Conducting scenarios 2 and 4
- Combination 3: Conducting scenarios 3 and 4
- Combination 4: Conducting all scenarios

All scenarios have been run on simulation. Tables 4.83 and 4.84 show the comparison of travel time and travel speed for morning and evening peaks, respectively.

Table 4.83 Simulation results by scenario for corridor 1 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both Directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	58	14	58	14	58	14
Scenario 2	59	14	58	14	59	15
Scenario 3	31	26	29	28	30	27
Scenario 4	51	15	44	19	48	17
Combination 1	30	27	29	28	30	27
Combination 2	41	20	38	21	40	20
Combination 3	35	23	33	24	34	24
Combination 4	30	27	29	28	29	28

Table 4.84 Simulation results by scenario for corridor 1 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both Directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	45	18	46	18	46	18
Scenario 2	46	18	46	18	46	18
Scenario 3	30	27	28	28	29	28
Scenario 4	46	18	39	20	42	19
Combination 1	30	27	28	28	29	27
Combination 2	44	19	38	21	41	20
Combination 3	30	27	29	28	29	27
Combination 4	31	26	28	28	29	27

Based on the simulation results in Table 4.83, the best travel time during morning peak that can be reached is 30 minutes; i.e., combinations 1 and 4 for the first direction (A-B) and 29 minutes; i.e., scenario 3, combination 1, and combination 4 for the second direction (B-A). Refer to Table 4.84, the best travel time during evening peak that can be reached is 30 minutes; i.e., scenario 3, combination 1, and combination 3 for the first direction (A-B) and 28 minutes; i.e., scenario 3, combinations 1, and 4 for the second direction (B-A). These scenarios have proved to lead the travel speed up to the standard of 25 kph as the rapid transit system. Theoretically, one of the two combinations can be the best proposed strategy. However, scenario 3, combination 1, and combination 4 show the best performances. Hence, for corridor 1, scenario 3 may be more cost effective to improve the performance, rather than the combination scenario. However, the combinations 1 and 4 involve scenario 2 which is crucial to satisfy the demand. Because the operational strategy is crucial, this study considers the demand satisfaction by improving the system capacity. On corridor 1, it lacks of capacity. As a recommendation, the scenario combination 1 is the best strategy to enhance the operational performance of corridor 1. The combination 1 offers the lower cost than combination 4 with the same results.

4.4.2 Simulation results for corridor 2

In order to make it easy for identifying links and nodes in the network of corridor 2, **Figure A.2** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 2 has been done, the visualization of a partial network is shown in **Figure 4.55** below.

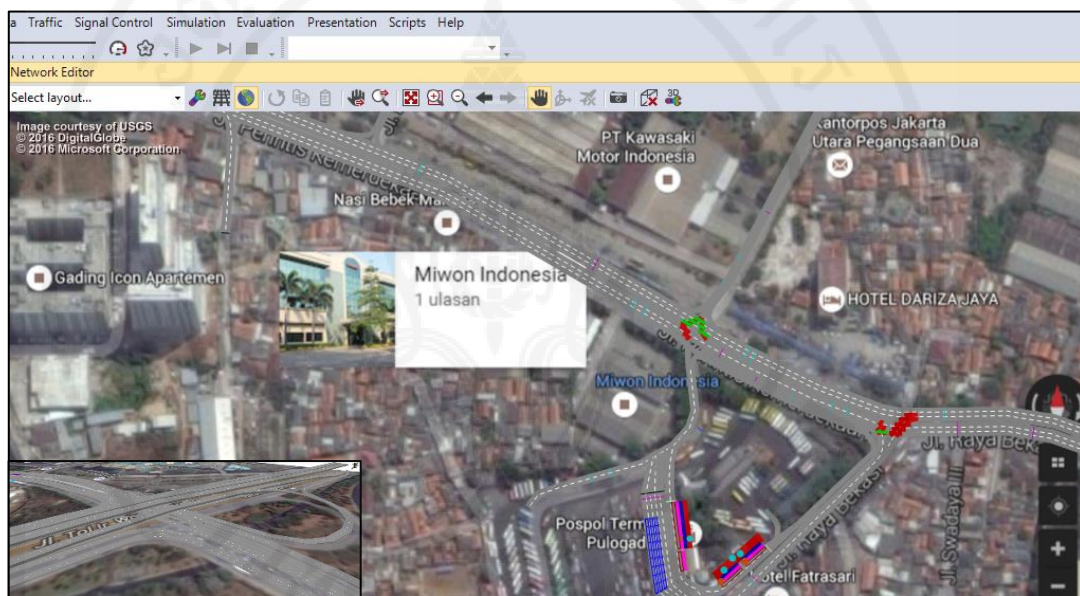


Figure 4.55. A part of simulated network of corridor 2

The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figures 4.56** and **4.57** show the comparison of arrival times during two peak periods.

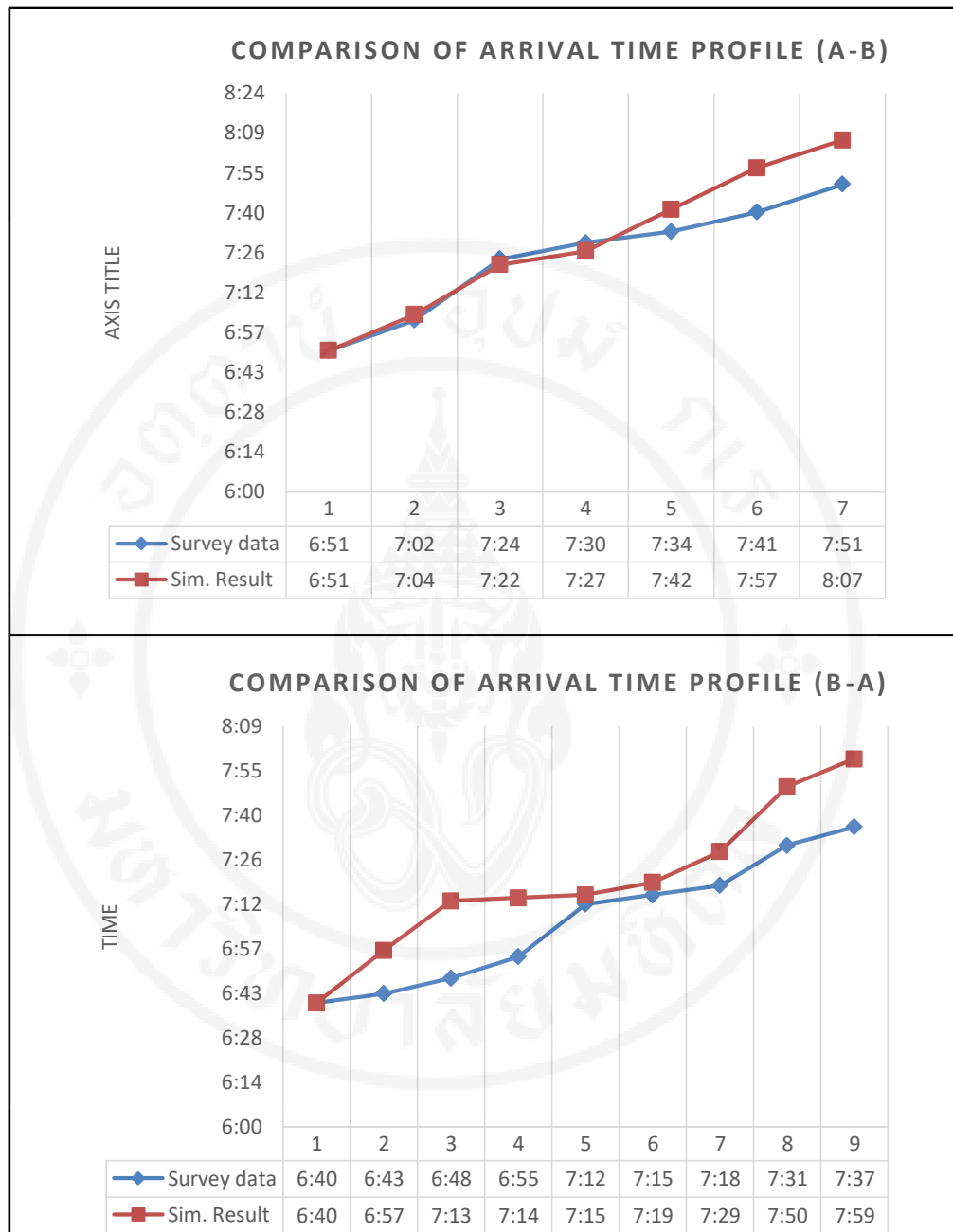


Figure 4.56 The comparison of arrival times for corridor 2 between actual and simulation results during morning-peak hour

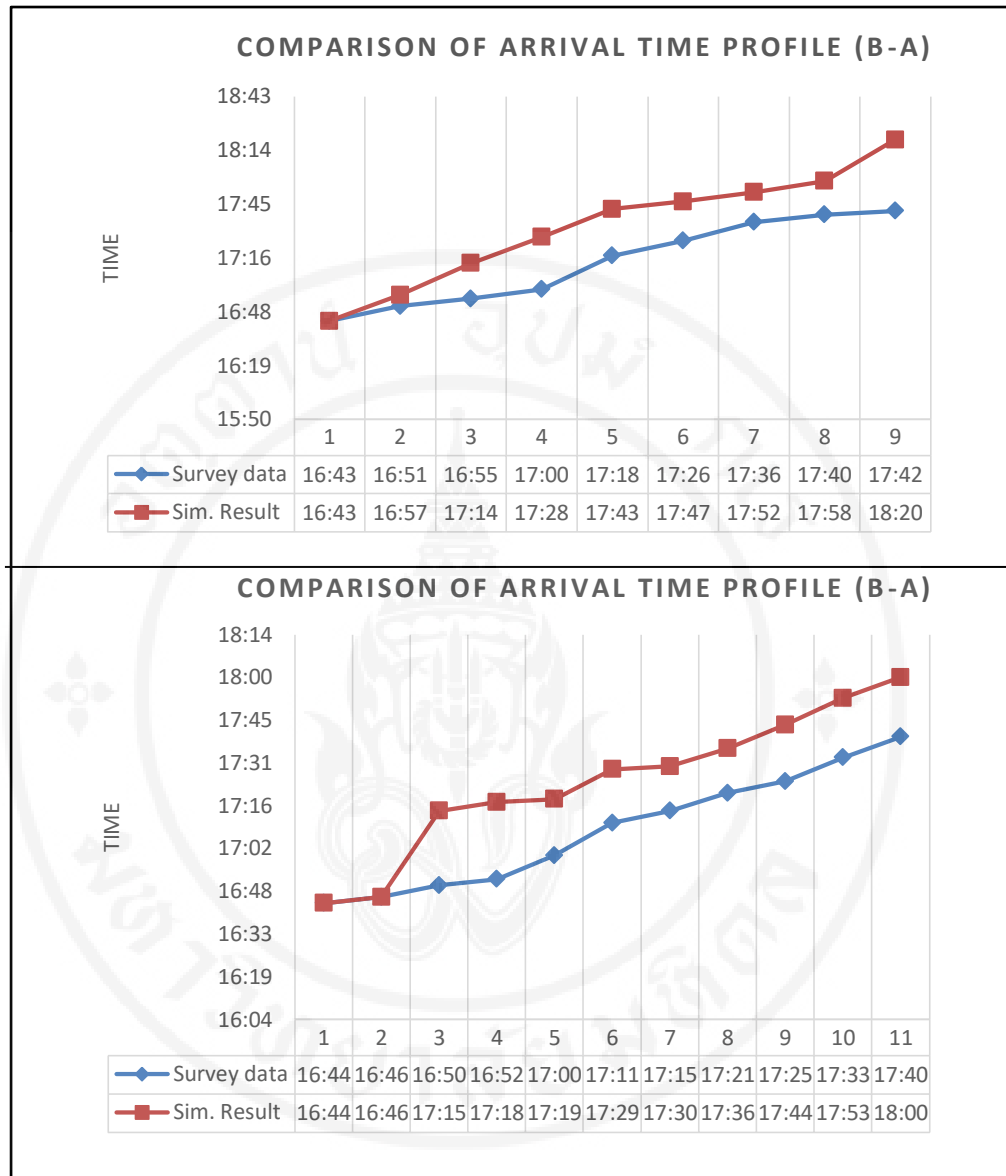


Figure 4.57 The comparison of arrival times for corridor 2 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.56** and **4.57** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 6 to 13 minutes during morning peak and 16 to 19 minutes during evening peak.

Figure 4.58 and **Figure 4.59** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.

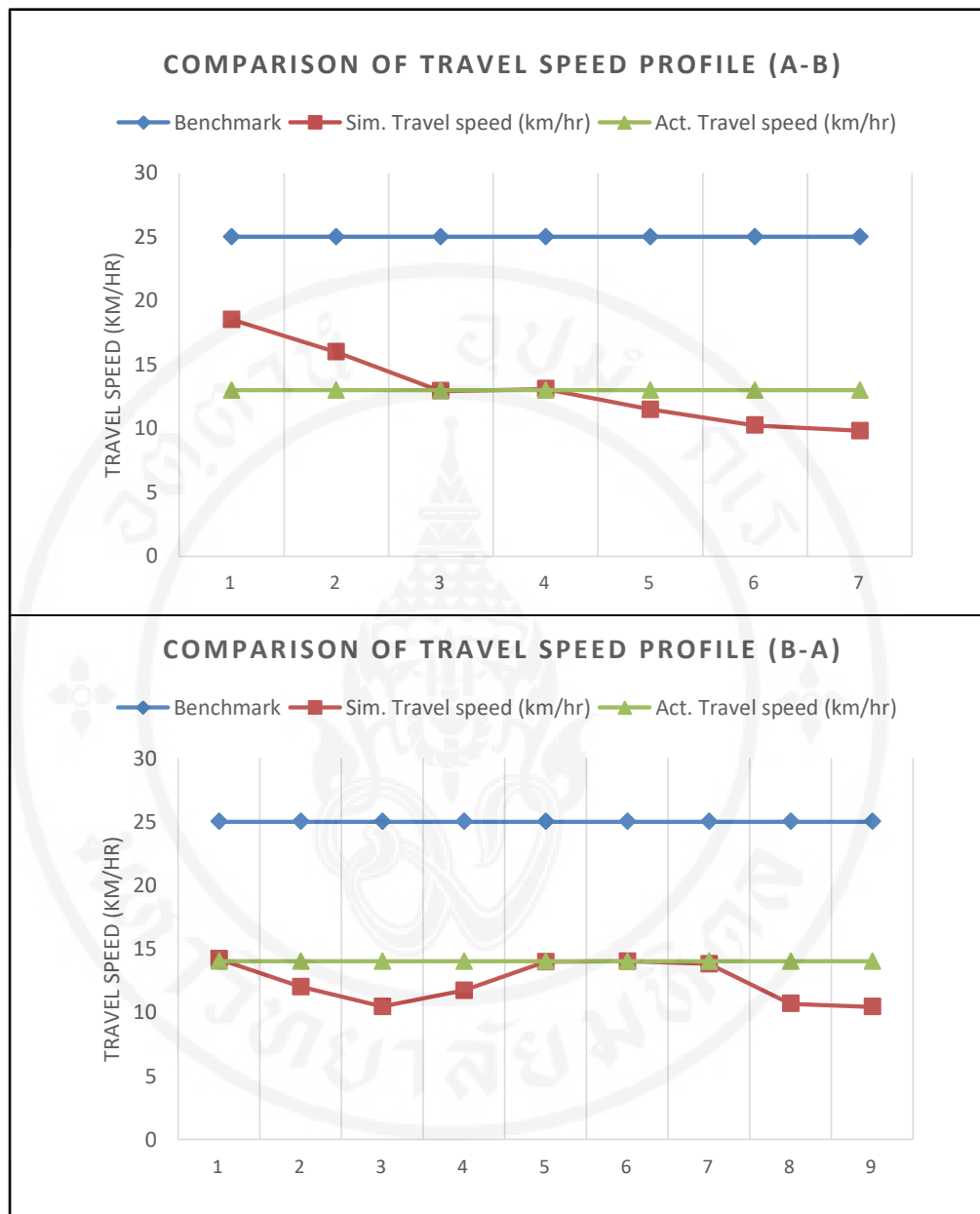


Figure 4.58 The comparison of travel speeds for corridor 2 between actual and simulation results, and the benchmark during evening-peak hour

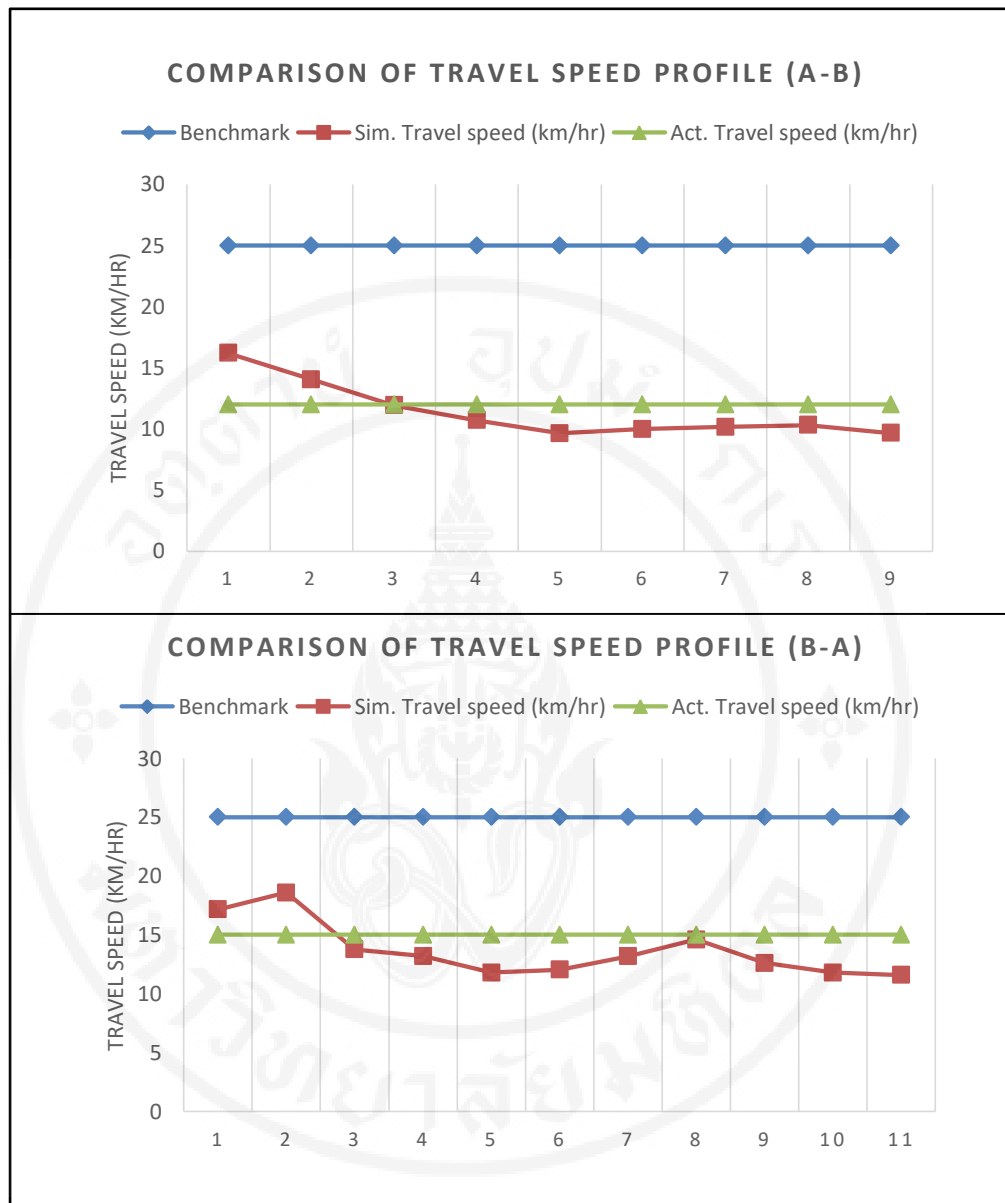


Figure 4.59 The comparison of travel speeds for corridor 2 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.58** and **4.59**, the final calibration shows 95% similarity of travel speeds during morning peak and 95% during evening peak between the simulation result and the actual result. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Tables 4.85 and 4.86. There is no significant difference between the average actual travel time and

simulated travel time for the first direction (A-B) and +12% difference for the second direction (B-A) during morning peak. Meanwhile, the difference during evening peak is +6% for the first direction (A-B) and +10% for the second direction (B-A).

Table 4.85 Percentage differences between actual and simulated travel times for corridor 2 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	62	42	-32	52	50	-4
2	62	49	-21	52	59	+13
3	62	60	-3	52	68	+31
4	62	59	-5	52	60	+15
5	62	68	+10	52	51	-2
6	62	76	+23	52	51	-2
7	62	79	+27	52	51	-2
8	-	-	-	52	66	+27
9	-	-	-	52	68	+31
$\bar{X}$	62	62	0	52	58	+12

Table 4.86 The percentage differences between actual and simulated travel times for corridor 2 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	66	48	-27	48	41	-15
2	66	55	-17	48	38	-21
3	66	65	-2	48	51	+6
4	66	73	+11	48	54	+13
5	66	81	+23	48	60	+25
6	66	78	+18	48	59	+23
7	66	76	+15	48	54	+13
8	66	75	+14	48	48	0
9	66	80	+21	48	56	+17
10	-	-	-	48	60	+25
11	-	-	-	48	61	+27
$\bar{X}$	66	70	+6	48	53	+10

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = Average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ Average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. The Table 4.87 shows the positive ranks and negative ranks from the SPSS output.

Table 4.87 Wilcoxon Signed-Rank test for validating the simulation results of corridor 2

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time	Negative Ranks	4 ^a	3.50	14.00
-				
act_trav_time	Positive Ranks	3 ^b	4.67	14.00
	Ties	0 ^c		
	Total	7		
Direction (A-B) (evening peak)				
sim_trav_time	Negative Ranks	3 ^a	5.00	15.00
-				
act_trav_time	Positive Ranks	6 ^b	5.00	30.00
	Ties	0 ^c		
	Total	9		
Direction (B-A) (morning peak)				
sim_trav_time	Negative Ranks	4 ^a	2.50	10.00
-				
act_trav_time	Positive Ranks	5 ^b	7.00	35.00
	Ties	0 ^c		
	Total	9		
Direction (B-A) (evening peak)				
sim_trav_time	Negative Ranks	2 ^a	5.00	10.00
-				
act_trav_time	Positive Ranks	8 ^b	5.63	45.00
	Ties	1 ^c		
	Total	11		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak:* The sum of ranks for negative differences is $T_n = 14$; the sum of ranks for positive differences is $T_p = 14$. Thus, we have $t_0 = \min(T_p, T_n) = 14$. It shows that $n = 7$ observations, the critical value of t_0 is $T = 2$ with $\alpha = 0.05$. Because the value $T = 14$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak:* The sum of ranks for negative differences is $T_n = 15$; the sum of ranks for positive differences is $T_p = 30$. Thus, we have $t_0 = \min(T_p, T_n) = 15$. It shows that $n = 9$ observations, the critical value of t_0 is $T = 6$ with $\alpha = 0.05$. Because the value $T = 15$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak:* The sum of ranks for negative differences is $T_n = 10$; the sum of ranks for positive differences is $T_p = 35$. Thus, we have $t_0 = \min(T_p, T_n) = 10$. It shows that $n = 9$ observations, the critical value of t_0 is $T = 6$ with $\alpha = 0.05$. Because the value $T = 10$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak:* The sum of ranks for negative differences is $T_n = 10$; the sum of ranks for positive differences is $T_p = 45$. Thus, we have $t_0 = \min(T_p, T_n) = 10$. It shows that $(n - \text{ties}) = 11 - 1 = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 10$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 2, there are 4 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Implement priority signal and mixed-traffic restriction on links 1, 13, 14, and 15
- Scenario 3: Install the extra platform and/or passing lane at stations II-a and II-18
- Combination: Conducting scenarios 2 and 3

All scenarios have been run on simulation. Tables 4.88 and 4.89 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks, respectively.

Table 4.88 Simulation results by scenario for corridor 2 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both Directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	62	13	52	14	57	14
Scenario 2	30	26	29	25	29	25
Scenario 3	62	13	51	14	57	14
Combination	30	26	29	25	30	25

Table 4.89 Simulation results by scenario for corridor 2 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	66	12	48	15	57	14
Scenario 2	32	24	30	24	31	24
Scenario 3	64	12	49	15	57	14
Combination	30	26	28	25	29	25

Based on the simulation results in Table 4.88, the best travel time during morning peak that can be reached is 30 minutes; i.e., scenario 2 and combination for the first direction (A-B) and 29 minutes; i.e., scenario 2 and combination for the second direction (B-A). Refer to Table 4.89, the best travel time during evening peak that can be reached is 30 minutes; i.e., combination for the first direction (A-B) and 28 minutes; i.e., combination for the second direction (B-A). Scenario 2 and combination scenario have the same result at the morning-peak period, but the scenario 2 failed to put the travel speed into standard of 25 kph for the second direction during evening-peak period. Otherwise, conducting the combination of scenario 2 and scenario 3 has proved to lead the travel speed up to 26 kph or above the standard of 25 kph. As a recommendation, the scenario combination is the best strategy to enhance the operational performance of corridor 2.

4.4.3 Simulation results for corridor 3

In order to make it easy for identifying links and nodes in the network of corridor 3, **Figure A.3** in the appendix A shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 3 has been done, the visualization of a partial network is shown in **Figure 4.60**.

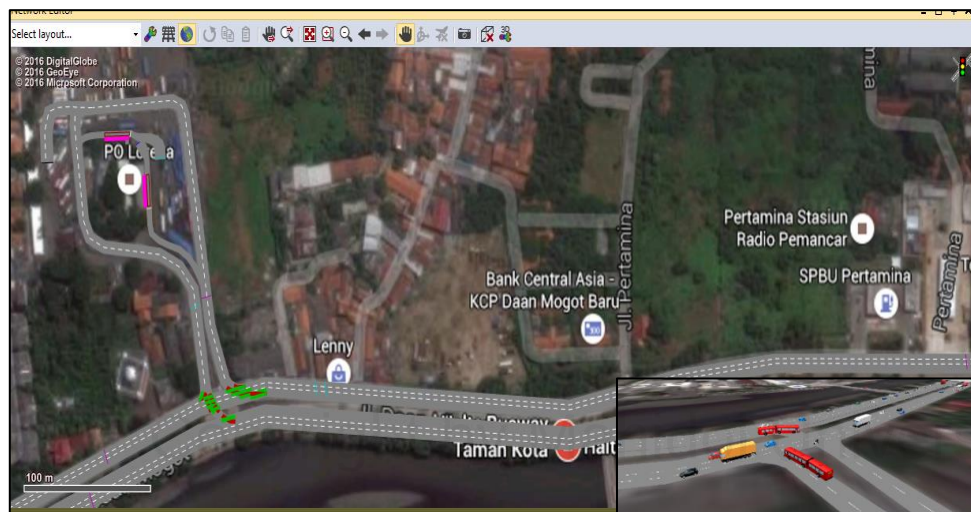


Figure 4.60. A part of simulated network of corridor 3

The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figures 4.61** and **4.62** show the comparison of arrival times during two peak periods.

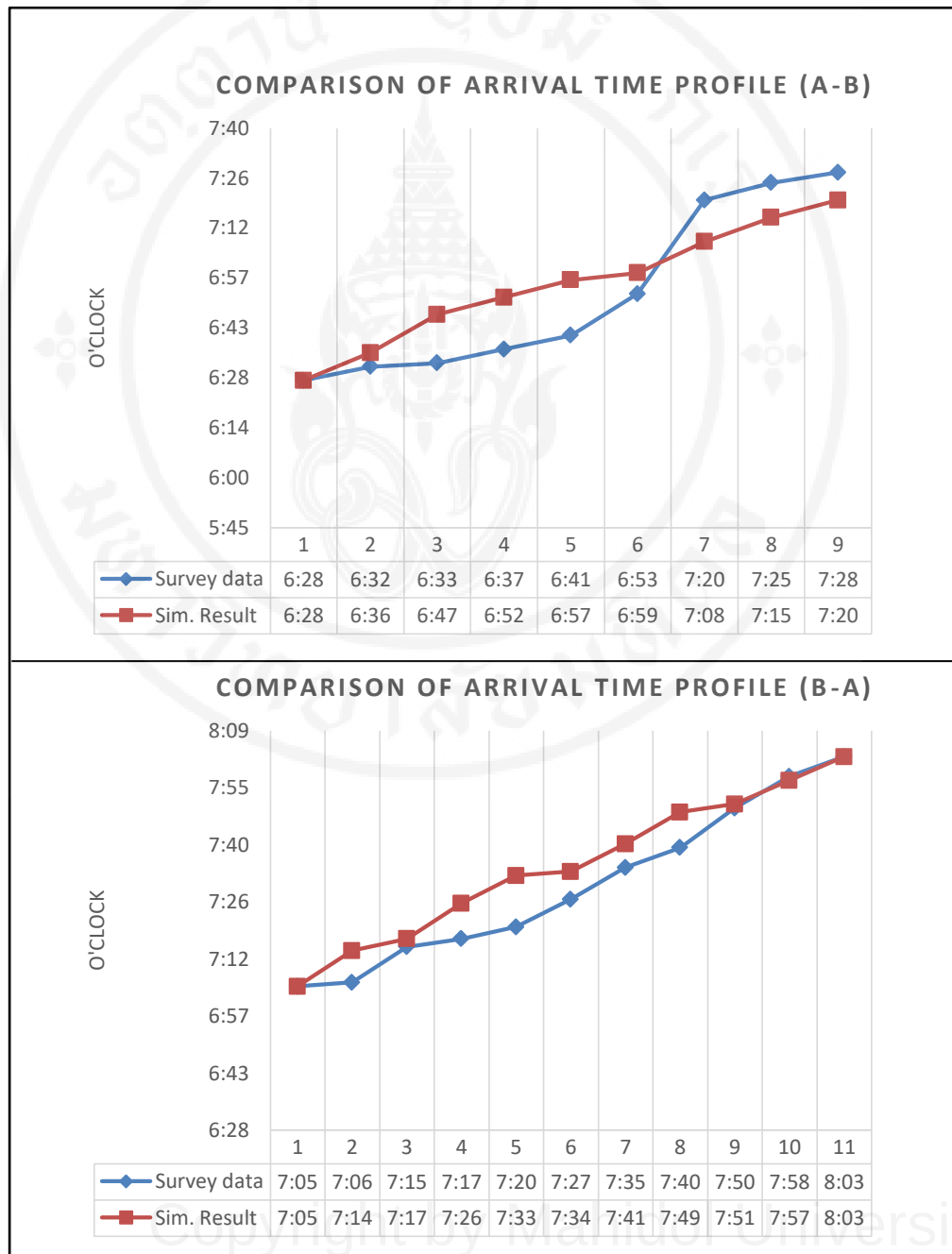


Figure 4.61 The comparison of arrival times for corridor 3 between actual and simulation results during morning-peak hour

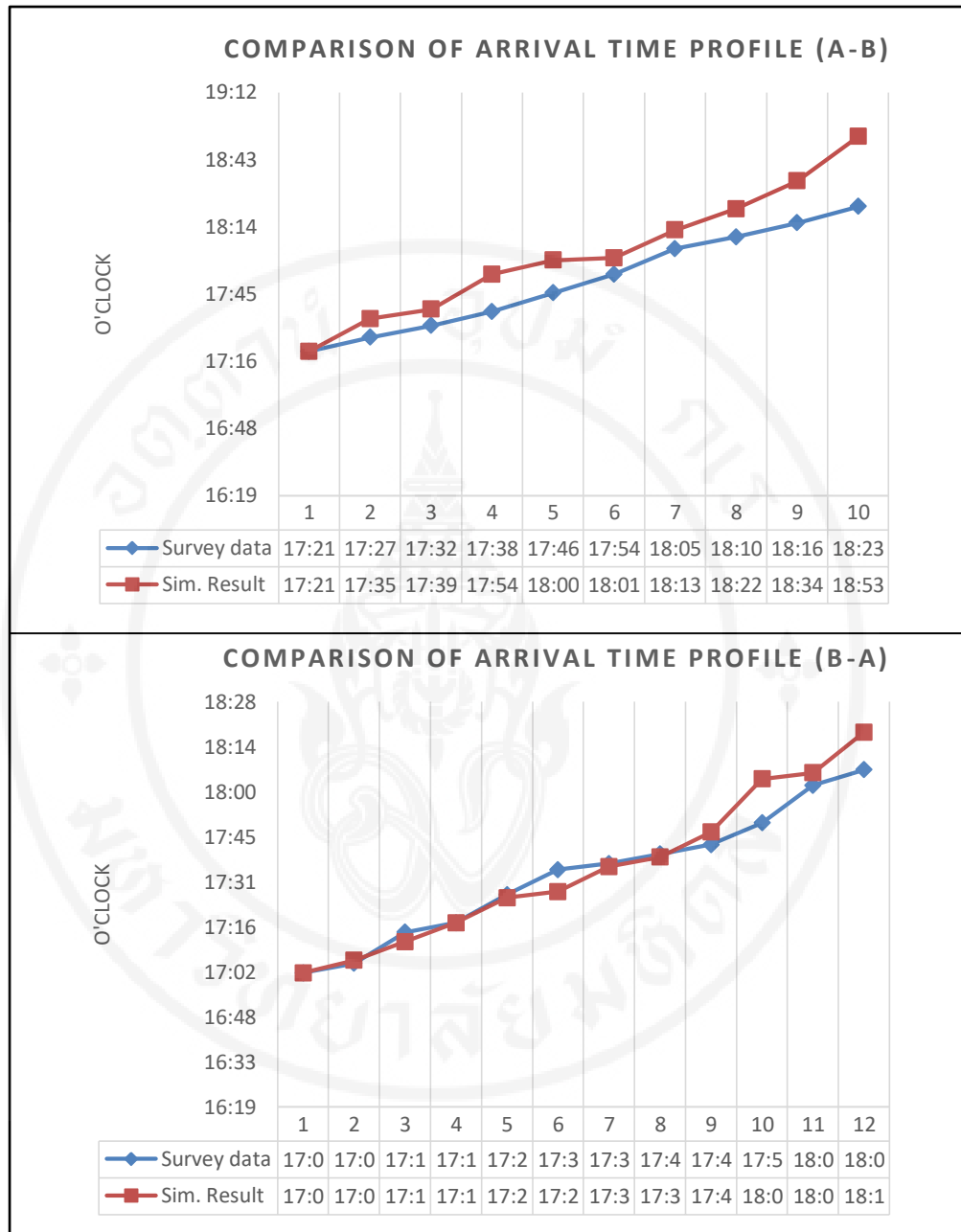


Figure 4.62 The comparison of arrival times for corridor 3 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.63** and **4.64** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 5 to 9 minutes during morning peak and 4 to 12 minutes during evening peak.

Figures 4.53 and 4.54 show the comparison of travel speed during morning-peak and evening-peak periods, respectively.

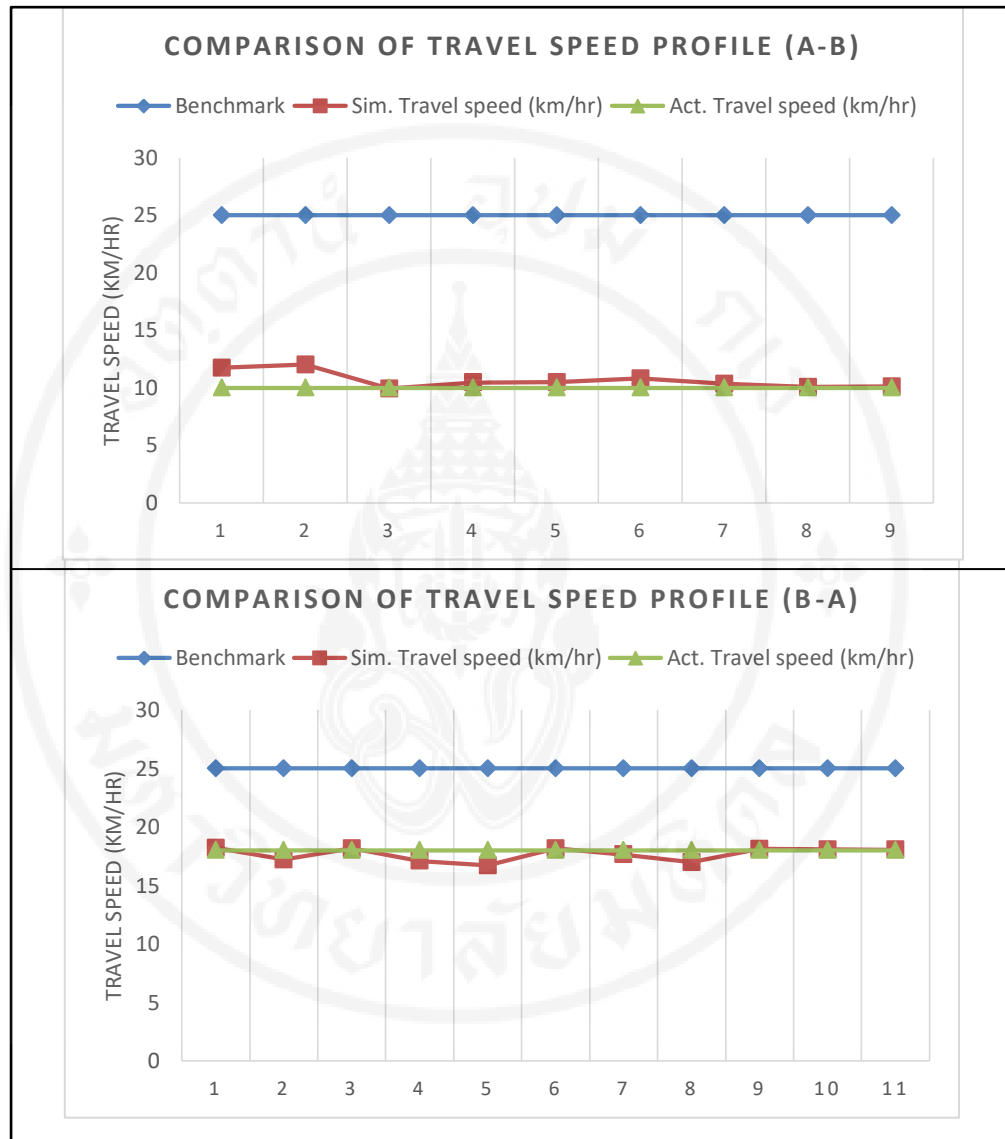


Figure 4.63 The comparison of travel speeds for corridor 3 between actual and simulation results, and the benchmark during morning-peak hour

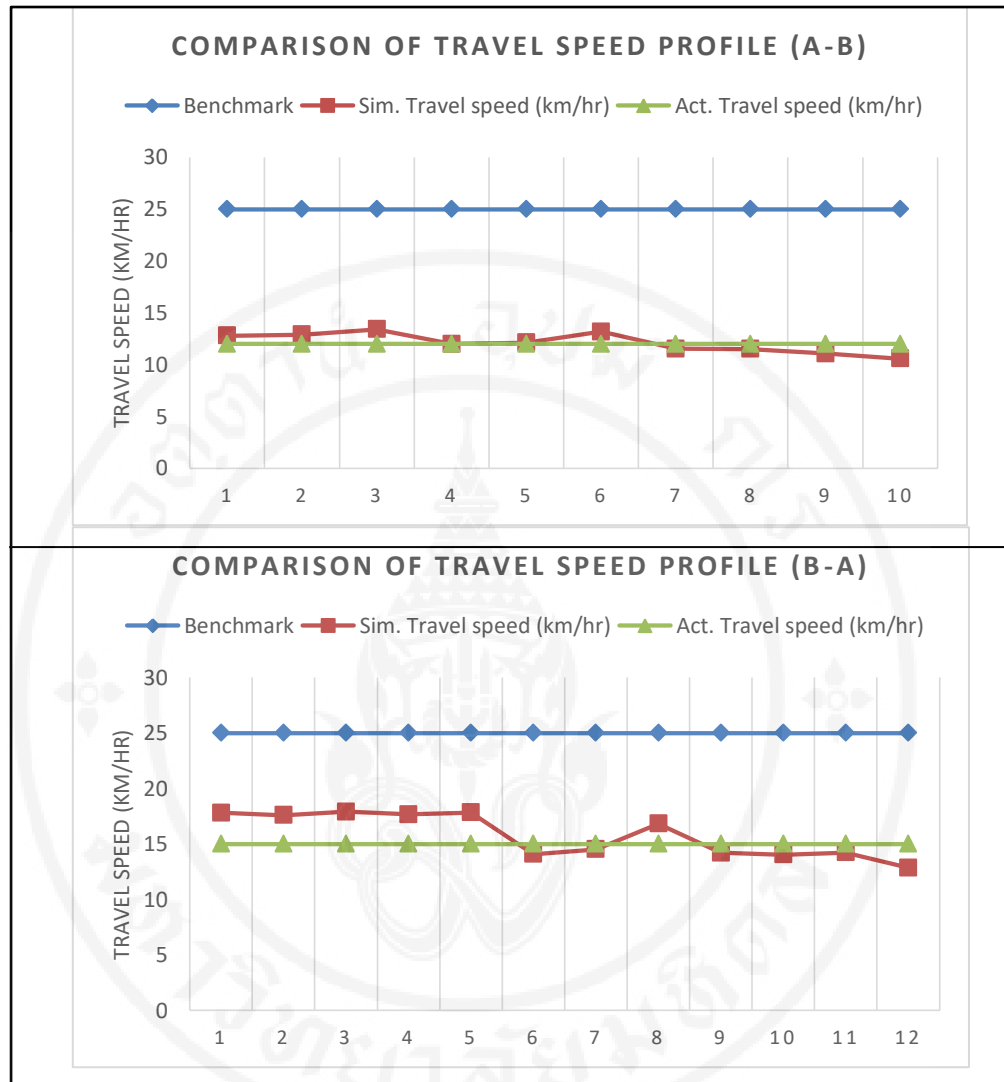


Figure 4.64 The comparison of travel speeds for corridor 3 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.53** and **4.54**, the final calibration shows 99% similarity of travel speeds during morning peak and 94% during evening peak between the simulation result and the actual result. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Tables 4.80 and 4.81. The difference between the average actual travel time and simulated travel time is -1% for the first direction (A-B) and 0% for the second direction (B-A) during

morning peak. Meanwhile, the difference during evening peak is -4% for the first direction (A-B) and -6% for the second direction (B-A).

Table 4.90 Percentage differences between actual and simulated travel times for corridor 3 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	86	77	-10	51	49	-4
2	86	75	-13	51	52	+2
3	86	90	+5	51	49	-4
4	86	86	0	51	53	+4
5	86	86	0	51	54	+6
6	86	83	-3	51	49	-4
7	86	87	+1	51	51	0
8	86	89	+3	51	53	+4
9	86	89	+3	51	50	-2
10	-	-	-	51	50	-2
11	-	-	-	51	50	-2
12	-	-	-	51	49	-4
$\bar{X}$	86	85	-1	51	51	0

Table 4.91 Percentage differences between actual and simulated travel times for corridor 3 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	78	70	-10	62	50	-19
2	78	70	-10	62	51	-18
3	78	67	-14	62	50	-19
4	78	75	-4	62	51	-18
5	78	74	-5	62	50	-19
6	78	68	-13	62	64	+3
7	78	78	0	62	62	0
8	78	78	0	62	53	-15
9	78	81	+4	62	63	+2
10	78	85	+9	62	64	+3
11	-	-	-	62	63	+2
12	-	-	-	62	70	+13
$\bar{X}$	78	75	-4	62	58	-6

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. Table 4.92 shows the positive ranks and negative ranks from the SPSS output.

Table 4.92 Wilcoxon Signed-Rank test for validating the simulation results of corridor 3

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	4 ^a	3.00	12.00
	Positive Ranks	3 ^b	5.33	16.00
	Ties	2 ^c		
	Total	9		
Direction (A-B) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	4 ^a	6.63	26.50
	Positive Ranks	6 ^b	4.75	28.50
	Ties	1 ^c		
	Total	11		
Direction (B-A) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	6 ^a	5.08	30.50
	Positive Ranks	2 ^b	2.75	5.50
	Ties	2 ^c		
	Total	10		
Direction (B-A) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	6 ^a	8.50	51.00
	Positive Ranks	5 ^b	3.00	15.00
	Ties	1 ^c		
	Total	12		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak*: The sum of ranks for negative differences is $T_n = 12$; the sum of ranks for positive differences is $T_p = 16$. Thus, we have $t_0 = \min(T_p, T_n) = 12$. It shows that $(n\text{-ties}) = 9 - 2 = 7$ observations, the critical value of t_0 is $T = 2$ with $\alpha = 0.05$. Because the value $T = 12$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak*: The sum of ranks for negative differences is $T_n = 26.5$; the sum of ranks for positive differences is $T_p = 28.5$. Thus, we have $t_0 = \min(T_p, T_n) = 26.5$. It shows that $(n\text{-ties}) = 11 - 1 = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 26.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak*: The sum of ranks for negative differences is $T_n = 30.5$; the sum of ranks for positive differences is $T_p = 5.5$. Thus, we have $t_0 = \min(T_p, T_n) = 5.5$. It shows that $(n\text{-ties}) = 10 - 2 = 8$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 26.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak*: The sum of ranks for negative differences is $T_n = 51$; the sum of ranks for positive differences is $T_p = 15$. Thus, we have $t_0 = \min(T_p, T_n) = 15$. It shows that $(n\text{-ties}) = 11$ observations, the critical value of t_0 is $T = 11$ with $\alpha = 0.05$. Because the value $T = 15$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 3, there are 4 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Implement mixed-traffic restriction at links 5, 6, 7 9, and 16
- Scenario 3: Install the extra platform and/or passing lane at stations III-6, III-7, III-9, III-10, III-12, III-14, and III-15
- Combination: Conducting scenarios 2 and 3

All scenarios have been run on simulation. Tables 4.93 and 4.94 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks hours respectively.

Table 4.93 Simulation results by scenario for corridor 3 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both Directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	86	10	78	12	82	11
Scenario 2	38	24	34	26	36	25
Scenario 3	85	10	77	12	81	11
Combination	38	24	34	26	36	25

Table 4.94 Simulation results by scenario for corridor 3 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both Directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	51	18	62	15	57	17
Scenario 2	40	23	34	26	37	25
Scenario 3	49	17	61	15	55	16
Combination	36	25	32	28	34	27

Based on the simulation results in Table 4.93, the best travel time during morning peak that can be reached is 38 minutes; i.e., scenario 2 and combination for the first direction (A-B) and 34 minutes; i.e., scenario 2 and combination for the second direction (B-A). Refer to Table 4.94, the best travel time during evening peak is 36 minutes; i.e., combination for the first direction (A-B) and 32 minutes; i.e., combination for the second direction (B-A). At both directions, the average travel speed of 25 kph during morning peak and 27 kph during evening peak can be reached by combination. As a recommendation, the scenario combination is the best strategy to enhance the operational performance of corridor 3.

4.4.4 Simulation results for corridor 4

In order to make it easy for identifying links and nodes in the network of corridor 4, **Figure A.4** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The visualization of a partial network is shown in **Figure 4.65** below.

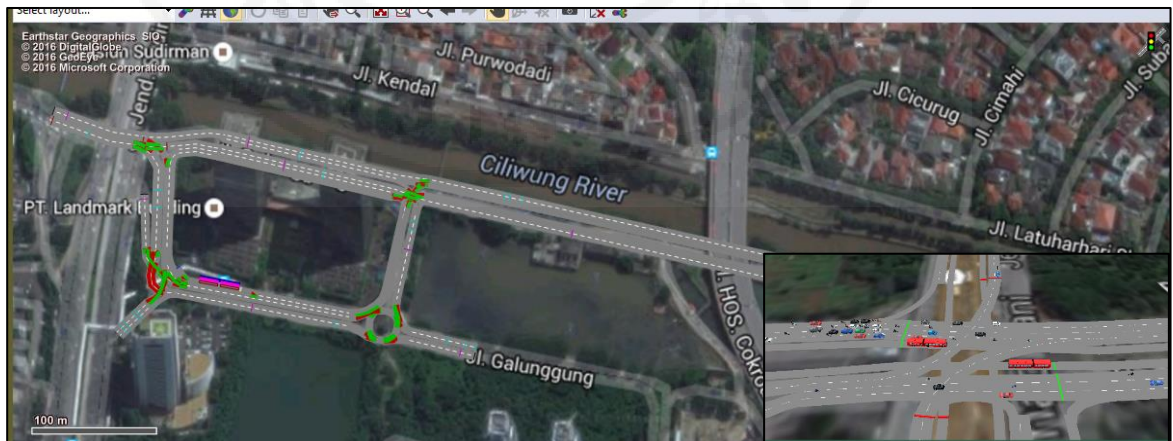


Figure 4.65. A part of simulated network of corridor 4

Figures 4.66 and 4.67 show the comparison of arrival times during two peak periods.

