RELIABILITY OF RAPID PENANG OPERATION IN MIXED TRAFFIC SITUATION

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By

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I hereby declare that all corrections and comments made by the supervisor(s) and examiner have been taken into consideration and rectified accordingly.

Signature: Approved by:

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(Signature of Supervisor)

Date : Name of Supervisor :

Date :

Approved by:

_____

(Signature of Examiner)

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Date :

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ABSTRAK

Sistem pengangkutan awam telah berkhidmat kepada para pengguna awam untuk sekian lamanya di seluruh dunia dengan pelbagai pilihan mod yang sedia ada; seperti teksi, kereta api, dan sistem pengangkutan bas awam merupakan salah satu pilihan mod. Ketersediaan sistem pengangkutan bas awam telah menyakinkan para pengguna awam dengan kualiti servis yang diberikan seperti kecekapan, kekerapan, keselesaan dan sebagainya. Justeru itu, kerajaan dan agensi berkaitan telah mengambil tanggungjawab untuk mengekalkan dan meningkatkan kualiti servis sistem pengangkutan bas awam bagi kesejahteraan para pengguna awam yang memilih mod ini sebagai pilihan dikehendaki untuk perjalanan harian kemana sahaja diingini. Kajian ini memfokuskan Rapid Penang untuk mengukur tahap prestasi sistem pengangkutan awam di Pulau Pinang. Daerah Timur Laut di Pulau Pinang merupakan kawasan terpilih kerana memiliki kepadatan penduduk yang tinggi dan terdapat tiga laluan bas yang dikehendaki dalam daerah ini iaitu laluan bas 101 untuk zon utara, laluan bas 203 untuk zon tengah dan laluan bas 301 untuk zon selatan berdasarkan kekerapan laluan bas. Daripada keputusan yang telah didapati, Rapid Penang telah mencapai prestasi yang amat baik. Laluan bas 203 telah mencapai tahap servis A semasa waktu puncak dan bukan waktu puncak. Manakala, laluan bas 101 dan 301 telah mencapai tahap servis A semasa waktu puncak pagi dan bukan waktu puncak serta tahap servis B semasa waktu puncak petang. Oleh itu, amatlah penting untuk memastikan serta mengekalkan prestasi sistem pengangkutan bas awam.

ABSTRACT

Public transportation system has been serving the public user for many years all over the world with variety of public mode available; such as taxi, railway, and public bus transportation system is one of the mode options. The availability of public bus transportation system in most of the countries has gained trusted and confidence from the public user for its quality of service in every aspect such as punctuality, frequency, comfortability and many more. In action to that, the government and related agency have taken responsibility to maintain and increase the quality of service of public bus transportation system for the sake of public user's prosperity and safety, which uses this public mode as their preferred choice for commuter trip to go anywhere they desired. In this study, Rapid Penang is the focus of the research as to evaluate the performance of public bus transportation system in Penang Island. Northeast Penang Island district is the selected study area as having the higher population and there are three bus routes selected in this district which are bus route 101 for the northern zone, bus route 203 for central zone and bus route 301 for southern zone based on most frequent bus routes. From the results obtained, Rapid Penang has managed to provide good services. Bus route 203 has achieved level of service of A during peak hours and non-peak hours. Meanwhile, bus routes 101 and 301 have achieved level of service of A during morning peak hours and non-peak hours but level of service of B during evening peak hours. Thus, it is important to keep and maintain the performance of public bus transportation system.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Reliability, in the context of public transportation system is a measure key of quality of service. Reliability is often regarded as one of the most important aspect to achieve satisfaction of passengers towards public transportation system, with regards to the bus service in particular. Saberi et al. (2013) mentioned that, as reliability is one of an important key in bus service, enhancing the reliability of bus service has the chance to increase the attractiveness of public transit to current and prospective riders. To some extent, reliability is about how reliable of the bus performance system is towards providing better service to the public.

As far as reliability is concerned, it is important to have an excellent performance of bus system as well as good impression from passengers' perspective. Thus, this is where Rapid Penang as bus operator in Penang plays the most crucial role for achieving this accomplishment. Rapid Penang aims to provide a comfortable, affordable and reliable public transport service for Penang. As previously stated, it is believed that reliability is one of significant aspect to attain these aims, moreover, in the case of in mixed traffic situation.

In the attempt of achieving the best reliability in bus services, mixed traffic situation is a condition or flow of road where it consists of a wide variety of vehicles from commercial, passenger and other, that are available in the same highway. Chandra and Sikdar (2000) wrote that in mixed traffic situation, the interaction amount is predicted to change with the mix characteristics prior to the different vehicles types

share the same roadway space in the absence of any physical segregation. It is also said that, during peak hour on urban roads, the connection among the vehicles is greatest. Indeed, during mixed traffic situation, reliability is most important manner especially for bus service. In this study, mixed traffic situation is merely a scene in order to investigate how reliable is the reliability of bus services in a city as there will be no trial run on how to measure the mixed traffic situation, which depends on the population density factor in an area.

Therefore, reliability is no doubt yet vital in public transportation system specifically bus services in mixed traffic situation.

1.2 Problem Statement

Bus service, especially in urban areas, is facing the challenge to enhance its reliability as the rapid increase in number of private vehicle ownership in Malaysia and due to the mixed traffic situations. In addition, the problem regarding availability of roads is caused by growth of vehicle ownership and the number of trips (Wijaya, 2009). According to Department of Statistic Malaysia (2015), the increasing total population of 31.7 million persons in Malaysia is parallel with the total registered vehicle, which is increasing from year 2010 to 2015 (Road Transport Department Malaysia, 2015) as shown in both Figure 1.1 and Figure 1.2 respectively.

Although a wide range of public transport preferential measures were proposed and implemented such as bus lanes, bus priority signals, passenger information systems, yet this implementation of such measures to improve the performance of bus services were somehow unsuccessful.

