

Characterisation of the taxi commuting system in South Africa: A case study with Menlyn Taxi Association.

BY

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ALL GLORY TO GOD.

Executive summary

Taxis are the main mode of transport used by commuters in South Africa. The management of transport utilized by commuters in developing countries has become problematic more especially in large metropolitan areas. The main cause of this is urbanization which is the movement of people to cities for better opportunities accessible, therefore this results in massive demand of public transport especially minibus-taxis.

In South Africa little research has been conducted on the management of minibus-taxi, improvement of the service and scheduling route for taxis. Scheduling bus system approach is used to solve scheduling problems within the taxi industry. A number of countries like Taiwan and Lisbon experience public transport problems. Therefore less attention given to public transportation may lead to commuter utilising private transportation which may result in congestion of roads.

The government has introduced Bus Rapid Transport (BRT) system in four cities which are Pretoria, Johannesburg, Cape Town and Nelson Mandela bay. This system will help in integrating bus, train and taxis into one but BRT is still under development in all the cities. Passengers encounter long queues in ranks during pick hours which in most cases results in long waiting period. In certain routes passengers wait long for taxis because they pass the area full especial on peak hours.

This study discusses the waiting time for passengers and taxi utilisation time cycle for each destination. The findings of this study will be used for recommendations on how the taxi services can be improved.

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Chapter 1

1 Introduction and background

1.1 Basis for minibus taxi and public transport in South Africa

In a developing country such as South Africa public transport is characterized by a number of peculiarities that are generally absent when compared to the public transport systems in first world countries (Walters, 2008). Approximately forty five percent of South Africans make use of public transport every day and about fifty five percent of commuters¹ use minibus taxis as a mode of transportation to and from work (Walters, 2008). Each year the number of passengers using public transport increases due to the increase of fuel price, tollgate system etc. Figure A below shows that the number of commuters using cars is 33% which is the highest followed by taxis with 26%, walking 24% then bus and train with 10% and 7% respectively. Taxis are dominant in the public transport with proportion of 26% as depicted in figure A, therefore it can be concluded that bus and taxi² services are relatively accessible than rail services in terms of working time compared to other transport modes. According to Walters (2008), this is due to the route and network flexibility characteristics of the bus and taxis services.

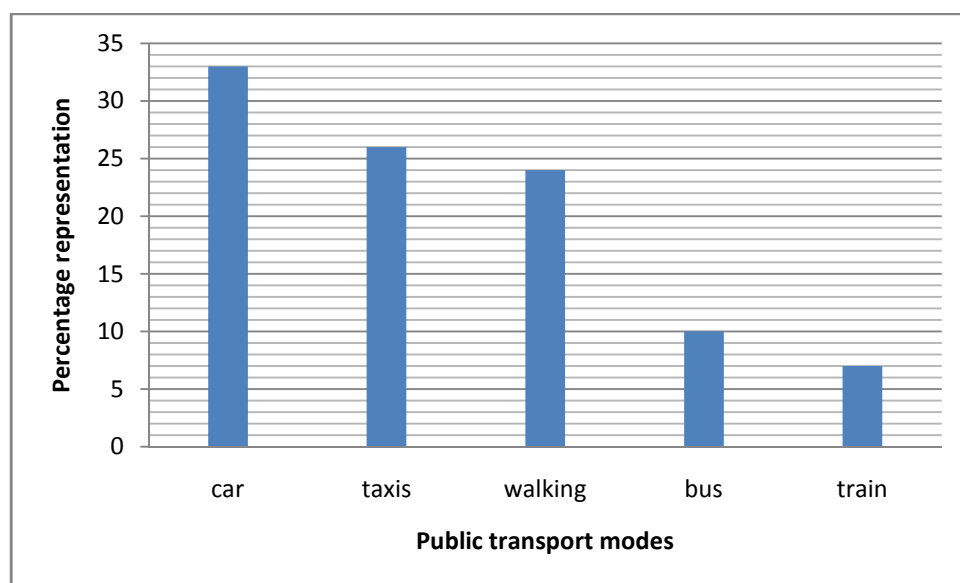


Figure A-source: NHTS page 15 (2008)

In developing countries managing public transport for the large metropolitan areas has become a big problem (Walters, 2008). This is due to the process of urbanization where by people move to city centre as a result of lack of opportunities in rural areas, looking for better job opportunities. Large metropolitan areas in South Africa are Pretoria, Johannesburg, Durban, Cape Town and Nelson Mandela Bay; these cities have been experiencing problems with public transport due of urbanization (Department of Transport, 2006)

¹ For the purpose of this document, the terms passenger and commuter refer to same group of people.

² For the remainder of the document, the terms taxi and minibus-taxi refers to same type of vehicle

Most passengers in the country cannot afford to buy their own car as the traveling costs would be too high to maintain with their low income. Commuters prefer to use public transport, with minibus-taxis being favoured by the majority of the public. The organisation of the taxi industry is not well structured as result many problems are experienced (SATAWU, 2003). The minibus-taxi industry started to operate in the late 1970's to meet the demand of the passengers for transport. Public transport started growing and more commuters are transported each year from late 1970's up until now and evolved into a critical industry in the economy of South Africa. Many factors affect the public from using public transport like poverty.

According to (Sohail, Maunder and Miles (2004)), urban public transport is a key link to access other services and livelihood assets. Majority of public transport users in urban areas use transport to go to work and to access other services like shops and schools. Users want to access amenities easily; they do not have much time to spend waiting for public transport (Sohail, Maunder, & Miles, 2004). Accessibility to transport has a number of dimensions for example it might be physical i.e. the user has to travel a long distance to find public transport, or else public transport might be financially unaffordable or the mode of transport might have inadequate capacity. Most urban public transport users complain about the accessibility, cost, quality and its safety of it (Sohail, Maunder, & Miles, 2004).

1.2 Current public transportation system in Pretoria

Pretoria has an extensive network of railway and bus services which have levels of subsidy. This was meant to facilitate the "apartheid city" with poor passengers living further from their work place. Minibus-taxis are not currently subsidized by the government.

From observation, there is a shortage of taxis in the mornings that travel from the metropolitan areas to the city centre. There are no specific waiting areas for commuters wanting to make use of taxis in the early hours of the mornings and they therefore have to walk into town to be transported or some areas where taxis pass through. Commuters feel like waking to ranks it wastes a lot of their time because ranks are a walking distance from where they stay. Other commuters use ventures¹³ to go to the main road which increases their expenses, therefore so others prefer using their own cars than public transport. Minibus-taxis in ranks do not leave until they are full, so passengers can end up waiting for long period of time inside the taxis. On average there are very few minibuses during the weekends and holidays.

1.3 Minibus-taxi performance.

Minibus-taxis are generally favoured by the commuters due to reliability, more flexibility and accessibility compared to bus systems and they are also safer than rail transport. Minibus-taxis move most passengers in South Africa, but because they are not regulated and monitored, the performance and utilization indicators are lacking.

Taxis start operating mostly between 04:30-05:00am picking passengers from their homes to their destinations. Taxi drivers have two options on how to pick passengers; either they go to rank or go around a route loading passengers. Taxis are fully functional during peak hours; around these hours there are more commuters in the ranks queuing as they wait for taxis. At the same time there

³ Venture-Is type of a car that load less than 8 people and they operate in one area like township not beyond bound areas. Ventures are local taxis.

are more commuters' on the roads waiting for floating taxis to load them. The waiting for transport by passengers is caused by a number of factors such as:

1. High traffic,
2. Bad road condition,
3. Insufficient taxis,
4. Bad taxi conditions and
5. Lack of management of commuter transport.

Most passengers who use taxis work between 7:30am -16:00pm, in the early hours of the morning and late afternoon as a result those are the busiest time. Typically minibus-taxis make about three trips in the morning between 6:00am-9:00am. From around 10:00am the passenger arrival rate drops and which allows taxi drivers to have breakfast and clean their vehicles around this time. Taxis start being busy again from around 14:00pm because of students from school around the Pretoria East and Pretoria Central area. The number of trips done by each driver is based on which destination they are assigned to, traffic on the road and which route they use on their way back.

1.4 Background of Menlyn Taxi Association

The Menlyn Taxi Association started to be functional after opening Menlyn shopping centre. The aim of the association was to provide transport to the public in order to access the shopping centre. The association loads passengers from Belle Ombre Interchange in Marabastad to Menlyn shopping centre, but there is no rank or holding facility in the Menlyn node for mini-bus taxis. As a result, taxis park on the sidewalks and the road reserve. Menlyn taxis utilise many streets to access the shopping centre. *Figure B* below shows where passengers can be dropped off to get inside the shopping centre and which streets can be used to access the shopping centre.

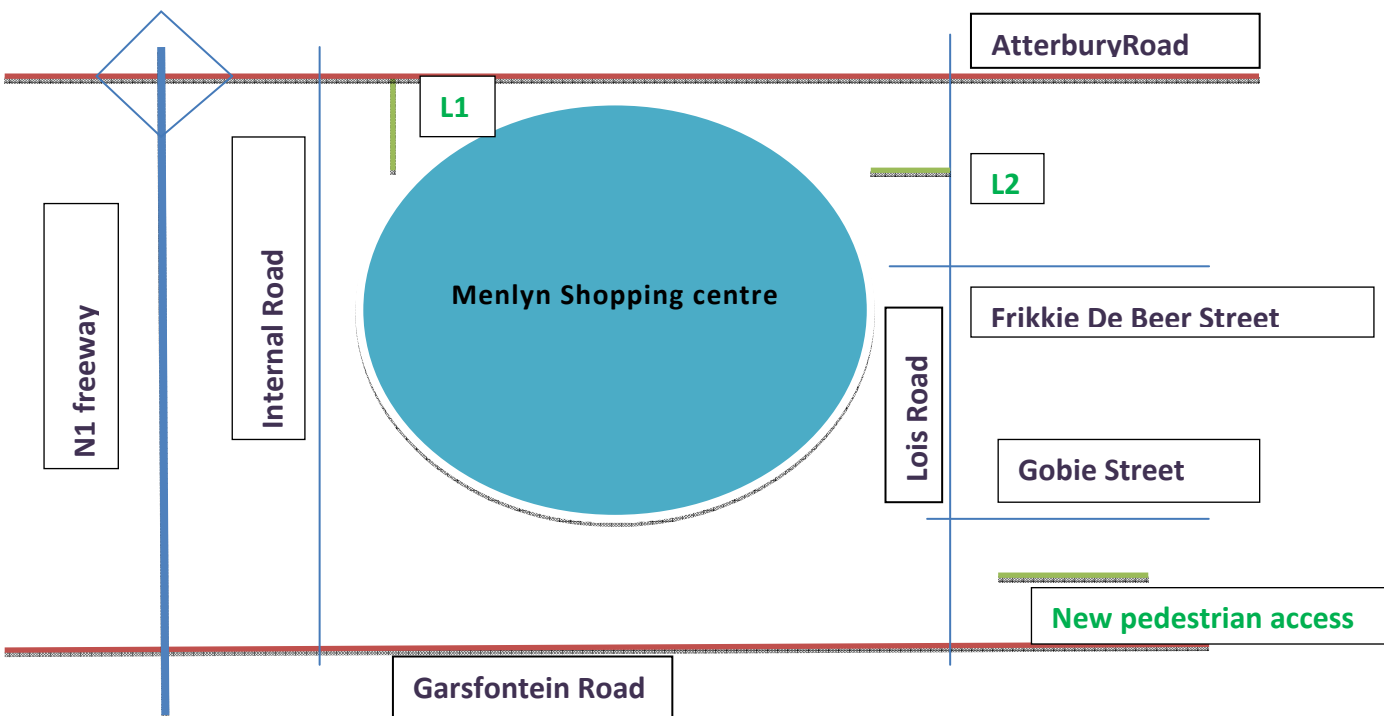


Figure B Menlyn Map

Legend

Short green lines labelled L1 and L2 are the places where taxis drop off passenger

Long red lines are the main roads to Menlyn

1.5.1 Present state

1.5.1.1 Ranks and sub-ranks

Due to urbanization Menlyn Taxi Association business has grown to an extent that additional sub-ranks have been established to meet the demand. Sub-ranks were developed in areas where there are lots of passengers going to like malls.

Area	Type of rank
Belle Ombre	Sub-rank
Hatfield plaza	Sub-rank
Woodlands	Main rank
Menlyn	Sub-rank
Prinsloo street	Main rank
Brooklyn mall	Sub-rank
Willows	Sub-rank

Table A - types of ranks

Belle Ombre: it used to be a main rank but after the Menlyn association recognized that there are more passengers going to Menlyn from Pretoria Central Prinsloo Street was changed to be a main rank.

Hatfield Plaza: it has a lot of passengers because of the university that is situated next to it and companies in the vicinity.

Brooklyn mall: it is a business place with many office parks and a shopping centre as a sub-rank was established.

Woodlands mall: it was built few years back and a lot of people were employed and passengers go to the mall to do their shopping due to that a sub-rank was established.

1.5.1.2 Routes and destinations

There can be more than one route between two end points. Passengers are therefore supposed to be asked their destination because taxi may go via a different route to the destination. To improve passenger's service at the taxi ranks different method of loading a taxi with passengers can be used.

Menlyn Taxi Association has eight destination points to which passengers are taken to (*Based on the interview*). The eight destination points are

- Brooklyn
- Mooikloofatterburry
- Mooikloof ridge
- Moreleta
- Faie glen
- Willows

- WoodLands⁴
- Garsfontein

Most of the time seven destinations are loaded, however Mooikloofridge is loaded when there are many commuters going to that destination. So when there are fewer commuters going there they are loaded with the Garsfontein passengers. Taxi drivers are not allowed to choose which destination they want to take rather allocated routes based on the rate and mixture of passenger arrivals. There is a system in place for loading, if all the taxis were empty the first passenger will go to the first taxi, if the second passenger is going to a different destination then he/she will go to the second taxi in the line until taxi number seven because there are seven destinations. If one of the seven taxis is full the next passenger who comes will go to taxi number eight in the line. Because of the strategy they are using it's possible that a taxi can go to one destination more than twice a day.

Depicted in **Table B** below are different routes where passengers can take any taxis passes through that area.

Area	Hatfield	Hillcrest	Park	Walker	Menlyn
Willows	yes	yes	Yes		
Garsfontein		Yes	Yes		Yes
woodlands				Yes	Yes
Moreleta				Yes	Yes
Faerie Glen				Yes	Yes
Brooklyn				Yes	Yes
Mooikloof Ridge				Yes	Yes
MooikloofAtterburry				Yes	Yes

Table B commonly shared points

Figure C it an area map shows the routes to destination from Pretoria central to Pretoria East. There are common routes in figure c that are used for destination routes, common routes used are routes running between point T and point S, and point T and point H.

⁴ For the this report Woodlands, Wood hills and Wooddley refer to same area

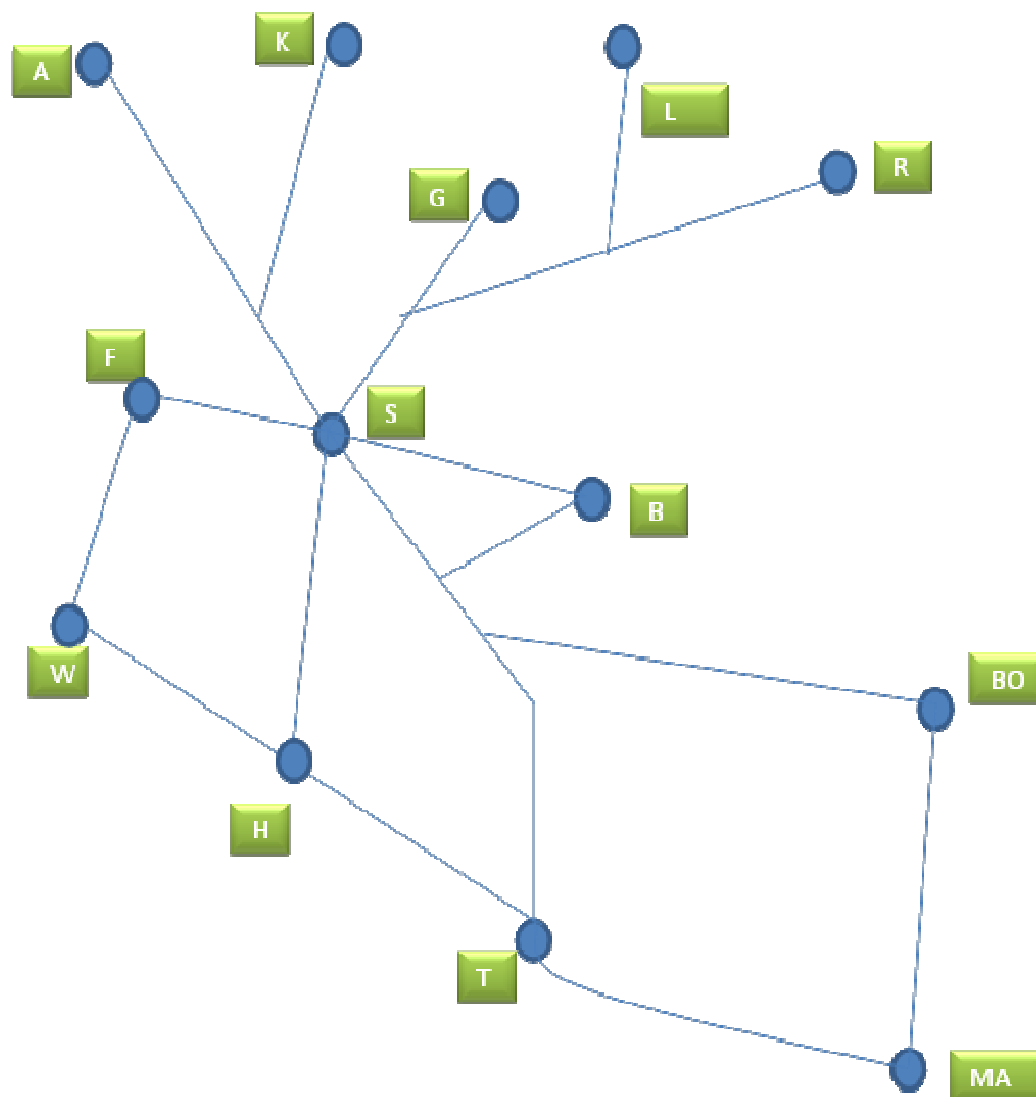


Figure C _route to destination

Figure D is legends showing codes used to requirement map figure C.