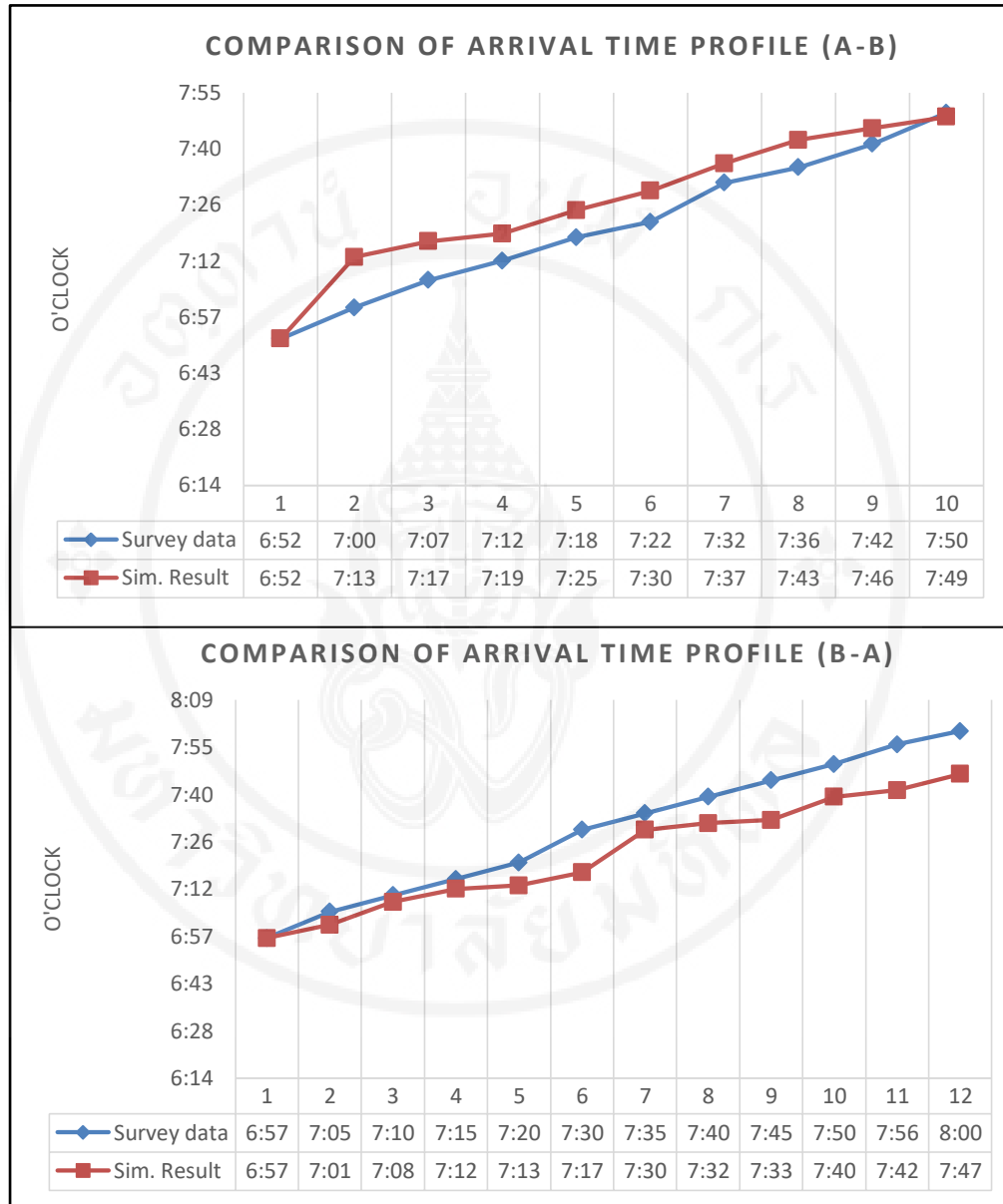


Figure 4.66 The comparison of arrival times for corridor 4 between actual and simulation results during morning-peak hour

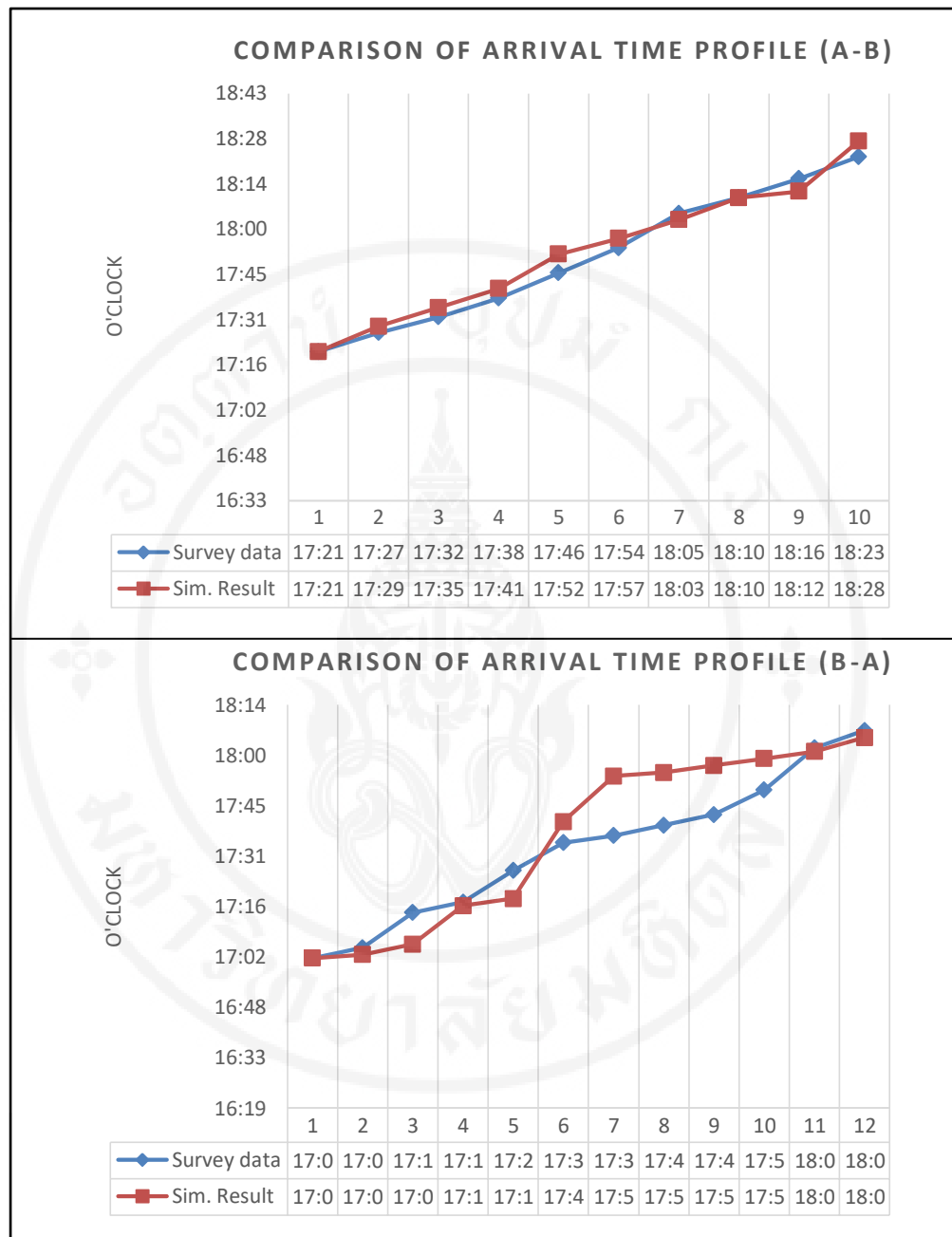


Figure 4.67 The comparison of arrival times for corridor 4 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.66** and **4.67** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 6 to 7 minutes during morning peak and 2 to 7 minutes during evening peak.

Figures 4.68 and **4.69** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.

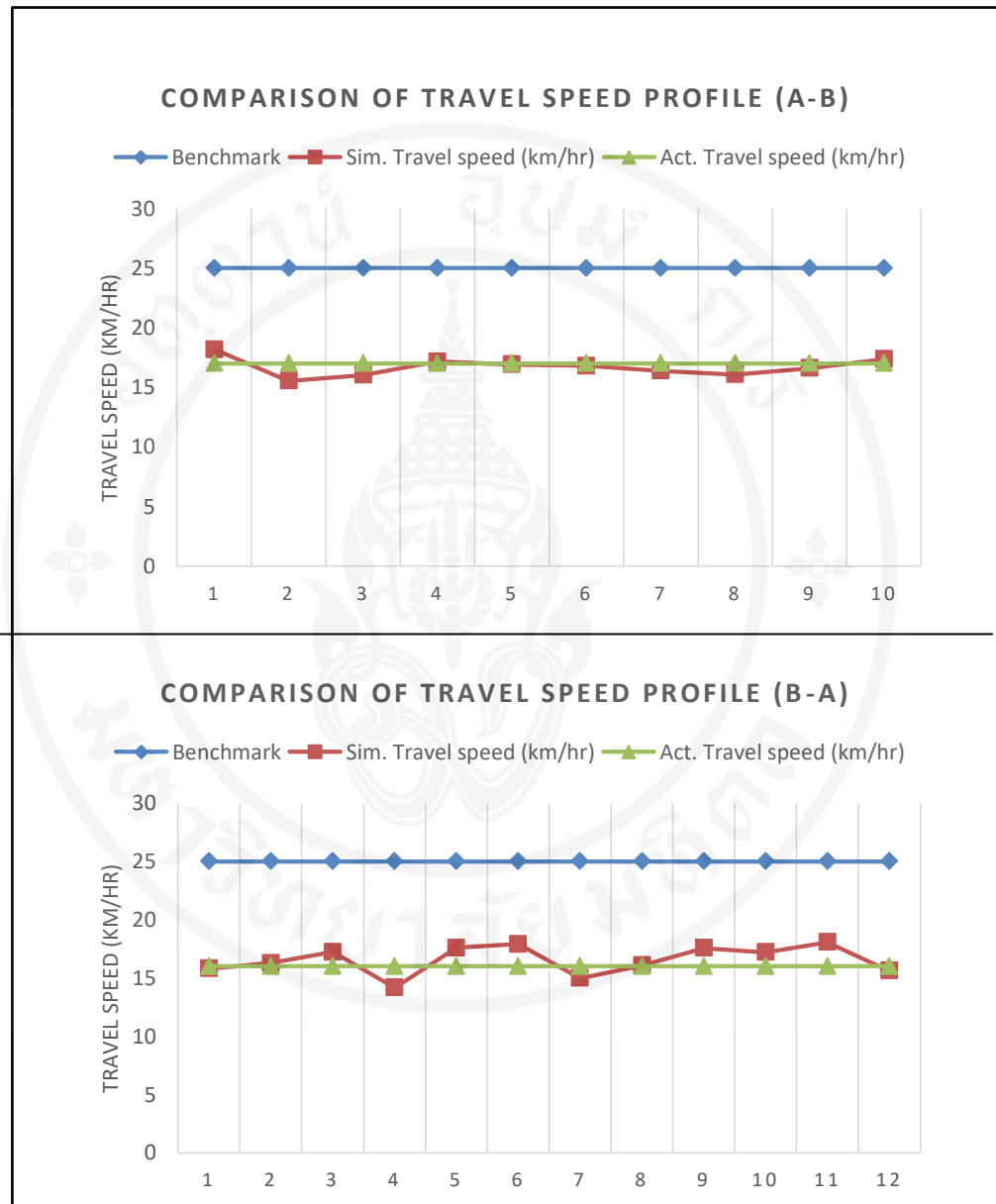


Figure 4.68 The comparison of travel speeds for corridor 4 between actual and simulation results, and the benchmark during morning-peak hour

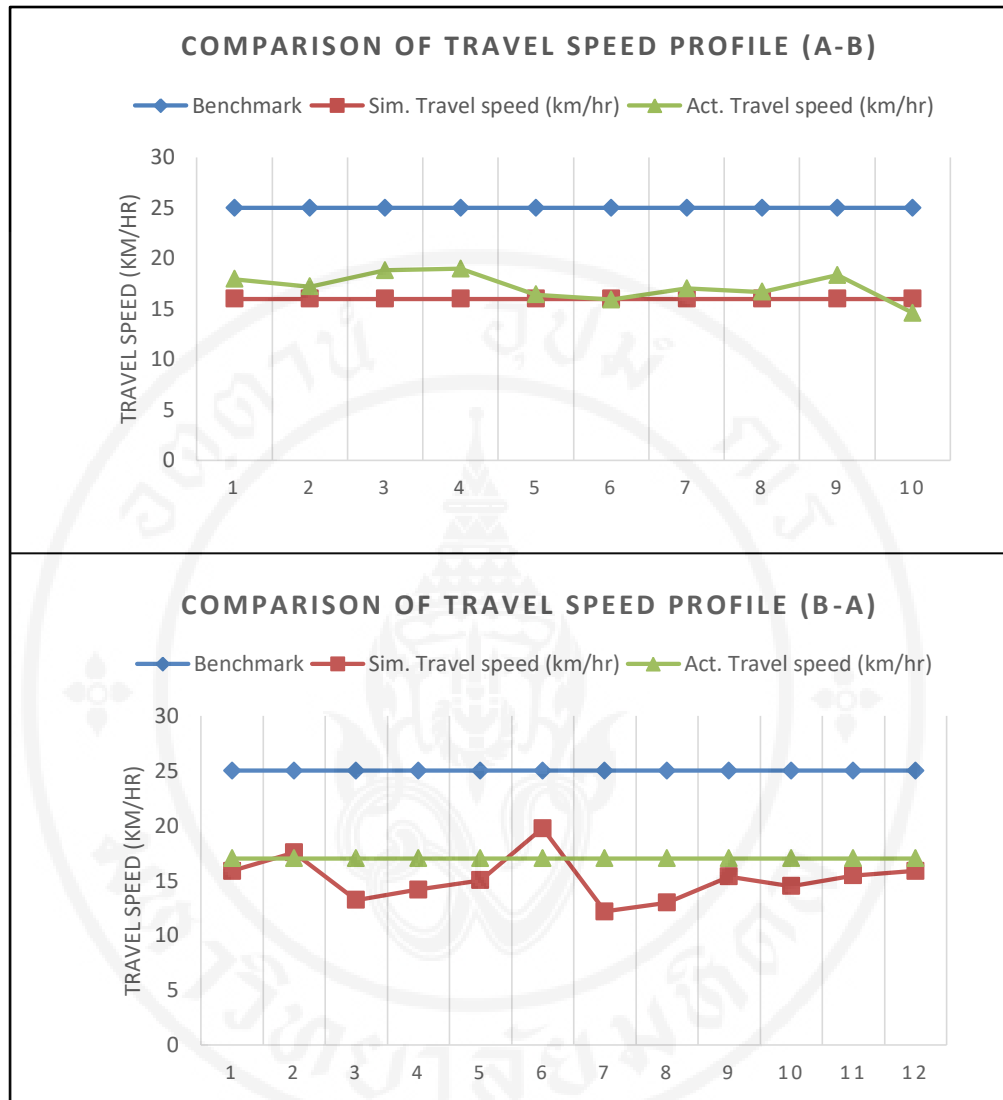


Figure 4.69 The Comparison of travel speeds for corridor 4 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.68** and **4.69**, the final calibration shows 98% similarity of travel speeds during morning peak and 93% during evening peak between the actual and simulation results. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Tables 4.95 and 4.96. There is no significant difference between the average actual travel time and simulated travel time for the first direction (A-B) and -4% for the second direction (B-

A) during morning peak. Meanwhile, the difference during evening peak is -5% for the first direction (A-B) and +9% for the second direction (B-A).

Table 4.95 Percentage differences between actual and simulated travel times for corridor 4 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	43	40	-7	46	46	0
2	43	46	+7	46	44	-4
3	43	45	+5	46	42	-9
4	43	42	-2	46	51	+11
5	43	42	-2	46	41	-11
6	43	43	0	46	40	-13
7	43	44	+2	46	48	+4
8	43	45	+5	46	45	-2
9	43	43	0	46	41	-11
10	43	41	-5	46	42	-9
11	-	-	-	46	40	-13
12	-	-	-	46	46	0
$\bar{X}$	43	43	0	46	44	-4

Table 4.96 Percentage differences between actual and simulated travel times for corridor 4 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	44	40	-9	43	36	-16
2	44	42	-5	43	45	5
3	44	38	-14	43	41	-5
4	44	38	-14	43	54	26
5	44	44	0	43	51	19
6	44	45	2	43	48	12
7	44	42	-5	43	36	-16
8	44	43	-2	43	59	37
9	44	39	-11	43	55	28
10	44	49	11	43	47	9
11	-	-	-	43	50	16
12	-	-	-	43	47	9
$\bar{X}$	44	42	-5	43	47	9

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. Table 4.97 shows the positive ranks and negative ranks from the SPSS output.

Table 4.97 Wilcoxon Signed-Rank test for validating the simulation results of corridor 4

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	4 ^a	4.88	19.50
	Positive Ranks	4 ^b	4.13	16.50
	Ties	2 ^c		
	Total	10		
Direction (A-B) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	7 ^a	5.29	37.00
	Positive Ranks	2 ^b	4.00	8.00
	Ties	1 ^c		
	Total	10		
Direction (B-A) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	2 ^a	4.75	9.50
	Positive Ranks	8 ^b	5.69	45.50
	Ties	2 ^c		
	Total	12		
Direction (B-A) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	3 ^a	5.17	15.50
	Positive Ranks	9 ^b	6.94	62.50
	Ties	0 ^c		
	Total	12		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak:* The sum of ranks for negative differences is $T_n = 19.5$; the sum of ranks for positive differences is $T_p = 16.5$. Thus, we have $t_0 = \min(T_p, T_n) = 16.5$. It shows that (n-ties) = $10-2 = 8$ observations, the critical value of t_0 is $T = 4$ with $\alpha = 0.05$. Because the value $T = 16.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak:* The sum of ranks for negative differences is $T_n = 37$; the sum of ranks for positive differences is $T_p = 8$. Thus, we have $t_0 = \min(T_p, T_n) = 8$. It shows that (n-ties) = $10-1 = 9$ observations, the critical value of t_0 is $T = 6$ with $\alpha = 0.05$. Because the value $T = 8$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak:* The sum of ranks for negative differences is $T_n = 9.5$; the sum of ranks for positive differences is $T_p = 45.5$. Thus, we have $t_0 = \min(T_p, T_n) = 9.5$. It shows that (n-ties) = $12-2 = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 9.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak:* The sum of ranks for negative differences is $T_n = 15.5$; the sum of ranks for positive differences is $T_p = 62.5$. Thus, we have $t_0 = \min(T_p, T_n) = 15.5$. It shows that $n = 12$ observations, the critical value of t_0 is $T = 14$ with $\alpha = 0.05$. Because the value $T = 15.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 4, there are 8 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Increase trip frequency by decreasing headway from 5 minutes to 4 minutes 17 seconds
- Scenario 3: Implement priority signal and mixed-traffic restriction on links 1, 2, and 12
- Scenario 4: Install the passing lane at stations IV-17 and IV-18
- Combination 1: Conducting scenarios 2 and 3
- Combination 2: Conducting scenarios 2 and 4
- Combination 3: Conducting scenarios 3 and 4
- Combination 4: Conducting all scenarios

All scenarios have been run on simulation. Tables 4.98 and 4.99 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks, respectively.

Table 4.98 Simulation results by scenario for corridor 4 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	43	17	46	16	45	17
Scenario 2	46	16	45	16	46	16
Scenario 3	31	23	27	27	29	25
Scenario 4	36	20	36	21	36	20
Combination 1	33	22	29	25	31	23
Combination 2	36	20	36	21	36	20
Combination 3	30	24	26	28	28	26
Combination 4	31	24	26	28	28	26

Table 4.99 Simulation results by scenario for corridor 4 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	44	16	43	17	44	17
Scenario 2	45	16	46	16	46	16
Scenario 3	32	23	29	25	31	24
Scenario 4	39	18	46	16	43	17
Combination 1	34	21	28	26	31	23
Combination 2	42	17	41	18	42	17
Combination 3	31	23	28	26	29	25
Combination 4	30	24	27	26	29	25

Based on the simulation results in Table 4.98, the best travel time during morning peak is 30 minutes; i.e., combination 3 for the first direction (A-B) and 26 minutes; i.e., combinations 3 and 4 for the second direction (B-A). Refer to Table 4.99 the best travel time during evening peak is 30 minutes; i.e., combination 4 for the first direction (A-B) and 27 minutes; i.e., combination 4 for the second direction (B-A). Both combinations 3 and 4 showed the excellent average travel speed (25 kph) during both peak periods. In the consideration of corridor capacity to satisfy the demand, the combination 4 is the best strategy to enhance the operational performance of corridor 4.

4.4.5 Simulation results for corridor 5

In order to make it easy for identifying links and nodes in the network of corridor 5, **Figure A.5** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 5 has been done, the visualization of a partial network is shown in **Figure 4.70** below.

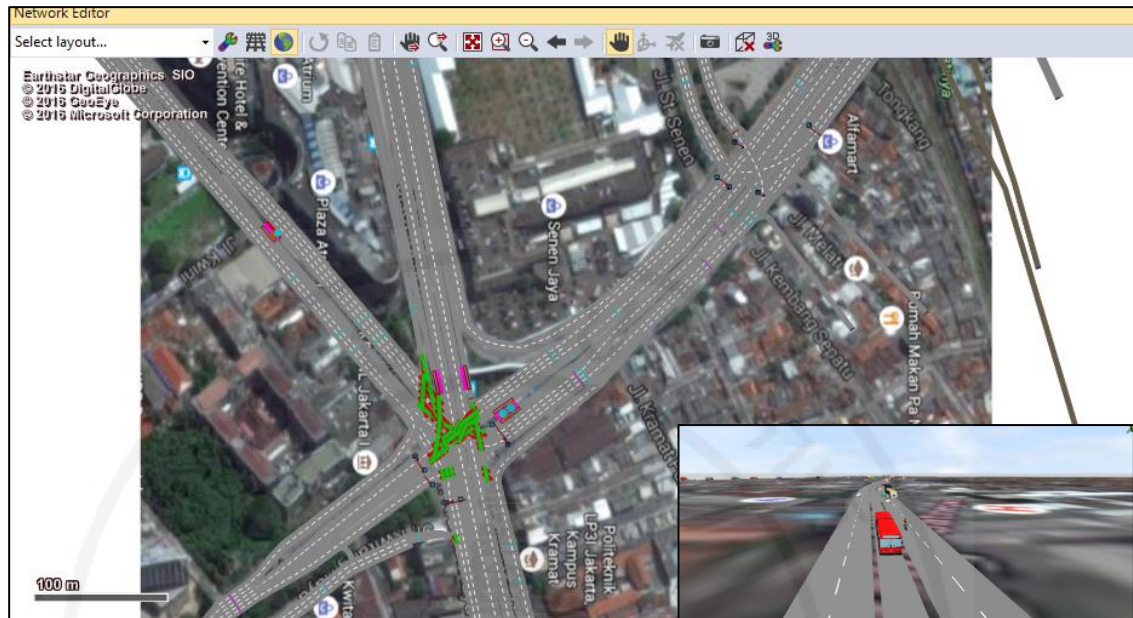


Figure 4.70. A part of simulated network of corridor 5

The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figures 4.71** and **4.72** show the comparison of arrival times during two peak periods.

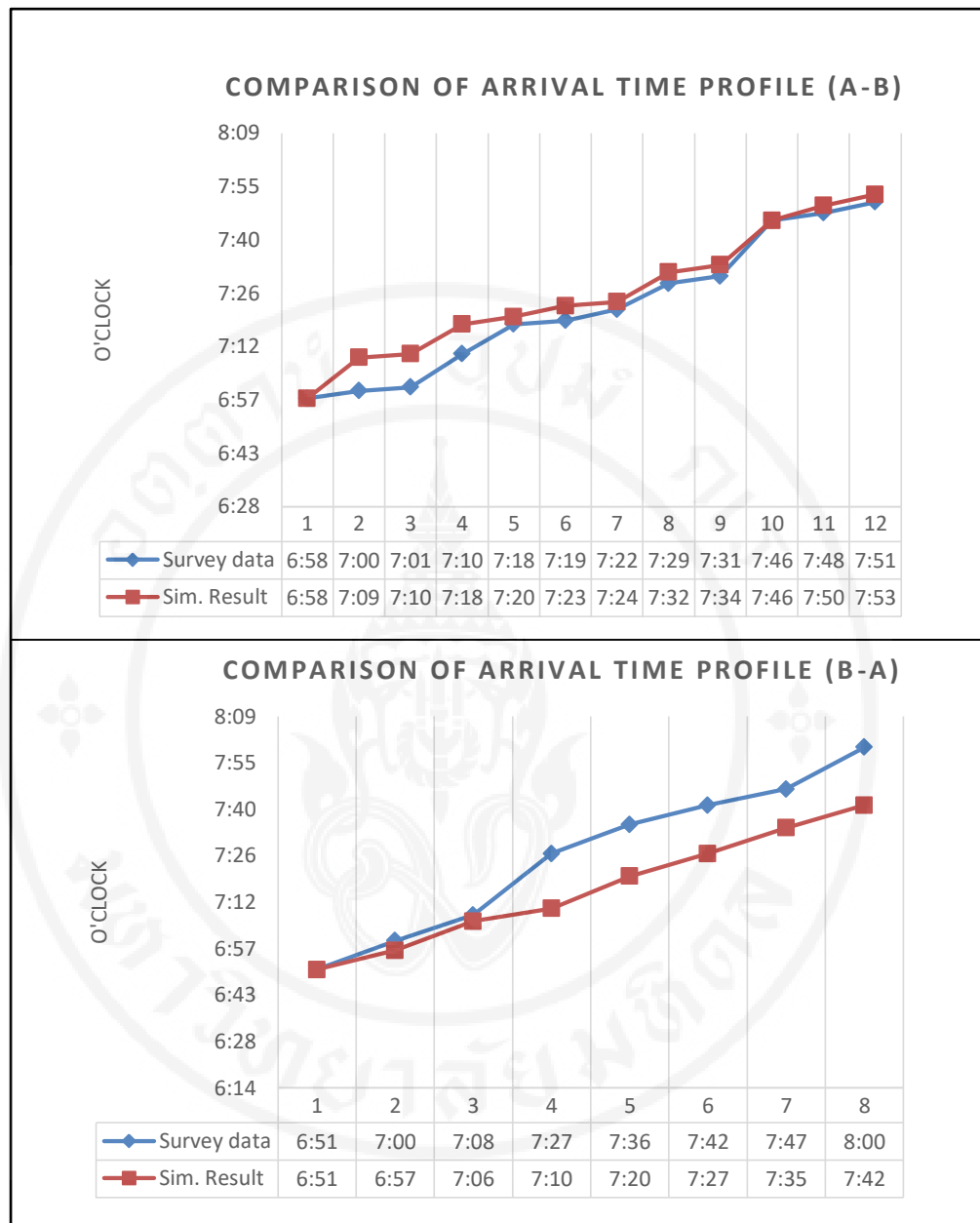


Figure 4.71 The comparison of arrival times for corridor 5 between actual and simulation results during morning-peak hour

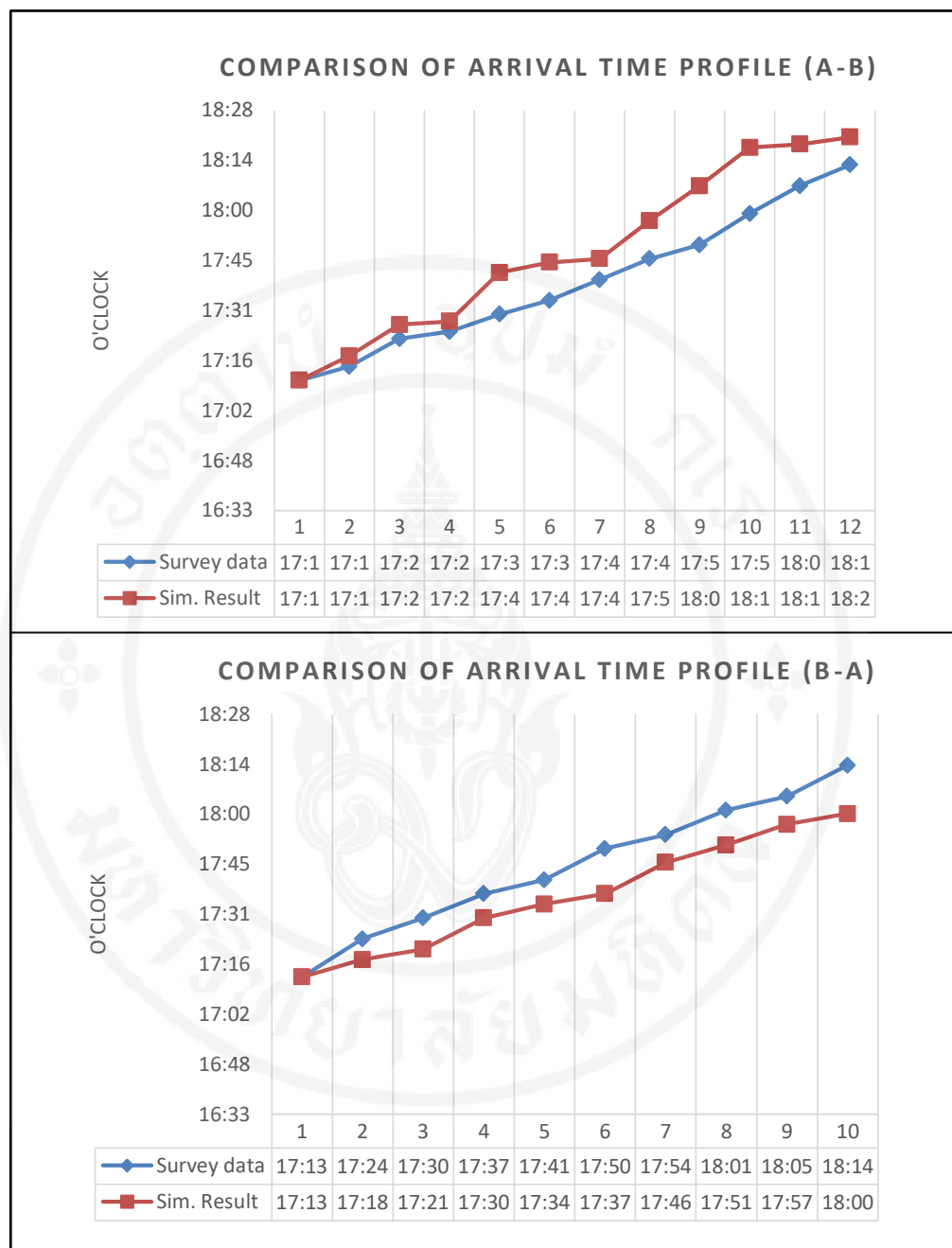


Figure 4.72 The comparison of arrival times for corridor 5 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.71** and **4.72** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 3 to 10 minutes during morning peak and 8 minutes during evening peak.

Figures 4.73 and 4.74 show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.



Figure 4.73 The comparison of travel speeds for corridor 5 between actual and simulation results, and the benchmark during morning-peak hour

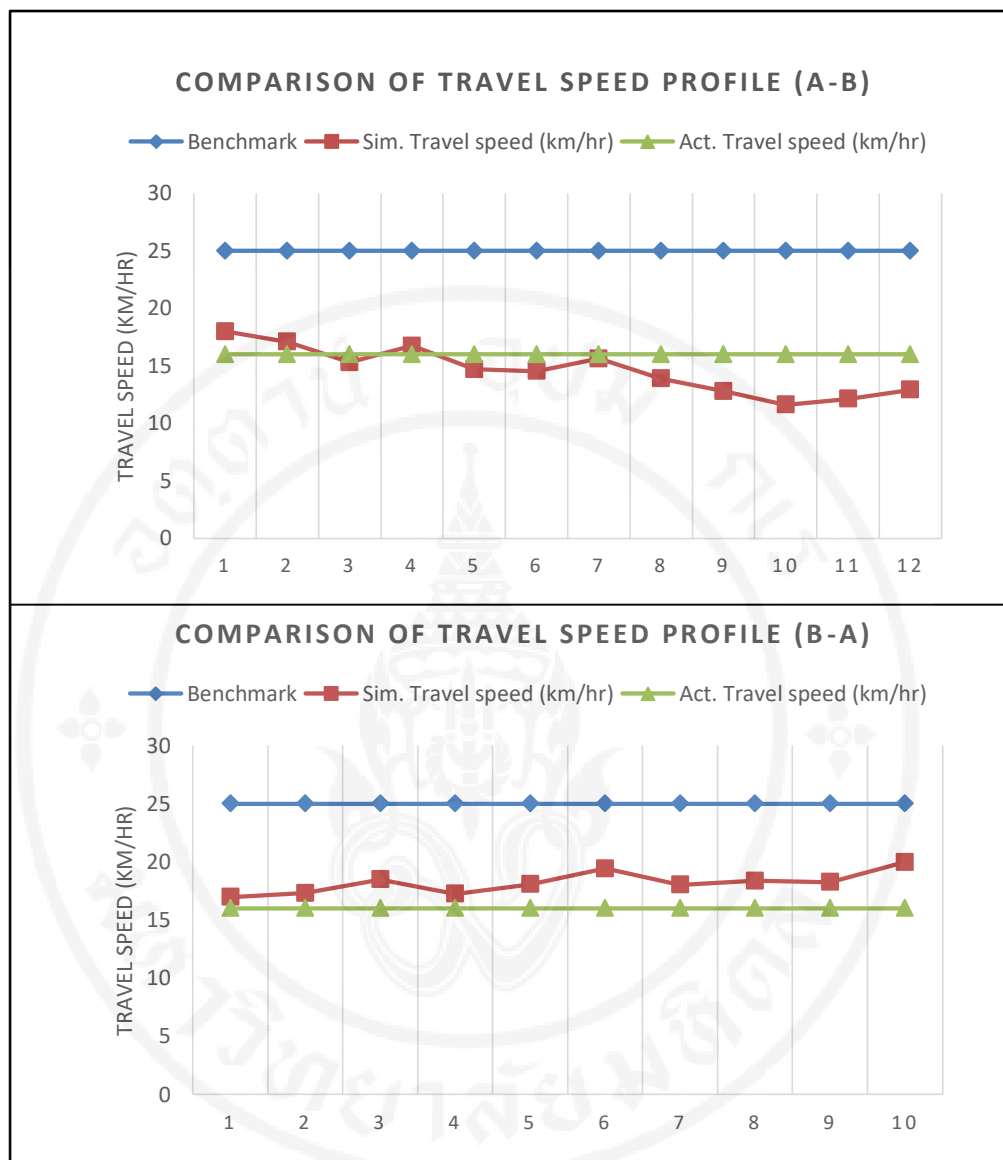


Figure 4.74 The comparison of travel speeds for corridor 5 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.73** and **4.74**, the final calibration shows 98% similarity of travel speeds during morning peak and 95% during evening peak between the actual and simulation results. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Tables 4.100 and 4.101. The difference between the average actual travel time and simulated travel

time is -2% for the first direction (A-B) and +2% for the second direction (B-A) during morning peak. Meanwhile, the difference during evening peak is +7% for the first direction (A-B) and 0% for the second direction (B-A).

Table 4.100 Percentage differences between actual and simulated travel times for corridor 5 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	51	50	-2	45	47	+4
2	51	56	+10	45	45	0
3	51	50	-2	45	47	+4
4	51	54	+6	45	44	-2
5	51	50	-2	45	46	+2
6	51	49	-4	45	46	+2
7	51	45	-12	45	47	+4
8	51	48	-6	45	46	+2
9	51	45	-12	-	-	-
10	51	52	+2	-	-	-
11	51	51	-	-	-	-
12	51	50	-	-	-	-
$\bar{X}$	51	50	-2	45	46	+2

Table 4.101 Percentage differences between actual and simulated travel times for corridor 5 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	45	39	-13	40	42	+5
2	45	41	-9	40	42	+5
3	45	46	+2	40	39	-3
4	45	42	-7	40	42	+5
5	45	48	+7	40	40	0
6	45	48	+7	40	37	-8
7	45	45	0	40	40	0
8	45	51	+13	40	39	-3
9	45	55	+22	40	39	-3
10	45	60	+33	40	36	-10
11	45	58	+29	-	-	-
12	45	54	-	-	-	-
$\bar{X}$	45	48	+7	40	40	0

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. The Table 4.102 shows the positive ranks and negative ranks from the SPSS output.

Table 4.102 Wilcoxon Signed-Rank test for validating the simulation results of corridor 5

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time	Negative Ranks	3 ^a	6.50	19.50
-				
act_trav_time	Positive Ranks	8 ^b	5.81	46.50
	Ties	1 ^c		
	Total	12		
Direction (A-B) (evening peak)				
sim_trav_time	Negative Ranks	6 ^a	4.25	25.50
-				
act_trav_time	Positive Ranks	1 ^b	2.50	2.50
	Ties	1 ^c		
	Total	8		
Direction (B-A) (morning peak)				
sim_trav_time	Negative Ranks	3 ^a	4.83	14.50
-				
act_trav_time	Positive Ranks	8 ^b	6.44	51.50
	Ties	1 ^c		
	Total	12		
Direction (B-A) (evening peak)				
sim_trav_time	Negative Ranks	5 ^a	4.20	21.00
-				
act_trav_time	Positive Ranks	3 ^b	5.00	15.00
	Ties	2 ^c		
	Total	10		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak:* The sum of ranks for negative differences is $T_n = 19.5$; the sum of ranks for positive differences is $T_p = 46.5$. Thus, we have $t_0 = \min(T_p, T_n) = 19.5$. It shows that (n-ties) = $12-1 = 11$ observations, the critical value of t_0 is $T = 11$ with $\alpha = 0.05$. Because the value $T = 19.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak:* The sum of ranks for negative differences is $T_n = 25.5$; the sum of ranks for positive differences is $T_p = 2.5$. Thus, we have $t_0 = \min(T_p, T_n) = 2.5$. It shows that (n-ties) = $8-1 = 7$ observations, the critical value of t_0 is $T = 2$ with $\alpha = 0.05$. Because the value $T = 2.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak:* The sum of ranks for negative differences is $T_n = 14.5$; the sum of ranks for positive differences is $T_p = 51.5$. Thus, we have $t_0 = \min(T_p, T_n) = 14.5$. It shows that (n-ties) = $12-1 = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 14.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak:* The sum of ranks for negative differences is $T_n = 21$; the sum of ranks for positive differences is $T_p = 15$. Thus, we have $t_0 = \min(T_p, T_n) = 15$. It shows that (n-ties) = $10-2 = 8$ observations, the critical value of t_0 is $T = 4$ with $\alpha = 0.05$. Because the value $T = 15$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 5, there are 4 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Implement signal priority and mixed-traffic restriction on links 1, 2, 3, and 18
- Scenario 3: Install the extra platform and/or passing lane at stations V-13 and V-14
- Combination: Conducting scenarios 2 and 3

The following Tables 4.103 and 4.104 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks, respectively.

Table 4.103 Simulation results by scenario for corridor 5 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both Directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	51	14	45	16	48	15
Scenario 2	30	24	31	23	31	23
Scenario 3	42	17	35	20	39	19
Combination	28	25	30	24	29	24

Table 4.104 Simulation results by scenario for corridor 5 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both Directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	51	14	45	16	48	15
Scenario 2	30	24	31	23	31	23
Scenario 3	42	17	35	20	39	19
Combination	28	25	30	24	29	24

Based on the simulation results in Table 4.103, the best travel time during morning peak is 28 minutes; i.e., combination for the first direction (A-B) and 30 minutes; i.e., combination for the second direction (B-A). Refer to table 4.104, the best travel time is 28 minutes; i.e., combination for the first direction (A-B) and 30 minutes; i.e., combination for the second direction (B-A). The scenario combination showed the best performance. As a recommendation, the scenario combination is the best strategy to enhance the operational performance of corridor 5.

4.4.6 Simulation results for corridor 6

In order to make it easy for identifying links and nodes in the network of corridor 6, **Figure A.6** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 6 has been done, the visualization of a partial network is shown in **Figure 4.75**.

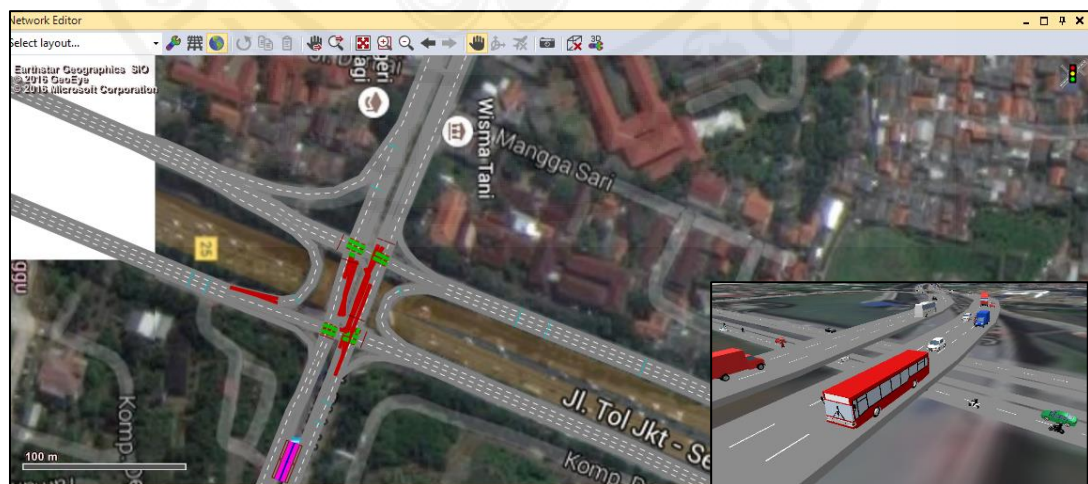


Figure 4.75. A part of simulated network of corridor 6

The model calibration has been done for 2 directions and for 2 peak periods. **Figures 4.76** and **4.77** show the comparison of arrival times during two peak periods.

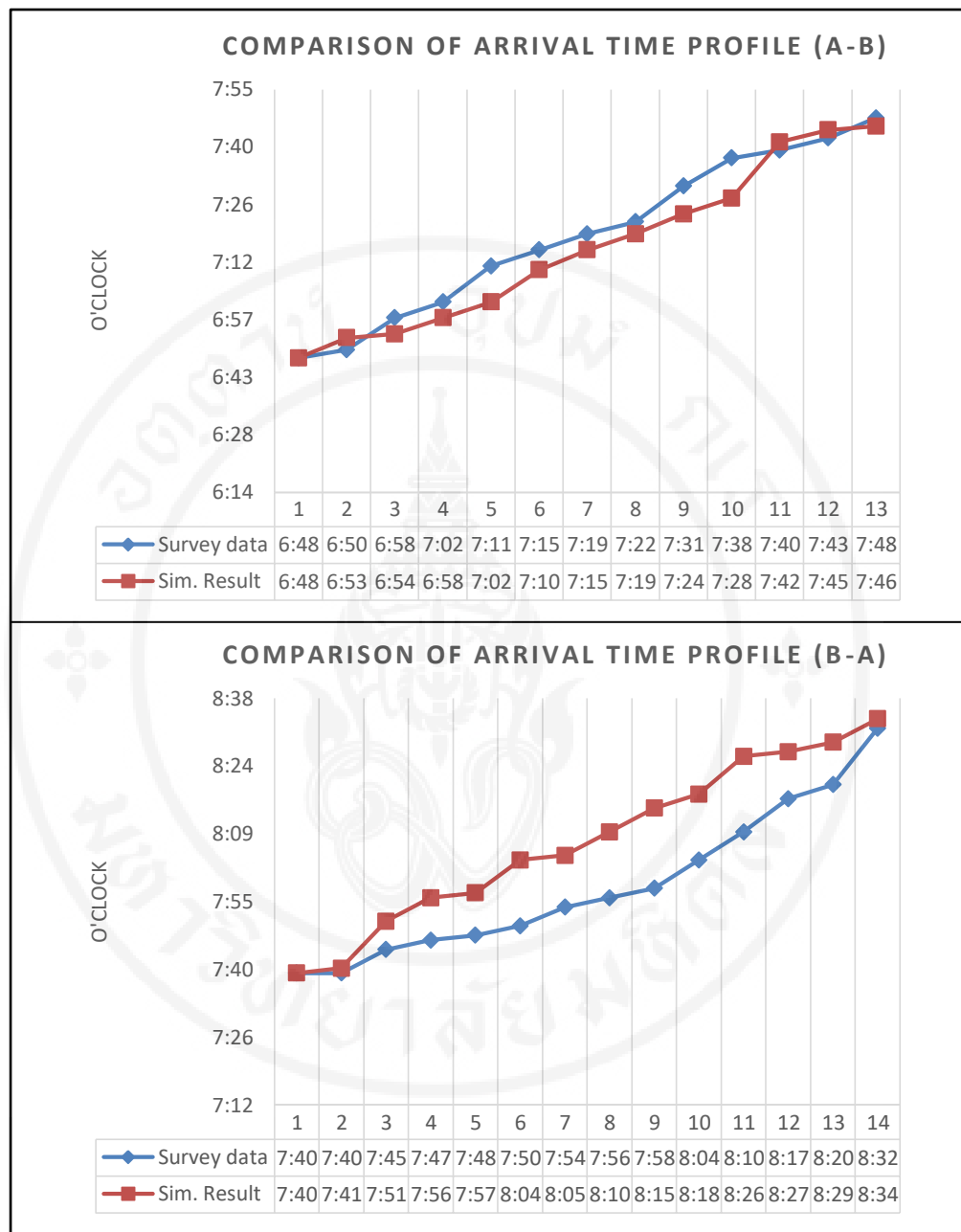


Figure 4.76 The comparison of arrival times for corridor 6 between actual and simulation results during morning-peak hour

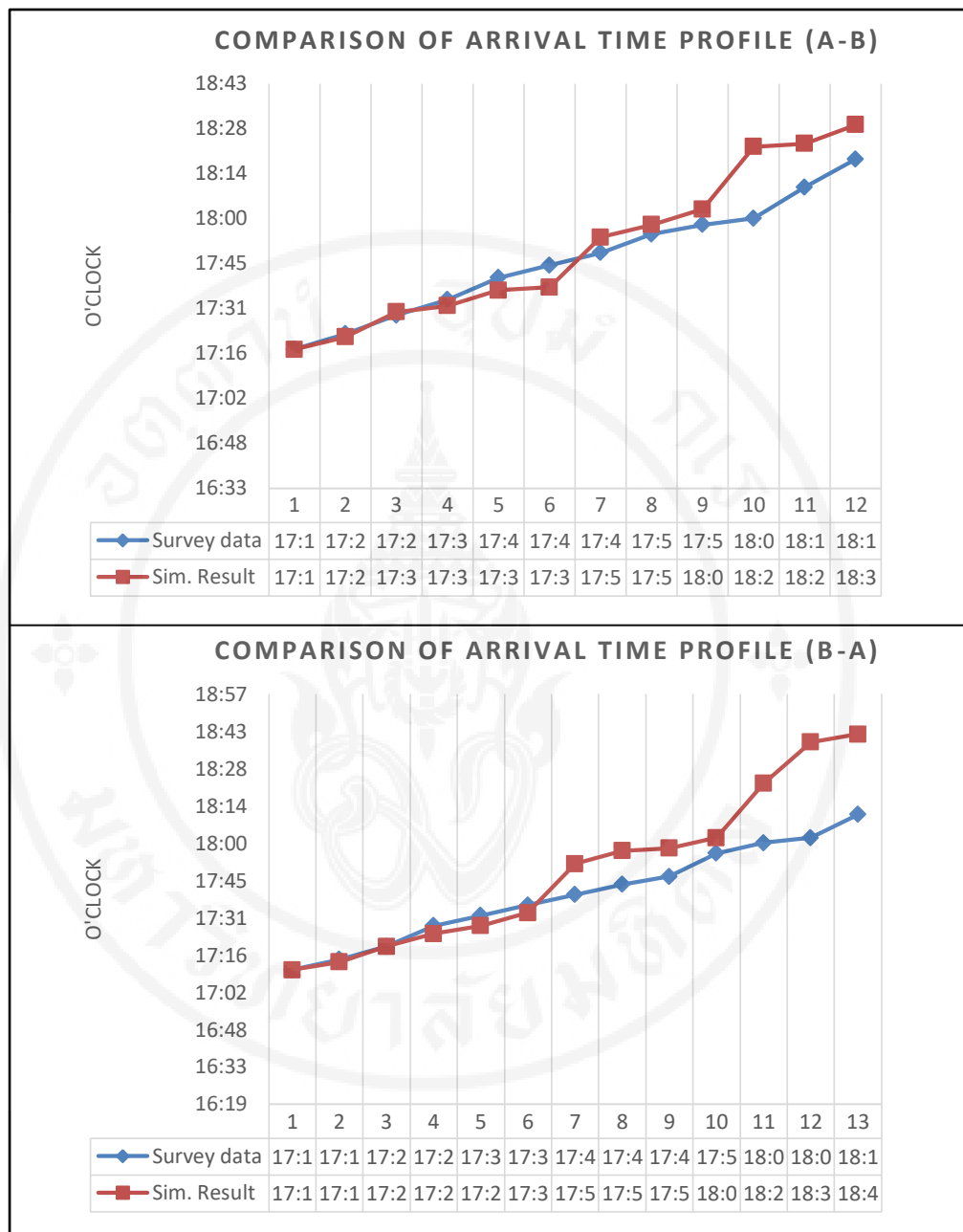


Figure 4.77 The comparison of arrival times for corridor 6 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.76** and **4.77** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 4 to 9 minutes during morning peak and 6 to 11 minutes during evening peak.

Figures 4.78 and **4.79** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.