Hence, this study attempts to investigate the reliability of bus performance system in mixed traffic situation by determining the factors affecting reliability and

develop reliability indicators and therefore, attributes that lead to the improvement of the transportation system as well as passengers' satisfaction.

In this study, most frequent bus routes in Pulau Pinang were selected. The selection was based on population density factor in a particular area in Pulau Pinang.

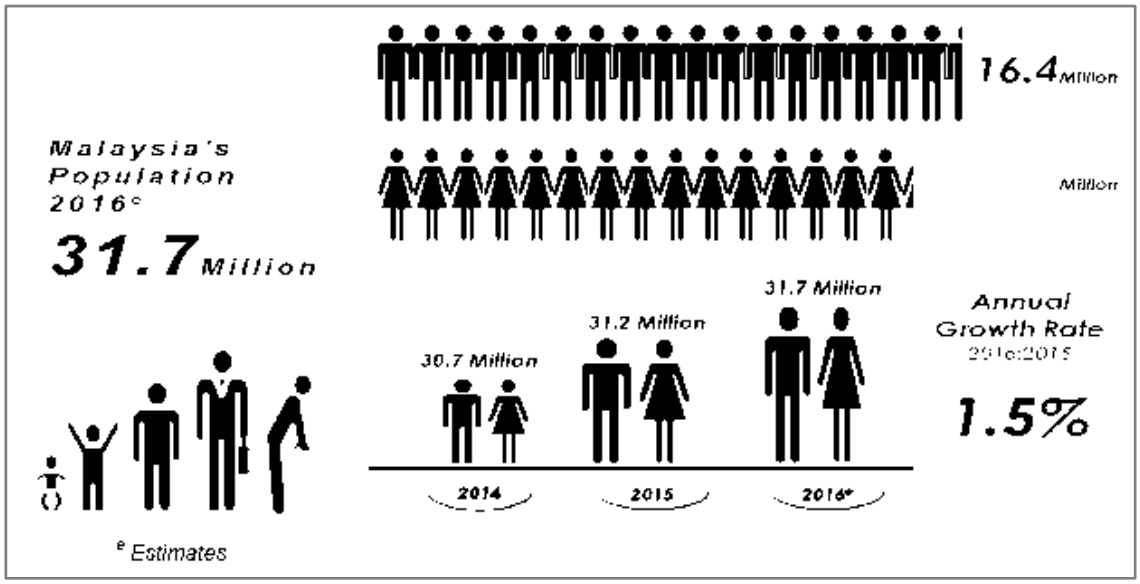


Figure 1.1: Population in Malaysia, 2014-2016
(Department of Statistics Malaysia, 2016)

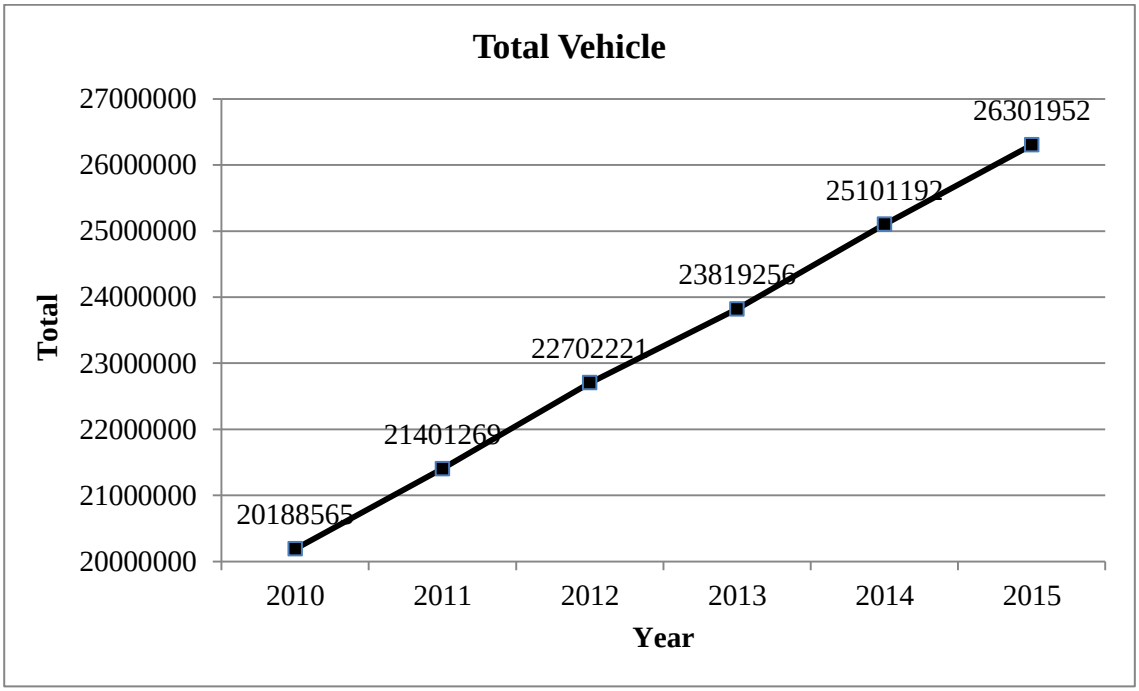


Figure 1.2: Total vehicle registered in Malaysia, 2010-2015
(Road Transport Department Malaysia, 2016)

1.3 Research Aim and Objectives

The aim of this study is to evaluate the bus performance system based on its reliability in mixed traffic situation. To achieve this aim, the following objectives have been identified:

i. To identify factor affecting the reliability of bus performance system in mixed traffic situation.

ii. To determine reliability indicators of bus performance system in mixed traffic situation.

iii. To investigate bus occupancy rates for different time periods.

1.4 Limitation of the Study

This research was a study of Rapid Penang operation in mixed traffic situation which took place in northeast of Penang Island as having the highest number of population, and only three bus routes had taken into consideration based on most frequent bus routes.

