

Operational Characteristics of City Bus Services in Ipoh
Route: Ipoh – Bercham

by

Aisyah Safiyah binti Yob Sa'ed

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)
JUNE 2010

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

Certification of Approval

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A project dissertation submitted to the
Civil Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfillment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(CIVIL ENGINEERING)

Approved by,



(Assoc. Prof. Dr. Madzlan bin Napiah)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

June 2010

Public transportation has become one of the major forms of transportation in Ipoh. In order to maintain the passengers' interest in using the service, the quality of service need to meet the passengers' satisfaction. Operational characteristics affect the quality of service and passengers' perception on the service is important to give an overview of the current service condition. The objective of this study is to obtain the operational characteristics of city bus services in Ipoh and to compare it with urban transit design calculation. The next objective is to measure the level of service (LOS) of the service based on the obtained operational characteristics. The last objective of this study is to gain basic passengers' characteristics and their perception on the bus service. A survey was conducted for a week to obtain the operational characteristics and questionnaires were handed out to random passengers to obtain their characteristics and perception. The operational characteristics were compared to the urban transit design. The characteristics that were compared were headway, cycle time, time at terminal and number of busses. The study shows that there is a difference of 38.18%. LOS was determined for frequency, passenger load, service span and reliability and the average LOS is a LOS C. From the questionnaire, majority of the passengers have income lower than RM1000.00 per month and mostly school students. For the service assessment, more than 50% of the passengers said that the waiting time for the service is long, the fare is expensive, the bus is not comfortable and not safe and also the facilities offered are in poor condition. From the results obtained, it can be concluded that there are improvements that need to be made both from the operational performance and the condition and service of the bus aspects in order to maintain and attract other passengers' to use the public bus service.

Acknowledgement

Firstly, I would like to give my appreciation and gratitude to Asc. Prof. Dr. Madzlna bin Napiah for the guidance and knowledge that he has given me during the year of completing my final year project. Not forgetting Mr Suwardo for the guidance and the references that has helped me to understand more on the project.

Thank you to the staffs, bus coordinators and bus drivers at Medan Kid for giving full cooperation during the survey of this project. Thank you also to my college, Nurul Ashikin, who has cooperated and helped me a lot during the year for this project.

Last but not least, thank you to my parents, family and also friends who have given me moral support and encouragement in pursuing this project

Thank You.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Ipoh is the fourth largest city in Malaysia and ranked sixth most populous city in Malaysia. With the population exceeding 700,000, public bus service has become one of the major forms of transportation in Ipoh to travel by. Ipoh is the centre of economic and administration activities. Ipoh also allocates several primary and secondary schools where the cheapest mode of travelling is by public bus service. Also in present situation, where there are a wide range of private vehicles that can be bought, where people use private vehicles to go to and from work place, picking up their children from schools and to go for entertainment. This situation leads to traffic congestion especially in the centre of Ipoh. This also increases the environmental pollution. Usage of public bus service can be one of the solutions to these problems.

Medan Kidd is the centre terminal for the inter-city public bus services that provide transportation to many destinations including to Medan Gopeng (express bus terminal), Cameron Highlands, Tapah, Lumut, Kampar, Bercham and also in the Ipoh city centre.

Quality of service of the bus services need to meet the passenger's satisfaction in order to maintain their interest in using the bus services. As stated in the Transit Capacity and Quality of Service Manual (2nd Edition), quality of service reflects the passenger's perception of transit performance. Quality of service is a measurement of the service that is been offered within the constraints of its budget, particularly on where the service is provided, the frequency and duration of the service, and the kind of service that is provided.^[1]

Quality of service is a user based qualitative assessment of how well a service or facility is operating. Level of service is a quantitative breakdown of the quality of service of a service or facility into six letter grade levels, with “A” describing the highest quality and “F” describing the lowest quality.^[9] Quality of service of measured in two categories which are the availability and also comfort and convenience. Both of the elements are further divided into three elements which are transit stops, route segments and system. In the Table 1.1 below, each division of the measures and the framework is shown.

Table 1.1: Framework for Service Measures^[1]

	<u>Service Measures</u>		
	Transit Stop	Route Segment	System
Availability	Frequency	Hours of Service	Service Coverage
Comfort & Convenience	Passenger Load	Reliability	Transit-Auto Travel Time

In obtaining and assessing the quality of service of the bus services, the operational characteristics of the bus service is vital as they are used to obtain the frequency, hours of service, passenger loads and the reliability. The operational characteristics that are going to be assessed and calculated are listed in Table 1.2.

Table 1.2: Operational Characteristics and its Meaning.

Operational Characteristics	Meaning
Travel distance, l_c	The distance between the terminals to the last terminal before it turns back.
Travel time, T_a	The time taken to go from one stop to another.
Maximum Capacity, C_m	The total maximum number passenger using the bus service at a certain time or period.
Bus Capacity, C_a	The total number of passengers that can use the bus service at a one time.
Headway, h_m	The time interval between two busses in service of the same route.
Loading Factor, α	The ratio of used capacity to offered capacity
Time at Terminal, T_t	The time the bus is at the terminal after each service.
Commercial Speed, V_c	The speed of the bus from one stop to another.

The operational characteristics are an overview of the qualitative measures of the current bus service and from there suggestions and recommendations can be made to improve the current public bus service so that it will be the user's priority way to travel in the future. The operational characteristics are also used to be compared to design calculation of the operational characteristics to make sure it serves the transit planning.

The quality of service can also be interpreted directly from the passengers where the condition of the bus and their perception of the service can be taken into consideration and can be assessed directly. The passengers' perception is vital as they are the 'clients' that need to be satisfied in this service. Perception of the condition of the bus, travel time, bus fare and also the safety provided is important in order to improve the service and to cater where it is needed.

1.2 PROBLEM STATEMENT

Due to increase demand of the bus services, the quality of the bus service is often neglected. The operational characteristics of the bus services do not tally with the demand, thus affecting the quality of the service and customer satisfaction. The uneven frequency of the bus service, the speed of the bus, the capacity and long stopping periods at the bus terminal affects the quality of the service. These situations and actions can cause additional time consuming for the users and it is affecting their daily routine if they depend on public bus service to get to workplace and schools. Inadequate seating capacity is also an issue that has to be assessed in order to clarify and notify if the capacity is enough to accommodate the passengers in the present situation. It can also be a guide to predict the demand of the future public bus service and measures of improvement can be proposed. Studies on the operational characteristics have to be done in order to improve the efficiency and quality of the bus service.

1.3 OBJECTIVES

The main objectives of this project are as follows;

- a) To study the operational characteristics of the city bus services in Ipoh and to compare selected operational characteristics with the urban transit design calculation.
- b) To assess the Level of Service (LOS) for the public bus service based on the operational characteristics obtained.
- c) To obtain the basic passengers' characteristics and their perception on the public bus service provided.

1.4 SCOPE OF STUDY

The study is focused on the inter-city bus service in Ipoh. One specific route is chosen from existing routes in Medan Kidd, which is the bus terminal for the inter-city bus services in Ipoh. The data will be collected to determine the operational characteristics of the bus services. Surveys will be conducted to get random information on the passengers. The operational characteristics are calculated using data's that are gathered in present situation to make sure the study is relevant. Information for assessing the quality of service of the bus service is taken directly from the customers as the assessment has to be done as accurate as possible. For one set of survey and data gathering, it will be conducted for one week and overall, minimum three sets of data and surveys will be obtained each day. The week of conducting the survey and data gathering is randomly selected to make sure the data and surveys are as close to real-life situation as possible. This is to ensure the outcome of the project is suitable and relevant to be applied in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 PUBLIC TRANSPORTATION AND BUS SERVICES

Public transportation provides a very important travel mode in human society and for decades has provided basic mobility for the vast majority of travelers.^[2] Most cities in developing countries rely heavily on the use of buses as the major means of mobility, particularly for the urban poor. Even in cities with extensive rail networks, the majority of trips are made on buses or minibuses. An estimated 600 million trips a day were being made in buses in the developing cities in 1980; by 2000 that figure will have at least doubled with so many people affected; it is not surprising to find the quantity and quality of bus services as a worldwide topic of considerable concern.^[3] Also, in present situation, where there are a wide range of private vehicles that can be bought, it causes traffic congestion and consequently causes other negative impacts such as environment and noise pollution. An improvement of the supplied service quality can attract further users thus could resolve many problems (e.g., helping to reduce traffic congestion, air and noise pollution, and energy consumption) because individual transport would be used less.^[4]

2.2 PASSENGERS' AND OPERATOR'S REQUIREMENTS

Passengers ask for a good service quality which means;

- a short travel time,
- a minimum number of transfers,
- a good service frequency and
- reasonable fares.

Operators and transit agencies need to provide this service in an economically efficient way. They need to monitor the performance of the existing service and forecast the impacts of proposed measures. The operator for example needs to know;

- the required fleet size,
- the operating costs,
- revenues from tickets and
- the cost coverage which indicates whether public subsidies are necessary.^[5]

These requirements show that to plan and analyse the service, it is not only important to obtain the passengers perception and evaluation, but also to obtain the operational characteristics and measures to make sure that it is balance between both parties and will gain fair evaluation.

2.3 QUALITY OF SERVICE

Quality of service is an important factor in the widespread use of public transportation.^[6] Service quality considers the requirements of travelers who ask for short travel times, short walking distances, frequent and reliable services, few transfers, decent comfort and appropriate fares.^[5] Transportation quality is acknowledged to consist of two parts: the objective aspect, such as performance measures, and the psychological aspect or service measures, such as how customers perceive the service.^[4] From a user's perspective "availability" or the equivalent term "existence" is the primary service measure assessing "quality of service" to a scheduled fixed route bus user. In general, to a user the single most important factor in determining the quality of service is bus availability (i.e., bus frequency).^[7] The fixed - route quality of service measures is divided into two main categories which are;

- availability – address the spatial and temporal availability of service
- comfort and convenience – evaluate user's perception of the quality based on experience of the service.^[1]

There are three categories of elements of a transit system that require different performance measures. The categories are as follows:

- **Transit Stops:** measures addressing transit availability and comfort and convenience at a single location. These measures depend on passenger volumes, scheduling, routing and stop and station design and tend to vary from one stop to another.^[1]
- **Route Segments/Corridors:** measures addressing availability and comfort and convenience along a portion of a transit route, a roadway, or a set of parallel transportation facilities serving common origins and destinations. These measures values will tend to have less variation over the length of a route segment, regardless of conditions at an individual stop.^[1]
- **Systems:** measures availability and comfort and convenience for more than one transit route operating within a specified area. System measures can also address door-to-door travel.^[1]

The service measures framework is simplified in the Table 2.1 below.