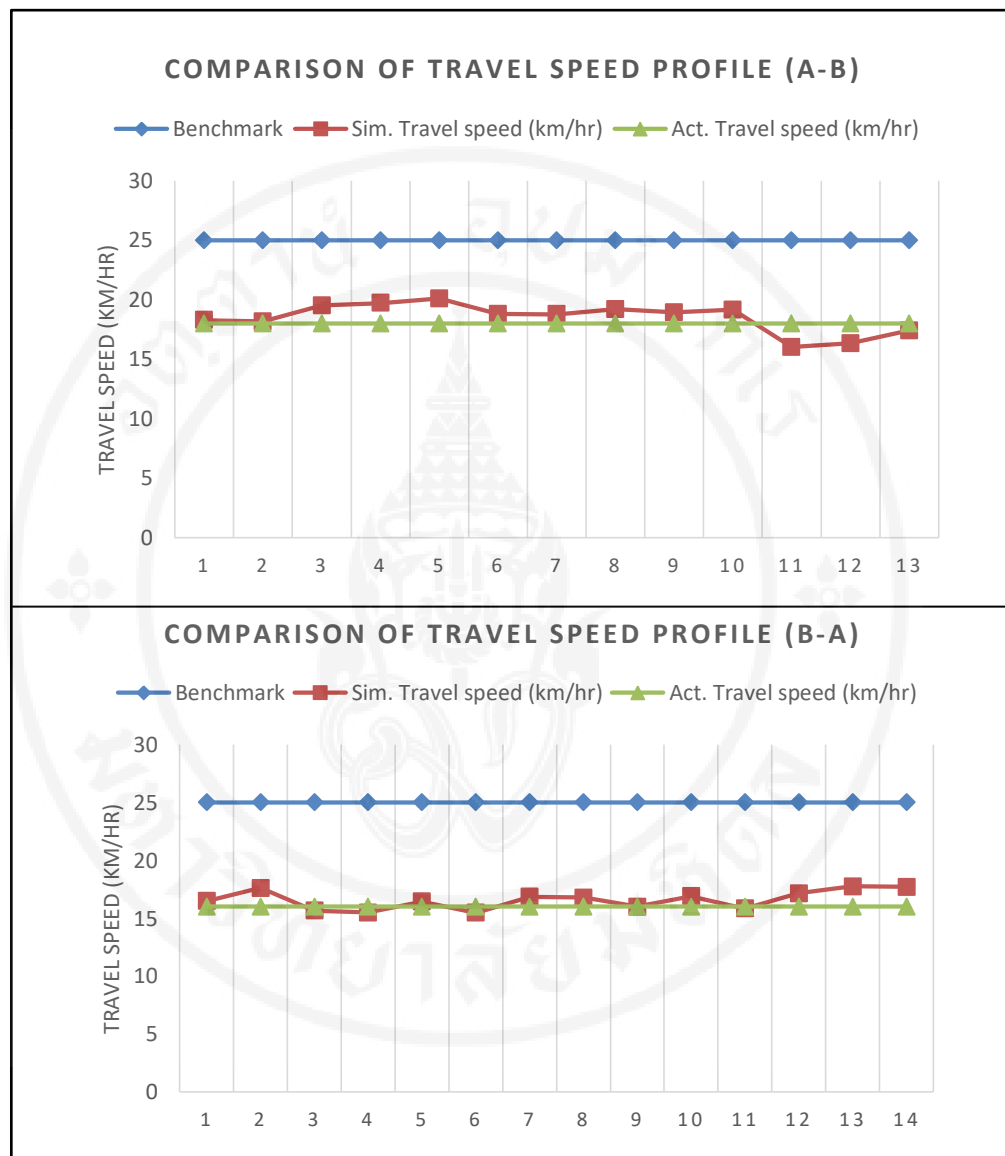


Figure 4.78 The comparison of travel speeds for corridor 6 between actual and simulation results, and the benchmark during morning-peak hour

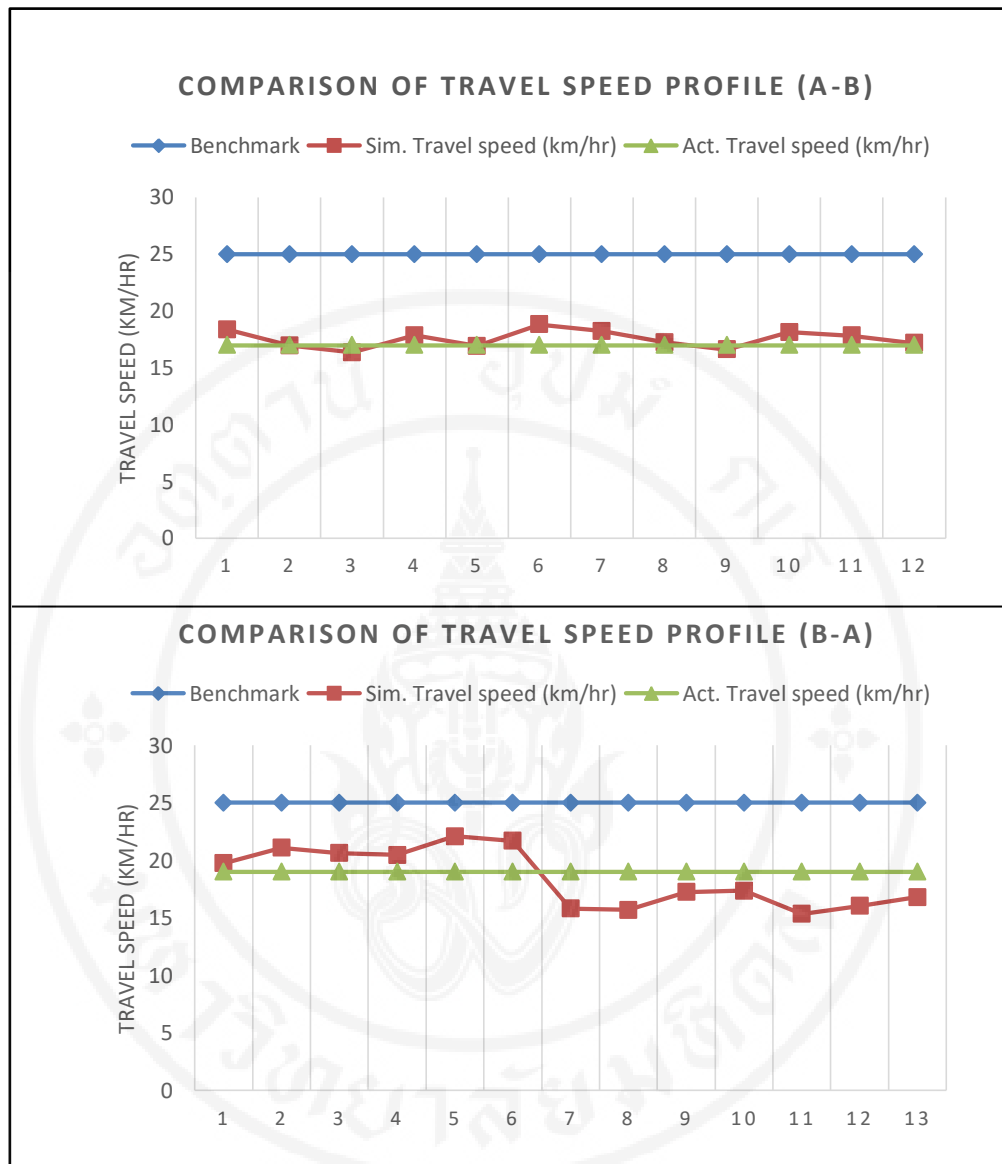


Figure 4.79 The comparison of travel speeds for corridor 6 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.78** and **4.79**, the final calibration shows 99% similarity of travel speeds during morning peak and 98% during evening peak between the actual and simulation results.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed. As shown in Table 4.105 for morning peak and Table 4.106 for evening peak. There is no significant difference between the average actual travel time and simulated travel time for the first direction (A-B) and -2% for the second direction (B-A) during morning peak. Meanwhile, the

difference during evening peak is +2% for the first direction (A-B) and -2% for the second direction (B-A).

Table 4.105 Percentage differences between actual and simulated travel times for corridor 6 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	49	49	0	48	48	0
2	49	49	0	48	45	-6
3	49	46	-6	48	50	+4
4	49	45	-8	48	51	+6
5	49	45	-8	48	48	0
6	49	48	-2	48	51	+6
7	49	48	-2	48	47	-2
8	49	47	-4	48	47	-2
9	49	47	-4	48	47	-2
10	49	47	-4	48	46	-4
11	49	56	-	48	49	+2
12	49	55	-	48	46	-4
13	49	51	-	48	44	-8
14	-	-	-	48	44	-8
$\bar{X}$	49	49	0	48	47	-2

Table 4.106 Percentage differences between actual and simulated travel times for corridor 6 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	50	49	-2	44	40	-9
2	50	53	+6	44	37	-16
3	50	55	+10	44	38	-14
4	50	50	0	44	38	-14
5	50	53	+6	44	35	-20
6	50	48	-4	44	36	-18
7	50	49	-2	44	50	+14
8	50	52	+4	44	50	+14
9	50	54	+8	44	45	+2
10	50	49	-2	44	45	+2
11	50	50	0	44	51	+16
12	50	52	-	44	49	+11
13	-	-	-	44	47	+7
$\bar{X}$	50	51	+2	44	43	-2

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. Table 4.107 shows the positive ranks and negative ranks from the SPSS output.

Table 4.107 Wilcoxon Signed-Rank test for validating the simulation results of corridor 6

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	8 ^a	5.06	40.50
	Positive Ranks	3 ^b	8.50	25.50
	Ties	2 ^c		
	Total	13		
Direction (A-B) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	4 ^a	2.75	11.00
	Positive Ranks	6 ^b	7.33	44.00
	Ties	2 ^c		
	Total	12		
Direction (B-A) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	8 ^a	6.44	51.50
	Positive Ranks	4 ^b	6.63	26.50
	Ties	2 ^c		
	Total	14		
Direction (B-A) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	6 ^a	9.08	54.50
	Positive Ranks	7 ^b	5.21	36.50
	Ties	0 ^c		
	Total	13		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak*: The sum of ranks for negative differences is $T_n = 40.5$; the sum of ranks for positive differences is $T_p = 25.5$. Thus, we have $t_0 = \min(T_p, T_n) = 25.5$. It shows that $(n - \text{ties}) = 13 - 2 = 11$ observations, the critical value of t_0 is $T = 11$ with $\alpha = 0.05$. Because the value $T = 25.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak*: The sum of ranks for negative differences is $T_n = 11$; the sum of ranks for positive differences is $T_p = 44$. Thus, we have $t_0 = \min(T_p, T_n) = 11$. It shows that $(n - \text{ties}) = 12 - 2 = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 11$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak*: The sum of ranks for negative differences is $T_n = 51.5$; the sum of ranks for positive differences is $T_p = 26.5$. Thus, we have $t_0 = \min(T_p, T_n) = 26.5$. It shows that $(n - \text{ties}) = 14 - 2 = 12$ observations, the critical value of t_0 is $T = 14$ with $\alpha = 0.05$. Because the value $T = 26.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak*: The sum of ranks for negative differences is $T_n = 54.5$; the sum of ranks for positive differences is $T_p = 36.5$. Thus, we have $t_0 = \min(T_p, T_n) = 36.5$. It shows that $n = 13$ observations, the critical value of t_0 is $T = 17$ with $\alpha = 0.05$. Because the value $T = 36.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 6, there are 8 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Increase trip frequency by decreasing headway from 5 minutes to 4 minute 37 seconds
- Scenario 3: Implement priority signal and mixed-traffic restriction at links 1, 7, 18, and 19
- Scenario 4: Install the passing lane at station VI-20
- Combination 1: Conducting scenarios 2 and 3
- Combination 2: Conducting scenarios 2 and 4
- Combination 3: Conducting scenarios 3 and 4
- Combination 4: Conducting all scenarios

All scenarios have been run on simulation, the following Tables 4.108 and 4.109 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks, respectively.

Table 4.108 Simulation results by scenario for corridor 6 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	49	18	50	18	50	18
Scenario 2	52	17	50	18	51	17
Scenario 3	29	24	31	25	30	24
Scenario 4	32	21	32	25	32	23
Combination 1	33	23	32	25	32	24
Combination 2	31	22	32	22	31	22
Combination 3	28	25	31	25	30	25
Combination 4	30	23	32	24	31	23

Table 4.109 Simulation results by scenario for corridor 6 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	48	16	44	19	46	18
Scenario 2	48	15	46	19	47	17
Scenario 3	29	24	34	23	31	24
Scenario 4	30	23	34	23	32	23
Combination 1	39	18	34	23	37	20
Combination 2	33	21	34	23	34	22
Combination 3	28	25	32	24	30	24
Combination 4	33	21	34	23	33	22

Based on the simulation results in Table 4.108, the best travel time during morning peak is 28 minutes; i.e., combination 3 for the first direction (A-B) and 31 minutes; i.e., scenario 3 and combination 3 for the second direction (B-A). Refer to table 4.109, the best travel time during evening peak is 28 minutes; i.e., combination 3 for the first direction (A-B) and 32 minutes; i.e., combination 3 for the second direction (B-A). For both directions, the combination 3 showed the best average travel speed of 25 kph in the morning peak and 24 kph in the morning peak. As a recommendation, the best strategy to enhance the operational performance of corridor 6 is the scenario combination 3.

4.4.7 Simulation results for corridor 7

In order to make it easy for identifying links and nodes in the network of corridor 7, **Figure A.7** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 7 has been done, the visualization of a partial network is shown in **Figure 4.80** below.

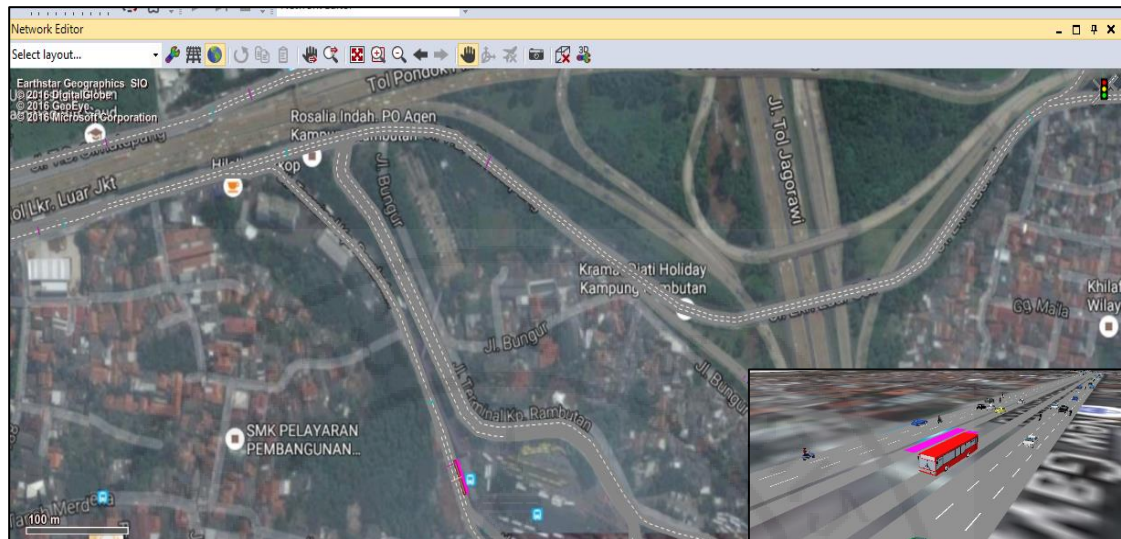


Figure 4.80. A part of simulated network of corridor 7

The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figures 4.81** and **4.82** show the comparison of arrival times during morning-peak and evening-peak periods, respectively.

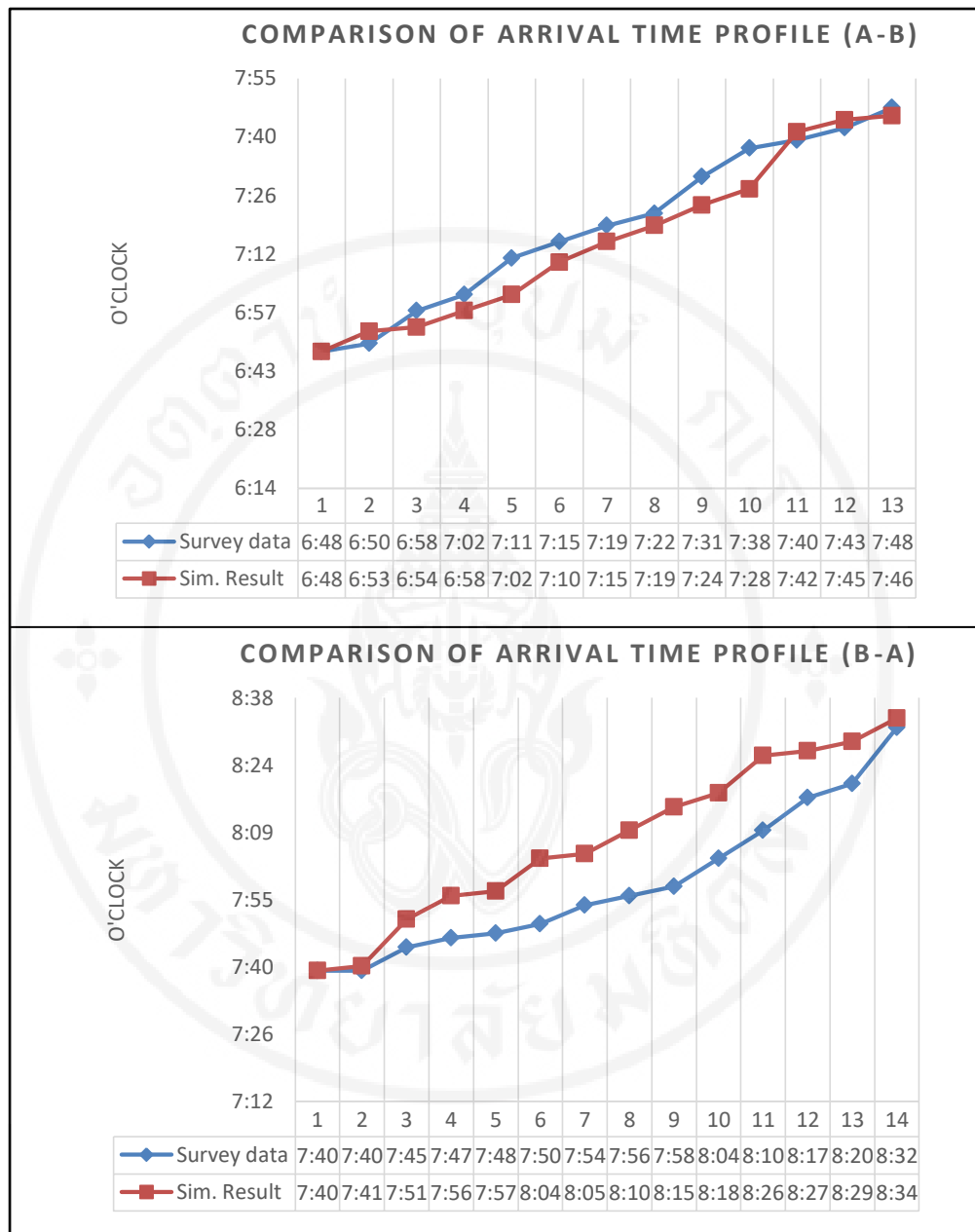


Figure 4.81 The comparison of arrival times for corridor 7 between actual and simulation results during morning-peak hour

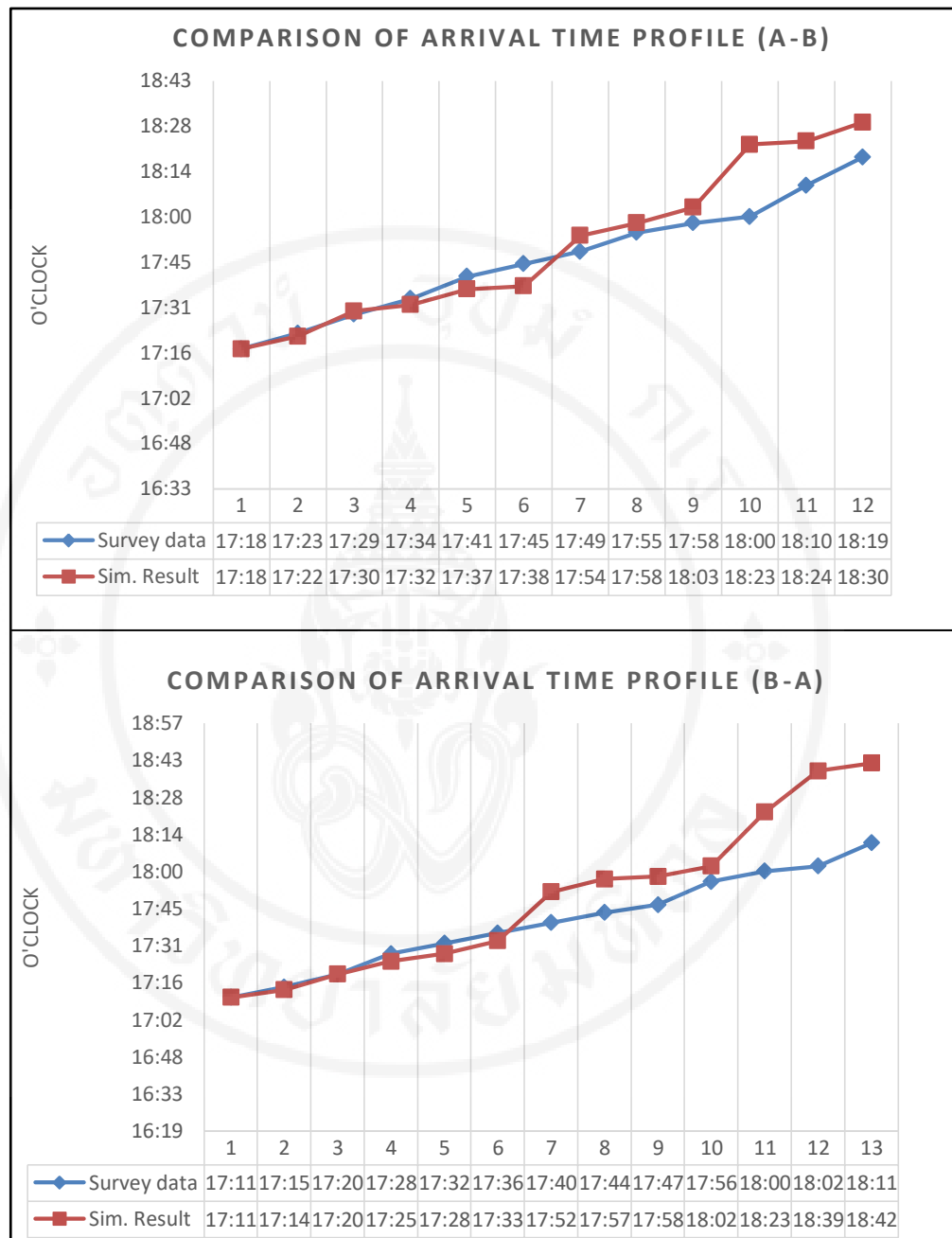


Figure 4.82 The comparison of arrival times for corridor 7 between actual and simulation results during evening-peak hour

Figures 4.81 and **4.82** show the similarity pattern of arrival times between actual and simulation results. The gap of arrival time between actual and simulation

results is around 3 to 4 minutes during morning peak and 1 to 4 minutes during evening peak.

Figures 4.83 and **4.84** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.

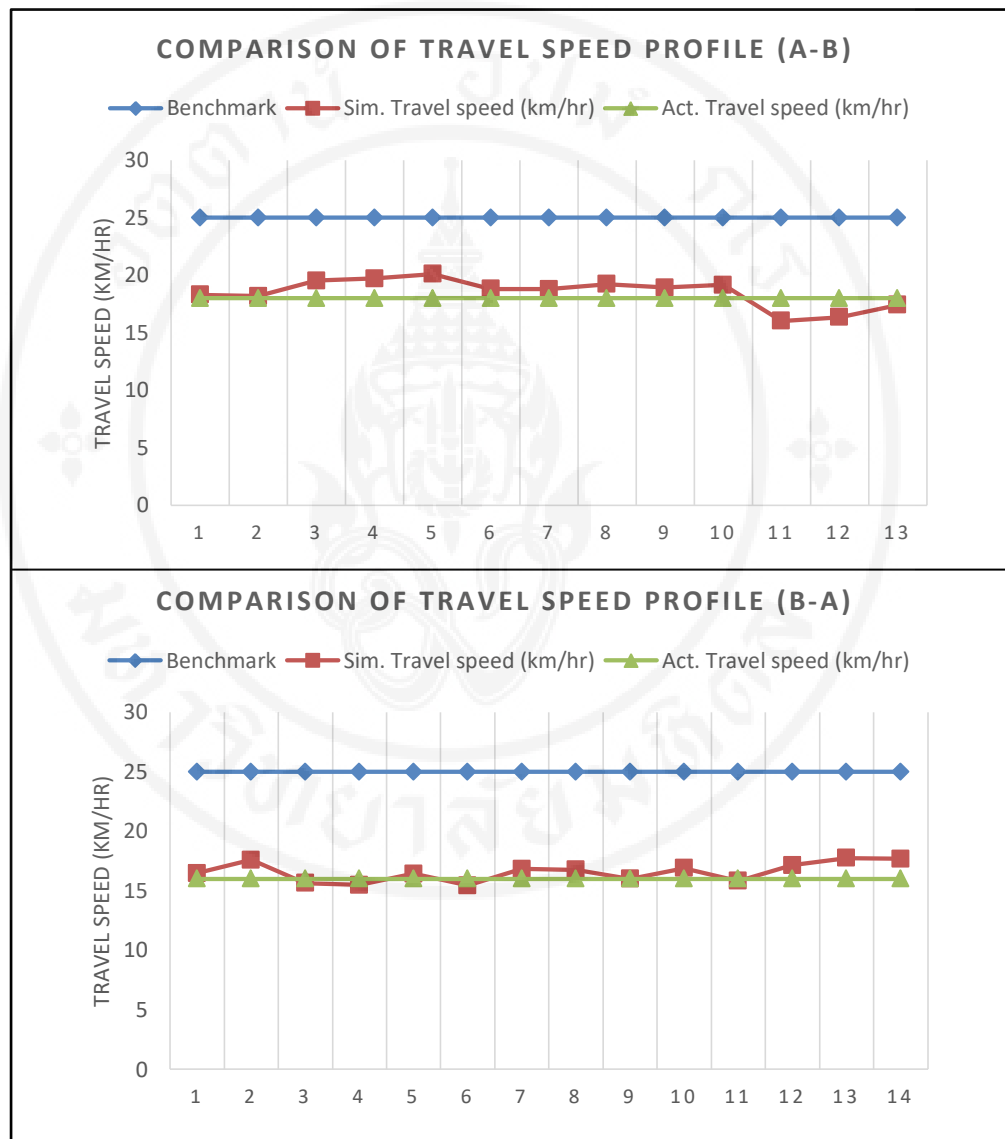


Figure 4.83 The comparison of travel speeds for corridor 7 between actual and simulation results, and the benchmark during morning-peak hour

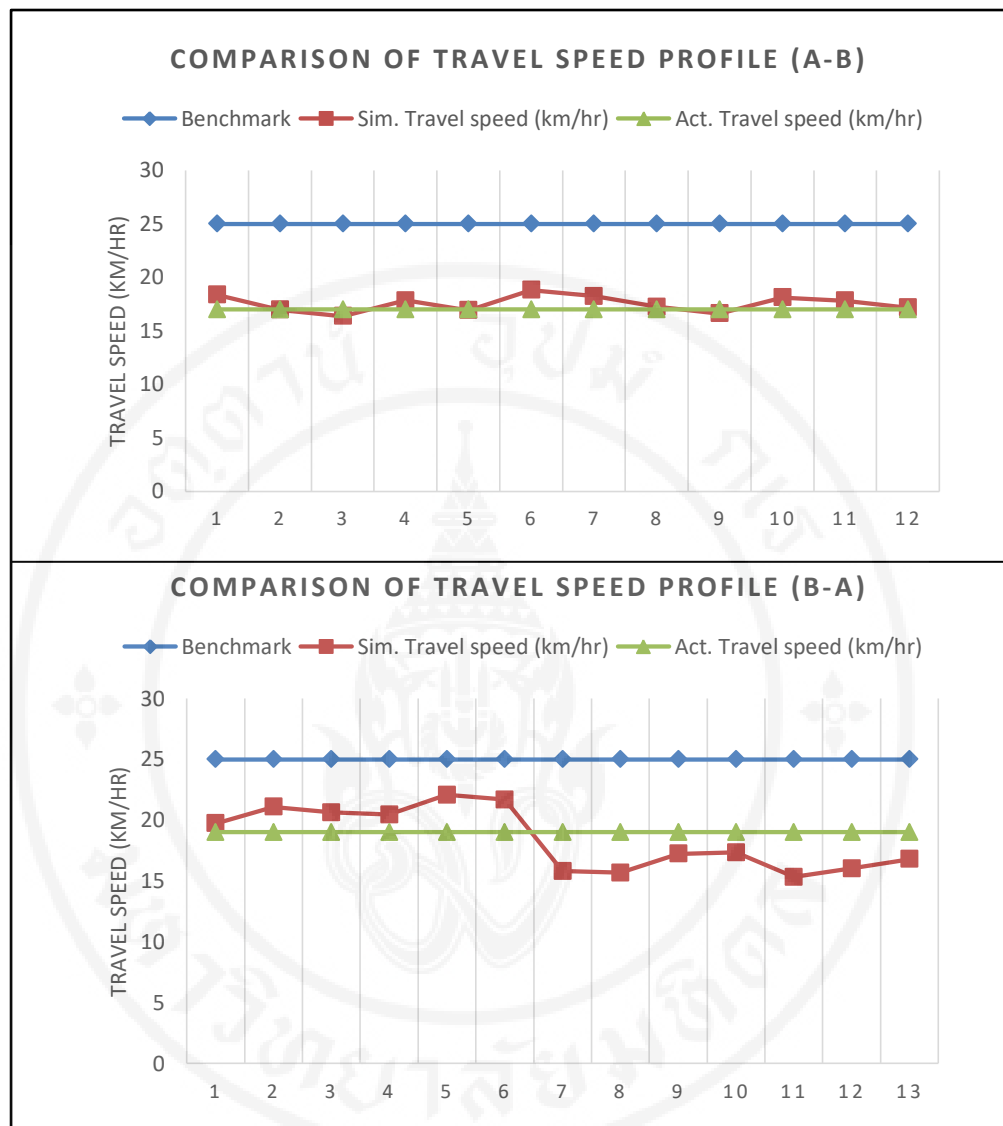


Figure 4.84 The comparison of travel speeds for corridor 7 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.83** and **4.84**, the final calibration shows 98% similarity of travel speeds during both morning peak and evening peak between the actual and simulation results. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Table 4.110 for morning peak and Table 4.111 for evening peak. The difference between the average actual travel time and simulated travel time is +3% for the first direction and 0% for

the second direction during morning peak. Meanwhile, the difference during evening peak is +3% for the first direction and no difference for the second direction.

Table 4.110 Percentage differences between actual and simulated travel times for corridor 7 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	33	34	+3	37	37	0
2	33	31	-6	37	38	+3
3	33	34	+3	37	37	0
4	33	37	+12	37	37	0
5	33	34	+3	37	36	-3
6	33	33	0	37	40	+8
7	33	35	+6	37	37	0
8	33	35	+6	37	36	-3
9	33	32	-3	37	39	+5
10	33	36	+9	37	37	0
11	33	33	-	37	39	+5
12	33	34	-	37	37	0
13	33	33	-	37	34	-8
$\bar{X}$	33	34	+3	37	37	0

Table 4.111 Percentage differences between actual and simulated travel times for corridor 7 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	34	33	-3	38	37	-3
2	34	34	0	38	37	-3
3	34	33	-3	38	38	0
4	34	33	-3	38	44	+16
5	34	33	-3	38	37	-3
6	34	35	+3	38	36	-5
7	34	35	+3	38	40	+5
8	34	38	+12	38	38	0
9	34	35	+3	38	37	-3
10	34	38	+12	38	37	-3
11	34	37	+9	38	39	+3
12	34	37	-	38	36	-5
13	34	38	-	38	37	-3
$\bar{X}$	34	35	+3	38	38	0

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. Table 4.112 shows the positive ranks and negative ranks from the SPSS output.

Table 4.112 Wilcoxon Signed-Rank test for validating the simulation results of corridor 7

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	8 ^a	5.06	40.50
	Positive Ranks	3 ^b	8.50	25.50
	Ties	2 ^c		
	Total	13		
Direction (A-B) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	4 ^a	2.75	11.00
	Positive Ranks	6 ^b	7.33	44.00
	Ties	2 ^c		
	Total	12		
Direction (B-A) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	8 ^a	6.44	51.50
	Positive Ranks	4 ^b	6.63	26.50
	Ties	2 ^c		
	Total	14		
Direction (B-A) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	6 ^a	9.08	54.50
	Positive Ranks	7 ^b	5.21	36.50
	Ties	0 ^c		
	Total	13		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak*: The sum of ranks for negative differences is $T_n = 40.5$; the sum of ranks for positive differences is $T_p = 25.5$. Thus, we have $t_0 = \min(T_p, T_n) = 25.5$. It shows that $(n\text{-ties}) = 13 - 2 = 11$ observations, the critical value of t_0 is $T = 11$ with $\alpha = 0.05$. Because the value $T = 25.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak*: The sum of ranks for negative differences is $T_n = 11$; the sum of ranks for positive differences is $T_p = 44$. Thus, we have $t_0 = \min(T_p, T_n) = 11$. It shows that $(n\text{-ties}) = 12 - 2 = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 11$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak*: The sum of ranks for negative differences is $T_n = 51.5$; the sum of ranks for positive differences is $T_p = 26.5$. Thus, we have $t_0 = \min(T_p, T_n) = 26.5$. It shows that $(n\text{-ties}) = 14 - 2 = 12$ observations, the critical value of t_0 is $T = 14$ with $\alpha = 0.05$. Because the value $T = 26.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak*: The sum of ranks for negative differences is $T_n = 54.5$; the sum of ranks for positive differences is $T_p = 36.5$. Thus, we have $t_0 = \min(T_p, T_n) = 36.5$. It shows that $n = 13$ observations, the critical value of t_0 is $T = 17$ with $\alpha = 0.05$. Because the value $T = 36.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 7, there are 8 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Increase trip frequency by decreasing headway from 5 minutes to 4 minutes
- Scenario 3: Implement priority signal and mixed-traffic restriction on links 2, 5, 8, 9, 10, and 13
- Scenario 4: Install the extra platform / passing lane / separator lane at stations VII-3, VII-4, VII-5, VII-6, VII-7, VII-8, VII-9, and VII-10
- Combination 1: Conducting scenarios 2 and 3
- Combination 2: Conducting scenarios 2 and 4
- Combination 3: Conducting scenarios 3 and 4
- Combination 4: Conducting all scenarios

All scenarios have been run on simulation. Tables 4.113 and 4.114 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks, respectively.

Table 4.113 Simulation results by scenario for corridor 7 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	33	22	37	20	35	21
Scenario 2	34	22	37	20	36	21
Scenario 3	29	25	26	28	28	27
Scenario 4	37	20	32	23	35	21
Combination 1	31	24	27	27	29	26
Combination 2	40	19	34	22	37	20
Combination 3	29	25	26	28	28	27
Combination 4	29	25	27	28	28	26

Table 4.114 Simulation results by scenario for corridor 7 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	34	22	38	20	36	21
Scenario 2	36	21	38	20	37	20
Scenario 3	28	26	26	28	27	27
Scenario 4	37	20	33	23	35	21
Combination 1	29	26	27	28	28	27
Combination 2	38	20	34	22	36	21
Combination 3	28	27	26	28	27	27
Combination 4	28	26	28	27	28	27

Based on the simulation results in Table 4.113, the best travel time during morning peak is 29 minutes; i.e., scenario 3, combinations 3, and 4 for the first direction (A-B) and 26 minutes; i.e., scenario 3 and combination 3 for the second direction (B-A). Refer to Table 4.114, the best travel time during evening peak is 28 minutes; i.e., scenario 3, combinations 3 and 4 for the first direction (A-B) and 26 minutes; i.e., scenario 3 and combination 3 for the second direction (B-A). Both combinations 3 and 4 showed the excellent average travel speed at both peak periods. In the consideration of corridor capacity to satisfy the demand. The combination 4 is the best strategy to enhance the operational performance of corridor 7.

4.4.8 Simulation results for corridor 8

In order to make it easy for identifying links and nodes in the network of corridor 8, **Figure A.8** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 8 has been done, the visualization of a partial network is shown in **Figure 4.85** below.

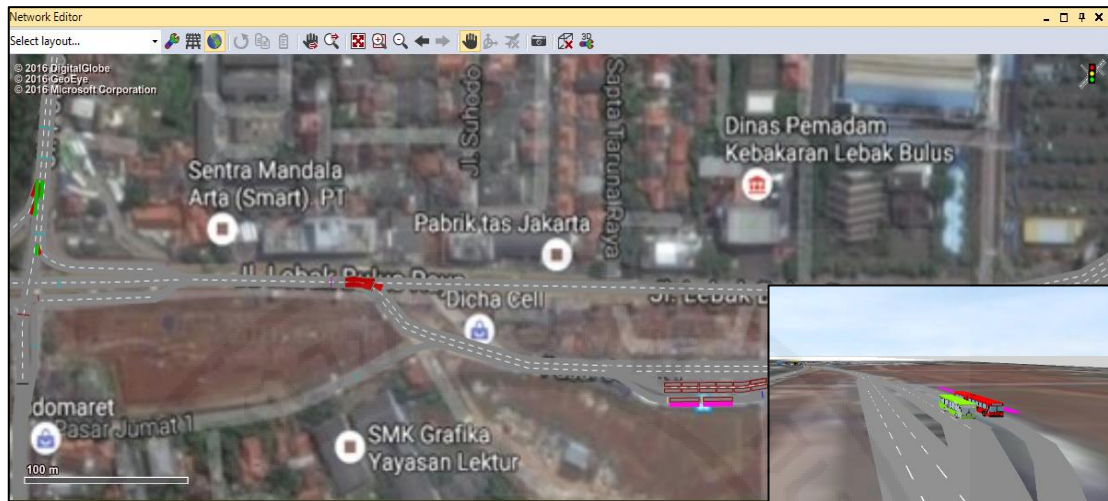


Figure 4.85. A part of simulated network of corridor 8

The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figures 4.86** and **4.87** show the comparison of arrival times during two peak periods.

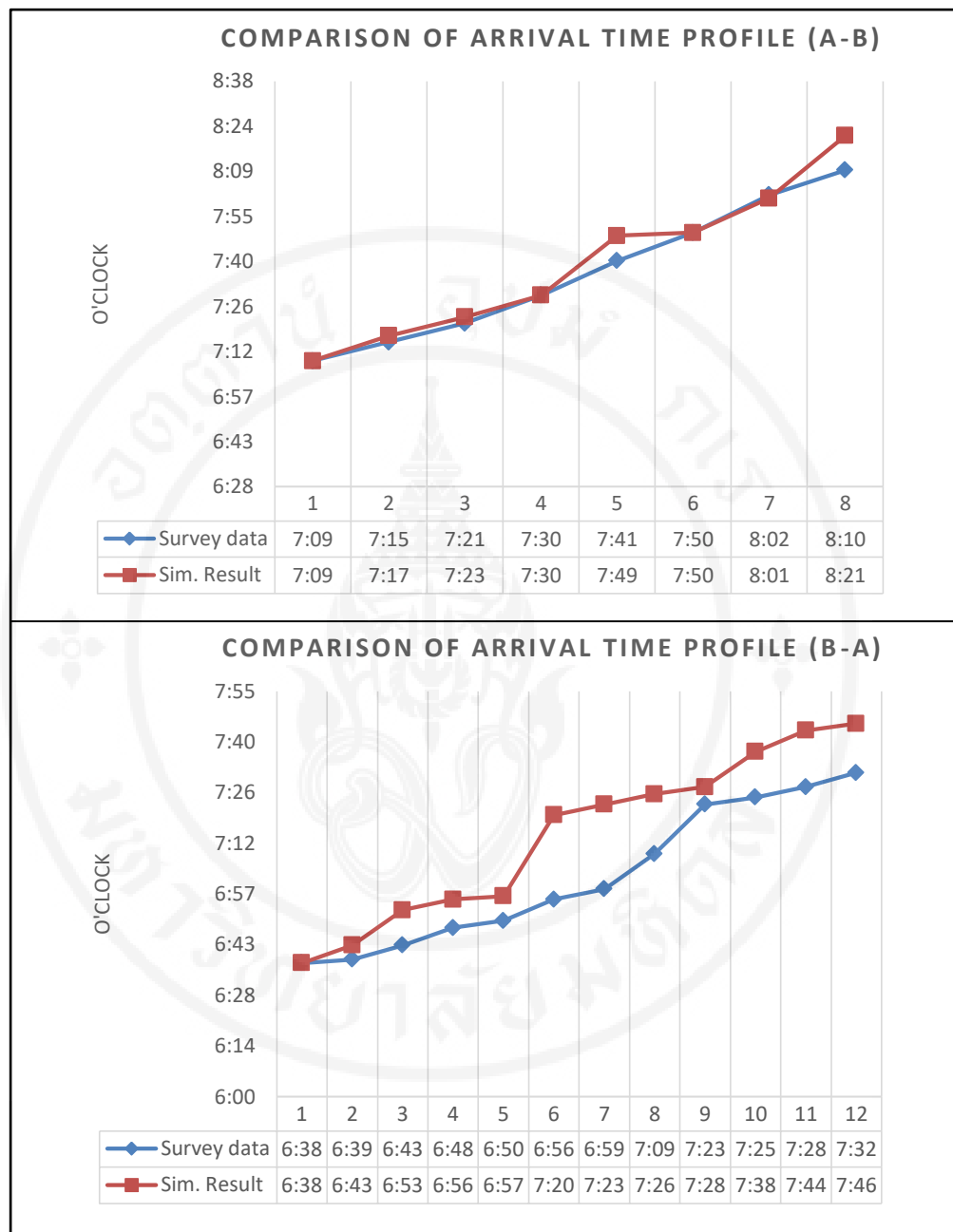


Figure 4.86 The comparison of arrival times for corridor 8 between actual and simulation results during morning-peak hour

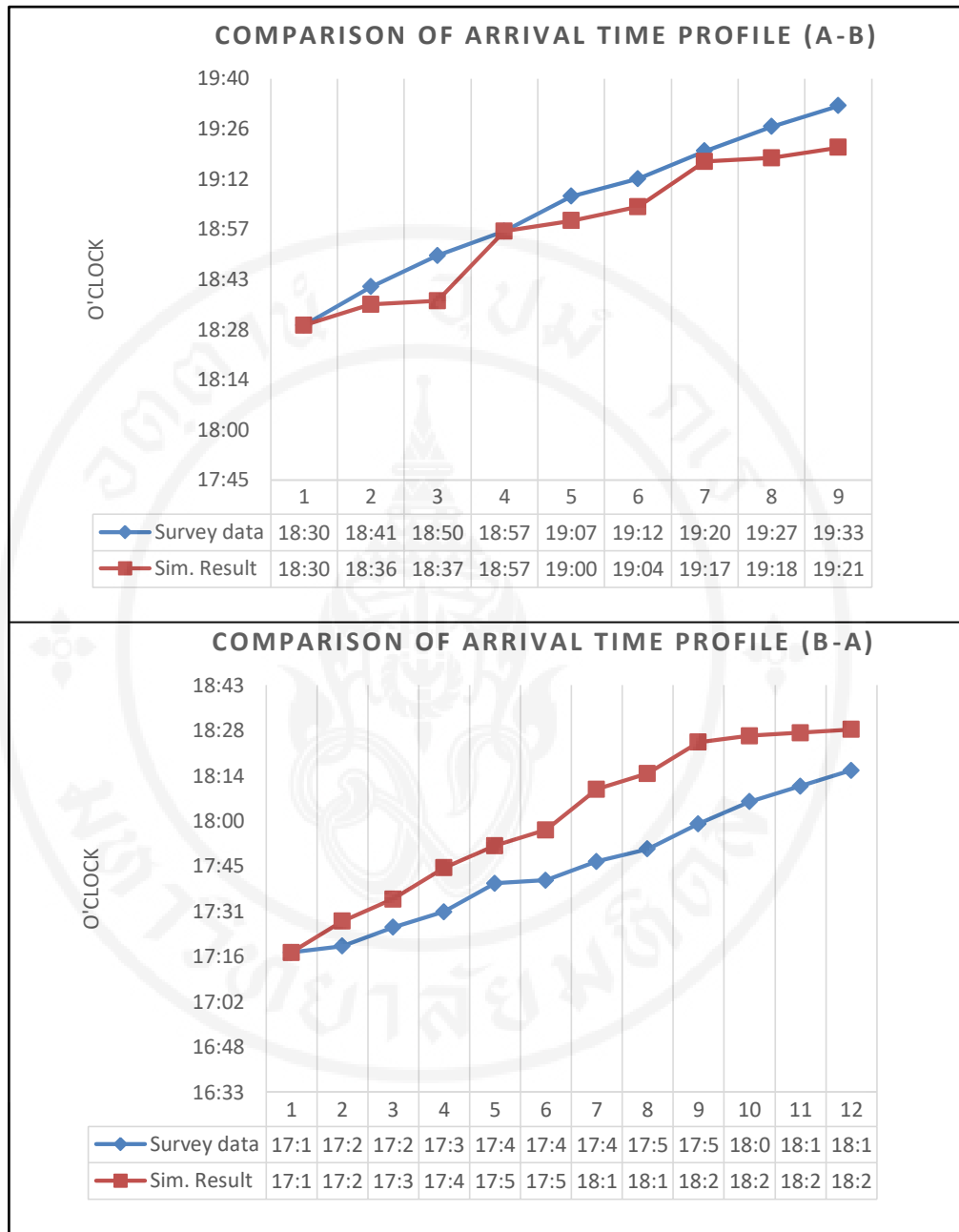


Figure 4.87 The comparison of arrival times for corridor 8 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.86** and **4.87** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 3 to 11 minutes during morning peak and 6 to 15 minutes during evening peak.

Figure 4.88 and **Figure 4.89** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.



Figure 4.88 The comparison of travel speeds for corridor 8 between actual and simulation results, and the benchmark during morning-peak hour

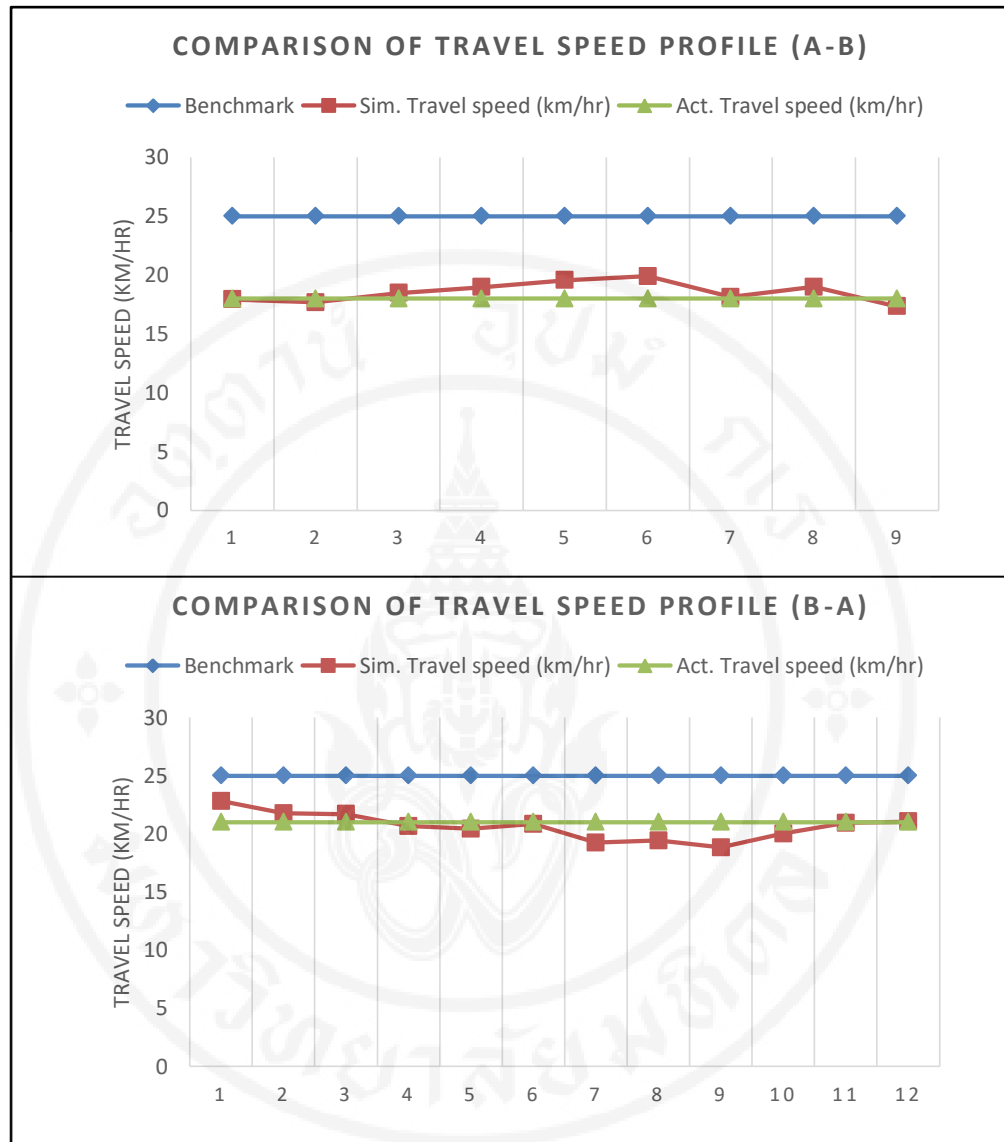


Figure 4.89 The comparison of travel speeds for corridor 8 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.88** and **4.89**, the final calibration shows 98% similarity of travel speeds during both morning peak and evening peak between the actual and simulation results. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Table 4.115 for morning peak and Table 4.116 for evening peak. The difference between the average

actual travel time and simulated travel time is -7% for the first direction (A-B) and 0% for the second direction (B-A) during morning peak. Meanwhile, the difference during evening peak is -2% for the first direction and +1% for the second direction.

Table 4.115 Percentage differences between actual and simulated travel times for corridor 8 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	83	72	-13	74	71	-4
2	83	72	-13	74	71	-4
3	83	70	-16	74	76	3
4	83	70	-16	74	73	-1
5	83	83	0	74	69	-7
6	83	76	-8	74	77	+4
7	83	80	-4	74	76	+3
8	83	92	11	74	74	0
9	-	-	-	74	71	-4
10	-	-	-	74	75	+1
11	-	-	-	74	73	-1
12	-	-	-	74	78	+5
$\bar{X}$	83	77	-7	74	74	0

Table 4.116 Percentage differences between actual and simulated travel times for corridor 8 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	84	84	0	73	67	-8
2	84	85	+1	73	70	-4
3	84	82	-2	73	71	-3
4	84	80	-5	73	74	+1
5	84	77	-8	73	75	+3
6	84	76	-10	73	73	0
7	84	83	-1	73	80	+10
8	84	80	-5	73	79	+8
9	84	87	+4	73	81	+11
10	-	-	-	73	76	+4
11	-	-	-	73	73	0
12	-	-	-	73	73	0
$\bar{X}$	84	82	-2	73	74	+1

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. Table 4.117 shows the positive ranks and negative ranks from the SPSS output.

Table 4.117 Wilcoxon Signed-Rank test for validating the simulation results of corridor 8

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time	Negative Ranks	6 ^a	4.17	25.00
-				
act_trav_time	Positive Ranks	1 ^b	3.00	3.00
	Ties	1 ^c		
	Total	8		
Direction (A-B) (evening peak)				
sim_trav_time	Negative Ranks	6 ^a	5.08	30.50
-				
act_trav_time	Positive Ranks	2 ^b	2.75	5.50
	Ties	1 ^c		
	Total	9		
Direction (B-A) (morning peak)				
sim_trav_time	Negative Ranks	6 ^a	6.25	37.50
-				
act_trav_time	Positive Ranks	5 ^b	5.70	28.50
	Ties	1 ^c		
	Total	12		
Direction (B-A) (evening peak)				
sim_trav_time	Negative Ranks	3 ^a	4.50	13.50
-				
act_trav_time	Positive Ranks	6 ^b	5.25	31.50
	Ties	3 ^c		
	Total	12		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak*: The sum of ranks for negative differences is $T_n = 25$; the sum of ranks for positive differences is $T_p = 3$. Thus, we have $t_0 = \min(T_p, T_n) = 3$. It shows that (n-ties) = 8-1 = 7 observations, the critical value of t_0 is $T = 2$ with $\alpha = 0.05$. Because the value $T = 3$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak*: The sum of ranks for negative differences is $T_n = 30.5$; the sum of ranks for positive differences is $T_p = 5.5$. Thus, we have $t_0 = \min(T_p, T_n) = 5.5$. It shows that (n-ties) = 9-1 = 8 observations, the critical value of t_0 is $T = 4$ with $\alpha = 0.05$. Because the value $T = 5.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak*: The sum of ranks for negative differences is $T_n = 37.5$; the sum of ranks for positive differences is $T_p = 28.5$. Thus, we have $t_0 = \min(T_p, T_n) = 28.5$. It shows that (n-ties) = 12-1 = 11 observations, the critical value of t_0 is $T = 11$ with $\alpha = 0.05$. Because the value $T = 28.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak*: The sum of ranks for negative differences is $T_n = 13.5$; the sum of ranks for positive differences is $T_p = 31.5$. Thus, we have $t_0 = \min(T_p, T_n) = 13.5$. It shows that (n-ties) = 12-3 = 9 observations, the critical value of t_0 is $T = 6$ with $\alpha = 0.05$. Because the value $T = 13.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 8, there are 4 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Implement signal priority and mixed-traffic restriction on links 1.1, 1.2, 2, 4, 5, 9, 17, 18, 25, and 26
- Scenario 3: Install the extra platform / passing lane / separator lane at stations VIII-3, VIII-4, VIII-7, VIII-9, VIII-17, VIII-18, and VIII-19
- Combination: Conducting scenario 2 and scenario 3

All scenarios have been run on simulation. Tables 4.118 and 4.119 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks, respectively.

