INVESTIGATING ICT SOLUTIONS FOR THE PUBLIC TRANSPORTATION SYSTEM IMPROVEMENT IN THE FREE STATE: OPPORTUNITIES AND CHALLENGES

By

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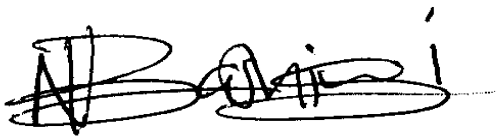
Declaration

I certify that the work in this dissertation submitted at the Central University of Technology is my own original work which has never been submitted to any institution. All sourced used in the work have been acknowledged through citations and a list of references.



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Abstract

Inefficiencies in the public transportation system in the Free State province resulting in poor quality public transportation has led to the investigation of Information and Communication Technology (ICT) solutions to improve the system, through integration, and the challenges and opportunities that may result from this integration.

This research investigates ICT solutions for public transportation improvement focusing on the challenges and opportunities for all stakeholders of the public transportation system. Critical review of South African legislation and policies on public transportation and ICT was carried out. This was to review government laws and policies governing public transportation development. It also reviewed how the government planned on improving public transportation, developments so far based on those plans and future plans, and how these legislations by the government have been carried out in the Free State province. A theoretical framework was developed to lay out expectations for the integration process including the adoption of technologies and adaptations to the new integrated public transportation system based on technology acceptance and diffusion theories. Questionnaire and Interview surveys were carried out on public transportation vehicle owners, drivers, public transportation users and non-users to assess the current state of public transportation, their needs that could potentially be solved by ICT and the challenges likely to be faced. The use of questionnaires was also to assist in identifying and defining elements needed for successful integration of ICT into the system. ICT experts, transportation planners, academics, public transportation owners and users were also interviewed to gain more understanding and insight on ICT solutions, the public transportation systems, technologies for potential use in the public transportation system and challenges that may arise due to integration.

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Acronyms And Abbreviations

AFC – Automated Fare Collection

APTS – Advanced Public Transport Systems

ATIS – Advanced Traveller Information Systems

AVL – Automatic Vehicle Location

CCT – City of Cape Town

CCTV – Closed Circuit Television

DoT – Department of Transport

DSL – Digital Subscriber Line

EDGE – Enhanced Data for Global Evolution

EFP – Electronic Fare Payment

GIS – Geographic Information Systems

GPRS – General Packet Radio Service

GPS – Global Positioning System

IBL – Interstate Bus Lines

ICT – Information and Communication Technology

ITS – Intelligent Transport Systems

LCD – Liquid Crystal Display

LED – Light Emitting Diode

MEC – Member of the Executive Council

MMM – Mangaung Metropolitan Municipality

MSA – Moving South Africa

NFC – Near Field Communication

NHTS – National Household Travel Survey

NLTA – National Land Transportation Act

PTES – Public Transport Enquiry Service

SANRAL – South African National Road Agency

SAP – Systems Applications and Products

SMS – Short Message Service

TMA – Technology Acceptance Model

USSD – Unstructured Supplementary Services Data

UTAUT – Unified Theory of Acceptance and Use of Technology

VMS – Variable Message Signs

WSNs – Wireless Sensor Networks

CHAPTER 1: INTRODUCTION AND BACKGROUND STUDY

1.1. Background

Public transportation is one of the major economy drivers worldwide.In South Africa it is at a very critical stage where authorities are gaining momentum and allocating resources to implement new strategies and initiatives to potentially improve the public transportation (van Ryneveld, 2008). One of the leading solutions to transportation problems is the deployment of Information Communication Technologies (ICT) which have been used in many countries and cities and provided positive results. These examples include Smart-cards, variable message signs and computer applications. Major factors affecting the quality and development of public transportation such as reliability, safety, convenience can be solved by integrating ICTs into the public transportation system. ICTs have improved safety, convenience, reliability and quality of the system in places such as London and New York; this is through applications such as NXTBUS and availability of on- street information display screens (Using NXTBUS-ACTION Buses, 2015). Public transportation systems with ICTs properly embedded into them have the ability to attract more customers resulting in improved business for the service providers, reduced private vehicle use which means less congestion on roads and reduced carbon emissions (due to fewer vehicles).

The public transportation sector involves different stakeholders with differing interests; The government, which regulates public transportation services through the Department of Transportation; Public transportation service providers, these are individuals and private companies providing bus and taxi services; Drivers who are sometimes taxi owners or employed by the companies or vehicle owners to operate the vehicles and Passengers who are the users and pay for the public transportation services. All these stakeholders face different challenges with the system which need to be solved to improve the system. Improving the system through ICT should therefore be beneficial to all the stakeholders,including people who currently do not use public transportation by fulfilling their current needs.

The Free State province is faced with challenges of improving the public transportation services they provide to the public in terms of reliability and quality as studies carried out, during the 2013 National Household Travel Survey, showed that people chose

their transportation modes based on reliability, safety and behaviour of drivers (Statistics South Africa, 2014). These factors, which currently are a disadvantage to the system, can be improved using ICTs. ICTs can potentially be a powerful driver to promote change; for example, on board user aid devices to educate and monitor the driver; improving efficiency; safety and reliability of public transportation (Baptista et al., 2012).

1.1.1. Information and Communication Technologies (ICT)

Cohen et al., (2002) defined ICT as "*a collection of electronic technologies, applications and services which facilitate the processing, storage, transferring and sharing of information, improving the performance of information related human activities provided by and benefiting the private and public sectors as well as the general public*". A later publication defined ICT as "*a set of heterogeneous technologies that allow for electronic communication, data collection and processing in a distributed network*", (Black and van Geenhuizen, 2006). ICT is also defined by (Kordha Tolica et al., 2015) as "*a term that stresses the role of unified communications and the integration of telecommunications, computers, middleware as well as necessary software, storage, and audio-visual systems, which enable users to create, access, store, transmit and manipulate information*" .These technologies range from devices such as cellphones, radios, display screen and computers to applications such as email, Short Message Service (SMS) and computer software (Warren et al., 2008). ICTs together with the internet have improved the accessibility of information to people all over the world. The cost of ICTs and internet has decreased over the years making it more affordable for developing countries and poor populations of the world.

South Africa as a developing country has experienced the emergence of a competitive ICT sector over the years, producing one dominant fixed-line operator, Telkom and five mobile owners (MTN, Virgin Mobile, Telkom (8ta), Vodacom and Cell C) (Gillwald et al., 2012). The Internet in South Africa, especially mobile internet, has become cheaper and more accessible over the years because of the increased competition between the service providers and increased use of mobile phones. These improvements are a result of the availability of affordable smart devices and reduced cost of services (Gillwald et al., 2012). Survey carried out in 2012 by Research ICT Africa, South Africa shows that the use of fixed – line internet is decreasing while

mobile internet use is increasing as 86% of respondents said that they used mobile internet (Gillwald et al., 2012).

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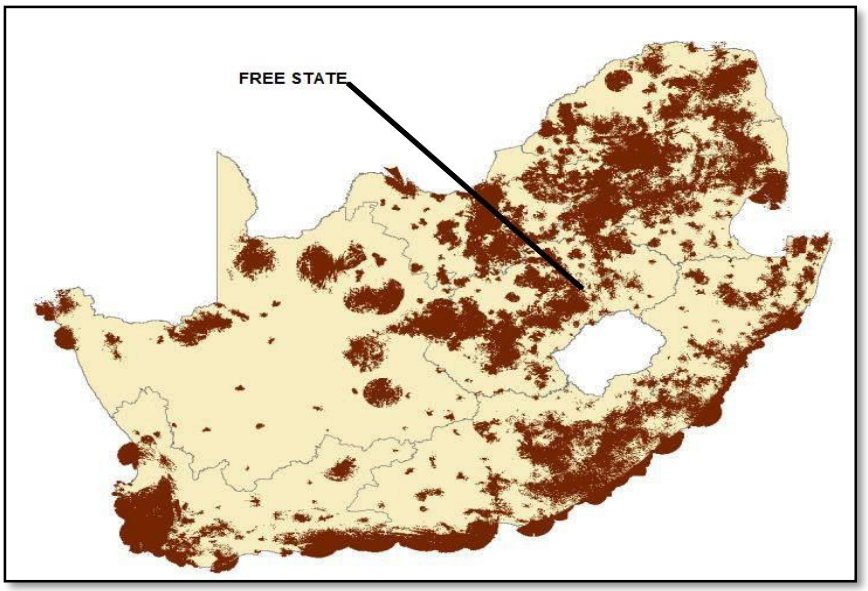

Figure 1. 1: Broadband Coverage map of South Africa (Research ICT Africa, 2012)

Figure 1.1 shows the broadband coverage map of South Africa; a large part of the Free State province has internet coverage but there are also areas within the province which do not have coverage. Remote areas in the Eastern, North West and South-Western areas of the province have little or no broadband coverage. The lack of coverage may be a result of the low population in rural areas as only 0.6 million of the people in the province lives in rural areas (Toba et al., 2012) and most of the uncovered areas are agricultural land. Urban areas of the province have denser broadband coverage.

1.1.2. ICT and Transportation

ICT and Transportation as far different disciplines are becoming more closer as a result of improved infrastructures and advancements in technology, and their relationship is expected to grow rapidly in future (Thomopoulos et al., 2015). Both ICTs and the public transportation system are seen as friction reducing technologies for their ability to reduce the cost of distance (Cohen et al., 2002). ICTs can be seen as enabling factors to the public transportation system as they offer tools to the sector which can help reduce costs, increase responsiveness and improved decision making

by stakeholders (Nair and Devi, 2011; Kramersetal, 2014). Improved ICT infrastructure, ICT components such as smartphones, travel applications and social networking have over the years improved the way transportation systems operate.

1.2. Problem Statement

The purpose of this study is to investigate ICT solutions for improvement of the public transportation system in The Free State Province. The study will do so by investigating the current public transportation system, the needs of the stakeholders, possible ICT solutions and likeliness of people using public transportation after ICTs are integrated into the system. Furthermore, it will explore the opportunities and challenges that can result from integrating ICT into the system for different stakeholders.

The current public transportation in the Free State Province does not fully satisfy the needs of the public in terms of quality and information availability. Based on observations, there is currently minimal use of ICTs in the public transportation system in the Free State province. The public transportation buses and minibus taxis are just vehicles with basic technologies for mechanical operation of vehicles.There is no electronic communication within the transportation system, i.e. the vehicles, the infrastructure, the passenger, the owners and other stakeholders.

Passengers sometimes do not make the right travel decisions due to lack of information and sometimes they find themselves in situations that could have been avoided had the public transportation owners communicated with them in time (Nunes et al., 2014; Minhans et al., 2015). For example, a passenger waiting at a bus stop scheduled for a certain time and the bus being delayed, because there is no way of communication between the passenger and the bus service provider. This passenger may wait for a very long time, but if there was a way of communicating to the passenger, he would have decided on other means of travelling and saved time. The National Household Travel Survey found out that 0.6% of public transportation users in the Free State province said that unavailability of timetables and inaccurate information influenced their choice of mode of travel (Statistics South Africa, 2014).

The Free State public transportation system needs a shift from conventional information communication methods such as newspapers and the use of intercoms to disseminate information to more advanced electronic technologies. These improvements in communication should result in an improved public transportation

system in the province with provison of real-time information regarding the public transportation system from bus routes, travel times, delays, nearest public transportation facilities etc.

Over the years,the government through the Department of Transport and some municipalities have introduced policies and strategies to improve public transportation. Some of these policies, regulations and action plans have not been implemented in the Free State province. Theories on adoption and diffusion of technologies have implied different approaches by people when it comes to accepting and using new technologies, for the purpose of this study, they have to be considered in order to accommodate human behaviour associated with acceptance and adaptation to technologies. The study reviews the policies, regulations and theories and proposed guidelines towards achieving an ICT-integrated public transportation system.

1.3. The Study Area

The Free State province is located in the center of South Africa and is the third largest province in South Africa. It covers 10.6% of the country's surface area (Statistics South Africa, 2011) and lies between the Vaal River and the Orange River. It has a population of 2 745 590 (Statistics South Africa, 2011), 2.6 million people living in the urban areas in the province and about 0.6 million living in the rural areas (Toba et al., 2012).The province is divided into four district municipalities and one metropolitan municipality. The district municipalities are, Fezile Dabi, Lejweleputswa, Thabo Mofutsanyane and Xhariep. Mangaung Metropolitan Municipality (MMM) is the only metropolitan municipality in the province. The capital city of the Free State province is Bloemfontein, which is also South Africa's legislative capital and located within MMM.

The Free State Province was selected as the study area based on the lack of improvement in its public transportation system with no evident ICT developments in the system. There is also no ICT and public transportation research in the area. The geographic location of the province and development state is less disadvantaged as compared to other more developed cities in more developed provinces such as Gauteng, Kwa-Zulu Natal and the Eastern Cape.

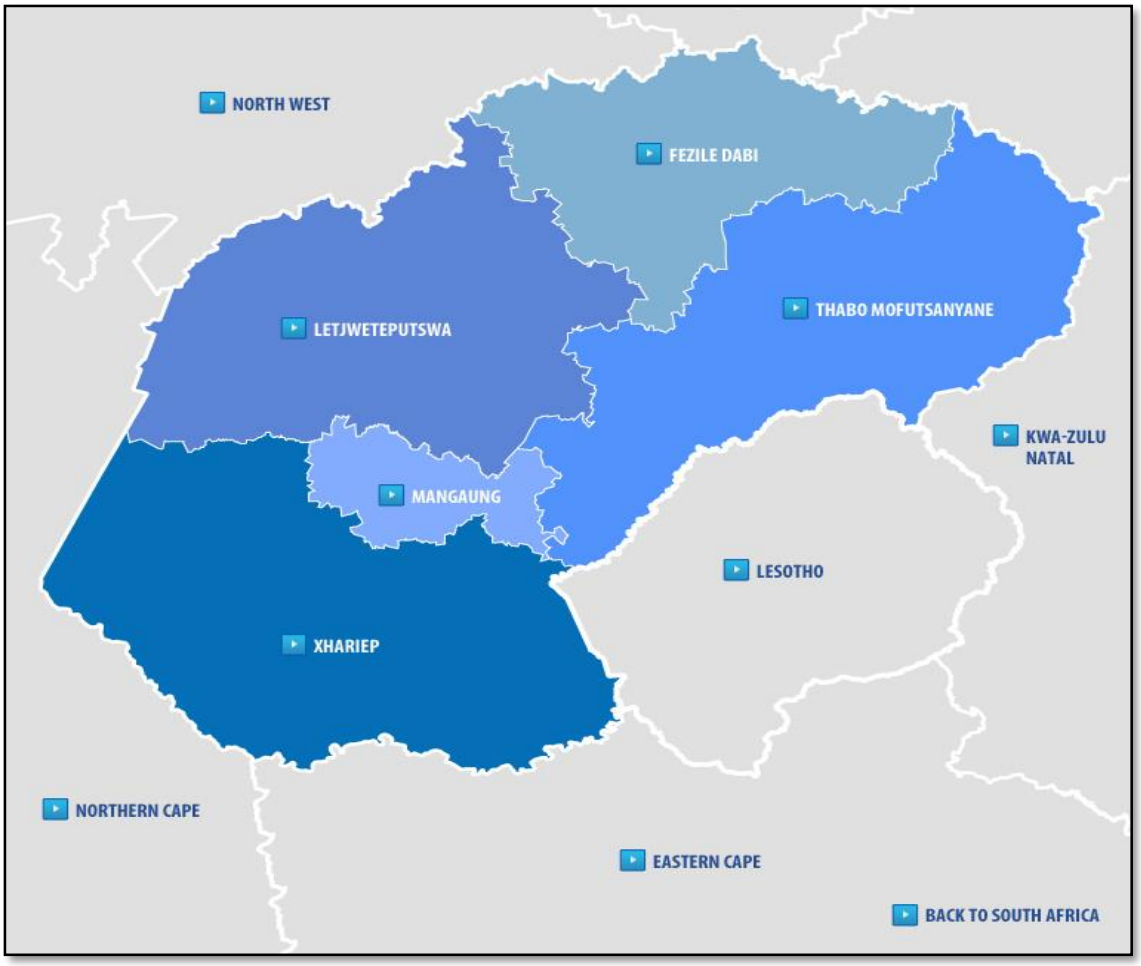

Figure 1. 2: Free State Municipalities map (Cohsasa, 2015)

1.3.1. Public Transportation in the Free State

Public transportation in the Free State province is faced with many challenges, among others, the decreasing number of people who use public transportation. There is still a large number of people reluctant to use public transportation, 30.2% workers in the province use public transportation (buses and taxis) while 34.9% use private transportation. (Statistics South Africa, 2013). More workers (34.5%) who travel on average five days a week to work, use their own vehicles (Statistics South Africa, 2013).

This study focuses only on the available modes of public transportation in the Province; buses and mini-bus taxis. Currently, the only public transportation bus service provider operating regularly in the Free State is Interstate Bus Lines (IBL) which is subsidised by the government through the Department of Transport. The Interstate Bus Lines operate in the MMM. Taxis are owned by individuals and private

companies and they operate under different Taxi Associations. ICTs available in buses are a fare payment system in which users load their fare into tag and tap it on a reader when entering the bus to get tickets (see Figure 1.3).

Among the reasons why public transportation in the Free State province is poor for users is the long waiting times at bus stops, bad taxi drivers behaviour, the safety concerns regarding taxis, as well as the overall taxi service (SANRAL community profile, 2006). This has not improved as a 2012 study showed that the public transportation services in Bloemfontein are considered poor to very poor by the public as 81% of people interviewed indicated (Toba et.al, 2012). Rural roads in the province are not in good condition; this is one of the main reasons people in rural areas do not have access to public transportation. Ninety-five percent of people living in rural areas do not have access to public transportation (Toba et al., 2012; Statistics South Africa, 2014). Public transportation service providers are not willing to drive on damaged roads to offer their services to the rural population as this damages their vehicles.

Waiting times for vehicles at bus stops are very high in the province: 8.2% people in the Free State wait for over 15 minutes for public transportation at bus stops, which is high compared to 4.5% for Eastern cape and 7.4% for Mpumalanga (NHTS 2013). Further research shows that travelling by taxis in South African metropolitan areas is time-consuming as it normally takes about 16 to 30 minutes for people in these areas before they can reach their destinations (Toba et. al 2012). For instance, Bloemfontein, Thaba Nchu and Botshabelo as the urban areas of the MMM in the province are experiencing these long waiting and travelling times.

Figure 1. 3: Existing ticketing system in Interstate buses

1.4. Aim and Objectives

The main aim of this research was to investigate ICT solutions to evaluate whether the Free State public transportation system is ready to support possible ICT solutions and what could be the possible challenges encountered in incorporating ICT solutions in the public transportation system. The aim was fulfilled by achieving the following objectives:

To find out the ICT needs in the public transportation system.

1. To identify and define key elements needed for successful use of ICTs in the public transportation system.
2. To create a theoretical framework of available parameters.
3. To develop guidelines on how to incorporate ICT in the public transportation system in the Free State.
4. To compare developed guidelines with those used in other provinces/cities and countries.

1.5. Research Questions

The aim and objectives of the study will answer the following research questions:

1. Can ICT solve public transportation problems in the Free State province?
2. What are the challenges and opportunities of integrating ICT solutions into the public transportation system?
3. Which ICT solutions and applications can best serve the public transportation system in the Free State?
4. What factors should be considered for successful integration of ICTs into the public transportation system?

1.6. Delimitations of study

This study does not develop or create any applications or devices to be used in solving public transportation problems, it however investigates and proposes considerations and guidelines for invention, development and integration of any technologies for the public transportation system.

1.7. Structure of the Dissertation

The continuing chapters of the study are arranged as follows:

Chapter 2: Literature Review: The chapter is a review of the international and national literature on public transportation and ICT solutions, South African National and the Free State province legislation and policies towards public transportation development and ICT. A framework based on the literature review and legislation is also developed in this chapter.

Chapter 3: Methodology; Methods of data collection and analyses used as well as the reasons for their selection is discussed in the chapter.

Chapter 4: Data analysis and discussion: This chapter is a presentation and analysis of results of the data collected. The data is discussed and interpreted.

Chapter 5: Guidelines: In this chapter, based on the literature review and data collected, guidelines on integrating ICT solutions into the public transportation system in the Free State are developed and compared to those identified in other places.

Chapter 6: Conclusion and recommendations: Chapter contains conclusions drawn from the study, limitations of the study, recommendations and suggestions based on the conclusions and limitations.

References: The section contains a list of literature materials used in the study.

Appendices: The following are attached in the Appendices section:

Interview request letter

Sample of questionnaire

Sample of interview guide.

Data tables not included in the data analysis and discussion chapter.

CHAPTER 2 : LITERATURE REVIEW

2.1. Introduction

Studies have shown that there are very strong relationships between communication and transportation systems. The relationships between transport and telecommunications have received ample attention over the last two decades, (Hepworth and Ducatel, 1992); this was further supported by Cohen et al., (2002) confirming that growing attention has been directed to the relationships between ICT and transport.These strong relationships are based on transportation and communication technologies' interdependence. ICTs have a relationship with transportation that is based on the need to improve connections between people and businesses and also reducing costs of commuting and information transfers. Based on the ICT attributes; extensibility, trackability and intelligence, it will be able to speed up and extend spatial interaction, develop tracks and steers on vehicles and goods and also speed up data retrieval, processing and steering (Kenney and Curry, 2001), (Black and Van Geenhuizen, 2006). ICT applied to public transportation systems for scheduling, route changes and logistics information can change service quality for the better, resulting in increased public transport customers and ridership due to the cost effectiveness of public transportation.