LEGEND:

H=HATFIELD	W=WILLOWS	T=PRETORIA CENTRAL
MA=MARABASTARD	BO=BOSMAN	B=BROOKLYN
L=WOODLANDS	K=MOOIKLOF CONTASTAIR	S=MENLYN
R=MORELETA	F=FAIRE GLEN	G=GARSFONTEIN
A=MOOIKLOF ATTEBERRY		

Figure D Legends

Detailed map for different destination is in Appendix A

1.6 Project outline

1.6.1 Project aim

The aim of this project is to investigate the pattern of the passenger clustering model on customer traveling time, taxi utilization level, taxi cycle time and customer waiting-time.

1.6.2 Project objectives

- Detailed documentation of how the taxi industry load and cluster passengers in South Africa.
- Identify key variables necessary on the trend of a typical taxi system in South Africa.
- To collect data on the identified parameters.
- Identify which options of loading and clustering performs better in application and the underlying conditions

1.6.3 Project scope

This project will cover geographical taxis under Menlyn taxi association in Pretoria; taxis that transport passengers from Pretoria Central at *Prinsloo Street* to Pretoria East areas. Taxis have limited routes that are used to respective destinations; passengers have to come to the main routes that are used by taxis.

To narrow the scope of this project, this research will only be focusing on three models of loading and three modes of clustering that will be used to investigate the effect of such models on the parameters of the taxi systems. Three main parameters of interest would be;

- Taxi utilization
- Taxi cycle time
- Commuters travel time

Case:

Menlyn taxi association was selected because:

- The number of destinations that taxi transport passengers to
- How ranks and sub-ranks function
- Number of ranks and sub-ranks in the area of function
- How passengers are loaded and clustered
- Size of the town and ability to conduct surveys on the taxi routes.

Taxi drivers have three options for loading during off-peak hours. These options are as follows:

- First option: drivers can go to the rank in Pretoria Central and wait in the queue for their turn to load then go to the destination they are assigned to.
- Second option: drivers can wait in the most busy areas where there are passengers going to Pretoria Central or Pretoria East areas
- Third option: drivers can leave from Pretoria Central to any destination of their choice taking passengers to their respective drop-off points and then turn back and go to Pretoria Central while loading passengers.

Taxi drivers have three options for clustering passenger on their way back to Pretoria Central

- First option: taxis may pick passengers of many destinations [going to different points that do not link] at once, cluster them into a taxi and swap them at the midpoint.
- Second option: taxis may pick strictly passengers going to their own intended destination
- Third option: taxis may pick passengers of many destinations that are linked and move from destination point to another until all passengers are dropped.

1.6.4 Project research questions

Based on the loading and clustering options available to drivers as discussed above, how is taxi utilization affected and which options are best to practice?

- For the first loading option how much time do they spend waiting in the queue and how would this affect them if the booking of a time slot is introduced.
- For the second loading option should they wait for the taxi to be full before they drive off to their destination?
- Drivers who choose loading options three will have to know which route is busy during which time of the day. Other factors that need to be looked at are: what is the capacity of the taxi and how routes are linked?
- For the first clustering option how does it affect the passengers when taxi stops and swaps passengers?
- For the second clustering option how does it affect the utilization of the taxi?
- Lastly how does going into many destination points affect the turnaround time of the taxi and the travel time of passengers?

1.6.4 Project deliverables

- Analyzed data
- Recommendation of how to progress with this project.
- Documented report
- Recommended methods/options on how taxis should operate during off-peak hours and peak hours

1.7 Summary

Chapter 1 gives a background of Menlyn Taxi Association. Menlyn Taxi Association has two types of ranks to load passengers from the sub-rank and the main rank. If passengers take a taxi at the rank it is highly possible that they will have to wait for it to be full or else they will have to wait at the bus stop where floating taxis pass. Passengers going to Pretoria East have eight destinations to go to and three to Pretoria central. The main highlights of this chapter are the loading and clustering models that form significant element of this research/study.

Chapter 2

2 Literature review

2.1 Problem Identification

The road-based public transport service is a big mover of passenger in South Africa it needs to be monitored. The minibus taxi problem is summarized into two sub-problems; firstly how to load and cluster commuters. Secondly the whole system is not managed further so it has become a problem that there are no proposed methods in how to work in order to get better and higher utilisation for each vehicle.

The greater efficiency of mass transportation must be exploited, it contended, by devoting more attention and money to the transformation and development of public convenience, which preserve the inner city area (Owen, 1966).

Few researches have been done on taxis and buses scheduling and modelling in South Africa. Research on urban bus routing has been performed by many on other countries, also public transportation problems experienced in Large Metropolitan areas.

For the purpose of this project will look into bus routing and scheduling in the developing countries and Metropolitan areas. Countries like Taiwan and Lisbon. As well as to how they develop and solve problems for public transport in the first and third world countries.

2.1.1 Loading and clustering commuters

Not choosing an optimal option in the correct hour of the day affects the driver in many ways and even the commuters can be affected by the decision of the driver.

2.1.2 Managing minibus-taxi

Taxis do not have a schedule on how to operate like other modes of transport, for example buses have a scheduled time where to load and at what time the passengers must be picked up and this information are made available to passengers. The problem lies in the fact that taxi owners have been largely self-regulating and do not want to be monitored by authorities because it has not been regulated. This makes it hard to improve the taxi service to be better.

2.2 Type of public transport and how they functions.

2.2.1 Bus Rapid transport [BRT]

A new integrated transport system was proposed to transform and to improve the value of service provided for the current commuters but also to attract new users.

This was a plan to achieve an integrated transport system by changing bus system into a bus rapid transit system. This system has been implemented in other third world countries like India and has achieved great success. The bus rapid transit is a system that provides fast, constant bus service thus minimising waiting time and queuing in bus stations. The above is achieved by putting into use the characteristics that have been implemented in other countries which have successful bus rapid transport system.

BRT is characterized by:

- Level boarding which reduces the time passengerstakegetting in and out of buses, as the buses are leveled with the sidewalk and also since its leveled it makes it possible for disabled passengers in wheelchair to use buses without any help
- Improve the service and to lessen dwell times in buses stations by getting passengers funding to get more buses to operate withinthe area so that the buses will be more consistent with the timetables that they work on also to lessen the time intervals that are used at the moment
- Buses and all other road bound of public transport are dedicated colored lanes in the area so as to reduce delays and shortage of public transport during peak hours when there is traffic congestion.
- Buses also have audio equipment and wider doors so to accommodate those commuters that are ably different.

The above discussed bus rapid transport system also use integrated ticketing system which is characterized by usage of the same ticket in the buses trains and taxis for an accounted amount for certain kilometres. To avoid fraud in the system there is pre-boarding ticket fare collection and ticket verification.

The integrated public transport plan is characterized mainly by the following:

- Color coding of all transport modes depending on the kind of service they provide and the routes that they use so as to transport more easily to access by all kinds of passengers even those that are illiterate.
- An integrated public transport facility in stations are all modes of public transport will be at service to the public with ticket purchasing of tickets at the entrance and a closed system with free transfer between corridors of all transport modes. So as to make public transport more accessible to passengers using all modes of transport and also to avoid walking long distances to the stations/ ranks

2.3 public transport in the Third World cities

2.3.1 History of Third World cities

Urban transport in the third world countries is characterised by rapid growth in demand which has overwhelmed transport capacity (Armstrong-Wright, 1993).

On average the urban population of third world countries are growing at about 6%. Well above average increases it being experienced in china where the annual growth rate was 11%. (Armstrong-Wright, 1993) Developing countries are also experiencing population growth in urban areas. These increases in urban population have in turn resulted in massive increase in the demand of public transport. Other factors started on accumulation significantly to the level of the demand are spread for urban areas leading to longer and motorised trips, increased commercial and industrial activity and a greater inclination to travel where income have risen (Armstrong-Wright, 1993). In most cities because of these factors of demand for public transport in particular, has grown even faster than the population. The modal share of urban transport trips (modal slip) is subjected to very widespread variation between urban areas within the same country.

Unlike industrial countries, most trips in the developing countries are made in some form of public transport. Generally the use of private cars is comparatively high, but is gradually growing in all but the lowest income countries

2.3.2 Managing traffic to gain less cycle time

In the most Third World municipalities public transport by a very wide variety of buses and minibuses at different levels of technology other cities have many taxis available for individual use. In few cities priority is given to public transport by establishment of bus-only lanes and segregated rights-of-way (Armstrong-Wright, 1993).

The situation of traffic volumes is often exacerbated by highly peaked demand with as much as 15% of passengers' flow occurring in the morning and evening peak hours. Measures in the Seoul to advance hours by 30 minutes and delay working hours by 30 minutes are expected to cut demand almost in half (Armstrong-Wright, 1993). Passengers do not like spending a lot of time in the road; traffic is one of the causes of long cycle time during peak hours.

Bus and minibus services are found to demonstrate significant flexibility in meeting changes in the arrangement of the city development and level of demand (Armstrong-Wright, 1993). The flexibility is of particular value in developing cities which are experiencing rapid growth and significant land use changes. However, in some cities flexibility is inhibited by unjustified procedures and slow government response to change.

Other countries maintain low traffic and low cycle time of buses and minibus have reserved bus and minibus lane and cross traffic turning signs. In some cases buses reserved bus lane permitted bus and minibus journey speeds to be increased. Generally the effectiveness of bus-only lanes has been very mixed.

Contra-flow bus-only lanes generally have achieved better result. They are to a certain extent self-enforcing. Encroachment by other vehicle is far more difficult and hazardous, and as a result is not as frequent as with "with-flow" bus-only lanes (Armstrong-Wright, 1993).

These have cause disadvantages in some cities that were experienced by pedestrians who are not expecting to see buses approaching from opposite direction to the main traffic flow. This happen in Rio de Janeiro this led to increase in pedestrian accidents (Armstrong-Wright, 1993).

2.3.3 Bus and taxi service

Bus services have in the past been dominated by many operations and currently most cities continue to have one or sometimes two or more publicly owned bus corporations. However they have suffered declining effectiveness and viability and have been quite unable to cope with the very rapidly growing demands of recent years. In most cities the gap has been readily filled by private operates who now command by far the greater share of the market despite often facing serious difficulties (Armstrong-Wright, 1993).

2.4 Control and supervision of bus services

Supervision was confined to inspectors at terminals and major intersections checking running numbers of buses (numbers assigned in a roster) against the scheduled timings. For example in Dublin it was found that inspectors at either end of a heavy cross-city route might issue contradictory instructions to drivers running out of schedule. A central control point may be able to detect overall pattern of delays and their causes of delay with only local knowledge available (White, 1976)

Systems now in use or being tested include:

1. Closed-circuit television (CCTV) are cameras mounted at strategic point in central area scan intersections and stopping points, usually with variable focus and direction. General traffic conditions, abnormally long queues are detected at central control room.
2. Radio telephone-Driver's report position at frequency intervals and receive instructions.
3. Bus Electronic scanning Indicator (BESI)-London Transport system using fixed scanners mounted on posts, emitting horizontal beam at about three meters above ground.
4. Marconi-London route –each bus is fitted with Odometer {accurate mileage indicators} connected to a coding device and radio transmitter (White, 1976)

Telecommunication- the greater emphasis being given to the improvement of telecommunication system can be expected to provide considerable benefits to urban transport. Firstly inadequate and unreliable telephone systems result in very many otherwise avoidable journeys having to be undertaken to hold discussions and to pass messages. In some cities these journeys add very considerably to traffic flow and congestion. Secondly poor telephone systems tend to inhibit balanced land use, as in the case of Caracas, where bad congestion is partly due to the concentration of offices in the city centre because of the wide practice of passing messages by carrier rather than by telephone. Studies in India indicate that industries are reluctant to move to development areas designed to minimise transport needs because telecommunication are not reliable. Thirdly many high technology transport systems such as area traffic control and surveillance make use of telecommunication networks for relaying data (Armstrong-Wright, 1993).

All the above systems are used to fill gaps in service, or reallocating vehicles between timing and routes at termini.

2.5 Taiwan

2.5.1 History for Taiwan

In the past timetable and schedules were made manually which it was inefficient. Inter-city passenger trips demand in Taiwan has increase drastically due to rapid economic growth. The number of carriers has also increased, making the markets very competitive (Yan & Chen, 2002). Due to congestion the government encouraged passengers to use public transportation and more passengers are using it, so the inter-city bus carriers are encouraged to efficiently conduct passengers' transfers, in these an environment, Taiwan's inter- city carriers have striven to improve their operations (Yan & Chen, 2002).

The following factors were looked at:

- Timetable setting,
- Bus routing,
- Timetable establishment,
- Bus maintenance and
- Crew scheduling.

Scheduling during this process was the fundamental focus because they affect bus usage efficiency

According to Ali and Mohauzadreza (2003), bus scheduling usually consists of four interrelated components:

1. design of routes
2. creation of timetables
3. scheduling vehicles to trips
4. And assignment of drivers.

The general vehicle scheduling problems are problems in which a number of vehicles starting from one or more rank have to collectively visit a number of demand points and then return to the rank from which they start (Ali, Mohauzadreza, & Kun-Hung, 2003)

2.5.2 Current state

Taiwan Inter-city bus carriers are currently using trial-and-error process for bus routing and scheduling practices. Where draft are given to planners and planners adjust the draft based on the number of available buses, average operating speed, the turn-around time at the station, and the bus balance at each station, and related cost/revenue of bus movements between cities. According to Yan and Chen, a timetable is design in accordance with the projected demand and the give right of way [licenced routes].

According to Yan and Chen ,in their paper, their model and given a solution algorithm that have been developed for intercity bus carries to efficiently and efficiently design their bus routes and schedules, so as to improve their profits and levels of services.

2.5.3 The model

To solve problem that Taiwan had with bus times they have model, where the model was demanded the optimal management of both bus and passenger movements in the network through the systematic manipulation of direct bus trips, multi-stop bus trip, and passenger transfer operations, utilizing such given data as the projected passenger trip, available fleet size, the bus operating speed, the station fun-around time (Yan & Chen, 2002).

This is one solution they have used to solve the problem by determining the lower bound solution.