Table 4.118 Simulation results by scenario for corridor 8 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	83	18	74	21	79	20
Scenario 2	59	26	59	26	59	26
Scenario 3	71	21	74	21	73	21
Combination	58	26	57	27	58	26

Table 4.119 Simulation results by scenario for corridor 8 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	84	18	73	21	79	20
Scenario 2	59	26	57	27	58	26
Scenario 3	72	21	72	21	72	21
Combination	58	26	56	27	57	27

Based on the simulation results in Table 4.118, the best travel time during morning peak is 58 minutes; i.e., combination for the first direction (A-B) and 57 minutes; i.e., combination for the second direction (B-A). Refer to table 4.119, the best travel time during evening peak is 58 minutes; i.e., combination for the first direction (A-B) and 56 minutes; i.e., combination for the second direction (B-A). The scenario combination showed the average travel speed of 26 kph during both peak periods. As a recommendation, the scenario combination is the best strategy to enhance the operational performance of corridor 8.

4.4.9 Simulation results for corridor 9

In order to make it easy for identifying links and nodes in the network of corridor 9, **Figure A.9** in the appendix show the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 9 has been done, the visualization of a partial network is shown in **Figure 4.90**.

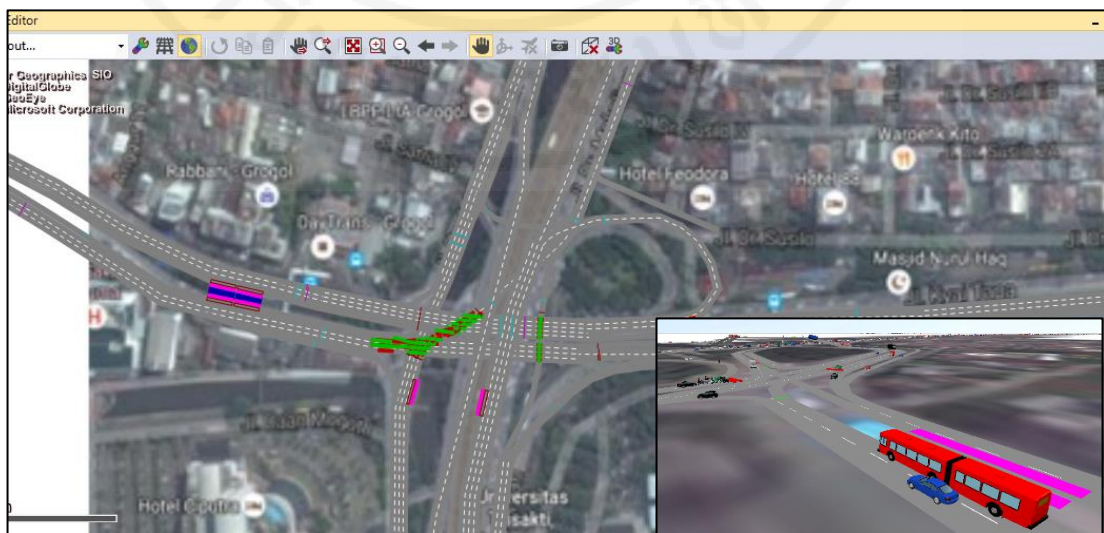


Figure 4.90. A part of simulated network of corridor 9

The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate

the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figure 4.91** and **Figure 4.92** show the comparison of arrival times during two peak periods.

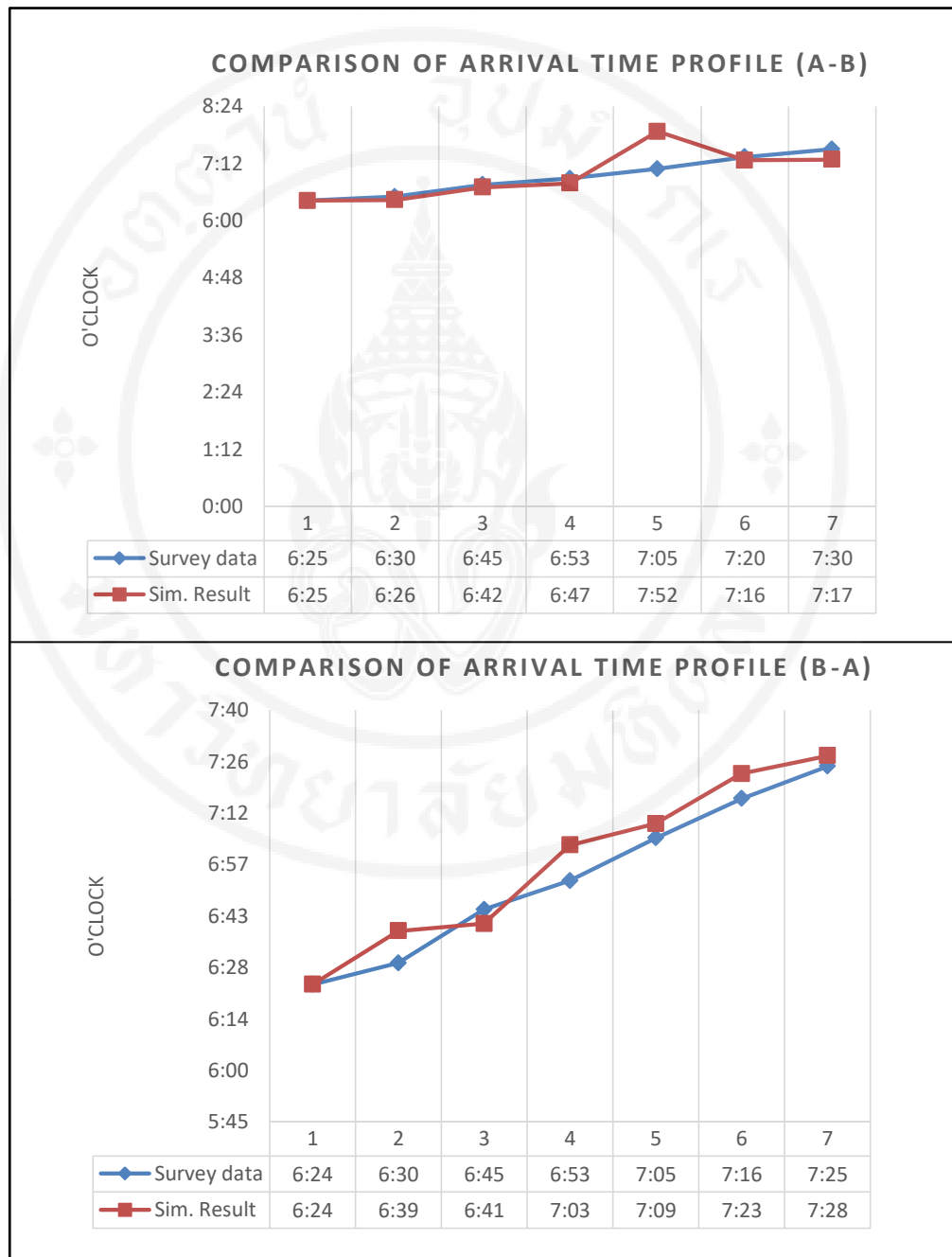


Figure 4.91 The comparison of arrival times for corridor 9 between actual and simulation results during evening-peak hour

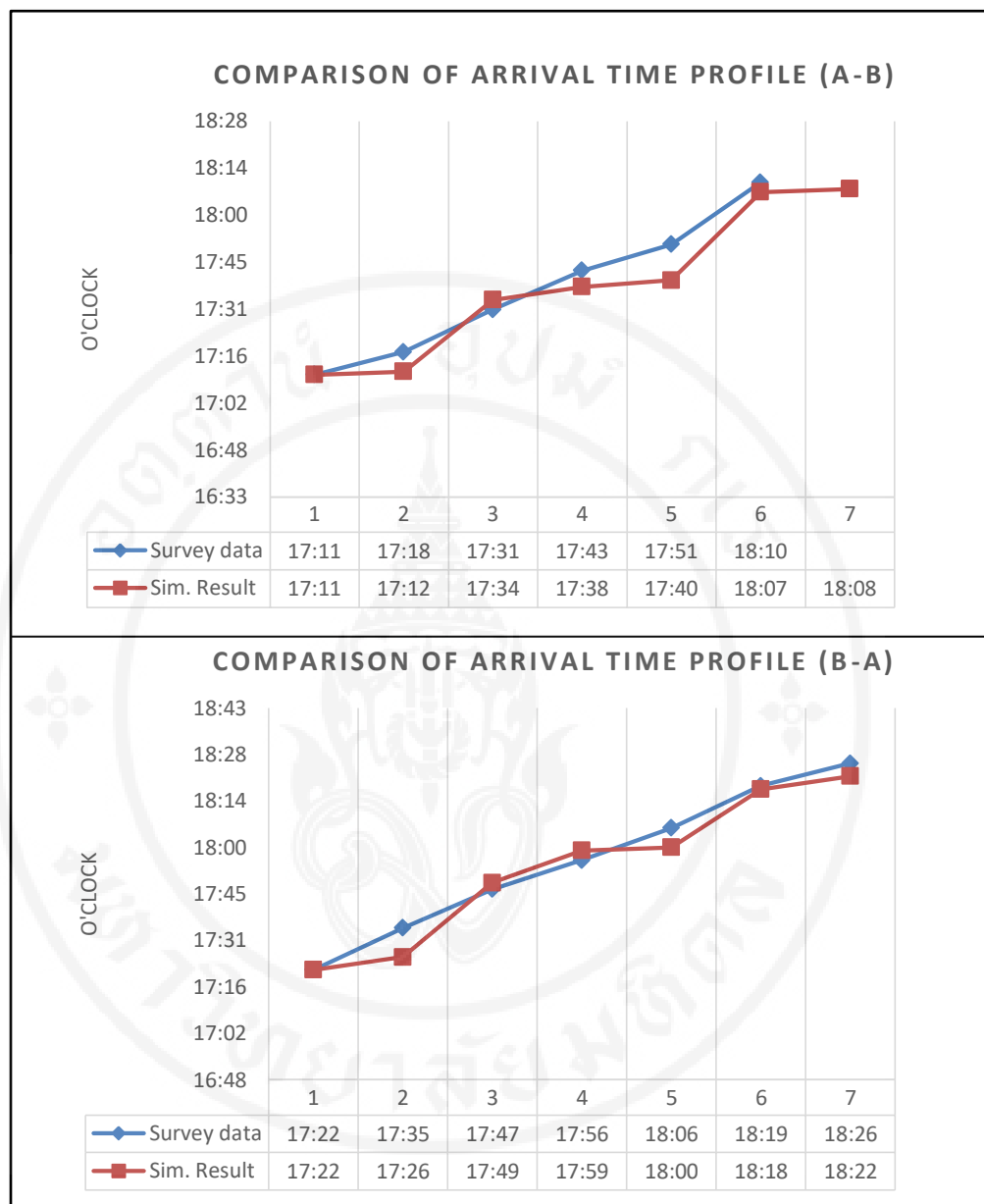


Figure 4.92 The comparison of arrival times for corridor 9 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.91** and **4.92** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 5 to 11 minutes during morning peak and 3 to 4 minutes during evening peak.

Figure 4.93 and **Figure 4.94** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.

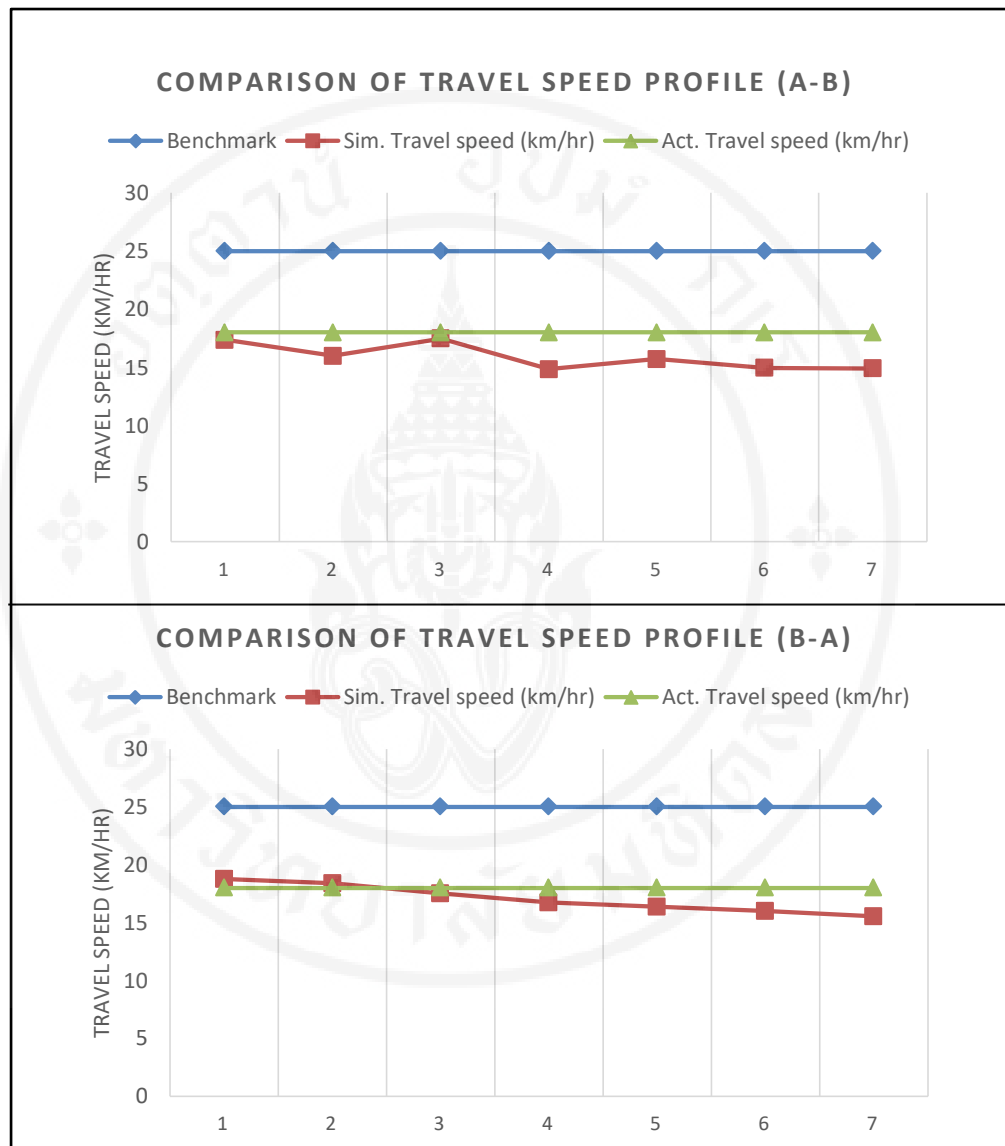


Figure 4.93 The comparison of travel speeds for corridor 9 between actual and simulation results, and the benchmark during morning-peak hour

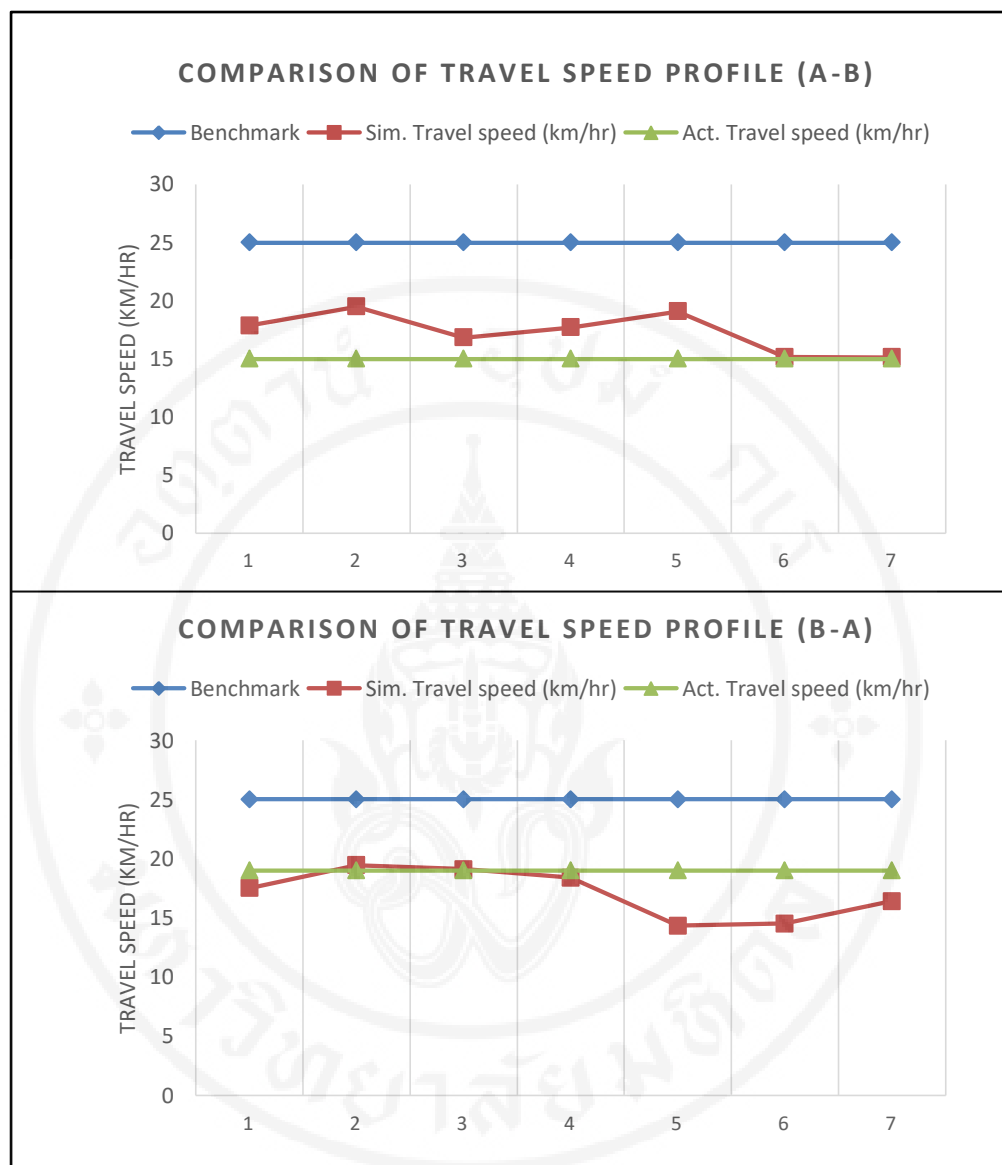


Figure 4.94 The comparison of travel speeds for corridor 9 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.93** and **4.94**, the final calibration shows 94% similarity of travel speeds during morning peak and 91% during evening peak between the actual and simulation results. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Tables 4.120 and 4.121. The difference between the average actual travel time and simulated travel

time is -5% for the first direction (A-B) and +8% for the second direction (B-A) during morning peak. Meanwhile, the difference during evening peak is -11% for the first direction (A-B) and +9% for the second direction (B-A).

Table 4.120 Percentage differences between actual and simulated travel times for corridor 9 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	114	98	-14	91	89	-2
2	114	107	-6	91	90	-1
3	114	98	-14	91	95	+4
4	114	115	+1	91	99	+9
5	114	109	-4	91	102	+12
6	114	114	0	91	104	+14
7	114	115	+1	91	107	+18
$\bar{X}$	114	108	-5	91	98	+8

Table 4.121 Percentage differences between actual and simulated travel times for corridor 9 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	112	96	-14	91	95	+4
2	112	88	-21	91	86	-5
3	112	102	-9	91	87	-4
4	112	97	-13	91	90	-1
5	112	90	-20	91	116	+27
6	112	113	+1	91	115	+26
7	112	113	+1	91	101	+11
$\bar{X}$	112	100	-11	91	99	+9

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

$$H_0: \text{Average actual travel time} = \text{average simulated travel time}$$

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. The Table 4.122 shows the positive ranks and negative ranks from the SPSS output.

Table 4.122 Wilcoxon Signed-Rank test for validating the simulation results of corridor 9

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	5 ^a	3.40	17.00
	Positive Ranks	1 ^b	4.00	4.00
	Ties	1 ^c		
	Total	7		
Direction (A-B) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	5 ^a	5.00	25.00
	Positive Ranks	2 ^b	1.50	3.00
	Ties	0 ^c		
	Total	7		
Direction (B-A) (morning peak)				
sim_trav_time - act_trav_time	Negative Ranks	2 ^a	1.50	3.00
	Positive Ranks	5 ^b	5.00	25.00
	Ties	0 ^c		
	Total	7		
Direction (B-A) (evening peak)				
sim_trav_time - act_trav_time	Negative Ranks	2 ^a	1.50	3.00
	Positive Ranks	4 ^b	4.50	18.00
	Ties	1 ^c		
	Total	7		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak:* The sum of ranks for negative differences is $T_n = 17$; the sum of ranks for positive differences is $T_p = 4$. Thus, we have $t_0 = \min(T_p, T_n) = 4$. It shows that (n-ties) = 7-1 = 6 observations, the critical value of t_0 is $T = 1$ with $\alpha = 0.05$. Because the value $T = 4$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak:* The sum of ranks for negative differences is $T_n = 25$; the sum of ranks for positive differences is $T_p = 3$. Thus, we have $t_0 = \min(T_p, T_n) = 3$. It shows that $n = 7$ observations, the critical value of t_0 is $T = 2$ with $\alpha = 0.05$. Because the value $T = 3$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak:* The sum of ranks for negative differences is $T_n = 3$; the sum of ranks for positive differences is $T_p = 25$. Thus, we have $t_0 = \min(T_p, T_n) = 3$. It shows that $n = 7$ observations, the critical value of t_0 is $T = 2$ with $\alpha = 0.05$. Because the value $T = 3$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak:* The sum of ranks for negative differences is $T_n = 3$; the sum of ranks for positive differences is $T_p = 18$. Thus, we have $t_0 = \min(T_p, T_n) = 3$. It shows that (n-ties) = 7-1 = 6 observations, the critical value of t_0 is $T = 1$ with $\alpha = 0.05$. Because the value $T = 3$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 9, there are 8 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Increase trip frequency by decreasing headway from 8 minutes 30 seconds to 2 minute 51 seconds
- Scenario 3: Implement signal priority and mixed-traffic restriction on links 2, 3, 5, 9, 13, 14, 15, 19, 21, and 25.2
- Scenario 4: Install the extra platform / passing lane / separator at stations IX-2, IX-3, IX-8, IX-11, IX-16, IX-20, IX-25, and IX-26
- Combination 1: Conducting scenarios 2 and 3
- Combination 3: Conducting scenarios 2 and 4
- Combination 3: Conducting scenarios 3 and 4
- Combination 4: Conducting all scenarios

All scenarios have been run on simulation, the following Tables 4.123 and 4.124 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks, respectively.

Table 4.123 Simulation results by scenario for corridor 9 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Existing	114	15	91	18	103	17
Scenario 2	100	17	95	18	97	17
Scenario 3	60	29	79	21	69	25
Scenario 4	77	22	90	19	84	21
Combination 1	63	27	85	20	74	24
Combination 2	77	22	93	18	85	20
Combination 3	58	29	76	22	67	26
Combination 4	58	29	82	21	70	25

Table 4.124 Simulation results by scenario for corridor 9 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Existing	112	15	90	19	101	17
Scenario 2	107	16	97	17	102	17
Scenario 3	59	29	79	21	69	25
Scenario 4	74	23	87	20	81	22
Combination 1	70	25	81	21	76	23
Combination 2	74	23	91	18	82	21
Combination 3	58	29	78	21	68	25
Combination 4	57	30	74	22	65	26

Based on the simulation results in Table 4.123, the best travel time during morning peak that can be reached is 58 minutes; i.e., combinations 3 and 4 for the first direction (A-B) and 82 minutes; i.e., combination 4 for the second direction (B-A). Refer to Table 4.124, the best travel time during evening peak is 57 minutes; i.e., combination 4 for the first direction (A-B) and 74 minutes; i.e., combination 4 for the second direction (B-A). The results from combination 4 showed the average travel speed of 25 kph during the morning peak and 26 kph during the evening peak. As a recommendation, the scenario combination 4 is the best strategy to enhance the operational performance of corridor 9.

4.4.10 Simulation results for corridor 10

In order to make it easy for identifying links and nodes in the network of corridor 10, **Figure A.10** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 10 has been done, the visualization of a partial network is shown in **Figure 4.95**.

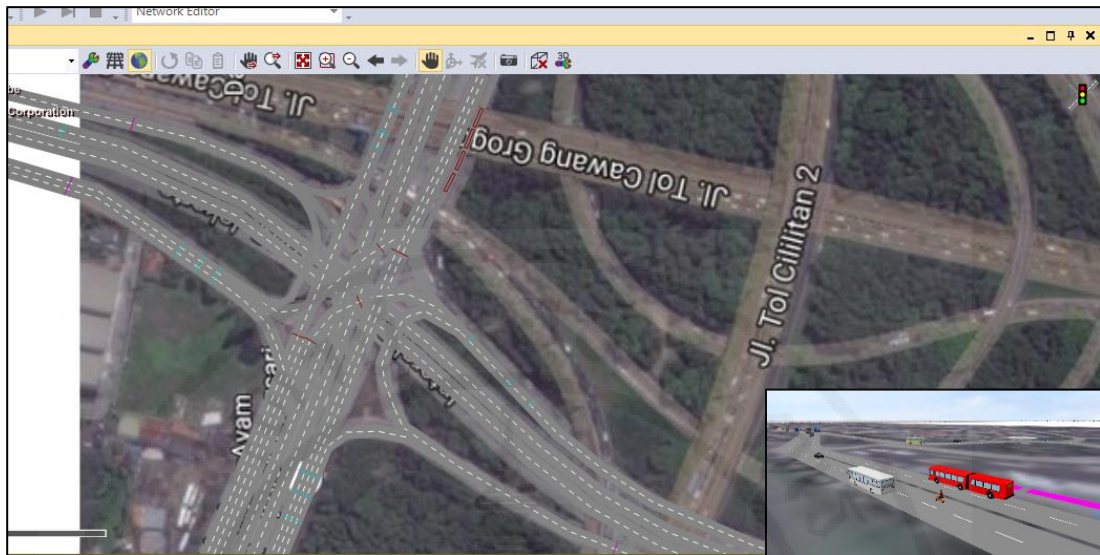


Figure 4.95. A part of simulated network of corridor 10

The model calibration has been done for 2 directions and for 2 peak periods. The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figures 4.96** and **4.97** show the comparison of arrival times during two peak periods.

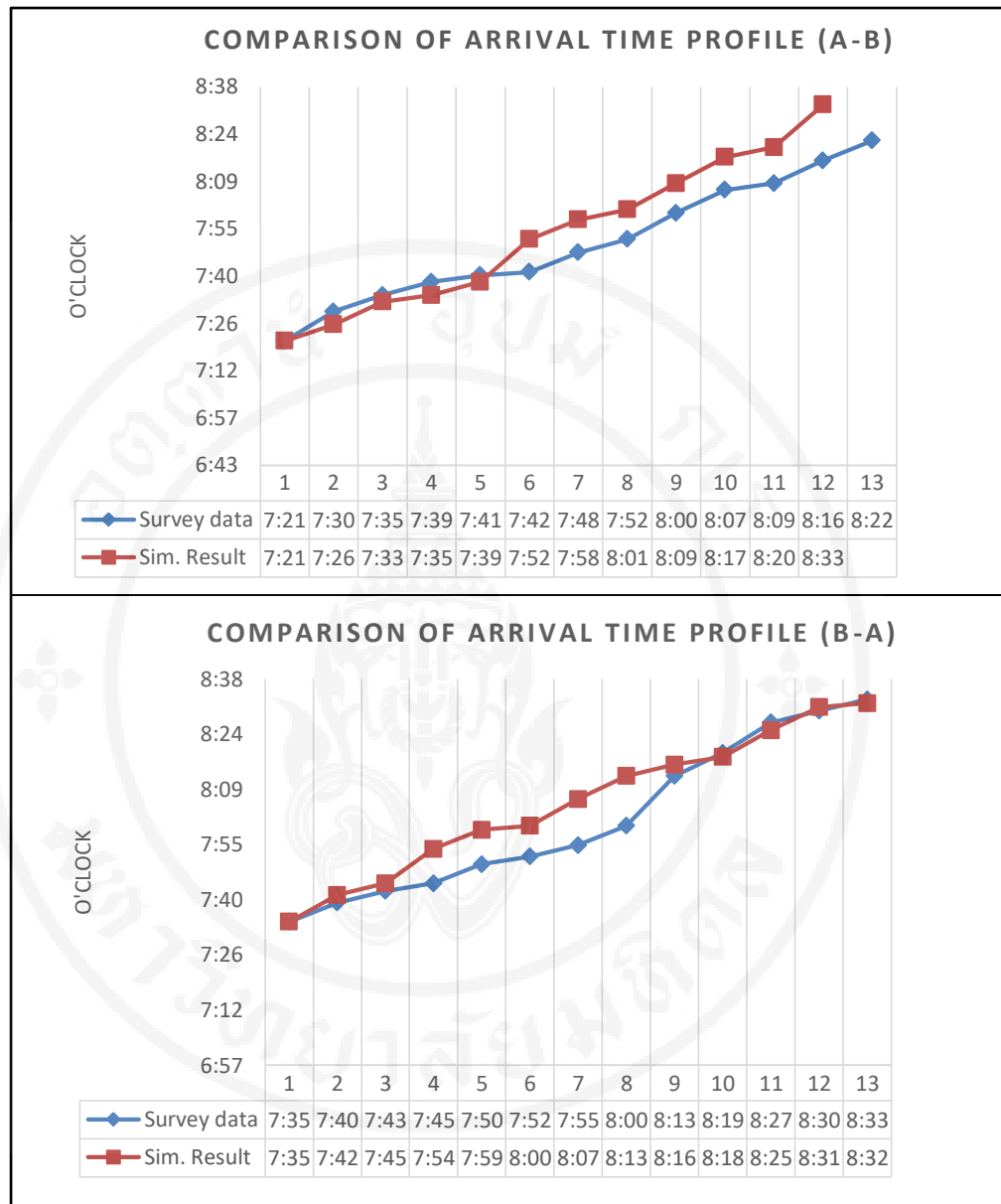


Figure 4.96 The comparison of arrival times for corridor 10 between actual and simulation results during morning-peak hour

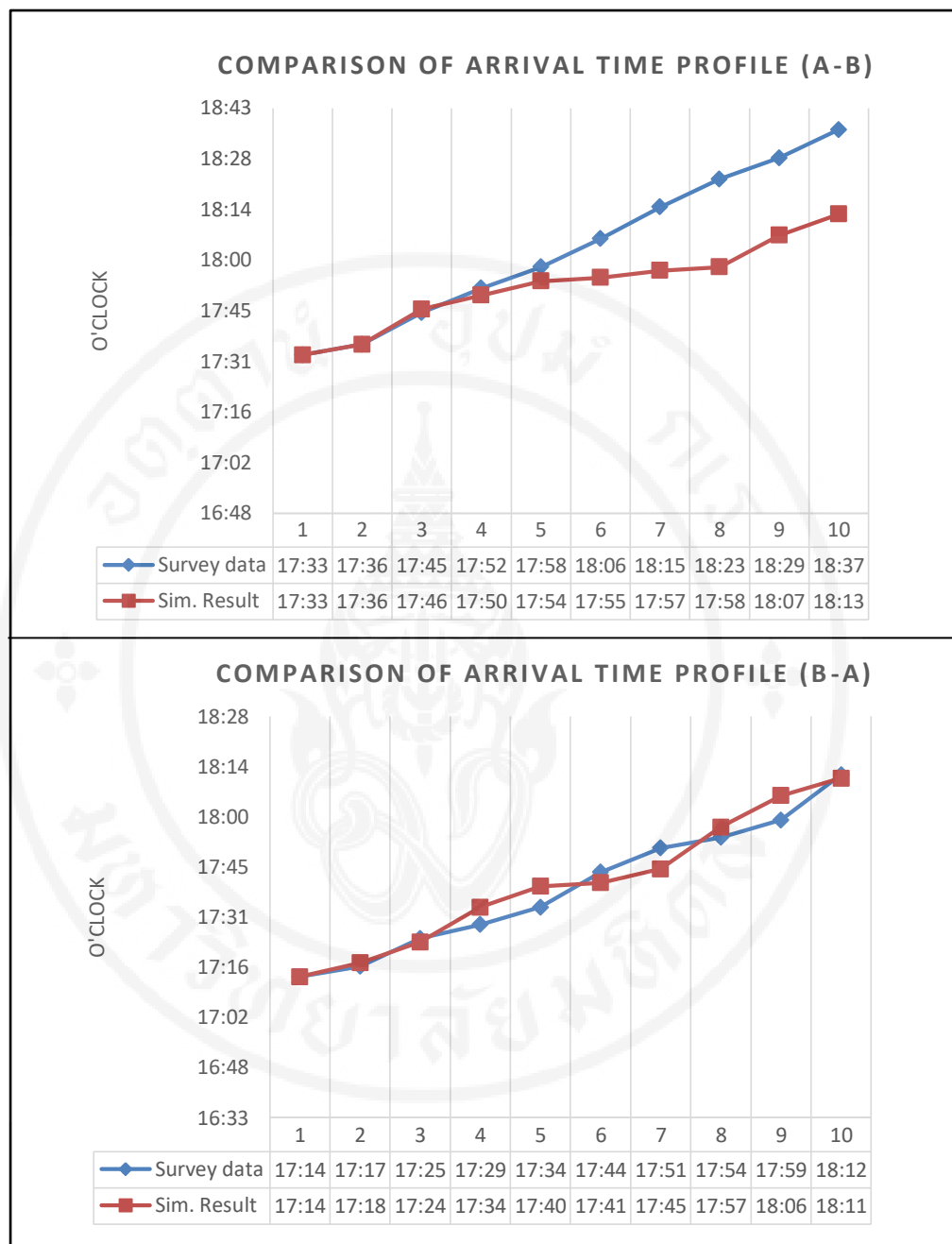


Figure 4.97 The comparison of arrival times for corridor 10 between actual and simulation results during morning-peak hour

The graphs in **Figures 4.96** and **4.97** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 4 to 7 minutes during morning peak and 3 to 10 minutes during evening peak.

Figure 4.98 and **Figure 4.99** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.

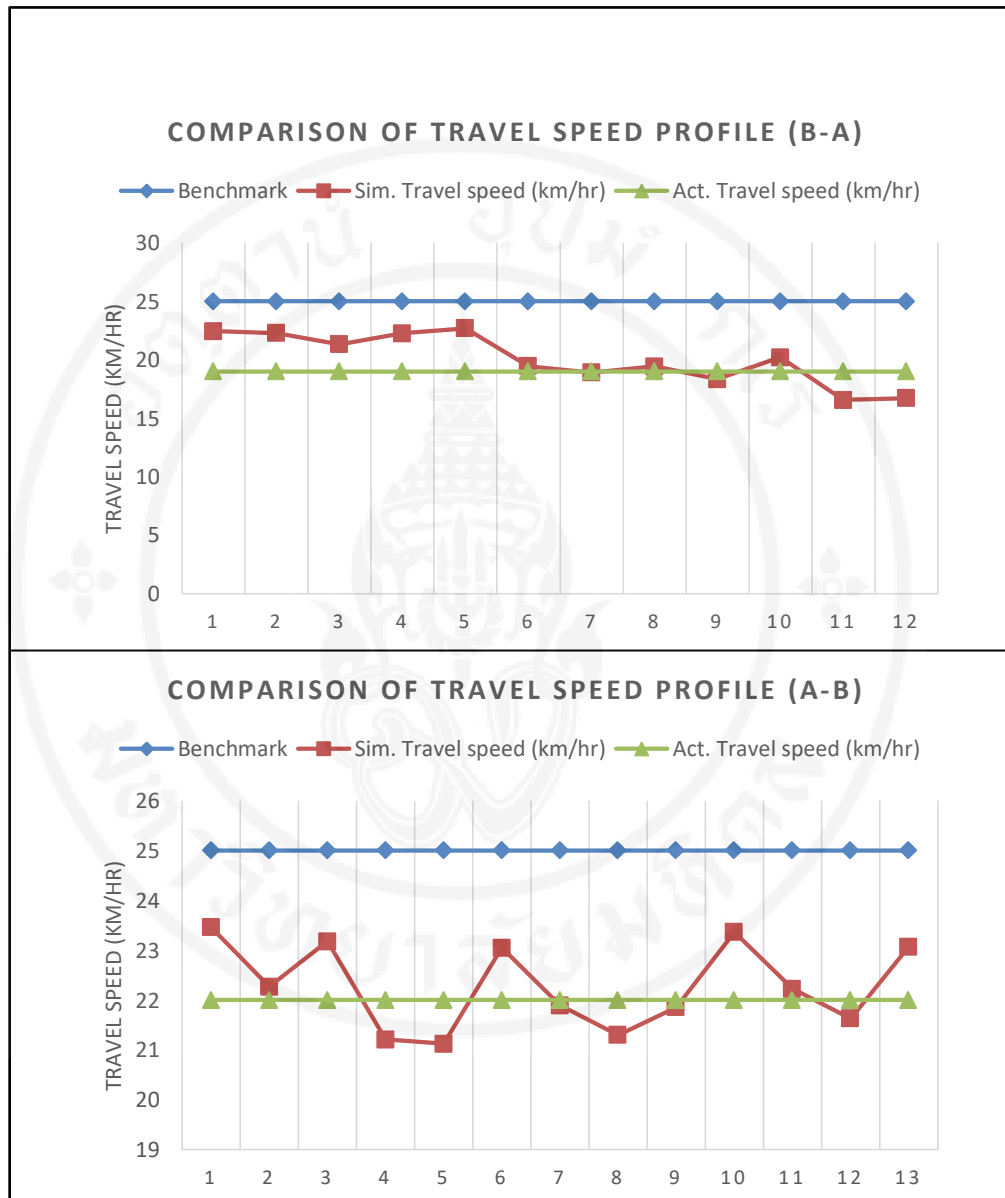


Figure 4.98 The comparison of travel speeds for corridor 10 between actual and simulation results, and the benchmark during morning-peak hour

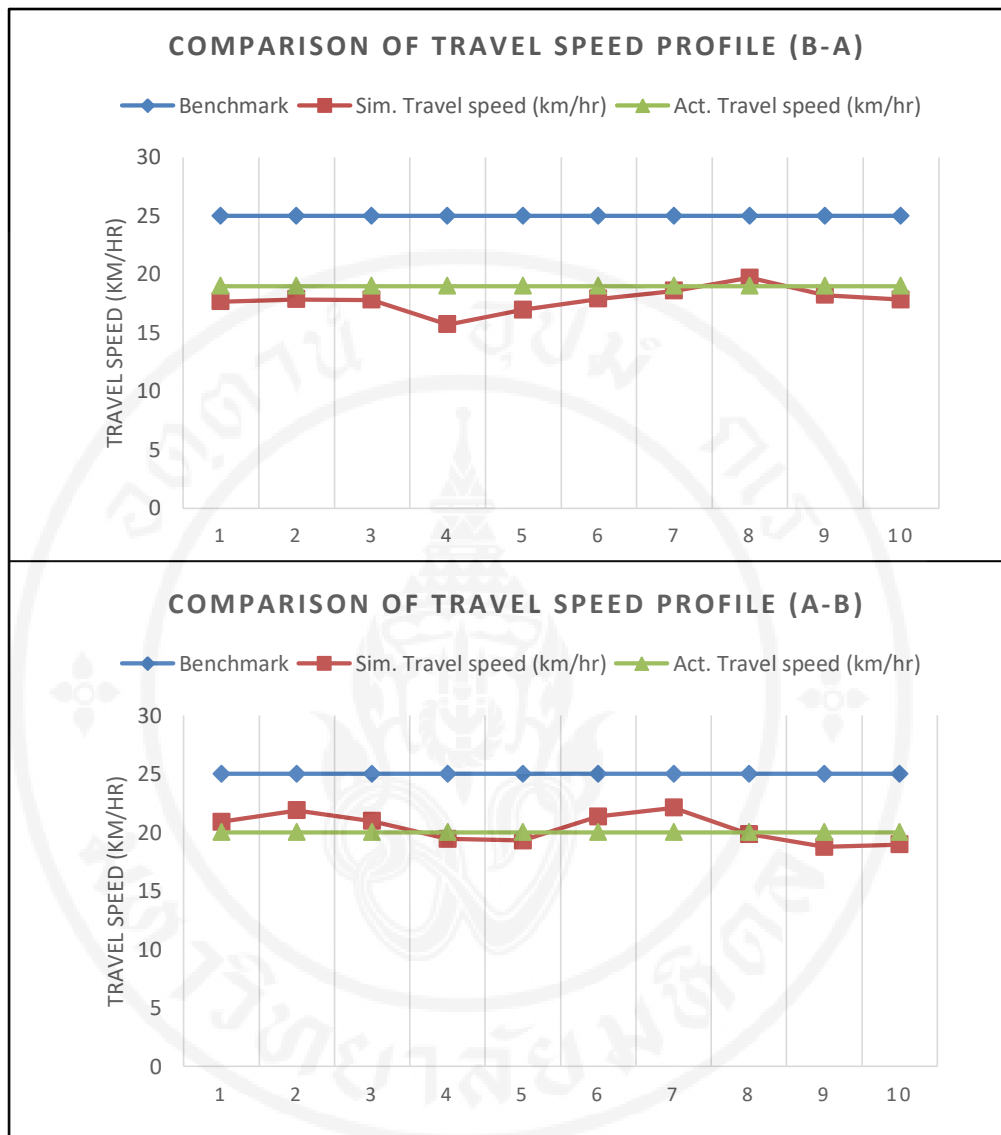


Figure 4.99 The comparison of travel speeds for corridor 10 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.98** and **4.99**, the final calibration shows 98% similarity of travel speeds during morning peak and 99% during evening peak between the actual and simulation results. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Table 4.125 for morning peak and Table 4.26 for evening peak. The difference between the average

actual travel time and simulated travel time is -2% for the first direction and no difference for the second direction during morning peak. Meanwhile, the difference during evening peak is +2% for the first direction and -2% for the second direction.

Table 4.125 Percentage differences between actual and simulated travel times for corridor 10 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	59	51	-14	51	49	-4
2	59	51	-14	51	51	0
3	59	53	-10	51	49	-4
4	59	51	-14	51	54	+6
5	59	50	-15	51	54	+6
6	59	59	0	51	50	-2
7	59	60	+2	51	52	+2
8	59	59	0	51	54	+6
9	59	62	+5	51	52	+2
10	59	56	-5	51	49	-4
11	59	69	+17	51	51	0
12	59	68	+15	51	53	+4
13	-	-	-	51	50	-2
$\bar{X}$	59	58	-2	51	51	0

Table 4.126 Percentage differences between actual and simulated travel times for corridor 10 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	63	64	+2	57	55	-4
2	63	64	+2	57	52	-9
3	63	64	+2	57	55	-4
4	63	72	+14	57	59	+4
5	63	67	+6	57	59	+4
6	63	64	+2	57	54	-5
7	63	61	-3	57	52	-9
8	63	58	-8	57	58	+2
9	63	63	0	57	61	+7
10	63	64	+2	57	60	+5
$\bar{X}$	63	64	+2	57	56	-2

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. The Table 4.127 shows the positive ranks and negative ranks from the SPSS output.

Table 4.127 Wilcoxon Signed-Rank test for validating the simulation results of corridor 10

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time	Negative Ranks	6 ^a	5.50	33.00
-				
act_trav_time	Positive Ranks	4 ^b	5.50	22.00
	Ties	2 ^c		
	Total	12		
Direction (A-B) (evening peak)				
sim_trav_time	Negative Ranks	2 ^a	7.00	14.00
-				
act_trav_time	Positive Ranks	7 ^b	4.43	31.00
	Ties	1 ^c		
	Total	10		
Direction (B-A) (morning peak)				
sim_trav_time	Negative Ranks	5 ^a	4.90	24.50
-				
act_trav_time	Positive Ranks	6 ^b	6.92	41.50
	Ties	2 ^c		
	Total	13		
Direction (B-A) (evening peak)				
sim_trav_time	Negative Ranks	5 ^a	6.50	32.50
-				
act_trav_time	Positive Ranks	5 ^b	4.50	22.50
	Ties	0 ^c		
	Total	10		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak:* The sum of ranks for negative differences is $T_n = 33$; the sum of ranks for positive differences is $T_p = 22$. Thus, we have $t_0 = \min(T_p, T_n) = 22$. It shows that $(n - \text{ties}) = 12 - 2 = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 22$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak:* The sum of ranks for negative differences is $T_n = 14$; the sum of ranks for positive differences is $T_p = 31$. Thus, we have $t_0 = \min(T_p, T_n) = 14$. It shows that $(n - \text{ties}) = 10 - 1 = 9$ observations, the critical value of t_0 is $T = 6$ with $\alpha = 0.05$. Because the value $T = 14$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak:* The sum of ranks for negative differences is $T_n = 24.5$; the sum of ranks for positive differences is $T_p = 41.5$. Thus, we have $t_0 = \min(T_p, T_n) = 24.5$. It shows that $(n - \text{ties}) = 13 - 2 = 11$ observations, the critical value of t_0 is $T = 11$ with $\alpha = 0.05$. Because the value $T = 24.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak:* The sum of ranks for negative differences is $T_n = 32.5$; the sum of ranks for positive differences is $T_p = 22.5$. Thus, we have $t_0 = \min(T_p, T_n) = 22.5$. It shows that $n = 10$ observations, the critical value of t_0 is $T = 8$ with $\alpha = 0.05$. Because the value $T = 22.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 10, there are 4 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Implement signal priority and the mixed-traffic restriction on links 1, 2, 4, 5, 6, 7, 13, 15, 16, 17, and 18
- Scenario 3: Install the extra platform / segregated lane / passing lane at stations X-2, X-3, X-4, X-6, X-20, and X-21
- Combination: Conducting scenario 2 and scenario 3

All scenarios have been run on simulation. Tables 4.128 and 4.129 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks respectively.

Table 4.128 Simulation results by scenario for corridor 10 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both Directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	59	19	51	22	55	21
Scenario 2	47	25	44	26	45	25
Scenario 3	55	21	50	23	52	22
Combination	45	25	42	27	44	26

Table 4.129 Simulation results by scenario for corridor 10 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both Directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	63	18	57	20	60	19
Scenario 2	46	25	42	28	44	26
Scenario 3	52	22	50	23	51	22
Combination	52	23	40	29	46	26

Based on the simulation results in Table 4.128, the best travel time during morning peak is 45 minutes; i.e., combination for the first direction (A-B) and 42 minutes; i.e., combination for the second direction (B-A). Refer to Table 4.129, the best travel time during evening peak that can be reached is 52 minutes; i.e., scenario 3 and combination for the first direction (A-B) and 40 minutes; i.e., combination for the second direction (B-A). The combination scenarios showed the travel speed of 26 kph during both peak periods. As a recommendation, the scenario combination is the best strategy to enhance the operational performance of corridor 10.

4.4.11 Simulation results for corridor 11

In order to make it easy for identifying links and nodes in the network of corridor 11. **Figure A.11** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 11 has been done, the visualization of a partial network is shown in **Figure 4.100**.

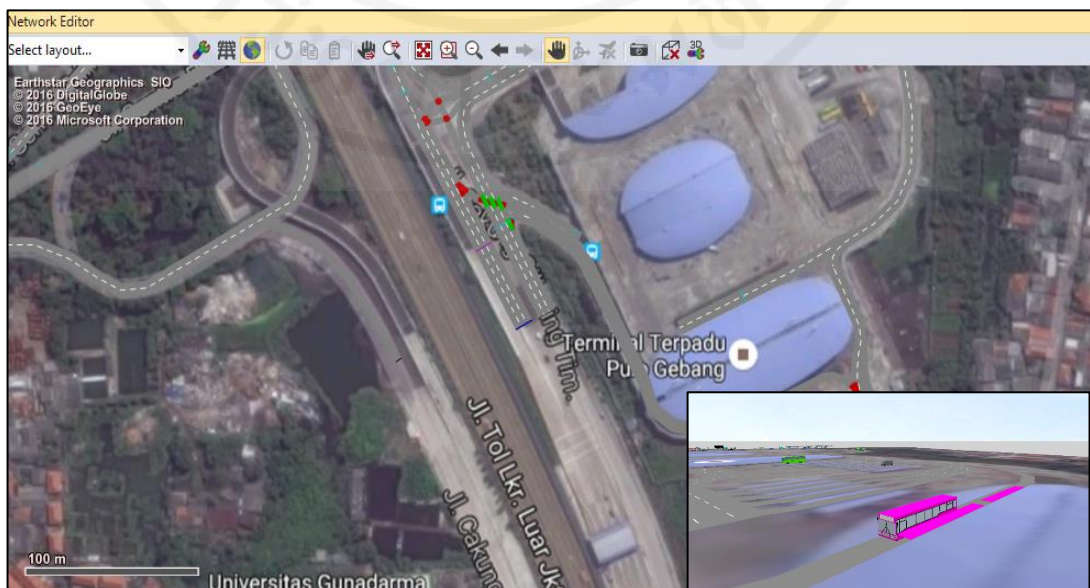


Figure 4.100. A part of simulated network of corridor 11

The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figures 4.101** and **4.102** show the comparison of arrival times during two peak periods.