Table 2.1: Framework for Service Measures^[1]

	Service Measures		
	Transit Stop	Route Segment	System
Availability	Frequency	Hours of Service	Service Coverage
Comfort & Convenience	Passenger Load	Reliability	Transit-Auto Travel Time

As for the relationship between “quality of service” and “level of service”, “quality of service” is a user based qualitative assessment of how well a service or facility is operating. “Level of service” is a quantitative breakdown of the “quality of service” of a service or facility into six letter grade levels, with “A” describing the highest quality and “F” describing the lowest quality. Although the term “level of service” is widely accepted in the U.S., in general, “quality of service” is more proper when the discussion is about the operations of a highway unless a specific “level of service (e.g., “A”) is being addressed.^[8]

2.4 LEVEL OF SERVICE

Transit level of service (LOS) can be described in terms of hours of service, headway, pedestrian environment (sidewalks, lights, shelters), safety, rider comfort, appearance, reliability, transfer, costs, and transit travel time, to name a few of the more common factors.^[9] Public opinion indicated increases in level of service as important factors for using transit. The availability of direct service from origin to destination, transit travel times that are not much greater than travel times by private automobile, more frequent service, and service on nights and weekends, are the types of services that are expected to encourage transit use.^[9] In a survey that included 14,500 surveys collected in six urban areas in Florida, transit users identified hours of service, location of routes and headways as the biggest concerns.^[7] Bad reliability measures of bus services are the worse among other measures because (a) they can cause the bus not attractive to customers and give a distorted view of bus service, and (b) they waste valuable resources that may be better used elsewhere. In other side, good reliability measures can provide customers with a realistic picture of their transit experience and knowledge in using public transport services.^[11]

2.5 OPERATIONAL CHARACTERISTICS

In order to analyse the characteristics of bus services in this study, principle data of bus operation were collected from field surveys which are travel time, headway, and load factor.^[12] Other characteristics are also important to analyse including capacity and numbers passengers boarding and alighting the bus service. Bus operations and characteristics were conducted and questionnaire surveys were employed on the bus users and their perceptions toward the bus service. The study of bus users characteristics were totally conducted through the questionnaire surveys.^[12] For example, a thousand of bus users and people either traveling or living along all 41 bus routes in Hanoi were interviewed to study their characteristics and perceptions toward bus service.^[12]

High capacity configurations can offer substantially superior performance.^[13] For bus speed and volume surveys, the first requirement was to measure bus commercial speeds, bus volumes and passenger volumes along selected busways.

Survey procedures, including registration plate matching, were devised to measure these variables.^[13] The variables are listed as follows;

- Bus number: usually the number allocated by the licensing authority or operator and displayed on the bus,
- Bus type: capacity-related categories were defined in each city, depending upon fleet characteristics,
- Time of passing survey point: hour-minutes seconds and
- Bus passenger loading: recorded on a seven-point scale.^[13]

For bus stop survey, at each stop, the following information was recorded for a sample of buses, together with the total bus flow;

- Bus number: as for the speed and volume survey,
- Entry time: the time a bus entered the bus stop area (the entry point was located upstream of the end of buses queuing to enter the stop and the exit point was located downstream of the bus stop, at the point of free flow conditions),
- Stop time: the time during which the bus wheels were stationary.^[13]

For the analysis of passengers boarding and alighting, The numbers of boarding and alighting passengers in each bus stop were collected in three time periods, which are morning peak period (7.00-9.00), midday off peak period (13.00-14.00) and evening peak period (16.00-18.00).^[12]

The basic of planning public transport in urban areas includes the determination of the headway, cycle time, time at terminal and also the number of busses. For transport planning, sufficient operational characteristics of the current service need to be obtained in order to detect the flares and improvement areas.

Below are some of the basic terminologies and relationships between the characteristics that is used in the urban transit planning;

- Hours of Service - Total clock hours over which public transport service is operated,
- Headway (Frequency) - Time in minutes between two arrivals (or departures) of buses which is measured as

$$\text{Headway} = \text{Cycle Time} / \text{Number of Busses},$$

- Terminal Time = Time scheduled for a respective vehicle between when it arrives at a terminal and when it departs for its next trip,
- Cycle Time = Total time required for a vehicle to make a complete round trip (loop) on a route which is measured as

$$\text{Cycle Time} = \text{Round Trip Running Time} + \text{Terminal Time},$$

- Capacity = Maximum number of passengers that can be carried on a vehicle at a time which is measured as

$$\text{Capacity} = \text{Number of seats} + \text{Number of permitted standing passengers},$$

- Maximum Capacity = Maximum number of passengers that can be carried on a vehicle in an hour.^[14]

CHAPTER 3

METHODOLOGY

3.1 RESEARCH METHODOLOGY

For this project, the research methodology is divided into four stages. Below, in Figure 3.1, is the flow diagram of the methodology of the research.

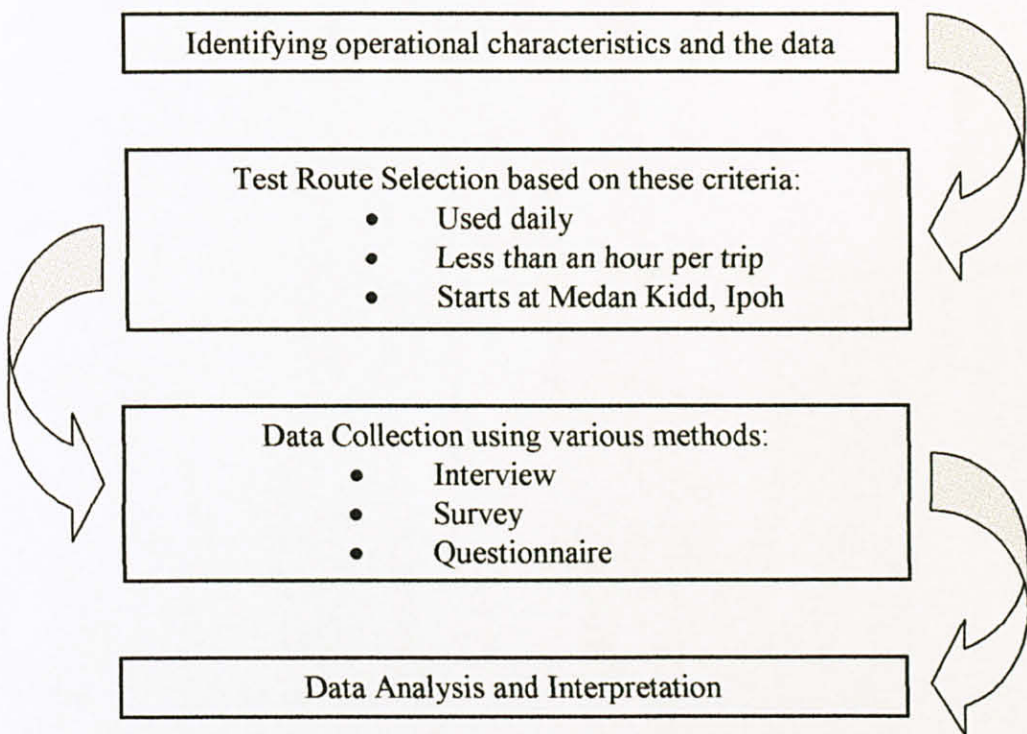


Figure 3.1: Stages of the Research Methodology

3.1.1 Identifying Operational Characteristics

The operational characteristics that are going to be obtained from this study are;

- a) Travel Distance, l_c
 - Travel distance is the distance measured in meters of the overall trip. The measurement starts at Medan Kid, Ipoh to the last bus stop of the route and back again to Medan Kid, Ipoh.
- b) Travel Time, T_a
 - Travel time is the time, in minutes, needed for the bus to complete one trip. The travel time from each stop to another is also taken.
- c) Maximum Capacity, C_m
 - Maximum capacity is the maximum number of passengers that can use the bus for the trip which for this study the maximum passengers in one hour service, which is measured in passengers per hour.
- d) Bus Capacity, C
 - The total amount of passengers that can occupy one bus at a time, both seated and standing up, measured in no of passengers.
- e) Headway, h_m .
 - Headway which is measured in time is the time interval of each bus going out of the terminal for the same route and service.
- f) Loading Factor, α
 - Loading factor is the ratio measurement of the passenger using the public bus service. As it is a ratio, it has no dimension but it is a ratio of the passengers seated and passengers standing up and the overall seats and number of possible standing up spaces.
- g) Time at Terminal, T_t
 - The time each bus spends on the terminal after each trip, which includes the time for passengers boarding from the terminal, measured in minutes.
- h) Commercial speed, V_c
 - The commercial speed is the average speed of the bus service on each trip, measured in km/hr.

3.1.2 Test Route Selection

For in-depth study of the operational characteristics and quality of service, one route was taken to be the test route. The route selection was done based on several criteria such as;

- a) The route is used daily by the passengers. This criterion is taken into consideration to make sure sufficient data and surveys are collected during the research.
- b) The route takes no more than one hour per one way trip. As the study is oriented on the service of public inter-city bus service, the duration of each route is minimised to less than an hour per one way trip, so that the route would not be too far.
- c) The route starts at Medan Kidd, Ipoh. Because the research is on the service of city bus in Ipoh, it is ideal to select a route which starts and ends in Ipoh, which Medan Kidd is the inter-city bus terminal.

After consideration of the above criteria, several routes were found to be appropriate for the study including from Ipoh to Menglembu, Bercham, Medan Gopeng, Simpang Pulai, Ulu Kinta, Gunug Rapat, Silibin, Jelapang, Lahat and Ipoh Garden East.