The use of ICTs has been growing rapidly all over the world since the beginning of the 'Information Age" (Hepworth and Ducatel, 1992). Morales–Gomez and Melesse (1998) commented that ICTs are increasingly playing a crucial role in many societies by improving their capacities to produce, access, adapt, and apply information, therefore exposing them to vast opportunities for facilitating the transfer and acquisition of knowledge.This growth of ICT is facilitated by the ever-improving electronic technology, improved and more accessible internet connectivity. The development of the internet and wireless communication, especially mobile phones revolutionised communication (Maritz and Maponya, 2010). Internet connectivity has become the spine to most ICTs and it is very important in the transportation sector as a communication mode. As indicated by Michael Clausecker during the proceedings of the 2012 International Transport Forum, connectivity is the key to increased demand for public transport (OECD 2012)

2.2. ICTs and Public Transportation

ICTs, through Intelligent Transportation Systems and Geographic Information Systems, can also help public transportation owners in managing their fleet. ITS are basically ICTs integrated within a transport system (Grant-Muller and Usher, 2014). Integrated ITS applications intend to sense transport movement by using the ever-present and dynamic connectivity to process and communicate information (in real-time) to public transport users and other stakeholders and facilitate more efficient transport networks (Grant-Muller and Usher, 2014).There should be communication between cooperative transportation systems being: Infrastructure to vehicles, Infrastructure to Infrastructure, Vehicle to Vehicle and Vehicle to Infrastructure systems in order to support ICT and ensure the development of better traffic management systems and improve road safety and efficiently(Van Grinsven et.al, 2012,Grant-Muller and Usher, 2014). Mobile ITS infrastructure located in vehicles or carried by people such as satellite navigation systems and advanced traveller information systems are one form of ITS infrastructure, which are less advanced than the cooperative transportation systems (Grant-Muller and Usher, 2014).

Coyle et al (2000) concluded that Information systems are designed to use available data to portray meaningful information to decision makers. This will help the government, bus and taxi service providers, companies, associations and the general public make better decisions with relevant information at their convenience. The study went on to say that logistics and transportation operations are sometimes overwhelmed with the large amounts of data available to them (Coyle et al., 2000;, therefore, transportation services companies should be concerned with adopting ICTs in order to stay relevant and competitive from a cost and service provision perspective. The use of ICT will solve data-handling problems for owners and other decision makers such as government departments associated with public transportation regulating as well as taxi associations. This is further emphasised by a statement that transportation systems cannot operate properly without internal communication systems that connect their sub-systems and external communication systems to enable them to communicate with their environment (Tiffin and Kissling, 2007).ICT solutions will function as those communication systems linking the public transportation system and its stakeholders.

The linking of telecommunications to computers in order to develop a new surge of growth is presumed to have an enormous impact on transport (Tiffin and Kissling, 2007). Digital information communication technology is advancing daily through new technologies and electronic devices, which when linked enable easier and faster communication. Developments in telematics and electronic ticketing have recently shown to be very important and are expected to improve for the better. New developments in ICT to improve the efficiency and provision of transport services enable these developments in telematics.

2.2.1. Overview Of Intelligent Transportation Systems

The different Information communication technologies used public transportation systems can be classified as part of Advanced Public Transportation Systems subcategory of Intelligent Transportation Systems (ITS). As previously defined, ITS are information communication technologies deployed into transportation systems. ITS are further classified into an assortment of systems categories according to their principal functional purpose. ITS are generally used in all transportation systems with traffic and logistics being the most common; this is due to early deployment of ICTs into their daily operations. Implementation of public transportation systems around the world has adopted the use of ICTs to improve service delivery and the general image of public transportation among other reasons.

Some of the ITS categories using ICT applications in public transportation are:

a) Advanced Traveller Information Systems (ATIS)

Advanced traveller Information systems' main focus is the provision of real-time information to travellers, mainly drivers. They provide information on traffic situations, congestion levels, accidents and delays on a specific route the driver is travelling on (Ezell, 2010).ATIS have also been proven to be a factor affecting travel choice behaviour of commuters (Sun et al., 2014).

Traveller information systems at bus stops have been studied and positive impacts of these at bus stops; these include less waiting times, increased willingness to pay for public transportation services, better ease of use and feeling of security, better and more efficient use of waiting times, improved customer satisfaction and a better overall

image of the public transportation system (Dziekan and Kottenhoff, 2007). Information systems have created a two-way fulfilling relationship between owners and travellers.

b) Advanced Transportation Management Systems (ATMS)

Transportation authorities, enterprises and government entities dealing with transport use information technologies to connect various devices to create an integrated view of traffic (Ezell, 2010). ATMS involve incident management and traffic demand management, basically dealing with managing the traffic in an area, improving mobility and improving safety for transportation users. These systems are known as Advanced Transport Management Systems; they deal with technologies such as Arterial Dynamic Message Signs, Microwave Vehicle Detection Systems and Travel Time Readers. These applications provide real-time information which can improve travel time reliability for all transportation users.

c) Advanced Public Transportation Systems (APTS)

Advanced Public Transportation Systems are a subset of intelligent transportation systems, referring to electronics and information communication systems deployed into public transportation to increase efficiency and safety within the public transportation systems and also provide accessible information on public transportation. This variety of ICTs that are integrated into the public transportation system forms homogenous multimodal system, which is APTS. These systems deal with the provision of real-time information for public transportation, automatic vehicle location (AVL) and electronic fare payments such as the use of smart-cards. APTS have made public transportation more attractive to the public as they provide enhanced visibility into timelines of buses, i.e. arrival and departure times (Ezell, 2010).

APTS are further divided into the following categories; according to (US Department of Transport: Federal Transit Agency, 2000)

- Fleet Management Systems (AVL, GIS, Automatic Passenger Counters and traffic priority signals).
- Traveller Information Systems (Real-time information systems in-vehicle and at terminals and stops).

- Electronic Payment Systems (Smart cards and electronic ticketing)
- Transport Demand Management (Ride-sharing services)
- The Transit Intelligent Vehicle Initiative (Advanced safety and Information systems for public transportation vehicle drivers)

2.2.2. ICT Applications And Technologies In Public Transportation Systems

a) Real-time information provision

Studies show that ICTs allow real-time information transfer between travellers and public transportation service providers (Filippi, Fusco and Nanni, 2013). Usability of public transportation can be improved significantly if good real-time traveller information systems are provided (Ferris, Watkins and Borning, 2010). Provision of real-time information will enable travellers to enquire about bus arrival and departure times at locations of their interest, and by the availability of this information increases public transport ridership as it reduces anxiety of passengers, therefore increasing a sense of reliability towards the public transportation systems (Ferris, Watkins and Borning, 2010;Park, Yang and Yi, 2011).

A vast range of technologies such as Geographical Information Systems, Global Positioning System (GPS), satellite technologies and wireless sensor network systems can be used to create, disseminate and display real-time information. This applies to real-time tracking of vehicles and route maps to knowing that a seat in a bus is occupied the moment a passenger takes a seat. The information goes on to be disseminated through computers, i.e. web-based and mobile applications and also displayed on screens and Variable Message Signs (VMS) boards. Light Emitting Diode (LED) dynamic message signs are a common way of displaying real-time information especially by public transportation companies and road and traffic authorities, information such as route number, destination and predicted arrival time for the next vehicle to arrive at a bus stop is normally displayed by these signs (Schweiger, 2003).

b) Public transportation mobile and web-based applications

Applications can be used to improve mobility and advanced infomobility; owners using these platforms to update travellers on current state of transportation system and multimodal transportation services (Filippi, Fusco and Nanni, 2013)

c) Social networks

Social networking platforms such as Facebook and Twitter are widely used by transportation agencies and travellers worldwide to communicate. These platforms are an effective way of empowering public transportation users and improving services (Filippi, Fusco and Nanni, 2013).

d) Trip planning

Trip planning initiatives have been adopted by many cities, transportation service providers, governments and transportation authorities around the world. Most of these journey planning platforms are internet based and use real-time information accessible through computers and mobile devices. Based on previous studies, most trip planning platforms allow travellers to plan their entire journey online. Content provided by these planners include a choice of mode of public transportation, timetables, schedules, routes and fares (Nelson and Mulley, 2013).

Trip planning requires quality, accurate and real-time data because trip planning systems use real-time information on the location of vehicles to help people plan their trips well (Nelson and Mulley, 2013; Borole et al.,2013). In cases where there is a lack of real-time information, dynamic networks are used by trip planner systems to search for travel plans (Borole et al., 2013). Most trip planners provide basic information, which is vital for passengers; this is the information that all trip planners should provide. Complex information which can include detailed routes numbering, unique bus stop numbers and graphical presentation of routes is barely provided but can, in future be considered for new design trip planners (Stefanescu et al.,2014).

Trip planners are very advantageous in public transportation as studies found out that they create more customers for public transportation owners and keeps the passengers informed about other possible alternatives such be faster, safer, cheaper and comfortable ways of public transportation. By so doing, they reduce the use of private vehicles and paper maps and schedules (Stefanescu et al., 2014).

e) Electronic fare payments

Electronic fare payments have made payment for journeys by public transportation more convenient and also made it easier for owners and bus conductors; improving public transportation for both passengers and service providers. These fare payment systems operate through electronic communication, data processing and storage techniques that have made manual fare collection an automatic, computerized system (Floridaapts, 2015). They have improved manual labour dealing with the handling of cash, safety and security reasons as bus drivers and conductors do not have to be at risk of robberies and hijackings targeting the money collected from passengers. EFP methods include electronic ticketing and smart cards.

f) Smart cards

Smart cards are an innovative and time-saving initiative, there are different types of smart cards used in transportation systems worldwide (Blythe, 2004; Iseki et al., 2008). They have the potential to improve the concept of seamless travel; their usage has made it easier for passengers to transfer between modes of transportation during a trip.

In general, where implemented, smart-ticketing have improved the public transportation systems as it has provided opportunities for growth by replacing paper-based tickets with a more technologically advanced system and understanding of traveller information such as travel patterns, and passenger flow. This has led to improved service delivery by public transport service providers by way of meeting the demands of the travellers (AECOM Limited, 2011). Studies carried out in Finland in 2000 showed that over 90% of people interviewed on benefits of using smart cards said that it was easier for passengers to board the vehicles (Blythe, 2004).

Even though smart cards have proven to be an effective way of electronic payment, there have been uncertainties regarding safety and cost. Safety mainly from the user's point of view and cost from the owners and authorities. Service providers, as they have access to passenger information, have tendencies to record the information which can be dangerous to the privacy of the passengers (Avoine et al., 2014). Smart cards were regarded as complex technologies as they required expensive equipment such as computers and card readers, there were questions as to whether the cost of installing

these computers and card readers in buses and stations was worth the presumed benefits of these cards (Iseki et al., 2008). Even though costs of smart cards may still be an area of concern according to recent studies, previous studies had forecasted that the cost of producing cards was reducing and the reliability of the cards increase (Blythe, 2004; Iseki et al., 2008).

g) Automatic Vehicle Location

AVL systems are computerised vehicle tracking systems. AVL systems provide the transportation industry with means to observe and manage vehicles (Predic et al., 2007). This technology has allowed for public transportation owners to monitor and track their vehicles at all times in real time. The U.S Department of Transportation,(2000), discussed GPS as the main technology used in locating vehicles and the use of satellites which receives data transmitted from antennas placed on top of buses in the form of signals, these signals are transmitted back to the GPS to locate the vehicle. AVL has made it easy for public transport establishments to provide passengers with real-time information on the status of buses. This includes monitoring, controlling and managing the vehicles (Predic et al., 2007: Predic, Rancic and Milosavljevic, 2010)

AVL systems have different functionalities dealing with the different types of data acquired from the moving vehicles. These systems have different components assigned to calculating the geographical information of buses and reporting the data to the control center using wireless internet technology (Predic et al., 2007). The downside to this technology could be problems associated with satellite technologies which tend to be interrupted by tall buildings and dense shrubs. However, GPS tend to work anywhere within satellite reach (U.S Department of Transportation, 2000).

AVL has made it possible for service providers to improve bus schedules as well as schedule observance and improve service delivery. Another benefit brought by AVL is the reduction in street supervision operations and personnel for vehicles (U.S Department of Transportation, 2000). AVL has also helped in improving safety in buses and improving response times in terms of emergencies (U.S Department of Transportation, 2000).

h) Variable Message Signs

VMS are used by transportation agencies to give travellers and drivers information. Variable message signs are defined as traffic control devices whose messages can be changed electronically, manually or electromechanically to provide information to road users (Oregon Department of Transportation, 2013). These signs are based on Light Emitting Diode (LED) technology (Mikulski, 2011). Even though the Oregon Department of Transport, (2013), defined them as traffic control devices, they can also be used to display travel information; both in real time or deferred.

Transportation service providers use VMS in combination with AVL to indicate whether their buses are on schedule: this provides passengers with departure and arrival times for better decision making and reduces anxiety (Hough et al., 2002). Mikulski, (2011) also highlighted that variable message signs are not necessarily expensive as panel VMS are affordable and economic as they do not need an excessive power supply to operate.

i) Destination display

These destination display systems use LED and LCD technologies and are in the form of signs mounted on front, back or sides of buses, showing the bus' next destination. The display signs are normally changed by the driver through a sign box which shows him what is displayed on the front exterior of the bus. Recent electronic displays are making use of LCD and LED illuminated panels to show animated text on destinations and routes.

j) Stop request buttons

Other technologies include stop request buttons which the passenger presses to notify the driver to stop. These buttons have replaced the hanging cords and bells. Hanging cords and bells which were commonly used by passengers are now being replaced with buttons (Tripadvisor.com, 2015). Passengers use these cords by pulling them to alert the driver to stop at the next stop.

2.2.3. Supporting Technologies And Devices Used In ITS

a. The Internet

The internet discovery made data available to people whenever needed, thus improving decision making and service delivery in various aspects of life. Most ICT applications used in public transportation are internet based. Mooney and Adam, (2003) described the internet as a very important means of acquiring and disseminating spatial information because of its high recognition and power of the web.

Internet-based public transportation trip planning systems, social networks, online ticketing systems, and virtual maps used in public transportation are enabled by the internet. Information such as bus schedules, prices, timetables and general information is provided by owners and companies through their websites, social networking sites and mobile applications, of which all use the internet.

b. Wireless communication technologies / wireless networks

Wireless technologies have grown tremendously in recent years in terms of mobile technologies and the number of users (Kumar et al., 2010). Wireless networks enable vehicle and infrastructure communication. They make rapid communication between the road and buses possible even though they might have a limited distance range of communication. Technologies such as GPS depend on data transmitted through wireless communications and their data has also become more accurate over the years. In 2000, studies showed that the accuracy of GPS data was about 100m and has since improved to below 20m (U.S Department of Transportation,2000). Some wireless communication technologies enabling ICTs in public transportation are:

(i) Near Field Communication Technology

NFC enables short-range wireless communication between devices that can both convey and receive data. This technology is used in contactless smart cards payment and on NFC-enabled mobile phones for paying fares. The NFC-enabled mobile phones which are normally linked to bank cards are swiped on an NFC reader (Coskun, Ok and Ozdenizci, 2011).

(ii) Wireless Sensor Networks (WSN)

Wireless sensor network devices are capable of computing, detecting and communicating; this allows them to be a bridge between the virtual and physical world. They have potential application in transportation (Krishnamachari, 2005). WSNs nodes contain GPS, sensors, radio transmitters and memory components. They are deployed in public transportation and ICT technologies such as seat detectors.

(iii) Cellular Telephone Systems

Cellular systems enable data and voice communication where there is enough coverage. These networks were designed to aid communication using mobile terminals inside vehicles with antennas placed on top of the vehicles roofs (Goldsmith, 2005).

(iv) Wireless Local Area Networks

Local Area Networks (LANs), provide data within small coverage areas and can be accessed using devices such as computers, laptops and mobile phones (Goldsmith, 2005)

(v) Wide Area Wireless Data Services

They provide data services to high-mobility users in large coverage areas and supported by base stations placed on top of towers, buildings or mountains. Even though these are wireless services, their base stations are sometimes connected to a support wired network (Goldsmith, 2005)

(vi) Satellite Networks

Satellite systems are among the main enablers of wireless communications, they provide two-way communication, location positioning and tracking possibilities (Goldsmith, 2005).

(vii) Bluetooth and Zigbee

Bluetooth and Zigbee radio technologies have been used in sensor networks and in applications. Bluetooth provides short-range connections between wireless devices with rudimentary networking capabilities (Goldsmith, 2005)

(viii) Wi-Fi

Wi-Fi is a WLAN based technology and supports both structured and ad-hoc networks i.e., computers and digital cameras. Wi-Fi is used in vehicles in support of Intelligent Transportation Systems (Ricci, 2010). Wi-Fi is also very robust against disasters and has flexible reception areas, therefore data can still be communicated between moving vehicles and companies during accidents and other emergencies.

Wireless technologies have many benefits:

- They enable fully comprehensive access technology portfolio to work with existing technologies such as DSL and cable.
- They go where wired networks cannot; therefore they can carry information across various geographical areas which can be difficult to access in terms of cost, time and location limitations.
- Wireless technologies involve reduced time to revenue; that means companies using them can save on time as they take less time to set up and activate.
- They complement broadband and wired technologies and provides access to areas which do not qualify for loop access.

c. Global Positioning System

GPS is a worldwide satellite navigation system formed by satellites revolving around the earth transferring radio signals to earth destined receivers (Thilagavathi and Rao,nd). Predic et al., (2007) stated that the AVL systems which were more reliable and economic then, were those using satellite-based GPS to determine the geographical location of the vehicle and cellular networks such as GPRS and EDGE for transmission of the data to control centers.

GPS technology is open to use without limitations and depends on the type of receivers available (Hofmann-Wellenhof, Lichtenegger and Collins, 2013). In public transportation, GPS has been used for AVL, Vehicle tracking, in-route guidance and in-vehicle navigation (Setiawan et al., 2012). GPS technologies are also used in trip planning. Trip planning platforms use GPS data in order to provide people wishing to travel with accurate data. The data is then processed and used to calculate the link

speed of active buses and GPS servers retain data such as bus ID and route numbers of all active buses. GPS servers then forecast the arrival of the bus at the next stop using the current speed and location of the bus (Borole et al.,2013).

d. Cameras

Cameras especially roadside cameras have been used in transportation systems, mostly by traffic departments and law enforcement agencies. Closed Circuit Television (CCTV) uses video cameras placed inside vehicles, at bus stops and bus stations for security reasons. These surveillance video cameras transmit the information to a set of monitors with people observing what is happening in those places in real time. Owners can also use these to monitor what is happening in vehicles and stops.

e. Light Emitting Diode (LED)

Light Emitting Diode technologies are not necessarily new technologies; they have undergone improvements recently which made them a popular technology (Held, 2009). LED technology is commonly used in display screens and VMS to display information.

f. Geographic Information Systems (GIS)

Geographic Information Systems are defined as a computer-based system that provides data capturing, preparation, management, storage, maintenance, manipulation and presentation capabilities to handle georeferenced data (De By and Huisman, 2009), while GIS Geography, (2014) defines them as a computer-based tool that stores, analyses, manipulates and visualises geographic information on a map

GIS technology is one of the leading technologies providing useful tools for mapping, data management and analysis, including successful transportation linear data management for companies .This allows for geo-referencing of bus routes, bus stops and other structures of the systems to a street centerline file and keeping all this data synchronised (Sutton, 2004).

GIS platforms have provided opportunities for development of useful toolboxes for the public transportation industry worldwide. Some trip planning systems and models for public transportation were developed from GIS platforms. Furthermore, transportation software providing scheduling, mapping and tracking programs use GIS-type

functionality (Sutton, 2004). GIS network analytic functions may apply in this case as they may consist of public transportation routes and may also include shortest path computations i.e., shortest distance and travel time between two points for routing purposes and visibility functions which are used to compute visible points from a location (de By and Huisman, 2009).

2.3. Opportunities For Public Transportation Improvement Using ICT

Studies on passengers in the United States of America found that there is an opportunity to improve the commuting experience using ICTs. ICTs will ease the public transportation trip making process by providing a platform for buying tickets, dissemination of real-time information to passengers. With the provision of enough internet and devices, public transportation can be a platform for working, socialising, advertisements and entertainment while on the road. (Gennvi-Gustafsson, 2013). In the United Kingdom, Netherlands and Norway these technologies have proven to be working. The Yorkshire County is an example of a place with a well-integrated, fully functional public transportation and ICT system through on-street information screens, smart phone applications, real time equipped buses and the use of SMS to get real-time bus information. This use of ICT in the public transport has significantly improved passenger transport. In Oslo, Norway there are more than seven hundred electronic display screens showing real-time information on expected arrival times of different modes of public transport (Weber et al., 2014)

ICTs can eventually be a powerful tool to promote change in the public transportation system by being applied to vehicles through onboard user aid devices for educating the driver, improving efficiency, reducing costs and impacts of transport on the environment. Mansfield (2014) wrote that buses in London are starting to get intelligent as they have display screens installed in them to show the number of occupied seats and live travel maps of where the bus is and distance to the next bus stops. These buses also have CCTV cameras operating in the bus for security surveillance which is much safer as criminals may hold back to committing crimes when they know they are being watched. In Shanghai, buses have real time communication devices, which allow communication between vehicles, owners and the infrastructure (roads and bus stops) which allows for monitoring of the vehicle driver behaviour, passenger numbers and location of the vehicle. This system is called

the ‘bus smart information system; also available are information screens on buses and at bus-stop signs, predicting how much time is left for the next bus to be at a certain bus stop (Karlenzig, 2011).