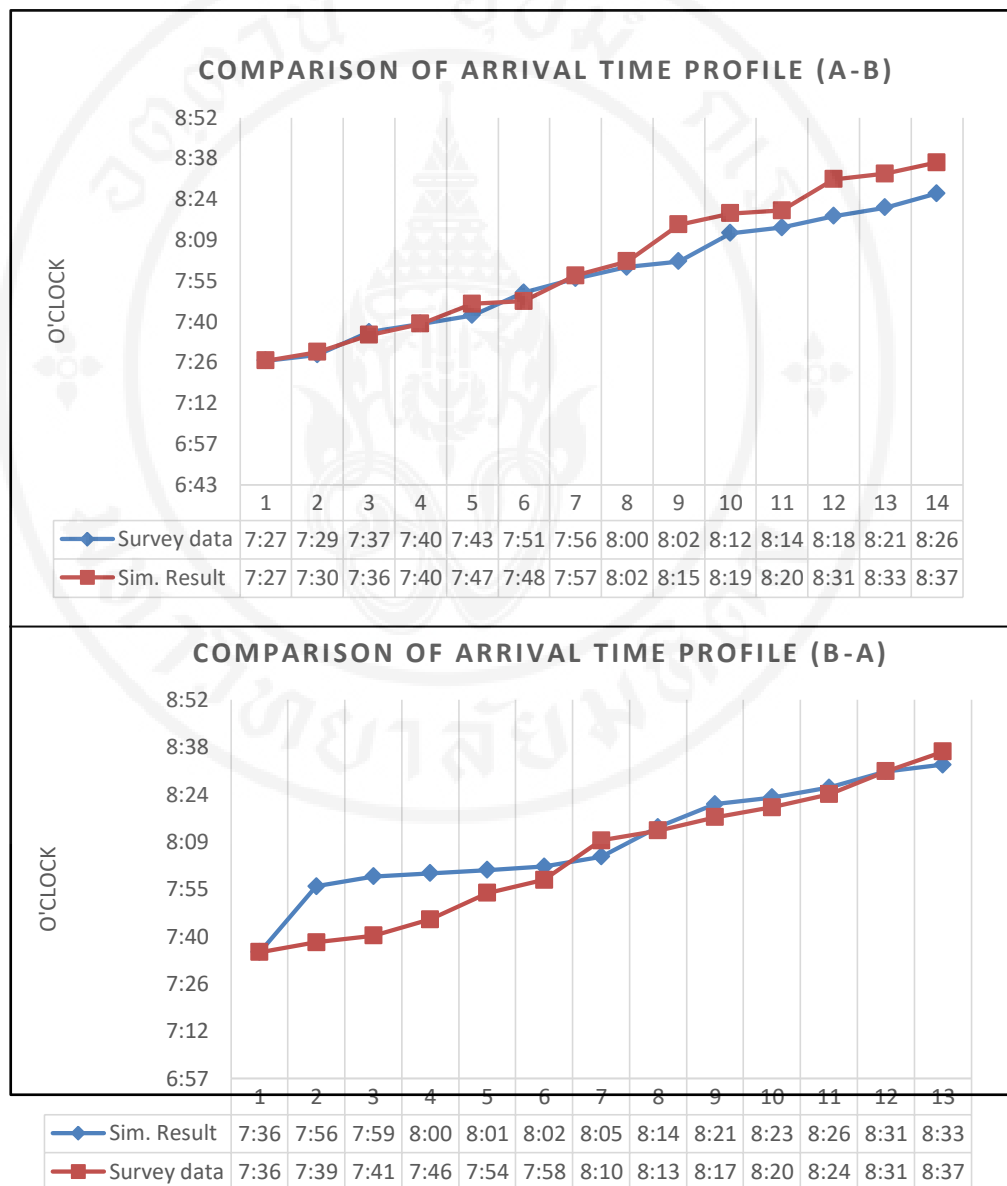


Figure 4.101 The comparison of arrival times for corridor 11 between actual and simulation results during morning-peak hour

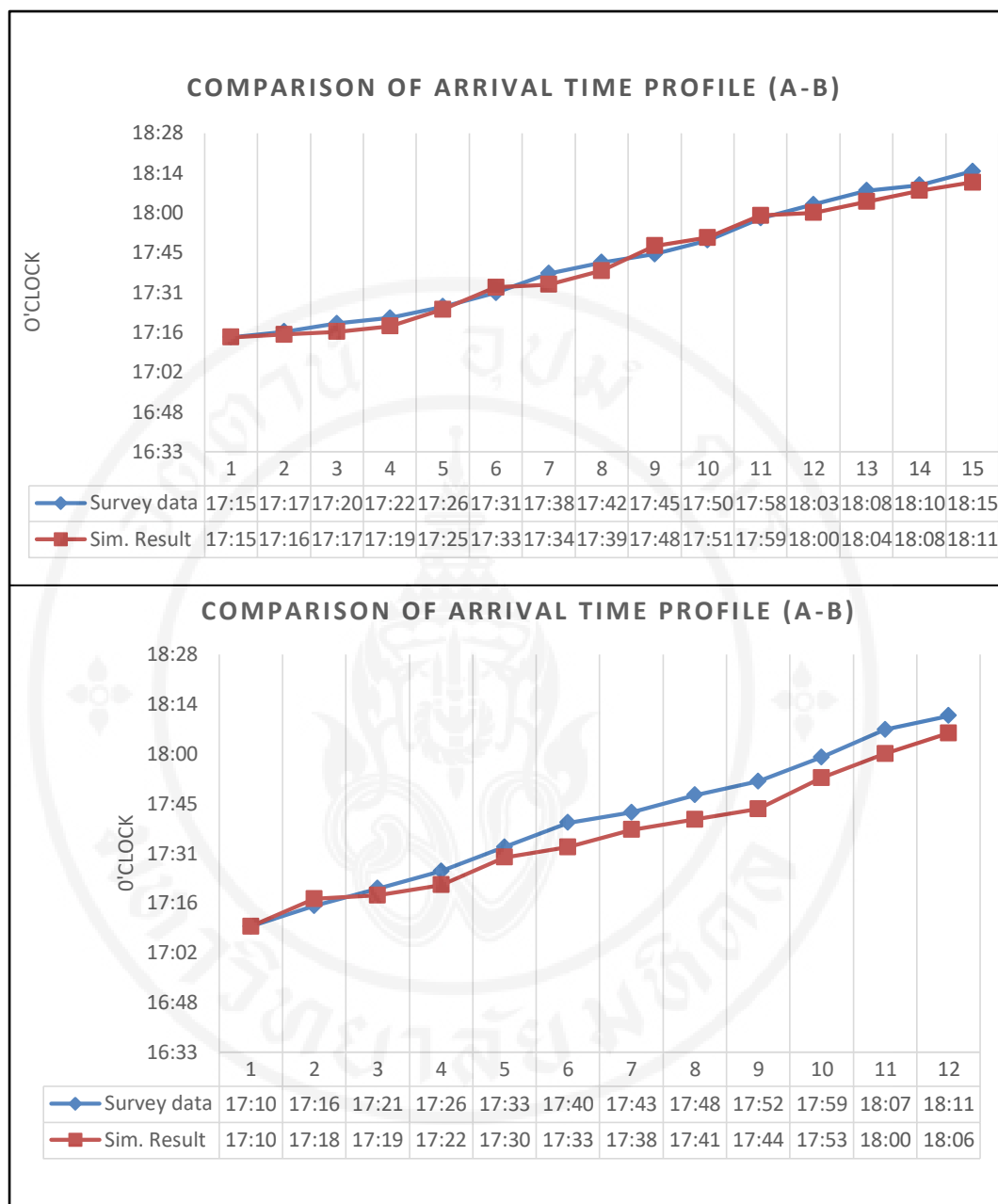


Figure 4.102 The comparison of arrival times for corridor 11 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.101** and **4.102** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 5 to 6 minutes during morning peak and 2 to 4 minutes during evening peak.

Figure 4.103 and **Figure 4.104** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.

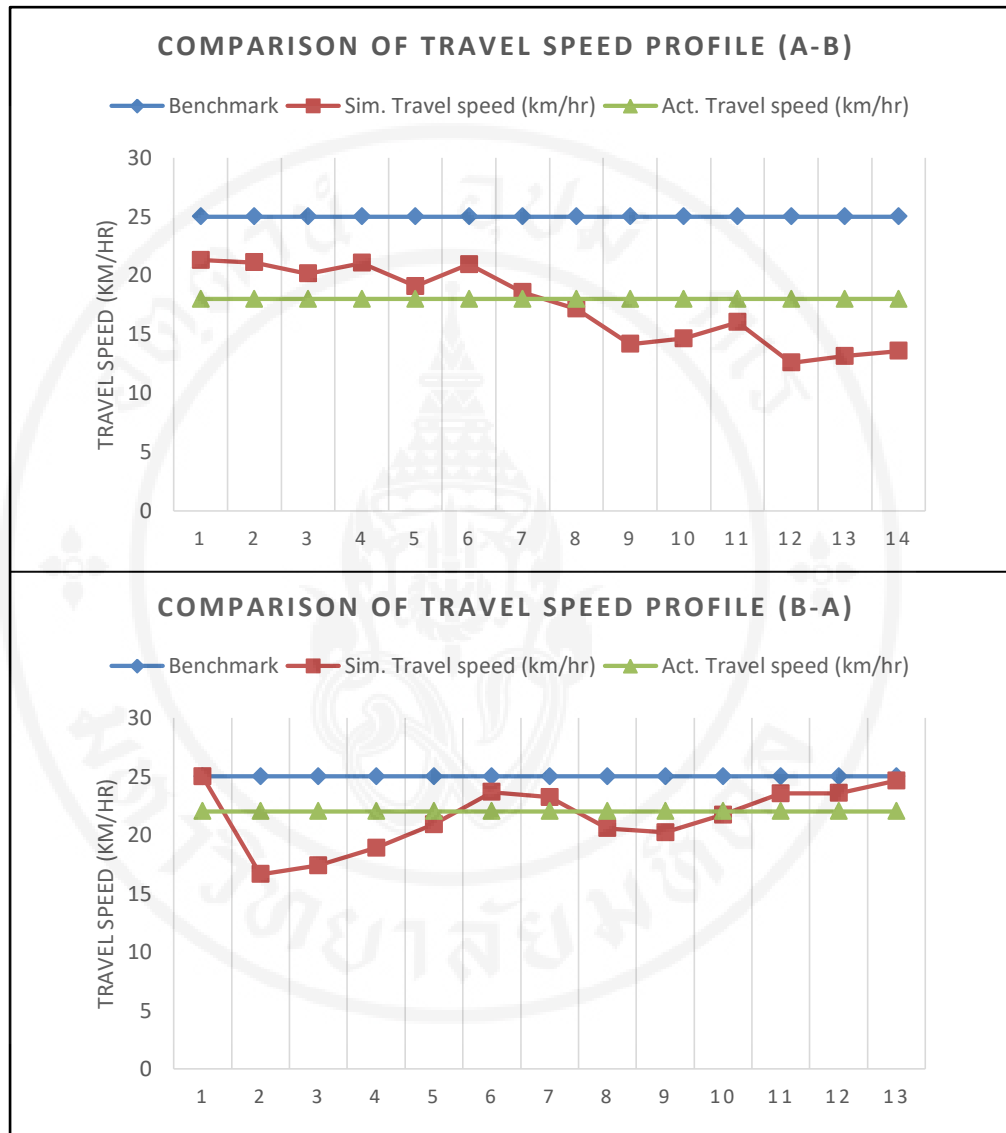


Figure 4.103 The comparison of travel speeds for corridor 11 between actual and simulation results, and the benchmark during morning-peak hour

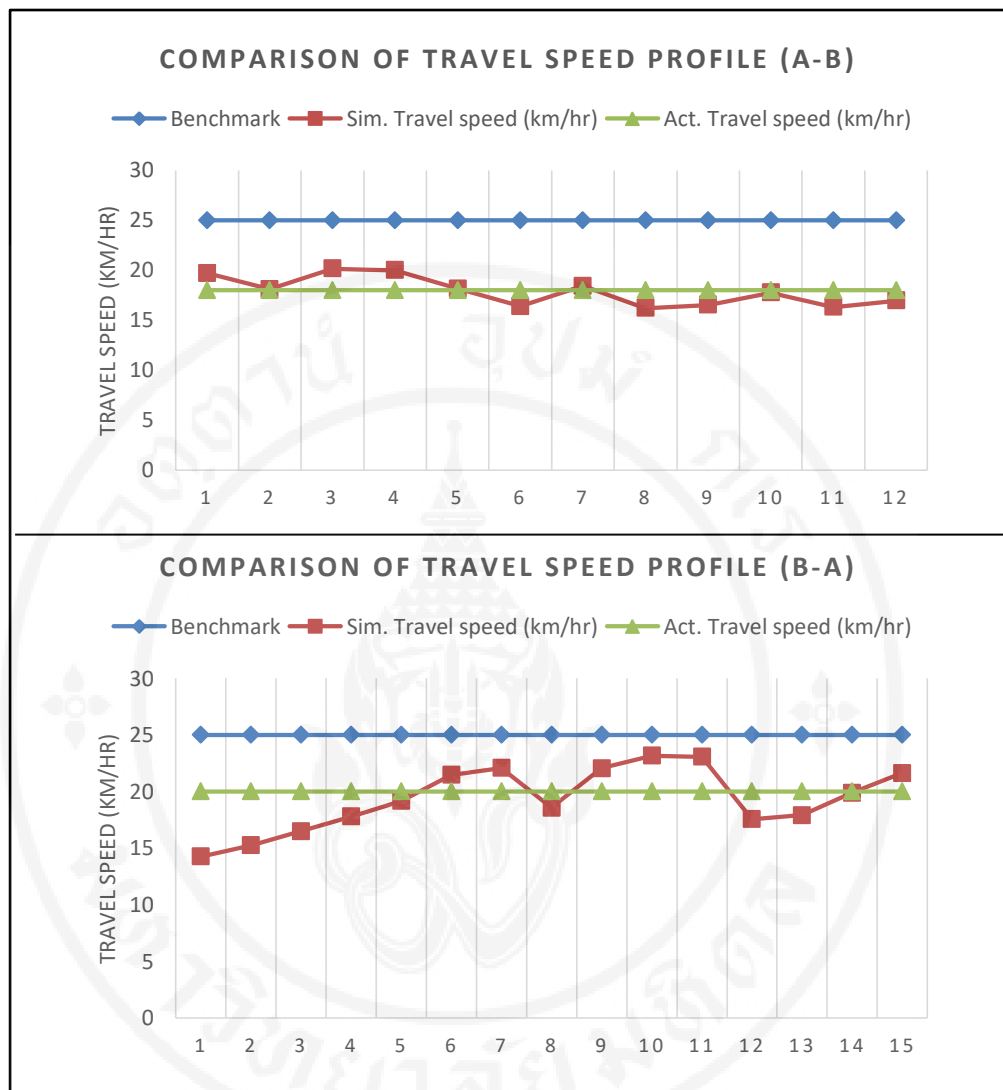


Figure 4.104 The comparison of travel speeds for corridor 11 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.53** and **4.54**, the final calibration shows 93% similarity of travel speeds during morning peak and 95% during evening peak between the actual and simulation results. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Table 4.130 for morning peak and Table 4.131 for evening peak. The difference between the average actual travel time and simulated travel time is +7% for the first direction (A-B) and

+6% for the second direction (B-A) during morning peak. Meanwhile, the difference during evening peak is -7% for the first direction and -4% for the second direction.

Table 4.130 Percentage differences between actual and simulated travel times for corridor 11 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	45	39	-13	35	31	-11
2	45	39	-13	35	47	+34
3	45	41	-9	35	45	+29
4	45	39	-13	35	42	+20
5	45	43	-4	35	38	+9
6	45	39	-13	35	33	-6
7	45	44	-2	35	34	-3
8	45	48	+7	35	38	+9
9	45	48	+7	35	39	+11
10	45	56	+24	35	36	+3
11	45	51	+13	35	33	-6
12	45	56	+24	35	33	-6
13	45	63	+40	35	32	-9
14	45	61	+36	-	-	-
$\bar{X}$	45	48	+7	35	37	+6

Table 4.131 Percentage differences between actual and simulated travel times for corridor 11 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	58	49	-16	46	46	0
2	58	44	-24	46	43	-7
3	58	46	-21	46	43	-7
4	58	47	-19	46	42	-9
5	58	49	-16	46	43	-7
6	58	69	+19	46	45	-2
7	58	64	+10	46	42	-9
8	58	59	+2	46	48	+4
9	58	54	-7	46	45	-2
10	58	58	0	46	46	0
11	58	53	-9	46	42	-9
12	-	-	-	46	45	-2
13	-	-	-	46	41	-11
$\bar{X}$	58	54	-7	46	44	-4

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. The Table 4.132 shows the positive ranks and negative ranks from the SPSS output.

Table 4.132 Wilcoxon Signed-Rank test for validating the simulation results of corridor 11

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time	Negative Ranks	7 ^a	5.00	35.00
- act_trav_time	Positive Ranks	7 ^b	10.00	70.00
	Ties	0 ^c		
	Total	14		
Direction (A-B) (evening peak)				
sim_trav_time	Negative Ranks	7 ^a	7.86	55.00
- act_trav_time	Positive Ranks	5 ^b	4.60	23.00
	Ties	0 ^c		
	Total	12		
Direction (B-A) (morning peak)				
sim_trav_time	Negative Ranks	6 ^a	5.00	30.00
- act_trav_time	Positive Ranks	7 ^b	8.71	61.00
	Ties	0 ^c		
	Total	13		
Direction (B-A) (evening peak)				
sim_trav_time	Negative Ranks	6 ^a	5.33	32.00
- act_trav_time	Positive Ranks	8 ^b	9.13	73.00
	Ties	1 ^c		
	Total	15		

Since, the sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak*: The sum of ranks for negative differences is $T_n = 35$; the sum of ranks for positive differences is $T_p = 70$. Thus, we have $t_0 = \min(T_p, T_n) = 35$. It shows that $n = 14$ observations, the critical value of t_0 is $T = 21$ with $\alpha = 0.05$. Because the value $T = 35$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak*: The sum of ranks for negative differences is $T_n = 55$; the sum of ranks for positive differences is $T_p = 23$. Thus, we have $t_0 = \min(T_p, T_n) = 23$. It shows that $n = 12$ observations, the critical value of t_0 is $T = 14$ with $\alpha = 0.05$. Because the value $T = 23$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak*: The sum of ranks for negative differences is $T_n = 30$; the sum of ranks for positive differences is $T_p = 61$. Thus, we have $t_0 = \min(T_p, T_n) = 30$. It shows that $n = 13$ observations, the critical value of t_0 is $T = 17$ with $\alpha = 0.05$. Because the value $T = 30$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak*: The sum of ranks for negative differences is $T_n = 32$; the sum of ranks for positive differences is $T_p = 73$. Thus, we have $t_0 = \min(T_p, T_n) = 32$. It shows that $(n - \text{ties}) = 15 - 1 = 14$ observations, the critical value of t_0 is $T = 21$ with $\alpha = 0.05$. Because the value $T = 32$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in a scenario. In the case of corridor 11, there is only one package of proposed strategies that is performed by scenario2; i.e., the mixed traffic restriction on links 3, 4, 5, 6, 8, 14, 15, and 16.1. Tables 4.133 and 4.134 show the comparison of travel time and travel speed among the scenarios for morning and evening peaks.

Table 4.133 The simulation result for scenarios of corridor 11 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	45	18	35	22	40	20
Scenario 2	32	26	26	26	29	26

Table 4.134 The simulation result for scenarios of corridor 11 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	48	17	39	20	44	19
Scenario 2	33	25	26	26	29	26

Based on the simulation results in Tables 4.133 and 4.134, the only proposed strategy which is scenario 2 showed the better result, as compared with the existing condition. The best average travel time that can be reached by scenario 2 during morning peak is 32 minutes for the first direction (A-B) and 26 minutes for the second direction (B-A). In the evening peak, the best average travel time is 33 minutes for the first direction (A-B) and 26 minutes for the second direction. The scenario 2 can perform better in terms of travel time and travel speed. As a recommendation, the

scenario 2 is an excellent strategy to enhance the operational performance of corridor 11.

4.4.12 Simulation results for corridor 12

In order to make it easy for identifying links and nodes in the network of corridor 12. **Figure A.12** in the appendix shows the network codification that consists of nodes (stations) and links (segments between stations).

a) Model validation

The development of simulation model for corridor 12 has been done, the visualization of a partial network is shown in **Figure 4.105**.

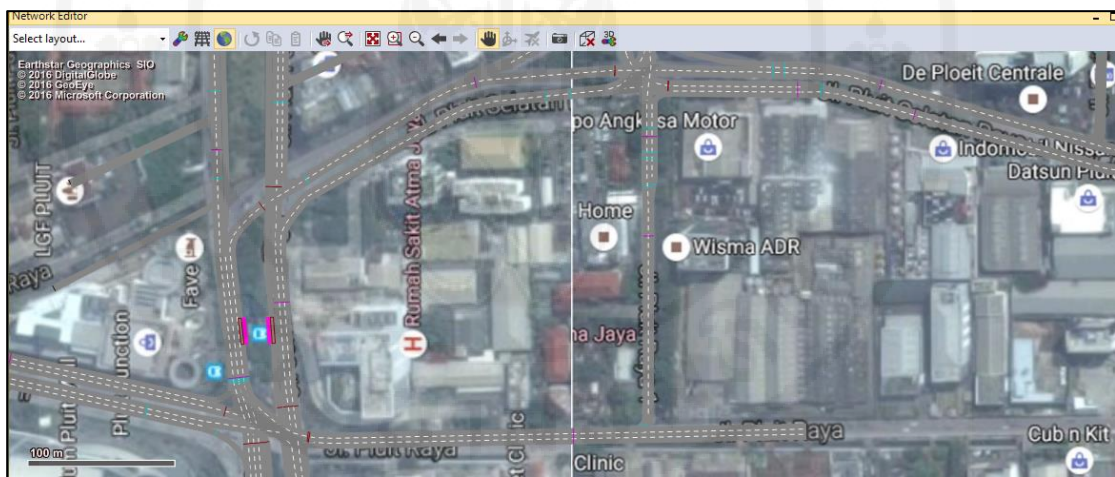


Figure 4.105. A part of simulated network of corridor 12

The model calibration has been done for 2 directions and for 2 peak periods. A statistical method of Wilcoxon Signed-Rank test is performed to validate the travel speed and travel time. The comparison of arrival time and travel speed between actual and simulation results is also performed and shown in the graph. **Figures 4.106** and **4.107** show the comparison of arrival times during two peak periods.

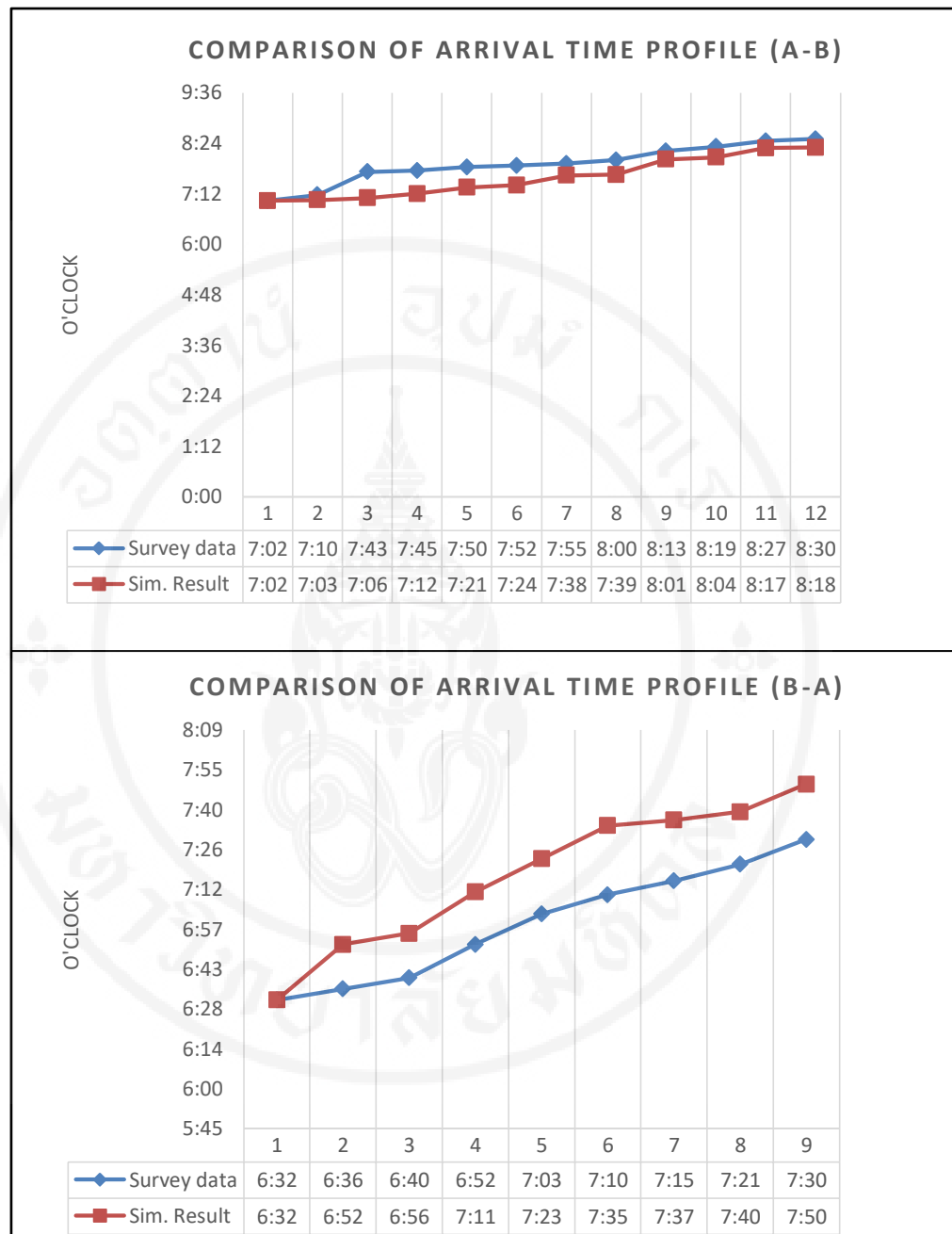


Figure 4.106 The comparison of arrival times for corridor 12 between actual and simulation results during morning-peak hour

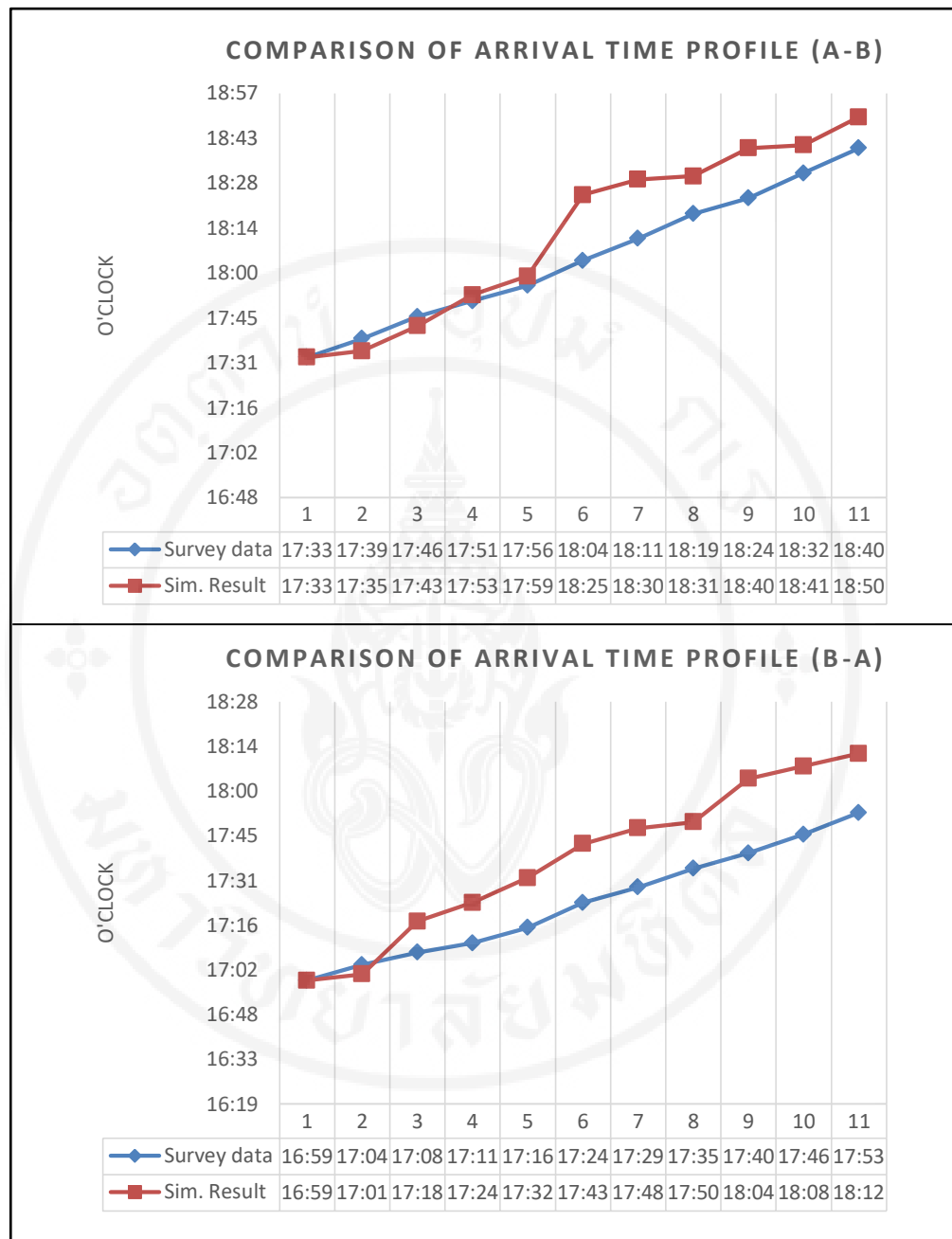


Figure 4.107 The comparison of arrival times for corridor 12 between actual and simulation results during evening-peak hour

The graphs in **Figures 4.106** and **4.107** show the similarity of arrival times between actual and simulation results. The gap of arrival time between actual and simulation results is around 15 to 18 minutes during morning peak and 9 to 14 minutes during evening peak.

Figure 4.108 and **Figure 4.109** show the comparison of travel speeds during morning-peak and evening-peak periods, respectively.

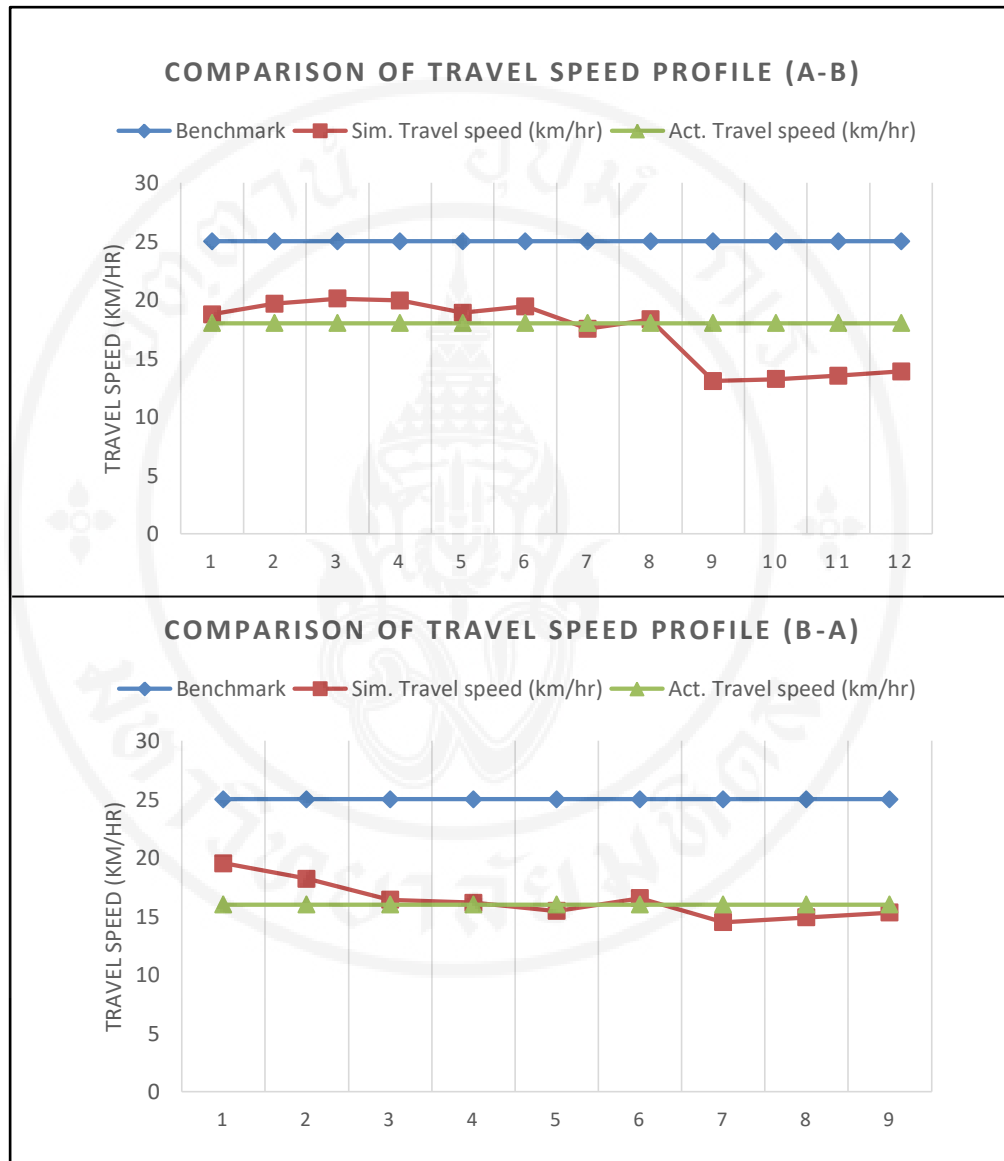


Figure 4.108 The comparison of travel speeds for corridor 12 between actual and simulation results, and the benchmark during morning-peak hour

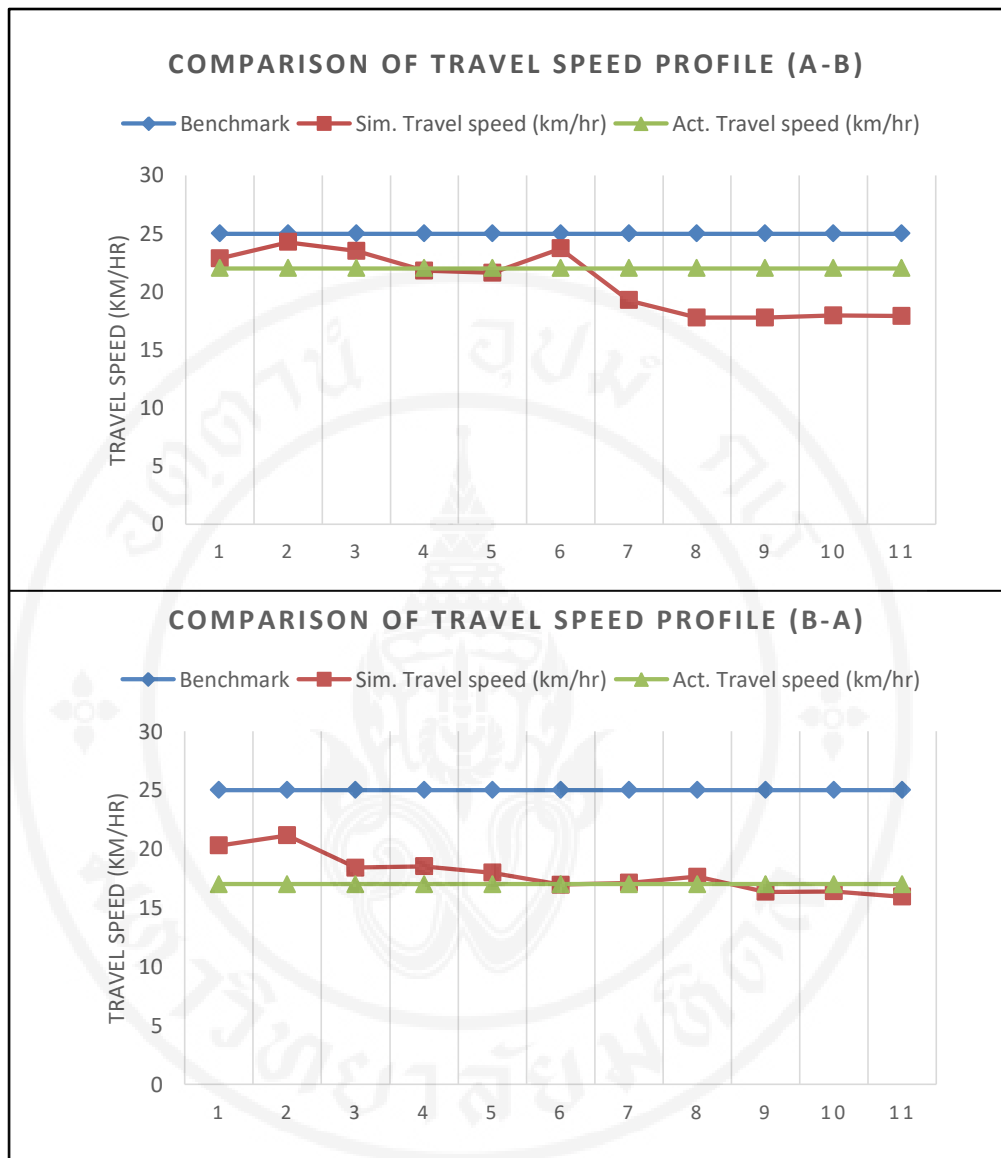


Figure 4.109 The comparison of travel speeds for corridor 12 between actual and simulation results, and the benchmark during evening-peak hour

In **Figures 4.108** and **4.109**, the final calibration shows 95% similarity of travel speeds during morning peak and 94% during evening peak between the actual and simulation results. Meanwhile, the benchmark of 25 kph is still above the actual travel speed.

In order to validate the model, the percentage differences between the actual travel time and simulated travel time are analyzed, as shown in Tables 4.135 and 4.136 for morning and evening peaks, respectively. The difference between the

average actual travel time and simulated travel time is +5% for the first direction (A-B) and no difference for the second direction (B-A) during morning peak. Meanwhile, the difference during evening peak is +6% for the first direction and -6% for the second direction.

Table 4.135 Percentage differences between actual and simulated travel times for corridor 12 during morning peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	84	82	-2	112	93	-17
2	84	79	-6	112	99	-12
3	84	77	-8	112	110	-2
4	84	77	-8	112	112	0
5	84	82	-2	112	117	+4
6	84	79	-6	112	109	-3
7	84	88	+5	112	125	+12
8	84	84	0	112	121	+8
9	84	98	+17	112	118	+5
10	84	107	+27	-	-	-
11	84	104	+24	-	-	-
12	84	101	+20	-	-	-
$\bar{X}$	84	88	+5	112	112	0

Table 4.136 Percentage differences between actual and simulated travel times for corridor 12 during evening peak

Bus no.	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)	Act. Travel time (mins)	Sim. Travel time (mins)	Difference (%)
Direction (A-B)				Direction (B-A)		
1	71	68	-4	108	89	-18
2	71	64	-10	108	86	-20
3	71	66	-7	108	98	-9
4	71	71	0	108	98	-9
5	71	71	0	108	101	-6
6	71	65	-8	108	107	-1
7	71	80	+13	108	106	-2
8	71	87	+23	108	103	-5
9	71	87	+23	108	111	+3
10	71	86	+21	108	111	+3
11	71	86	+21	108	114	+6
$\bar{X}$	71	75	+6	108	102	-6

In addition, the non-parametric statistical method, *Wilcoxon Signed-Rank test* is used to validate the simulation model by considering the travel time.

The null hypothesis is that two mean travel time of populations are identical, or

H_0 : Average actual travel time = average simulated travel time

Against the alternative hypothesis:

H_1 : Average actual travel time $\neq$ average simulated travel time

The significant level α 5% is adopted. The confidence interval is $1 - 0.05 = 0.95$ or 95%.

The hypothesis test was performed using the statistical software SPSS 17.0. The Table 4.137 shows the positive ranks and negative ranks from the SPSS output.

Table 4.137 Wilcoxon Signed-Rank test for validating the simulation results of corridor 12

		N	Mean Rank	Sum of Ranks
Direction (A-B) (morning peak)				
sim_trav_time	Negative Ranks	6 ^a	4.17	25.00
-				
act_trav_time	Positive Ranks	5 ^b	8.20	41.00
	Ties	1 ^c		
	Total	12		
Direction (A-B) (evening peak)				
sim_trav_time	Negative Ranks	4 ^a	2.50	10.00
-				
act_trav_time	Positive Ranks	5 ^b	7.00	35.00
	Ties	2 ^c		
	Total	11		
Direction (B-A) (morning peak)				
sim_trav_time	Negative Ranks	4 ^a	4.38	17.50
-				
act_trav_time	Positive Ranks	4 ^b	4.63	18.50
	Ties	1 ^c		
	Total	9		
Direction (B-A) (evening peak)				
sim_trav_time	Negative Ranks	8 ^a	6.63	53.00
-				
act_trav_time	Positive Ranks	3 ^b	4.33	13.00
	Ties	0 ^c		
	Total	11		

The sample size is small ($n \leq 15$), the normal distribution does not necessarily provide a good approximation to the distribution of “Z”. The hypothesis analysis is described as follows.

- *Direction (A-B), morning peak*: The sum of ranks for negative differences is $T_n = 25$; the sum of ranks for positive differences is $T_p = 41$. Thus, we have $t_0 = \min(T_p, T_n) = 25$. It shows that (n-ties) = 12-1 = 11 observations, the critical value of t_0 is $T = 11$ with $\alpha = 0.05$. Because the value $T = 25$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (A-B), evening peak*: The sum of ranks for negative differences is $T_n = 10$; the sum of ranks for positive differences is $T_p = 35$. Thus, we have $t_0 = \min(T_p, T_n) = 10$. It shows that (n-ties) = 11-2 = 9 observations, the critical value of t_0 is $T = 6$ with $\alpha = 0.05$. Because the value $T = 10$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), morning peak*: The sum of ranks for negative differences is $T_n = 17.5$; the sum of ranks for positive differences is $T_p = 18.5$. Thus, we have $t_0 = \min(T_p, T_n) = 17.5$. It shows that (n-ties) = 9-1 = 8 observations, the critical value of t_0 is $T = 4$ with $\alpha = 0.05$. Because the value $T = 17.5$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.
- *Direction (B-A), evening peak*: The sum of ranks for negative differences is $T_n = 53$; the sum of ranks for positive differences is $T_p = 13$. Thus, we have $t_0 = \min(T_p, T_n) = 13$. It shows that $n = 11$ observations, the critical value of t_0 is $T = 11$ with $\alpha = 0.05$. Because the value $T = 13$ exceeds the critical value, there is not enough evidence to refuse the null hypothesis. It means that both travel times are equal statistically.

Both simulation results for the two peak periods have been validated. It means that the simulation model is ready to be used for the assessment of proposed strategies.

b) The assessment: Running on scenario

The assessment is performed by using simulation in several scenarios. In the case of corridor 12, there are 4 scenarios as follows:

- Scenario 1: The existing condition
- Scenario 2: Implement signal priority and mixed-traffic restriction on links 1.2, 1.3, 2, 3, 8.2, 9.1, 9.2, 15.2, 16, 17, 18, 19.1, 21, 22, 24, and 25
- Scenario 3: Install the extra platform / passing lane / separator at stations XII-1, XII-2, XII-5, XII-6, XII-9, XII-10, XII-11, XII-12, XII-13, XII-15, XII-16, XII-17, XII-18, and XII-19
- Combination: Conducting scenarios 2 and 3

All scenarios have been run on simulation, the following Tables 4.138 and 4.139 show the comparison of travel time and travel speed among the scenario for morning and evening peaks respectively.

Table 4.138 Simulation results by scenario for corridor 12 (morning peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	84	18	112	16	98	17
Scenario 2	56	28	78	23	67	26
Scenario 3	84	18	100	18	92	18
Combination	56	28	78	24	67	26

Table 4.139 Simulation results by scenario for corridor 12 (evening peak)

Result	Direction (A-B)		Direction (B-A)		Both directions	
	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)	Average Travel Time (mins)	Average Travel Speed (km/hr)
Scenario 1	71	22	108	17	90	20
Scenario 2	58	27	76	24	67	25
Scenario 3	70	22	98	18	84	20
Combination	57	27	73	25	65	26

Based on the simulation results in Table 4.138, the best average travel time that can be reached during morning peak is 56 minutes; i.e., scenario 2 and combination for the first direction (A-B) and 78 minutes; i.e., scenario 2 and combination for the second direction (B-A). Refer to Table 4.139, the best travel time that can be reached during evening peak is 57 minutes; i.e., combination for the first direction (A-B) and 73 minutes; i.e., combination for the second direction (B-A). The scenario combination showed the excellent average travel speed of 26 kph during both morning and evening peaks.

4.5 Summary

The study to enhance the performance of TransJakarta has been done. They consist of the performance evaluation, problem identification, and proposing strategies. The final recommendation for each corridor has been drawn. In order to get the general figure of TransJakarta, this section shows the summary of the performance evaluation, problem identification, and proposed strategies for all corridors.

4.5.1 Performance evaluation results

The performance has been analyzed corridor by corridor in detail. The average travel speed and load factor can be seen in Table 4.66. Table 4.140 shows the summary of travel speed of each corridor by direction. As mentioned before, there is no single corridor which can reach the minimum standard travel speed of 25 kph as the rapid transit system.

Table 4.140 Summary of average travel speed by corridor by direction

Corridor	Morning peak		Evening peak	
	Direction A-B (kph)	Direction B-A (kph)	Direction A-B (kph)	Direction B-A (kph)
Corridor 1	14	18	14	18
Corridor 2	13	14	12	15
Corridor 3	10	18	12	14
Corridor 4	17	16	17	17
Corridor 5	14	16	16	18
Corridor 6	18	16	18	18
Corridor 7	15	20	15	19
Corridor 8	18	21	18	21
Corridor 9	15	18	15	18
Corridor 10	19	22	18	20
Corridor 11	18	22	17	20
Corridor 12	18	16	22	17

Table 4.141 shows the average waiting time by corridor. There are 5 corridors that have average waiting time over the acceptable 5 minutes. Note that the waiting time reliability requires that more than 85% of passengers must have the waiting time within 5 minutes in the peak period. The analysis shows that there are 9 corridors which failed.

Table 4.141 Summary of average waiting time by corridor by direction

Corridor	Morning peak		Evening peak	
	A-B (mins)	B-A (mins)	A-B (mins)	B-A (mins)
Corridor 1	4	5	4	5
Corridor 2	6	9	4	7
Corridor 3	3	7	4	5
Corridor 4	4	5	4	5
Corridor 5	11	4	6	3
Corridor 6	4	11	4	9
Corridor 7	4	3	4	4
Corridor 8	5	13	4	7
Corridor 9	15	7	14	8
Corridor 10	4	4	4	4
Corridor 11	3	3	2	3
Corridor 12	7	4	4	4

Table 4.142 shows the trip realization of all corridors during peak-hour by direction. The standard of transit system requires at least 98% of all assigned trips be executed. As analyzed before, nine of twelve corridors failed to execute all assigned trips during peak-hours.

Table 4.142 Summary of trip realization by corridor by direction

Corridor	Direction A-B	Direction B-A
Corridor 1	100%	81%
Corridor 2	77%	65%
Corridor 3	100%	69%
Corridor 4	92%	77%
Corridor 5	69%	92%
Corridor 6	96%	96%
Corridor 7	100%	100%
Corridor 8	81%	65%
Corridor 9	100%	100%
Corridor 10	100%	81%
Corridor 11	100%	112%
Corridor 12	81%	92%

Table 4.143 shows the punctuality of all corridors by direction. The standard rapid transit system requires that at least 85% of trips must arrive on schedule. Based on the observation in peak period, there is no single corridor that can fulfill the standard requirement.

Table 4.143 Summary of punctuality by corridor by direction

Corridor	A-B		B-A	
	Start	Finish	Start	Finish
Corridor 1	73%	38%	14%	62%
Corridor 2	70%	13%	47%	50%
Corridor 3	96%	44%	28%	70%
Corridor 4	75%	10%	25%	17%
Corridor 5	0%	79%	88%	11%
Corridor 6	48%	52%	24%	89%
Corridor 7	46%	65%	73%	73%
Corridor 8	43%	12%	47%	71%
Corridor 9	71%	29%	79%	64%
Corridor 10	81%	43%	33%	70%
Corridor 11	81%	97%	34%	44%
Corridor 12	37%	8%	22%	48%

Table 4.144 shows the average headway. At least 85% of arrival busses must be within the planned headway. Based on the observation, only corridor 9 can perform up to the standard. The remaining corridors failed. Overall, the performance of TransJakarta needs to be improved to the ideal BRT level.

Table 4.144 Summary of average headway by corridor by direction

Corridor	Planned H (mins)	Morning peak		Evening peak	
		First station (mins)	Last station (mins)	First station (mins)	Last station (mins)
Corridor 1	5	4	5	5	6
Corridor 2	5	6	10	5	7
Corridor 3	5	4	7	5	7
Corridor 4	5	5	6	5	6
Corridor 5	5	9	5	6	5
Corridor 6	5	5	4	5	5
Corridor 7	5	5	4	5	5
Corridor 8	5	6	8	6	7
Corridor 9	10	10	10	10	9
Corridor 10	5	4	6	5	6
Corridor 11	5	4	4	4	4
Corridor 12	5	6	5	5	5

4.5.2 Problems identification

The problem identification was analyzed based on the framework which is shown in the **Figure 3.6**. In summary, various corridors experienced different problems, as described below.

- Corridor 1 faces the problem in terms of operational, network, and infrastructure aspects.
- Corridor 2 faces the problem in terms of network and infrastructure aspects.
- Corridor 3 faces the problem in terms of network and infrastructure aspects.
- Corridor 4 faces the problem in terms of operational, network, and infrastructure aspects.

- Corridor 5 faces the problem in terms of network and infrastructure aspects.
- Corridor 6 faces the problem in terms of operational, network, and infrastructure aspects.
- Corridor 7 faces the problem in terms of operational, network, and infrastructure aspects.
- Corridor 8 faces the problem in terms of network and infrastructure aspects.
- Corridor 9 faces the problem in terms of operational, network, and infrastructure aspects.
- Corridor 10 faces the problem in terms of network and infrastructure aspects.
- Corridor 11 faces the problem in terms of network problem.
- Corridor 12 faces the problem in terms of network and infrastructure aspects.

Overall, five corridors face the operational problem, all corridors face the network problem, and eleven corridors face the infrastructure problem.

4.5.3 Recommendations

Following the framework in the **Figure 3.6**, the necessary strategies have been simulated both individually and combination. Then, the final recommendations have been drawn. The recommended enhancing strategies are summarized by corridor below.

- Corridor 1: Increase trip frequency and implement mixed-traffic restriction
- Corridor 2: Implement mixed-traffic restriction and station improvement
- Corridor 3: Implement mixed-traffic restriction and station improvement
- Corridor 4: Increase trip frequency, implement mixed-traffic restriction, and station improvement

- Corridor 5: Implement mixed-traffic restriction and station improvement
- Corridor 6: Increase trip frequency and implement mixed-traffic restriction
- Corridor 7: Increase trip frequency, implement mixed-traffic restriction, and station improvement
- Corridor 8: Implement mixed-traffic restriction and station improvement
- Corridor 9: Increase trip frequency, implement mixed-traffic restriction, and station improvement
- Corridor 10: Implement mixed-traffic restriction and station improvement
- Corridor 11: Implement mixed-traffic restriction
- Corridor 12: Implement mixed-traffic restriction and station improvement

Based on the simulation results, the average time saving that can be gained by implementing the recommended strategies is summarized by corridor in **Figure 4.110**.