From the above list of appropriate routes that can be studied, the selected route for this research is from Medan Kidd, Ipoh to Bercham. This route was chosen because the duration of the route (approximately 40 minutes per one way trip) gives sufficient time for the passengers to evaluate the service as the duration is not too short or not too long.

The driving distance between Medan Kidd, Ipoh to Bercham is approximately 15km and the distance back is 8km which takes about 75 minutes bus service for one trip. Below in Figure 3.2, is the route map from Ipoh to Bercham.

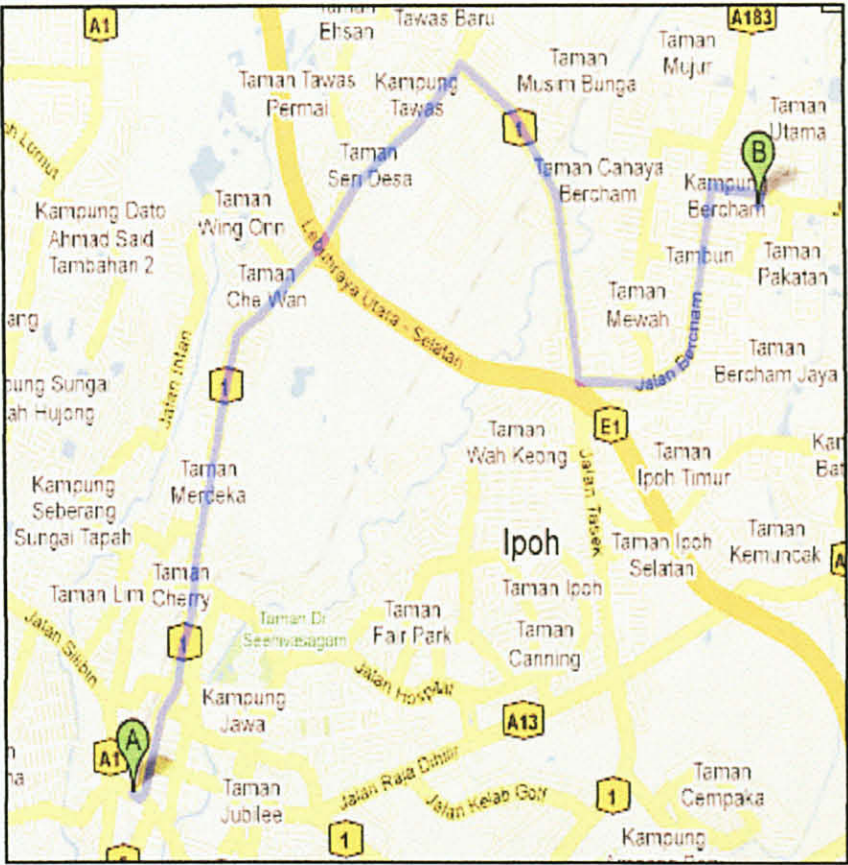


Figure 3.2: Route Map from Ipoh (A) to Bercham. (B)

3.1.3 Data Collection

The data collection is done in to obtain at least 3 readings a day. It was divided into three sessions which were morning session, afternoon session and evening session, so minimum one reading in each session. The data collection is going to be conducted in a week, which represents each day of the week. The data collection started at the first bus service for the day, and ends at the final bus service for the selected route which from Ipoh to Bercham. There were three methods of collecting the data which were:

- Interview
- Survey
- Questionnaire

Interview

The interview is conducted with the person in charge of the bus service. The interview is held in the office of the bus service management which is situated in the second floor of the bus terminal. The interview is done to get information on the public bus service that is going to Bercham.

Inquiries asked during the interview include;

- the timetable and schedule of the bus service,
- the routes and possibly the map for the route,
- total busses that is provided for the bus service,
- the bus fare,
- estimated time of each trip that is used to plan the schedule.

The fare for one way to Bercham costs RM 1.90 per trip for the non-air-conditioned bus and RM2.20 per trip for air-conditioned bus. The route of the service is as shown below in the Figure 3.3. One of the bustop in the route is shown in Figure 3.4. There are 3 busses that are offered for the service and goes to a scheduled headway of 20 minutes. The service starts at 5.50 am in the morning and the last service is at 7.50 pm daily. The picture of the air-conditioned bus is shown in Figure 3.5.

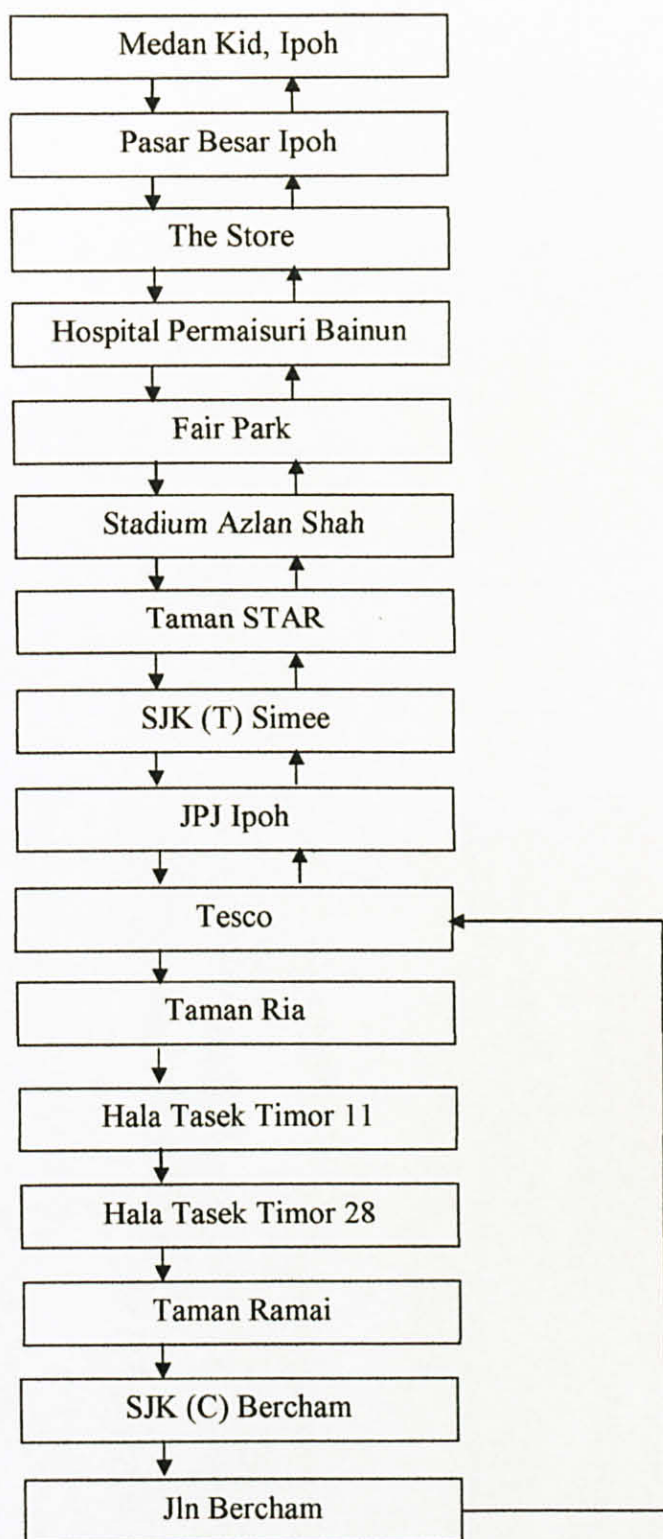


Figure 3.3: The Route for Medan Kid – Bercham Service

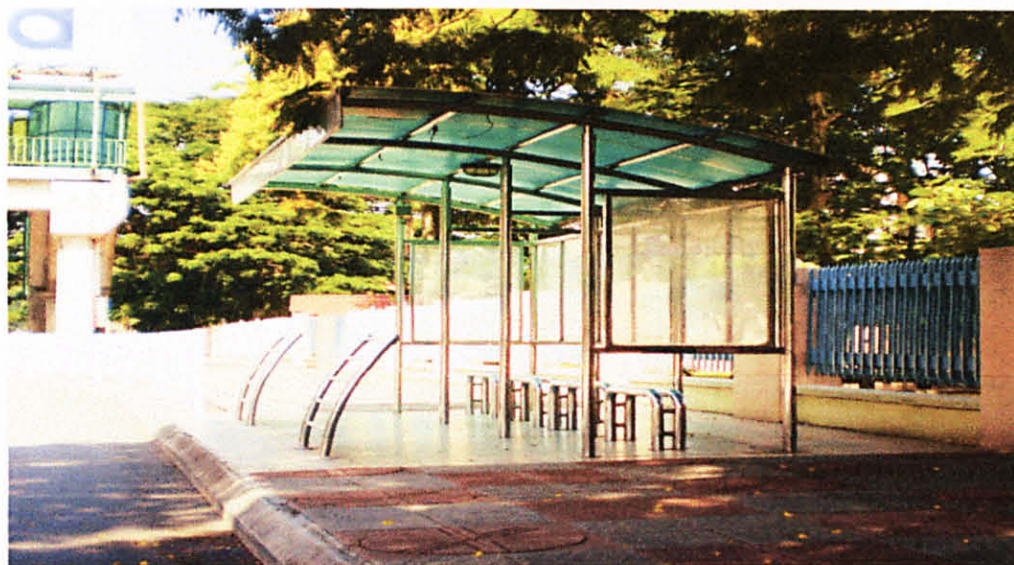


Figure 3.4: One of the Bustops along the Route



Figure 3.5: Bus for Service to Bercham.

Survey

Survey is conducted during the running of the service. The data are needed to obtain the operational characteristics. In table 3.1, the method of measuring each data in the survey is explained.

Table 3.1: Operational Characteristics and the Data Needed.