Urban transportation systems have seen some of the most active areas of deployment of ICT, particularly through mobile devices that the public has access to such as cell phones. Public transportation systems in some countries have the most active use of ICT through electronic mobile devices such as cell phones which use alerts on information routes and schedule changes and the use of e-payment to buy tickets online using computers and phones. Examples of these are the use of the Lipa Na M-Pesa services in Kenya whereby passengers pay their bus and taxi cab fares using M-Pesa which they access using their cell phones (Sato, 2013) and in the Netherlands whereby smart cards are used by passengers to pay for different types of public transportation, therefore improving seamless connections within the public transportation system. A case study carried out in Kgautswane, South Africa, showed that mobile phones can be used by public transportation users to show that they need transportation, however it was concluded that SMS cannot be used as they are more expensive, instead, USSD was deemed suitable as it was cheaper and easier to use compared to SMS. (Maritz and Maponya, 2010)

Internet connectivity and its speed play an integral part in ICT because fast and reliable travel information will enable passengers to plan their journey using different modes of public transport. In the Netherlands, there is a system already in place whereby passengers use a smart card only once to pay for the entire trip even though they change vehicles and even modes along the way. This has improved seamless connections within the public transport and ICT systems (OECD 2012). Provision of enough accessible internet in vehicles, bus terminals and bus stops to passengers for entertainment, working and socialising while waiting or travelling is also a way of providing information and attracting more customers to the public transport (Gennvi-Gustaffson,2013). Also available are public transport enquiry services (PTES) management programs whereby there is one portal with map and route information on public transport which can be used to choose the suitable public transport route based on trip duration, bus fee, available interchanges or the mode of transport preferred by the passenger (Nair and Devi, 2011).

The use of social media such as Facebook and twitter especially by taxi companies could enable sharing of information by the various stakeholders of the system; also customers could use these social networks to contact taxi owners. Personal assistive guidance systems can be used at bus terminals and taxi ranks by the public in order to access the information they need at that particular moment. It was also shown that there is current use of high-quality ICT measures in the public transportation system in the Netherlands, Austria and the USA and this has improved the image, quality of transport and rural connectivity (Malicet, 2013; Eickelpasch, 2013).

There is also opportunities for improved security in the system by using automatic camera enforcement and Closed Circuit Television (CCTV) cameras installed in vehicles will result in an improved sense of safety assurance to the public. More advanced safety systems such as vehicle tracking using GPS technologies and provision of real-time location of the vehicle and its distance to the next bus stop can be used for the convenience of the passengers (Nair and Devi, 2011). Using these systems, passengers can arrange everything such as the time they leave home to the bus stop, and arranging for their own protection once they get off the bus or taxi.

2.3.1. Cases Of ICT Solutions in Public Transportation Systems Worldwide

2.3.1.1 United Kingdom

i. Yorkshire

Yorkshire County in the United Kingdom is one example of fully integrated public transportation. The transportation matters are overseen by transportation authorities. The West Yorkshire Integrated Transportation Authority deals with transportation matters according to the West Yorkshire Local Transport Plan (2011 – 2026). Its main objectives are to improve connectivity, to make substantial progress towards a low carbon sustainable transport system and improve the quality of life of people visiting and those living in West Yorkshire (Bradford, 2015)

The Yorkshire County has a smart ticketing system (Yorcard) for buses and trains which became operational in 2011 by the South Yorkshire Passenger Transport Executive and the West Yorkshire Passenger Transport Executive. It provides smart ticketing services to public transportation users by storing tickets electronically on a microchip. The system allows for seamless travel using various modes of public transportation. In 2014, most buses in Yorkshire were equipped with smart enabled

ticket machines (Yorcard.co.uk, 2015). The provision of accurate travel information to the public using communication technologies was also introduced in some towns such as Bradford in the Yorkshire region; these include using variable message signs and sharing of other information relating to congestion and delays on roads. Real-time information displays showing arrival and departure times of buses are also to be made available in bus shelters, together with a real-time bus priority system. The provision of in-shelter CCTV at bus stops and interchange stations is another way ICTs are used in Yorkshire (Bradford.gov.uk, 2015). Some features in place ICTs in Yorkshire includes travel enquiry technologies with some having been made possible by the European Regional Development Fund (Fenoughty and Holmes, 2008).

In October 2014, the "*Yorkshire's Improving Transport and Accessibility*", through new communication technologies programme held a training workshop to teach passengers and journey planners the basic use of computers and the internet to plan journeys and book tickets in Dales. The programme also aimed at teaching the public how to use journey planners through software which enables users to book trips by public transport on computers, phones and tablets.

The iTravelYork web portal is a real-time online information provision platform which is available to access through mobile phones and computers. This allows the public to plan journeys, book tickets and even displays bus route maps. Contact details of bus owners and bus fares are also provided.

ii. London

Transport for London is London's transportation statutory body, which promotes safe, integrated, efficient and economic transport facilities in London. As the city's transport authority, it oversees all transportation matters and has by far introduced various information and communication technologies to improve public transportation services.

One–ticket-for-everything systems are already in place in London. Passengers planning on using public transportation use one ticket for all available modes of public transportation (Teach-ict.com, 2015). These payments for trips are made through the London Oyster card; these smart cards holds pay as you go bus tickets. Countdown display screens are placed at bus stops to show passengers time left for buses to

arrive at that particular stop. These countdown times are available at 2500 bus stops in the city of London. Information is also available for customers by text messages.The buses also have buttons for passengers to alert the bus drivers to stop for them. (Transport for London, 2012)

2.3.1.2 Kenya

The public transportation system in Kenya has improved tremendously since the introduction of M-Pesa in early 2007. M –Pesa is an SMS technology based mobile payment system which was launched by Safaricom, the largest mobile service provider in the country. The system started as a money transfer mobile system and has been expanding and breaking into various spin-offs for different sectors. The system used for public transportation is called Lipa-Na-Mpesa and allows passengers to pay for bus and minibus fares using virtual currency through their cell phones instead of carrying cash. Over the years, the system has been improving technologically, from the SMS based payments to smart cards. A few cards have been introduced, they include Google Bebapay , Kenya Bus Service's Arbiria cards and My1963 which are provided by Fibre Space, which is a technology firm in Kenya. Money is loaded onto the cards from the M-Pesa platform and can be used for bus fare. (Mulipi, 2005).

The 2006 ICT Policy promotes the need for policy, legal and regulatory framework to ensure affordability of access of ICT throughout the whole nation (Ministry of Information and Communications, 2006) . M-Pesa has led to rising ownership of mobile phones in Kenya and the system provides services to people and it is very affordable. The policy goes on to emphasise that more focus would be directed towards providing ICT support infrastructure and this includes roads. The provision of roads also benefited the public transportation system as more people are now able to access public transportation services.

Even though the Lipa-Na-Mpesa system has been a success, there has been slow uptake and adoption of the system especially by bus drivers and other owners regardless of it being implemented in public transportation vehicles for some time. Bus drivers and conductors also bypass the system by demanding cash from passengers and not allowing the use of smart cards.These challenges are mainly because the public transportation is mainly controlled by the private owners of the vehicles

(Omwansa, 2009) . To improve the situation the government decided to pass legislation for cashless fare system to be compulsory in all vehicles and take action against owners who defy the system.

The use of the Lipa-Na-Mpesa system in Kenya shows that ICT solutions can be deployed even on the most conventional public transportation systems and can be made affordable to the public. The system uses basic technologies, majority of the people, including adults and children are able to use it regardless of their literacy status (Mas and Ng'weno, n.d.) This also shows that full investment into ICT by stakeholders, i.e., the government, internet service providers, technology firms public transportation owners and the general public can result in improvement of public transportation.

2.3.1.3 Netherlands

The use of ICTs in public transportation in the Netherlands dates as far back as the early 1990s when passengers used telephones to call a national public transportation number to get travelling information such as departure times and fares (Ministry of Transport, Public Works and Water Management, 2010).

Public transportation in the Netherlands is made of buses, trains, trams and metros. Over 4.5 million trips are made by bus; tram and metro daily in the Netherlands and 1million are made by train. (Ministry of Transport, Public Works and Water Management, 2010).

Travel information was made available online since 1998 and currently the 9292 online based travel information platform provides information on various modes of transportation in the Netherlands. The travel information is also provided through mobile applications available on Google play, Appstore and Blackberry World, social networks such as Twitter and direct telephone services from owners. Information offered by 9292 includes maps, public transportation fares of all the available modes of public transportation. Contact details of public transportation service providers are also provided. (9292.nl, 2015)

Dutch Public Transport Smart Card, called the OV-chipkaart, which was introduced in 2010 is used on all available forms of public transportation in the country. The card works as an e-purse as passengers load credit onto the card and use it as bus tickets (Ministry of Transport,Public Works and Water Management, 2010; Amsterdamtips.com, 2015). The card just like the London oyster card is embedded

with a chip and passengers check in and out of terminal gates and vehicles by tapping the card on a card reader. The card reader flashes a green light or prompts a message to notify that you can now board the vehicle.

One goal of the 2000 Transport Act was to improve quality and innovation in public transportation, and it is without a doubt that the quality has improved and one reason for this improvement is real-time information availability (van de Velde, Eerdmans and Westerink, 2010). According to Ministry of Infrastructure and the Environment, (2012), the Multimodal Travel Information Approach,2009 had intentions of offering people wishing to travel an optimum choice of transport, travel times and routes by providing information at any time and any location in the Netherlands by 2015.

Real-time information is provided at bus stops and stations. Buses also have destination displays on the exterior front for passengers at bus stops. This has been made possible by combining information and hardware from the various public transport owners and defined in a uniform manner, therefore improving the availability and quality of data to be always up to date, reliable and cover all area in the country. (Ministry of Transport, Public Works and Water Management, 2010; Ministry of Infrastructure and the Environment, 2012)

These technologies have evidently improved the public transportation in the Netherlands as the provision of information through mobile internet has proven to offer passengers huge benefits in cases of unexpected service disruptions (Ministry of Transport, Public Works and Water Management, 2010). The real-time information system provides additional opportunities for monitoring of vehicle and operator performance. This has also made it possible for people to switch from private vehicles to public transportation by comparing journey times (Ministry of Transport, Public Works and Water Management, 2010).

2.3.1.4 United States of America

As one of the leading developed countries in the world, the United States of America has been leading with enabling technology for public transportation. Electronic fare payments using Metro cards for public transportation such as buses, trains and subways have been used since January 1994 (Opurum, 2012) . Real-time information through mobile applications and display screens are available for the public to use. This involves trip planning, mapping of journeys, booking and online ticketing.

2.3.1.5 Singapore

Singapore is one of the first countries in the world to adopt ITS in its transportation systems; the introduction of e-ticketing began in the late 1980s in the form of magnetic tickets and fare cards then later evolved to contactless smart cards (Prakasam, 2009). The Land Transport Authority which oversees transportation matters in the country has established ways to improve public transportation, i.e. improving the quality of service and commuter experience using ICTs; by making efforts to provide more and better travel information. The country has a website, TransportSG, established in 2008 which provides information on public transportation (Public Transport SG, 2013). The information provided includes: list of bus services, bus routes and any updates about buses. This information helps commuters plan their journey (Land Transport Authority, 2013) MyTransport.sg™ is another platform which offers services such as calculating transportation fares online, online maps and bus arrival times (MyTransport.SG, 2015). These services are made possible by the Land Transport Authority which also offers free Wi-Fi at some public transport stations and mobile public transportation applications available for download using smartphones (Lta.gov.sg, 2015).

The public transportation system also uses an e-ticketing; it uses smart cards for fare payments. This Enhanced Integrated Fare System has resulted in the improvement of public transport for both bus drivers and passengers as passengers do not have to waste time calculating fares and disturbing the bus driver to get their change back, therefore the drivers focus fully on driving (Prakasam, 2009)

2.3.1.6 China

The public transportation system in China, especially buses, use Electronic Fare Payment system where bus fares are paid for using magnetic ID cards. This is part of the urban transportation integrated information platforms through intelligent transportation systems for scheduling, dispatching of transport to ensure prompt operation of the public transportation system (Mackett et al., 2013). Information on all mode of public transportation is also made available on internet platforms such as the internet. Real-time information is provided online and in the form of information display screens in vehicles and public transportation stations.

2.3.1.7 Australia

Smart card ticketing is used in most Australian public transportation vehicles. The *myki* initiative was established in order to integrate fare collection systems in the country and provide seamless travel of passengers across all modes of transportation. Passengers have to tap the card on the card reader when entering the vehicle and when getting out at the end of their journey. This has allowed the government in terms of data gathering and analysis for improved public transportation efficiency and planning. This card system has proven to be effective in terms of saving time as passengers do not have to spend a lot of time queuing before boarding the vehicle, the card can also be linked to passengers' bank account for easy loading of travel credit (NNT DATA, 2015).

The *BusPlus* system, offered by *National ICT Australia* as their approach to public transport innovation uses ICTs through a system where bus users book a vehicle through the website, a phone or through a mobile application which can be downloaded. Booking can be done 15 minutes before the time a passenger wishes to start their journey and the system will plan the whole route. This as indicated by NICTA, (2015) has resulted in faster travel times, and since it is a demand responsive service has, allowed for reduction in carbon emissions because there are no unnecessary buses on the roads when there are not in demand.

2.3.1.8 South Africa

i. Gauteng

Public transportation in the Gauteng province is one of the most efficient in South Africa. Modes of public transportation in the province include train, buses and taxis. The train has ICT services such as SMSes, social networking, electronic payment system, routes and map information ,online platforms and mobile applications for information exchange with the public (Gautrain, 2016).

ii. Cape Town

The City of Cape Town is currently in a process to transform its public transportation system; this transformation includes the introduction of a Bus Rapid Transit system and integration of ICTs into the existing and the integrated systems. The City of Cape Town has formulated Transport for Cape Town, which is a transport authority and custodian to plan and manage transportation matters in Cape Town (City of Cape Town, 2013). This authority's mandate is to plan and implement proper transport by

fulfilling administrative, planning, communication, contracts, regulation, monitoring and evaluation, management and operation of transportation infrastructure and services. The Cape Town Economic Growth Strategy also aims at providing the right basic transportation and ICT infrastructure service. One of the key aspects of Cape Town's Integrated Transport Plan (City of Cape Town, 2013) was to urgently improve data collection and information management systems and this is under implementation as the city has put into practice various ICT measures since then.

The city has also recently launched a mobile transportation application which maps out the different modes of public transportation within the city and tells passengers which mode to use. The application provides information on bus stops, distance and directions to bus stations and bus stops (Phakathi, 2014). The application also notifies passengers about vehicle delays, accidents, roadworks and road closures. Furthermore, as of November 2014, the city was to offer free Wi-Fi at *MyCiti* bus stations around the city through its partnership with local and international internet service providers with the aim of attracting more people to use public transportation (Phakathi, 2014).

Other technologies adopted by the City of Cape Town include the use of Automated Fare collection through smart cards. These cards are used as electronic purse and passengers can load and use a travel package offered by the city. (City Of Cape Town,2015). The MyConnect fare collection and ticketing technologies are overseen by the Transport Cape Town which distributes it to all road based public transport services.

The city's public transportation system has also adopted Intelligent Transport Systems to enable, manage, operate and optimise operations of the public transportation system. (City of Cape Town, 2013)The ITS has been made possible by using an integrated real-time system which collects real-time passenger data and also relays travel information back to passengers, CCTV monitoring of public transportation interchange stations for security and public law enforcement reasons and the integration of schedules and adaptation of operations to deal with delays and other incidents.

2.4 Public Transportation And ICT Challenges In The Free State

The Free State province's public transportation system is still conventional as compared to other cities having Bus Rapid Transit systems, for example Rea Vaya in Gauteng, which is in a better position of supporting ICT. This provides an opportunity for the bus owners to upgrade their fleet to incorporate various technologies at the same time increasing efficiency and economic growth of the system. This does not necessarily mean all public transportation vehicles must be upgraded; it depends on what technology, electronics, devices and applications are decided to be used in which transport mode. Mobile phone applications such as SMS and Unstructured Supplementary Services Data do not require any special changes to vehicles. Display screens may not be a feasible idea for smaller mini-bus taxis but can be well accommodated in quantum taxis and buses. Upgrading the vehicles to support various ICTs will give it a more appealing appearance will also help attract customers.

One of the major challenges of the public transportation system in South Africa is to integrate modes of transportation using integrated transportation plans and to render public transportation services across all transport areas. This can be made possible through one of the main objectives of the Department of Transport which is to provide citizenry with a better customer experience by integrating ICT in the form of e-Transport solution (Walters, 2008). Internet accessibility, the presence of CCTV surveillance and availability of real-time information are some technologies which can improve passenger experiences. They will also attract more people who have previously been using private vehicles. The public transportation functional area of the Department of Transport is responsible for development and implementation of interventions seeking to promote public transport over private car use with the help of Integrated Public Transport Networks (DOT strategic plan 2011/12 – 2013/14) (Department of Transport 2011). It has been observed that the reluctance of the public to shift from the use of private vehicles to the use of public transport is partially due to lack of information on the public transportation system. With the use of ICT, the general public can access information anytime and this could possibly result in an increase of people using public transportation. Less private vehicles on the roads will mean a reduced number of vehicles and reduced negative environmental impacts caused by vehicles such as air pollution, reduced carbon emissions and noise. The shift from the

use of private vehicles to public transportation system will also be a step towards attaining one of the goals of the Moving South Africa: Public Transport Strategy and Action Plan of reducing dependence on cars by encouraging the use of public transportation among others. ICTs have the ability to attract current car users to the public transportation system (South African Department of Transport, 1998). In order to meet the goals of different initiatives which were put on paper years ago, public transportation needs to attract enough customers daily to sustain operations and keep service fees affordable to all and keep generating funds to maintain the vehicles and the infrastructure (Department of Transport, 1998).

Informal public transportation services have also been a problem in South Africa since the regulation of the public transport system and are not easy to regulate and can be difficult to account for from a policy implementation standpoint (Dimotrou and Gakenheimer, 2011). Illegal or unregistered public transportation, especially taxis operating in rural areas cannot be controlled, monitored and even integrated with other vehicles if a policy to integrate ICTs in the public transportation system was to be implemented.

Factors such as cost and affordability, availability and accessibility, illiteracy and awareness can hamper the uptake of ICTs in the public transport system. ICT infrastructure in South Africa is more advanced than in most African countries but its rural areas are faced with difficulties in education and poor ICT infrastructure (Maritz and Maponya, 2010). Technologies to be integrated into the public transport system should be affordable to the users. Lack of knowledge on ICTs and lack of education will also determine acceptance of these technologies by the public and other stakeholders especially taxi drivers. Not all people who can have access to these ICTs will be able to because of reasons such as illiteracy and unwillingness to learn. Internet accessibility is still a problem in South Africa as 40. 9% households had at least one member who have access to the internet (Statistics South Africa, 2013). The lack of internet connectivity may become a problem now and in future as studies show that connectivity will play a very integral part in future commuting. The rapid increase in the use of mobile phones especially smartphones as well as mobile data provides new information on commuter sentiments and new opportunities, thus improving the whole commuting experience (Gennvi- Gustaffson, 2013).

2.5 Critical Review of Legislation And Policies With Regards to ICT and Public Transportation in South Africa

2.5.1 Introduction

Public transportation is governed by the public sector. The government through its three spheres of government puts in place some legislation to guide the development. This legislature is in the form of policies, strategic development plans. This chapter reviews these laws and policies set forth by the different government spheres, whether they have been acted upon in the Free State province and how the provincial government or provincial department of transport is dealing with public transportation and how they have acted fulfill these laws.

This section aims at:

- Reviewing the legislation and policies relevant to public transportation with regards to ICT solutions in South Africa.
- Critically analysing ICT strategies and Integrated Transportation and Development Plans in the province and their approach to public transportation and ICT.
- Investigating whether the laws and policies are actually being obeyed at all levels of the public transportation system and how adequate they are in terms of public transportation systems and ICT.
- Investigating the progress and achievements of the public transportation sector in the Free State province with regards to ICT, emphasizing on the provincial and municipal spheres.

2.5.2 The Green Paper On National Transport Policy And The White Paper On National Transport Policy (Department Of Transport, 1996)

Both the Green and White Papers on National Transport policy: The White paper was the draft to the final policy (The White paper), or the results of the revision of the Green Paper's vision of South African transport was to transform the transportation system to a system which will *"provide a safe, reliable, effective, efficient and fully integrated transport operations and infrastructure which will best meet the needs of freight and passenger customers at improving levels of service and cost in a fashion which*

supports government strategies for economic and social development while being environmentally and economically sustainable" (Department of Transport, 1996)

Transportation under these policies is deemed one of the main priority areas for socio-economic development, this means that the transportation holds the potential to improve the social and economic lives of the general population of South Africa. One of the National policy imperatives of the country's transport strategy is to bring positive impact to social and economic development by taking part in broader policy making and decisions which affect demand for transport, together with other sectors. The transportation sector should therefore collaborate with the ICT sector through the provincial department of Transport and the Department of Communications for the integration of ICT in the public transportation system. This will improve demand for public transportation.