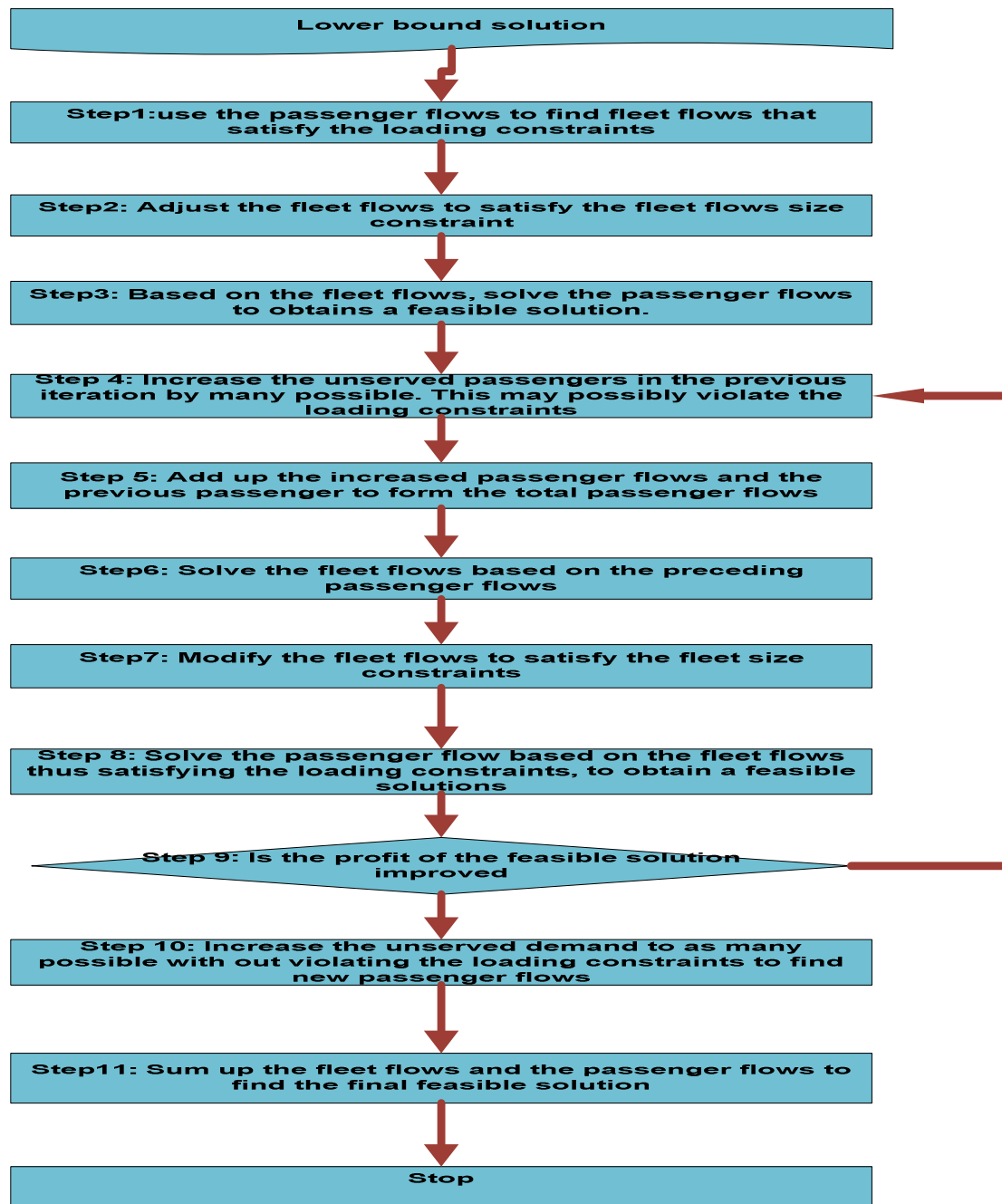


Figure E-lower bound solution

A new optimisation procedure to design minibus services (Yan & Chen, 2002)

2.6 Lisbon Metropolitan Area

The Lisbon has an objective to develop a comprehensive methodology to design a service that would try to attract users from the private vehicle especially for commuting trips, during peak hours, improving the efficiency of urban mobility. Optimisation problems applied to bus system design, setting of frequencies, timetabling, scheduling of vehicle, and crew assignment (Guihaire & Hao, 2008).

The problem was divided into four phases (Eiro, Viegas, & Martinez, 2011)

- An initial phase, which assessed the behavior of potential users in the study area, using a decision tree model to estimate the willingness of travellers to use new service. The phase was based on attributes of their current trips chain configuration and lifestyle designated as demand estimates.
- Second phase, the potential location of the stops of the system is computed, based on the estimated potential demand of the different places in the study and demand periods designated as stops location.
- Third phase ,model estimated the potential demand of each links between the defined minibus stops, and set the system potential O/D matrix designated as Minibus Link Load Estimation.
- Last phase model computed the most profitable minibus routes for the given O/D matrix and defined the path of each vehicle and it occupation during the analysis time period designed as Minibus Routing.

Simplified methodology encompassed of two was used.

First stage, the main variables that could have more influence in willingness to change to this new service were identified [number of daily trips, public pass ownership, daily distance, car availability, daily activity time and the existence, or not, of a non-commute subway trip], in the second stage a simplified Delphos method was used estimate the weight that each selected attribute would have on the choice.

2.7 summary

In Chapter 2 public transport in developing countries, like South Africa is discussed. These include ways in which transport has been developed in these countries. Taiwan and Lisbon are discussed to see the methods they have used for public transport. The characteristics of BRT and fit functions are also discussed in the chapter.

Chapter 3

3 The research methodology

3.1 Introduction

An investigation into minibus-taxi is a very sensitive and at times risks have to be taken into consideration (Mashiloane, 1998). The nature in which minibus-taxis owners operate is different from their competitors. The research has to be structured so that new facts are discovered and in a way that can influence the investigation in a positive way. It is vital to implement a research method that ensures a degree of success in the gathering of data, this should be done without any fear of unfairness, and all the parties should understand why this is done. Workers these days are not secure with their jobs because of economic crisis so it is hard for them to give information out during research.

The importance of a research design as a scientific method is a systematic, organised series of steps that ensure maximum objectivity and consistency in researching a problem. Therefore, this research should be planned and organised to get information in each phase of that collection (Mashiloane, 1998).

This chapter discusses the research method used in this project. This ensures that information that is needed for the success of the project is gathered in a correct way.

3.2 Type of study

Public transport in Pretoria Central to Pretoria East is used by passengers who travel to work, school and shopping centre. Data that needs to be collected must show the following:

- Passenger arrival rate
- Passenger waiting time
- High picking spots
- Minibus-taxi utilization
- Minibus-taxi arrival rate
- Loading time
- Taxi cycle time
- Passenger travelling time

The study must be done in a very descriptive way according to the method used to explore the area of work. A quality study is essential because minibus-taxis have reserved little attention in terms of research. This can be done in a situation where data is collected in observation and time studies are taken. Therefore information captured must be recorded correctly to generate valid findings.

The data was also collected in a form of an interview environment where relevant questions were presented to taxi owners, queue marshals⁵, taxi drivers and passengers. This was done in order to get a better understanding of how taxi industry functions, as well as problems experienced and what

⁵ Query marshals are responsible for determining which taxi takes the next passengers at the rank and complaints of passengers

is the service level of the industry. The participants' responses are very important because they show how the industry is operating and also gives public views about minibus taxi industry.

3.3 Data collection and Type of data

3.3.1 Primary research

A numbers of interviews with key industry stakeholders were conducted during the data collection phase and even attending few meetings with the executive members of Menlyn Taxi Association.

3.3.2 Secondary research

Secondary research consists of in depth reviews of the state of the public transport existing literature concerning the current transport situation in Pretoria Central and Pretoria East. How has public transport in South Africa, especially the taxi industry, been improved and remodelled to meet world standards, and what are the plans of hand for the government to examine other modes of transport and how they function to meet their passengers' needs.

Further examinations of international studies dealing with the issue are addressed in this report.

3.3.3 Data collection methods and research tools

Data collection is characterised as providing either on-board survey information or passenger counts, information on origin to destination movement, which are readily obtain only from passenger surveyor, provide the best basis for good short range planning decisions (Anthony & Nigel, 1982)

An overview of the public transport system in Menlyn Taxi Association was prepared in term of a series of A4 information sheets, one of which relating to the origin area and destination; traveling information was sourced in the database. The A4 information sheets were used to collect data.

The first data sheet ⁶which is called **data form 1** contains table of information with a unique registration number, taxi arrival time at the rank, time taxi start to load, time last passenger went in the taxi, departure time from the rank, capacity of the taxi and destination. A complete **data form 1** example is in a appendix A. A number of factors/ information can be calculated for information from **data form 1**:

- How much time it takes to load a taxi looking at all factors that are involved?
Examples of such information include:
 - Capacity of the taxi
 - Time of the day
 - Destination for the taxi
- Also from **data form 1** information like which routes have more passengers going to and how it changes over the course of the day?
- How much time it takes for each taxi to come back and load at the rank?
- What is the arrival rate of passengers and taxis

⁶ For the remainder of the document the, term data sheet and data form refers to same document.

REGISTRATION NUMBER	NUMBER OF PASSENGER	TIME				DESTINATION
		TAXI ARRIVAL	FIRST PASSENGER	LAST PASSANGER	DEPART TIME	
105 MFM GP	15	06:00	06:00	06:01	06:01	brooklyn
BC 85 SK GP	14	05:58	05:58	05:59	06:00	brooklyn
NTK 026 GP	15	06:00	06:00	06:01	06:02	brooklyn
PRB 711 GP	15	06:00	06:00	06:02	06:02	brooklyn
SKG 909 GP		06:00	06:00	06:01	06:02	garsfontein
686 MJM GP	15	06:00	06:01	06:01	06:02	garsfontein

Table C data form 1

The second type of data sheet is called **data form 2** it was used to collect information to show passengers distribution from place of origin to destination which contain the following information

- Unique registration number

This information is important cause each time a trip is done it must be possible to compare each driver to the other. These are unique attribute that we can see show how each driver drives.

- Depart time at the origin,
- Time at the midpoint,

Each route from Pretoria Central to Pretoria East a midpoint has been previously selected. More information about midpoint was discussed in previous chapters.

- Number of passengers the driver started with,
- Number of passengers inside the taxi at the midpoint,
- Number of passengers that joined the taxi between origin and midpoint
- Number of passengers that joins the taxi after midpoint
- Time arrived at the destination
- Destination
- Comments

Comment information is important because from it more detailed information can be extracted for example if a driver turns on the way because he/she had no passengers in the taxi.

Example of the passengers' distribution to destination table with information

passengers distribution to destination									
registration no:	depart time:	destinati on	time @ midpoint	no of passenger started wit	no of passenger left at the midpoint	no passenger joint the taxi at the midpoint	no of passengers joint after midpoint	time @ destination	comments
22/08/2011									
ZVK 128 GP	13:54	willows	14:15	21	16	8	1	14:30	waiting to load until 15:50
	15:55	town	16:12	21	20	0	5	16:37	
	16:50	willows	17:16	21	16	0	0	17:41	
	17:46	town	17:55	21	21	0	2	18:24	waiting to load until 19:03
	19:20	willows	19:34	21	13	6	3	19:49	

Table Ddata form 2

The third type of data sheet is called **data form 3** that was used to collect data in the taxi exchange points; the form contains the following information:

- Unique registration number,
- Minibus-taxi arrival time,
- Number of passengers taxi arrive with,
- Number of passengers minibus-taxi departed with,
- Number of passengers moved to other minibus-taxis,
- Minibus-taxi depart time
- and assigned destination

Example of taxis exchange point data form and with information and a complete **data form 2**an example is in the appendix A.

taxi exchange points

registration no:	arrival time:	destination	# passengers arrive with	no passenger left taxi	total left with	new passenger	depart time
VTM 635 GP	12:32	Bosman	7	4	8		12:35
XRR 075 GP	12:33	Town	13	5	14		12:35
YXY 504 GP	12:33	Marabastad	9	6	8	1	12:35
BD 96 SW GP	12:34:00	Town	5	1	6		12:35
WGF 587 GP	12:34	Town	12	3	9		12:36
VWF 793 GP	13:34	Marabastad	6	4	9		12:36
PJM 155 GP	12:35	Bosman	7	4	10		12:37
VFM 676 GP	12:35	Town	10	5	6	2	12:37
YDS 656 GP	12:36	Marabastad	6	2	12	2	12:37
BC 60 XW GP	12:37	Town	11	4	12		12:38

Table Edata form 3

Example of a full **data form 3** in the appendix A

3.4 Data process

Data process deals with the management of data. This includes analysis of data, and interpretation of the results or findings (Mashiloane, 1998).

In the analysis of the data specific observation can be found in each data form where information can be interpreted in graphs to show the findings and results of the data collection. Qualitative discussion on results will be discussed in the following chapters

3.5 Summary

The research method has been to a minor extent been shaped by the work condition of taxi industry: this chapter shows how information was extracted from the stakeholders and how it was captured.

This report is an attempt to bring structure to the taxi association and due to the lack of documentation on the Menlyn taxi association; the information was gathered via interviews. Thus the type of research conducted is an observatory type of study to obtain the current patterns of the loading and clustering conditions. Data was collected through interviews, time studies, trips done with minibus-taxis, and observing certain areas of work, data forms/sheets were used to store the information. The proceeding chapters provided a detailed analysis of the collected data.

Chapter 4

4 Discussion of findings from data sheet

4.1 Introduction

This chapter discusses the findings and observation that were found during data collection which it was discussed in the previous chapter of this report. This chapter will lead to the understanding of the loading and clustering problems happening in the minibus-taxi system. By analysing data to see how the service is and how passengers are loaded and clustered from origin to their destinations. This ensures that information collected is used to build the simulation model to see which areas are lacking and need to be improved. Findings are needed for the success of the project.

4.2 Findings obtained during data collection

4.2.1 Information from data table 1

Minibus-taxi start operating mostly around 04:30 am each day because most passengers start working at 7:30. Commuters leave their house early so that even if taxi gets stuck in traffic or there are no taxis in the rank, so that they do not get late to work. Minibus-taxis do not have schedule time which makes it hard to determine what time passengers will get transport. Sometime taxis may pass one after the other but only to find that they are all full.

Most commuters wait for minibus-taxis on Monday morning and Friday afternoon due to many passengers on Monday coming back from visiting their families and on Friday afternoon they go home. As a result of many passengers during those hours it caused passengers to wait for a longer time than usual.

4.2.1.1 *Waiting time for minibus-taxi*

Minibus-taxi in the rank waits in the queue until its loading. Waiting time differs from time to time.

Figure F is an example how long taxis wait when they come in the platform to load on a given day.

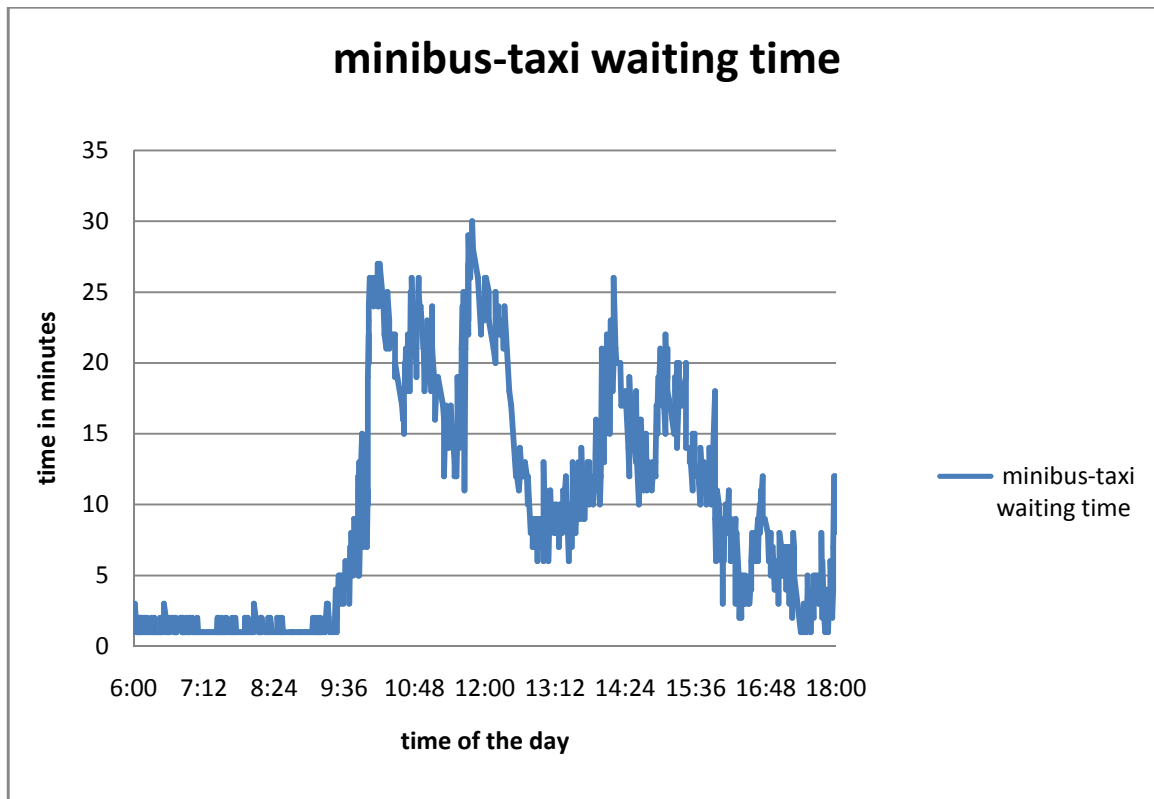


Figure F_Waiting time

Figure F above reveals how long the minibus-taxi waits from the time it arrives to load until the depart time. Waiting time between 06:00am-09:00am is very short because a great number of commuters that there are in the rank to be loaded. Between 09:30am-13:00pm and 14:30 pm-15:30 the waiting time increases. Around 15:30pm it starts decreasing again.

4.2.1.2 Passenger waiting time

Commuters waiting time is one of the main problems that affect the performance of minibus-taxi, commuters decide to use their own cars because of the inconvenience. Waiting time for passengers inside the taxi differ from one passenger to the other, a passenger who was first in the taxi will have high waiting time than passengers that will follow him/her. The figure G below shows waiting time from when the first passenger gets in until the taxi is full for a given day.