1.5 Organizations of the Study

This organization of the study is presented in order to guide the reader through this study and to give a brief overview of each chapter. This study is divided into five chapters which are included as follows:

Chapter 1 describes about general background of the study, statement of the problem, research aim and objective, limitation of the study and the organization of the study.

Chapter 2 deals with literature review from previous study related to the study area, which is reliability of bus performance system.

Chapter 3 provides the research methodology adopted for the study to be carried out, whereas the selection of study area and bus routes is the critical part in this chapter.

Chapter 4 presents the analysis of tabulated data and interpret all the data collected from selected bus routes in the study area with the help of field visit, on board survey and observations.

Chapter 5 summarizes the research work performed. It develops a clear view about the study in the form of conclusions.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter deals with various concepts regarding reliability of bus performance system in mixed traffic situation reviews all the available journals, books, thesis, journal articles and other favourable materials.

2.2 Definition of Reliability

The term reliability refers to the quality of being trustworthy or of performing consistently well. Reliability is something that can be trusted or believed of something which it works well in the way from one's expectation. In transportation system, there has been a number of ways where the term reliability can be defined as, yet it is most commonly used to refer as the average waiting time of passengers. In the same way, Chen (2009) points out that, from one point of view, reliability of bus service influence the amount of time passengers must wait at a transit stop for a bus to arrive, as well as the consistency of a passenger's arrival time at a destination from day to day. Similarly, a definition provided by Leong (2016), service reliability is a key attribute of the travel experience for many public transport users.

In the previous study conducted by Parasuraman et al. (1991), there are five aspects of quality of service, and reliability is of the aspect (as cited in Wijaya, 2009). In his study, reliability is the capability to afford services agreed to the right (accurately) and the competence to be trusted (dependably), primarily to sustain services in a timely manner (on time), in the same manner prior to the schedule that has been assured, and without underestimation every time. The virtue in this aspect is:

i. Skill to carry out the agreed service dependably and accurately

ii. Provision to services as promised

iii. Devotedness in handling customers' service problems

iv. Performing services right the first time

v. Affording services at the agreed time

vi. Keeping customers know what's what regarding the performance of service

Likewise, Eboli and Mazulla (2012) propose that service reliability is one of the utmost investigated transit service feature and it is take into account as a notably weighty for the transit users. The Highway Capacity Manual (2010) defines transit service reliability as the "unplanned passenger waiting time at the stop" and it is also suggests that transit vehicle reliability is reflected by that excess wait time. Commenting on reliability, Vincent and Hamilton (2008) observe that the term reliability relates to doubt in the duration taken to travel from the beginning until the end of a person's itinerary in a transport context.

2.3 Public Bus Transportation System as Reliable Public Service

Public transportation system has been widely influential and remarkable in all countries; either it is developing or developed nations. In accord with, transportation is a main element in the system of life and the life, the government system, social system (Wijaya, 2009). Also, according to Wijaya (2009), bus services take the primary part in providing of public transport. As Vincent and Hamilton (2008), agrees that reliability is crucial for both operators and passengers. Essentially, reliability in public transportation system, prior to public bus transport is one of the greatest aspects to afford better service to the public.

Although this may be true, public transport users are distressed regarding lateness on arrival at their journey's end (Vincent and Hamilton, 2008). From judgements of customer, the expectations which correspond to the demand of service, and the perceptions, which correspond to the acceptance of service (Parasuman et al., 1985 cited in Eboli and Mazzulla, 2012). From these, the service demand and the service acceptance by the customers should be compliance to each other; this is where service reliability represents both of these attributes. As a matter of fact, Wijaya (2009) concludes that well-informed of customer's expectations and the extent to which those expectations are being met is important to straighten out service.

Wijaya (2009) also writes that, in order to increase the accessibility of society, it is important to focus on developing public transport which is convenient, safe and cheap from the dimension of social justice reviewing the reliability of transportation as a public service.

2.4 Public Bus Transportation Characteristics

In technical definition, bus is a vehicle that operating individually with rubber tires, with manual lateral and longitudinal controls (Wilson, 2006). Meanwhile, Wijaya (2009) defines that bus transport is a vehicle that has more than 8 (eight) seats not including the four drivers to sit, either with or without baggage transportation equipment.

Public bus transport has served the public for many years, all over the world. Bus transportation provide mean to travel from one to another place within uncertainty duration, at an affordable ticket price. Furthermore in Chapter 6, Ponnuswamy and Victor (2012) provide a definition where buses are an affordable means of transportation, and serve flexibility and convenience when compared with other modes.

Additionally, in most city areas, buses form the predominant mode for length of trip more than 3 to 8 km but below 200 km.

Ponnuswamy and Victor (2012) point out that during peak hour, average speeds are 16 to 20 km per hour (kph) on typical city roads, and in highly congested areas, the average speeds can even be 8 to 16 km per hour (kph). Thus, bus headways rely on demand of traffic, and may differ between 5 and 60 minutes on a normal urban route. As for bus noise level, at a speed of about 50 km per hour, it may normally be 80 dBA inside the bus while 84 dBA outside from the bus on plain ground at a distance of 15 m.

According to Ponnuswamy and Victor (2012), there are four agencies involved in bus transport operation as shown in schematic diagram in Figure 2.1, which are:

a) The passengers
b) The operator: Generally the State Transport Undertaking, responsible for transit operation for the concerned city. Furthermore, they receive fare revenue as input and deliver the service of transport to the passengers, and supplement to the community welfare and to the government objectives indirectly.
c) The society: Supplies land, energy and resources to the operator, and gets back economic and environmental impacts from the transport operation.
d) The government: Imposes taxes on the society and receives taxes, and effect of social and political from the operator. In the meantime, supporting the transport operation through regulations, subsidies and provision of the roadway on which the buses operate.