Operational Characteristic	Data Needed	Method of Measuring Data
Travel distance, l_c	Overall distance	The route taken is established on GPS and the distance is taken from there.
	Distance of Each Stops	The route taken is established on GPS and the distance is taken from there.
Travel time, T_a	Overall time	Initial time minus arrived time.
	Time from one stop to another	Using timer to get the time taken from one stop to another.
Maximum Capacity, C_m	Number of possible passengers of each trip	The maximum number of passengers that can use the service in an hour.
Bus Capacity, C_b	Number of seats	Counting the number of all the seats
	Number of standing up spaces	Calculating the overall area for standing and dividing it with estimated individual standing space.
Headway, h_m	Interval time in between each trip.	This data can be obtained from the monitoring of the incoming and outgoing bus at the counter.
Loading Factor, α	Seated Passengers	Counting the number of seated passengers in a trip.
	Number of Seats	Counting the number of all the seats
Time at Terminal, T_t	Time at the terminal	This data can be obtained from the monitoring of the incoming and outgoing bus at the counter.
Commercial Speed, V_c	Overall distance	The route taken is established on GPS and the distance is taken from there.
	Overall Time	Initial time minus arrived time.

Questionnaire

Questionnaire forms were distributed to obtain the basic information on the randomly chosen passengers. The questionnaires were distributed to the passengers that were using the bus service and to the passengers waiting at Medan Kid. The information asked were divided into two parts which were the passengers' characteristics and the bus service assessment.

For the passengers' characteristics, the attributes that were inserted in the questionnaire are as follows;

- gender
- age
- race
- occupation
- Salary
- Bus usage frequency

The second part of the questionnaire is the bus service assessment. This part of the questionnaire was inserted to obtain the basic passengers' perception on the bus service. The assessment is done by ranking each attribute from 1 to 5 where 1 is the worst and 5 is the best. The attributes are as follows;

- Punctuality
- Travel time consistency
- Route suitability
- Waiting time
- Bus quantity
- Suitable bus fare
- Bus comfort
- Bus safety
- Facilities offered
- Overall service

An example of the questionnaire sheet is inserted in Appendix 1.1 which is used to get all the information.

3.1.4 Analysis and Interpretation

The operational characteristics are used to analyse the basic performance and quality of service of the bus service. The operational characteristics have close relationship and affect the performance and quality of service of the bus service.

Maximum capacity, bus capacity and loading factor are calculated to analyse the capacity aspect of the service. Insufficient capacity can affect the service availability. If a bus stop at a bustop and the bus is already full, it will cause the waiting passengers to wait for another bus to come and have affected the effective frequency for them. The passengers may also lack of interest in using the public bus service if there are lacks of seats and have to stand up in the trip. The crowdedness of passenger loads can be measured based on the occupancy of the bus relative to the number of seats expressed as load factor. A factor of 1.0 means that all the seats are occupied. Value of more than 1.0, means that there are passengers that are standing up.

Headway is obtain to assess the reliability of the bus service. As stated earlier, headway is the interval time of the one bus after another going for the same route (same service). Reliability encompasses both on-time performance and the regularity of headways between successive trips. Time spent in terminals after each trip also have to be assessed as it affects the headway. Uneven headways results in uneven passenger loading and affecting the time schedule of the passengers, which further decreases the interest of the passengers in using the public bus service in the future.

Travel time and speed of the service is also important to be used in assessing the quality of service. If the travel time and speed is really longer and slower than by automobile, it may be seen to the passengers as less convenient. The passengers also have personal time schedule and time usage is at its optimum for some passengers. Wasting time is not an option.

Further using the operational characteristics obtained, the Level of Service (LOS) can be assessed for the reliability, hours of service, frequency and passenger loading. For the Urban Transit Design, calculations were made based on the equations from the World Bank Manual for Planning and Regulation.^[14] The equations used are listed below;

Minimum Headway, $h_m = T_c / N$

where T_c = Cycle Time

N = Number of Bus

Cycle Time, $T_c = T_a + T_t$

where T_a = Travel Time

T_t = Time at Terminal

Maximum Capacity, $C_m = 60 C_c / h_m$

where C_c = Carry Capacity

h_m = Minimum Headway

Carry Capacity, $C_c = C_a + \alpha C_s$

where C_a = Seats

α = Loading Factor

C_s = Allowable Standing Passengers.

3.2 PROJECT ACTIVITIES

For this project, it is necessary to conduct the data collection by using the bus service to get accurate results. The survey of the bus service has to be done as many as possible, possibly from the start of the service till it ends. On the bus, surveys were conducted on the duration of service, speed of service, capacity of service, dwell times and other operational characteristics parameters. Questionnaires were given out to the random passengers on the bus of each trip. Interviews are also conducted to the bus drivers and bus conductors to know in detail the flow of the service. The schedule of this study which is stretched in a year (2 semesters) is shown in the Gantt chart included in Appendix 3.1.

3.3 TOOLS AND APPARATUS

Not many tools or apparatus are needed to do this research. GPS and GIS system may be needed to get an accurate distance measurement of the routes. It may also be needed to get an accurate speed of the bus service. It is also to detect other possible routes that can be taken. To ease the paying of bus fare of each trip, boarding pass is needed so the bus fare can be paid accumulately.

3.4 HAZARD ANALYSIS

Possible hazards that may occur are analysed and precautions are taken into consideration to be prepared for any unplanned situations that may occur. A possible hazard that may occur is individual safety. This is because, it is dangerous to conduct the research alone, especially for a girl, as the duration of the research starts early in morning for the first bus service which is at 6.30a.m and ends at around 10.00p.m which is the last bus service to the selected route. To prevent any unwanted situations, the research is done in pairs so there is another person accompanying.

CHAPTER 4

RESULT AND DISCUSSION

The results and discussion is divided into two parts where the first part elaborates on the operational characteristics and continues with the second part which is the questionnaire.

4.1 OPERATIONAL CHARACTERISTICS

A survey was done throughout one week for three sessions a day to obtain the operational characteristics. As explained in methodology, the operational characteristics includes travel distance, travel time, maximum capacity, bus capacity, headway, loading factor, time at terminal and commercial speed. Analysis of the operational characteristics is further divided into three parts where the first part is to list down all the operational characteristics obtained from the survey. The second part of the analysis is to compare the obtained results with the Urban Transit Design calculation of the characteristics. The third analysis is to obtain the Level of Service (LOS) from the obtained operational characteristics. The survey data is inserted in Appendix 4.1.

4.1.1 Survey Result

Travel Distance

The travel distance that the bus service provides from Medan Kid, Ipoh to last stop in Bercham which is Taman Bercham Baru is 13.8 km. But the service going back from Taman Bercham to Medan Kid, Ipoh is slightly shorter because it does not go back to some of the stops that it has previously gone through, which is 9.1 km. The overall distance for this service is 22.9 km

Travel Time

The travel time is taken for the whole trip which is from Medan Kid to Taman Bercham Baru and back to Medan Kid, through a loop trip directly back to the origin. Throughout the survey, the time for each trip does not show significant difference for each trip. Below in Table 4.1 shows the average travel time for trip from Medan Kid to Taman Bercham and the journey back to Medan Kid.

Table 4.1: Average Travel Time from Medan Kid to Bercham and Back

Route	Average Travel Time (Minutes)
Medan Kid – Bercham	49.20
Bercham – Medan Kid	26.34
Total Travel Time	75.54

Headway

The scheduled headway is 20 minutes. During the service, it was obtained that the average headway is 25 minutes.

Time at Terminal

Each bus is scheduled to be on the service every 1 hour 20 minutes. Using the average time travel obtained earlier, the maximum time for the bus at the terminal is calculated as follows:

Time at Terminal = Scheduled Service – Average Travel Time
 = 1 hour 20 minutes – 75.54 minutes
 = 4.46 minutes
 ≈ 5 minutes.

Commercial Speed

The commercial speed for the bus service is 60 kmph. The average speed for this study is obtained as 17.91 kmph.

Bus Capacity

There were three busses that were provided for this route from Medan Kidd. The bus capacities are as shown in Table 4.2 below.

Table 4.2: Bus Capacity

Bus	Seats	Standing Up	Total Capacity (Passengers)
Bus 1	48	17	65
Bus 2	44	10	54
Bus 3	44	10	54
Total			173

Maximum Capacity

Maximum capacity is the maximum number of passengers that can use the service in an hour. In an hour, the maximum busses for the service are 3 busses. The capacity for each bus has been elaborated above and for this service, all the busses are used in each hour. The maximum capacity is the total capacity for all three busses which is 173 passengers per hour.

Loading Factor

To obtain the loading factor, the maximum number of passengers boarding the bus at a certain time have to be known as the loading factor is the ratio of the maximum passengers at one time with the total number of seats. Throughout the study, the maximum number of passengers that boarding the bus at a certain time is 23 passengers. The loading factor is calculated as follows;

$$\begin{aligned}\text{Loading Factor} &= \text{Max Passengers at one time} / \text{Seats (average)} \\ &= 23 / ((44+44+48)/3) \\ &= 23 / 45 \\ &= 0.51\end{aligned}$$

4.1.2 Urban Transit Design

The second part of the operational characteristics analysis is to obtain the urban transit design for the characteristics and compare with the survey results. The results that are compared including headway, cycle time, time at terminal and number of busses. The calculations are done using the equations stated in methodology and the results are shown in Table 4.3;

Table 4.3: Designed Calculation of the Characteristics

Operational Characteristics	Calculated
Headway	25 minutes
Cycle Time	80 minutes
Time at Terminal	5 minutes
Number of Busses	3

The calculation for the designed characteristics is inserted in Appendix 4.2. Tabulated in Table 4.4 is the comparison of both results and the percentage difference between the survey results and the design calculation.

Table 4.4: Comparison of Actual and Calculated Characteristics.

Operational Characteristics	Actual	Calculated	Percentage Difference
Headway	25 minutes	18 minutes	38.9 %
Cycle Time	80 minutes	90 minutes	11.1 %
Time at Terminal	5 minutes	15 minutes	66.7 %
Number of Busses	3	5	40 %
Average			38.18 %

The average percentage difference is 38.18 % where it shows that the service can be improved in order to meet the designed calculation.

4.1.3 Level of Service (LOS)

As stated in Transit Capacity and Quality of Service Manual (Second Edition), LOS is the designated ranges of values for a particular service measure, such as “A” (highest) and “F” (lowest). For this study, two LOS aspects were analysed which are the transit availability and comfort and convenience for fixed route service are provided at transit stops and route segments and corridors.