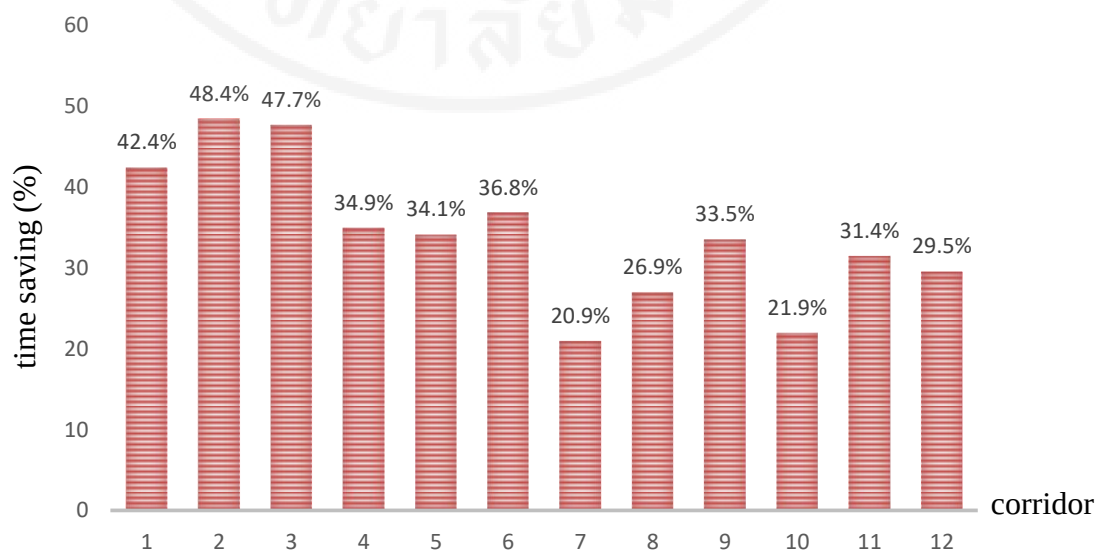


Figure 4.110 The average time saving by corridor after recommendation

All achieved saving times lead the travel speed up to standard of 25 kph in operation. The time saving of approximately 50% can be gained by corridors 1, 2, and 3. Meanwhile the significant time saving can be gained for remaining corridors. The detailed modification in network and infrastructure aspects can be seen in Tables B.1 to B.12 in Appendix B. Finally, improving TransJakarta's performance can be realized by conducting the enhancement in operational, network, and infrastructure aspects. Its performance can be in line with the standard of rapid transit system.

4.5.4 Time saving effects

This study has simulated the recommendation in 3 aspects; i.e., operational, network, and infrastructure. They have also been simulated simultaneously. The time saving are different across aspects. Each corridor has different characteristics and problems. The time saving effects by conducting the enhancement in operational aspect are summarized in **Figure 4.111**.

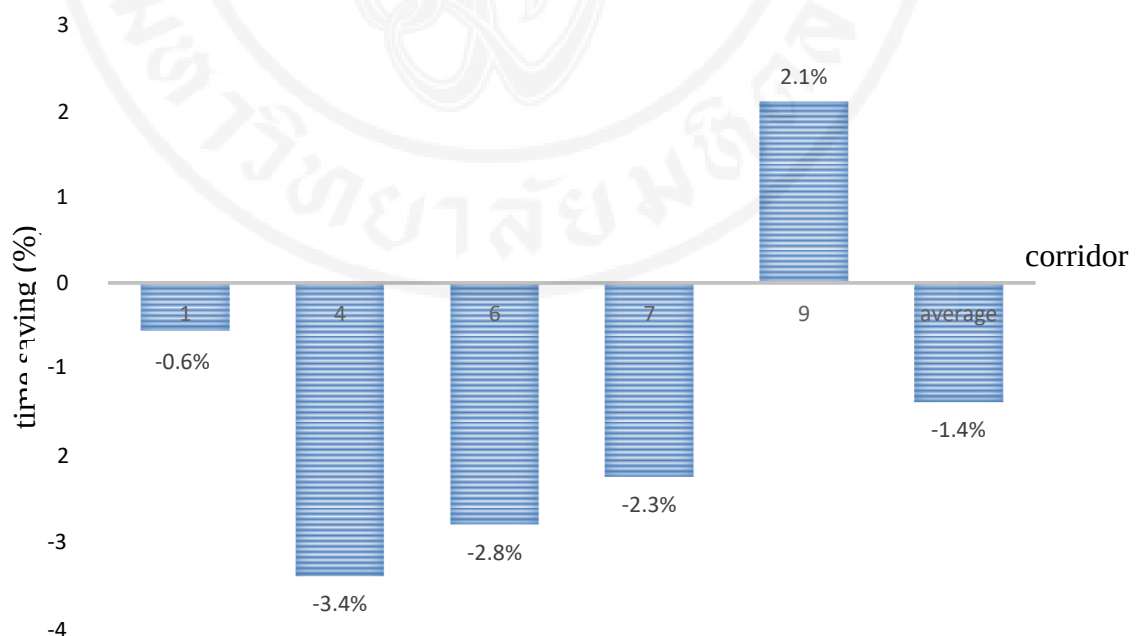


Figure 4.111 Time saving effects from operational strategy

The strategy in operational aspect is proposed for 5 corridors; i.e., corridors 1, 4, 6, 7, and 9. Most corridors experienced poor travel time. These bad

effects occurred because the involved corridors lack infrastructure and experience network delay. The increasing trip frequency to satisfy the operation demand has to be supported with sufficient infrastructure and network capacities.

The time saving effects by simulating the enhancement in network aspect are summarized in **Figure 4.112**. The strategy in network aspect is proposed for 11 corridors. The time saving is quite significant by giving the priority in network. The time saving of close to 50% is achieved by corridors 1, 2, and 3. Giving priority to BRT movement in network is the best option and crucial key to reach the standard performance as required to be the rapid transit system.

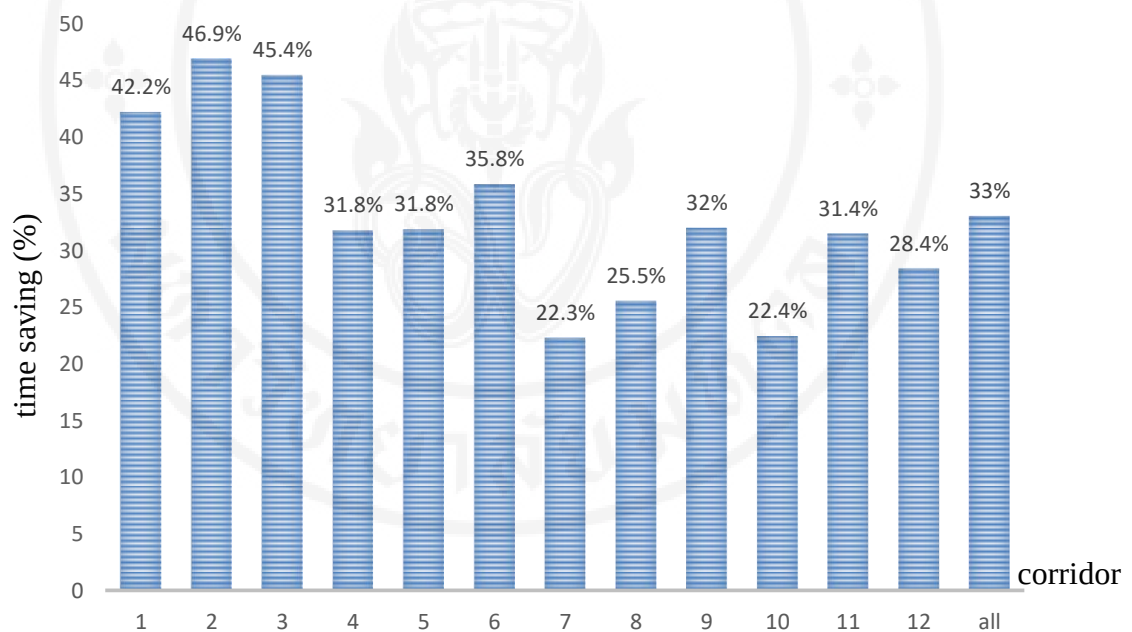


Figure 4.112 Time saving effects from network strategy

The time saving effects by simulating the enhancement in infrastructure aspect are summarized in **Figure 4.113**. The strategy in infrastructure aspect also contributed to time savings. Increasing station capacity is conducted to avoid bus queue at the station. It shortens the dwelling time for bus. Corridor 6 achieved 33% of time saving by simulating strategy in infrastructure aspect. Simulating strategy

simultaneously in all aspects is one of the recommendation options for corridors 1, 4, 6, 7, and 9.

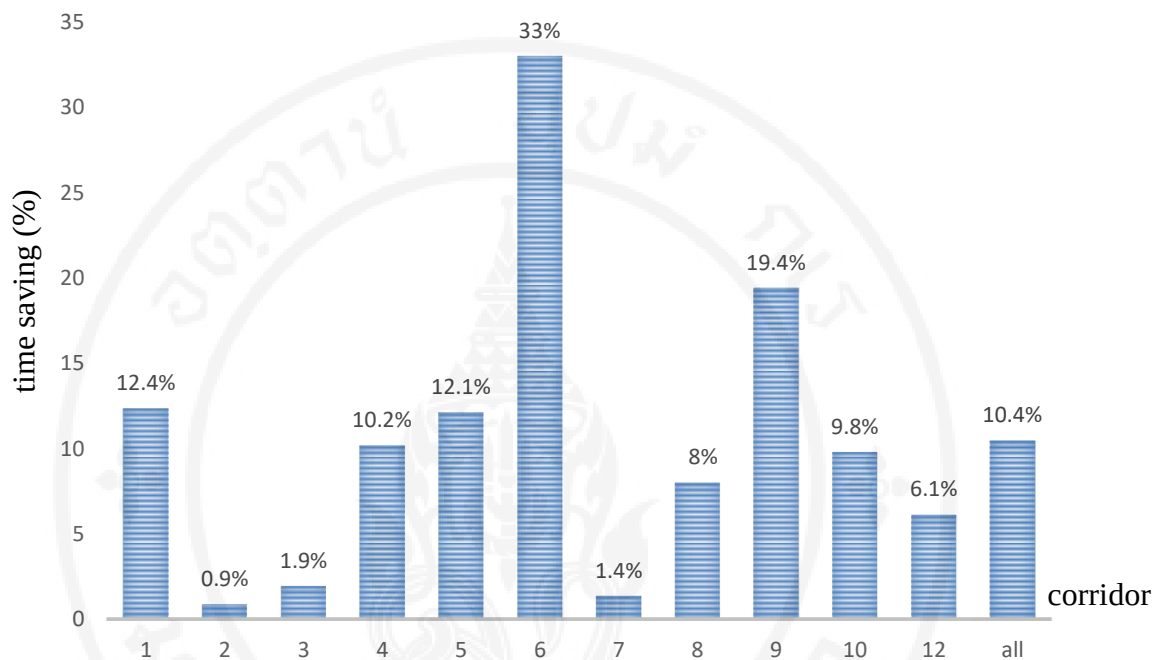


Figure 4.113 Time saving effects from infrastructure strategy

The time saving effects by simulating strategy in all aspects are summarized in **Figure 4.114**. A significant time saving is achieved by all corridors which get them to the standard performance of rapid transit system. The operational strategy is conducted in order to satisfy the demand, then it must be supported by the sufficient infrastructure capacity and priority on its movement in network.

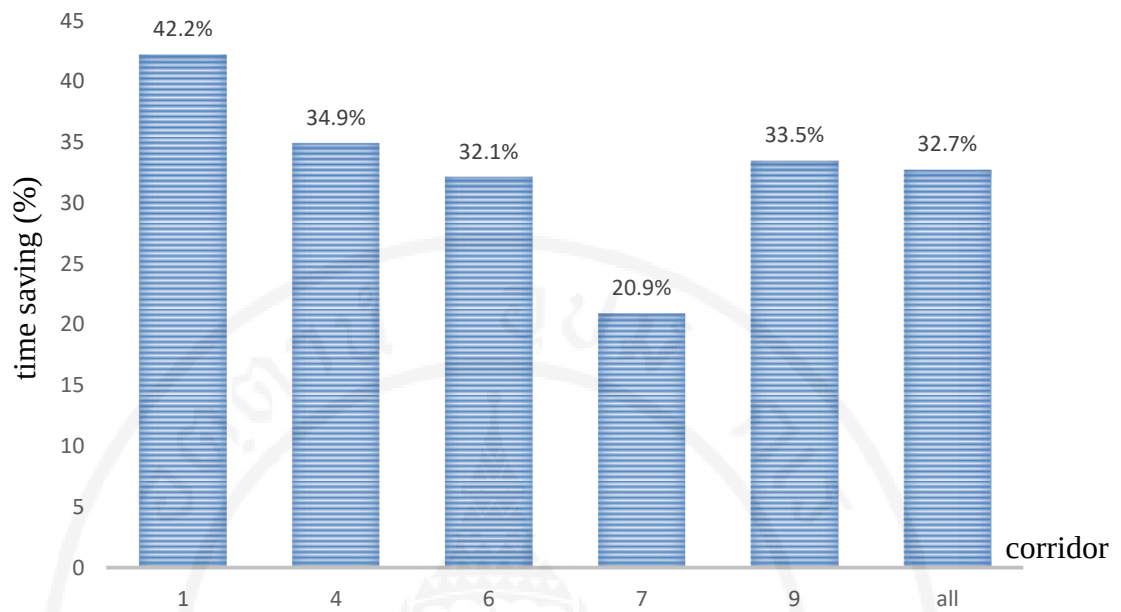


Figure 4.114 Time saving effects from the combination of all strategies

CHAPTER V

CONCLUSIONS

This research sets two following objectives; i.e., to study the physical and operational characteristics of Bus Rapid Transit System in Jakarta and Bangkok and to improve the performance of TransJakarta by proposing suitable strategies. As started with objectives and research questions in the first chapter, this section answers the research questions and draws the conclusion of this study.

5.1 Characteristics of TransJakarta and Bangkok BRT

As analysis, the characteristics refer to the standard features of a full BRT system. The required features lead BRT to the ideal system as public rapid transit. TransJakarta still needs 6 more features which are necessary to be fulfilled. Meanwhile, Bangkok BRT needs 4 features. The 2 features (integrated route and terminal) cannot be fulfilled by the current system of Bangkok BRT due to insufficient network. Both systems are more than half way to be qualified as the ideal BRT system. However, the extending network is important for Bangkok BRT. The priority on the link and grade separation at intersection are necessary to be conducted perfectly for both TransJakarta and Bangkok BRT systems in order to optimize the system into the full BRT system. The remaining standard features such as integrated routes, enhanced station, self-financing, GPS usage, ridership, and facilities for the disable are necessary to be improved as well.

Furthermore, the big difference in terms of physical characteristics between TransJakarta and Bangkok BRT is the vehicle type. As mentioned before, the high capacity of articulated bus is generally used by TransJakarta, whereas the low capacity of small bus is used by Bangkok BRT. Overall, the maximum capacity of the current Bangkok BRT system can accommodate 26,438 passengers/day, while the actual daily demand is about 15,000 passengers in 2016 which is 0.06% of all daily

trips within and around Bangkok Metropolitan Area. On the other hand, the big system of TransJakarta can accommodate 756,570 passengers/day, while the actual daily demand is about 319,351 passengers in 2016 which is 0.66% of all daily trips within and around Jakarta Metropolitan City. However, the current ridership of TransJakarta system is still below the system capacity due to delays. TransJakarta faces severe delay in the operational and network aspects. Even though, the TransJakarta's fleet movement is more protected than Bangkok BRT, but the travel speed of TransJakarta is still below the standard of 25 km/hour, whereas the lone corridor of Bangkok BRT can reach 28 km/hour. The complicated problem of TransJakarta must be identified in order to maximize its capacity. This is the second objective of this research.

5.2 Enhancement of TransJakarta

As mentioned before, there are 319,351 daily passengers that must be served by TransJakarta with the acceptable load factor. The current system of TransJakarta actually has sufficient capacity to accommodate the daily demand, but the ridership cannot perform optimally due to the severe delay. In terms of travel time and travel speed as the main performance indicators, there is no single corridor of the 12 corridors that has average travel speed up to the standard of 25 kph as the rapid transit system. On the other hand, the service reliability is expressed by 6 parameters; i.e., waiting time, trip realization, load factor, punctuality, safety, and regularity. The study found that TransJakarta can fulfill 36 % of the service reliability standards.

The problem with TransJakarta is categorized into three aspects; i.e., operational, network, and infrastructure aspects. The study found that 5 corridors face the operational problem, 11 corridors lack of infrastructure, and all corridors face the delay in the network. The network problem is mostly faced by all the corridors, mostly because of mixed-traffic on the opened lane. The unnecessary queue of buses is still occurring in the integrated stations. The longest queue occurs at Harmoni and Dukuh Atas stations. Therefore, the proposed strategies have been assessed by the simulation.

Based on analysis and simulation results, the increasing trip frequency is recommended for corridors 1, 4, 6, and 9. In order to give the priority in the network, the signal priority and the mixed-traffic restriction are recommended for all corridors.

In order to avoid the delay at the station, the physical improvement is highly recommended for corridors 2, 3, 4, 5, 7, 8, 9, 10, and 12. The station is necessary to be improved by installing the extra platform and protected passing lane. Generally, conducting those strategies gives different effects on travel time savings both in individually or simultaneously. **Figure 5.1** shows the average time saving among the strategies which are categorized by 3 aspects; i.e., operational, network, and infrastructure aspects based on the simulation results of all corridors.

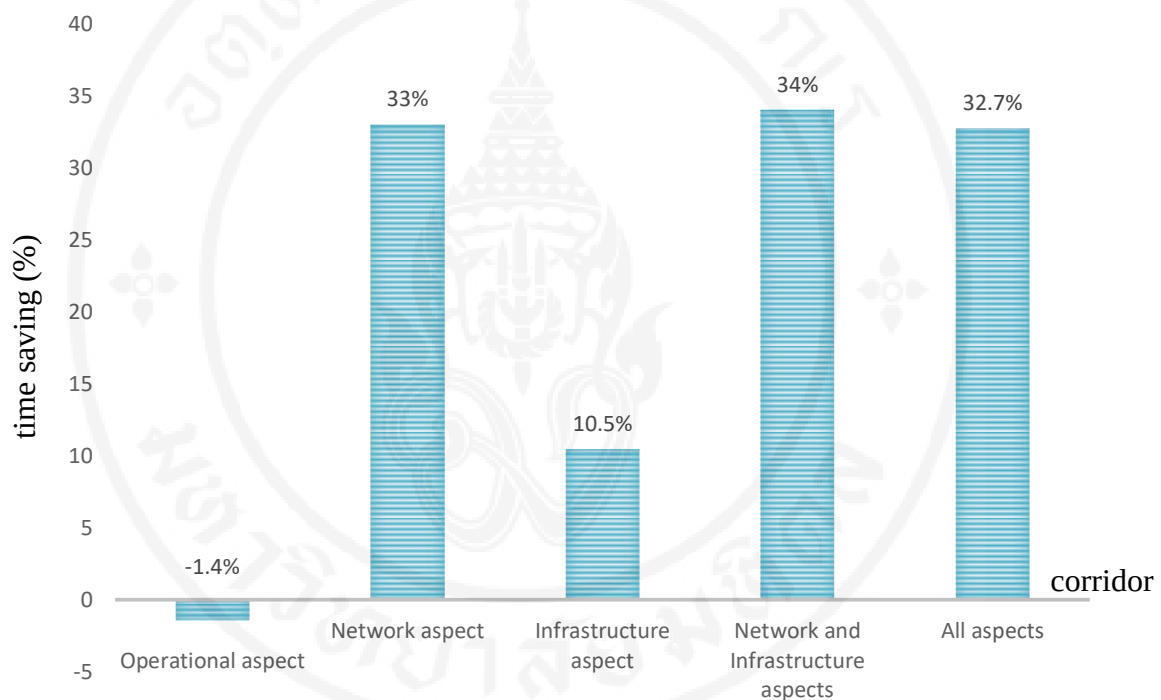


Figure 5.1 Comparison of time savings among the strategies on various aspects

The strategies in network and infrastructure aspects become the best option for decreasing travel time on 12 corridors of TransJakarta. By only conducting the mixed-traffic restriction in the network, 33% of time saving can be gained. In terms of operational aspect, the supply must accommodate the demand with the acceptable load factor. On the contrary, by only increasing trip frequency (operational aspect) gives negative effect in operation if there is a lack of infrastructure and delay in the network. The high trip frequency must be supported by the enhanced station and busway, together with the priority in the network. As shown in the **Figure 5.1**, the enhancement of all aspects (32.7%) simultaneously has lower time saving than the enhancement in the network and infrastructure aspects (34.0%) with the gap of 1.3%.

However, the gap is still acceptable as long as the demand can be satisfied by the suitable trip frequency. Hence, the increasing trip frequency in operation is the top priority for corridors with inadequate capacity. Most corridors are recommended to be enhanced in the network and infrastructure aspects.

5.3 Recommended future research

The simulation has been done in this study by using VISSIM 8 licensed to Transportation, Traffic, and Logistics EXpert Center (T-LEX). The license has no limitation in terms of network, but there is a limitation on the number of pedestrians. The number of pedestrians cannot exceed 30. The problem came into the passenger distribution. The simulation program considers the alighting and waiting passengers as the pedestrians. However, the number of pedestrians is limited to only 30. It affects the dwelling time which is an important factor to determine the travel time in the simulation. The best solution is to integrate VISSIM with the VISWALK program to get the unlimited number of pedestrians. Another solution which has been taken by this study is to calculate the dwelling time based on dummy alighting passengers. It means the boarding passenger is considered as the alighting passenger. The purpose is to avoid the waiting passenger on the station because the alighting passenger will disappear from network immediately after get off the bus. This condition will minimize the excessive number of pedestrians in the simulation network. As for the future research, the program VISSIM might be perfect if it is integrated with the VISWALK program in terms of public transport simulation. This study deals with the biggest BRT system in the world. Hence, the number of passengers is very large. The passenger distribution must be considered very carefully.

Furthermore, the simulation study in terms of network size is interesting to be conducted. In this study, the calibration and validation of simulation model is developed corridor by corridor. The calibration and validation might face the different challenge if it is developed on a larger network, such as two or more corridors in one simulation model. As mentioned before, TransJakarta is the biggest BRT system in the world. The recent study deals with the characteristics and performances of TransJakarta with the base year data of 2015 – 2016. As the recent time, the expansion

of TransJakarta has been run by the Local Government of Jakarta. In addition, the Mass Rapid Transit (MRT) has been developing in 2016 – 2020 in Jakarta City. The integration between the two rapid transit systems must be in the consideration by the transportation planner. In order to support the MRT system, TransJakarta has to be assured as the reliable public transit system. The study about characteristics, problem, and suitable strategy for TransJakarta has been carried out. The method and results of this study can be one of the base consideration for the expanding TransJakarta. Furthermore, the impact of the expanding BRT and MRT systems in Jakarta on the mixed-traffic can be a good topic for future research. The study should be very useful for the traffic engineering management.

In terms of data management, the data collection system of TransJakarta is recommended to be improved by installing the counter barrier or surveillance system that can provide the actual demand data both onboard passengers and offboard passengers on all stations. Currently, the number of onboard passengers can be counted through ticketing system, but the offboard passengers are impossible to be counted because there is no barrier at the exit gate at any station. The actual number of on/off-board passengers is important to optimize the real-time operation of BRT. The operation can be monitored easily by utilizing the real-time data management.

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APPENDIX A
THE NETWORK CODIFICATION MAP