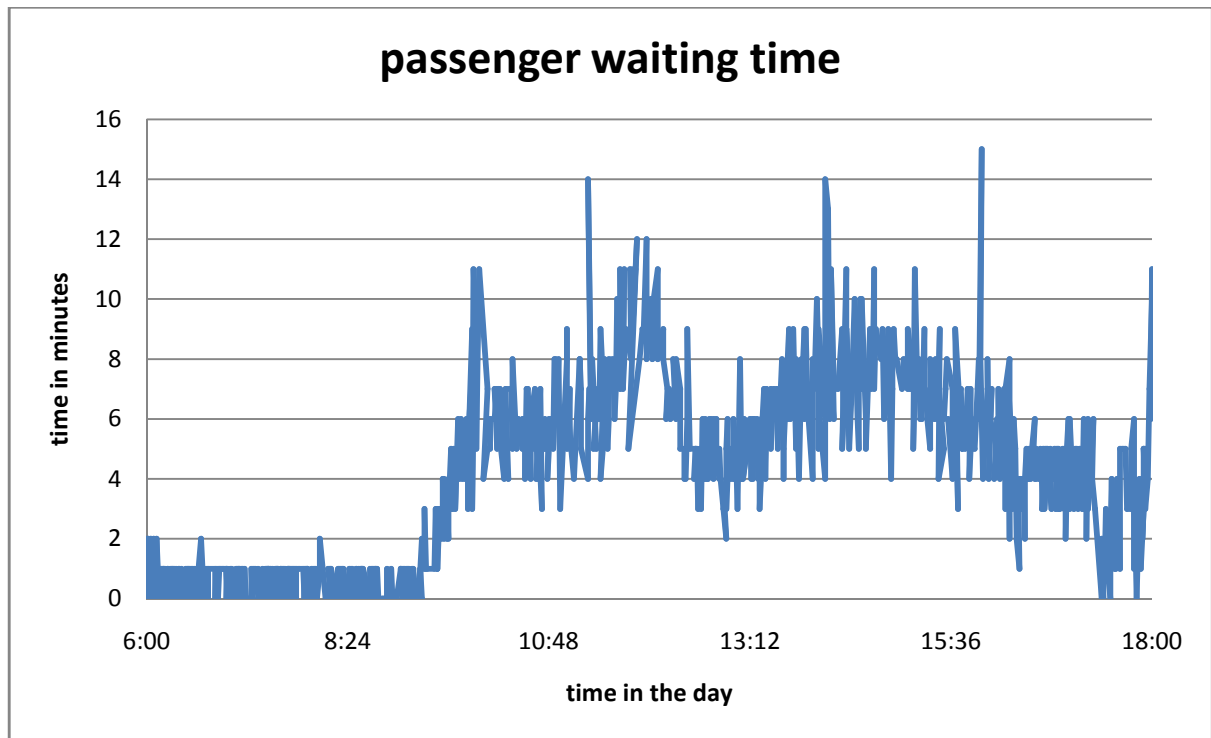


Figure G_Passenger waiting time

4.2.1.3 Depart rate for taxis

Departure rate shows how many minibus-taxi leave the rank on the given time. Depart rate is calculated for every 30 min from 06:00am until 06:00pm. It reveals the busiest time of the day in the taxi industry. *Figure H* below shows data for minibus-taxi.

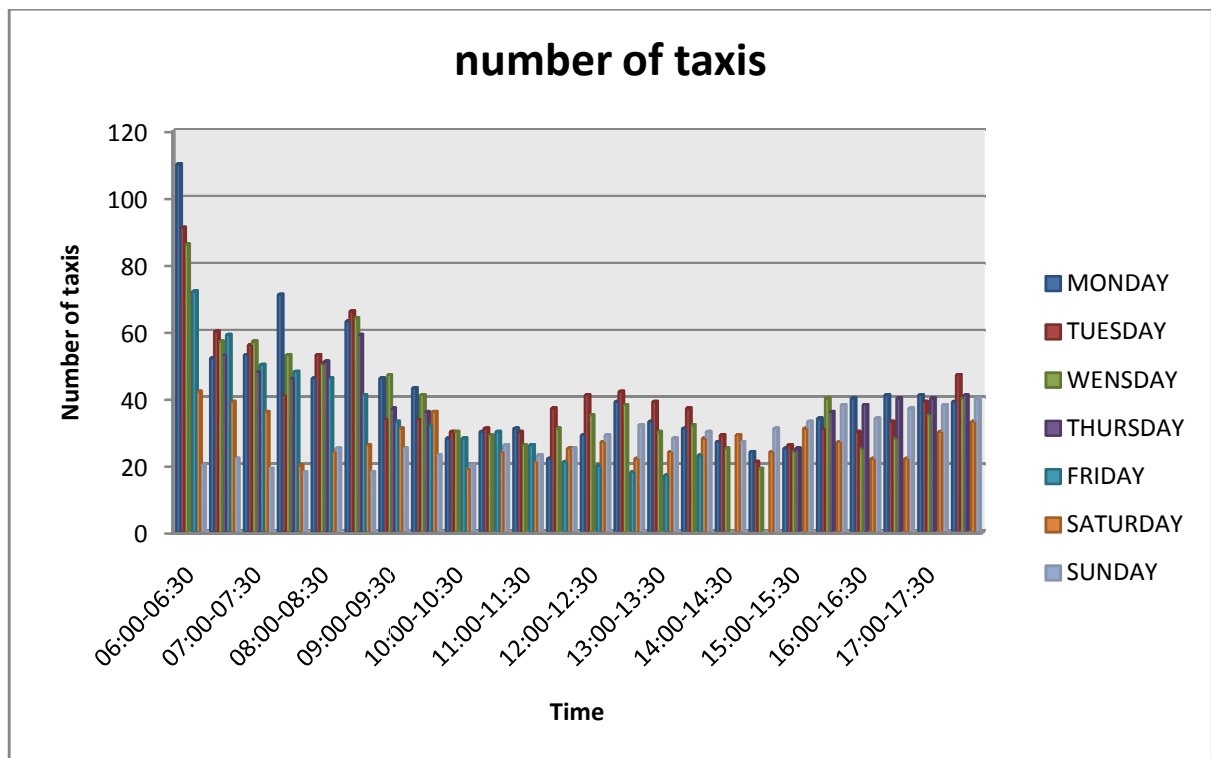


Figure H Number of taxis

4.2.1.4 Rate of transporting commuters

Number of commuters transported each hour differs from the next because of vehicle capacity and the rate which commuters come to the rank.

Menlyn taxi association has about 380 taxis that operate in a given day. The distribution of the capacity is as follows:

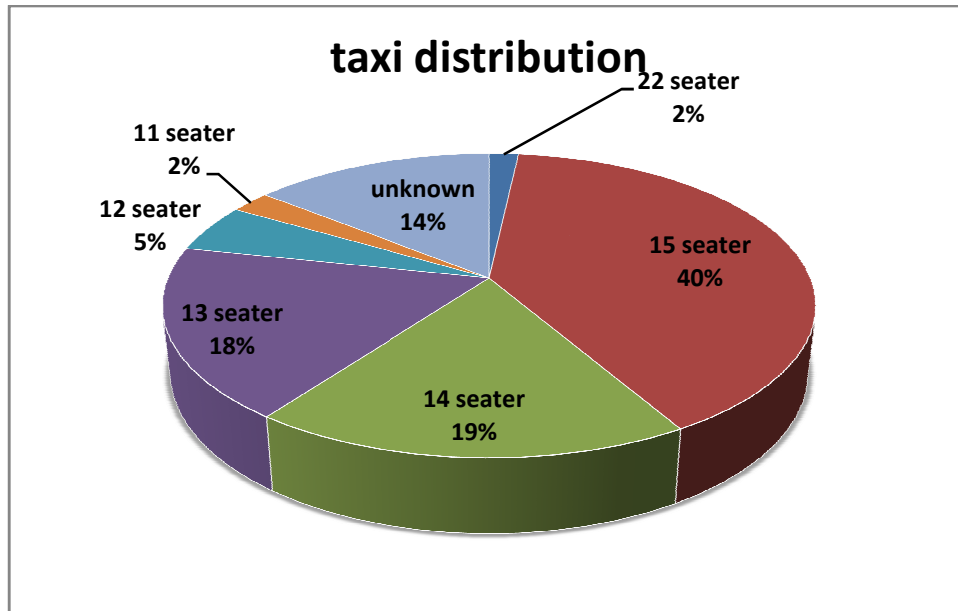


Figure I Taxi distribution

This shows that there are more 15 seaters followed by 14, 13, 12 then 11 and 22 seaters; 14, 13 and 12 seaters were introduced 3 years back and early last year 22 seaters were introduced by the government to replace all the other small capacity minibuses. The aim was to introduce midi-bus⁷ taxis which are 18, 22 and 35 seaters but only 22 seaters is successful so far. Due to the difference in capacity of minibus-taxis, the number of transported commuters differs each time.

The rate at which commuters come to the rank is a random distribution but the distribution follows in a certain pattern during the entire day. There are more passengers in the morning and afternoon compared to midday. *Figure J* is an example of what happens on Monday to Sunday in different times of the day.

⁷Midi-bus-taxi is any taxi that is between 18 to 35 seater for passengers.

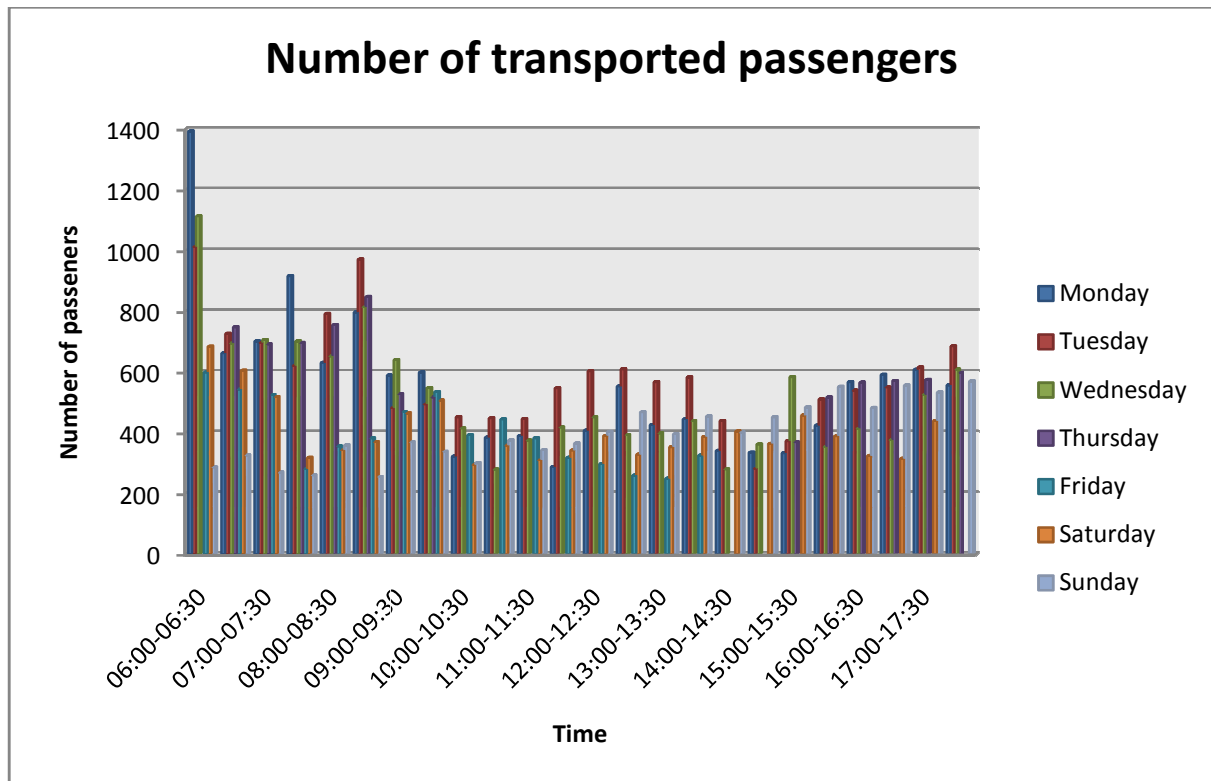


Figure J Number Of transported passengers

4.2.1.5 Depart rate for taxis vs. rate of transported commuters

Figure K and figure L show that due to capacity of the taxi can affect rate of transportation. When the number of passengers transported is calculated, the finding reveals that passengers at a specific point in time exceed the seating capacity of taxis. This is due to grouping of taxis in a random hour for instance the seating capacity of taxi differs at a given time, one hour 15 and 22 seaters and next hour more of 13 and 14 seaters.

The figure K and figure L below show the relationship between departed taxis and transported passengers at the same time. Between 6:00am and 6:30am the blue bubble in figure K shows that more taxis were used on Monday compared followed by Tuesday then Wednesday, but checking on the figure L the blue bubble at the same time as in figure K more passengers were transported compared to Tuesday while Tuesday more taxis were used. In figure K between 10:00am and 10:30am on Tuesday and Wednesday same number of taxis were used, and in figure L for same number of taxis used but different number of passengers were transported.

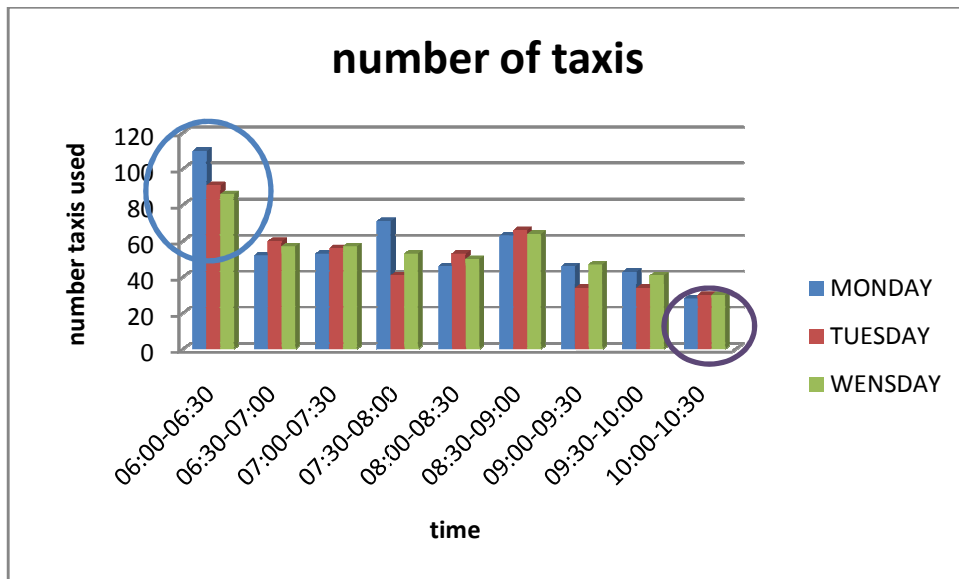


Figure K Number of Taxis

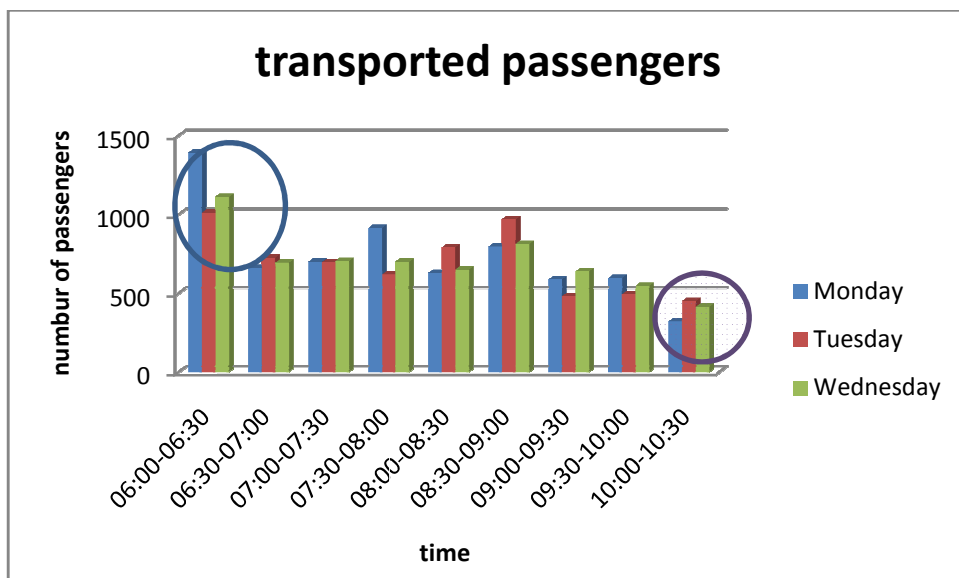


Figure LTransported passengers

4.2.1.6 Distribution rate to areas

Number of trips done in a specific destination it based on what is the rate of passengers going to each destination. This information helps us to be able to distribute minibus –taxis by the end of the day to which areas/destinations to go and fetch passengers back to Pretoria Central. **Figure M**belowshows which destinations have lot of passengers going to it until the East destination with fewer passengers going to it.