Availability – Transit Stops

Availability at transit stops basically means the service frequency or how many times in an hour the passengers have access to the bus service from one bus stop. The service measure used is average headway. In Table 4.5 shows the LOS values and description for the availability at transit stops measures.

Table 4.5: LOS Values for Service Frequency LOS

LOS	Avg. Headway (min)	veh/h	Comments
A	<10	>6	Passengers do not need schedules
B	10-14	5-6	Frequent service, passengers consult schedules
C	15-20	3-4	Maximum desirable time to wait if bus/train missed
D	21-30	2	Service unattractive to choice riders
E	31-60	1	Service available during the hour
F	>60	<1	Service unattractive to all riders

The average headway obtained is 25 minutes where from the table, it goes under LOS D. At LOS D, the service is unattractive to the passengers. This means that the service is only available about twice an hour and requires passengers to adjust their routines to fit the service provided.

Availability – Route Segments/Corridors

The availability along route segments means the service span or the hours of service provided in one day. The LOS for hours of service is based only on those hours when service is offered at essentially a minimum of one hour frequency.

Calculation of the hour of service is as follows;

$$\begin{aligned}\text{Hours of Service} &= (\text{Departure Time of Last Run} - \text{Departure Time of First Run}) \\ &\quad + 1 \text{ hour} \\ &= (19.50 - 5.50) + 1 \\ &= (14) + 1 \\ &= 15 \text{ hours.}\end{aligned}$$

Table 4.6 shows the LOS values and the LOS description for hours of service.

Table 4.6: LOS Values for Hours of Service

LOS	Hours of Service	Comments
A	19-24	Night or "owl" service provided
B	17-18	Late evening service provided
C	14-16	Early evening service provided
D	12-13	Daytime service provided
E	4-11	Peak hour service only or limited midday service
F	0-3	Very limited or no service

As seen in the table, for 15 hours of service, it goes under LOS C. it is stated that the service is provided in the early evening. This is so but it still provides some flexibility in one's choice of time for the trip home.

Comfort and Convenience – Transit Stops

The comfort and convenience at transit stops can be measured using the passenger loads. Passenger loads reflect the comfort level of the on-board vehicle portion of the trip. This is in terms of being able to find a seat and in overall crowding levels in the bus. A poor passenger load LOS indicates that dwell times will be longer for the passengers boarding and alighting demand at transit stop, and consequently travel times and service reliability will be negatively affected. Passenger load LOS is based on two measures which are the load factor and standing passenger area. The standing passenger area is only used when the passengers must stand in a service. Throughout the study, all the passengers get to sit down in seats so only the load factor is taken

into consideration. Below in Table 4.7 shows the LOS values and description for passenger load factor.

Table 4.7: LOS for Load Factor

LOS	Load Factor (p/seat)	Standing Passenger Area		Comments
		(ft ² /p)	(m ² /p)	
A	0.00-0.50	>10.8†	>1.00†	No passenger need sit next to another
B	0.51-0.75	8.2-10.8†	0.76-1.00†	Passengers can choose where to sit
C	0.76-1.00	5.5-8.1†	0.51-0.75†	All passengers can sit
D	1.01-1.25*	3.9-5.4	0.36-0.50	Comfortable standee load for design
E	1.26-1.50*	2.2-3.8	0.20-0.35	Maximum schedule load
F	>1.50*	<2.2	<0.20	Crush load

*Approximate value for comparison, for vehicles designed to have most passengers seated. LOS is based on area.

†Used for vehicles designed to have most passengers standing.

The loading factor was calculated in the previous part and was obtained as 0.51, this falls under LOS B which means the some passengers will have to sit next to each other, but others will not.

Comfort and Convenience – Route Segment/Corridor

The comfort and convenience along the route segment is measured by the reliability of the service. To measure the reliability, headway adherence was chosen to be assessed which is the consistency or evenness of the interval between transit vehicles. The measure is based on the coefficient of variation of headways and is calculated as follows;

$$C_{vh} = \frac{\text{standard deviation of headway deviations}}{\text{mean scheduled headway}}$$

where:

C_{vh} = coefficient of variation of headways.

Which using the obtained data, C_{vh} is calculated as follows;

$$\begin{aligned} C_{vh} &= 10.94615 / 21.36 \\ &= 0.51 \end{aligned}$$

From the Table 4.8 below, C_{vh} of 0.51 falls under LOS D which means the service has irregular headways with some bunching.

Table 4.8: LOS for Coefficient of Variation of Headways

LOS	C_{vh}	$P(h_i > 0.5 h)$	Comments
A	0.00-0.21	$\leq 1\%$	Service provided like clockwork
B	0.22-0.30	$\leq 10\%$	Vehicles slightly off headway
C	0.31-0.39	$\leq 20\%$	Vehicles often off headway
D	0.40-0.52	$\leq 33\%$	Irregular headways, with some bunching
E	0.53-0.74	$\leq 50\%$	Frequent bunching
F	≥ 0.75	$> 50\%$	Most vehicles bunched

NOTE: Applies to routes with headways of 10 minutes or less.

The summary of the LOS obtained are as shown in Table 4.9 below.

Table 4.9: Summary of LOS obtained

Performance Aspect	Service Measures	LOS	Elaboration
Availability – Transit Stop	Average Headway	C	Maximum desirable time to wait if bus missed.
Availability - Route Segments	Service Span	C	Early evening service provided.
Comfort and Convenience	Load Factor	B	Passengers can choose where to sit.
Headway Adherence	Headway Adherence	D	Irregular headways with some bunching.

4.2 QUESTIONNAIRE

The survey was done to a hundred randomly chosen passengers to get basic information on their details and also their perception on the quality of the bus service. The overall data for the questionnaire are attached in Appendix 4.3.

4.2.1 Passenger's Characteristics

The details include gender, age, race, occupation, salary and bus usage frequency. Below are the outcomes from the survey of each detail of the passengers, shown in Figure 4.1 to Figure 4.6. Starting the survey with analyzing passengers' gender, as seen in Figure 4.1, male passengers are slightly higher in total compared to female passengers.

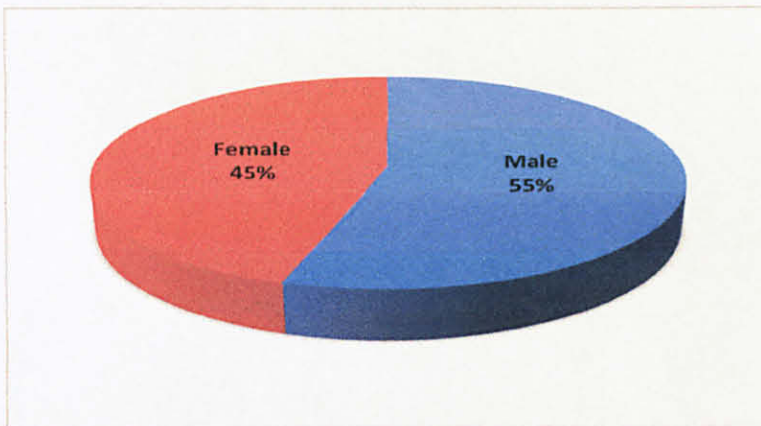


Figure 4.1: Percentage of Passengers by Gender

Moving on to the race perspective, nearly half of the passengers are Malays, followed by Indians, Chinese and others. This is shown in Figure 4.2. Looking at the passengers' age distribution, the highest group is used by teenagers aged between thirteen to seventeen years old. This is maybe because they use public bus as transport to go to school. It is least used by children under thirteen years of age. This is shown on Figure 4.3.

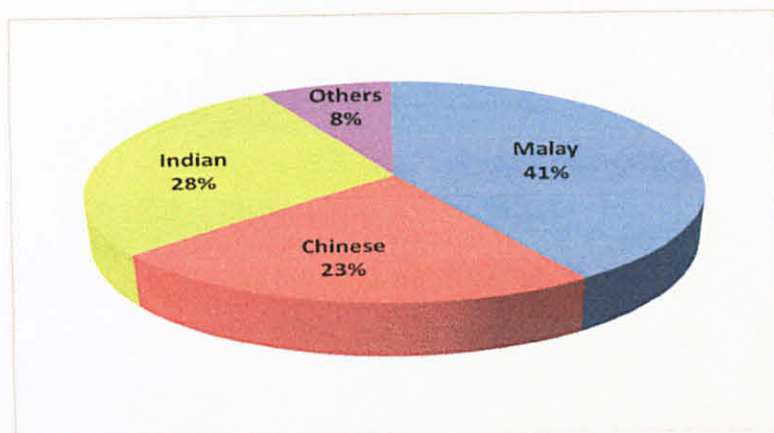


Figure 4.2: Percentage of Passengers by Race

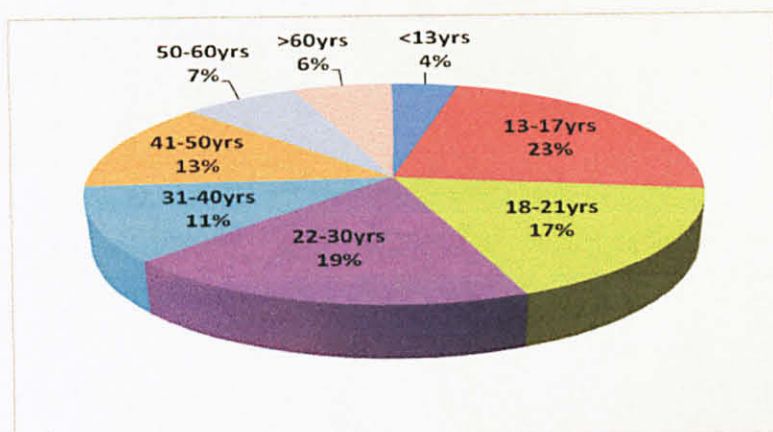


Figure 4.3: Percentage of Passengers by Age.

The passengers are also categorized by the occupation and salary. For occupation, the largest public users are students which includes both in schools and higher institutions which accommodates 43%, as shown in Figure 4.4. This also affects the salary distribution as students earn less than RM1000.00 per month. This also shown in Figure 4.5 where the highest percentage of the salary for the passengers is less than RM1000.00 which is 58%. The maximum salary of the passengers in this survey is between RM2000-RM2500.