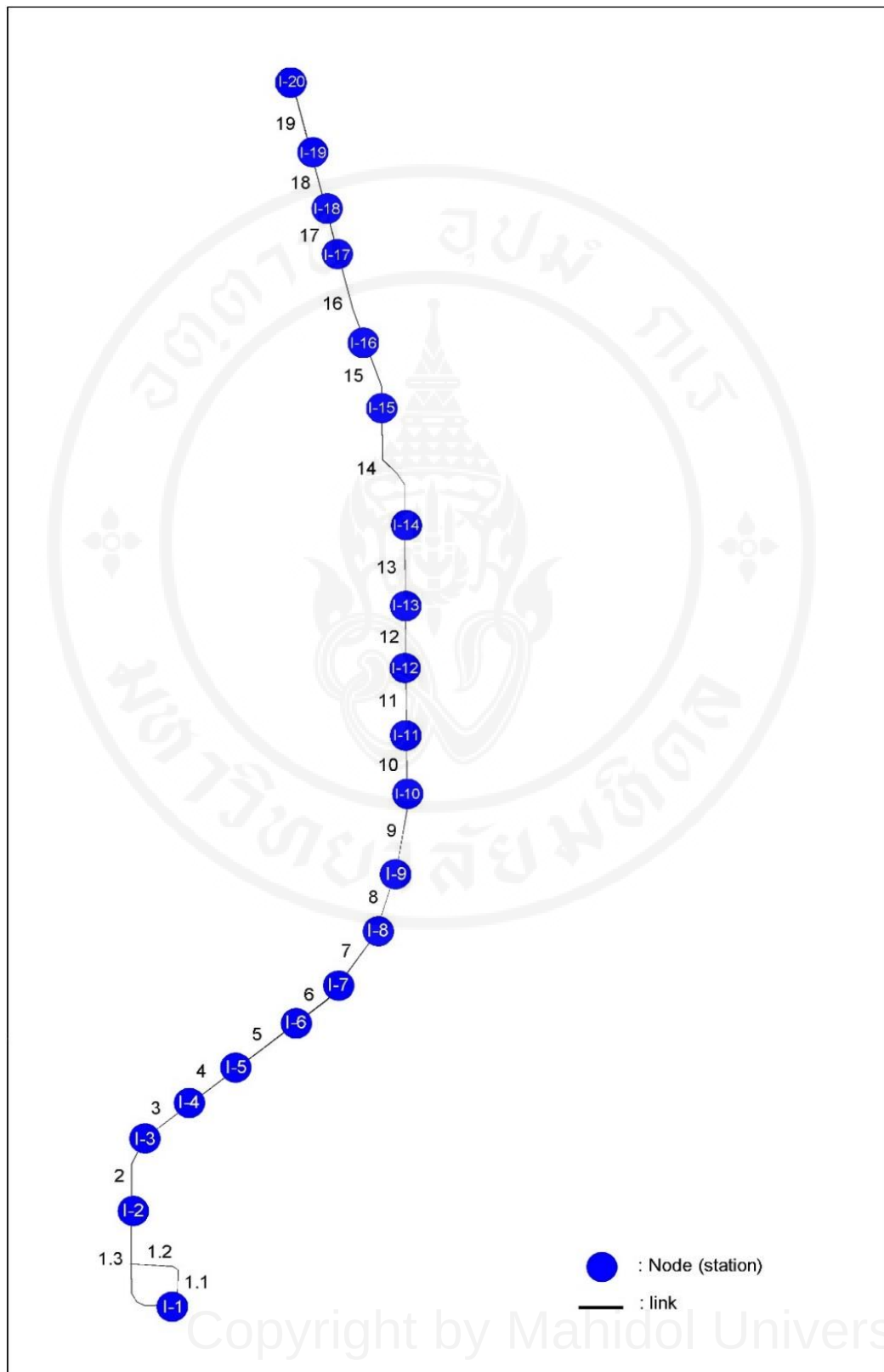


Figure A.1 The network codification of corridor 1

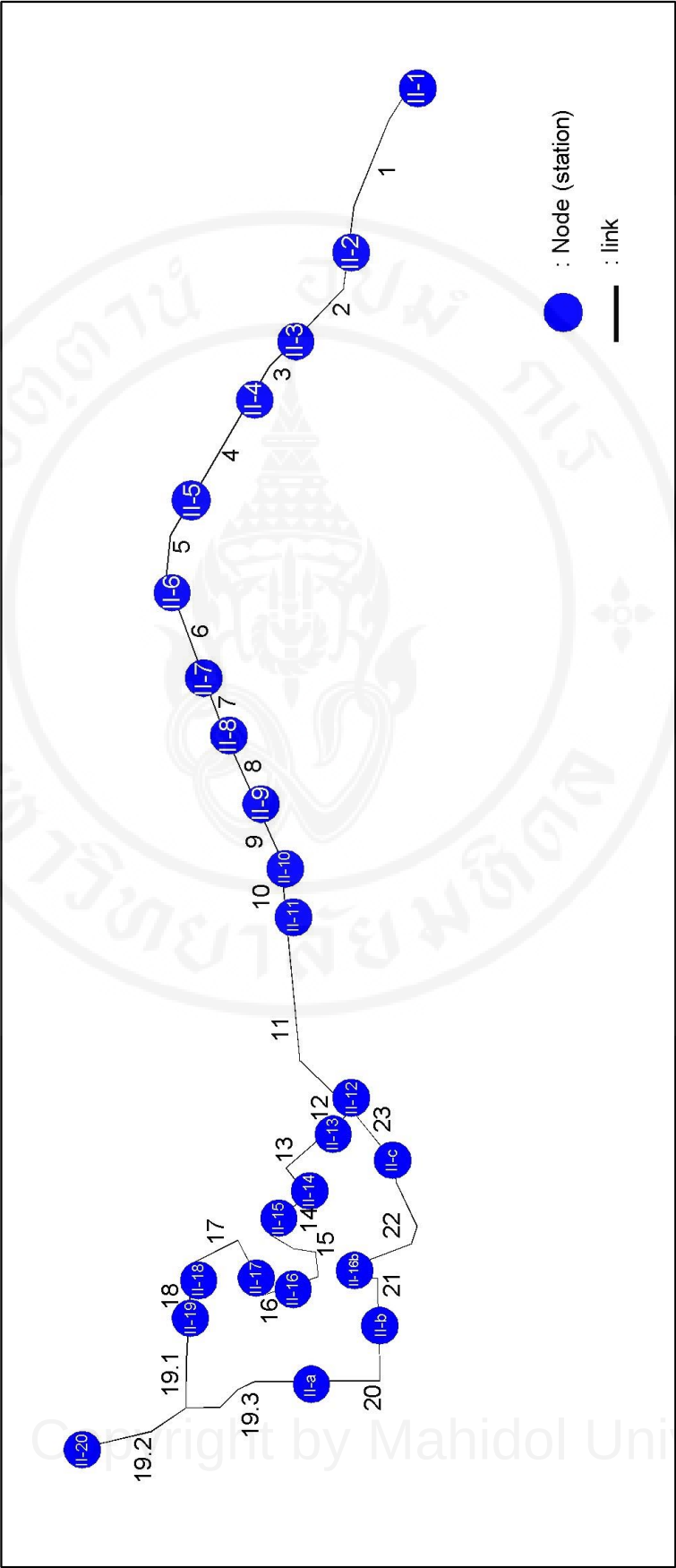


Figure A.2 The network codification of corridor 2

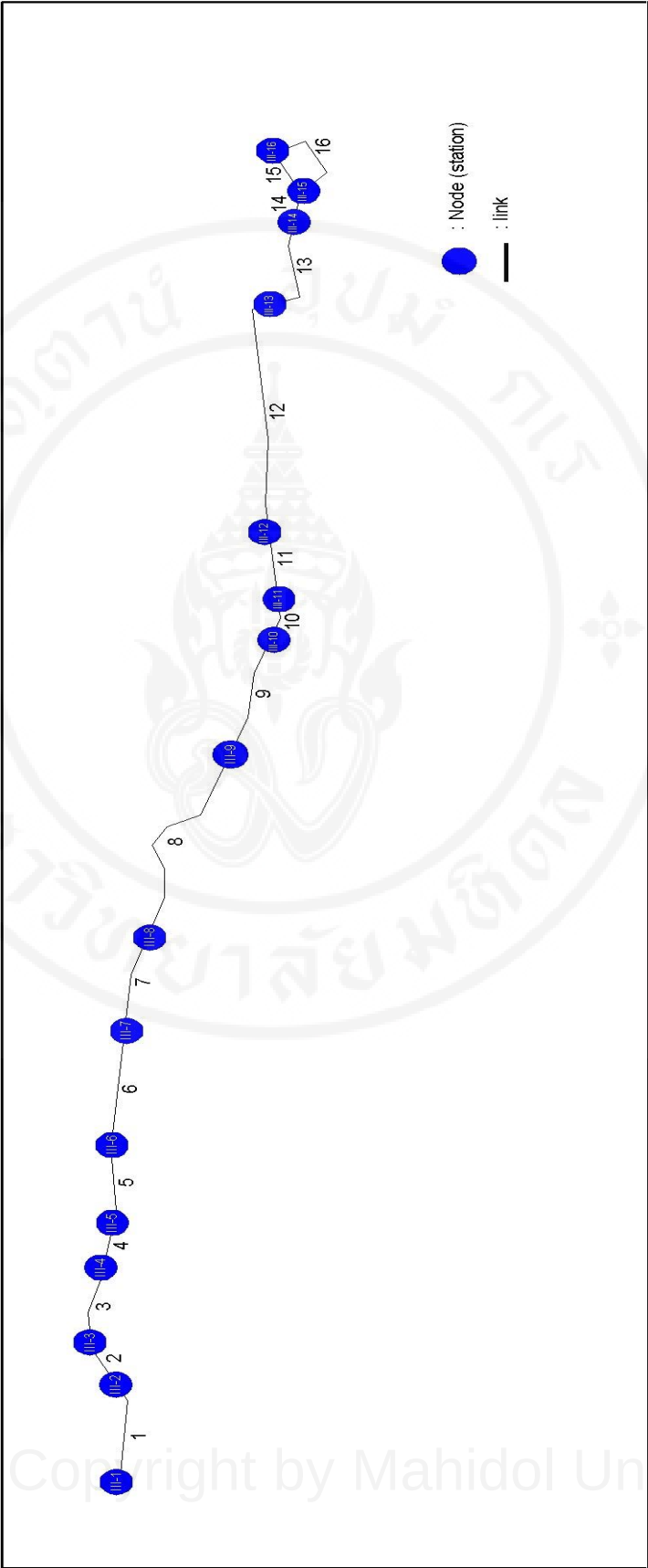


Figure A.3 The network codification of corridor 3

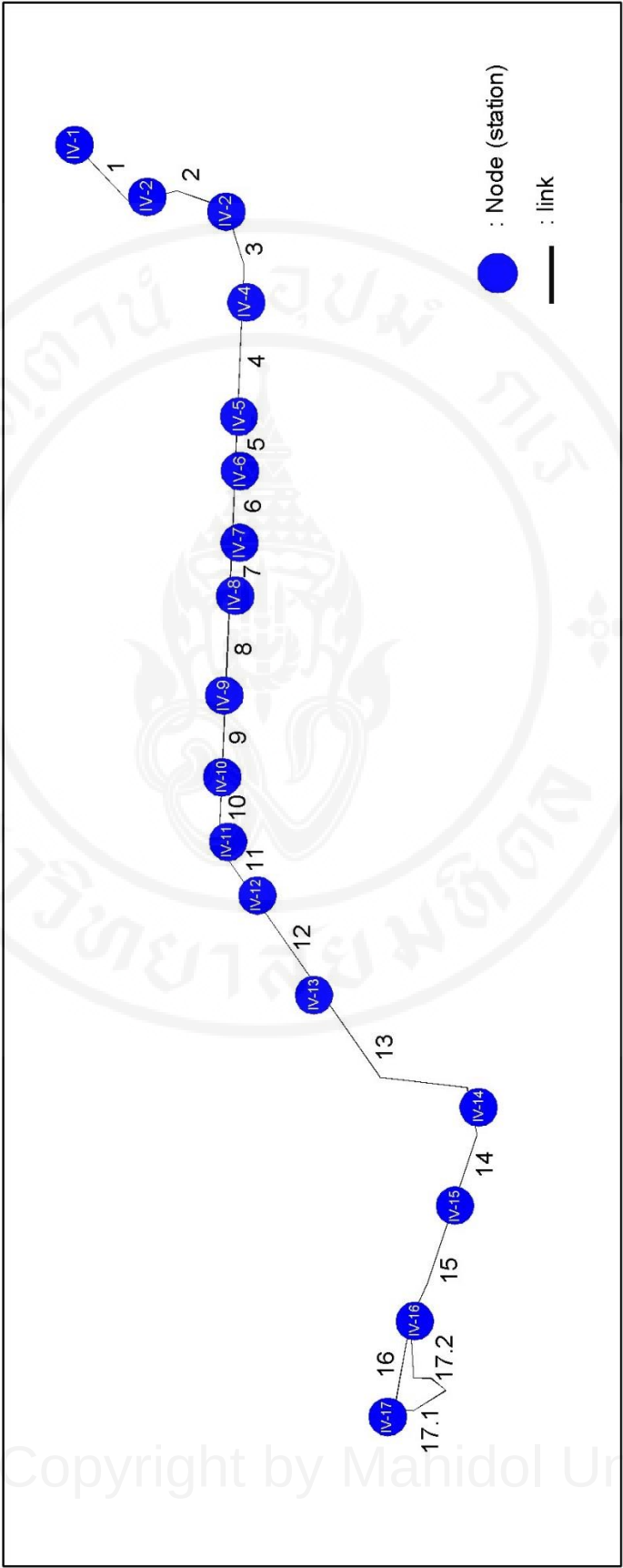


Figure A.4 The network codification of corridor 4

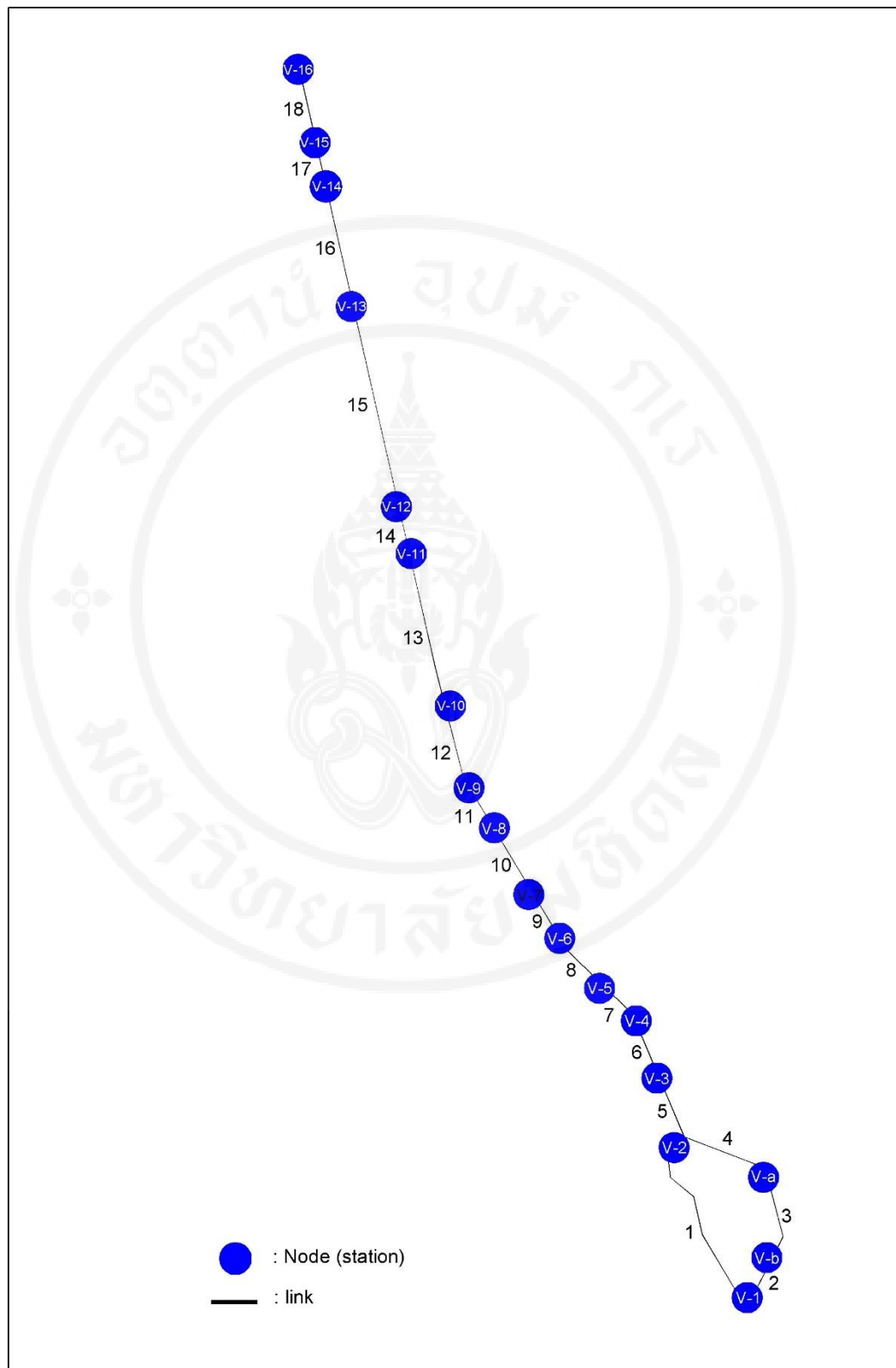


Figure A.5 The network codification of corridor 5

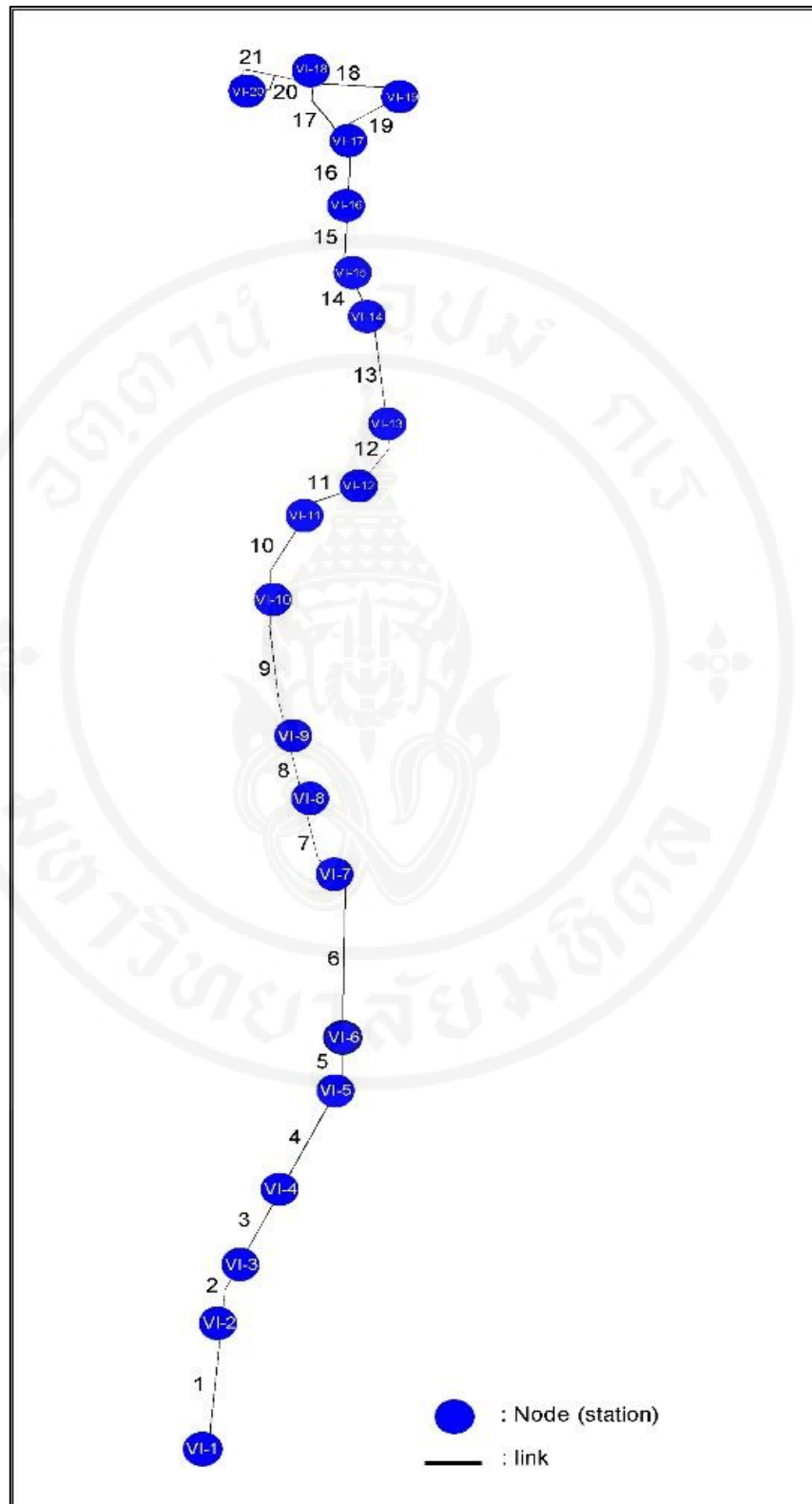


Figure A.6 The network codification of corridor 6

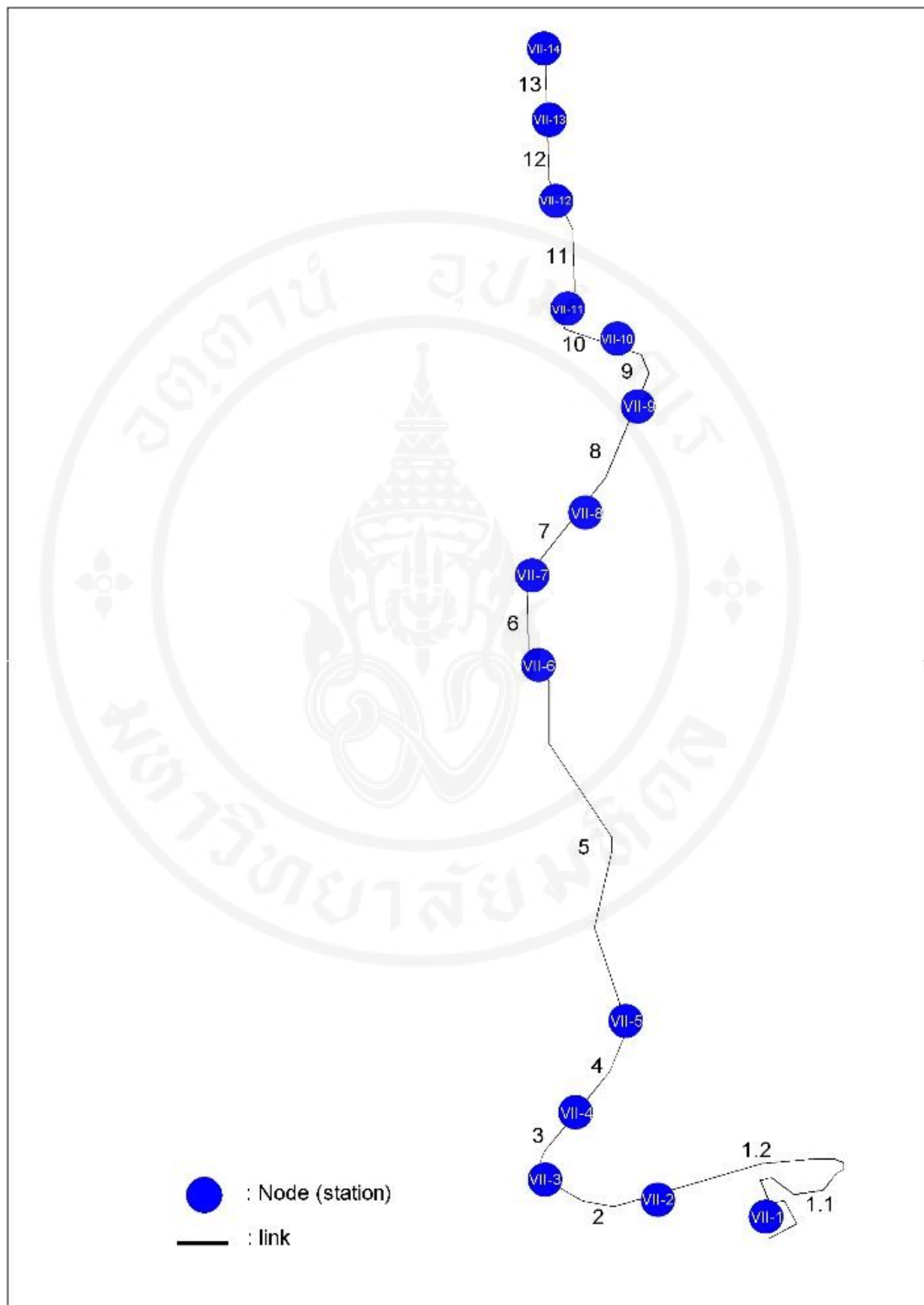


Figure A.7 The network codification of corridor 7

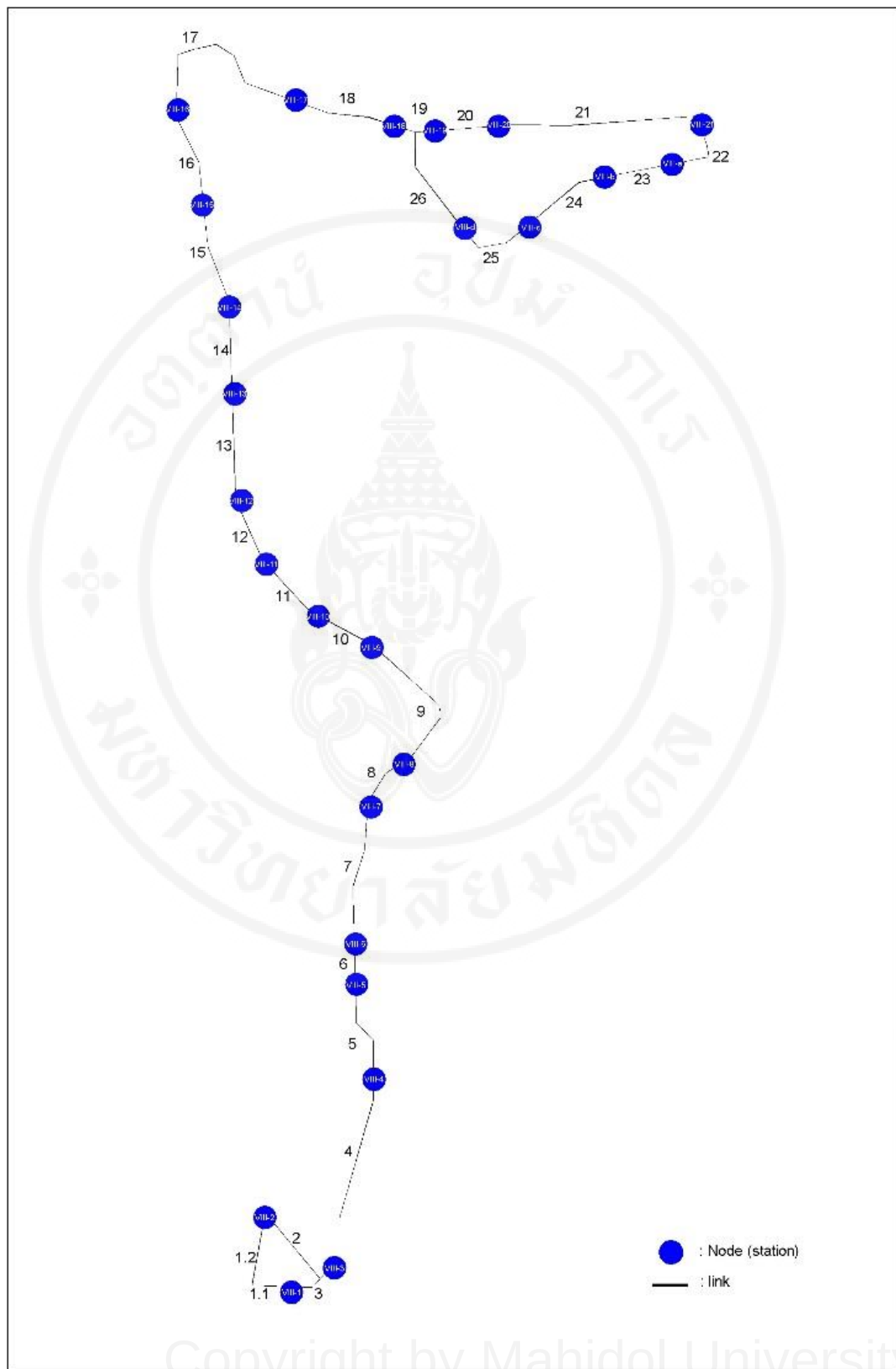


Figure A.8 The network codification of corridor 8

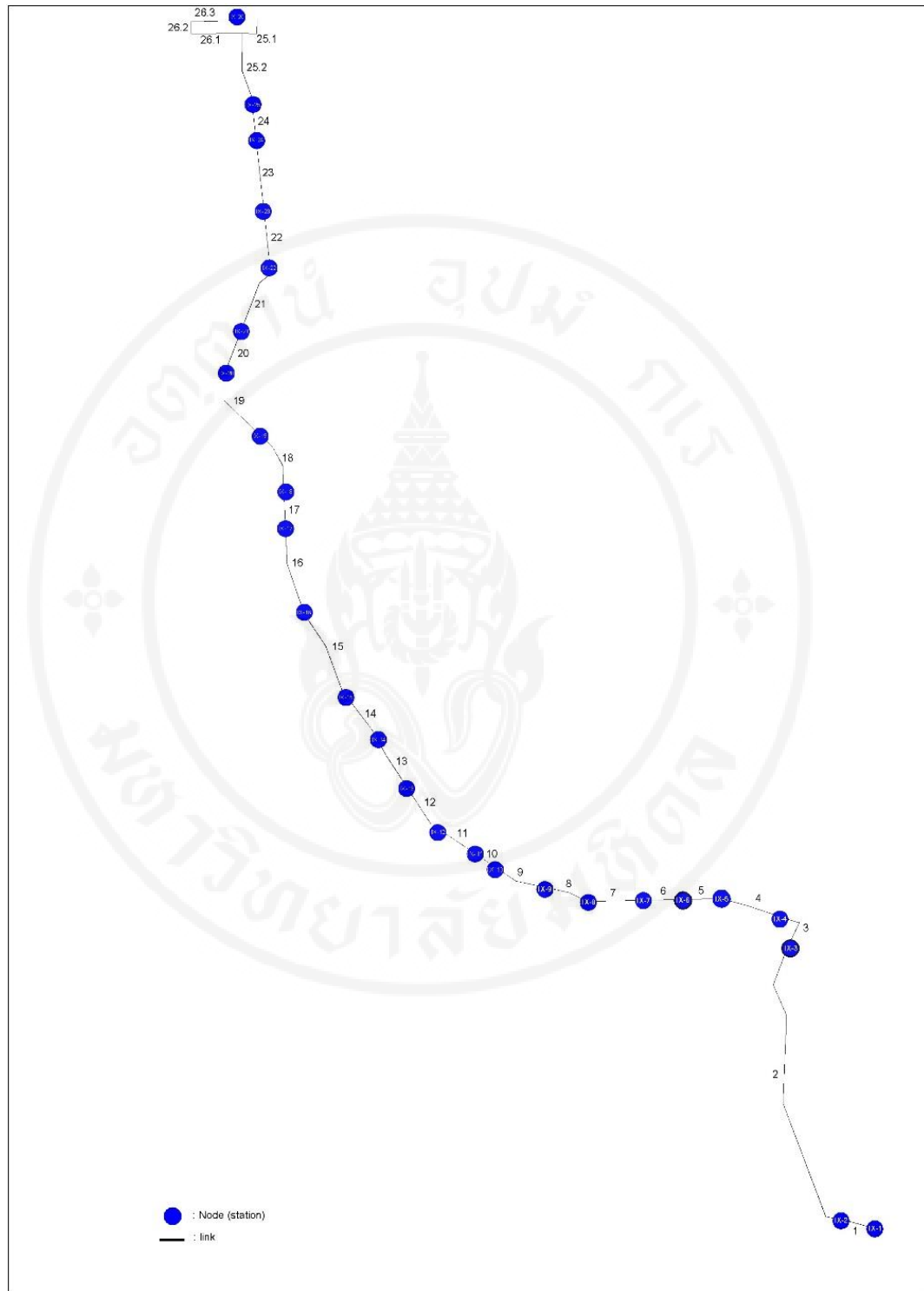


Figure A.9 The network codification of corridor 9

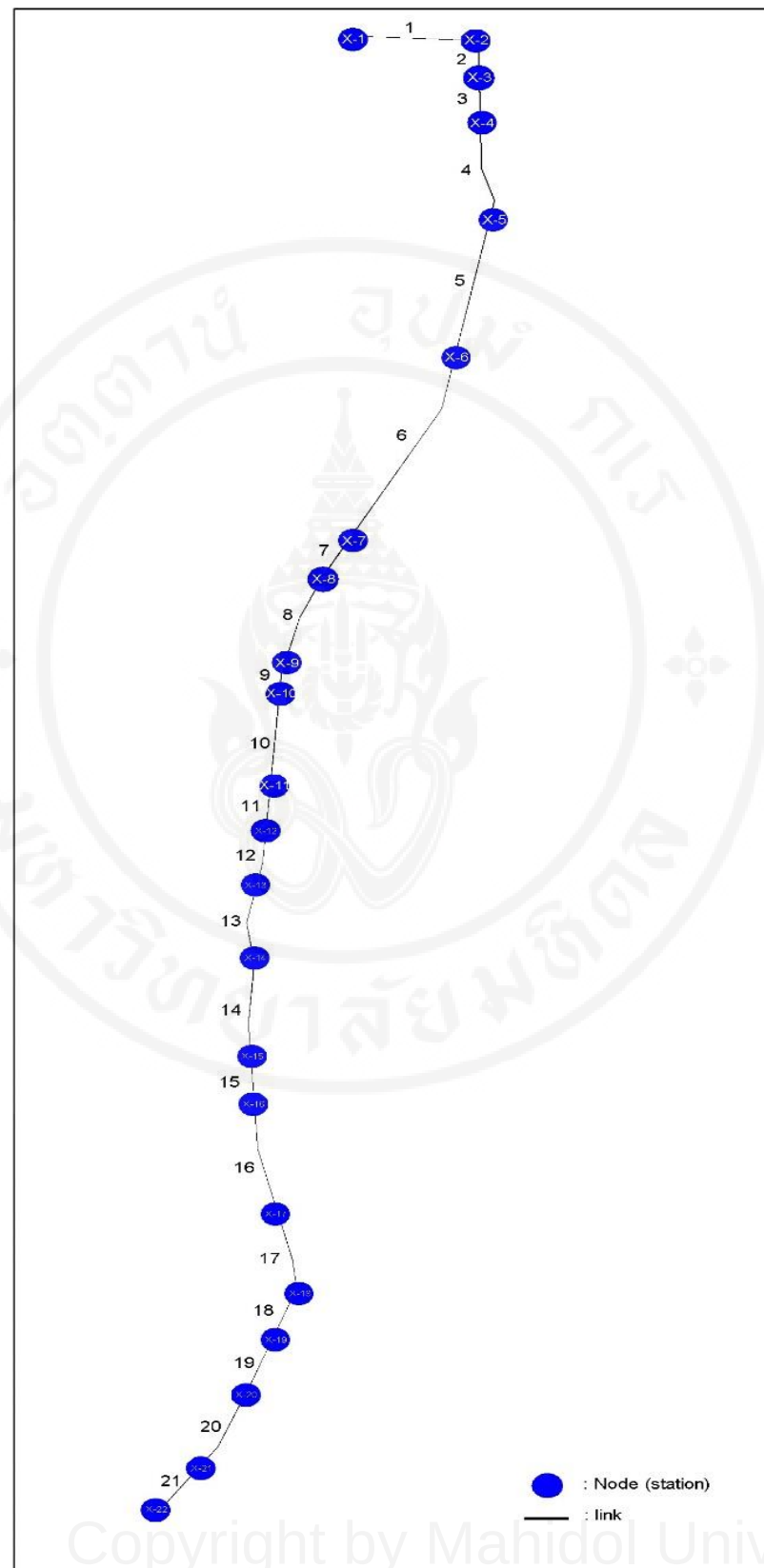


Figure A.10 The network codification of corridor 10

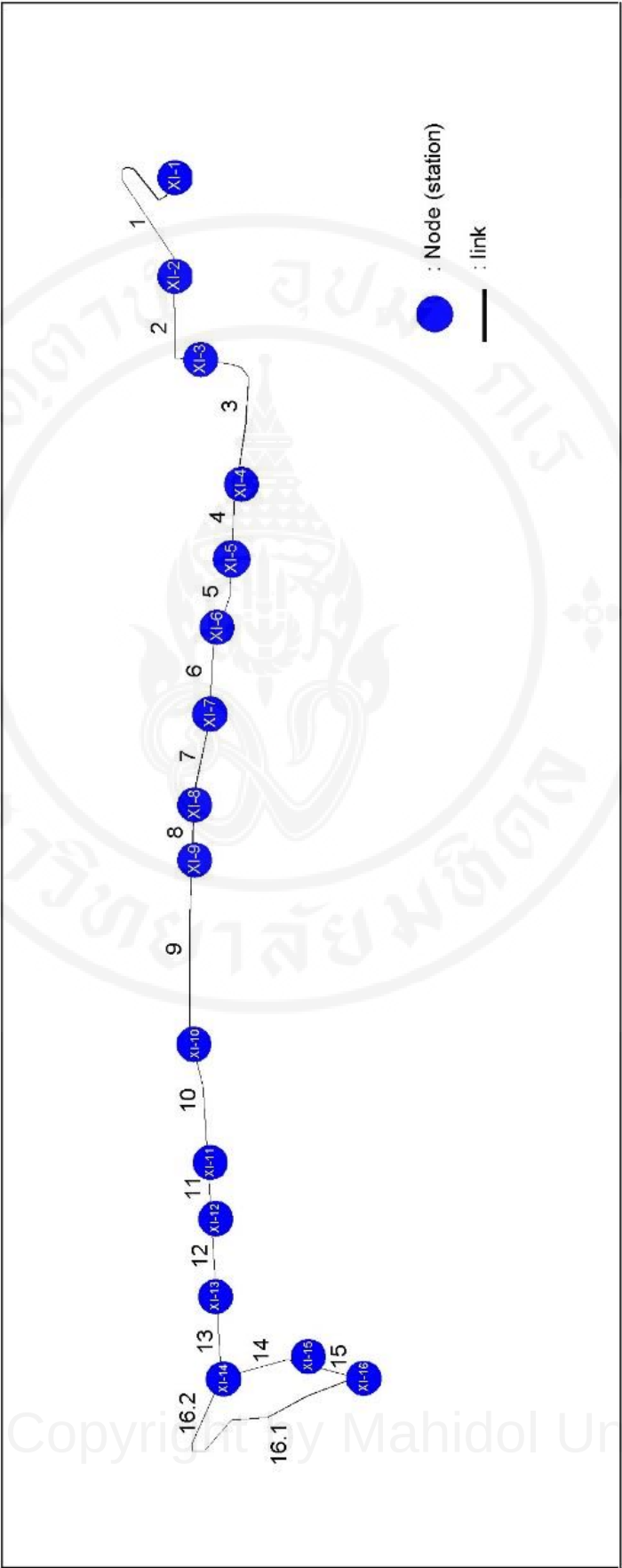


Figure A.11 The network codification of corridor 11

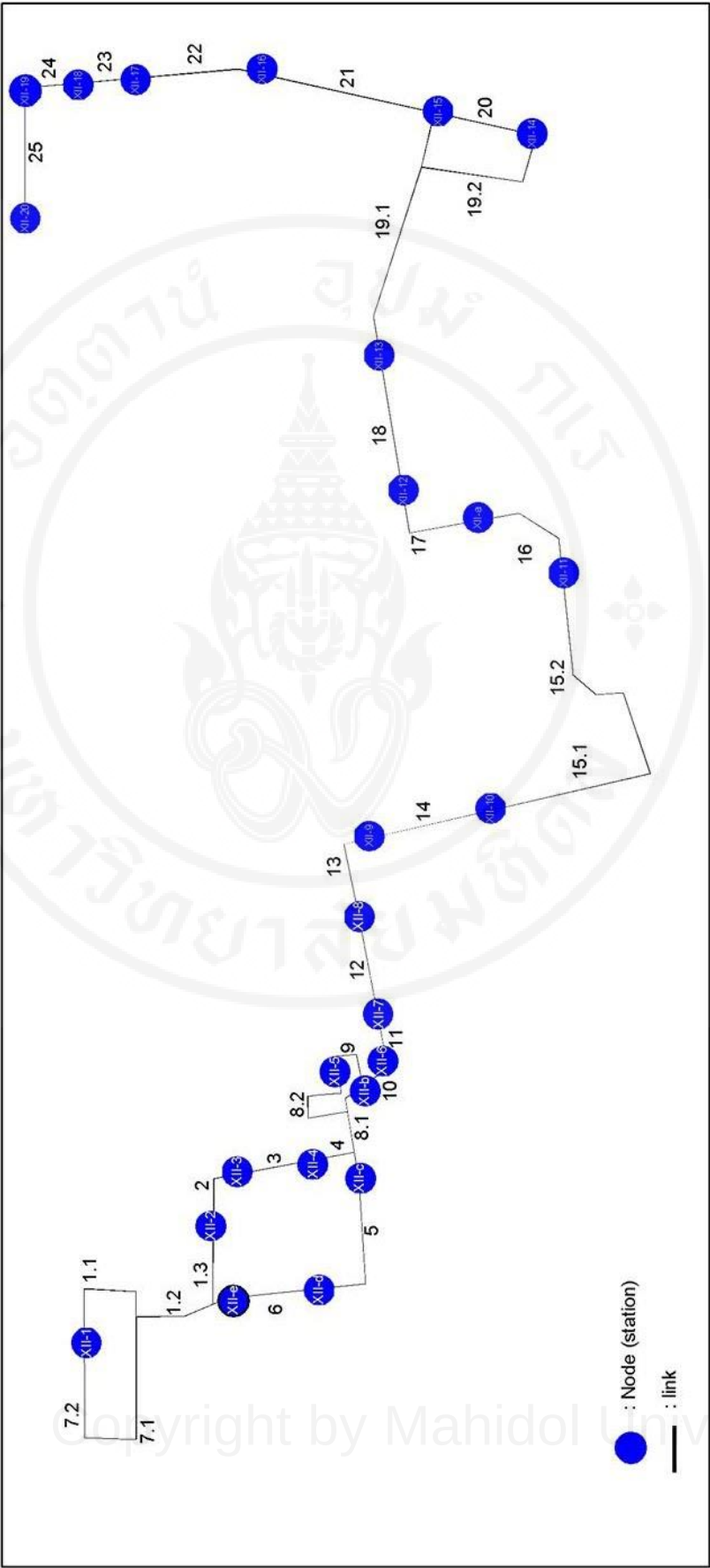
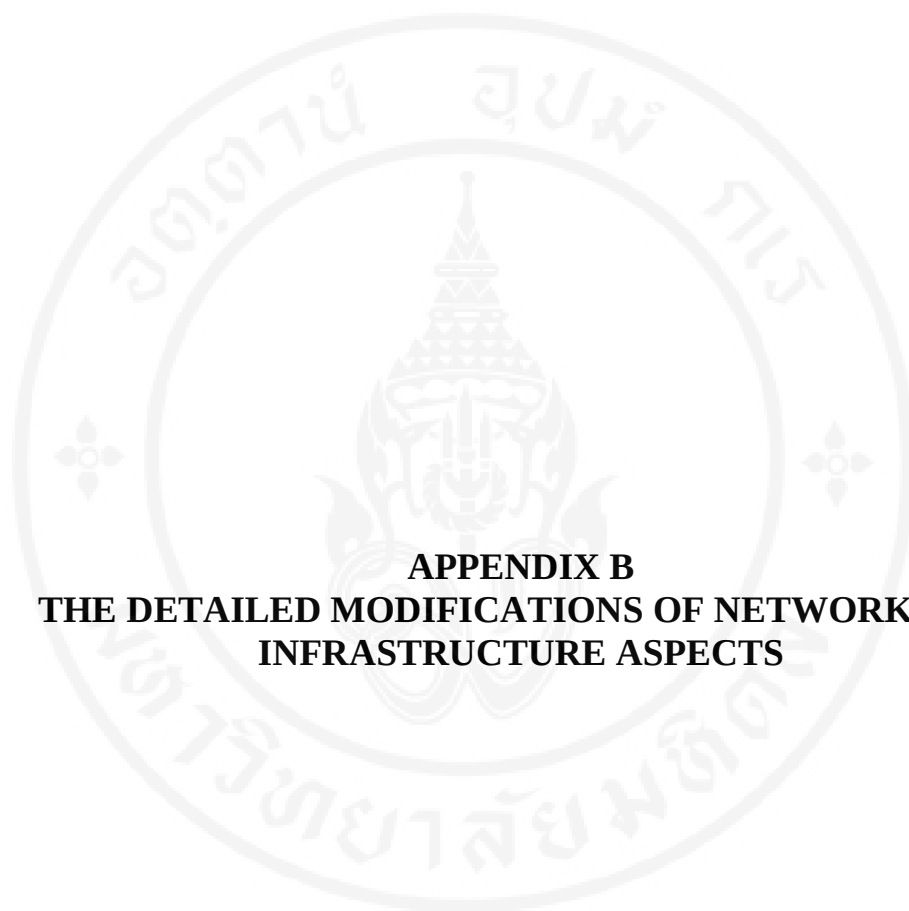


Figure A.12 The network codification of corridor 12



APPENDIX B
THE DETAILED MODIFICATIONS OF NETWORK AND
INFRASTRUCTURE ASPECTS

Table B.1 The link and station modifications of corridor 1

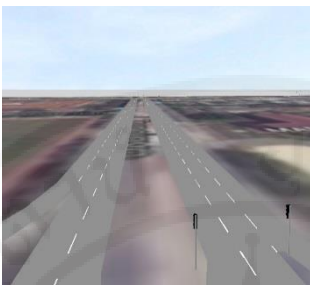
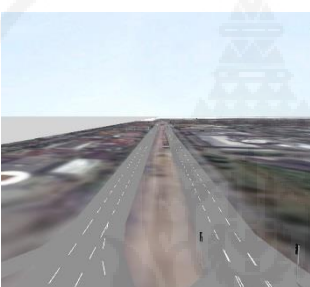
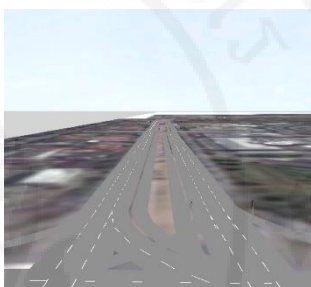
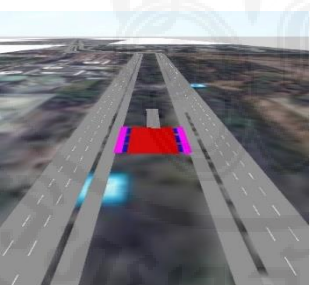
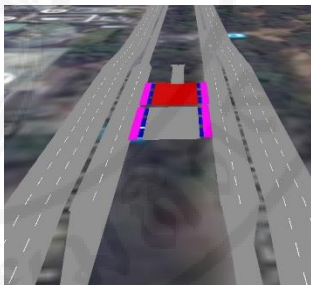
No	Link / station number	Visualization		Description
		Existing	Recommendation	
1	link 1.2			The installation of a segregated lane
2	link 1.3			The installation of a segregated lane
3	station I-14			The installation of extra platform and passing lane

Table B.2 The link and station modifications of corridor 2

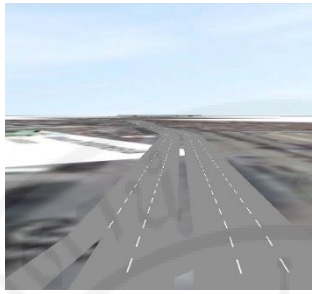
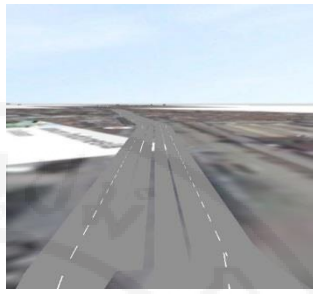
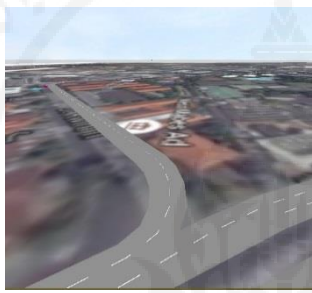
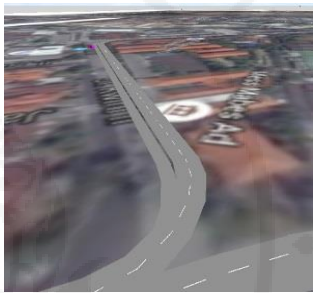
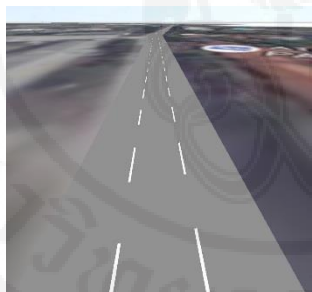
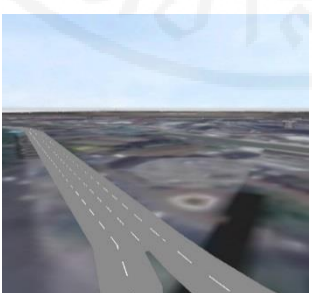
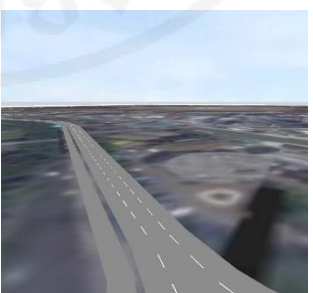
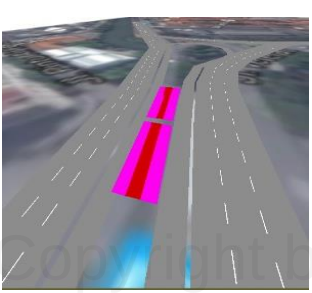
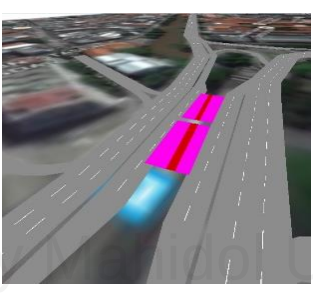
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 1			A lane separation for the BRT
2	link 13			The installation of a segregated lane
3	link 14			A lane separation for the BRT
4	link 15			A lane separation for the BRT
5	station II-18			The installation of a passing lane

Table B.2 The link and station modifications of corridor 2 (Continue)

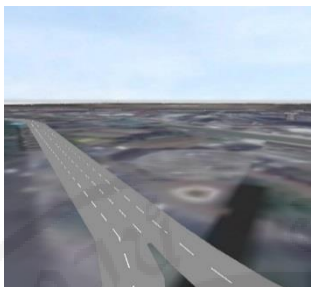
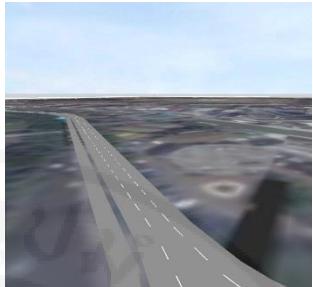
No	Location	Visualization		Description
		Existing	Recommendation	
6	station II-a			The installation of extra platform and passing lane



Table B.3 The link and station modifications of corridor 3

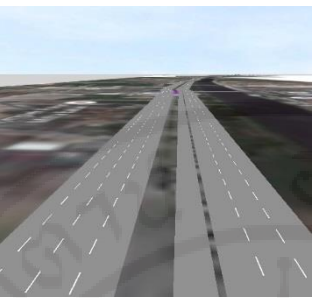
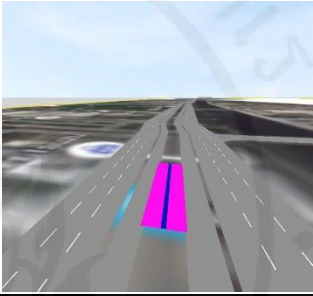
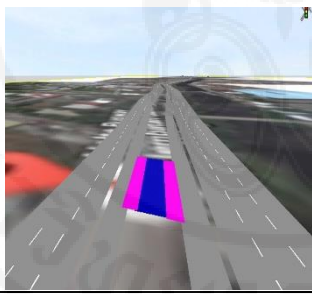
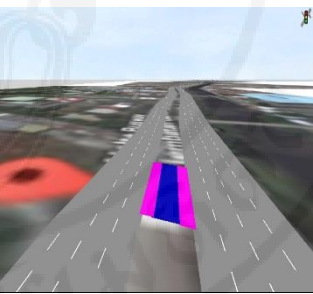
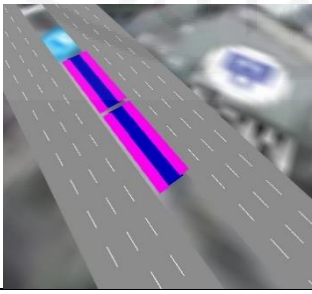
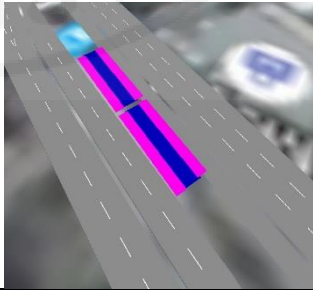
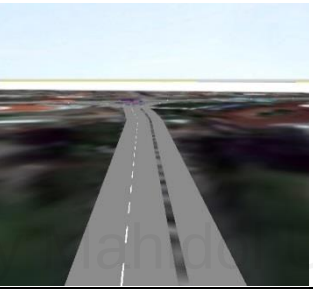
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 5			A lane separation for the BRT at the first direction
2	link 6			A lane separation for the BRT at the first direction
3	link 7			A lane separation for the BRT
4	link 9			A lane separation for the BRT
5	link 16			A lane separation for the BRT

Table B.3 The link and station modifications of corridor 3 (Continue)

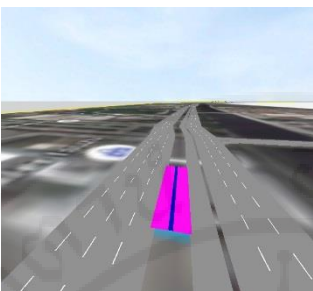
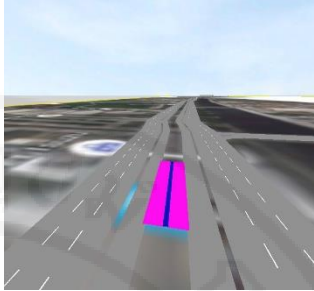
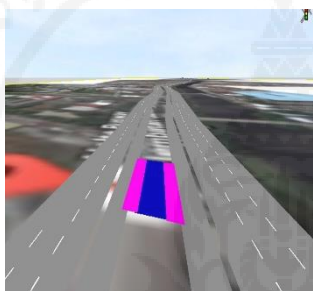
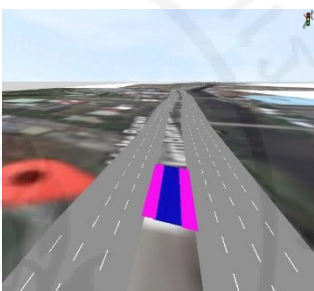
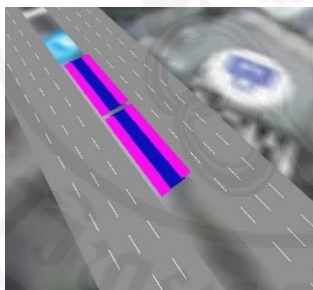
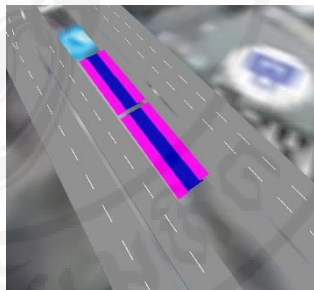
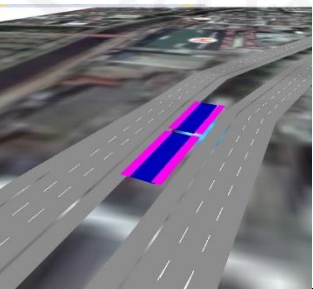
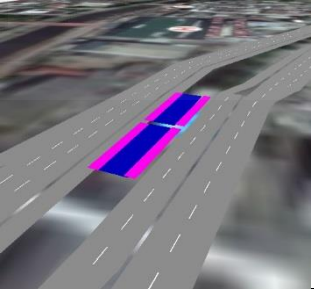
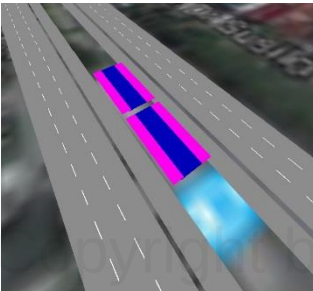
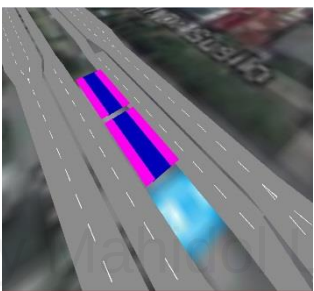
No	Location	Visualization		Description
		Existing	Recommendation	
6	station III-6			The installation of a segregated lane
7	station III-7			The installation of a segregated lane
8	station III-9			The installation of segregated lane and passing lane
9	station III-10			The installation of a passing lane
10	station III-12			The installation of a passing lane

Table B.3 The link and station modifications of corridor 3 (Continue)

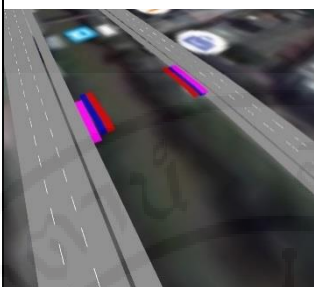
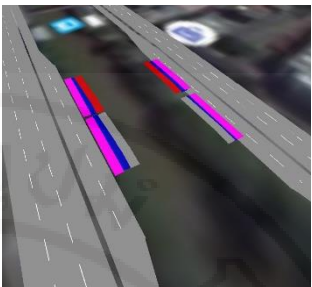
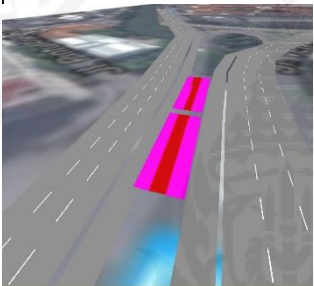
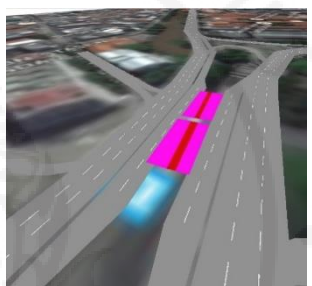
No	Location	Visualization		Description
		Existing	Recommendation	
11	station III-14			The installation of extra platform and passing lane
12	station III-15			The installation of a passing lane

Table B.4 The link and station modifications of corridor 4

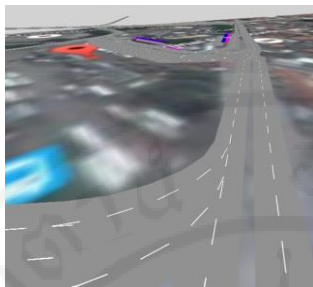
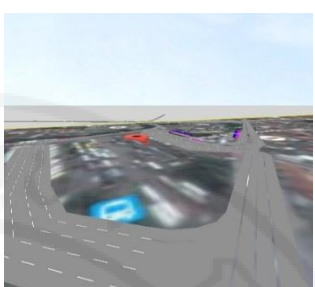
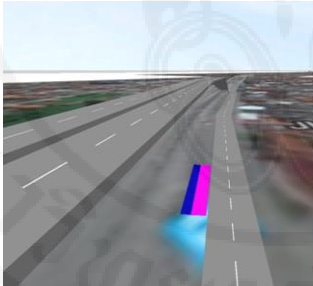
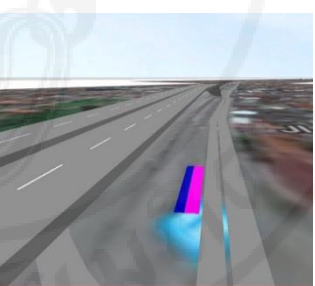
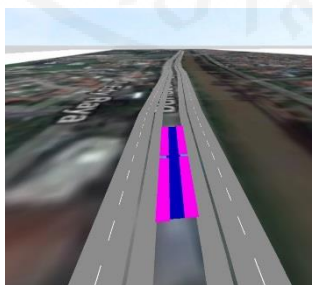
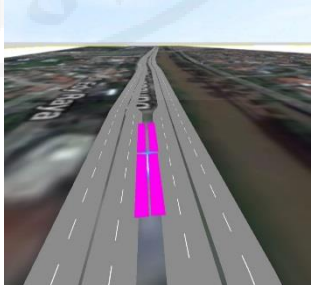
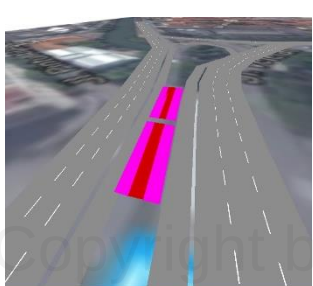
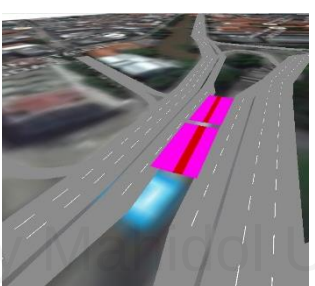
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 1			A lane separation for the BRT
2	link 2			The installation of a segregated lane
3	link 12			A lane separation for the BRT
4	station IV-17			The installation of a passing lane
5	station IV-18			The installation of a passing lane

Table B.5 The link and station modifications of corridor 5

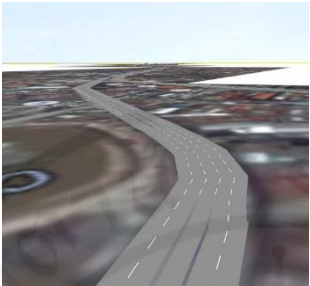
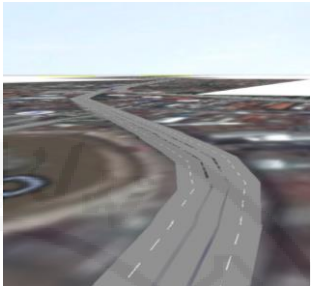
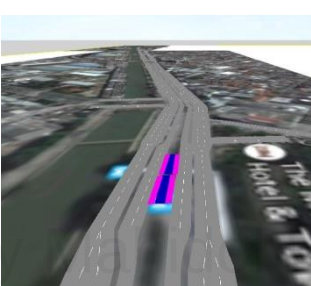
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 1			A lane separation for the BRT
2	link 2			A lane separation for the BRT
3	link 3			A lane separation for the BRT
4	link 18			A lane separation for the BRT
5	station V-13			The installation of extra platform and passing lane

Table B.5 The link and station modifications of corridor 5 (Continue)

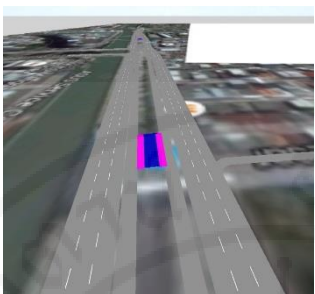
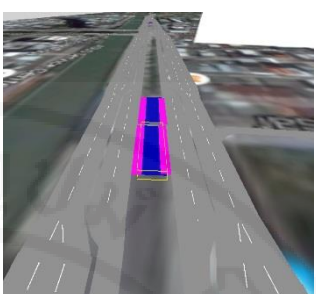
No	Location	Visualization		Description
		Existing	Recommendation	
6	station V-14			The installation of extra platform and passing lane

Table B.6 The link and station modifications of corridor 6

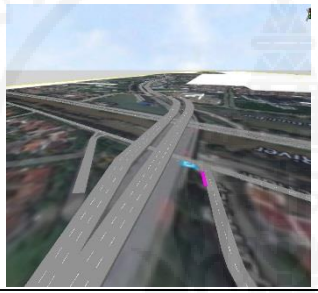
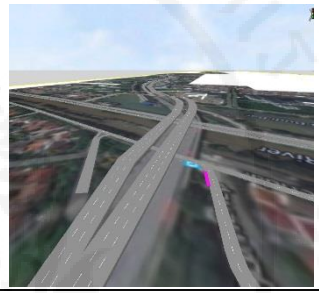
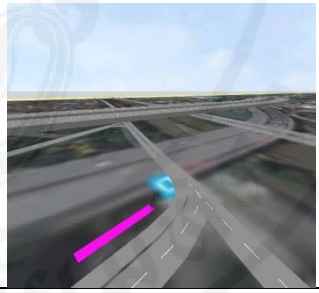
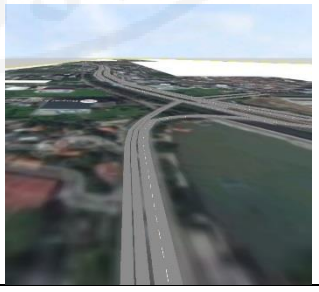
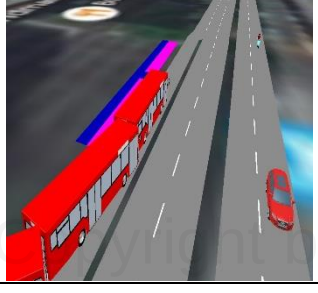
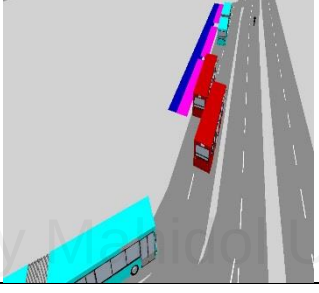
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 1			A lane separation for the BRT
2	link 16			Separation by regulation
3	link 18			The installation of a segregated lane
4	link 19			A lane separation for the BRT
5	station VI-20			The installation of extra platform and passing lane

Table B.7 The link and station modifications of corridor 7

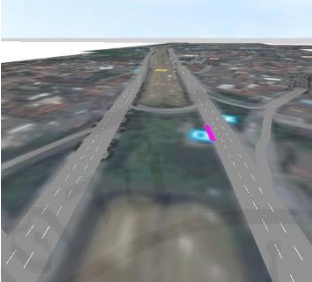
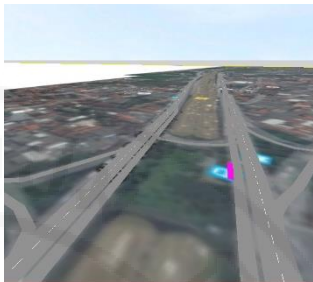
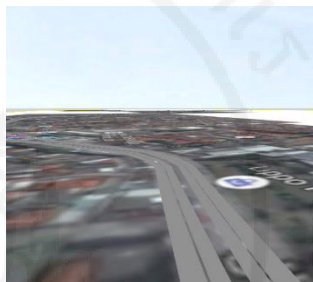
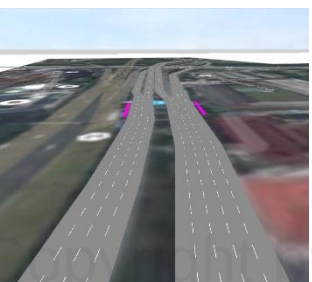
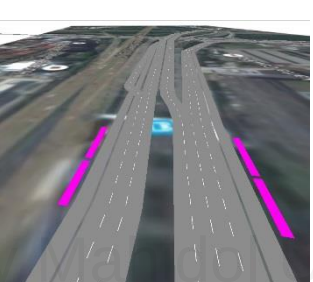
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 2			A lane separation for the BRT
2	link 5			A lane separation for the BRT
3	link 8			The installation of a segregated lane
4	link 9			The installation of a segregated lane
5	link 10			A lane separation for the BRT

Table B.7 The link and station modifications of corridor 7 (Continue)

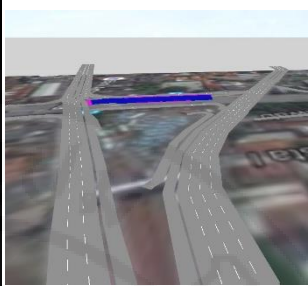
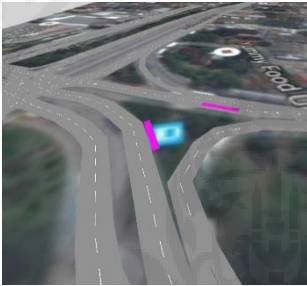
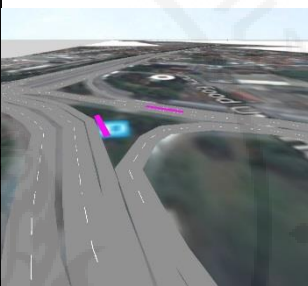
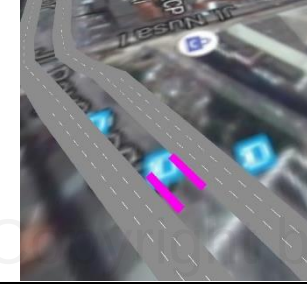
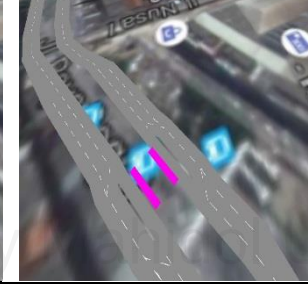
No	Location	Visualization		Description
		Existing	Recommendation	
6	link 13			A lane separation for the BRT
7	station VII-3			The installation of a segregated lane
8	station VII-4			The installation of a segregated lane
9	station VII-5			The installation of a segregated lane
10	station VII-6			The installation of a segregated lane

Table B.7 The link and station modifications of corridor 7 (Continue)

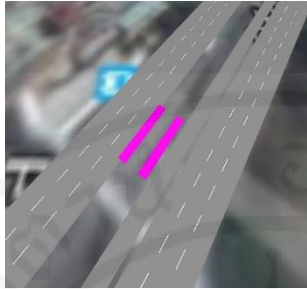
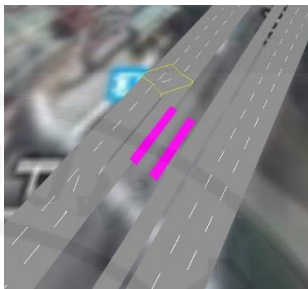
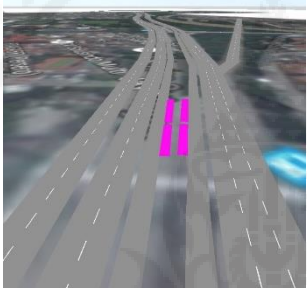
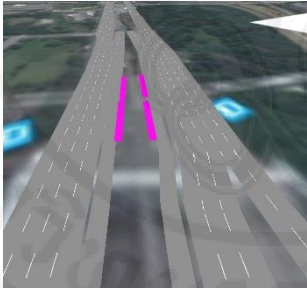
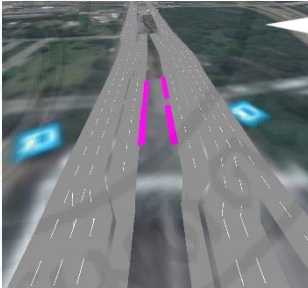
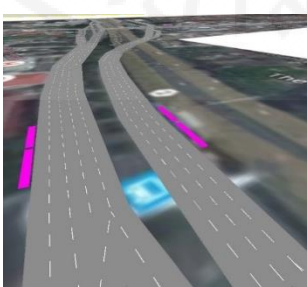
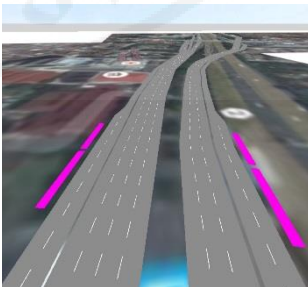
No	Location	Visualization		Description
		Existing	Recommendation	
11	station VII-7			The installation of a segregated lane
12	station VII-8			The installation of a passing lane
13	station VII-9			The installation of a passing lane
14	station VII-10			The installation of segregated lane and passing lane

Table B.8 The link and station modifications of corridor 8

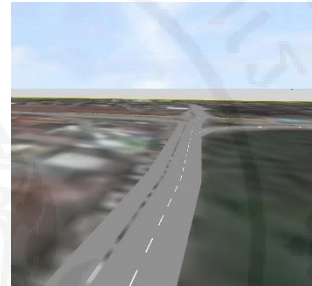
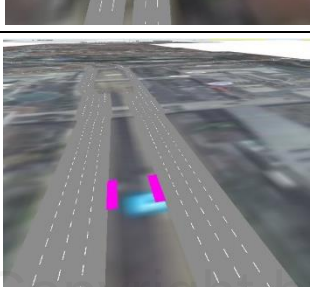
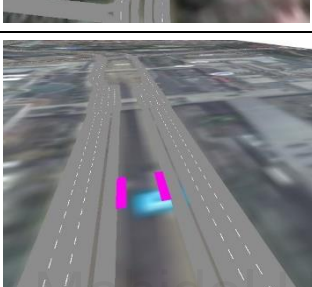
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 1.1.			The installation of a segregated lane
2	link 1.2			A lane separation for the BRT
3	link 2			A lane separation for the BRT
4	link 4			A lane separation for the BRT
5	link 5			A lane separation for the BRT

Table B.8 The link and station modifications of corridor 8 (Continue)

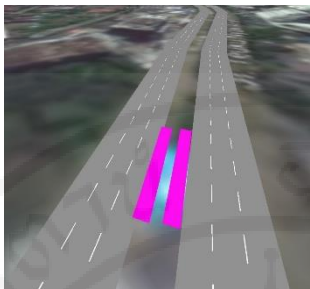
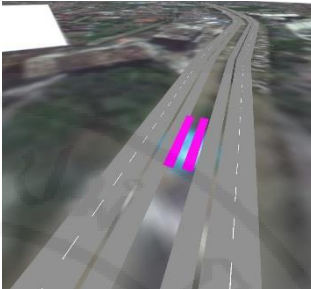
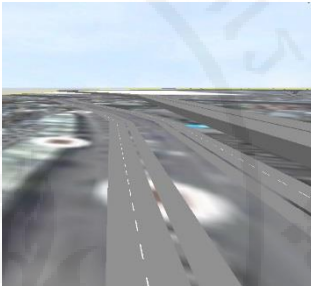
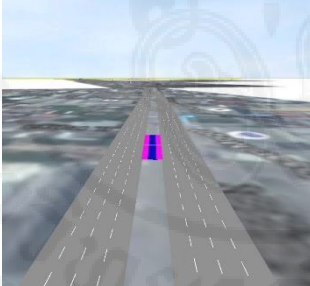
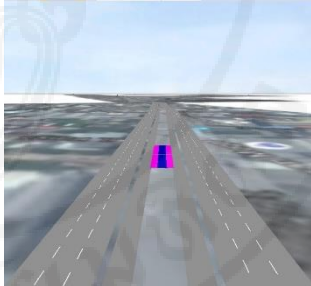
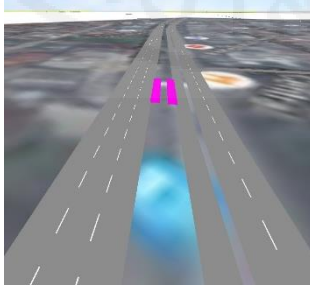
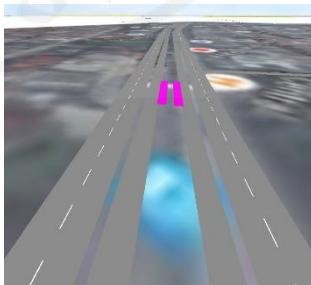
No	Location	Visualization		Description
		Existing	Recommendation	
6	link 9			A lane separation for the BRT
7	link 17			A lane separation for the BRT
8	link 18			A lane separation for the BRT
9	link 25			A lane separation for the BRT at the first direction
10	link 26			A lane separation for the BRT at the first direction

Table B.8 The link and station modifications of corridor 8 (Continue)

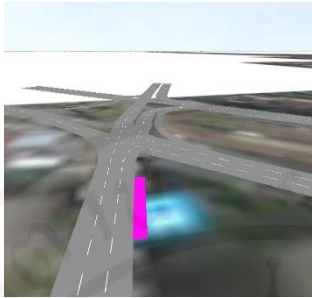
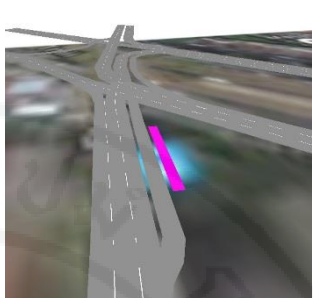
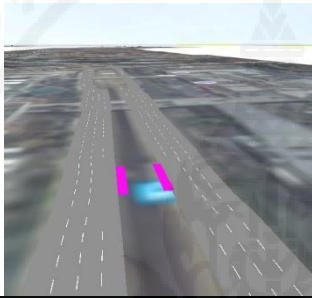
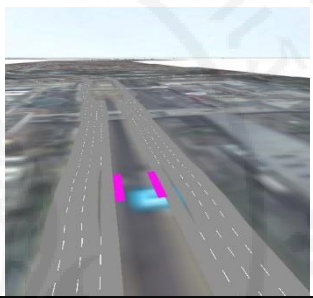
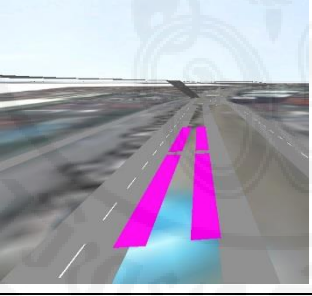
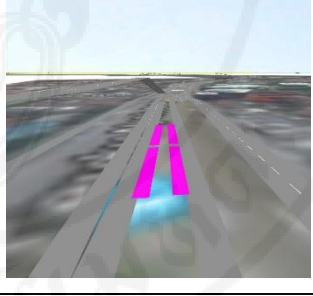
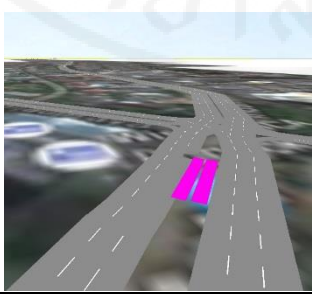
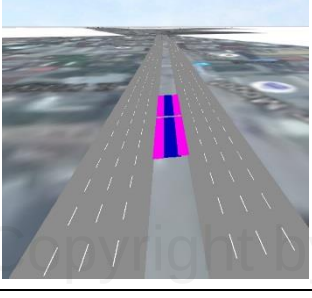
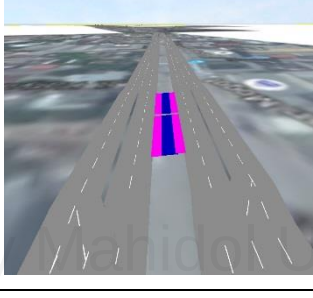
No	Location	Visualization		Description
		Existing	Recommendation	
11	station VIII-2			The installation of a segregated lane
12	station VIII-4			The installation of a segregated lane
13	station VIII-7			The installation of a segregated lane
14	station VIII-13			The installation of a segregated lane
15	station VIII-17			The installation of segregated lane and passing lane