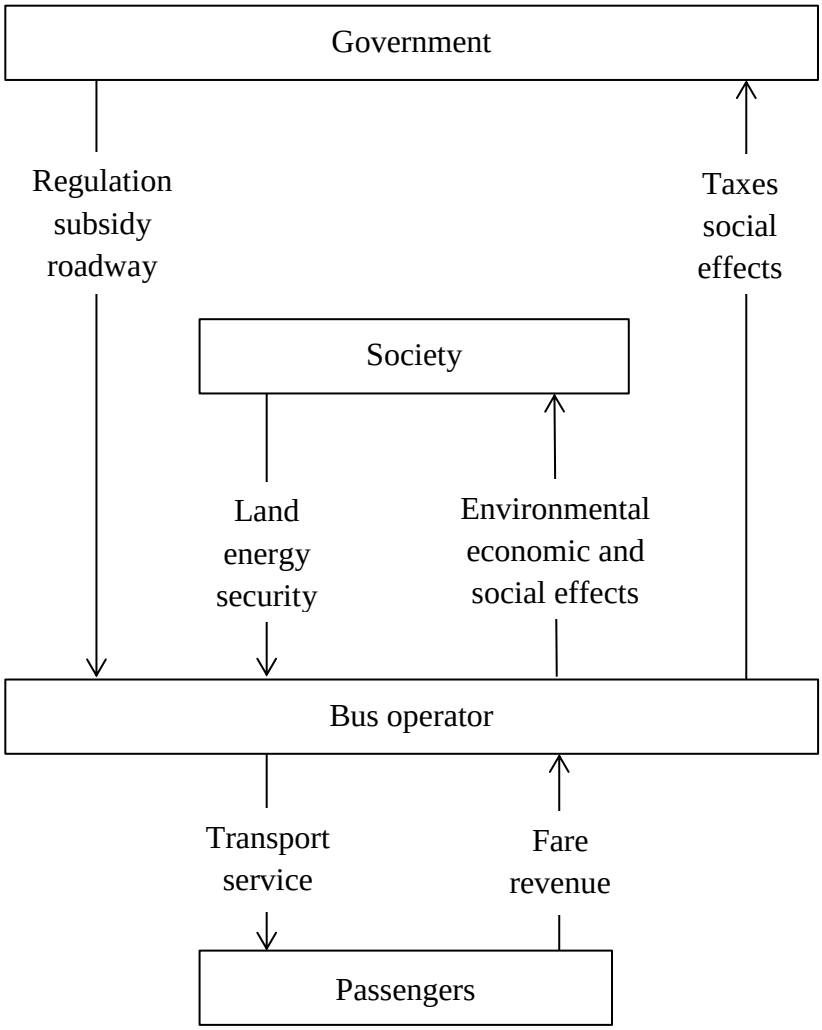


Figure 2.1: Role of Four Agencies in Bus Transport System
(Ponnuswamny and Victor, 2012)

2.5 Mixed Traffic Situation Characteristics

In many developing countries and areas, mixed traffic flow comprises the existence of motorised and non-motorised universally, chiefly at road segments without median separation (Luo et. al, 2014). Similarly, traffic flow contained vehicles of different group including car, bus, truck, motorized two wheelers etc. and such that these vehicles distinguish in characteristics of mobility and speed according to Dhamaniya and Chandra (2013). In addition, Dhamaniya and Chandra (2013) mentioned that, there are more than then different car sizes on the road and unlike operating characteristics although in the same division of car and makes the movement of traffic an extremely complex phenomenon due to all these combinations in a mixed traffic situation.

Furthermore, the behaviour of metropolitan traffic in most of the developing countries is greatly different from developed nations, due to these high compositions in mixed traffic of two-wheelers, autos and non-autos three wheelers, cars, buses, trucks, bicycles and various types, yet two-wheelers are the main mode of transportation (Patel et al., 2015). Mixed traffic situation is indeed a heterogeneous traffic flow as it is composed of variety of vehicle, which differs in speed, size, operating characteristics etc.

2.6 Factors Affecting Reliability of Bus Performance System

Reliability is influenced by a number of factors. As listed in the Transit Capacity and Quality of Service Manual (2004), these factors include:

- Traffic conditions
- Road construction
- Quality of vehicle and maintenance
- Availability of vehicle and staff
- Transit preferential treatments
- Schedule achievability
- Evenness of passenger demand
- Differences in operator driving skills, route familiarity, and adherence to schedule
- Wheelchair lift and ramp usage (generally dwell time)
- Route length and number of stops
- Operations control strategies
- Weather
- Incidents

On the other hand, according to previous study conducted by Wijaya (2009), there are several factors affecting reliability, which are:

- Waiting time for the bus: The bus did not come immediately and literally the waiting time of the bus in shelter is very long, which both scenes had experienced by passengers.
- On time departure: Both customers and bus drivers know the signification of on time departure, and due to the bus frequently run on

time, or in a period of a few minutes of schedule, it is achievable to depend on the static time-table to a great extent.

- On time arrival at the next stop: The time consuming of the bus trip and uncommonly due to the interruption in the bus lane lead to the arrival delay of the bus in the subsequent bus stop.
- Bus drivers driving: Bus drivers detain a very critical part in the bus. The control of the bus is highly reliant on the abilities and behaviours in the driving of bus driver.

2.7 Reliability Indicators of Bus Performance System

The literature on reliability of bus performance system has highlighted several reliability indicators in previous study during the past few years. There are three indicators that will be discussed in this study, which are: (a) on-time performance, (b) headway regularity and (c) running time adherence.

2.7.1 On-time Performance

According to Chen et al. (2009), an on-time performance represents the degree of success of the bus services remaining on the advertised schedule. On-time performance can be evaluated by considering the percentage of transit vehicles departing from or arriving to a location on time (Eboli and Mazzulla, 2012).

2.7.2 Headway Regularity

Lin et al. (2008), sees headway regularity (measured in percentage) as the difference of average between the actual and the scheduled headways relative to the scheduled headway. Likewise, Transportation Research Board (2003a) holds the view that headway regularity as the evenness of intervals between transit vehicles which

expressed in percentage. It is calculated as the ration of the average difference between the actual and the scheduled headway corresponding to the scheduled headway.