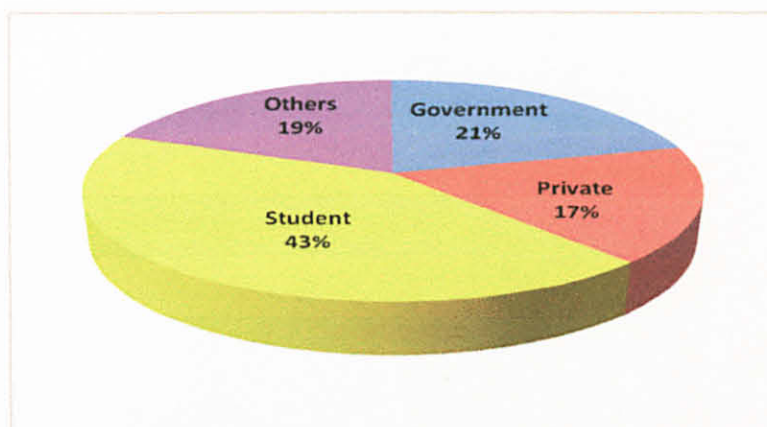


Figure 4.4: Percentage of Passengers by Occupation.

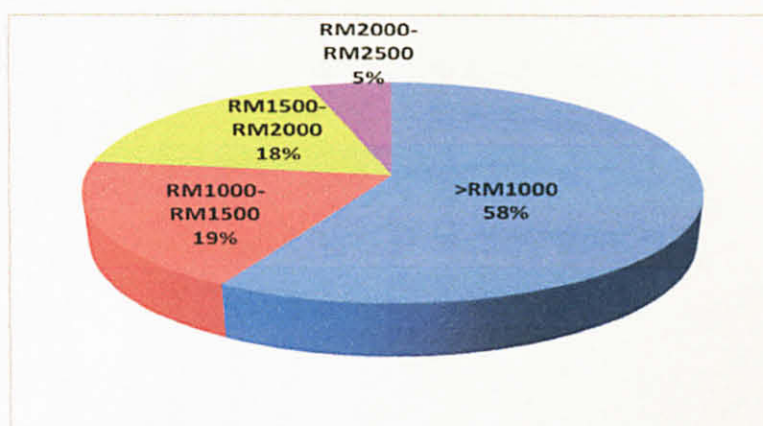


Figure 4.5: Percentage of Passengers by Salary.

The frequency of the bus usage for these passengers is shown in Figure 4.6. 42% of the passengers use the public bus daily where the lowest is has never used the public bus which only accommodates 1%. The service maybe used daily because the school students used the service to go to and from school.

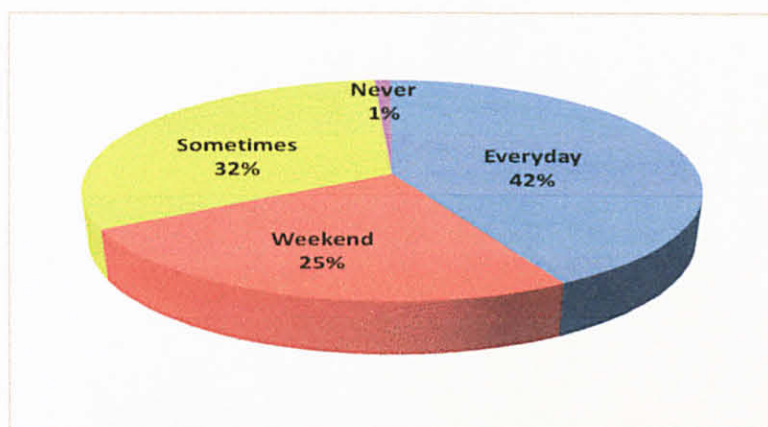


Figure 4.6: Percentage of Passengers by Usage Frequency.

4.2.2 Bus Service Assessment

The bus service assesment was done during the survey to get the basic perception of the passengers on the quality of the public bus service in Ipoh. Ten attributes were taken into consideration which are;

- Punctality
- Travel time consistency
- Route suitability
- Waiting time
- Bus quantity
- Suitable bus fare
- Bus comfort
- Bus safety
- Facilities offered
- Overall service

Each attribute will be ranked from 1-5 where 1 is worst and 5 is the best accordng to each attribute. Below, from Figure 4.7 until Figure 4.16 are the outcomes from the quality assesment survey for each attribute and their ranking distribution.

Punctuality of the bus service is ranked by bad lagging, lagging, sometimes punctual, punctual and very punctual. The percentage of the rankings are shown in Figure 4.7 below. The rankings show that it is fairly punctual but 30% of the passengers thought that the service lags. Only 18% thinks that the service is punctual.

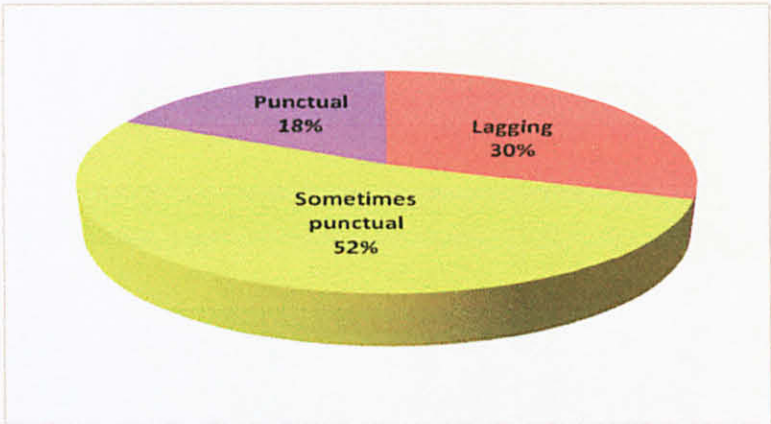


Figure 4.7: Percentage of Ranking for Punctuality

Travel time consistency and route suitability of the bus service are ranked by very good, good, average, bad and very bad. The percentage of the rankings for both attributes are shown in Figure 4.8 and Figure 4.9 respectively below.

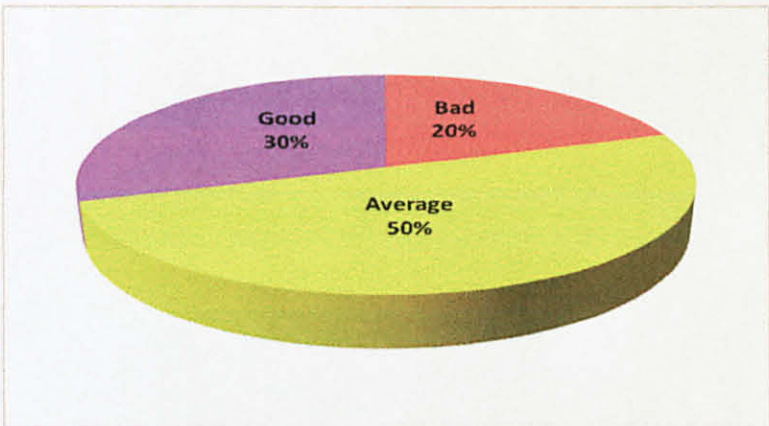


Figure 4.8: Percentage of Ranking for Travel Time Consistency

For travel time consistency, the passengers' perception is half average, which means the travel time is fairly constant for each trip.

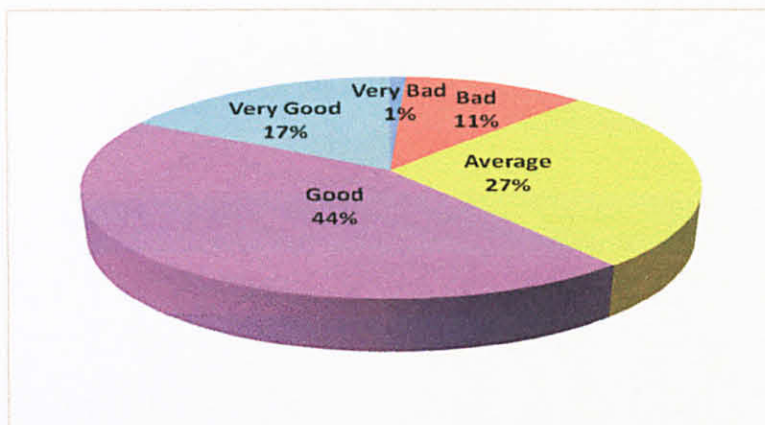


Figure 4.9: Percentage of Ranking for Route Suitability

73% of the passengers think that the routes offered is suitable for the service as it covers the routes in Ipoh city centre and also in Bercham. Waiting time for the bus is ranked by very long, long, average, short and very short. The percentage of the rankings are shown in Figure 4.10 below.

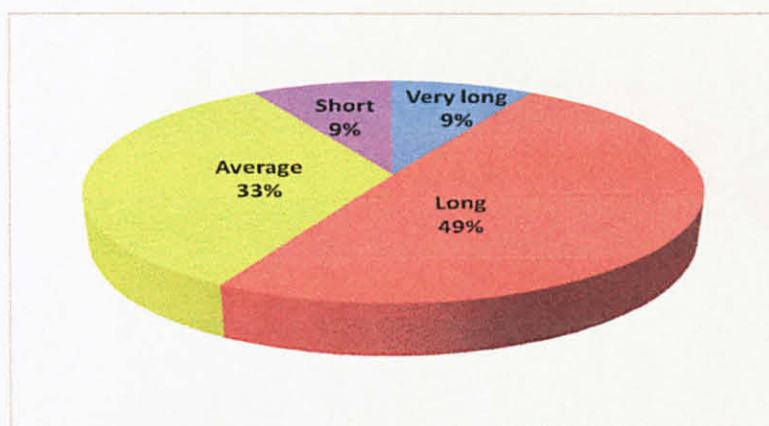


Figure 4.10: Percentage of Ranking for Bus Waiting Time

58% passengers think they have to wait for a long time for the bus service. The bus quantity according to the passengers is ranked by very insufficient, insufficient, enough, more than enough and too much. The percentage of the rankings are shown in Figure 4.11 which shows that the bus for the service is sufficient.