Table B.8 The link and station modifications of corridor 8 (Continue)

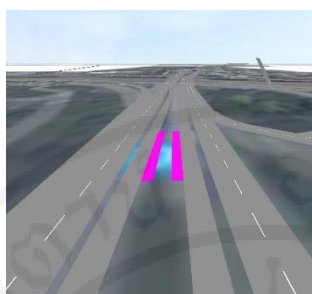
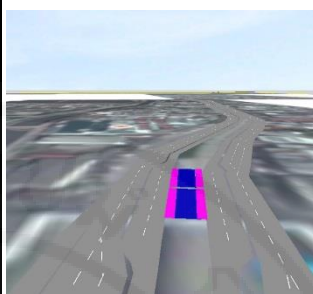
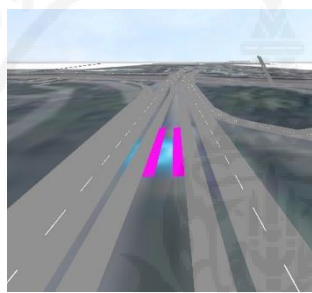
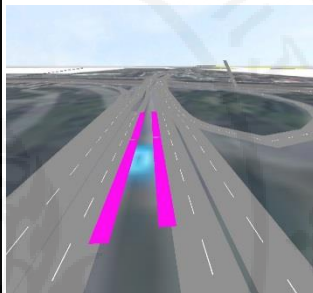
No	Location	Visualization		Description
		Existing	Recommendation	
16	station VIII-18			The installation of extra platform and passing lane
17	station VIII-19			The installation of extra platform and passing lane

Table B.9 The link and station modifications of corridor 9

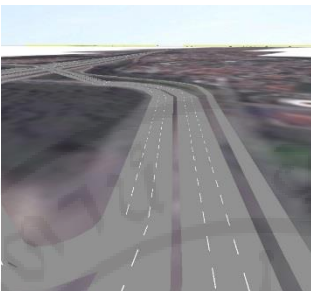
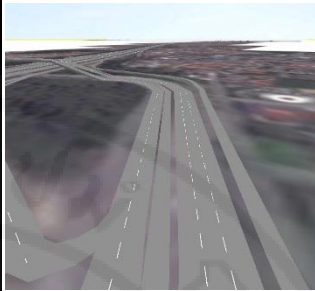
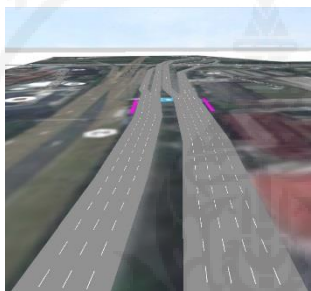
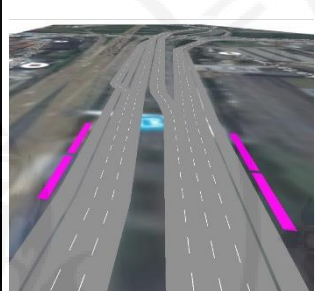
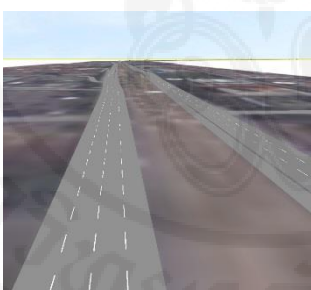
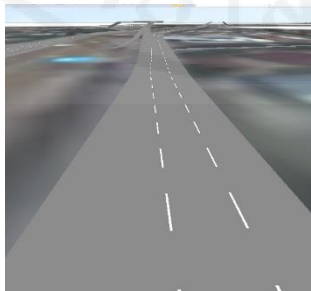
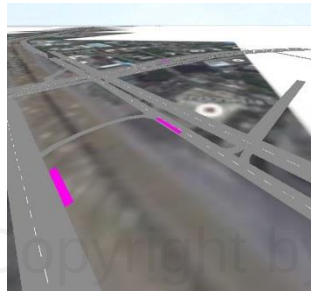
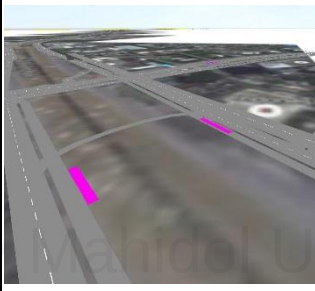
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 2			A lane separation for the BRT at the first direction
2	link 3			A lane separation for the BRT
3	link 5			A lane separation for the BRT
4	link 9			A lane separation for the BRT
5	link10			A lane separation for the BRT

Table B.9 The link and station modifications of corridor 9 (Continue)

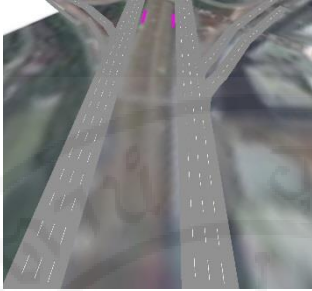
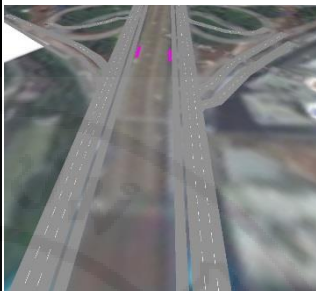
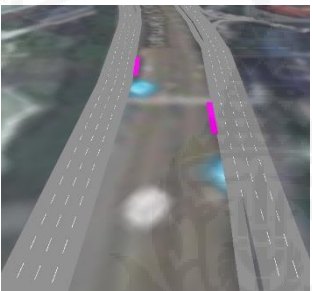
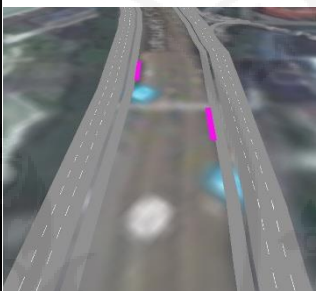
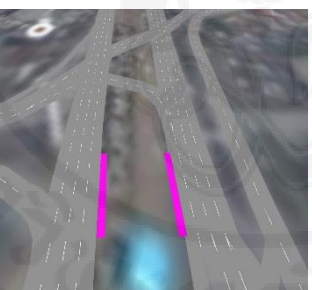
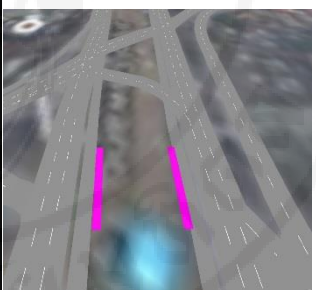
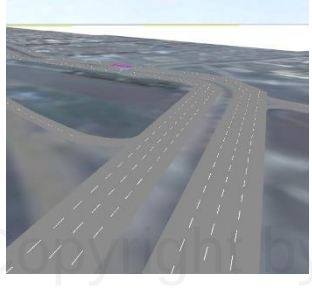
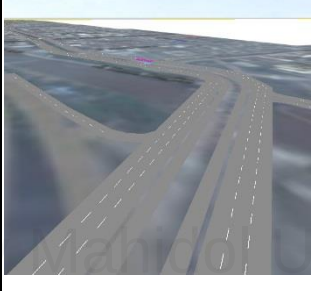
No	Location	Visualization		Description
		Existing	Recommendation	
6	link 13			A lane separation for the BRT
7	link 14			A lane separation for the BRT
8	link 15			A lane separation for the BRT
9	link 19			A lane separation for the BRT
10	link 21			A lane separation for the BRT

Table B.9 The link and station modifications of corridor 9 (Continue)

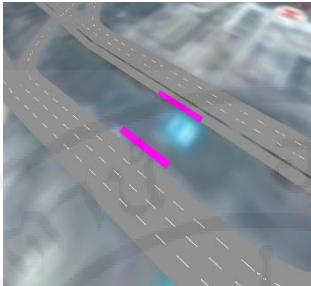
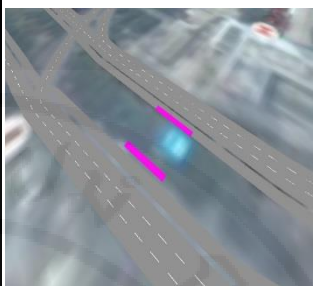
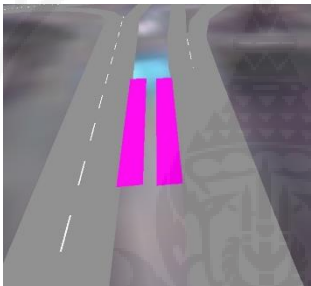
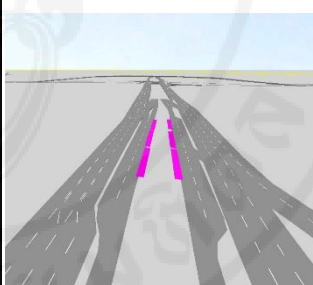
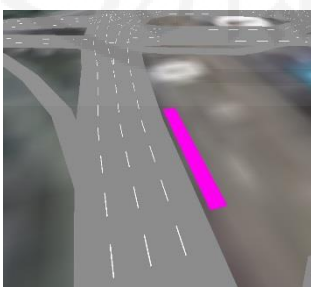
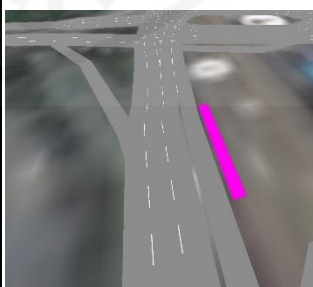
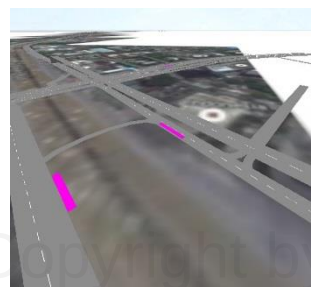
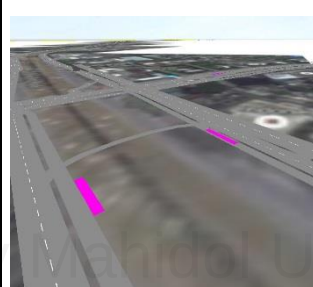
No	Location	Visualization		Description
		Existing	Recommendation	
11	link 25.2			A lane separation for the BRT at the first direction
12	station IX-2			The installation of a segregated lane
13	station IX-3			The installation of extra platform and passing lane
14	station IX-8			The installation of a segregated lane
15	station IX-11			The installation of a segregated lane

Table B.9 The link and station modifications of corridor 9 (Continue)

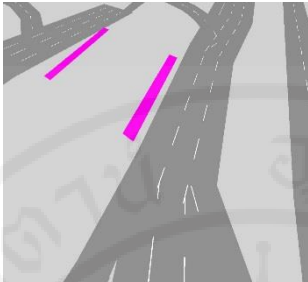
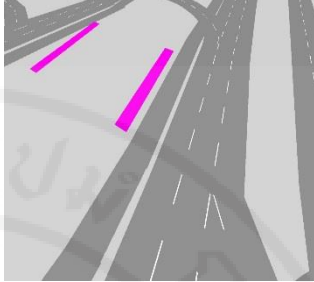
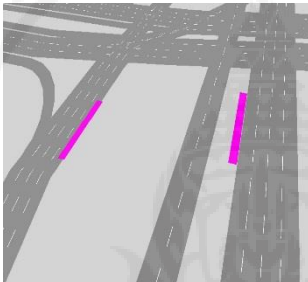
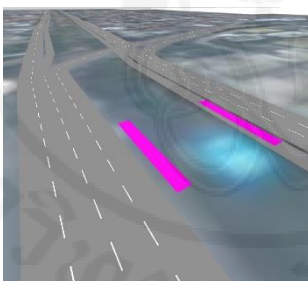
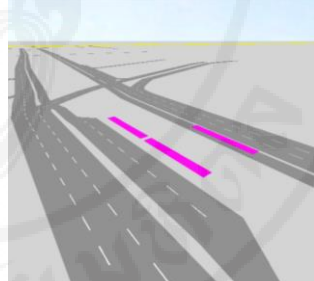
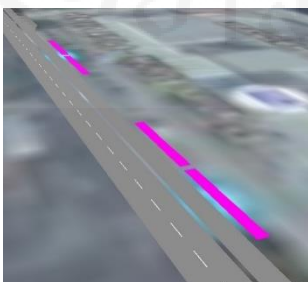
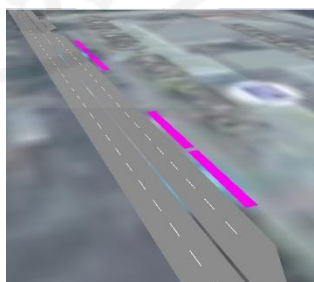
No	Location	Visualization		Description
		Existing	Recommendation	
16	station IX-16			The installation of a segregated lane
17	station IX-20			The installation of extra platform and passing lane
18	station IX-25			The installation of extra platform, segregated lane, and passing lane
19	station IX-26			The installation of a passing lane

Table B.10 The link and station modifications of corridor 10

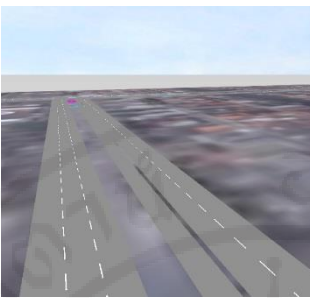
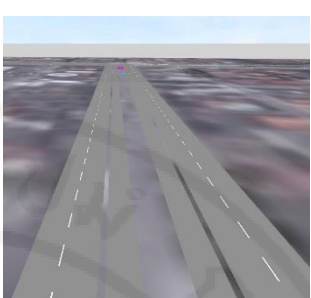
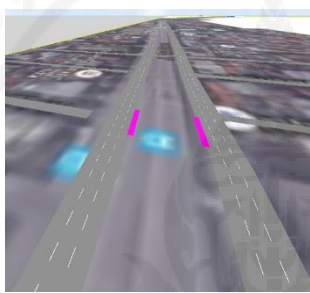
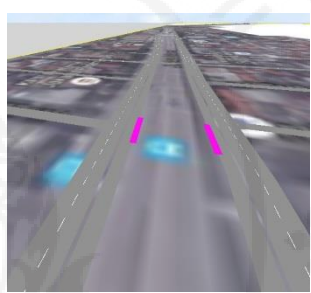
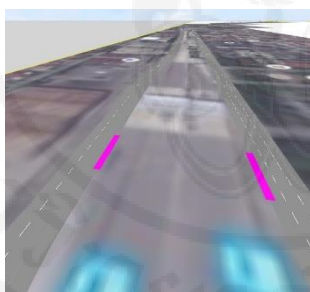
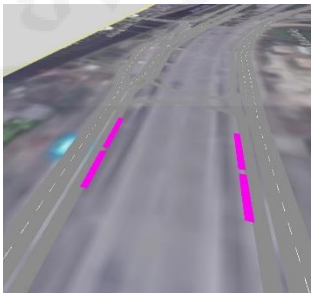
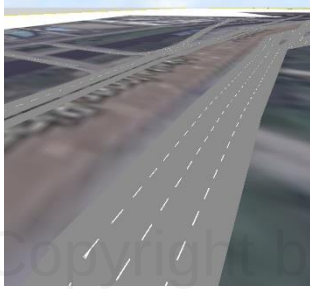
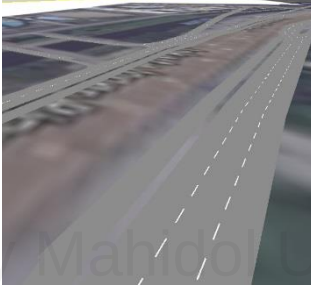
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 1			A lane separation for the BRT at the first direction
2	link 2			A lane separation for the BRT
3	link 4			The installation of a segregated lane
4	link 5			A lane separation for the BRT
5	link 6			A lane separation for the BRT

Table B.10 The link and station modifications of corridor 10 (Continue)

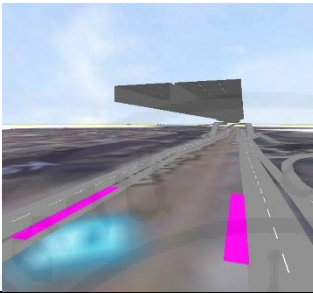
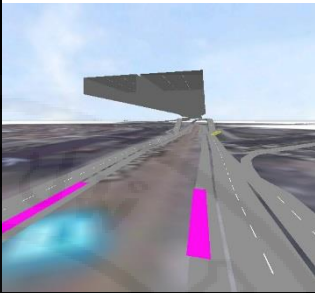
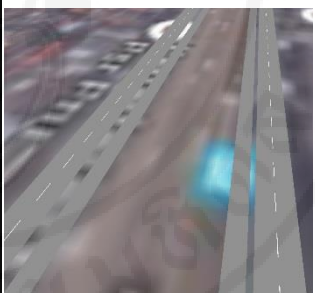
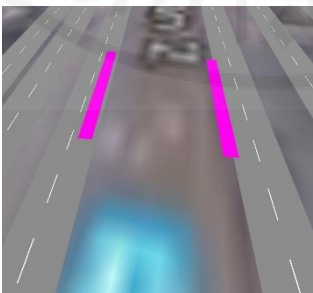
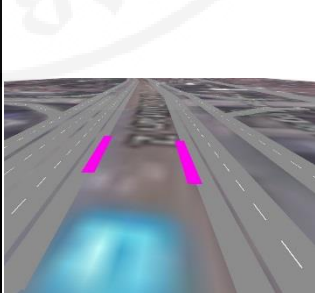
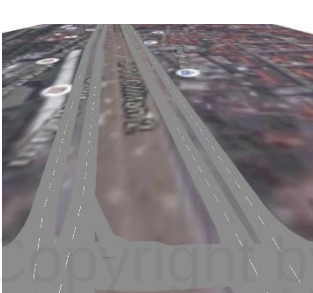
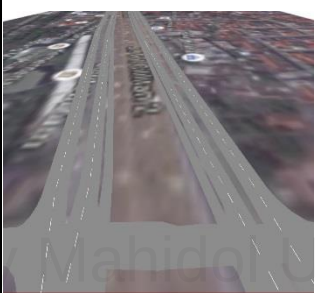
No	Location	Visualization		Description
		Existing	Recommendation	
6	link 7			The installation of a segregated lane
7	link 13			A lane separation for the BRT
8	link 15			A lane separation for the BRT
9	link 16			The installation of a segregated lane
10	link 17			The installation of a segregated lane

Table B.10 The link and station modifications of corridor 10 (Continue)

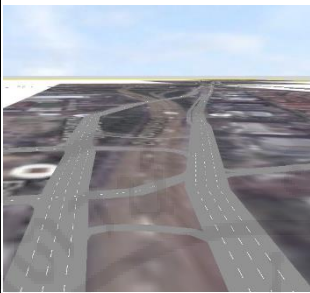
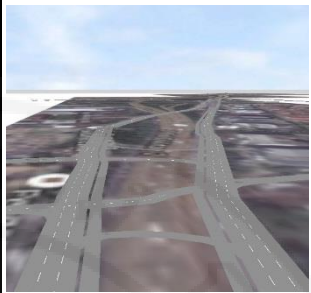
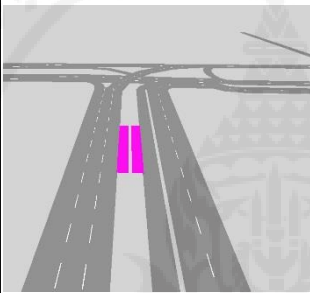
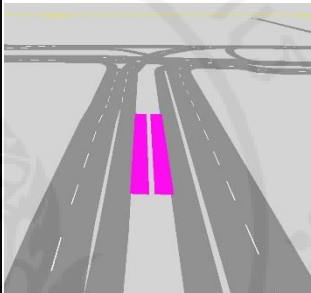
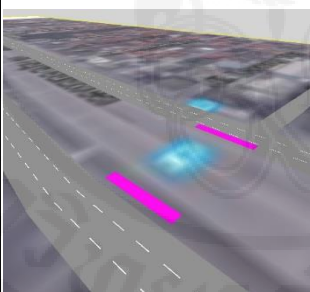
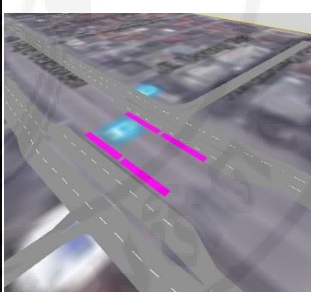
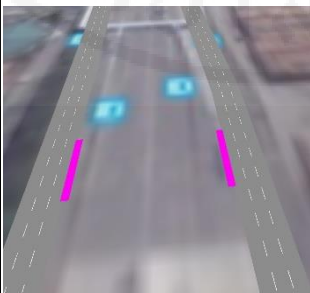
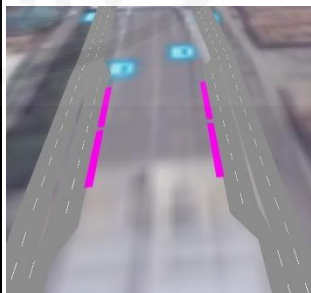
No	Location	Visualization		Description
		Existing	Recommendation	
11	link 18			A lane separation for the BRT
12	station X-2			The installation of a segregated lane
13	station X-3			The installation of extra platform, segregated lane, and passing lane
14	station X-4			The installation of extra platform, segregated lane, and passing lane
15	station X-5			The installation of segregated lane and passing lane

Table B.10 The link and station modifications of corridor 10 (Continue)

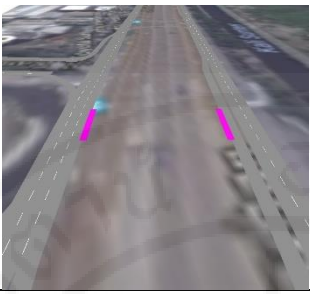
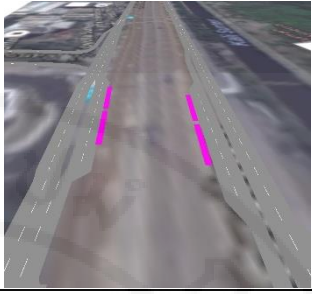
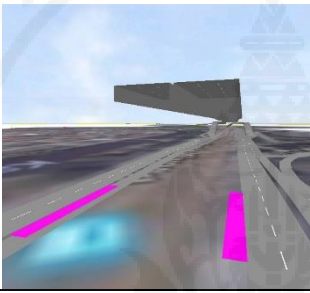
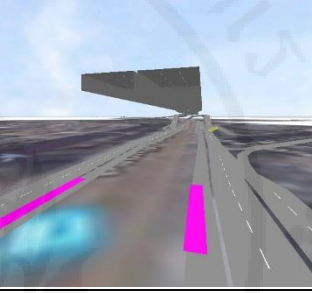
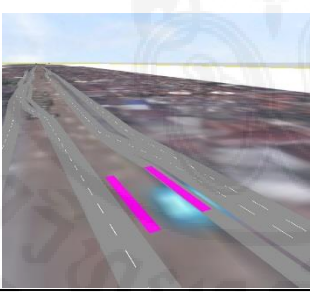
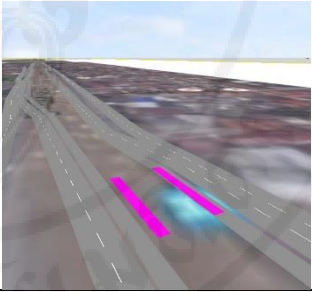
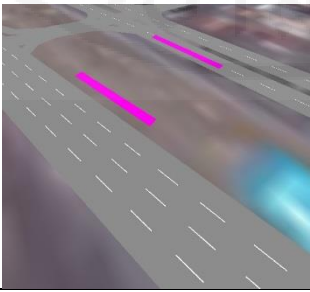
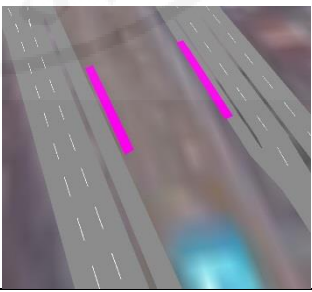
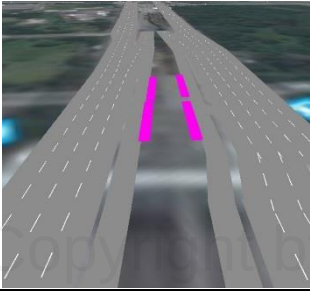
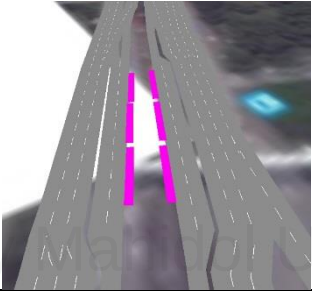
No	Location	Visualization		Description
		Existing	Recommendation	
16	station X-6			The installation of extra platform, segregated lane, and passing lane
17	station X-7			The installation of a segregated lane
18	station X-14			The installation of a segregated lane
19	station X-17			The installation of a segregated lane
20	station X-20			The installation of extra platform and passing lane

Table B.10 The link and station modifications of corridor 10 (Continue)

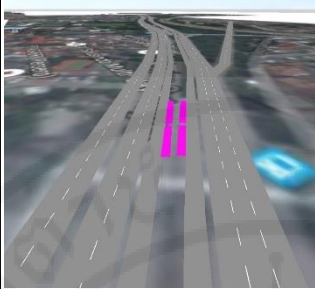
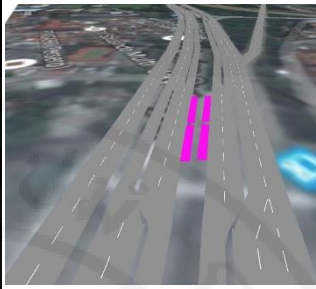
No	Location	Visualization		Description
		Existing	Recommendation	
21	station X-21			The installation of extra platform and passing lane

Table B.11 The link and station modifications of corridor 11

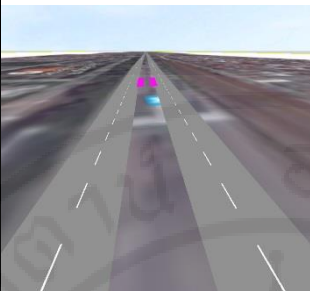
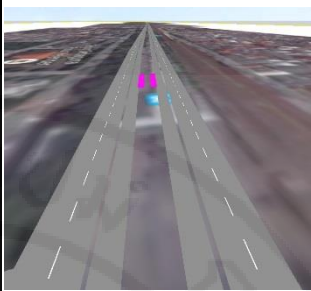
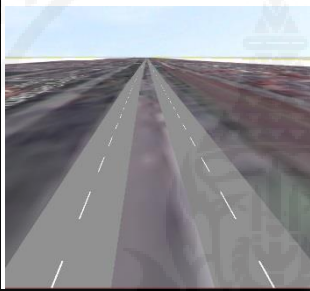
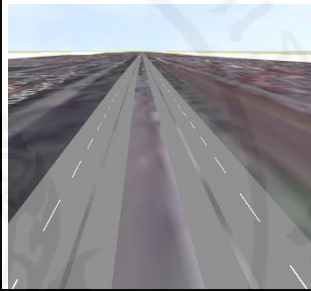
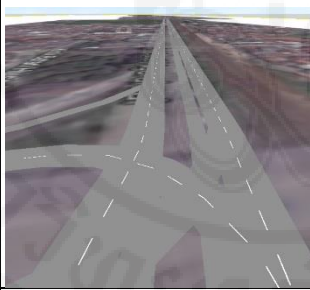
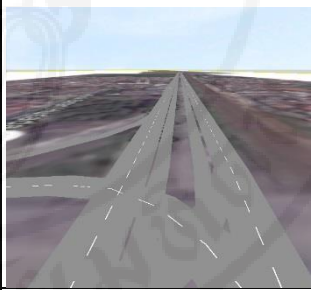
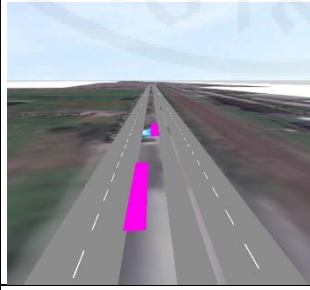
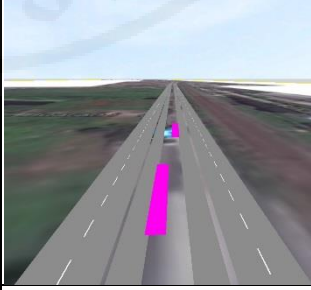
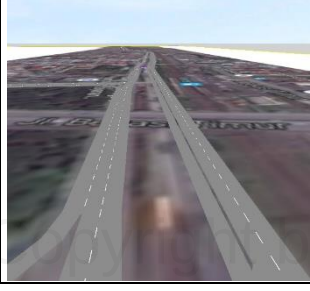
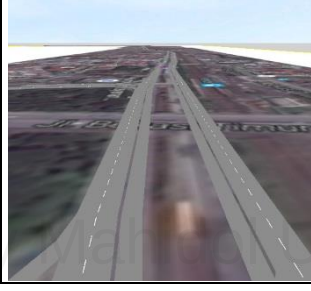
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 3			The installation of a segregated lane
2	link 4			The installation of a segregated lane
3	link 5			The installation of a segregated lane
4	link 6			The installation of a segregated lane
5	link 8			A lane separation for the BRT

Table B.11 The link and station modifications of corridor 11 (Continue)

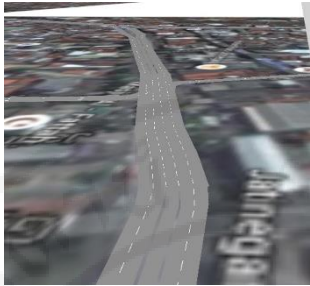
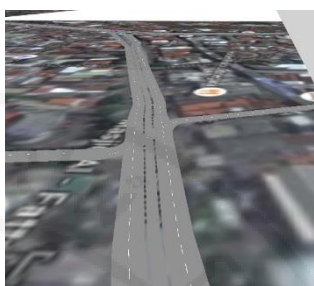
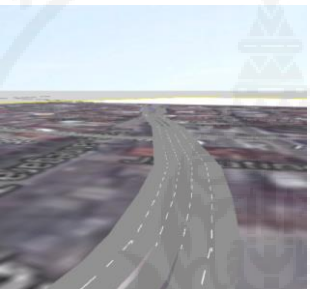
No	Location	Visualization		Description
		Existing	Recommendation	
6	link 14			A lane separation for the BRT
7	link 15			A lane separation for the BRT
8	link 16.1			A lane separation for the BRT

Table B.12 The link and station modifications of corridor 12

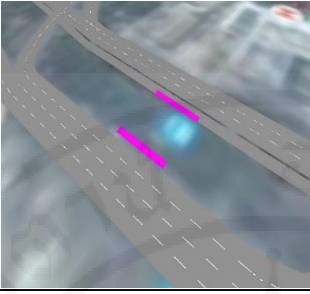
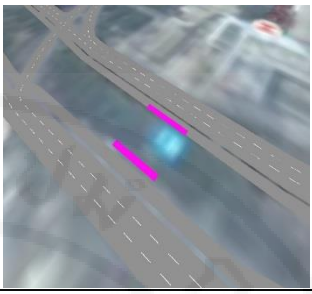
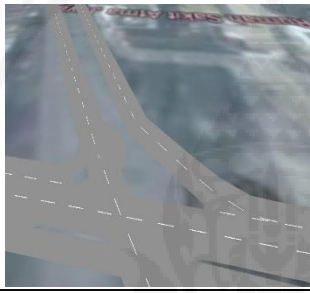
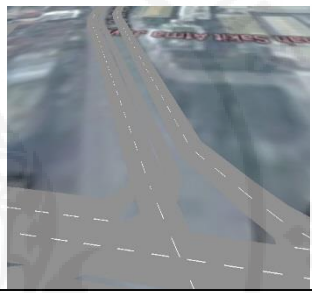
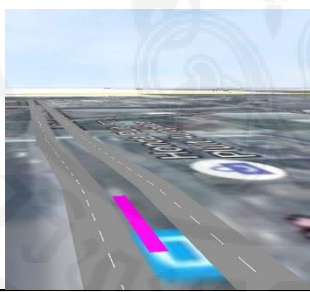
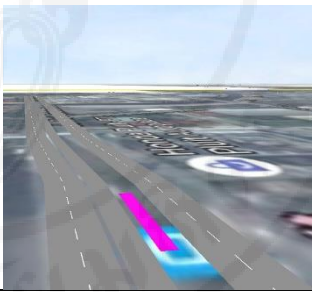
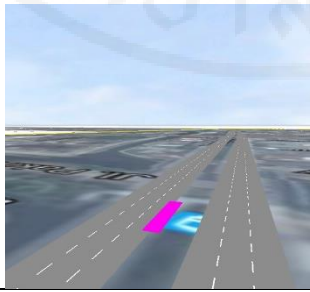
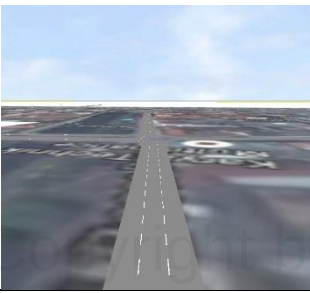
No	Location	Visualization		Description
		Existing	Recommendation	
1	link 1.2			A lane separation for the BRT at the first direction
2	link 1.3			The installation of a segregated lane
3	link 2			The installation of a segregated lane
4	link 3			The installation of a segregated lane
5	link 8.2			A lane separation for the BRT

Table B.12 The link and station modifications of corridor 12 (Continue)

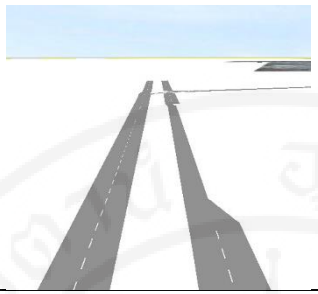
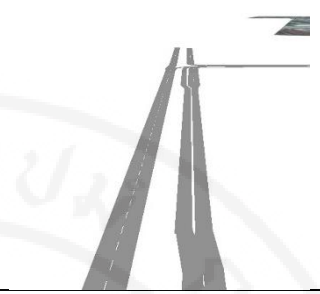
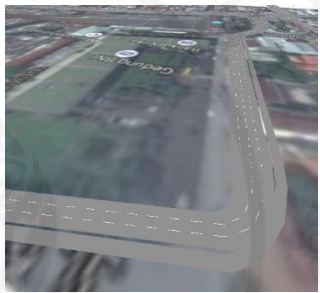
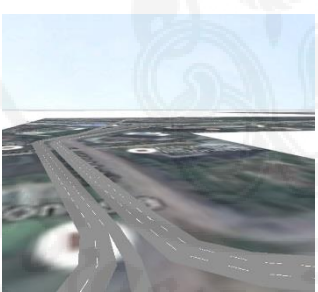
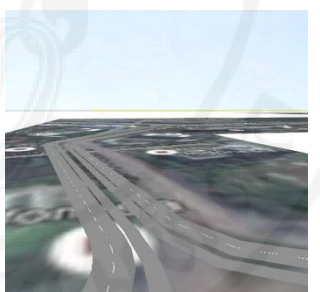
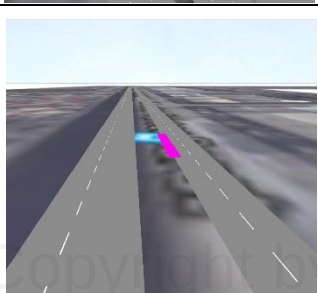
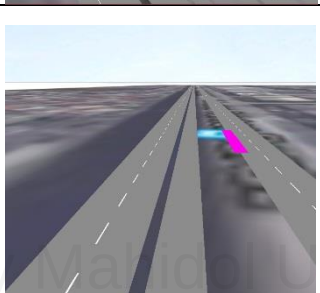
No	Location	Visualization		Description
		Existing	Recommendation	
6	link 9.1			The installation of a segregated lane
7	link 9.2			A lane separation for the BRT
8	link 15.2			A lane separation for the BRT
9	link 16			A lane separation for the BRT
10	link 17			A lane separation for the BRT

Table B.12 The link and station modifications of corridor 12 (Continue)

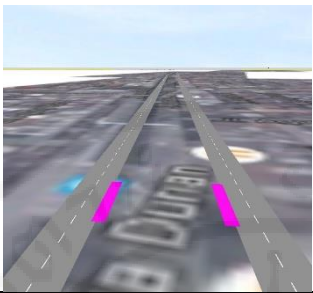
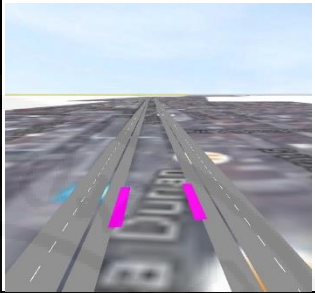
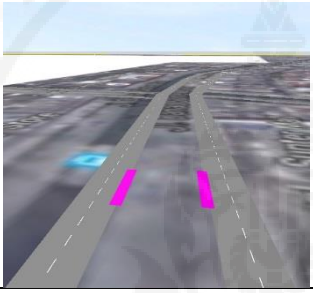
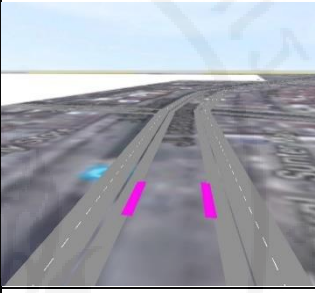
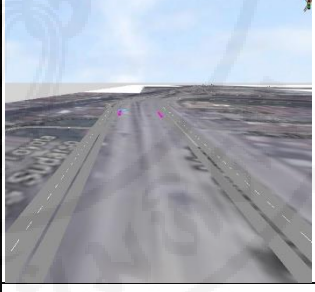
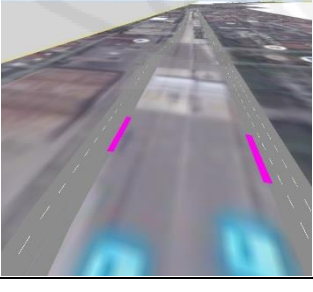
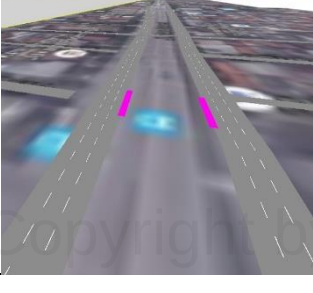
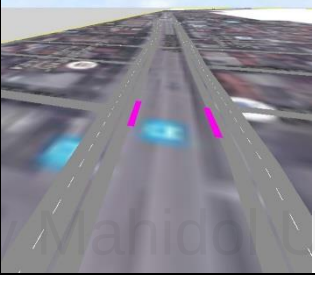
No	Location	Visualization		Description
		Existing	Recommendation	
11	link 18			The installation of a segregated lane
12	link 19.1			The installation of a segregated lane
13	link 21			A lane separation for the BRT
14	link 22			A lane separation for the BRT
15	link 24			A lane separation for the BRT

Table B.12 The link and station modifications of corridor 12 (Continue)

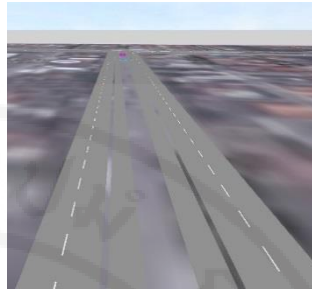
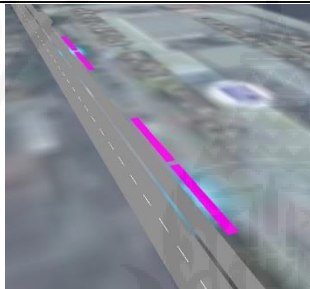
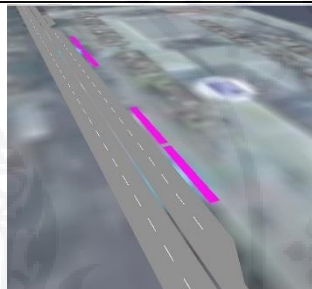
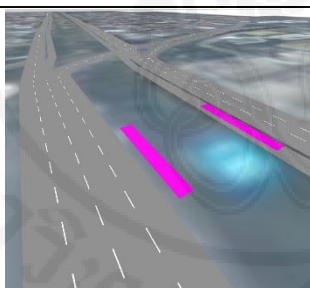
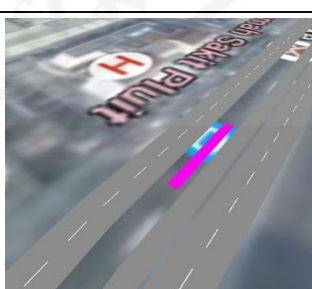
No	Location	Visualization		Description
		Existing	Recommendation	
16	link 25			A lane separation for the BRT at the first direction
17	station XII-1			The installation of a passing lane
18	station XII-2			The installation of extra platform, segregated lane, and passing lane
19	station XII-5			The installation of a segregated lane
20	station XII-6			The installation of a segregated lane

Table B.12 The link and station modifications of corridor 12 (Continue)

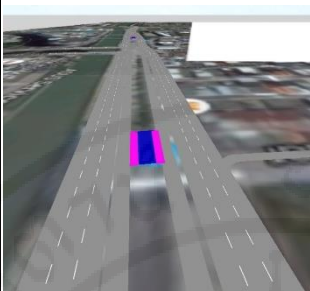
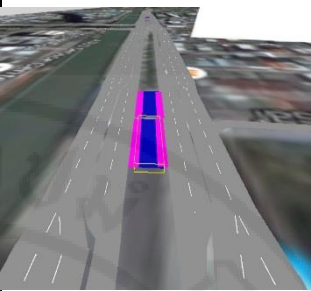
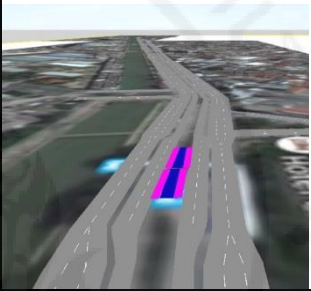
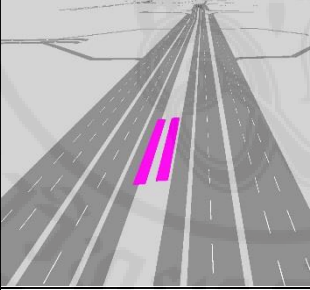
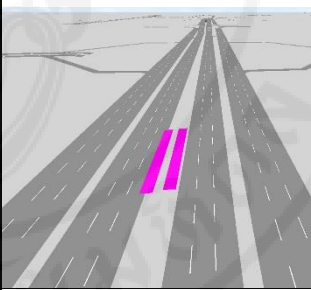
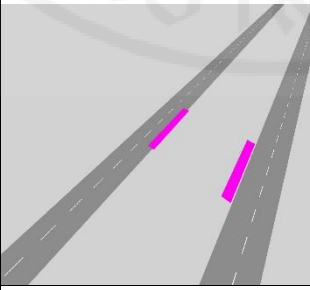
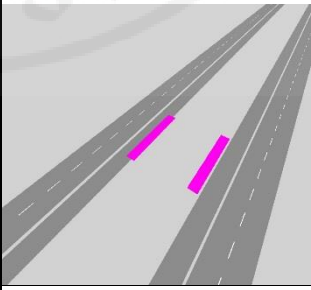
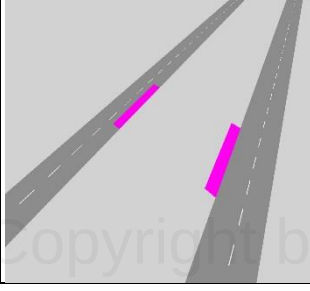
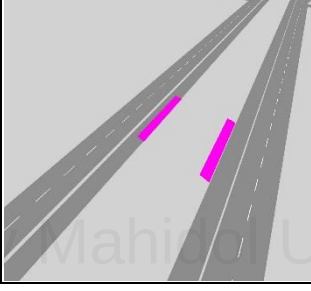
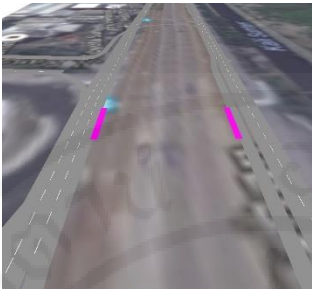
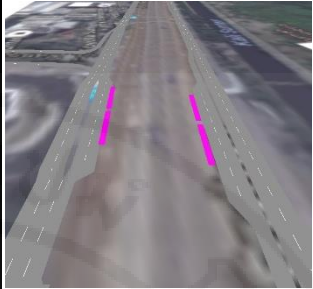
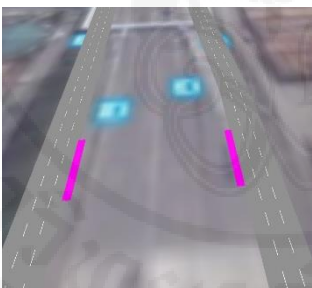
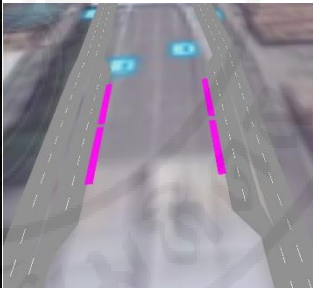
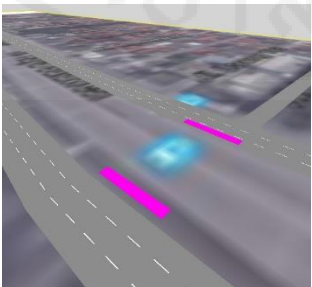
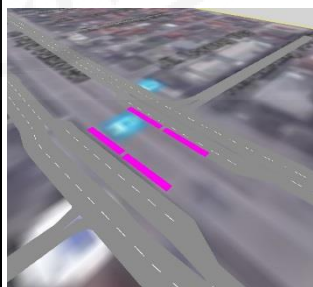
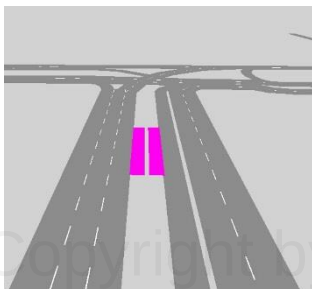
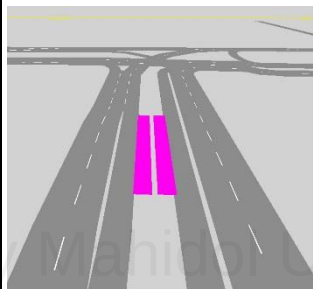
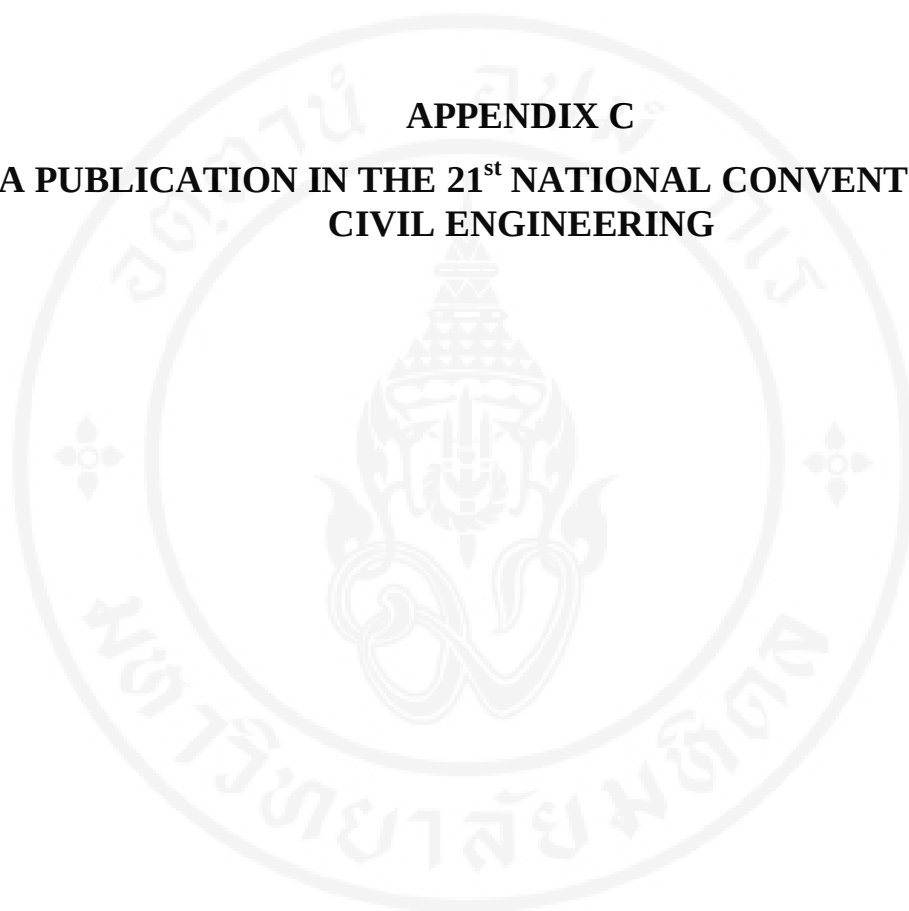
No	Location	Visualization		Description
		Existing	Recommendation	
21	station XII-9			The installation of extra platform and passing lane
22	station XII-10			The installation of extra platform and passing lane
23	station XII-11			The installation of a segregated lane
24	station XII-12			The installation of a segregated lane
25	station XII-13			The installation of a segregated lane

Table B.12 The link and station modifications of corridor 12 (Continue)

No	Location	Visualization		Description
		Existing	Recommendation	
26	station XII-15			The installation of extra platform, segregated lane, and passing lane
27	station XII-16			The installation of segregated lane and passing lane
28	station XII-17			The installation of extra platform, segregated lane, and passing lane
29	station XII-18			The installation of extra platform, segregated lane, and passing lane
30	station XII-19			The installation of a segregated lane

APPENDIX C
**A PUBLICATION IN THE 21st NATIONAL CONVENTION ON
CIVIL ENGINEERING**



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BIOGRAPHY

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DATE OF BIRTH	05 February 1989
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INSTITUTIONS ATTENDED	The Graduate School of Land Transportation, 2008 – 2012 Bachelor of Applied Science (Land Transportation) Mahidol University, 2014-2017 Master of Engineering (Civil Engineering)
HOME ADDRESS	Perhubungan Darat Residence, Setu Rd, km 3.5, Cibitung, Bekasi district, West Java province, 17001 Tel: +62 822-1817-6001
PUBLICATION / PRESENTATIONS	Yudhanto Maharuto and Somchai Pathomsiri. (2016) “The comparison study of physical, operational, and performance characteristics of Bus Rapid Transit (BRT) system in Jakarta Metropolitan City and Bangkok.” In the Proceedings of the 21 st National Convention on Civil Engineering, Songkhla, Thailand, June 28-30, 2016.