Lin et al. (2008) points out, if two successive buses are distant from one another than the scheduled headways, it is called a longer difference of headway. In much the same way, it is called a shorter difference of headway if two following buses are adjacent to each other than the scheduled headway. The definition equations for headway regularity metrics are shown in equations (2.1) and (2.2).

$$\Delta\%\ longer\ headway = 100\ \% \times \left(\sum_n \frac{actual\ headway_i - scheduled\ headway_i}{scheduled\ headway_i}\right) / n \qquad (2.1)$$

$$\Delta\%\ shorter\ headway = 100\ \% \times \left(\sum_l \frac{|actual\ headway_j - scheduled\ headway_j|}{scheduled\ headway_j}\right) / l \qquad (2.2)$$

where n is the numbers of longer headway and l is the numbers of shorter headway difference at time points in the same route-direction. A high value of headway metric indicates poor headway regularity adherence and vice versa.

According to Saberi et al. (2013), the scheduled headway at a particular stop can be take account as the scheduled stop time for trip i at a stop minus the scheduled stop time for trip i-1 at the same stop as shown in equation (2.3).

$$\text{Scheduled headway} = \text{leave time}_i - \text{leave time}_{i-1} \qquad (2.3)$$

In a like manner, actual headway, delay and headway deviation can be computed based on equations (2.4), (2.5) and (2.6) respectively.

$$\text{Actual headway} = \text{leave time}_i - \text{leave time}_{i-1} \qquad (2.4)$$

$$\text{Delay} = \text{leave time}_i - \text{stop time}_{i-1} \qquad (2.5)$$

$$\text{Headway deviation} = \text{Actual headway} - \text{Scheduled headway} \quad (2.6)$$

2.7.3 Running Time Adherence

Running time adherence, an indicator measured in percentage is defined as the difference of average between the actual and the scheduled running times with respect to the scheduled running time (Lin et al., 2008). Similarly, Eboli and Mazzulla (2012) defines running time adherence, analogously to the headway regularity, as the difference of average between the actual and the scheduled running times concerning to the scheduled headway in terms of percentage.

According to Lint et al. (2008), the measure is called shorter running time when the actual running time is shorter than the schedule, and otherwise, it is called longer running time. The definition equations for running time adherence metrics are shown in the equations (2.6) and (2.7).

$$\Delta\%\ longer\ headway = 100\ \% \times \left(\sum_k \frac{actual\ run\ time - scheduled\ run\ time}{scheduled\ run\ time}\right) / k \quad (2.6)$$

$$\Delta\%\ shorter\ headway = 100\ \% \times \left(\sum_m \frac{|actual\ run\ time - scheduled\ run\ time|}{scheduled\ run\ time}\right) / m \quad (2.7)$$

where k is the numbers of longer running time events and m is the numbers of shorter running time events between two consecutive time points in the same route-direction. A high value metric of running time indicates poor running time adherence and vice versa.

2.8 Summary

As a conclusion, reliability in the aspect of public bus transportation system is one of the qualities of service for bus passengers as commuter trip for work or traveling to preferred destination throughout their daily life; such that reliability influence the time period of passengers from one place to another place. If the bus arrives on its scheduled, the passengers will arrive early on destination and contrarily. Another is, public bus transportation provides an affordable ticket price at all ages yet kids (under aged of 7), student and senior citizen have priority prior to ticket price. Furthermore, the reliability is often related to its factor affecting the bus performance system such that it is influenced by traffic conditions, road construction, route length and number of stops and many others. To add on, another several factors affecting reliability are waiting period for the bus, on-time departure and arrival and the behaviour of bus drivers. There are three highlighted reliability indicators to evaluate bus performance system that has been mentioned previously; on-time performance, headway regularity and running time adherence.

CHAPTER 3

METHODOLOGY

3.1 Overview

This study focused on Rapid Penang Operation service quality in Pulau Pinang. Time of this study is conducted in March 2017. As this study is carried out in Pulau Pinang, a plan of preliminary site survey was conducted as to have an overview of Rapid Penang network system. Upon preliminary site survey, it is then necessary to have a closer look into districts of Pulau Pinang which has the most population. This is to identify the critical bus route from the chosen area which is also based on the most frequent route. Afterwards, parameters to be investigated through survey and observation in selected bus route were identified in field for data collection. From the collection of data, it was measured and analysed for the outcome result and hence a conclusion was made at the end of the study. The methodology of this study can be summarised in the flowchart as shown in Figure 3.1.