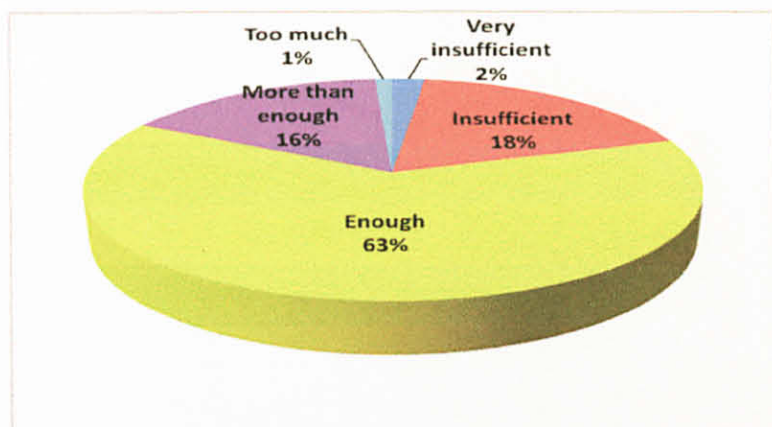


Figure 4.11: Percentage of Ranking for Bus Quantity.

Bus fare is ranked by very cheap, cheap, average, expensive and very expensive. The percentage of the rankings are shown in Figure 4.12 below. More than half thinks that the fare is expensive. This maybe because majority of the passengers are students and those who have salary less than RM1000.00.

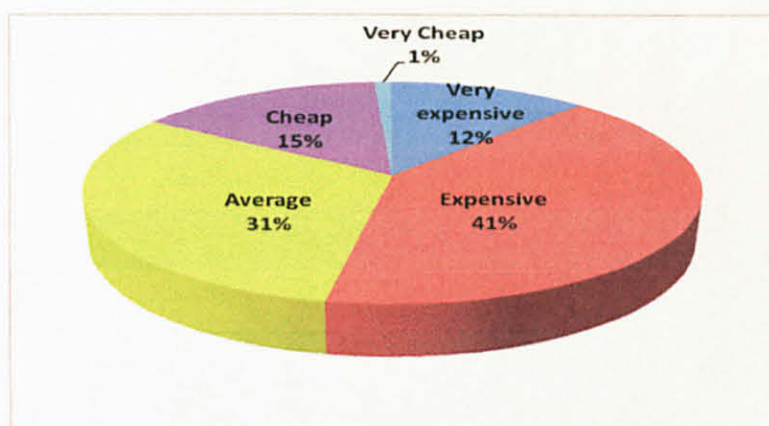


Figure 4.12: Percentage of Ranking for Bus Fare

The bus comfort is ranked by very uncomfortable, uncomfortable, average, comfortable and very comfortable. The percentage of the rankings are shown in Figure 4.13. As seen in the figure, half of the passengers perceived that the bus is uncomfortable. This maybe because of the seats which some are falling off and not attached properly. Another reason for lacking of comfort is maybe because not all the bus are air-conditioned.

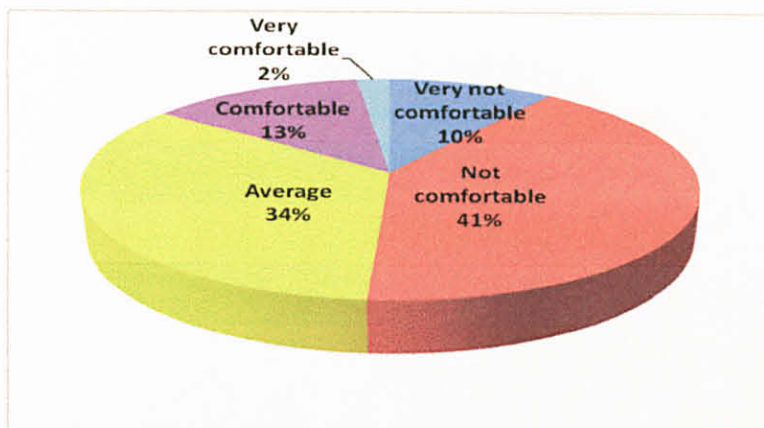


Figure 4.13: Percentage of Ranking for Bus Comfort

Bus safety is ranked by very not safe, not safe, average, safe and very safe. The percentage of the rankings are shown in Figure 4.14 below.

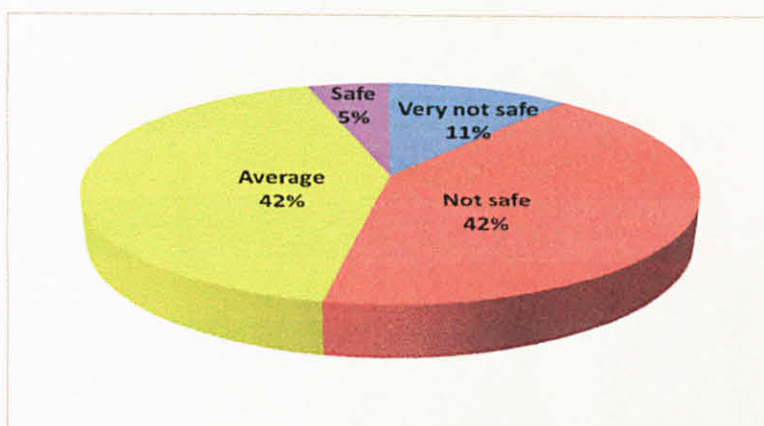


Figure 4.14: Percentage of Ranking for Bus Safety

Ranking of the facilities offered and the overall service are categorized by very good, good, average, bad and very bad. The percentage of the rankings are shown in Figure 4.15 and Figure 4.16 respectively below.

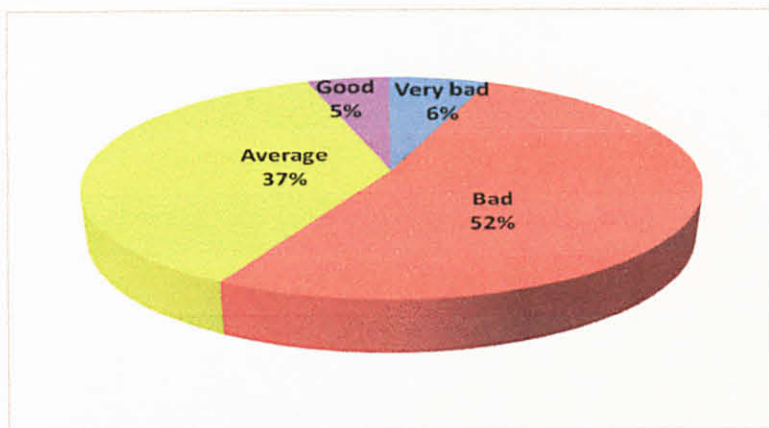


Figure 4.15: Percentage of Ranking for Facilities Offered.

For the facilities offered, this is more to the facilities offered mainly in Medan Kid, Ipoh. Facilities such as public toilets, seats and shops are not in good condition and this could also be improved to give a more pleasant environment for the passengers to wait, board and alight the busses. For overall service, the passengers think it is average and still in consideration to be used. This may also be because this is the only mode of transportation that they have and to them, they can still bear with the current condition.

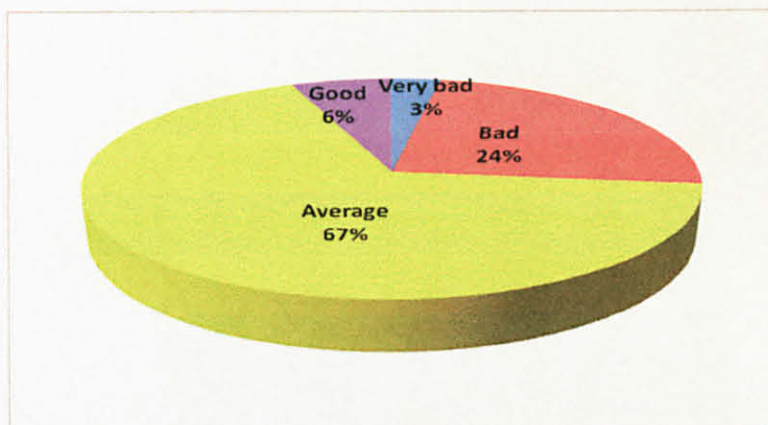


Figure 4.16: Percentage of Ranking for Overall Service.

CHAPTER 5

ECONOMIC BENEFITS

5.1 PROJECT COST

The overall cost for this project is mainly on the travelling cost to go on the busses for the trips. There are also preliminary items such as questionnaire forms and stationary for the questionnaire filling purposes. The fare for one way to Bercham costs RM 1.90 per trip for the non-air-conditioned bus and RM2.20 per trip for air-conditioned bus. In Table 5.1 below, is the cost that is used to conduct the research for one week.

Table 5.1: Overall Project Cost

Cost Allocation	Cost per Unit	No. of Unit	Total
Bus fare	Non-airconditioned RM3.80 / loop trip	8	RM30.40
	Airconditioned RM4.40 / loop trip	13	RM57.20
Questionnaire forms	RM0.10	100	RM10.00
Stationary	RM0.70	25	RM17.50
Car petrol	RM10.00 / day	7	RM70.00
Total			RM175.10

There is no boarding pass for study purposes provided by the bus company so the bus fare needs to be paid for each trip separately.

5.2 BUSINESS ELEMENT

The data obtained from this research can be used as business wise mainly for the enhancement of the public bus service in Ipoh. From the data, sufficient improvements can be made which consequently attract more passengers and would gain more profit for the bus company.

The operational characteristics can be used to enhance the efficiency of the service and the supply meets the demands. Enhanced efficiency ensures the demands are met, which contributes to the passengers' loyalty to use the service and also makes the service more systematic, which further reduces additional management costs.

From the questionnaire, the bus company can take into consideration on the condition of the service and bus that need to be improved. When there is initiative to enhance the bus condition and investments have been made, most probably, there would be initiative to maintain the improvements as the bus company would want to minimize future investments in repair the bus.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

The operational characteristics were obtained from the survey study that was done in Medan Kid, Ipoh for the route to Bercham. The study for one week gave the basic operational characteristics and the basic passengers perception on the service provided. The obtained operational characteristics are summarised below in Table 6.1 below.