Under Customer imperatives, one of the goals is to create a fully integrated transport and information system which permits seamless, efficient and transparent passenger logistics in the country, region and globally. It goes on to state that this will demand a flexible transportation system and transport planning process which can respond to customer requirements, while providing on-line information to the user to allow choices to be made. (Green paper / Department of Transport, 1996) Up to date, there are no available platforms offering on-line real-time information to public transportation users in the Free State province. The responsible authorities should have taken into advantage this policy to create platforms allowing this to be achieved.

On meeting investment criteria, the policy states that information systems should be developed to provide quality information to help decisions. This also reflects on the issue of information, and no implementation has been done in the Free State province. Information availability is still one of the reasons why people find public transportation inconvenient. One of the strategic objectives of land passenger transport on the white paper is that transport should be customer based through the provision of readily-accessible information for the assistance of passenger transport users.

The responsibilities and functions of the provincial government with regards to public transportation according to the policy is:

- Developing provincial land passenger transport legislation, coordinating passenger transportation among lower-level authorities, implementing, monitoring and revising provincial passenger transport policy.

The provincial government, as it is supposed to oversee and coordinate public transportation among municipal governments, should lead by example. The lack of ICT policies, lack of ICT in public transportation in the province should be the responsibility of the provincial government.

The White Paper also states that the government will support the development of and implementation of appropriate and innovative technologies to meet present needs, as well as to keep pace with the rapid development of advanced transportation and information technologies internationally. By doing so, the government creates an environment open to the introduction of various technologies to solve transportation problems.

2.5.3 The White Paper On Science And Technology (1996) (Department Of Arts, Culture, Science And Technology, 1996)

The White Paper on Science and Technology's aim was to promote the entire field of science and technology within the context of problem-solving to provide for national needs.

On the promotion of technological change the white paper states that there is a need to define a sustainable path for South African social and economic development and the relationship between this path and technology investment. In order to do so, we must be aware of relevant global trends. The context of this can be used to promote technological growth in public transportation by adopting information communication technologies and following the example set forth by other countries globally.

On promoting an information society, the policy elaborates South Africa's vision of an information society, which "*should seek to ensure that the advantages offered by the information revolution reach down to every level of society and achieve as best a balance between individuals and social groups, communities and societies as is practically possible*." The public transportation system being used by people in rural areas and the poor, if integrated with ICT solutions, it would promote this as more information would reach the remotest areas of the province through technologies in public transportation.

The White paper on science and technology (1996) highlighted that as South Africa is part of the global arena, it is faced with challenges and pressure that needs innovative and flexible responses in order to adapt to the changing global environment, of which the major challenge at that time was successful integration into global systems and communities while fulfilling the needs of the population. The needs of the Free State population, with regards to transportation at this point are not being entirely fulfilled as compared to other countries. Globally, innovations in technology for public transportation and integration of technology has been successful as far as fulfilling the needs of the public is concerned. Not enough has been to innovatively solve the public transportation needs of the public to place the province in a global standard.

On the Government context of the white paper, it also states that “no government can order innovation to take place, but the government can ensure that a competent pool of expertise from which innovation can spring is grown and maintained” (Department of Arts, Culture, Science And Technology, 1996). Public transportation, and transportation in general is presenting opportunities for innovative growth, a gap to fulfil this lies within the public transportation sector.

The policy set forth by the white paper on science and technology presents other government sectors with openings or opportunities they can take advantage of and benefit both sectors involved. The Free State transportation sector, such as other provinces and cities have done, should integrate innovative technologies and applications into its public transportation system.

2.5.4 Moving South Africa (MSA) (1998)

The MSA scheme’s initiative was “*to provide an effective and sustainable urban transport system, planned and regulated through the lowest possible level of government, based on competition and largely private sector operation, which reduces system costs and improves customer service in order to meet customer and national objectives for user cost, travel times, choice, and safety*” (Department of Transport: Moving South Africa, 1998)

The plan was to provide a long-term strategic plan for transportation in South Africa, from 1998 to 2020. With a few years left to 2020, the goals of this strategic plan have not been fully met and very far from being fulfilled in the Free State province. As one of the aims was reducing the use of private vehicles and promoting public

transportation, it seems more people still use their vehicles and more vehicles are being bought daily due to an increase of the working class group. ICT is a potential reviver of the situation, information made available to everyone and other efficiency and accessibility improving technologies brings hope for an improved public transportation system reliable enough to attract people.

This vision of the MSA strategy however suggests that even lower government spheres such as local municipalities can in their own capacity provide the best possible public transportation legislation within their jurisdictions in order to improve the effectiveness and sustainability of public transportation.

Local municipalities, especially in rural areas should take incentive of this objective and be able to improve the public transportation systems through ICT solutions. The inaccessibility and limited mobility of public transportation in rural areas can be solved without waiting for legislation and orders from higher spheres of government.

2.5.5 The National Land Transport Act (2000 - 2009), Act 22 Of 2000

The National Land Transport Act provides legislation towards planning transportation service provision by all levels of government and outlines the duties of the responsible political leaders.

Under the NLTA of 2000, chapter 22 **,** some of the principles listed in the National Land Transport policy are that public transportation services are designed to achieve integration of modes, cost efficiency and service quality and that all role players must strive to achieve an effective land transport system by using integrated planning, provision and regulation of infrastructure and services and diligent and effective law enforcement. The aspects mentioned above can be achieved using ICTs.

The computerised land transport information systems of the national government, provinces, municipalities and transport authorities must be compatible with one another and must be designed as to allow mutual access as well as access by the systems of the provinces' boards and the systems of planning authorities. The Act discusses only internal information systems used within the Department of Transportation and municipalities. There is no platform bringing together all the stakeholders.

It is the duty of the minister to prescribe requirements for integrated fare systems, comprising fare structures, levels and technology, to ensure compatibility between such systems. This highlights the issue of political will, implementation happens because the people with authority to pass prescriptions are willing to do so, therefore until the minister permits or deems necessary, integration of fare systems may not happen.

The same Act also indicates that for the establishment of transportation authorities, MECs and municipalities of a transportation area can form a transport authority by a written founding agreement between them. As per the Act, the function of transportation authorities are to promote security in public transport, encourage and promote use of public transportation to enhance its effectiveness and reduce travelling times and costs, develop, operate and maintain a land transport information system, provide information to users or potential users if public transport, introduce or establish, or assist in or encourage, promote and facilitate the introduction or establishment of integrated ticketing systems and determine or prescribe measures for the regulation and control of revenue-sharing among the owners involved in that system (NLTA, 2000) . The Integration of ICT generally lies on jurisdictions of Transportation Authorities, which the Free State province do not have.

The NLTA 2007 and 2009 provides further the process of transformation and restructuring the national land transport system initiated by the National Land Transport Transition Act, 2000 (Act No. 22 of 2000).

2.5.6 Integrated Transport Plan: Department Of Transport. Government Gazette, 30 November 2007. NO 30506.

The National Land Transport Transition Act, 2000 (Act No.22 of 2000), Integrated Transport Plans: Minimum requirements in terms of the National Land Transport Act. The strategy in relation to operational planning responsibilities states that Comprehensive and District Integrated Transport Plans must contain a long-term component of long-term vision and objectives for the transport systems of the specific regions and the strategy to develop the transport system over time to achieve set objectives.

This Integrated Transport Plan focused mainly on Integrated Rapid Public Transport Networks (IRPTNs) which aims at improving public transportation nationally by

upgrading the fleet and operations to implement high-quality networks of car competitive services in the form of Bus Rapid Transit systems. In the Free State Province, then Mangaung Local Municipality is the only municipality which fell under the twelve cities identified by the Department of Transport as part of the Integrated Public Transport Network.

The Act does not have any obvious strategies pertaining to ICT as part of these ITP strategies.

2.5.7 Department Of Transport- Strategic Plan 2011/12 – 2013/14: Revised 2011/ 12 – 2013-14

Objectives of the Department of Transport's Strategic Plan (2011/12 – 2013/2014) include obtaining approval for the establishment of a transport information technology hub and providing secure, reliable and easily accessible transport related information. These objectives were justified by the Department's hope for easily available, accessible and Integrated Transport Information Systems and their key performance indicators being implementing business intelligence, corporate governance and consolidated key ICT operations in the transport family and the development of the public transport industry.

The strategic plan further aimed at overseeing and managing the implementation of the public transport strategy and action plan by facilitating and promoting an integrated approach to the provision of public transport services, which ensures the integration of modes and the use of vehicles that are acceptable standards and are accessible to all to develop and empowerment schemes within the public transport sector on an ongoing basis.

2.5.8 Free State Legislation And Policies

In order to fulfill the objectives of the National Land Transport Act,2000, which was subsequently revised in 2007 and 2009 different cities and municipalities drew up their Integrated Transport Plans.

2.5.8.1 Motheo District Municipality: Public Transport Plan: May 2006: For The Period 2005 – 2010 And Mangaung Local Municipality: Integrated Transport Plan 2006 – 2010

The Motheo District and Mangaung Local Municipality transportation plans have the same goals and policies. One of the visions of the Mangaung ITP, to support the goals

of the white paper, one of the objectives of the ITP was to ensure that public transport is affordable, to promote safe and secure, reliable and sustainable passenger transport and to provide readily-accessible information. This was one of the proposed goals for 2010, readily accessible or real-time information on public transportation is still not achieved in Mangaung, which is now a Metropolitan municipality. The local municipality also aimed to be a nationally and globally well-recognised municipality by 2015 served by an effective, efficient, reliable, safe, affordable and convenient transport system with a public transportation providing high levels of mobility and accessibility. This was proposed to be achieved through the following goals:

1. To Improve mobility and accessibility of the people of Mangaung
2. To achieve appropriate planning and transport development
3. To ensure safe transport according to the public demand
4. To prioritise public transport over private transport to ensure the development of a livable city.

The above goals have not been fully met but can be achieved through utilization of ICTs.

2.5.8.2 Mangaung Metropolitan Municipality Integrated Development Plan 2013/2014, 2014 – 2015

The plan reviewed in 2013 makes reference to the National Development plan 2030's objective of ensuring spatial development by 2030 through reliable public transportation. Public transportation is also one of the key development priorities which the municipality wants to revive the system and develop public transportation infrastructure to ensure safe, efficient and affordable public transport. Also to promote the NDP 2030 visions of expanding infrastructure, transforming urban and rural spaces, improved quality of life, the metropolitan municipality aims to improve public transport system and services and improve transport service delivery by grouping transport functions into a single, well-managed and focused institutional structure and this objective is to be fulfilled by establishing a transportation authority within the next five years.

2.6 Theoretical Framework

Successful integration of ICT into the public transportation system means complete acceptance and uptake by all the stakeholders, provided the legislative environment permits. Adopting ICT and adaptation to a new system by the owners is necessary as

it will assist the integration process. All influencing aspects of ICT integration should be considered.

Over the years, theories on ICT and technology has been formulated, Roger's diffusion Of Innovation (DOI) model (1995), Technology Acceptance Model (TAM) by Davis et al (1989) which has since been adopted and reproduced by various authors including, Cloete and Courtney (2002). Reviewing these models and associating them with adoption and integration of ICTs into the public transportation system in the Free State will provide a framework for ICT integration.

a. Diffusion Of Innovation theory

The theory implies that diffusion of technology is a continuous and slow process compared to the invention of technology, diffusion determines the rate or pace of growth. (Hall and Khan, 2003).

Therefore by adopting ICT, stakeholders will be absorbed into taking new technologies and likely to continue to the upgrades and other introduced technologies and rarely abandoning these technologies for the old ones. Older technologies would likely remain in use by older people and people with limited literacy levels because of their usability. If the benefits of new technologies are more than the cost can also dictate the rate of adoption.

An accurate prediction based on human behaviour is difficult as other behavioural factors should be considered too, such as: perceptions, trust, especially dealing with new technologies. Hall and Khan, (2003) annotated facts such as new technologies are rarely abandoned by users to go back to old ones and that uncertainty about new technologies can result in delays in adoption.

b. Technology Acceptance Model (TAM)

The Technology Acceptance Model (Davis et al.,1989) was adopted to explain possible links between determinants of computer acceptance and user behaviour, can also be adopted to determine acceptance of ICTs by public transportation users as their perceptions of how the technologies will be useful to them and how easy to use they will also determine their attitude towards particular technologies or applications. Perceived usefulness and perceived ease of use therefore are seen as the crucial

factors determining acceptance. Perceived usefulness of technologies also influences the person's behaviour with regards to their intention to use or not use the technology. If the user's main concern is the usefulness and ease of use of ICT and the technologies turn out to be useful and easy to use, the users might therefore, regardless of the current satisfaction improve their likeliness to use public transportation after the technologies are integrated.

c. Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003)

This model explains user behaviour towards ICT and why people use ICT,and uses performance expectancy, effort expectancy, social influence and facilitating conditions as ways of determining acceptance of ICT by users and usage behaviour. This theory helps forecast and determine the likeliness of introduction of technologies to succeed and understand reasons why technologies are accepted. This model is recommended for users who are less likely to adopt and use new technologies or systems (Korpelainen, 2011).

From the above literature, a framework for integrating ICT solutions was developed: Highlighting the inefficiency of public transportation and minimal use of ICTs in the public transportation in the province and how they can be solved. The framework consists of the following:

1. **The problem**: Inefficient public transportation system and minimal use of ICT in the public transportation system, which are a result of the stagnancy of the public transportation contradicting the ever advancing ICT sector.
2. **Considerations**: Even though ICT is growing and the public transportation system is stagnant and there is evidence tat ICT can potentially improve public transportation, there are factors to be considered and addressed before the integration can occur.
3. **Integration**: Integrating ICT solutions also allows for opportunities in the public transportation system to be achieved, and ICTs to be used in the system to be revised.
4. To determine what technologies, applications and devices are to be used, usability and perceived usefulness also have to be considered.

5. **Opportunities**: Realisation of opportunities, together with perceived usefulness and willingness to use also influence the output of the process.
6. **Diffusion**: After integration, the diffusion of the technologies process starts, which involves adoption of technologies and adaptation to the new system.
7. **Outcome**: This will then determine the outcome of the process, an efficient ICT integrated public transportation system.

Figure 2.1 is a diagrammatic illustration of the framework developed for the parameters of this study for integration of ICT into the public transportation system.

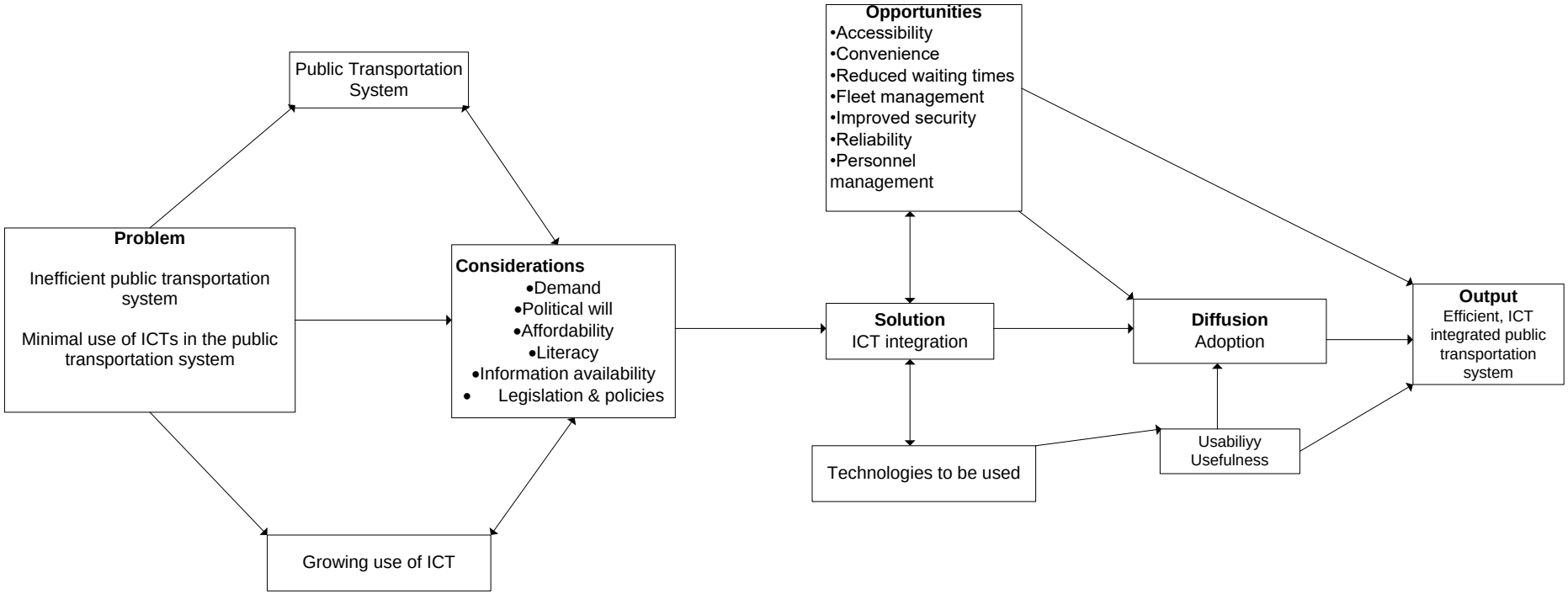

Figure 2.1: Theoretical Framework for integration of ICT into the public transportation system

2.7 Summary Of Literature Review

2.7.1 Summary Of ICT Solutions And Public Transportation

It is evident that ICT solutions can be successfully deployed in public transportation to improve the system. Developed and developing countries are using transportation authorities as the driving force to integrating their public transportation systems. As the main focus of these authorities is to improve the system and accelerate service delivery to the people, they have ICTs as a catalyst for this integration process. Many countries and cities have adopted the use of a single transportation authority to oversee all transportation matters and this has improved their public transportation systems.

The creation of a single transportation authority to deal with all transportation matters in an area has proved to be efficient in Cape Town even though previous studies indicated some had reservations on the formation of single transport authorities (Wilkinson,2002). Fears for the possibility of problems arising from municipalities due to the formation of transport authorities whose responsibility will be to undertake transportation planning and management functions in those particular areas which could possibly cover or overlap with the municipalities' jurisdictions. Bickford, (2013) suggests more research should be carried out in order to scrutinise the challenges and success of these transport authorities as they become very important stakeholders in cities' transportation systems. The Free State public transportation is still overseen by the government through the Department of Transport which deals with licensing and other transport issues. As these authorities are in charge of all transportation matters, the stakeholders of the transportation system in the Province can create one which can enforce and regulate the use of ICTs in the public transportation system.

Participation by various stakeholders in the integration process has sped up the improvement of public transportation is some areas such as Kenya and Cape Town. The success of the integration of ICT solutions in other countries' public transportation systems is a result of full participation of different stakeholders in the ICT and public transportation sectors as well as other parties such as banks who might have financial motives. Nonetheless, this has helped improve the respective transportation systems

Information availability has also played a key position in the deployment of ICTs. Data needs to be available in abundance for use in technologies such as creating databases and application. Availability of up-to-date quality data and transparency play a major role in the development of applications and technologies. This has led to the successful implementation of ITS and real-time provision in the Netherlands as they use a collective data system which gathers information from public transport users and owners, and generate and distribute the data to be used again by authorities, travelers and owners (Ministry of Infrastructure and the Environment, 2012).

Various ICT solutions can be used according to their affordability, looking at the development status of the countries which already have ICT solutions for their public transportation, it shows that the economic situation of a place is not the main factor influencing the use of ICTs. Kenya, Singapore and the Netherlands are at very different economic and development levels but they all have measures in place even though they vary in magnitude and technological advancement. The situation of Kenya shows us that despite the country's economic level, affordable solutions can be made available to even the poorest communities. It all depends on the types of technologies found feasible to use in a certain place. The adoption of ICTs by the transportation systems, especially at the municipal level will be determined by various factors, depending on the type of technologies proposed for use. (Wang and Feeney, 2014)

2.7.2 Summary Of Legislation And Policies

The legislation surrounding the development of public transportation seems to be mostly concerned with providing transportation services, i.e moving people from origin to destination, even though the quality of service is theoretically thought of, implementation of the policies seems to be a far-fetched idea at this point. The philosophies and theories of the policies and other forms of legislation therefore remain inadequate without any action.

The government has put forward various policies over the years which their underlying objective is to improve the efficiency and effectiveness of public transportation through improving reliability, safety, accessibility, affordability and mobility of public transportation, but has action been taken to implement the plans to achieve the desired public transportation systems. Policies have been put in place

while execution powers lie with political leaders who without will, no action to improve public transportation can take place.

The Free State province at this moment has no transportation authority, only plans to create and implement transport authorities and have a functional transportation authority in the next five years. As the target of the MMM of having an operational transportation authority by 2014/ 2015 did not succeed, this could also be a result of lack of political will as there should be an agreement between political leaders, in this case MECs and the municipality which wants to set up a transportation authority.

Most of the goals set forth by the above-discussed policies have not been achieved in the Free State province, which means the laws and orders are not being obeyed as standing in the Free State province as no action has been taken even though it has been over a decade since some legislations were passed. Progress regarding ICTs and improving public transportation hasn't really been achieved. There is a stagnant change in the public transportation system.

While responsibility lies within the government to see improvement in the system, the private sector should also take responsibility as it benefits equally from the public transportation industry. The private sector and the public have the potential to improve the system, this applies to passengers, who can come up with their own ICT-based solutions to the public transportation problems they are currently facing, or owners in their own capacities to improve their vehicles, and therefore improving the service they offer the public.