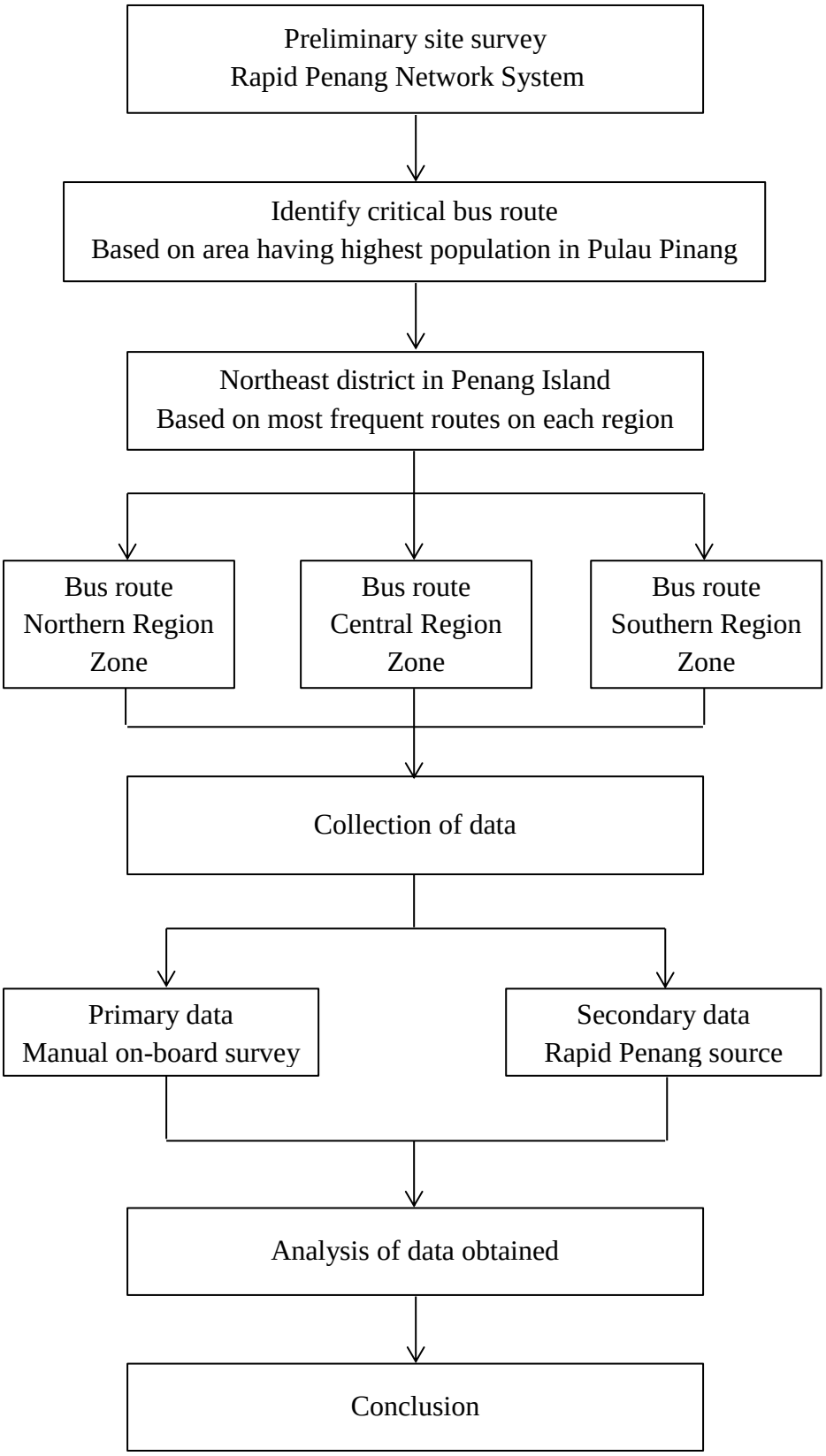


Figure 3.1: Flow chart of the study

3.2 The Study Area

The first step in this study was to acquire more information about Rapid Penang. The second step was selecting the study area and finally, selection of the critical bus routes in the study area that will be investigated.

The selection of study area was made based on population density factor which represented a higher number of populations in an area. As for this study, northeast district in Penang Island has selected which having the highest population compared to other districts such as southwest and Seberang Perai consists of north, central and south region as shown in Table 3.1. Map of Pulau Pinang by district is shown in Figure 3.2.

According to Northeast Penang District and Land Office (2016), northeast Penang Island district covers an area of 122.79 square km and has a population of 520,242 people.

Table 3.1: Population by district in Penang (Department of Statistics Malaysia, 2012)

District	2012	
	1×10^6	%
Northeast	529.4	32.86
Southwest	209.1	12.98
North Seberang Perai	303	18.81
Central Seberang Perai	384	23.83
South Seberang Perai	185.6	11.52
Pulau Pinang	1,611.10	100.00