Table 6.1: Summary of Operational Characteristics

Operational Characteristics	Data Obtained
Travel distance, l_c	22.9 km
Travel time, T_a	75 minutes
Maximum Capacity, C_m	173 passengers / hour
Bus Capacity, C_a	173 passengers (3 busses)
Headway, h_m	Scheduled:20 minutes Average:25 minutes
Loading Factor, α	0.51
Time at Terminal, T_t	5 minutes
Commercial Speed, V_c	Commercial speed:60 kmph Average Travelling:17.91 kmph
Headway	25 minutes
Cycle Time	80 minutes
Time at Terminal	5 minutes
Number of Busses	3

The operational characteristics were compared to the urban transit design. the characteristics that were compared was headway, cycle time, time at terminal and number of busses. the study shows that there is a difference of 38.18% between the two sets of characteristics. This shows that the current service need to be improved in order to meet the designed calculations.

From the operational characteristics obtained, the Level of Service (LOS) were graded based on the grades set in the Transit Capacity and Quality of Service Manual Manual – 2nd Edition. The four service measures that were taken into consideration were the frequency, hours of service, loading factor and reliability of the service. For frequency, the service gained a LOS D where it is unattractive to choice riders. LOS C was ganed for the hours of service where it provides early evening service. For loading factor and reliability, LOS B and D were gained where for loading factor, the passengers can choose where to sit. Last but not least, for the reliability, the service has irregular headways with some bunching.

From the questionnaire, passengers' characteristics and basic perception on the bus service were obtained. Majority of the passengers have income lower than RM1000.00 per month and mostly school students. They use the service daily to go to and from either work or school. For the service assessment, more than 50% of the passengers said that the waiting time for the service is long, the fare is expensive, the bus is not comfortable and not safe and also the facilities offered are in poor condition. These conditions show that the service provided need to be improved in order to maintain the passengers interet in using the public bus service.

Recommendations for further studies mainly focusses on the longer study period and also to study the operational for other routes. For this study, the period for survey is one week, so maybe for future studies, the duration can be extended to gain more accurate and stronger results. As for other routes, maybe other route's service shows different result and can be compared to and analyse the reasons why the results differ.

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APPENDICES

Appendix 1.1 : Questionnaire Forms

Appendix 3.1 : Gantt Chart

Appendix 4.1 : Survey Data

Appendix 4.2 : Operational Characteristics Calculation

Appendix 4.3 : Questionnaire Data

Appendix 1.1 : Questionnaire Forms

Borang Soal Selidik

Sila tandakan X pada ruang yang sesuai mengikut soalan

1. Jantina
 Lelaki..... ☐
 Perempuan..... ☐

2. Bangsa
 Melayu..... ☐ India..... ☐
 Cina..... ☐ Lain-lain..... ☐

3. Umur
 Bawah 13 tahun..... ☐ 31-40 tahun..... ☐
 13-17 tahun..... ☐ 41-50 tahun..... ☐
 18-21 tahun..... ☐ 50-60 tahun..... ☐
 22-30 tahun..... ☐ Melebihi 60 tahun..... ☐

4. Pekerjaan
 Kerajaan..... ☐ Pelajar..... ☐
 Swasta..... ☐ Lain-lain..... ☐
 .. ☐

5. Pendapatan
 Bawah RM 1000..... ☐ RM 2001 – RM 2500..... ☐
 RM 1000 - RM 1500..... ☐ RM 2501 – RM 3000..... ☐
 RM 1501 – RM 2000..... ☐ Melebihi RM 3000..... ☐

6. Kekserapan menggunakan perkhidmatan bas antara Bandar Ipoh
 Setiap hari..... ☐ Kadang-kadang..... ☐
 Hujung minggu..... ☐ Tidak pernah..... ☐

Penilaian perkhidmatan bas antara bandar Ipoh

Sila tandakan X pada ruang yang sesuai (Skor 1- terendah hingga 5-tertinggi)

		1	2	3	4	5
1.	Perkhidmatan bas mengikut jadual yang disediakan					
2.	Masa bagi setiap perjalanan adalah tetap (konsisten)					
3.	Laluan bas adalah bersesuaian					
4.	Masa yang diambil untuk menunggu bas adalah berpatutan					
5.	Jumlah bas adalah mencukupi					
6.	Tambang adalah berpatutan					
7.	Keselesaan di dalam bas adalah memuaskan					
8.	Keselamatan di dalam bas adalah memuaskan					
9.	Kemudahan- kemudahan yang disediakan adalah memuaskan					
10.	Keseluruhan perkhidmatan adalah memuaskan					

Appendix 3.1 : Gantt Chart

Key Milestone for Final Year Project 1

No.	Detail / Week	1	2	3	4	5	6	7	Mid Semester Break	8	9	10	11	12	13	14
1	Selection of Topic															
2	Preliminary Research Work – Background of project, Journals of related topic															
3	Seminar 1															
4	Project Work – Route identification, research on methodology															
5	Progress Report 1 & 2 Submission															
6	Seminar 2															
7	Project Work – Interviews, Communication with the bus agency, First set of research data (if possible)															
8	Interim Report Final Draft Submission															
9	Oral Presentation															

Key Milestone for Final Year Project 2

No.	Detail / Week	1	2	3	4	5	6	7	Mid Semester Break	8	9	10	11	12	13	14
1	Project Work - Second set of data, Data Interpretation															
2	Progress Report 1 Submission															
3	Project Work – Third set of data, Data Interpretation															
4	Progress Report 2 Submission															
5	Seminar															
6	Project Work – Data Analysis, Intrepretation of all datas, Discussion, Conclusion															
7	Poster Exhibition															
8	Dissertation Submission (soft bound)															
9	Oral Presentation															
10	Project Dissertation Submission (hard bound)															

Appendix 4.1 : Survey Data

Survey Data

Monday			
	Morning	Afternoon	Evening
Average Travel Time, minutes	82	67	98
Distance, km	22.9	22.9	22.9
Maximum Capacity, passengers	27	27	31
Average Speed, kmph	16.72	20.51	14.02

Tuesday			
Average Travel Time, minutes	65	81	74
Distance, km	22.9	22.9	22.9
Maximum Capacity, passengers	12	33	24
Average Speed, kmph	21.14	16.96	18.57

Wednesday			
Average Travel Time, minutes	76	90	90
Distance, km	22.9	22.9	22.9
Maximum Capacity, passengers	14	17	26
Average Speed, kmph	18.08	15.27	15.27

Thursday			
Average Travel Time, minutes	65	84	57
Distance, km	22.9	22.9	22.9
Maximum Capacity, passengers	16	21	22
Average Speed, kmph	21.14	16.36	24.11

Friday			
Average Travel Time, minutes	83	61	76
Distance, km	22.9	22.9	22.9
Maximum Capacity, passengers	16	8	23
Average Speed, kmph	16.55	22.52	18.08

Saturday			
Average Travel Time, minutes	81	103	66
Distance, km	22.9	22.9	22.9
Maximum Capacity, passengers	29	32	26
Average Speed, kmph	16.96	13.34	19.08

Sunday			
Average Travel Time, minutes	86	73	83
Distance, km	22.9	22.9	22.9
Maximum Capacity, passengers	28	24	31
Average Speed, kmph	15.98	18.82	16.55

Appendix 4.2 : Operational Characteristics Calculation

Maximum Capacity, $C_m = 60 C_c / h_m$
where C_c = Carry Capacity
 h_m = Minimum Headway

Carry Capacity, $C_c = C_a + \alpha C_s$
where C_a = Seats
 α = Loading Factor
 C_s = Allowable Standing Passengers

$$C_c = [(44 + 0.51(10)) + (44 + 0.51(10)) + (48 + 0.51(17))] / 3 \\ = 51.62 \approx 52 \text{ passengers}$$

$$\text{Minimum Headway, } h_m = 60 C_c / C_m \\ = 60 (52) / 173 \\ = 18 \text{ minutes}$$

$$\text{Minimum Headway, } h_m = T_c / N \\ \text{where } T_c = \text{Cycle Time} \\ N = \text{Number of Bus}$$

$$\text{Cycle Time, } T_c = T_a + T_t \\ \text{where } T_a = \text{Travel Time} \\ T_t = \text{Time at Terminal}$$

$$T_c = 75.54 + 5 \text{ minutes} \\ = 80.54 \text{ minutes} \approx 80 \text{ minutes}$$

$$\text{Number of Bus, } N = T_c / h_m \\ = 80 / 18 \\ = 4.44 \approx 5 \text{ busses}$$

To get the designed cycle time and time at terminal, $h_m = 18$ minutes and $N = 5$ busses is inserted in the equation as follows;

$$\text{Cycle Time, } T_c = h_m \times N \\ = 18 \times 5 \\ = 90 \text{ minutes}$$

$$\text{Time at Terminal, } T_t = T_c - T_a \\ = 90 - 75.54 \\ = 14.46 \approx 15 \text{ minutes}$$

Appendix 4.3 : Questionnaire Data

Sample	Question 1		Question 2			Question 3										Question 4				Question 5							Question 6			
	Men	Female	Male	Chaper	Indian	Others	<17yrs	17-19yrs	18-21yrs	22-30yrs	31-40yrs	41-50yrs	50-60yrs	>60yrs	Que	Proven	Student	Others	<RM1k	1K-1.5K	1.5K-2K	2K-2.5K	2.5K-3K	>3K	Everyday	Weekend	Seasonal	Never		
1																														
2	1		1												1				1	1								1		
3																														
4	1	1				1												1									1		1	
5	1					1												1									1			
6		1				1												1									1			
7		1				1												1									1			
8	1					1									1												1		1	
9	1					1									1												1		1	
10		1				1												1									1		1	
11		1				1												1									1		1	
12	1					1												1									1		1	
13		1				1									1				1								1		1	
14		1				1									1				1								1		1	
15	1					1									1												1		1	
16		1				1												1									1		1	
17		1				1												1									1		1	
18	1					1									1				1								1		1	
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