2.7.3 Summary Of Theoretical Framework

The framework is based on the literature reviews on ICT and public transportation, different types of ICTs, cases of public transportation systems which already have ICT integrated systems, South African national and the Free State provincial lagislation and policies concerning ICT and the development of public transportation as well as technology adoption and acceptance theories. The framework assisted in the developing of questions to ask during the primary data analysis and the development of guidelines, which are presented in the next chapters of this study.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The purpose of this chapter is to describe and support the method of research used in this study, research design and methods of data collection in order to achieve the aims and objectives of this study. It explains how the research design influenced data collection, analysis and modelling.

3.2 Research Design and Instruments

3.2.1 The Research Method

Multiple research methods are in this study. The approaches are based on assumptions that for circumstances to improve accuracy and meaningfulness of inferences and a complete imagination of those circumstances and reconfirm findings, more than one method of research belonging to either the qualitative and quantitative paradigms needs to be employed (Ranjit, 2014). Quantitative methods use rationalisation in order to quantify variation and relay the findings in an analytical manner while qualitative methods are imperialistic, open, flexible, diverse and explorative instead of relying solely on quantity. Quantitative methods also narrate feelings, perceptions and experiences without measuring them (Ranjit, 2014). For these reasons, Questionnaires used both qualitative and quantitative approaches while interviews, literature review; review of cases of already in-place ICTs for public transportation, review of legislature and policies used the qualitative approach. These study tools and processes were arranged as follows:

3.2.1.1 Data gathering tools

- Literature study
    a. Review of case of ICT in public transportation
    b. Critical review of legislation and policies with regards to ICT and public transportation
    c. Theoretical framework
- Questionnaires
- Interviews

3.2.2 Literature Study

Literature in the form of books, journal articles and online platforms were made available through the Central University of Technology Library and Information Services. Information on what is going on with regards to ICT innovations in the global

scene through up-to-date research articles and websites accessed through the internet.

Literature from published articles, books covering ICT, public transportation, Intelligent Transportation systems are included in the study, covering topics describing ICT and their relationship with public transportation, the need for ICT investment in public transportation by private and government sectors and the current state of public transportation in the Free State. The literature review leads to a review of cases on ICT in public transportation in other countries and cities besides the Free State province.

3.2.2.1 Study of existing cases of ICT in public transportation

As part of the literature review, a study of existing cases of ICTs being used in public transportation was used as an investigative tool to investigate between the phenomenon of ICT integration into public transportation and real life context.

The cases selected were significant to the study so that they contribute to improvements in anticipated practice. These cases are also used as opportunities to learn as they are taken from studying existing ICTs in public transportation systems around the world. Studying how different countries, cities or areas were able to successfully integrate ICTs into their transportation system allows for the Free State province to possibly apply some of those strategies and tactics to create its own integrated public transportation system. Existing literature and online platforms such as the countries and cities' public transportation websites and trip planning and platforms were studied, together with the technologies and devices they use. Studying the different cases was used as a base to strengthen the ideas showing that it is possible for ICT to effectively be used in public transportation.

3.2.2.2 Critical review of legislation and policies with regards to ICT and public transportation

Further literature review was carried out by studying existing government, municipal or town legislation, policies and development plans on public transportation and ICT. The documents provided insight as to how the government planned on improving public transportation, developments so far based on those plans and future plans. They also aided in analysing how these legislations by the government had been carried out in the Free State province. The section also reviewed whether the laws governing public transportation in the country are adequate; up-to-date with

technological advancements and innovations in the public transportation sectors all over the world and whether the Free State province is following these legislations and their proposed timelines. How well the Department of transportation and other stakeholders are following these strategies, laws and policies. What development plans are proposing for the future of public transportation? By reviewing these legislations and policies and critically analysing them, arose questions as to whether the public transportation system in the province in developing the way it should be and fulfilling the needs of its users.

After reviewing the existing cases of ICTs in public transportation from around the world together with South African national and the Province's legislation, a theoretical framework on what needs to be taken into account for successful deployment of ICT in the Free State public transportation system was developed.

3.2.2.3 Theoretical Framework

A theoretical framework was developed as a guideline to view the research topic and illustrate the problem based on theories and literature review. This shows perspectives on what is really needed to address the research topic and different points of view to solving the problem in the research study. The framework was organised and a graphical model developed to guide the research. The theoretical framework is basically a set of interrelated constructs, definitions and propositions presenting the systematic relationship between variables in order to define the main problem to be solved by the study (Anfara and Mertz, 2015).

3.2.3 Questionnaires

Field work at bus and taxi ranks, bus station, department of transport licensing office was carried out from June 2015 – September 2015. This was the significant part of the research as it gathered information and reflected on the real stakeholders of the system.

Questionnaire surveys were conducted on 162 respondents that included public transportation users travelling within the Free State province, non- public transportation users, drivers, public transportation owners. Public transportation users and drivers' questionnaires were conducted at taxi ranks in Bloemfontein when users are waiting for the vehicles to depart. These were people travelling to areas in different districts within the province and those travelling locally within Bloemfontein. Taxi

owners' questionnaires were carried out at the Department of Police, Roads and Transport, at the public transportation owners licencing office. The random selection of respondents also helps in the data representing the majority of the population.

Questionnaires were used to gather primary data from the stakeholders within the public transportation system in order to fulfil the following objectives:

1. Finding out the ICT needs in the public transportation system.
2. Identifying and defining key elements needed for successful use of ICTs in the public transportation system.

Respondents were asked to respond to the same set of questions in a pre-determined order to fit the above mentioned the objectives of the research (Gray, 2014). The respondents in this study were randomly selected based on their involvement with the public transportation system. They included regular public transportation users, non-users, drivers, public transportation owners. The questionnaire can be viewed in Appendix B. The questionnaire required demographic background of the respondents firstly before proceeding to relevant information regarding the research, which was designed as follows;

3.2.3.1 Overview of questionnaire design:

The questionnaire was designed in order to cover the following areas;

a) Assessing current state and usage of public transportation.

To understand the current state of public transportation from stakeholders' point of view, questions aimed at assessing how the users, drivers, owners used and felt about the system were designed.

b) Assessing ICT awareness and usage.

Participants were asked whether they knew anything about ICT, computer awareness and literacy levels were also involved in this section because in order to deploy and utilise ICTs in public transportation, or introduce any new technologies, some level of awareness is required from the people it is intended for.

c) Assessing ICT needs of passengers and owners

The questions under this section were to understand the needs of the passengers and owners, this included things they needed in order to enhance public transportation that can be solved by ICT.

d) Assessing current ways of communication.

How stakeholders within the system communicate, communication between the driver-the operator and the passenger during trips or potential passengers planning to use the system or waiting for vehicles before trips.

e) Assessing ICT technologies public transportation owners are willing to integrate into their services and challenges that could be faced.

This section was for public transportation owners, who were asked about technologies they are willing or have plans of incorporating into their services in future and the challenges they could face. This allows for recommendations on what technologies will be suitable for the province's public transportation system.

f) Assessing willingness by stakeholders to use public transportation after ICT integration.

The public, i.e. existing public transportation users and non-users of public transportation's willingness to continue using public transportation after ICT integration is a critical part of this study. People's interest, opinions, perceptions and fears must be addressed before implementation for successful uptake and actual improved efficiency of the public transportation system to be visible. Respondents were asked if they would use public transportation if ICT were to be integrated into the existing public transport system and to measure their likeliness to do this using a 10-point scale.

3.2.4 Interviews

Interviews were also carried out between the months of June and September 2015. An interview guide was used in this technique of data gathering. A sample of 15 people was interviewed based on their involvement in either the ICT or transportation sectors and stakeholders in the public transportation system; They included officials from the provincial department of Transport, public transportation owners and users, transport planning academics, IT academics, civil engineering academics and ICT industry experts

Interviews were carried out for more insight and in-depth understanding of ICT and the public transportation system from experts and stakeholders in both fields. The purpose of this method was to get expert opinions from individuals from disciplinary areas of expertise required by the study.

The subjects were asked open-ended questions in order to solicit their varying opinions on the subject matter and acquire expert opinions, therefore combining

different viewpoints of professionals in the ICT and public transportation industry and the decision makers in the public transportation system in the province. The interview questions can be viewed in Appendix C.

3.2.4.1 Overview of interview questions design

The interview questions were designed as follows;

a) Assessing problems faced by the public transportation system which can be solved by ICT, public transportation areas that need improvement and suitable technologies for these problems.

To assess the above, respondents were asked to give their views on what they see lacking in the public transportation system and problems that can be solved through ICT solutions. Varying areas within the public transportation system were listed as choices for respondents to select as those they thought needed much improvement and the reasons for their responses. Respondents were asked to suggest technologies they saw fit to solve these problems.

b) Assessing challenges likely to be faced in integrating ICTs into public transportation:

This section assessed the problems that might arise from integrating ICT solutions into the public transportation system by all stakeholders.

c) ***Assessing the possible opportunities of using ICTs in public transportation system:***

This section investigated the opportunities that might arise from ICT integration for all the stakeholders i.e. for the public, the owners, and drivers and for both the government and private sectors; what benefits might be brought about by ICT integration.

d) Assessing available ICT infrastructure in the province to support ICT incorporation into public transportation.

For ICTs to be successfully implemented in the public transportation system, there has to be adequate infrastructure to support these technologies, therefore experts in the ICT industry under this session had to attest to the availability or non- availability of such infrastructure.

e) Assessing what can be done to raise ICT awareness by the public.

The section of the interview was aimed at evaluating ways to improve ICT awareness by the public.

f) Assessing how real-time information can be provided to the public by public transportation owners.

Real-time information is an essential ICT tool in public transportation. This section was to source ideas from experts, public transportation users, owners on what can be done or what they wish owners can do to provide real-time information to the public.

g) General comments and considerations

Respondents were asked to give recommendations or comments that could assist in the integration of ICT solutions into the public transportation system and general comments regarding the public transportation system or ICT.

All questionnaires and interview transcripts were properly labelled and kept for accountability purposes.

3.3 Primary Data Analysis

3.3.1 Coding Questionnaire and Interview Responses

Coding is a way of grouping structured responses into more abstract explanations from elaborate statements. This was done for both questionnaire and interview data. Questionnaire and interview responses were coded for easy data handling and preparation for data analysis.

3.3.2 Statistical Analysis

Data from questionnaires and interviews was then analysed using Excel and SPSS. This produced percentages and graphs showing statistical and pictorial representation of the information gathered. Analysis of the primary data included carrying out a regression analysis to correlate between some of the variables measured through questionnaires. The t-test was used to find out the significance of variables to be considered in the generated models.

a. Regression Analysis

Questionnaire data was further analysed by means of regression analysis in order to predict the future of public transportation usage after ICT integration. The variables used were some of the significant ones for prediction purposes. Even though this method was chosen and a model developed from it, its prediction of what might happen in future is not a certainty (Harrell, 2008).

3.4 Discussing Analysis Results

After the primary data analysis, the results were discussed in order to draw conclusions to the overall statistics they presented. Questionnaire data was analysed and quantified in the form of tables and graphs. The data is reported in chapter 4. Data collected from interviews is also used in chapter 4 to support the quantitative findings and as part of recommendations after results are discussed.

3.5 Development and Comparison of Guidelines

Guidelines were developed based on the data gathered by questionnaires, interviews, case studies, literature review and legislation to assist the stakeholders and decision makers in creating an efficient ICT integrated public transportation system. The guidelines address the challenges and opportunities and how they can be mitigated and encouraged respectively. After these guidelines were developed, they were compared to those of places that already have effectively functioning ICT in public transportation. The guidelines are reported in chapter 5 of this study.

3.6 Summary

The purpose of the study was to identify challenges and opportunities of ICT solutions in the public transportation system that might arise as a result of integrating ICT into the public transportation system. This methodology brought together the different stakeholders', their needs, opinions and expectations from the system, government legislation and learning opportunity examples from around the world. The methodology allowed the research to cover all the important aspects of investigating stakeholders' needs before future implementation in order to anticipate challenges and embrace the possible opportunities that may come as a result of ICT and public transportation integration.

CHAPTER 4: DATA ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter methodically presents and discusses the qualitative data gathered using questionnaires and interviews. Data samples are also described in this chapter. The general overview of data presented and discussed shows the needs of the system as indicated by the majority of the respondents. There is a lack of basic ICT technologies in most vehicles and bus stations and stops. Some vehicles, have ICT technologies but there are mostly used for entertainment, except for ticketing system and vehicle destination displays in some of the Interstate buses. There are no technologies for information dissemination to the public or between the stakeholders.

There is desperate need to incorporate updated ICT solutions into public transportation vehicles for their daily operations to improve the efficiency of the system. Financial stability, ICT awareness and education are very critical to the integration of ICT solutions into the public transportation system. People should have ICT knowledge and be able to afford them. These needs and challenges addressed, it is likely to have a successful integration process.

4.2 Questionnaire Data Results

4.2.1 Background And Demographic Information

Tables 4.1 shows that out of the 159 respondents to the question, 71.1% of respondents were below the age of 41, 27 % of the respondents are above the age of 40 but below 60. Only 1.9% of the respondents were over 60years old. Out of a total of 162 respondents, 3 did not respond to this question. It also indicates that out of the 162 respondents, 71 were female while 87 were male. There is a 10.2% difference between male and female respondents, with the majority (55%) of the respondents being male as indicated in table 4.2, 4 of the respondents did not respond to this question.Occupations of respondents are indicated in table 4.3; 38.8% respondents are full-time workers; 25% are students; 19.08 are unemployed; 9.21% are part-time workers while 7.25% of the respondents chose other occupations and 10 did not respond.

The age of respondents, with the majority being 18 – 24, who were the majority of respondents could have an impact on ICT awareness and usage as well as likeliness of respondents using ICTs if there are incorporated into the public transportation

system. Gender does not have a significant impact on the use and adoption of ICTs. The occupation has an impact on the use of public transportation as many students and full-time employees commute regularly to go to their respective workplaces and schools.

Table 4.1 Age of Respondents

AGE		Frequency	Valid Percent
Valid	18-24	48	30.2
	25-30	34	21.4
	31-40	31	19.5
	41-50	31	19.5
	51-60	12	7.5
	> 60	3	1.9
	Total	159	100.0
Missing	7	3	
Total		162	

Table 4.2 Gender statistics of respondents

GENDER		Frequency	Valid Percent
Valid	Female	71	44.9
	Male	87	55.1
	Total	158	100.0
Missing	3	4	
Total		162	

Table 4.3 Occupation

OCCUPATION		Frequency	Valid Percent
Valid	Full-time worker	59	38.8
	Part-time worker	14	9.2
	Unemployed	29	19.1
	Student	39	25.7
	Other	11	7.2
	Total	152	100.0
Missing	6	10	
Total		162	

4.2.2 Current State And Usage Of Public Transportation

This section aims at investigating the current public transportation system usage; numbers of people using public transportation and those who do not and the reasons for using or not using public transportation; as well as whether the public transportation users are satisfied with the services being offered.

The results indicated that 70.2% of the 161 respondents use public transportation while 29.8% do not use public transportation. Figure 4.1 indicates the reasons why respondents use public transportation. The most significant influence on the use of public transportation is its affordability which 59% of the respondents chose. 45% of the respondents use public transportation because of lack of private vehicles while 41% use public transportation because of its reliability. Other reasons for using public transportation includes the inability to drive, avoiding driving in traffic and environmental concerns which was 21%, 28% and 19% respectively.

Figure 4.2 illustrates reasons why some of the respondents do not use public transportation. 30 % of respondents indicated lack of information as one of the reasons for not using public transportation; 28% of respondents indicated that they do not use public transportation because of safety reasons and another 28% indicated taxi driver behaviour as their reason. 25% of respondents indicated the poor state of public transportation vehicles as the reason they do not use public transportation. 21 % indicated that public transport is not convenient, 15% indicated that public transportation is not easily accessible. Further, 13% cited poor quality of service in public transport, while another 13% indicated that they used private vehicles. 6 % of the respondents do not use public transportation as it is not reliable. Of all the respondents, 6% did not respond to the question.

Factors that influence the use of public transportation or lack thereof were investigated. From the respondents who use public transportation, most of them use taxis compared to buses. People use public transportation mostly because of its affordability and lack of private vehicles while main reasons for not using public transportation are lack of information on public transportation, safety reasons and behaviour of taxi drivers. These contradicting reasons for and against the use of public transportation indicate that if public transportation prices were to be increased or people currently using public transportation could afford their own vehicles they would

no longer use public transportation, and on the other hand if public transportation was safer and information made available to the public more people would use public transportation.

The number of people using public transportation for its reliability compared to those not using it because it is unreliable indicates that public transportation in the Free State province is reliable, according to its users. However, the information may be biased as it was obtained from various stakeholders (owners and vehicle owners are likely to indicate that it is reliable to protect their investment, while people who do not use public transportation may say it is unreliable based on their own experiences). With the use of both taxis and buses reviewed and for the above-mentioned reasons, whether the service is satisfactory to users is also evaluated and the results indicate that more people are satisfied with the taxi services as compared to the bus services.