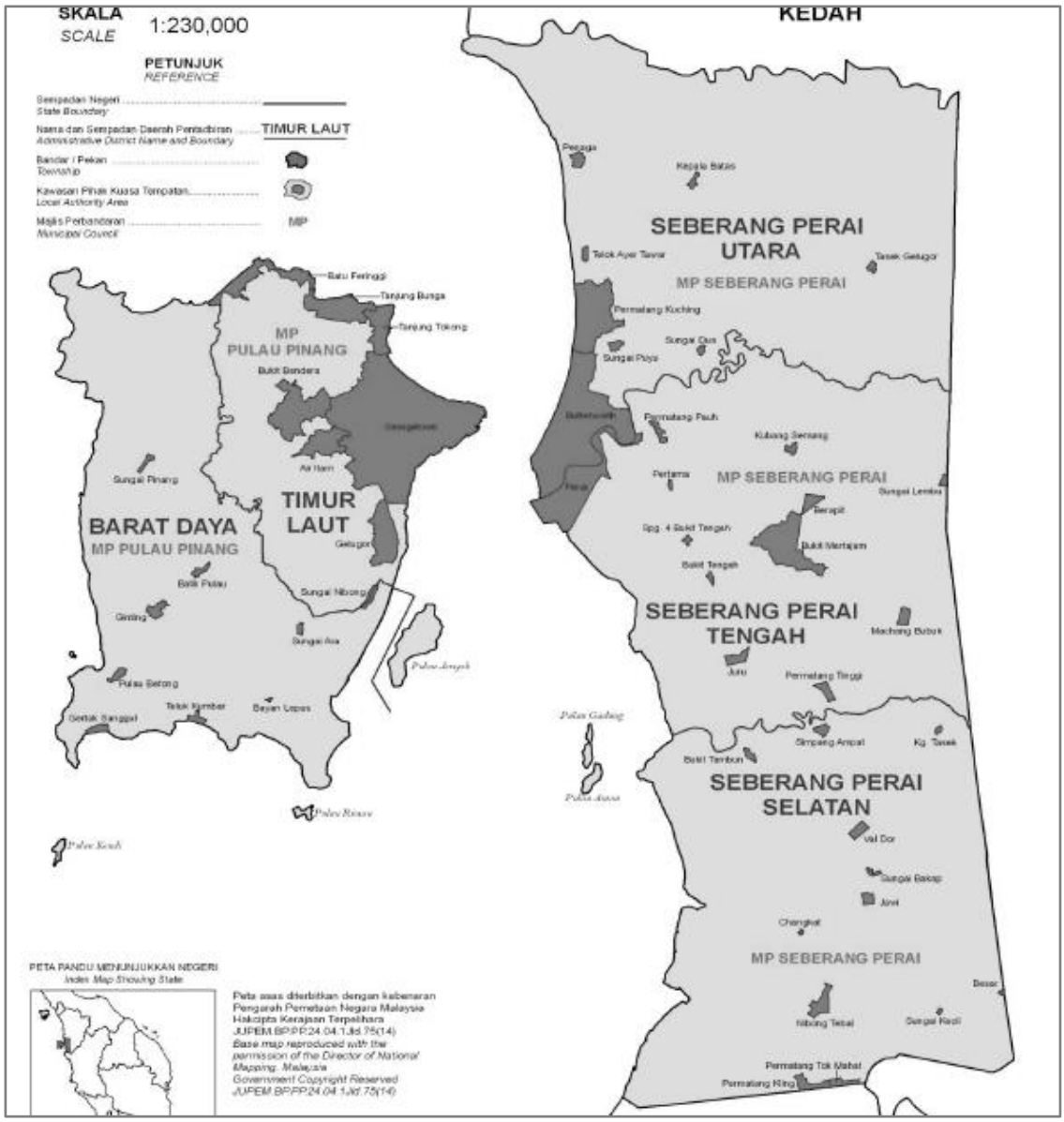


Figure 3.2: Map of Pulau Pinang by district
(Department of Statistics Malaysia, 2012)

3.3 Selection of Bus Route in Study Area

As discussed previously regarding the study area, the selection of the bus route was based on most frequent bus routes according to Rapid Penang (2015) as shown in Table 3.2. It was decided to take up three bus routes in northeast Penang Island district, which was bus route 101, 203 and 301. All these bus routes started from Jetty or known as Weld Quay Ferry and Bus Terminal, and ended at respective hub station of bus route 101, 203 and 301. The following section had discussed in detailed for each bus route.

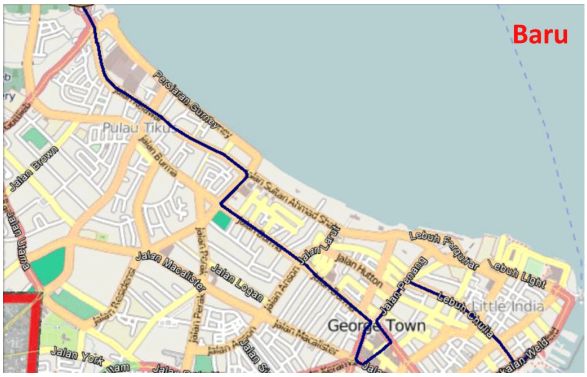
Table 3.2: Top 10 most frequent bus routes (Rapid Penang, 2015)

No	Service	Average monthly passengers	Average daily passengers	% share of total users
1	101*	220,084	7,336	11.78
2	301*	132,388	4,413	7.08
3	302*	129,508	4,317	6.93
4	303*	93,314	3,110	4.99
5	401 (EX)*	90,611	3,020	4.85
6	203*	85,446	2,848	4.57
7	201*	82,697	2,757	4.43
8	202*	80,985	2,700	4.33
9	801^	76,059	2,535	4.07
10	702^	64,654	2,155	3.46
* = Island, ^ = Mainland				

3.3.1 Bus Route 101

Rapid Penang Bus 101 is a bus route from Jetty to Teluk Bahang and back. Bus 101 covers the northern coast of Penang Island. From the Jetty, it passes through the northern suburb of Pulau Tikus before continuing to Tanjong Tokong, Tanjung Bungah, Batu Ferringhi and Teluk Bahang, all the way to the gate of the Penang National Park. As shown in Figure 3.3(a), the blue line represented the going journey from Jetty to Teluk Bahang, meanwhile the red line drawn represented the a part of return journey from Teluk Bahang to Jetty due to one-way road system. This route covers 35.1 km and through 20 roads as seen in Figure 3.3(b).

Figure 3.3(a): Route Map for Bus Route 101 (Google Map, 2016)



No	No Laluan	Jarak (km)	Tambang	Daerah
1	101	31.4	4.00	Timur Laut

Maklumat Laluan

Pergi : Pengk Weld (Weld Quay)- Gat Lbh Chulia- Lbh Chulia- J Penang- J Dr. Lim Chwee Leong- J Ria- Term Bas Komtar- J Magazine- J Penang- J Burma- J Pangkor- J Perak- **J Kelawei -** J Bagan Jermal- J Tg Tokong- J Tg Bunga- Term Bas Tg Bunga- J Bt Feringgi- J Tk Bahang- J Hassan Abbas **Balik:** J Tk Bahang- J Bt Feringgi- J Tg Bunga- J Tg Tokong- J Bagan Jermal- J Burma- J Pangkor- J Perak- J Macalister- J Penang- J Transfer- J Sri Bahari- J Penang- Lbh Chulia- Gat Lbh Chulia- J Pengk Weld- Pesara King Edward dan Pengk Weld (Weld Quay)

Figure 3.3(b): Route Map for Bus Route 101 (Rapid Penang, 2016)

3.3.2 Bus Route 203

Rapid Penang bus 203 is a bus route from Jetty to Air Itam through Farlim or Bandar Baru Air Itam. Bus 203 is a commuter bus route used mostly by the locals. It passes through both Farlim and Air Itam. As shown in Figure 3.4(a), the blue represented the going journey from Jetty to Air Itam, meanwhile the red line drawn showed a part of return journey different in route due to one-way road system from the Jalan Dato Keramat to Jetty. This route covers 13.6 km and through 18 roads as seen in Figure 3.4(b)