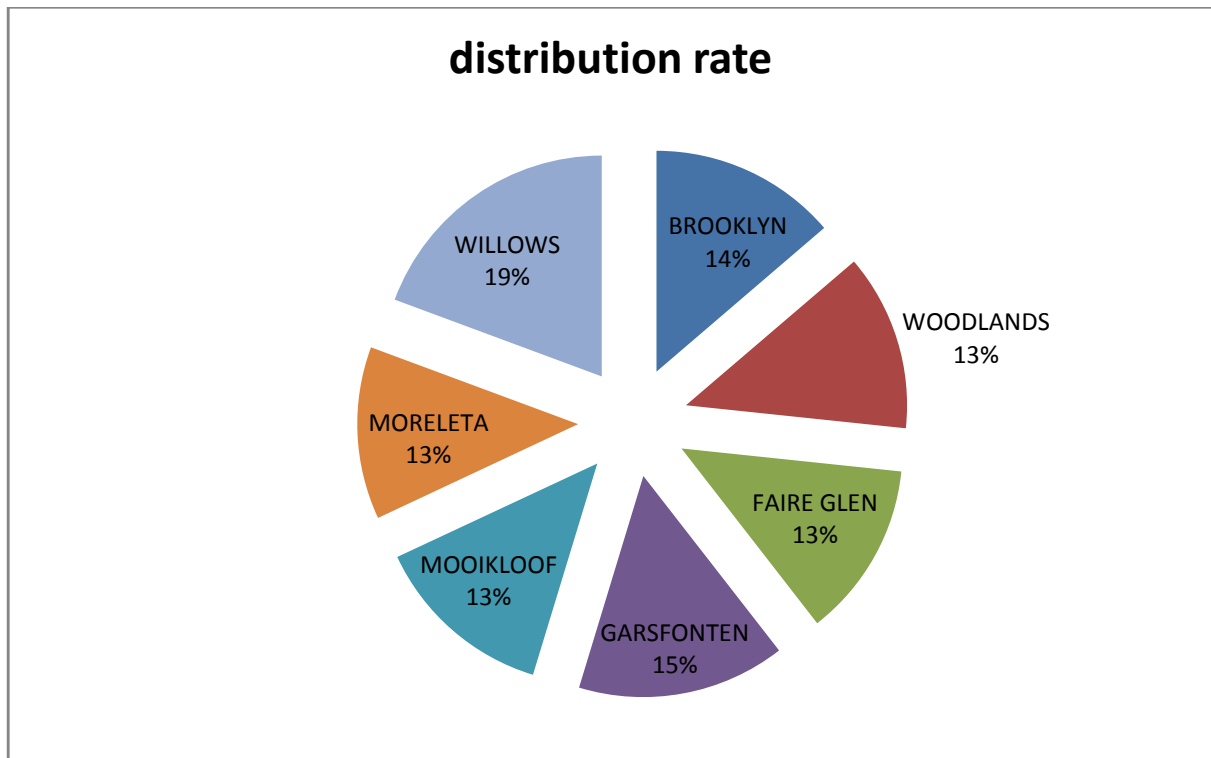


Figure M Distribution rate

To explain further how the distribution of passengers to their destinations more attention is to how many trips in total are done per day. Details how many trips are done per hour to each destination. The *figure N* below shows how many trips were done and which destinations had many trips to them.

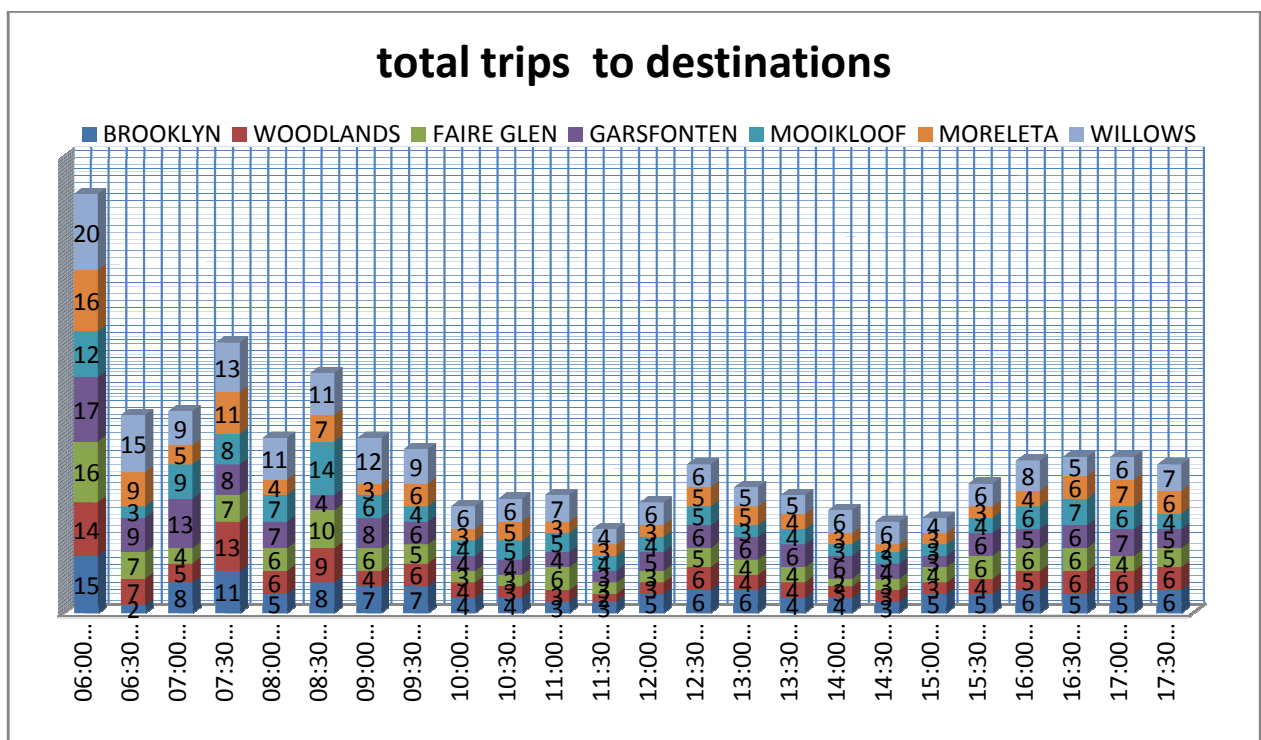


Figure N Total trips to destinations

Information from the data collection [dataform1](#) shows number of finding that will be analysis in the following chapter, information like waiting times for passengers and minibus-taxis, depart rate for taxis, rate at which passengers are transported and distribution rate to destinations.

4.2.2 Information from data table 2

4.2.2.1. Cycle times

It is typically known also that traffic volumes can vary from day to day and hour to hour. Traffic volumes cannot be determined or predicted and minibus-taxis always run away from traffic by using routes parallel to ones they supposed to use with traffic. Due to traffic problem it makes it hard to determine cycle time during peak hours. From the data table 2 as it show in the previous chapter, information that can be found from [table F](#) is cycle time. Cycle times differ from routes to route and time of the day as it is showing [table F](#).

cycle time	peak hour	non peak hour
<i>mooikloof ati</i>	55	41
<i>mooikloof ric</i>	52.5	39
<i>faire glen</i>	32.5	27.5
<i>garsfontein</i>	44	37.5
<i>menlyn</i>	30	21
<i>moreleta</i>	40	35
<i>woodlands</i>	41	33
<i>willows</i>	42	30
<i>brooklyn</i>	31.5	27

Table F Cycle time

From this table it can be seen that MooikloofAtteberry has longer cycle time is 55 min and nonpeak hour it has a cycle time of 41min and the shortest time is Menlyn it has 30 minutes during peak hours and 21 minutes during nonpeak hours

Factors that increase cycle time are:

- using a different route

Taxi drivers always check the traffic on the road and which routes have lots of passengers during that hour of the day, so drivers will use different route base on that to get to destination they going to.

- Traffic

During peak hours there is traffic on the road taxis are delayed by traffic that is why cycle time increases during peak hours.

- Loading and off-loading passengers

The rate at which passengers are loaded and off-loaded affect the cycle time of the taxi, during peak hours there are lots passengers on the road and you may find that the driver load or off-load every second street which increase the cycle time.

- Exchange passengers

Taxis stops in exchange points to swap passengers if drivers have passengers going to different destination

- Stopping at areas where there is lot of passengers

During off-peak hours there are fewer passengers on the road compering to peak hours so drivers stops in schools trying to fill their taxis before going back to town.

4.2.2.2 Passengers on the road

Most of the time drivers decide to go around so that they can get passengers because during the day the arrival rate for passengers goes down. Number of passengers in the road differs from time to time; sometime the driver can drive from origin to destination without having any passenger in the taxi. So the driver needs to be strategic to know which areas have passengers around which time of the day. *Figure O* below shows the number of passengers that were picked by taxis and the number of passengers the taxi start with to the destination. *Figure O* the blue line shows number of passengers started with and the red shows total number of passenger transported when the taxi gets to the destination. The different between the total passengers transported and passengers started with gives numbers of passengers transported from the way which will be discuss in paragraph 4.2.2.5.

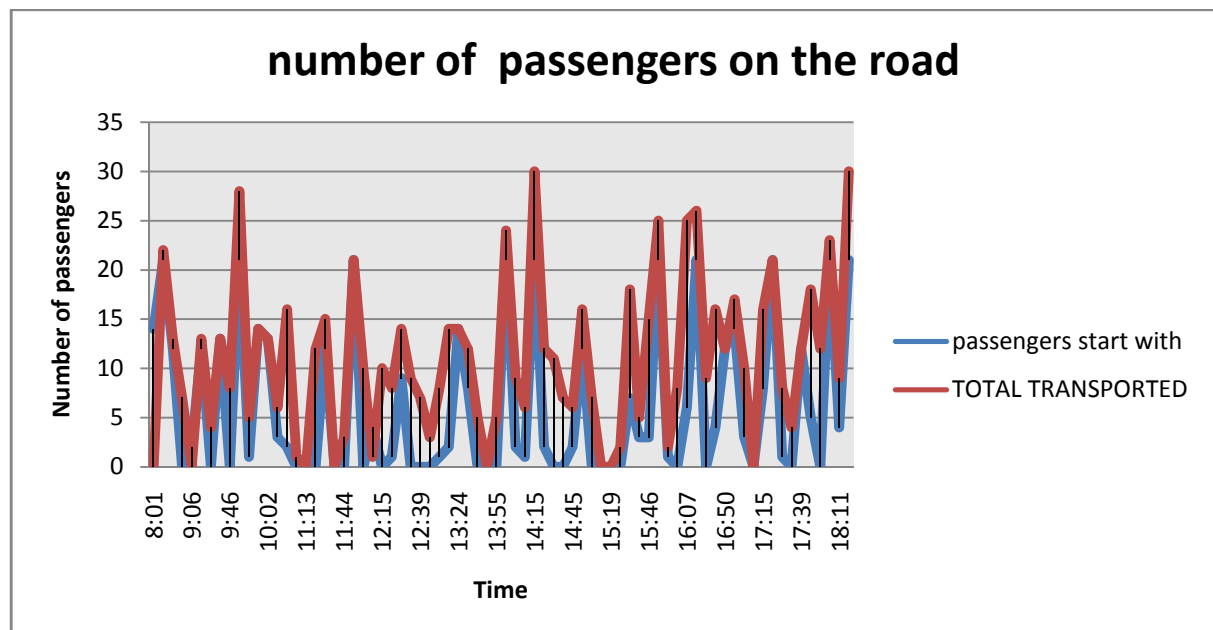


Figure O Number of passengers on the road

4.2.2.3. Number of passengers dropped before midpoint

Passengers may drop before the midpoint which spaces may be created in the taxi for the drivers to load more passengers to the destination. The rate at which passengers drops it changes with time in the morning you can find that higher number of passengers drop at/before the midpoint based on which areas are before the midpoint. Certain times of the day passengers don't go in numbers to certain areas like in the mall fewer passengers will go to it around 10:00am -11 am, and you find areas with schools you will find lot of passengers going to them around those times. *Figure P*

below shows information discussed about and the areas where the bar graph is negative it so that the taxi has dropped passengers that were loaded before the midpoint. The negative area shows that had start with no passengers or less than the number of passengers that were dropped.

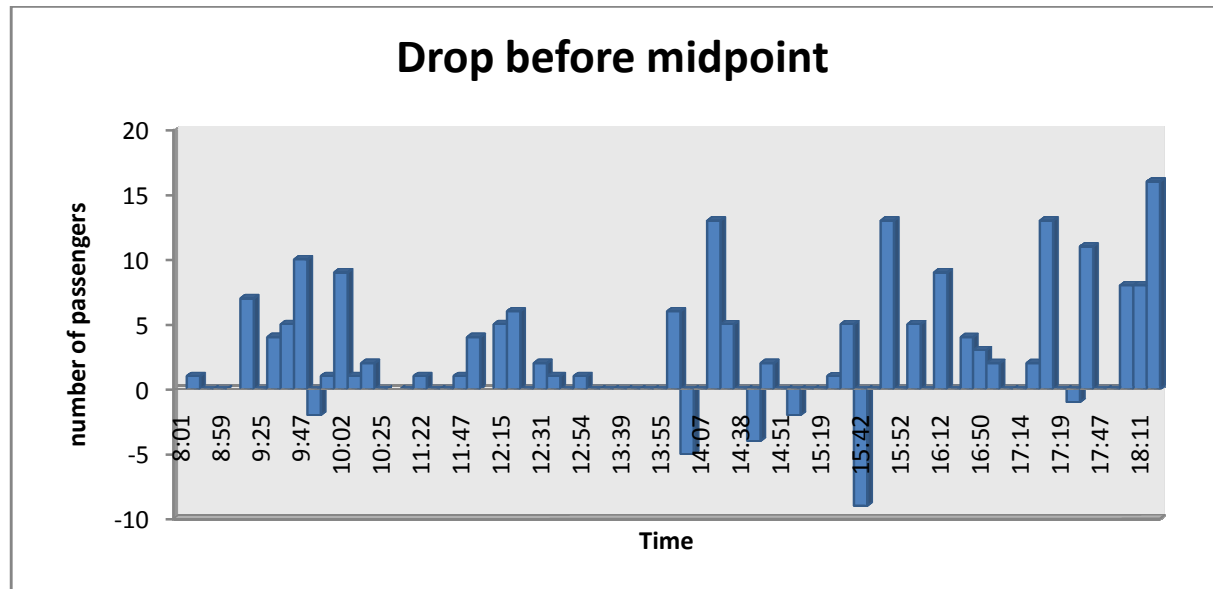


Figure P Drop Passenger before midpoint

4.2.2.5 Passengers picked on the road

The rate at which a passenger is picked on the road is based on the time of the day, the route which the driver uses and the availability of space in the taxi. More space is available in the taxi more passengers can be picked if they are there. Figure Q below shows which time of the day drivers had picked a lot of passengers on the road.

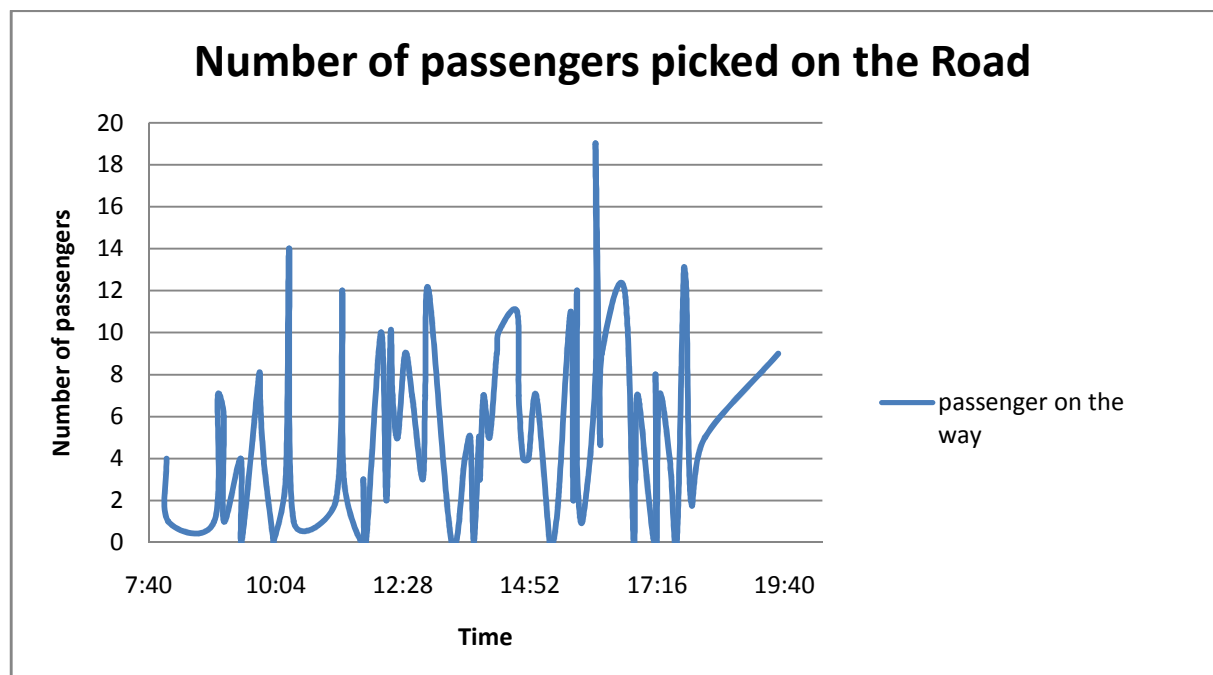


Figure Q Number passengers on the road

Information from the data collection *data form 2* shows number of finding that can be used to build the simulation model, information like cycle time, number of passenger pick on the way and dropping rate

4.2.3 Information from data form 3

Passengers coming from Pretoria East have three destinations that they can go to in Pretoria Central. These destinations are:

- Bosman
- Town {Pretoria CBD}
- Marabastad

Passengers when coming from the East are not always loaded and clustered according to their destinations points. It is only in Menlyn were passengers are loaded according to their destination points, so if taxis coming from the east have passenger going via Hatfield they are exchanged at Menlyn because most taxis use a different route. Due to how passengers are loaded and clustered it lead drivers to exchange passengers among themselves according to their destinations. Place where drivers exchange passengers are called exchange points. There are two exchange point on the way to Pretoria central are at:

- DTI Building {corner Schoeman street and Nelson Mandela drive}
- Corner Van der Walt and Walker street

In DTI Building exchange all three destinations are available but in the other exchange point only two destination are available because passengers to Bosman passengers walk to Bosman.