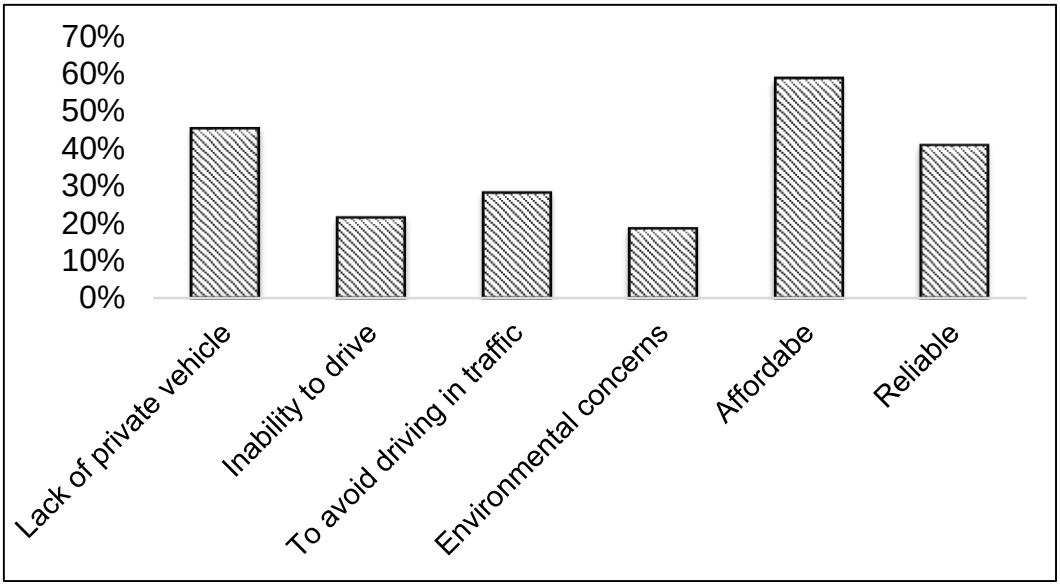

Figure 4.1:Reasons for using public transportation

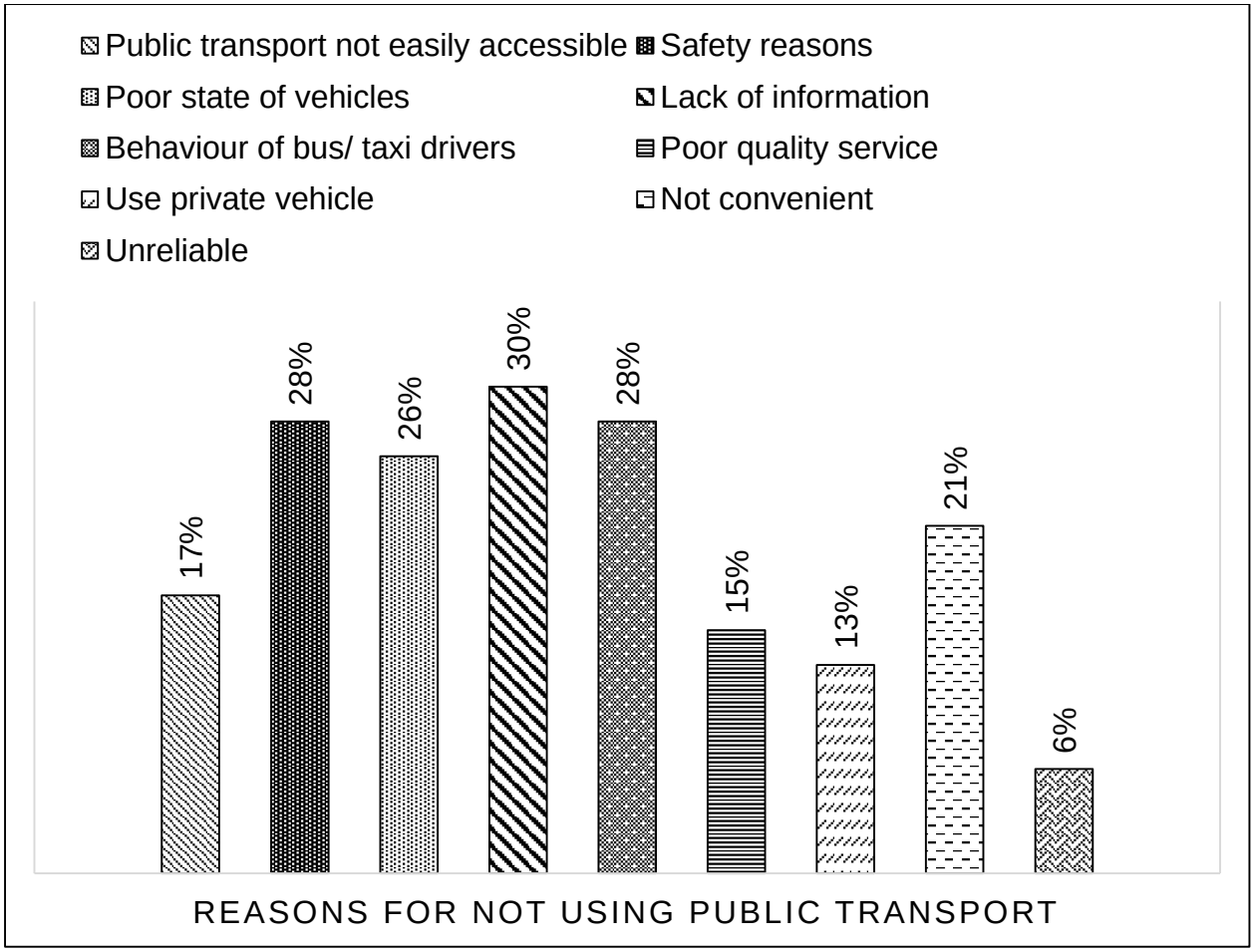

Figure 4.2: Reasons for not using public transportation

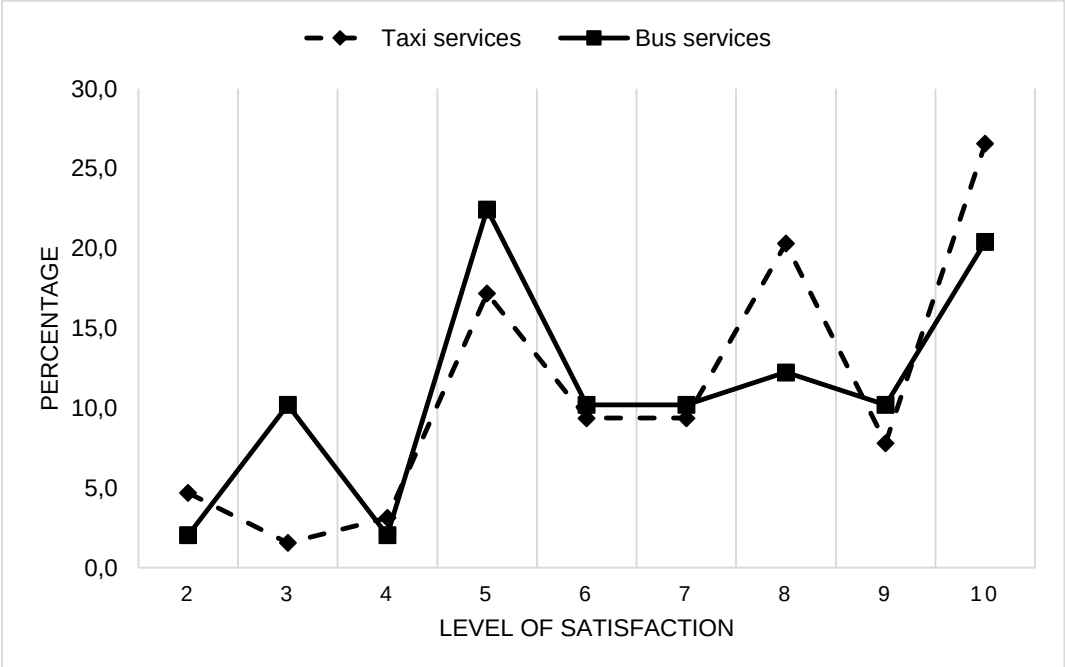

Figure 4.3: Satisfaction with public transportation services

Figure 4.3 shows the distribution of respondents' satisfaction with both the taxi and bus services in the province, on a ten – point scale; zero being not satisfied at all and 10 being extremely satisfied, 26.6% of the respondents chose 5 and below, 73.4% chose between 6 and 10. The mean level of satisfaction with the taxi services is 7.33. With regards to the level of satisfaction with the bus service, 36.7% respondents rated their satisfaction below 5; 63.3% rated between 6 and 10. 113 respondents did not answer the question. The mean satisfaction with the bus service is 6.88.

An Independent t-test was further used to analyse and test the difference between the means for satisfaction with both the taxis and buses. A null hypothesis that the respondents using buses and taxis are the same and are equally satisfied with the services offered was used.

Equation 1: Null hypothesis

$$H_{0:}\,\mu_{1=}\,\mu_{2}$$

Null hypothesis: Mean 1 = Mean 2 ; Where 1 = taxis and 2 = buses.

Table 4. 4: Group Statistics

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	Taxis	64	7.33	2.317	.290
	Buses	49	6.88	2.472	.353

Table 4.5: Independent Sample Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Score	Equal variances assumed	.581	.447	.995	111	.322	.451	.453	-.447	1.348
	Equal variances not assumed			.987	99.861	.326	.451	.457	-.455	1.357

The results show that $H_{0:}\, \mu_{1\neq}\, \mu_2$ because the probability value is greater than 0.05, which means that the null hypothesis is rejected. This means that people are not equally satisfied with bus and taxi services.

4.2.3 Accessibility of Public Transportation

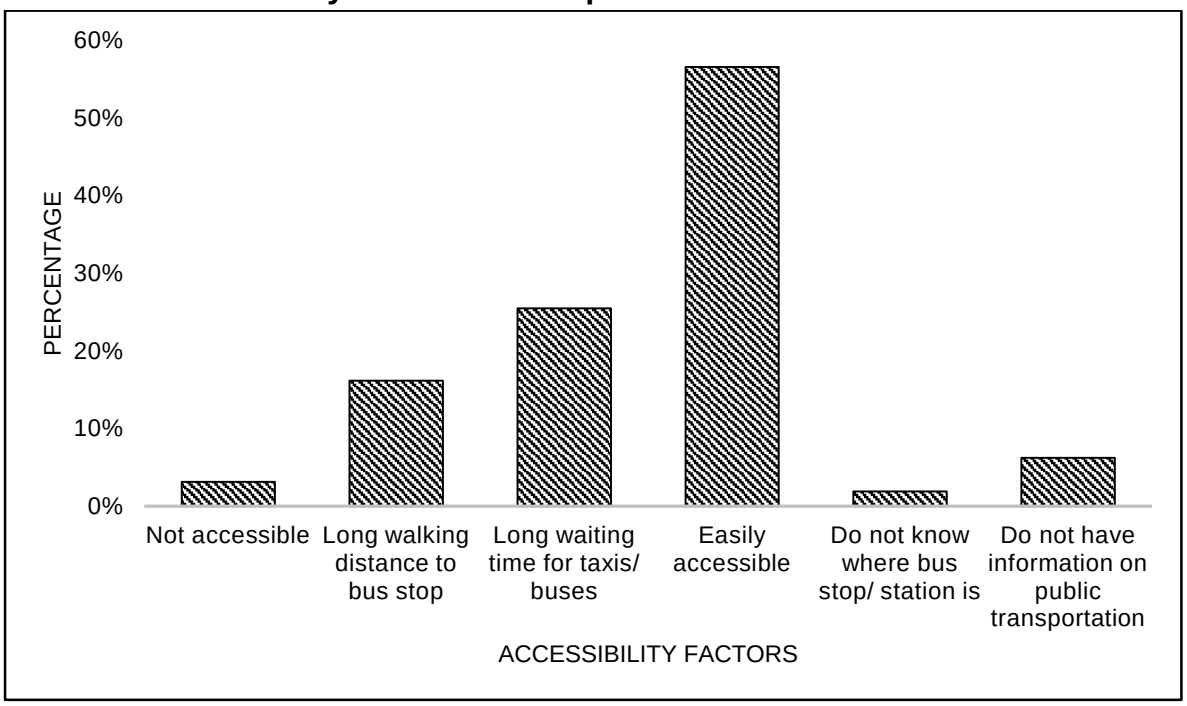

Figure 4. 4: Accessibility of public transportation

Figure 4.4 shows accessibility factors of which the respondents relate with; 57% of the respondents easily access public transportation; 25% wait for a long time at taxi and bus stops and ranks; 16% walk long distances to the bus stops and stations; 6% do not have information on public transportation, 3% responded that public transportation is not accessible and 2% does not know where bus stops or stations are located.

Accessibility contributes to the overall satisfaction with public transportation services. The high statistics of people who can easily access public transportation, may be a result of bias by the respondents; public transportation owners and drivers biased in the interest of their businesses and jobs. Factors reflecting negatively on the accessibility indicate that there are accessibility problems in the Province. Long waiting times, having to walk long distances to bus stops and stations and lack of information can be solved using ICTs.

4.2.4 ICT Awareness And Usage

This section aimed at finding out whether people in the Free State are aware or have a sense of understanding regarding ICT and whether they use ICT. 53% of respondents know how to use a computer while 47% do not know how to use a computer.From the respondents who do not know how to use a computer majority (82%), are willing to learn, 18% of them are not interested in learning how to use a computer. The results also indicate that 71 % of respondents have internet access while 29 % do not have any access to the internet. Out of 162 respondents, 12 did not respond to the question.

ICT awareness will be a major influence on the uptake and integration of ICT solutions in the public transportation system. Awareness in this case was measured by factors such as computer literacy, internet access and ICT devices and applications respondents use regularly. Nearly half of the respondents do not know how to use computers; this will become a problem if ICTs are introduced without educating people on how to use computers, but, the majority of those who are computer illiterate are willing to learn how to use them. With many people being open to learning, it gives more confidence regarding towards the number of people who will be able to use these technologies once put in place.

Table 4.6: Internet access

Internet Access		Number	Percentage
Frequency of internet access	Daily	75	71.4
	Weekly	16	15.2
	Monthly	14	13.3
	Total	105	100.0
Missing	4	57	
Total		162	
Places of internet access	Home	51	60.7
	Work	9	10.7
	School	13	15.5
	Internet Cafe	10	11.9
	Mobile	1	1.2
	Total	84	100.0
Missing	6	78	
Total		162	
Reasons for lack of internet access	Do not need it	1	2.8
	Expensive	11	30.6
	Not interested	6	16.7
	Willing to use if available	18	50.0
	Total	36	100.0
Missing	5	126	
Total		162	

Table 4.6 indicates the frequencies at which respondents get access to the internet. 57 respondents did not respond to this question. Out of the 105 who responded, 71.4% indicated that they have daily access to the internet, 15.5 % have weekly internet access while 13.3 % accesses the internet once a month. It also indicates that 70.7 % of the respondents access the internet from their homes. 10.7% access the internet from work while 15.5% and 11.9% get internet access from school and internet cafes respectively. Only 1.2 % of respondents said they have access to mobile internet while 78 of the 162 respondents did not answer. Reasons for the respondents' lack of internet access are also shown in table 4.6. 50% of respondents are willing to use the

internet if made available to them; 30.6% respondents do not have internet access because it is expensive; 16.7% are not interested in having access to the internet while 2.8% do not have access to the internet as they do not need it.

The majority of people have access to the internet, which is a threshold for information dissemination; therefore if the information is availed, more people will have instant access to it also considering that more of those with no access to it currently are willing to use the internet if made available. The main reason for the lack of internet by people in the area is the high prices of internet and mobile data. This could be a hindering factor to use of ICTs if there are made available but with limited accessibility to those who cannot afford internet access.

The results also showed that most people access it from home, followed by at school, workplaces or internet cafes; which are not very convenient especially for real-time information when passengers are travelling. The less number of people accessing the internet on their mobile phones may be because of prices of mobile data.

4.2.5 Devices And Applications Preferred By Users

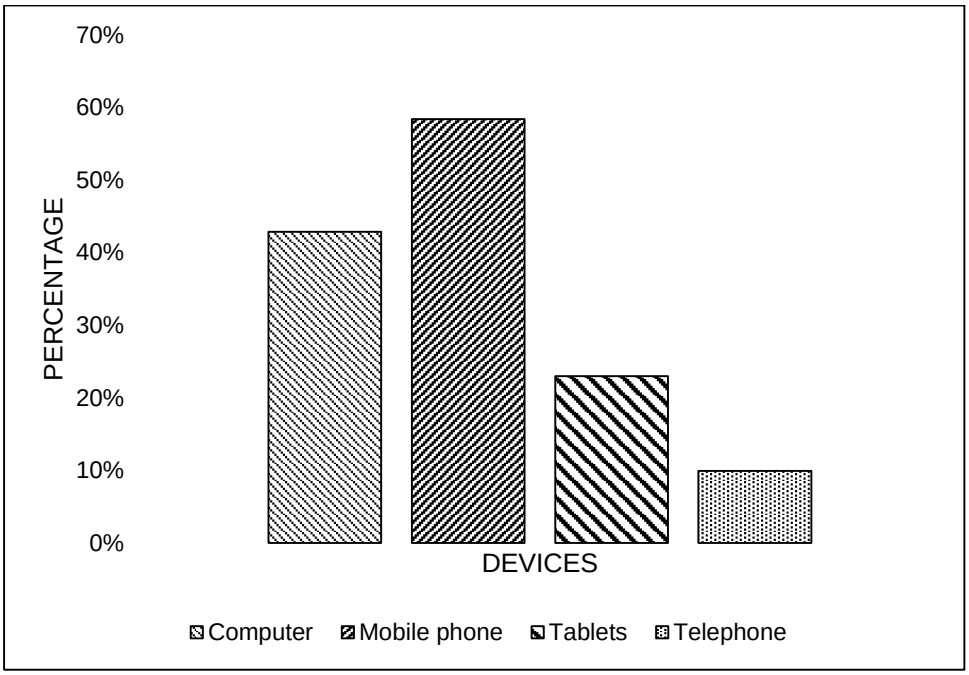

Figure 4.5: ICT devices preferred by respondents

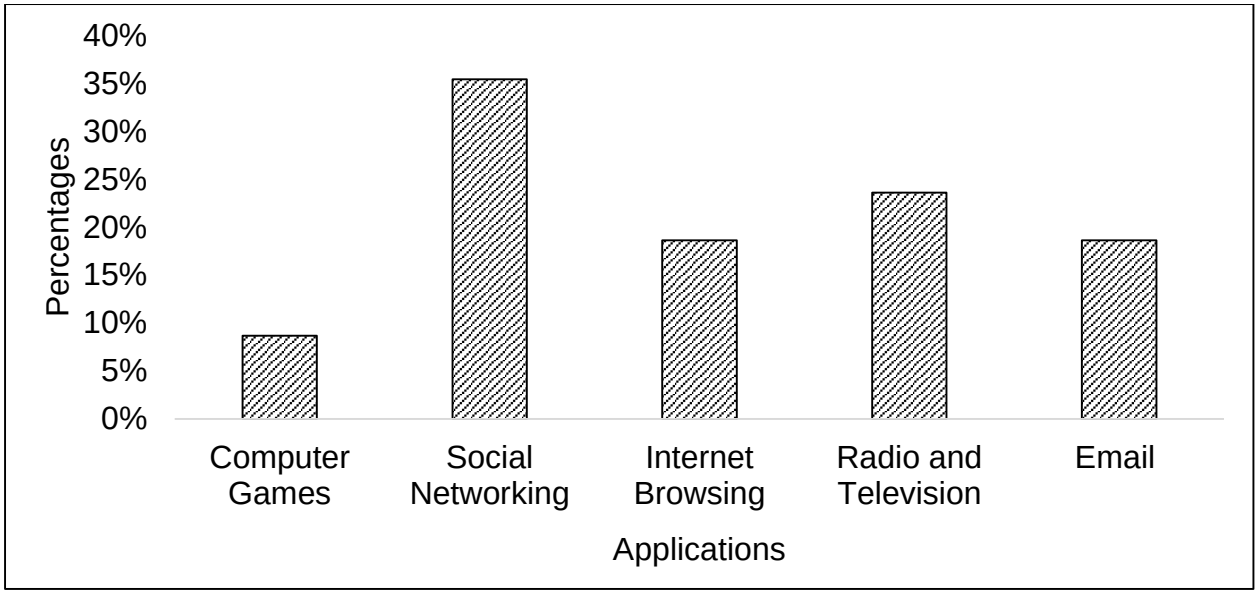

Figure 4.6: ICT applications preferred by respondents

Figure 4.5 indicates the types of ICT devices respondents prefer using; 42.9% respondents prefer using a computer; 58.4% prefer mobile phones; 23% respondents prefer tablets, 9.9% prefer using a telephone. 9.9 % of the respondents did not answer this question. Figure 4.6 indicates ICT applications respondents prefer using. The majority of the respondents, 35% prefer using social networking applications; 24% prefer radio and television; 19% prefer internet browsing and another 19% prefer email communication. Only 9% of the respondents prefer computer gaming. 40.4% of the respondents did not answer the question.

Results on devices and applications respondents prefer using indicate the best platforms that could be used if ICTs are going to be integrated into the public transportation system. Mobile phones, followed by computers and tablets are the devices respondents would rather use. Even though most people prefer using mobile phones, their internet access through mobile phones is limited. Comparatively, most people prefer using social networking applications, radio and television, internet browsing and email communication. Based on the results, whichever applications and devices are to be considered for use for public transportation in future should be compatible with the above. i.e. Applications should be accessible by either mobile phones, computer or tablets, and devices should support social networking, internet browsing, radio and TV and email communication.

4.2.6 ICT Needs In The Public Transportation System

This section discussed public transportation system needs for ICTs to be fully integrated it also included ways to address the needs and the respondents' outlook on the relevance of ICT solutions.

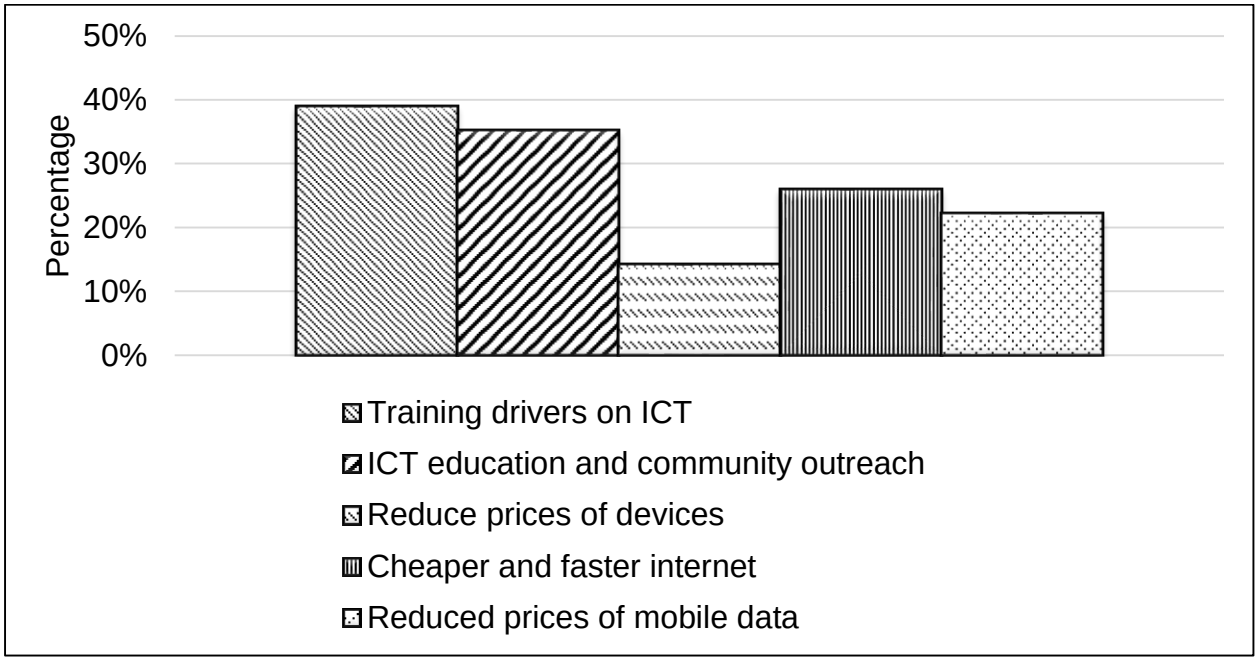

Figure 4.7: Ways of improving ICT awareness

Figure 4.7 shows ways in which ICT awareness can be improved. 39% respondents chose training drivers on ICT; 35% chose ICT education and community outreach; 14% wanted a reduction of prices of devices: 26% and 22% wanted cheaper and faster internet, and reduced prices of mobile data respectively. 4.32% did not answer.