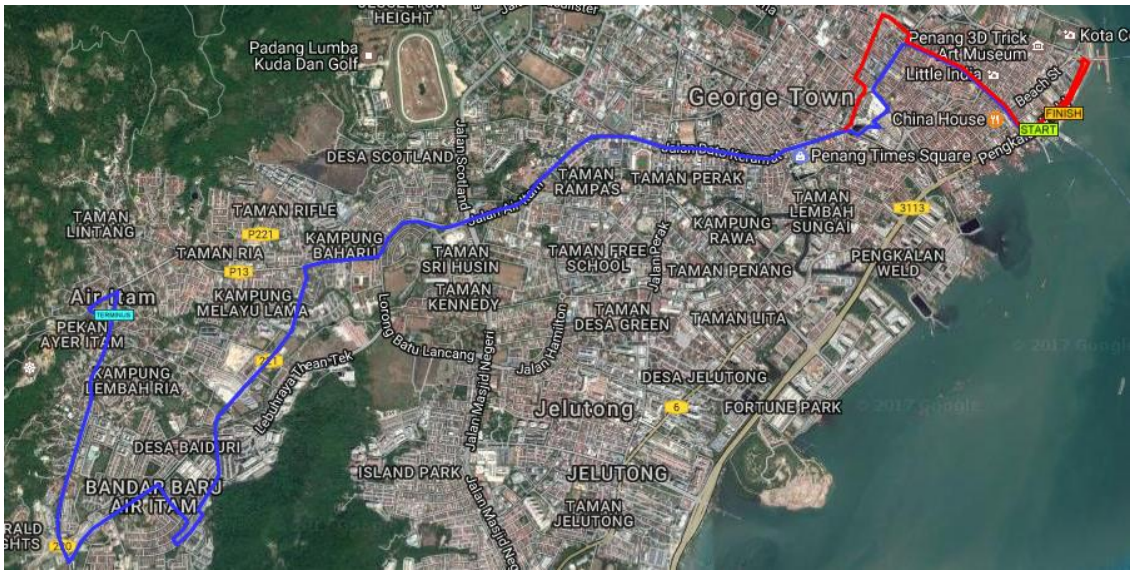


Figure 3.4(a): Route Map for Bus Route 203 (Google Map, 2016)

Figure 3.4(b): Route Map for Bus Route 203 (Google Map, 2016)

3.3.3 Bus Route 301

Rapid Penang bus 301 is a bus route from Jetty to Relau through Jalan Sg Dua. Bus 301 serves the south central neighbourhoods of Penang Island. It starts at the Jetty and ends at the fast developing suburb of Relau. The blue line as shown in Figure 3.5(a) represented the going journey from Jetty to Relau. A red line is drawn from the Jalan Dato Keramat junction shows different route in return journey due to one-way road system. This route covers 18.2 km and through 22 roads as seen in Figure 3.5(b).

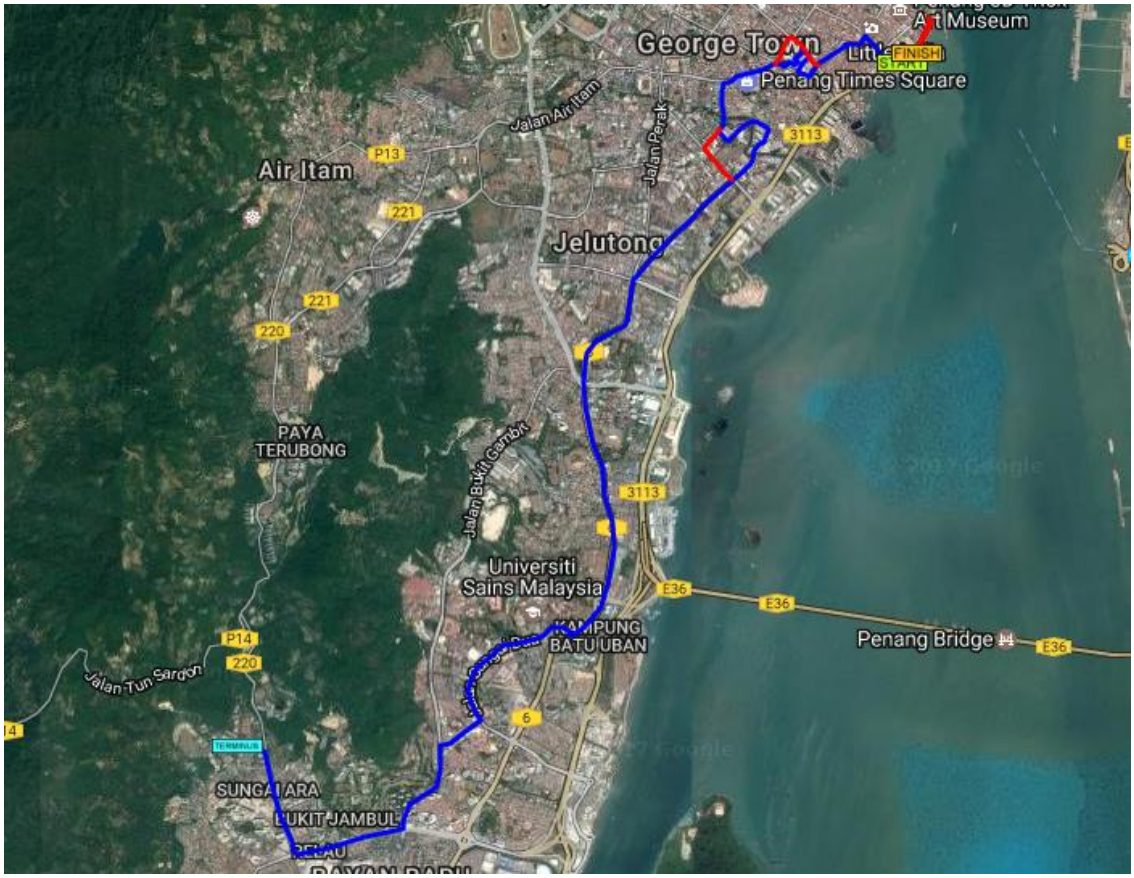


Figure 3.5(a): Route Map for Bus Route 301 (Google Map, 2016)