4.2.3.1 Waiting time in exchange points

Passengers time in the taxi increases because of the exchange points which increase the cycle time of the taxi. Waiting time differ in certain hour of the day, the difference in waiting time is cause by

- In the morning there are no enough taxis to change passengers among which lead sometimes taxis from DTI going to corner Van Der Walt and Walker to change passengers there. Due to less number of taxis available in the morning many taxi driver decides to take passenger going to one specific destination
- Late in the afternoon it is because of the are many taxi to the exchange point and the is limited space which cause taxis to wait for a space for parking and they have to make sure that all the passengers they came with are in taxis before the driver can go.

time	waiting time(min)
8:00-9:00	1
9:00-10:00	1.5
10:00-11:00	1.5
11:00-12:00	1
12:00-13:00	1
13:00-14:00	1
14:00-15:00	1
15:00-16:00	1.5
16:00-17:00	1.5
17:00-18:00	1

Table G Waiting time at the exchange points

4.2.3.2 Distribution of taxis at the exchange point

Number of taxis living the exchange points goes to different destinations, which are Bosman, town which is Pretoria Central and Marabastad. 52 % of taxis end up going to Town, 24% going to Bosman and Marabastad. **Figure R** shows the percentages below.

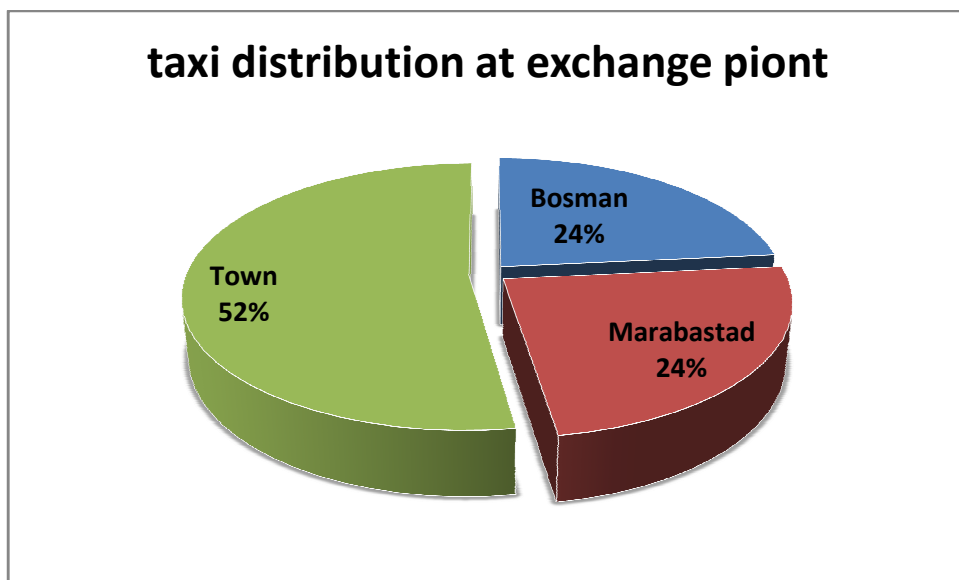


Figure R Taxi distribution

4.2.3.3. Taxi distribution per hour

Numbers of taxis that come to the change points differ from hour to hour because of number of passengers available to be transported (peak or off-peak hour). **Figure S** below shows that number of taxis coming to the exchange point increase each hour where between 10:00-11:00 have fewer taxis with 5% and between 16:00-17:00 have the highest percentage of taxis that have left the exchange point with 20%.

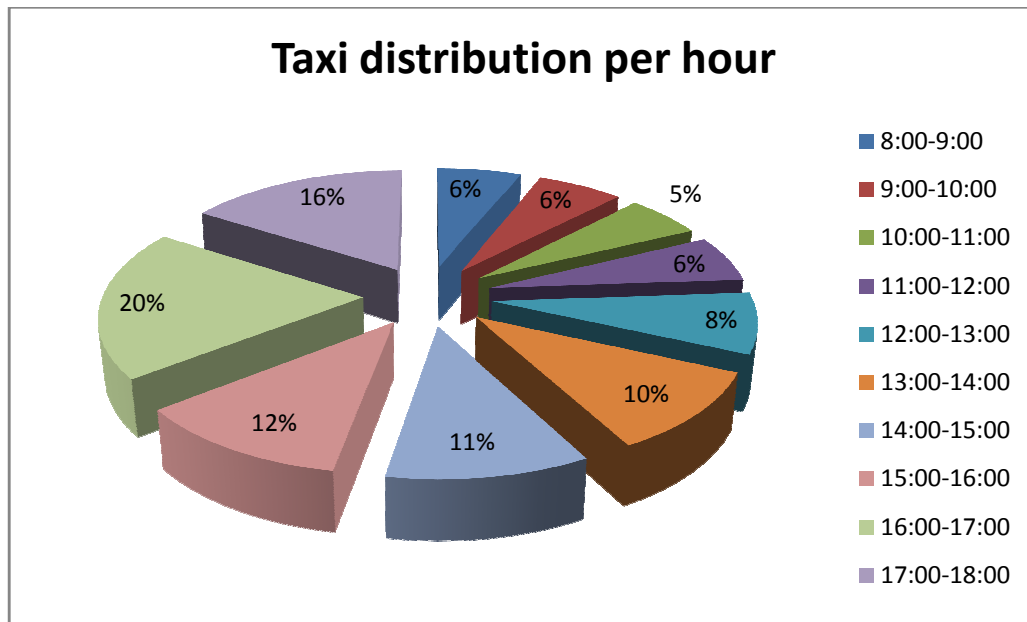


Figure S Taxi distribution per hour

4.2.3.4. Taxi distribution to destination per hour

Taxis that come to the exchange points go to different destinations after drivers have exchange passengers figure T below shows which destination have lot of taxis going to it and at which hour. Town have lot of taxis going to almost the whole day while other destinations differ from hour to hour.

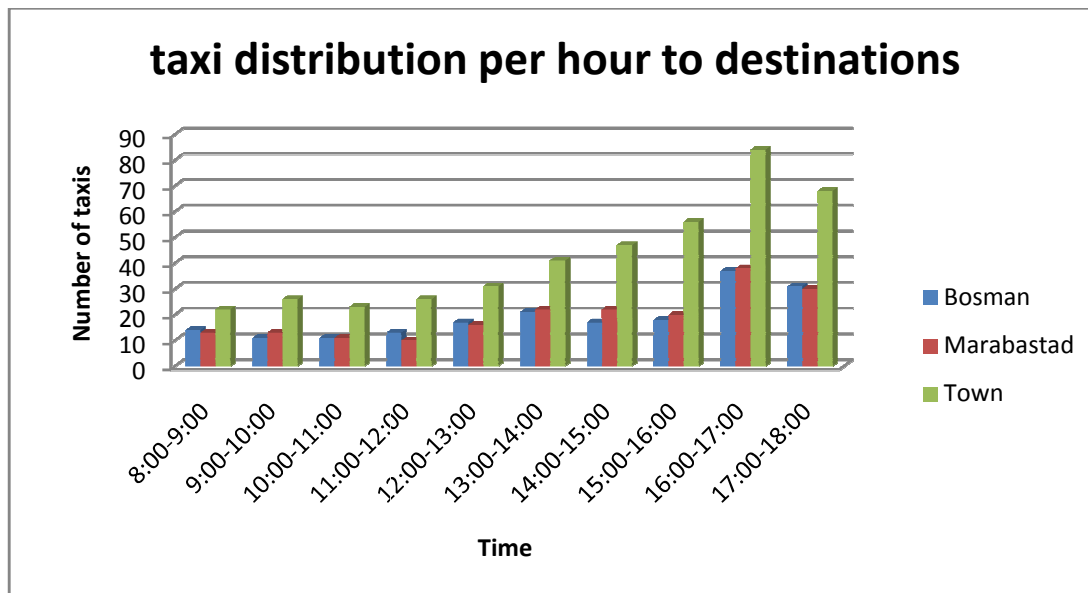


Figure T. Taxi distribution per hour to different destinations

4.2 3 5 Distribution of passengers at the exchange

The number of passengers at the exchange point goes to different destinations, percentage of passenger going to each destination differ to the next destination. Figure U below shows percentage of passenger going to each destination where town have the highest percentage of 51 % followed by Marabastad with 26 % and then Bosman with 23%.

Passenger percentage to destination

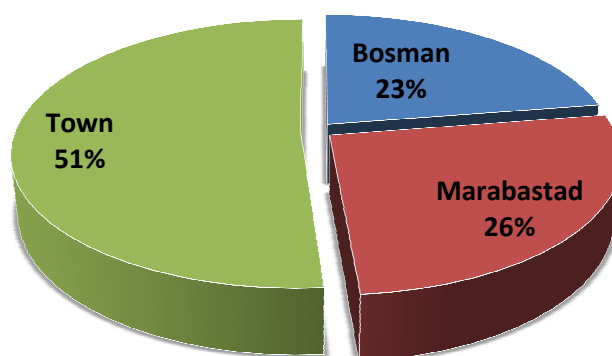


Figure U. Percentage of passengers to destinations

4.2.3.6 Passenger percentages per hour

Number of passengers exchanged at the exchange point differs from hour to hour. Figure V below shows how many percent of passengers were transported to their destinations each hour, where highest percent of passengers transported between 16:00-17:00 with 22% and the lowest with 4% between 08:00-09:00 in the morning.

passenger percentage per hour

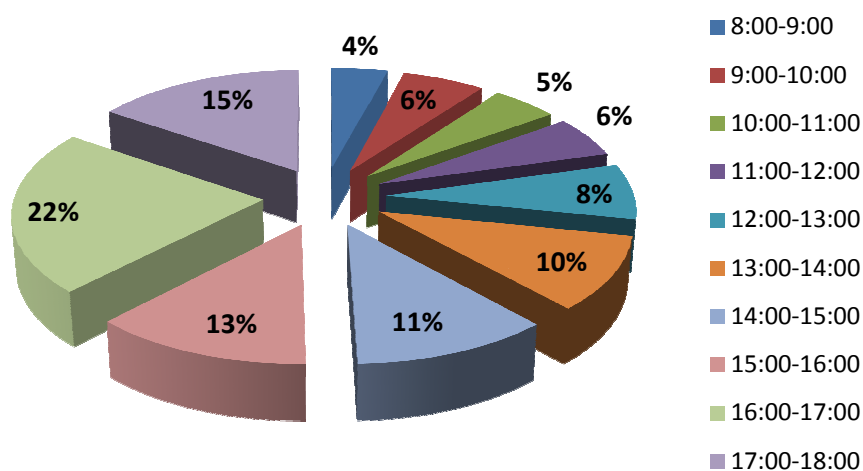


Figure V. Passenger percentage per hour

4.2.3.7 Distribution of passenger to destinations

Number of passengers going to destination differs from destination to the other and **figure W** below shows number of passengers transported to different destinations and what is the number of passengers going to each destination per hour.

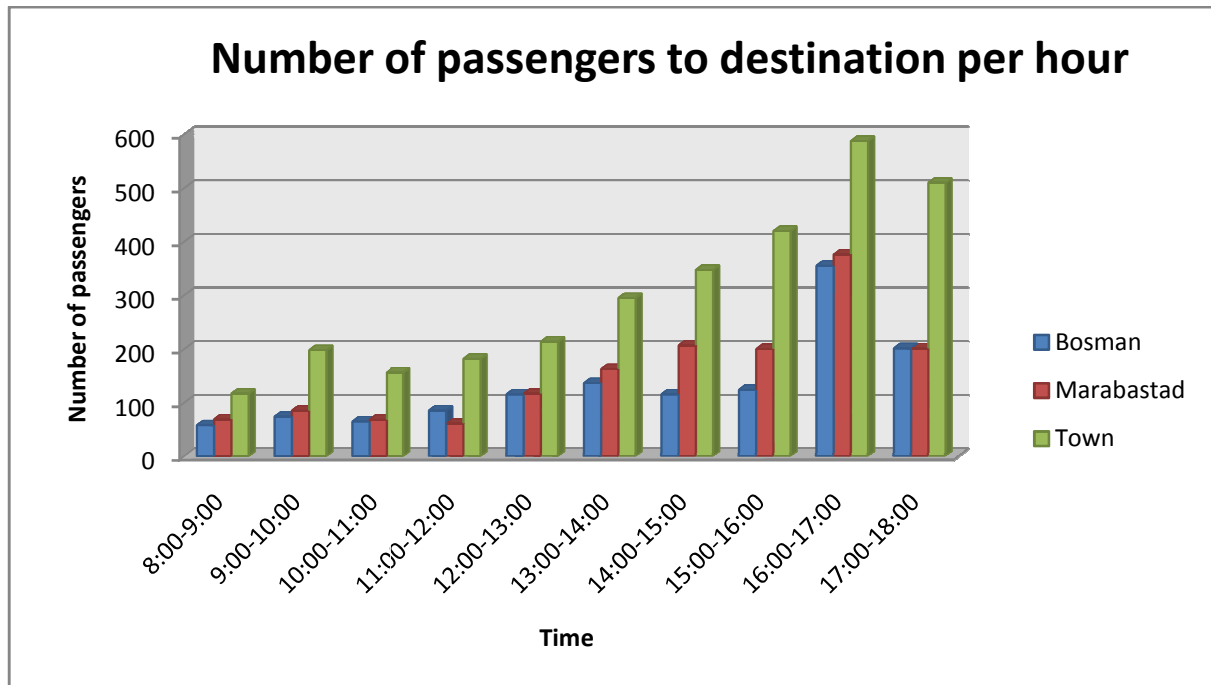


Figure W Number of passengers to destination

4.4 Summary

Chapter four discusses the findings of the research done from the methods discussed in chapter three. The information that is found in this chapter will be used to compare with the results from the simulation model; also it will help for the understating of operating nature in taxi industry. Information like cycle time, taxi waiting time, passenger waiting time and distribution rate for passengers to destinations were found and discussed in this chapter. Result for this chapter will be used next chapter.

Chapter 5

5 Discussion of results

5.1 Introduction

In this chapter the results found in chapter four are discussed as the data is processed in the input analyser from Arena Simulation. The input analyser is used to calculate the percentage error of the data that will be used in building the system model for public transport.

5.2 Input analyser

The types of distribution fit that will be used are Beta, Triangular, Normal, lognormal, Gamma and Weibull. The selection of any of the five types of fit because they are having the lowest square error compare to other fits.

5.2.1 Data analyses from data form 1

Information from [data form 1](#) which was discussed under the heading [4.2.1 Information from data table 1](#). Information that was obtain form data table 1 loading time, waiting time for taxis and passengers and distribution rate destinations. For this chapter results for loading time and queuingtime will be discussed due to the size of the data from the [data form 1](#). Then data was divided in two parts and the starting time is 9:30 to 18:00 cut-off time for 14:30 because of the changes that appeared in those periods. Performance for two sample t-test with the same variance on the data before and after cut off for each day. Tests were run for the null of the same population against different population t 95% level of significance for each case. The test results rejected some population but for those times which were significant enough the null was accepted. To those that null was rejected, it was divided according to time marks.

5.2.1.1 Queuing time

[Table H](#) below shows two equal variance used for queuing time.

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	Variable 2
Mean	2.826923	4.6
Variance	3.620239	11.45161
Observations	104	125
Pooled Variance	7.89817	
Hypothesized Mean Difference	0	
Df	227	
t Stat	-4.75355	
P(T<=t) one-tail	1.77E-06	
t Critical one-tail	1.651594	
P(T<=t) two-tail	3.55E-06	
t Critical two-tail	1.970469	

Table H Variance

The time that passengers queue is not constant through the day it is based on the availability of taxis and the arrival rate of taxis. Depicted in **table I** below are values of square error, test statistic and P-value of different distribution fit. The data in the table is for the first cut off time.

Distribution	Square error	Test statistic	P-value
Normal	0.008578	5.34	=0.0735
Beta	0.008316	7.02	=0.148
Weibull	0.007670	4.16	=0.137
Triangular	0.039421	167.1	<0.005
Lognormal	0.024222	31.5	<0.005

Table I queuing distribution

Comparing results from **table I** Weibull have both lowest square error of 0.007670 and test statistics of 4.16 compared to other distribution fit, and high P-value of 0.137. Results from the table show that Beta distribution is better than the other distribution fits. So queuing time for passengers is Weibull distributed. **Figure X** below shows the Beta distribution and the distribution summary.