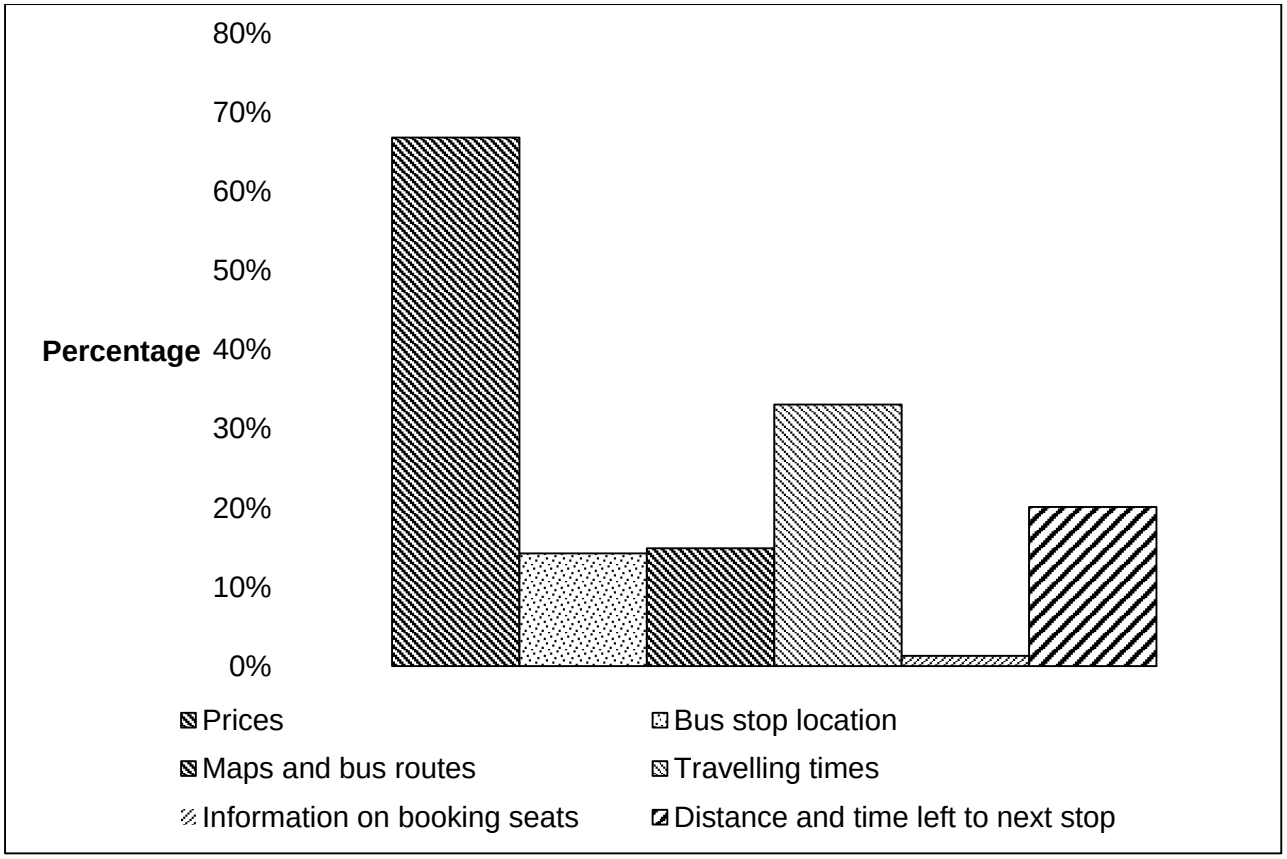

Figure 4.8: Type of information needed by public transportation users

Figure 4.8 indicates the type of information public transportation users usually need before and during their trip by public transport. 66.9% respondents need information on public transportation prices; 14.3% need bus stop location information; 14.9% need information on maps and bus routes. On the other hand, 33.1% of respondents need bus and taxi travelling times information; only 1.3% needs information on booking seats; 20.1% of respondents need to know the distance and time left to the next stop. 6.5% of respondents did not answer.

Most of the needs are ICT awareness and education related; training drivers on ICT and doing community outreach on ICT. Introducing ICTs to people who are unaware and do not have skills to use the technologies would not bring much improvement to the system as people would not use them. There is a need for affordable ICT devices, the internet and mobile data. The high cost of devices and connectivity impact ownership and accessibility of ICT facilities. Provision of cheaper devices and free internet especially at bus stations or in vehicles would is needed for efficient operation of the system. Faster internet would be efficient for the provision of real-time

information. Slow internet means receiving information late, either a device taking a long time to connect to the internet or connecting only at certain places.

Public transportation users and potential clients need information before and during their trips. Prices on bus and taxi fares are the information most needed, followed by travelling times and distance and time to reach their destinations. This information is essential in trip planning and if made available promptly would improve the public transportation system. Other information needed include maps and bus routes, bus stop location which may be crucial for novices to be able to access when needed. Potential clients end up not using public transportation due to lack of information, and all the above information can be provided in real time to passengers through ICTs.

Very few people need information on booking seats. This may be because of the way the public transportation system currently works; both long and short distance vehicles within the province do not have a booking system.

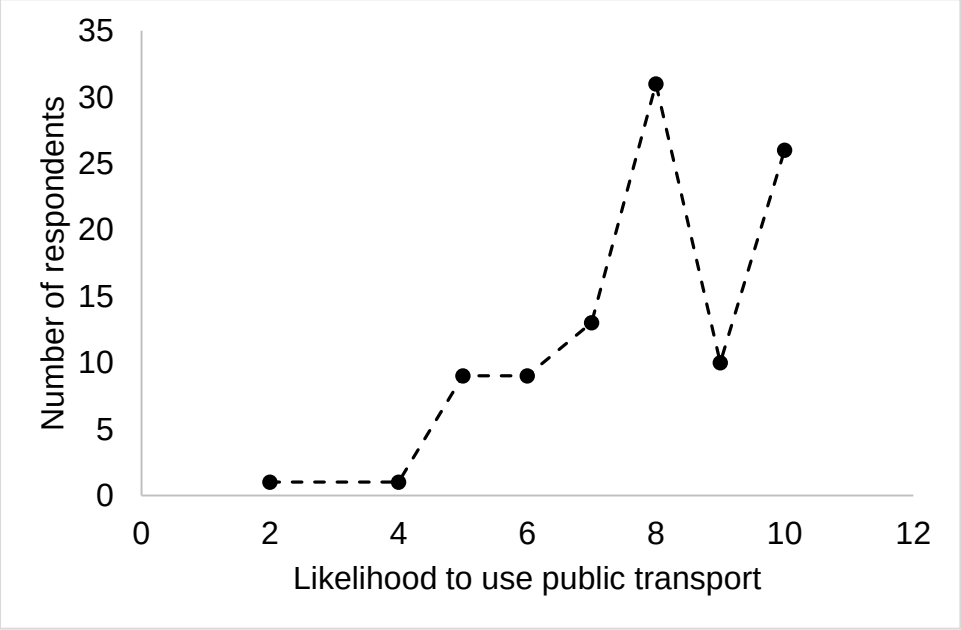

Figure 4.9: Likelihood of respondents using public transportation after ICT integration

Figure 4.9 represents the likelihood of respondents using public transportation after ICT solutions have been incorporated into the system. On a 10 point scale basis, the mean likelihood is 7.94. This was to predict the need for ICT in the public transportation system, the likelihood of respondents using the transportation system after ICT integration, and the results show that there are high chances of people using public transportation after ICTs are introduced.

The likelihood to use public transportation after integration was further analysed to develop a model to forecast how people might use the ICT integrated public transportation system. Likelihood to use public transportation was used a dependent variable together with relevant variables from the questionnaire data as independent variables. Average responses for every 5 respondents were used, which resulted in 23 observations from the 113 public transportation users and non-users. Independent variables used were: Age, Occupation, Public transportation usage, satisfaction with taxis, computer literacy and internet access.

The aim of the regression analysis was to verify the relationship between different variables, using a multiple regression formula:

Equation 2: Regression model

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 \dots\dots\dots + \beta_p x_p$$

Table 4. 7: Model Summary Output

SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0,742
R Square	0,551
Adjusted R Square	0,382
Standard Error	0,678
Observations	23

R^2 = 0.551, which means that the model summary indicates that 55.1% of the relationship between likeliness to use public transportation after ICT integration, can be explained by the independent variables; Age, Occupation, Public transportation usage, satisfaction with taxis, computer literacy and internet access. These results indicate that the model accounts for 55.1% of likelihood of using public transportation after ICT integration. (Adjusted R^2 value is 0.382 = 38.2%)

Table 4. 8: ANOVA

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	9,0020	1,5003	3,2685	0,0271
Residual	16	7,3445	0,4590		
Total	22	16,3465			

The above table shows the significance of the model; it has a significance value of less than 0.05 i.e. $p < 0.05$. This means that the R^2 is significantly greater than 0.

The independent variables account for a significant amount of variance in likeliness to use public transportation (dependent variable).
The overall regression model is significant: F (6, 16) = 3.268, R^2 = 0.551.

Coefficients:

The following coefficients for the model were found using the LINEST function on excel:

Table 4.9: Coefficients

Variables	Age (X_1)	Occupation (X_2)	P/T usage (X_3)	Satisfaction with taxis (X_4)	Computer literacy (X_5)	Internet access (X_6)	α
β	**-0,185**	-0,314	0,350	0.575	-0.214	-0.145	5,201

Therefore, the final model presented by these results;

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 \dots\dots\dots + \beta_p x_p$$

Likelihood to use Public Transport after ICT integration = $5.201 - (0.185\text{Age}) - (0.3140\text{ccupation}) + (0.350\text{Public Transportation Usage}) + (0575\text{Satisfaction with Taxis}) - (0.214\text{Computer Literacy}) - (0.145\text{Internet Access})$

Simulation And Discussion

Table 4.10: Simulation

Scenarios	Age	Occupation	P/Tusage	Satisfaction with taxis	Computer literacy	Internet access	Likelihood to use P/T
1	3	2	1	7	1	1	8,032
2	1	1	0	0	1	1	4,343
3	4	3	1	6	0	0	7.316
4	2	4	0	4	1	1	5,514

Table 4.10 shows different scenarios simulated to the regression model developed.

1. Scenario 1: A person aged between (31-40) who is a part-time worker, uses public transportation, is 70% satisfied with the current taxi service, computer literate and has access to the internet has an 80.32% chance of using public the integrated public transportation system.
2. Scenario 2: An 18- 24years old full-time worker who does not currently use public transportation, is not satisfied with the current taxi services, is computer

literate and has access to the internet has a 43.43% probability of using the integrated public transportation system.

3. Scenario 3: A 41-50 years old, unemployed person who uses public transportation, 60% satisfied with taxi services, not computer literate and does not have internet access has a 73.16% chance of using public transportation once ICTs are introduced.
4. Scenario 4: A 25 -30year old student, currently not using public transportation and is 40% satisfied with the taxi services, is computer literate and has internet access is 55.14% likely to use public transportation after ICT integration.

The results indicate an R^2 value closer to 1, which means that the model has high chances of accuracy, even though it does not mean the model is perfectly accurate. The model and its simulations can be explained by:

1. The simulation indicated that people with higher satisfaction levels with the current taxi services, computer literate and have access to the internet are more likely to use the ICT integrated public transportation system. People who do not currently use public transportation and are not satisfied with taxi services are less likely to use the public transportation once ICTs have been integrated into the system. For successful integration and uptake, it would have been ideal if the currently less satisfied would be willing to use public transportation after integration and would support attracting people previously using their private vehicles to now use public transportation.

Based on the variables used and their relationship, which the dependent variable relies upon human behaviour and some of the independent variables are based on individual's feelings towards the existing transportation system, the possible explanation to this are the different perceptions people might have towards adopting ICTs, which will impact how they adapt to the new ICT integrated public transportation system.

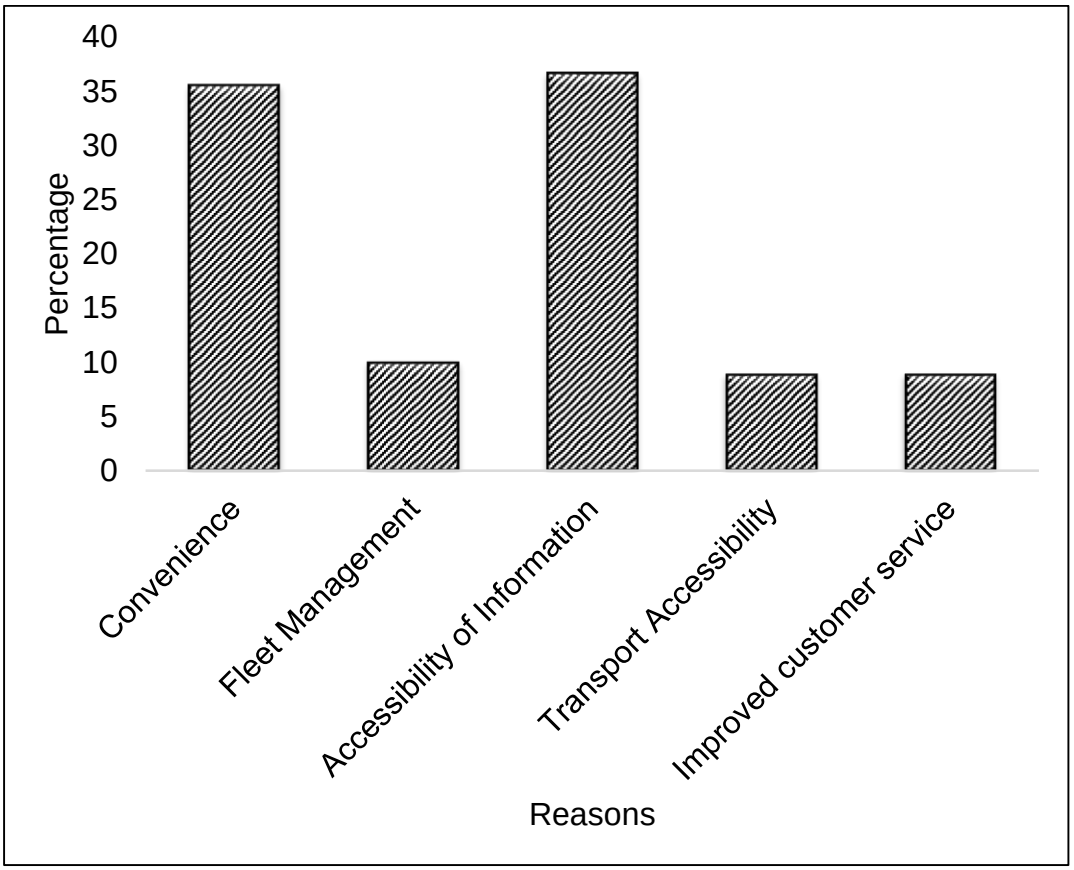

Figure 4.10: Reasons why ICTs are relevant in the public transportation system

Respondents' opinions on the relevance of ICT to the public transportation system showed that 95.4% people think that ICT solutions are relevant in public transportation; 4.6% do not think ICTs are not relevant in the public transportation system. Fifty-four people did not respond. Figure 4.10 shows the percentages of respondents and the reasons why they thought ICTs are relevant in the public transportation system; 37% of respondents gave accessibility of information; 36% indicated convenience related reasons; 10% indicated fleet management reasons. 9% indicated transportation accessibility while another 9% indicated improved customer service related reasons.

The relevance of ICT in the public transportation system is not questionable looking at how it has transformed other cities and countries public transportation systems. The respondents also agree to this as the majority of them indicated that ICT is relevant in the public transportation system. Accessibility of information and convenience were indicated as the main reasons for ICT relevance. People need information and having information on public transportation makes it more accessible. For owners, ICT would

help with managing their vehicles, through monitoring and tracking technologies and improve the service they offer their customers.

4.2.7 Current Communication State Within The Public Transportation System

The section aimed at finding the current communication methods among the public transportation stakeholders.

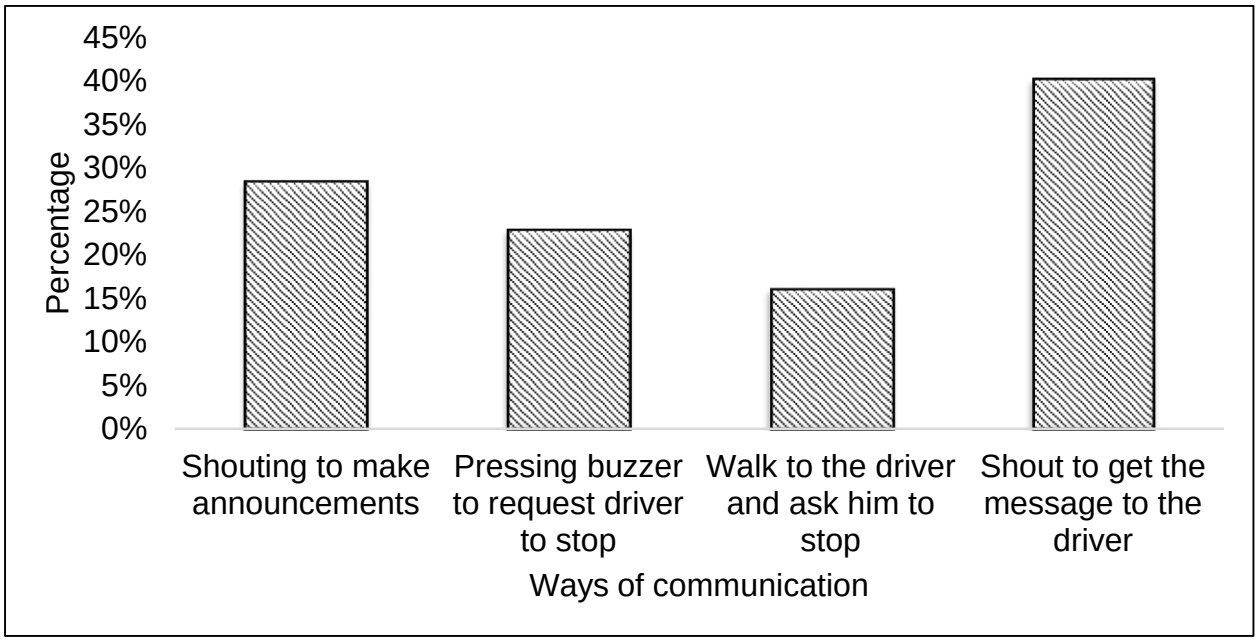

Figure 4.1: Current ways of communication between passengers and drivers

Figure 4.11 shows current ways of communication between passengers and drivers in public transportation vehicles. 40% of passengers shout or speak up to get the message to the driver ; 28% of drivers shout to make announcements; 23% press the buzzer to request the drivers to stop; 16% of the respondents walk to the driver and ask them to stop. 9.3% of the respondents did not answer the question.

4.2.8 Devices Currently Available In Public Transportation Vehicles

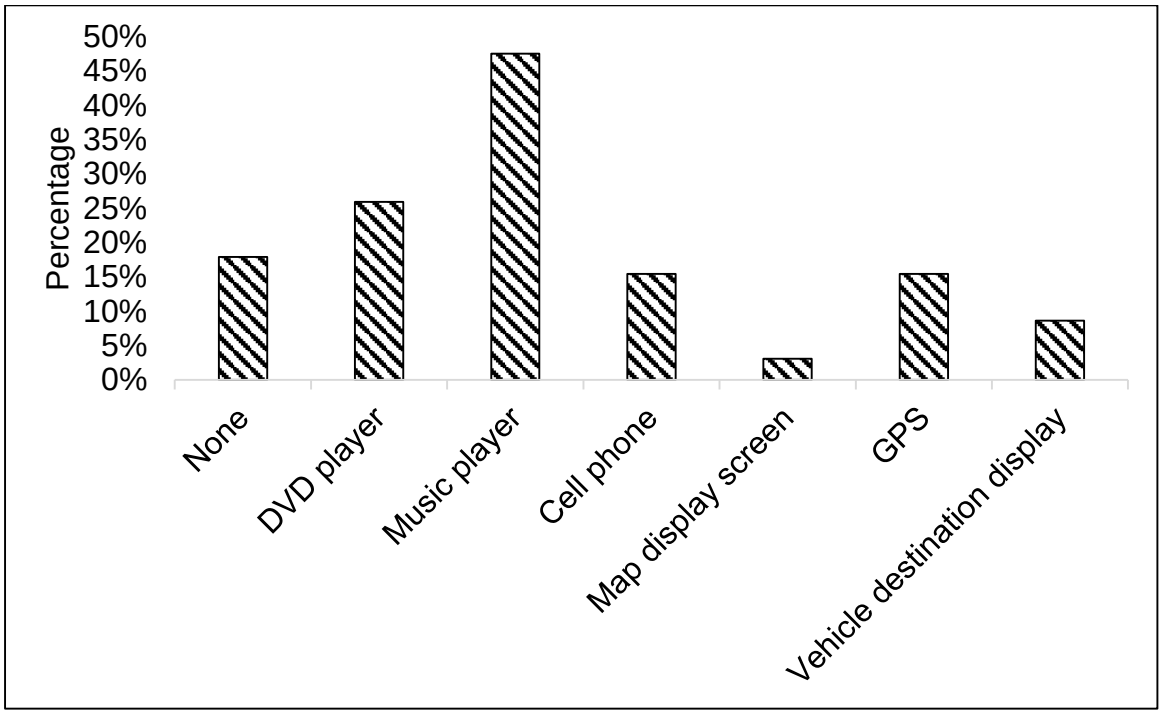

Figure 4.22: Devices currently available in public transportation vehicles

Figure 4.12 shows the different devices already available in public transportation vehicles. 17.9% of respondents indicated that there are no available devices in public transportation vehicles; 25.9% indicated that DVD players are available; 47.5% indicated that music players; 15.4% indicated mobile phones are available in vehicles; 15.4% respondents indicated availability of GPS in public transportation vehicles while 8.6% indicated that vehicle destination displays are available in public transportation vehicles; 11% of respondents did not answer this question.

Communication; between owners, drivers and passengers before, during and at the end of a trip is a vital aspect of the public transportation system. Information has to be conveyed between the stakeholders for smooth operation. For a vehicle to stop, the passenger has to indicate their desire to debus, a driver also have to make announcements to passengers during the trip. Currently, communication is done by shouting depending on how far from the driver a passenger is, or walking up to the driver in long buses without buzzers. Some buses have buzzers passengers can press to alert the driver to stop while taxis do not have any form of technology to do that.