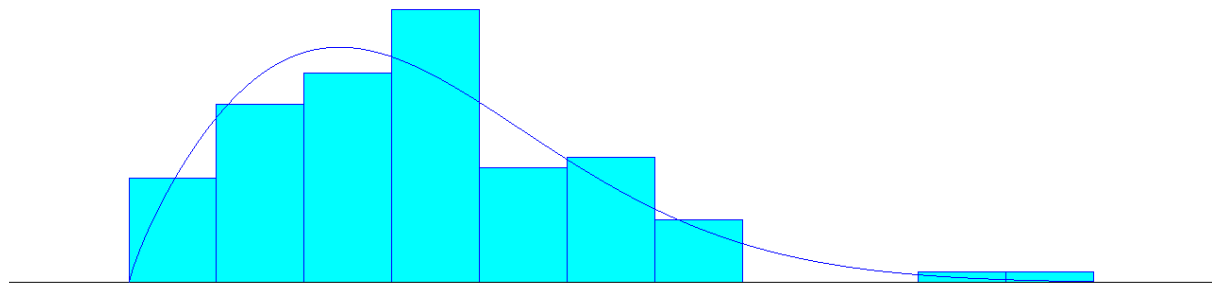


Figure X Beta di

Distribution Summary

Distribution: Weibull
 Expression: $-0.5 + \text{WEIB}(0, 0)$
 Square Error: 0.007670

Chi Square Test

Number of intervals = 5
 Degrees of freedom = 2
 Test Statistic = 4.16
 Corresponding p-value = 0.137

Data Summary

Number of Data Points = 104
 Min Data Value = 0

Max Data Value = 10
 Sample Mean = 2.83
 Sample Std Dev = 1.9

Histogram Summary

Histogram Range = -0.5 to 10.5
 Number of Intervals = 11

Part 2

Distribution	Square error	Test statistic	P-value
Normal	0.024222	31.5	<0.005
Beta	0.011172	15.7	<0.005
Weibull	0.013129	22.8	<0.005
Triangular	0.010770	19.9	<0.005
Lognormal	0.024222	31.5	<0.005

Table J queuing distribution

Table J above shows the results for distribution fit for part 2 for the cut off time from 14:30 and the best fit is triangular with square error of 0.010770, test statistic of 31.5 and P-value Of less than 0.005. Figure Y shows the results for the triangular distribution fit and the data summary below.

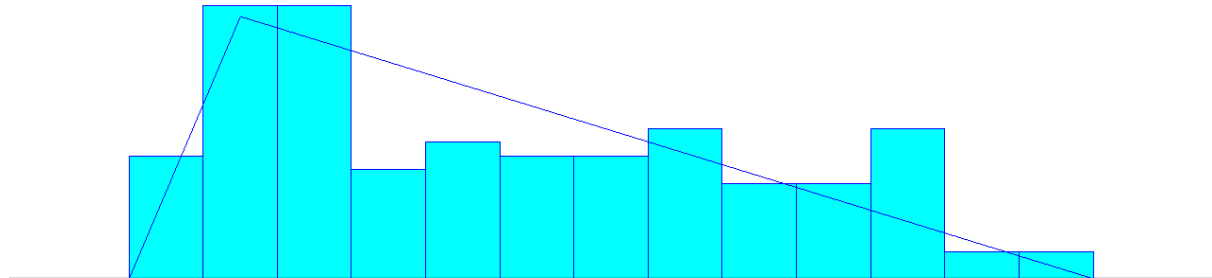


Figure Y Normal distribution

Distribution Summary

Distribution: Triangular
 Expression: TRIA (0, 0, 0)
 Square Error: 0.010770

Chi Square Test

Number of intervals = 8
 Degrees of freedom = 6
 Test Statistic = 19.9
 Corresponding p-value < 0.005

Data Summary

Number of Data Points	= 125
Min Data Value	= 0
Max Data Value	= 12
Sample Mean	= 4.6
Sample Std Dev	= 3.38

Histogram Summary

Histogram Range	= -0.5 to 12.5
Number of Intervals	= 13

5.2.1.2 Loading time

Table K below shows two equal variances used for loading time

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	Variable 2
Mean	0.411504	5.140351
Variance	1.212134	2.138602
Observations	226	342
Pooled Variance	1.770306	
Hypothesized Mean Difference	0	
Df	566	
t Stat	-41.4595	
P(T<=t) one-tail	5.9E-174	
t Critical one-tail	1.64755	
P(T<=t) two-tail	1.2E-173	
t Critical two-tail	1.964164	

Table K Variances

Distribution	Square error	Test statistic	P-value
Lognormal	0.010622	26.7	<0.005
Beta	0.004138	10.3	=0.186
Weibull	0.004119	14.1	=0.0241
Triangular	0.024551	101	<0.005
Normal	0.006413	10.3	=0.187

Table L Loading distribution

Results from table L shows that best results comparing the distribution fit in the table is Weibull distribution with square error of 0.004119, test statistic of 14.1 and P-value of .0241. Figure Z below shows the Weibull distribution fit and distribution summary.

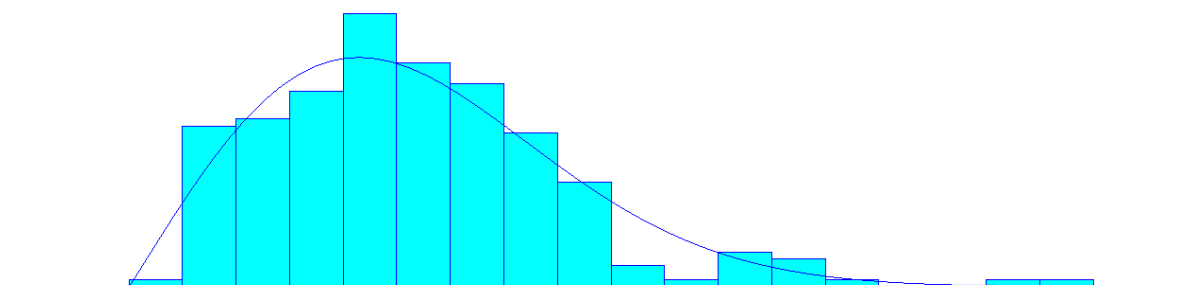


Figure Z Weibull distribution

Distribution Summary

Distribution: Weibull
 Expression: $0.5 + \text{WEIB}(0, 0)$
 Square Error: 0.004119

Chi Square Test

Number of intervals = 9
 Degrees of freedom = 6
 Test Statistic = 14.6
 Corresponding p-value = 0.0241

Data Summary

Number of Data Points = 229
 Min Data Value = 1
 Max Data Value = 18
 Sample Mean = 5.83
 Sample Std Dev = 2.8

Histogram Summary

Histogram Range = 0.5 to 18.5
 Number of Intervals = 18

5.2.2 Data analyses from data form 2

The information that is found from [data form 2](#) was discussed under the heading [4.2.2 Information from data table 2](#) is taxi cycle time, number of Passengers loaded on the road, number of passengers dropped before midpoint and total number of passengers loaded. [Table M](#) below shows values from input analyser and identifies the ones which have the best distribution fit.

Distribution	Square error	Test statistic	P-value
Lognormal	0.017887	16.3	<0.005
Beta	0.013684	3.04	>0.75

Weibull	00.13267	2.02	>0.75
Triangular	0.013521	2.56	>0.75
Normal	0.013195	2.78	=0.735

Table M Cycle time distribution

Comparing results from Table M above Normal distribution has a lower square error of 0.03195, test statistic of 2.78 but Triangular and Weibull have less Test statistic compared to normal fit, and P-value of =0.735 is higher than P-value for Lognormal which has a higher value of square error and test statistic. So the Normal distribution is the best fit in the data used. Figure AA below shows the distribution graph and is followed by the distribution summary.

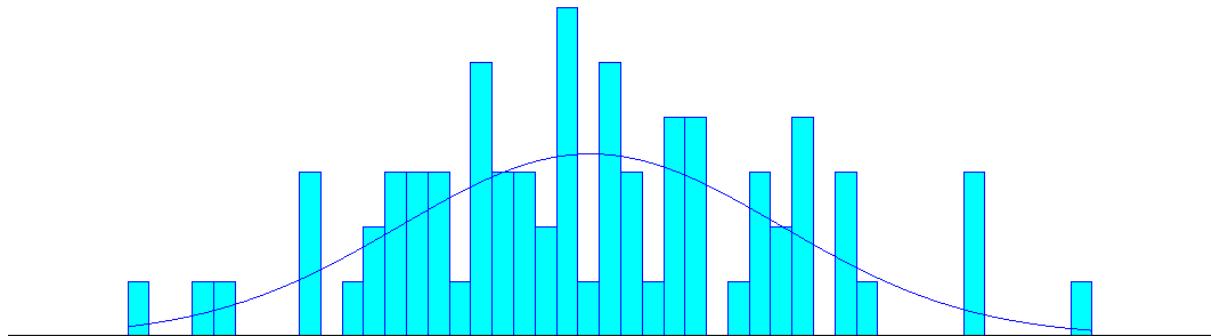


Figure AA Normal distribution

Distribution Summary

Distribution: Normal
Expression: NORM(0, 0)
Square Error: 0.013195
Chi Square Test
Number of intervals = 8
Degrees of freedom = 5
Test Statistic = 2.78
Corresponding p-value = 0.735

Data Summary

Number of Data Points = 74
Min Data Value = 16
Max Data Value = 60
Sample Mean = 37.1
Sample StdDev = 8.92

Histogram Summary

Histogram Range = 15.5 to 60.5

Number of Intervals = 45

5.2.3 Data analyses from data form 3

Information that is found from the taxi exchange form which was discussed in heading 4.2.3

Information from data form 3 waiting time, distribution of taxis, distribution of passenger, taxi distribution to destination, passenger distribution to destination and taxi and passenger percentage to different destinations. For the input analyser these are the results.

Distribution	Square error	Test statistic	P-value
Lognormal			
Beta	0.000916	0.0338	
Weibull	0.001198	0.0507	<0.005
Triangular			
Normal	0.000889	0.0115	<0.005

Table N waiting time

Comparing results from Table N above Normal distribution has a lower square error of 0.000889, test statistic of 0.0115 and P-value of <0.005 compare to all other distribution. So the Normal distribution is the best fit in the data used. Figure BB below shows the distribution graph and is followed by the distribution summary.

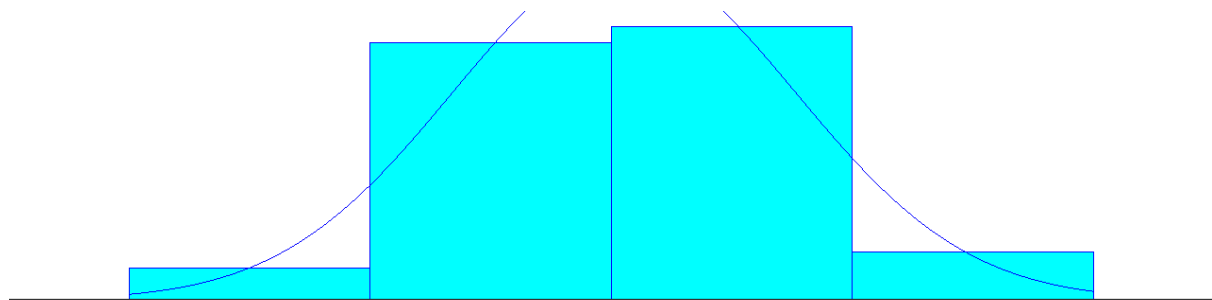


Figure BB Normal distribution

Distribution Summary

Distribution: Normal

Expression: NORM(0, 0)

Square Error: 0.000889

Chi Square Test

Number of intervals = 2

Degrees of freedom = -1

Test Statistic = 0.0115

Corresponding p-value < 0.005

Data Summary

Number of Data Points = 38

Min Data Value = 0
Max Data Value = 3
Sample Mean = 1.55
Sample StdDev = 0.724

Histogram Summary

Histogram Range = -0.5 to 3.5
Number of Intervals = 4

5.3 Summary

Chapter 5 discusses the results from the input analyser. Data collected from chapter 3 used where in from data form1 loading and queuing time was analysed and queuing time was divided into two parts with a cut-off time of 9:30am and 14:30pm. In the first part the distribution has a Beta distribution fit and the second part which is the afternoon has a Triangular distribution fit. The loading time has a Weibull distribution fit. From the information in data form 2 cycle time was focused with the Normal distribution fit. In data form 3 change time was focused with the Normal distribution fit.

Chapter 6

6 Conclusion

6.1 Introduction

This chapter concludes the findings and results found in previous chapters its gives recommendations for future work.

6.2 Recommendations

Taxis are largely affected by traffic during peak hours, and so the government must consider implementing more projects that would assist towards the objective to reduce traffic on South African roads in order to diminish the cycle time. Methods like taxi only lanes which can attract more passengers in using public transport.

Taxis can be divided in percentage during the day to allocate them in ranks, sub-ranks and routes this will increase the utilisation of taxis and it will trim down the passengers waiting time in all the route during off-peak hours.

Taxis exchange points can be used from around 10:00am because of the less number of taxis that come to exchange points, less number of passengers going to different destinations and higher waiting time.

To increase the utilisation of the excess capacity of the taxi during off-peak hour, taxis can in the tourism industry. Menlyn Taxi Association is around Union Building and in the city centre of the capital city of South Africa where tourist always come. Usage of taxis during the day it will increase the productivity of both taxi works and drivers in the taxis industry.

6.3 Future work

Despite the work and results obtained from this project, there still exist plenty opportunities for further research. Taxi improvement and development of a better public transport in South Africa is still need to be developed to reach best world class public transport.

Work that need to be done for a better project from this and gaps that need to be filled:

- Good communication with the taxi industry especial the Association and government official in the department of transport.
- To mitigate the possibility human errors better methods can be used to collect data that is more accurate in future. Global Positioning System (GPS) and On-board survey device as alternative methods for data collection.
- Survey can be given to passengers to help with information or possible way to improve public transport system
- Team of people to collect data in one station at the same time because sometime taxi move quicker which turn to be hard for a person to record everything.
- Time studies to be done in seconds because during morning takes load and depart in less than a minute.

To improve data forms that were used more column and focus to other area's must be add, areas like:

- Information for rank capacity must be added in the research because it affects the usage and utilization by changing the arrival time that appear in the data form. Taxi spend time outside the rank waiting for space to park inside the rank
- Information in ranks and sub-ranks must be taken at the sometime so that taxis can be trace from one station to the next.
- Study must be done to see how taxi using different routes during peak hours affects cycle time for both passengers and taxis.
- Information on how long does taxis waits to load and drop passengers every time the taxis stops.
- Column named number of passengers not picked on the way due to taxi full or taxi not going to that route the passenger going to it, in data form 3.
- Study to be done in total time taxis are not in utilized in the ranks
- More information to be collected in sub-ranks.

6.4 Conclusion

Public transport is growing in South Africa mainly in Large Metropolitan area, due to the effect of urbanisation. The public transport industry has radically changed and developed over the past years. There is a lack of interest in the issue of improvements of taxi system. Most researches in public transportation systems do not improvement studies into considerations.

The aim of this project is to investigate the effect the passenger clustering model on customer travelling time, taxi utilization level, taxi cycle time and customer waiting time. This problem presented itself a research problem where data was collected. Data it was analysed using excel and Arena simulation input analyser, and findings and results were discussed to show what the distribution fit for taxis and passengers are Normal distribution.

Data can n be used to improve the current state of the Menlyn Taxi Association, but future project can be undertaken for research in areas not covered which can be used to improve and simulate the taxi system. Both technological and organisational improvements are important for the public transport service development.

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Appendix A

REG NO: ▼	ARRIVAL TIME: ▼	1ST PASSENGER IN: ▼	LAST PASSENGER IN: ▼	DEPART TIME ▼	DESTINATION ▼	capaci ▼
BC 51 NZ GP	13:39	13:42	13:45	13:45	WILLOWS	14
RGZ 847 GP	13:40	13:43	13:50	13:50	GARSFOTENT	15
WGG 764 GP	13:40	13:45	13:50	13:50	WILLOWS	15
696 MJM GP	13:40	13:44	13:51	13:51	MORELETA	15
NBP 006 GP	13:45	13:49	13:56	13:56	WILLOWS	15
BNV 262 GP	13:45	13:50	13:57	13:57	GARSFOTENT	15
PJW 155 GP	13:40	13:46	13:57	13:57	WOODDLEY	15
ZHB 270 GP	13:42	13:47	13:58	13:58	BROOKLENY	14
WLT 102 GP	13:42	13:48	13:58	13:58	MOOIKLOF	15
TJT 551 GP	13:46	13:56	14:01	14:01	MORELETA	15
RYM 722 GP	13:46	13:56	14:03	14:03	WOODDLEY	15
SNR 366 GP	13:50	13:56	14:05	14:05	FAIRE GLEN	15
330 PMS GP	13:50	13:58	14:06	14:07	BROOKLENY	15
JCD 210 GP	13:51	14:00	14:08	14:08	MOOIKLOF	15
STL 659 GP	13:55	14:01	14:09	14:09	WILLOWS	13
PJY 122 GP	13:57	14:03	14:08	14:09	MORELETA	13
ZXL 956 GP	13:57	14:04	14:10	14:10	WOODDLEY	15
004 MFM GP	14:03	14:08	14:11	14:11	FAIRE GLEN	13
VWF 854 GP	14:05	14:09	14:11	14:11	GARSFOTENT	13
SKM 499 GP	13:59	14:07	14:13	14:13	BROOKLENY	15
RYM 331 GP	14:00	14:07	14:17	14:17	GARSFOTENT	15
TWB 177 GP	14:06	14:15	14:17	14:17	MORELETA	15
WPB 509 GP	14:02	14:08	14:18	14:18	WILLOWS	15
XDW 916 GP	14:10	14:18	14:22	14:22	WOODDLEY	13
RNX 772 GP	14:06	14:16	14:23	14:23	MOOIKLOF	15
ZGN 950 GP	14:06	14:11	14:23	14:24	WILLOWS	22
006 MFM GP	14:10	14:23	14:25	14:25	WILLOWS	13
YZW 922 GP	14:08	14:19	14:25	14:25	WILLOWS	14
MSW 198 GP	14:15	14:22	14:30	14:30	MORELETA	15
TSD 334 GP	14:15	14:22	14:32	14:32	FAIRE GLEN	13
VXZ 088 GP	14:22	14:24	14:33	14:33	MOOIKLOF	14
WGF 587 GP	14:23	14:27	14:33	14:33	WILLOWS	14
WTZ 642 GP	14:25	14:28	14:32	14:33	GARSFOTENT	15
VLT 907 GP	14:29	14:32	14:36	14:37	MOOIKLOF	12
VRK 077 GP	14:29	14:35	14:39	14:39	GARSFOTENT	15
STL 157 GP	14:30	14:32	14:42	14:42	BROOKLENY	15

Table O data form 1

registration no: ▼	depart time: ▼	destinatio n ▼	time @ midpoi nt ▼	no of passenger started wit ▼	no of passenger left at the midpoint ▼	no passenger joint the taxi at the midpoint ▼	no of passengers joint after midpoint ▼	time @ destination ▼	comments ▼
25/08/2011		13 seater							
WVN 338 GP	09:44	faire glen	10:02	13	4	0	0	10:14	
	10:12	marastard	10:20	2	0	0	14	10:50	he had lunch from 11:00
	11:46	willows	12:04	0	4	8	2	12:32	via menlyn and stopped
	12:45	Bosman	12:54	1	5	5	2	13:14	
	13:18	Atterberry	13:45	0	4	4	1	14:00	via hatfield then he wen
	14:20	town	14:40	0	4	0	7	15:07	
	16:25	Garsfontein	16:50	12	9	0	0	17:00	waiting to load at the rar
	17:00	Town	17:15	8	8	2	6	17:34	

Table P data form 2

taxi exchange points

registratio n no: ▼	arrival time: ▼	destinati ▼	# passengers arrive with ▼	no passenger left taxi ▼	total left ▼	new passenge ▼	depart time ▼
VTM 635 GP	12:32	Bosman	7	4	8		12:35
XRR 075 GP	12:33	Town	13	5	14		12:35
YXY 504 GP	12:33	Marabastard	9	6	8	1	12:35
BD 96 SW GP	12:34:00	town	5	1	6		12:35
WGF 587 GP	12:34	Town	12	3	9		12:36
VWF 793 GP	13:34	Marabastard	6	4	9		12:36
PJM 155 GP	12:35	Bosman	7	4	10		12:37
VFM 676 GP	12:35	town	10	5	6	2	12:37
YDS 656 GP	12:36	Marabastard	6	2	12	2	12:37
BC 60 XW GP	12:37	Town	11	4	12		12:38
YJB 863 GP	12:39	Bosman	7	5	6		12:40
WPB 509 GP	12:40	Bosman	4	2	3		12:40
RBZ 154 GP	12:40	Town	5	4	7		12:42
VGJ 522 GP	12:41	Marabastard	4	1	8		12:42
BC 85 SK GP	12:43	Town	6	2	9		12:44
YNG 461 GP	12:43	Marabastard	8	5	7		12:44
WSG 783 GP	12:43	Bosman	13	5	12		12:45
ZTW 392 GP	12:44	Town	4	1	3		12:45
898 MJM GP	12:45	Town	7	3	9		12:47
SSM 439 GP	12:47	Marabastard	9	4	14		12:49
NGN 206 GP	12:48	Bosman	10	6	11	1	12:49
BB 40 MB GP	12:49	Marabastard	4	2	7	2	12:51
RYM 722 GP	12:51	Town	7	4	8		12:52
YZB 909 GP	12:51	Bosman	5	3	4		12:53
SBN 521 GP	12:51	Town	8	3	7		12:53
KTX 285 GP	12:52	Town	6	4	4		12:54
JTL 278 GP	12:54	Marabastard	5	3	6		12:54
104 MFM GP	12:54	Bosman	4	2	6		12:55
ZBT 577 GP	12:54	Marabastard	9	5	9	1	12:56
YZV 388 GP	12:55	Town	4	1	9		12:56
YRF 538 GP	12:56	Bosman	7	5	5		12:58
LZD 722 GP	12:56	Town	14	8	9		12:59
VZY 298 GP	12:57	Town	7	2	6		13:00
WTZ 642 GP	12:59	Marabastard	3	1	7	1	13:00
ZMR 436 GP	12:59	Bosman	5	1	5		13:00
XLL 969 GP	13:00	Town	9	5	10		13:01
VXZ 088 GP	13:00	Bosman	3	1	7		13:02
330 PSM GP	13:01	Marabastard	14	6	11		13:02

Table Q Data form3

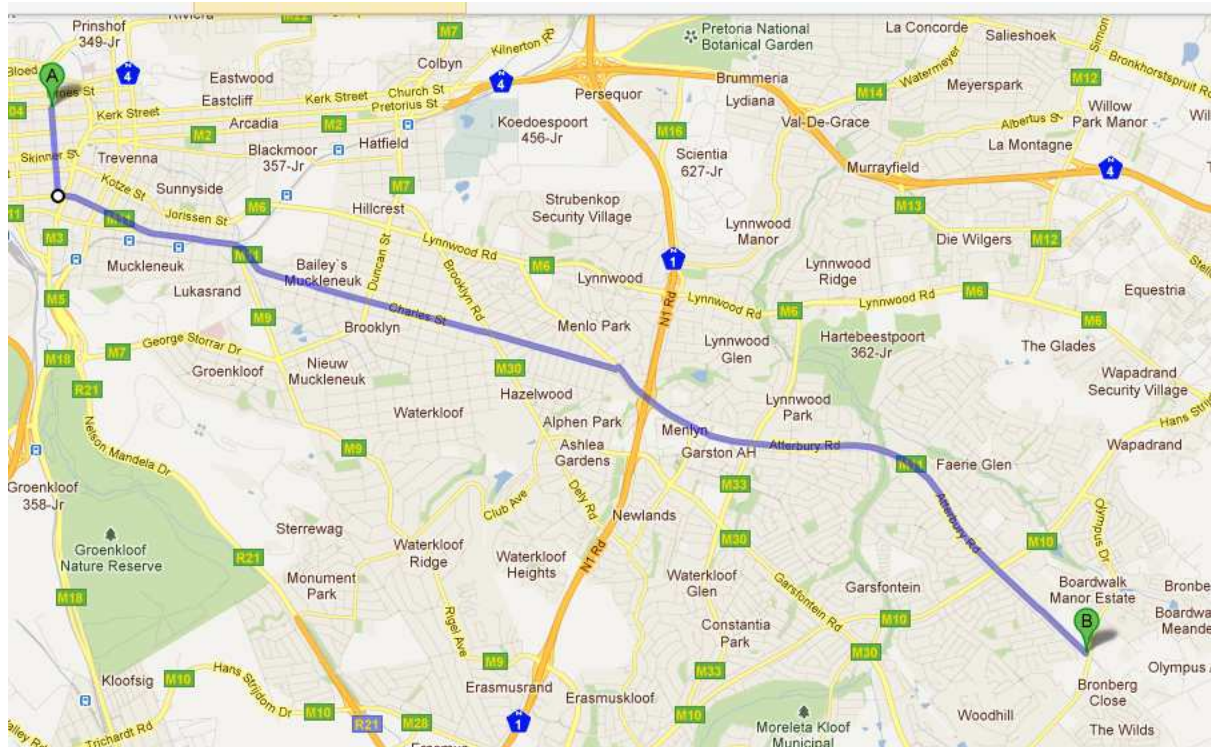


Figure CC map to MooikloofAtterbury

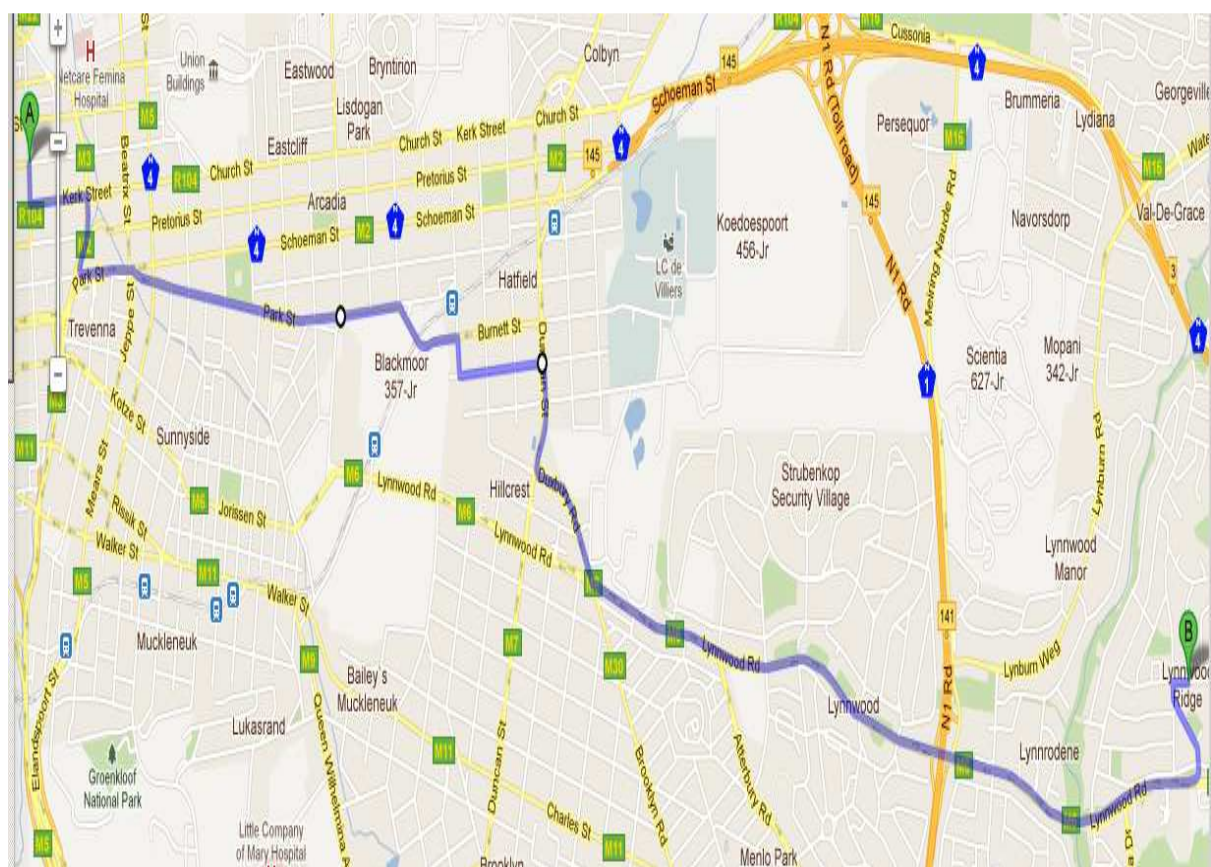


Figure DD map to Willows

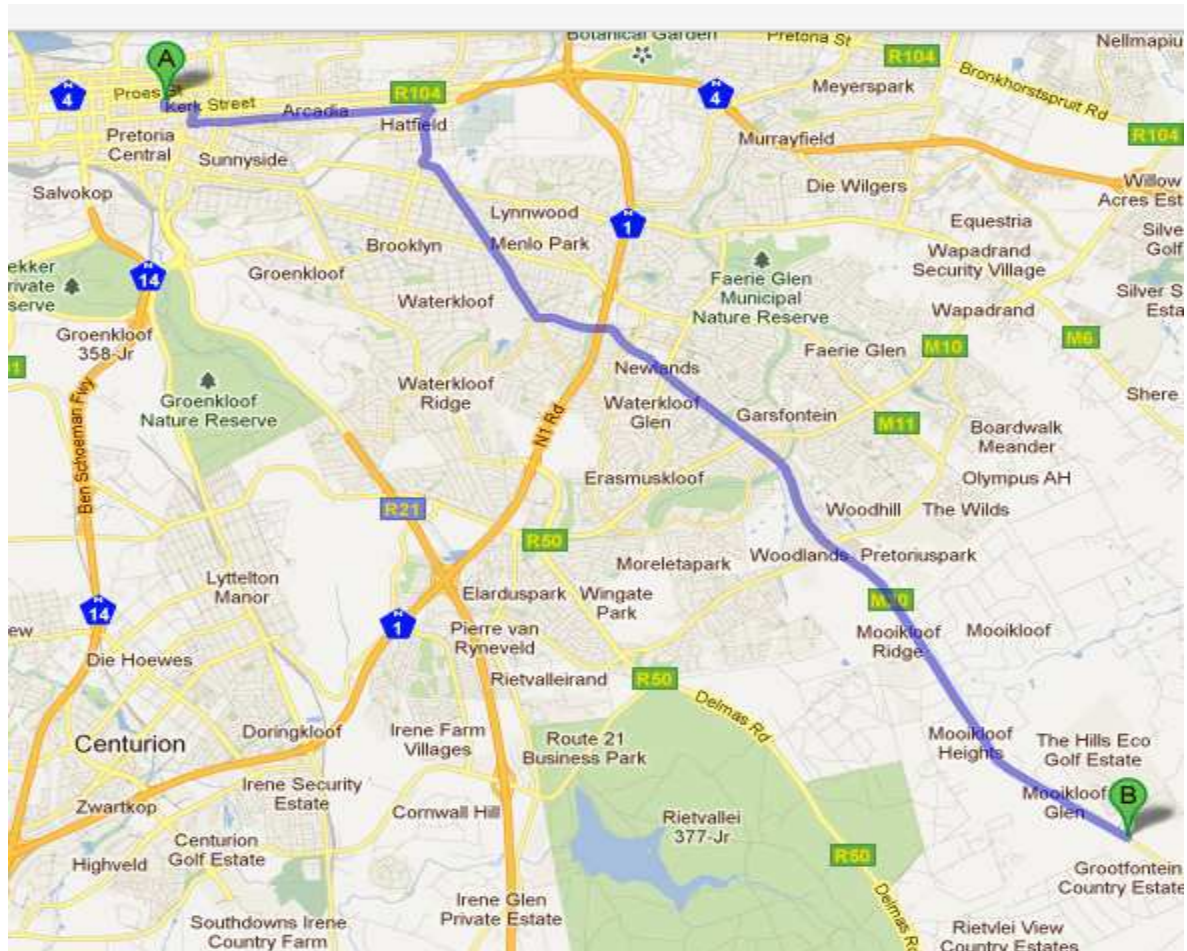


Figure EE map to Mookkloof Ridge

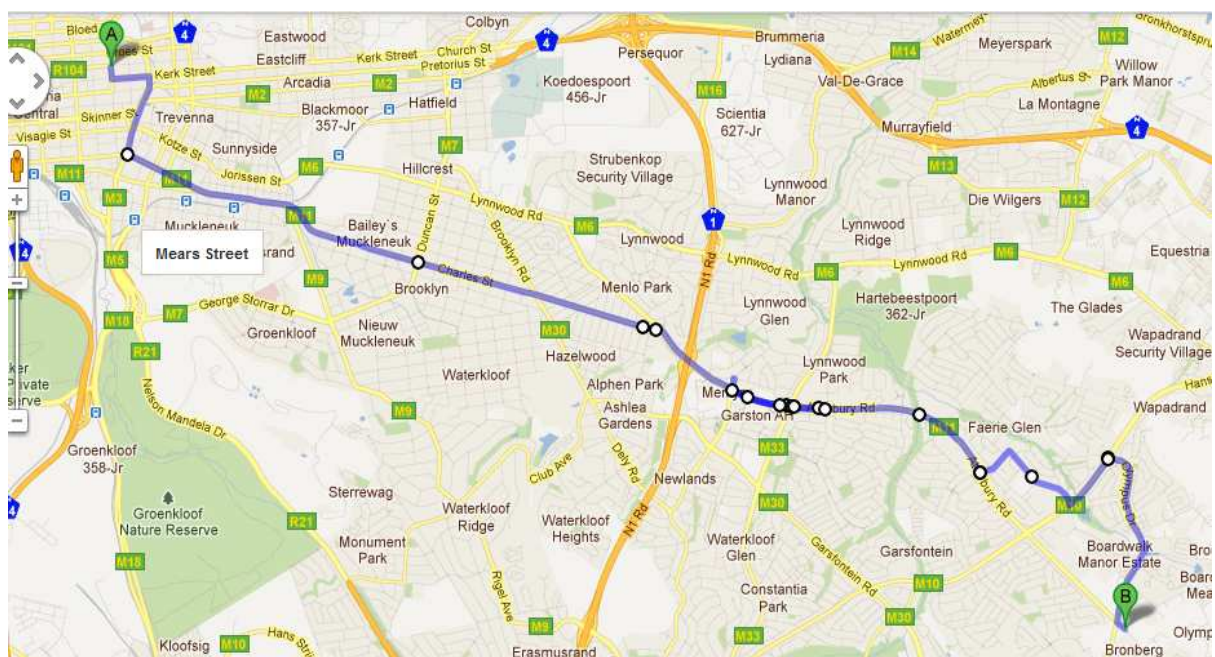


Figure FF Map to Faerie Glen