Devices currently available in taxis are mostly entertainment devices, music and DVD players. They may help to keep passengers entertained during trips but in most cases they serve the driver, especially in taxis. GPS systems are available in some vehicles

to help the driver with location and directions. Buses have destination displays which show passengers where the bus is going before they board it. Although some respondents indicated the availability of map display screens in public transportation vehicles, there are not available. Most drivers have personal cellphones when driving; this is where the owners communicate with them during trips.

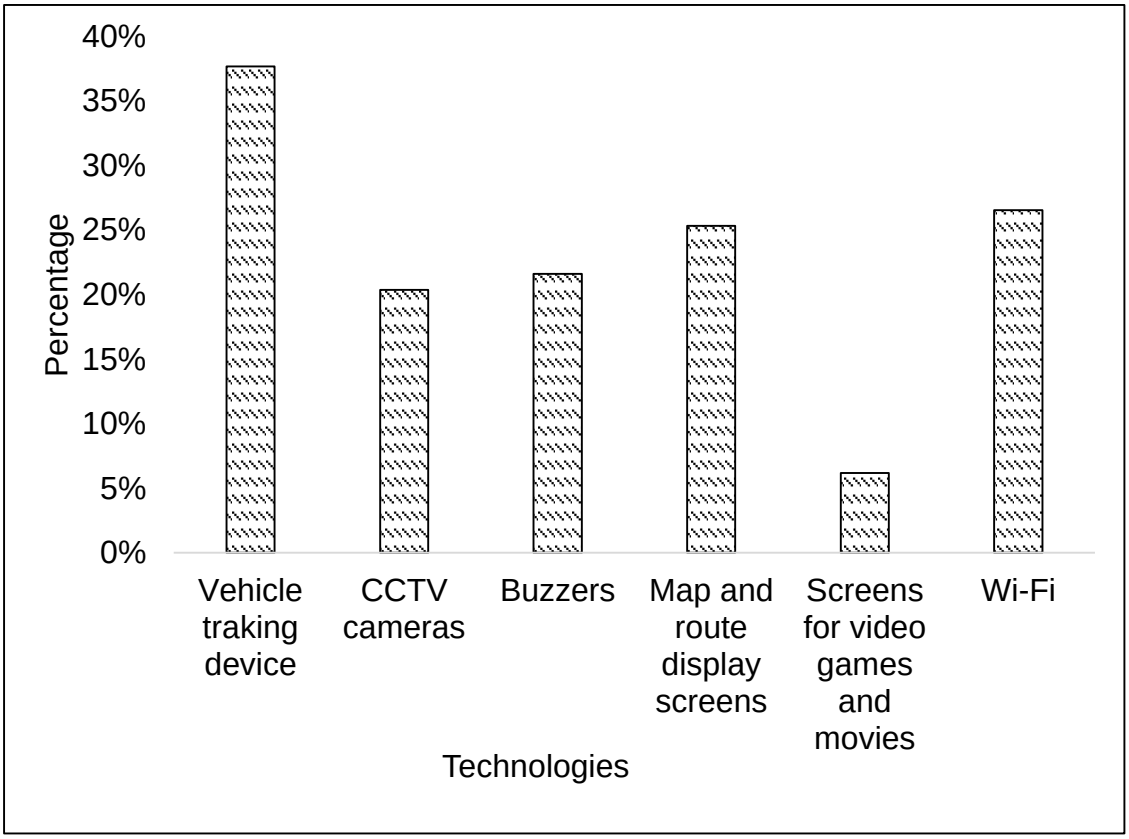

Figure 4.3: In-vehicle technologies respondents are willing to use

Figure 4.13 shows in-vehicle technologies respondents are willing to use; 38% respondents are willing to use vehicle tracking devices; 20% are willing to use CCTV cameras; 22% are willing to use buzzers. Furthermore, 25% of respondents are willing to use map and route display screens; 6% are willing to use video game and movie screens while 27% are willing to use Wi-Fi. 13.6% of respondents did not answer the question.

With limited ICTs currently available, respondents are willing to use new technologies if there are introduced. The majority of people, especially owners are willing to use vehicle tracking devices and CCTV cameras to monitor their vehicles. This would improve fleet management and safety. Map and route display screen which would

show passengers their location, route and distance left in real time, Wi-Fi and buzzers will also be welcome to public transportation users. Provision of Wi-Fi can solve connectivity problems. Even though there are people willing to use screens to play video games and watch movies during trips, the number is not convincing enough.

4.2.9 The Future of the Public Transportation System and ICT

This section looks into the future of the public transportation system in relation to ICT. The possibilities of public transportation owners integrating ICT solutions into the services they are currently offering. All the bus and taxi owners indicated that there are possibilities of them integrating ICT solutions into their services in future.

4.2.9.1 ICTs public transportation owners are willing to integrate into their services in future.

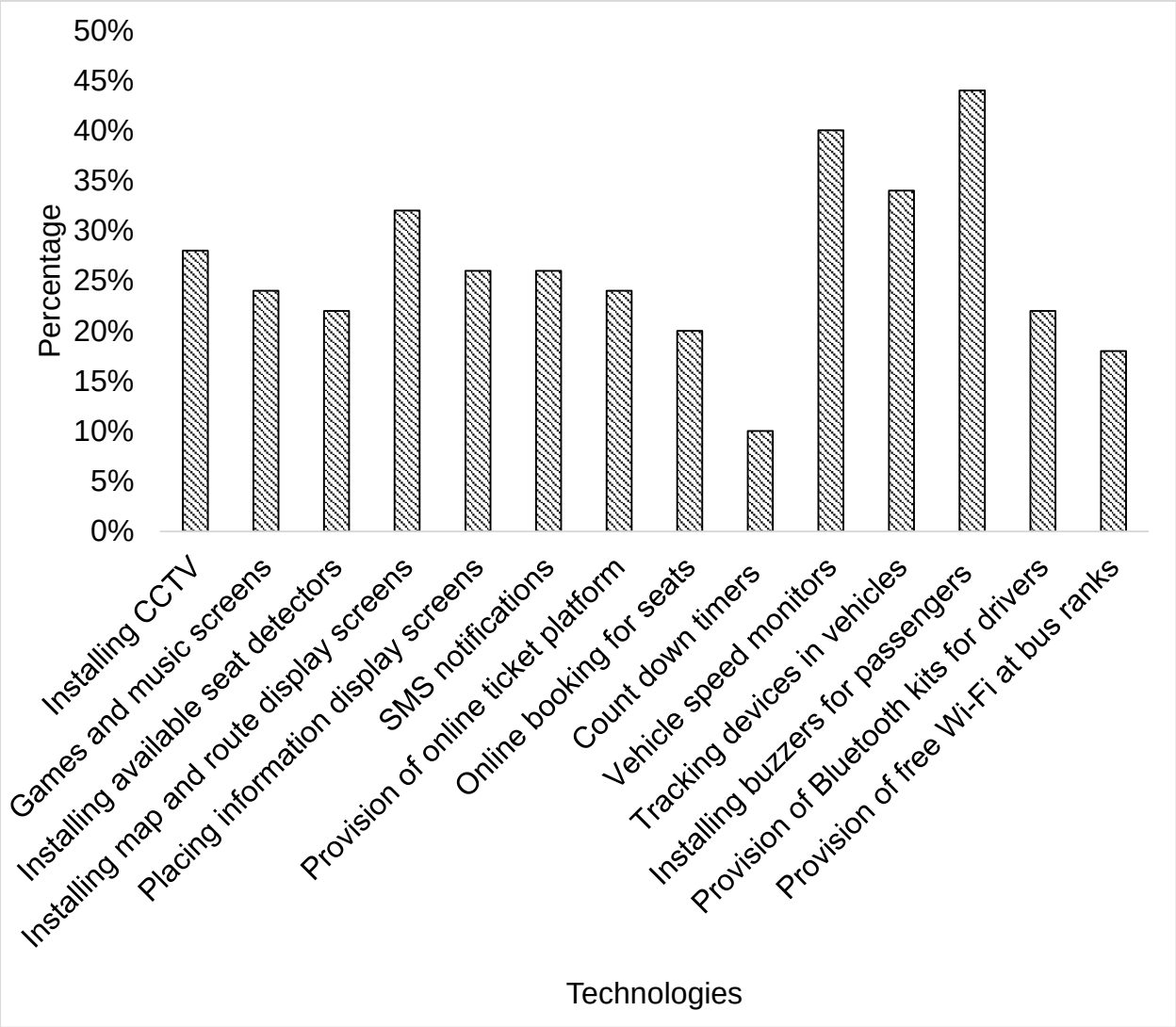

Figure 4.14: ICTs owners are likely to incorporate into their services in future

Figure 4.14 shows ICTs public transportation owners are likely to incorporate into their services in future. 28% respondents are likely to install CCTV; 24% are likely to install

screens for video games and music for passengers: 22% are likely to install seat detectors. 32% are likely to install map and route display screens; 26% respondents are likely to install information display screens at bus stops; another 26% of respondents are likely to introduce SMS notifications to passengers in situations where vehicles are delayed. 24% are likely to provide an online ticket purchasing platform; 20% respondents are likely to provide online booking of seats. Only 10% of respondents are likely to install count-down timers for departure and arrival times of vehicles at bus stops or stations; 40% are likely to install vehicle speed monitors; 34% are likely to install tracking devices in their vehicles while 44% are likely to install buzzers for passengers to alert drivers to stop for them. 22% of the respondents are likely to provide Bluetooth kits for drivers for communication on the road while 18% are likely to provide Wi-Fi at bus ranks. 16% of respondents did not answer the question.

Through investigating what is likely to happen to the public transportation system in future, in relation to ICT solutions, public transportation owners fully agree that there are possibilities of them integrating ICT solutions into their services. The data shows that technologies they are mostly likely to incorporate are mostly for fleet management reasons; speed monitors, vehicle tracking devices and CCTV surveillance. Even though these would improve the system, they should also look at technologies to improve customer service. Some have indicated possibilities of future installation of buzzers, map and route display screens, information display screens and SMS notification to passengers. Countdown timers at stations and provision of Wi-Fi are also possible but because the system is operated by private companies and individuals, implementation of such would need to be spearheaded by the government.

4.2.9.2 *Challenges likely to be faced in integrating ICT solutions to the public transportation system*

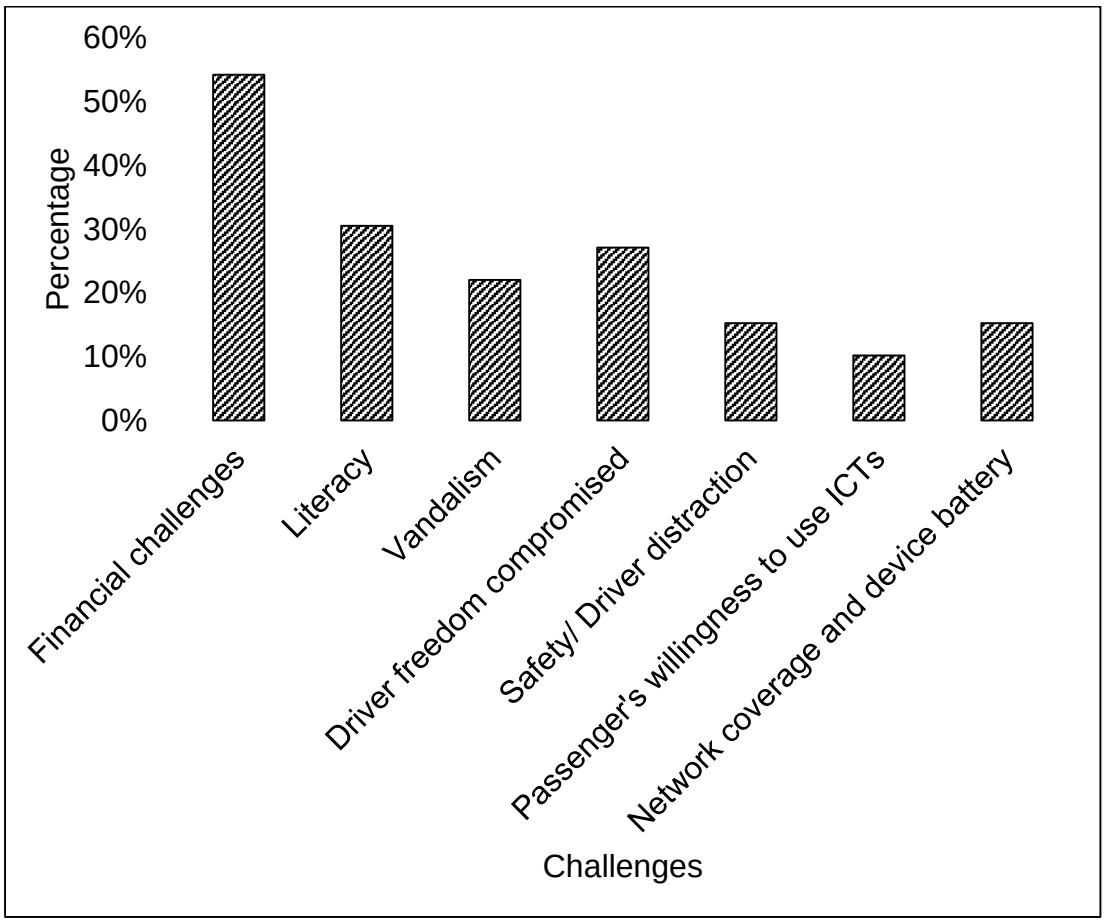

Figure 4.15: Challenges likely to be faced

Figure 4.15 shows the challenges that could be faced when integrating ICT solutions into the public transportation system. 54 % of the respondents cited financial challenges; 31% cited challenges associated with literacy; 22% of the respondents mentioned vandalism; 15% mentioned reasons relating to safety and distracting the driver while 27 % thought driver freedom would be compromised. Other challenges were passenger's willingness to use ICTs and network coverage or device battery life with 10% and 15% respectively.

Financial challenges are the main challenge indicated by most respondents. Purchasing, installation, maintenance and training staff and educating the public would be costly activities. Literacy, looking at that some of the people using public transportation are the elderly and cannot read will be a major challenge, and also

computer literacy which will be needed to access information through computer-based applications and the internet contributes to the literacy challenges.

One challenge which may be faced due to the installation of tracking devices and CCTV surveillance is compromising driver freedom. Drivers would not be free working while their every move is tracked, monitored and recorded. Also drivers may be distracted by some technologies especially those that have the potential to grab their attention such as entertainment screens and noise producing applications. This may lead to other safety hazards.

Even though ICT technologies might seem to provide a solution to safety and security threats, there might also be a risk to vandalism, in a sense that people may vandalise the devices installed in vehicles and bus stops.

4.3 Interview Data Results

4.3.1 Problems Currently Faced By The Public Transport System Which Can Be Solved By ICT Solutions.

This question looked at existing problems in the public transportation system which can be solved through ICT solutions. Respondents 1, 6, 7, 8,11 and 14 listed complete lack of information, real-time information on routes and lack of ways of communication between drivers and passengers as problems that could be solved using ICT solutions. Respondents 2, 4 and 11 indicated that safety problems can be solved using ICTs.Respondent 2 indicated lack of connectivity as a problem and that can be solved by ICTs. Respondents 3, 9, 11, 12,13 and 15 indicated delayed vehicles and scheduling as problems with the current public transportation system. Respondents 6 and 7 indicated lack of integrated ticketing system and the current taxi fare payment system as a problem. Respondents 7 and 13 indicated that congestion could be solved by ICTs. Respondent 5 indicated the public transportation owners permit application process and respondents 2, 4 and 7 indicated the poor quality of roads, driver behaviour and poor conditions of vehicles. Respondent 10 indicated management of the public transportation system as a problem.

The responses in this section clearly indicate that there are problems with the current public transportation system which can be solved by using ICTs. Reviewing Chapters 1 and 2 also proves that public transportation problems can be solved using ICTs. The system faces problems such as:

a) Lack of information; which can be solved dissemination of information using applications, e.g. SMS, social networks and devices such as cell phones and display screens. Provision of real time information on public transportation to the public through applications can solve this problem.

b) Safety; of passengers and drivers, this can be solved through CCTV surveillance inside vehicles and at bus stations and stops and vehicle tracking. Safety has been an issue with the Free State public transportation for a long time as SANRAL community profile, 2006 and Toba et al indicated on their studies. Safety issues can also be solved using electronic fare payment methods as (Florida apts 2015) indicated that they have improved issues of handling cash and risks of robberies and hijackings of personnel and passengers.

c) Delays of schedules and delayed vehicles can be solved using vehicle tracking and monitoring through ICTs, Fleet management using ICTs and providing passengers with real-time notifications about delays due to accidents, vehicle breakdown or congestion. Monitoring of vehicles includes the use of AVL systems which are means of observing, monitoring and managing vehicles in real time (US Department of Transport.,2000; Predic et al., 2007)

d) Lack of connectivity; which can be solved by the provision of sufficient internet coverage and provision of Wi-Fi at bus stations. Connectivity by means of both wireless and broadband would make data accessibility easier provided the information is made available by owners or governing bodies.

e) Lack of an integrated ticketing system; this problem can be solved by using electronic fare payment systems and smart cards. Currently there is an electronic ticketing system available only on some of the interstate buses; even though it solves convenience problems it somehow does not completely improve the system. Passengers still have to queue to load trips onto the tags which is time-consuming. Another problem with the system is it is still paper based as once a passenger swipes the tag; the machine produces a paper receipt which is not sustainable and environmentally friendly. Therefore a much efficient payment method using ICT can be the use of smart cards which passengers can load trip credit online. Smart cards have proven effective and improved service delivery and better meet demand of the passengers (AECOM Limited, 2011)

f) Public transportation operating permits: The problem with operator permits is mostly encountered by owners and the Department of transport

licensing office. The owners have to wait unknowingly until after the minimum permit processing day to go back to that office to collect their permits. In cases the operator finds their permit unprocessed of which if he/ she knew would have saved time and travelling resources. A tracking application would be ideal for this problem.

g) Congestion on the roads leads to delays in public transportation vehicles. Congestion increases passenger waiting time and also the vehicle's journey time. ICT systems would inform drivers of alternate routes and also inform waiting passengers of changes in arrival times of vehicles.

h) Management of the public transportation system. The public transportation system management includes many levels of the Department of Transportation, licensing and operations levels, public transportation owners and their associations. For owners management of personnel and vehicles could use ICTs such as AVL, GPS and CCTV. The Department of transport could use cameras, GPS and tracking devices to monitor and manage public transportation routes.

4.3.2 Technologies And Applications Suitable For Use In Free State

This section focused on respondents stating the types of technologies and ICT applications that would be suitable for use in the Free State public transportation system. Respondents 1, 3, 4, 6, 8 and 11 indicated ticketing and fare payment technologies and applications such as smart cards, electronic payment systems and mobile payment applications would be suitable for convenience and safety. However, respondents 2, 4, 5 and 6 indicated vehicle monitoring, tracking and reporting technologies and applications such as Machine to Machine (M2M) technologies, integrated cameras, enterprise mobility applications, GPS tracking, CCTV and AVL systems to monitor and report driver behaviour, vehicle movement and location, and vehicles operating in unauthorised routes. Respondents 3 indicated that Radwin VMU technology and Ruckus technologies for connectivity and providing commuter Wi-Fi. Respondent 7 indicated social networks through mobile phones would be suitable as more people have access to them. Respondents 6, 9, 12 and 14 indicated technologies and applications providing information and simplified communication such as Advanced Communication System, mobile applications through smartphones, information screens to provide real-time information when needed. Respondent 10 indicated Internet Of Things technology as a suitable technology for the public transport system. Respondent 13 indicated that ICT technologies that can reduce

carbon emissions produced by the public transport vehicles would be suitable. Respondent 8 and 16 did not answer the question.

This section was in relation to solving the problems discussed above. The responses indicated that there are indeed technologies available and that can be suitable to the Free State province.

a) Ticketing and Fare payment technologies are much needed and smart cards or mobile payment systems would be very suitable for safety reasons and convenience. Electronic fare payment systems are safer than cash payments on taxis and buses. Passengers and even buses are robbed and hijacked but in a case where they system does not use cash, criminals targeting money would not have many reasons to break into vehicles.
b) Tracking and monitoring technologies: Machine to Machine technologies, integrated cameras, GPS, CCTV surveillance and AVL technologies. These systems would monitor the location of vehicles at all times, monitor activities in the vehicles, monitor driver behaviour, vehicle speed, routes, bus stations and bus stops. These technologies would improve the safety of vehicles and at the same time increase response time in terms of emergencies and improve schedule observance by owners and drivers (U.S Department of Transport, 2000). GPS technologies, which work anywhere where there is satellite reach, would be much suitable in places of limited infrastructure.
c) Social networking sites and applications would also solve problems relating to lack of information. These platforms e.g. Facebook, Twitter and Instagram are current trends on their own with large numbers of users of which and public transportation service providers and decision makers could use them to provide real-time information. This would also improve reliability on the system by passengers and potential users. For these to work efficiently, the connectivity issue should be addressed as these applications function through internet connectivity. The use of social networks works well for the Yorkshire public transportation system (Itravelyork.info, 2015) as information disposal platform by the various stakeholders.
d) Connectivity technologies: Connectivity is a major factor in ICT, it connects telecommunication systems. The internet, NFC, Cellular telephone systems and Wireless connectivity systems are all technologies that can be used to

provide connectivity in all areas where the public could have access to information through compatible devices. Radwin Vehicular Mobile Unit technology allows for high-speed transmission of data in vehicles while they are moving, which means it can be used by passengers on the move and can also support tracking and monitoring technologies. . This technology would be very convenient to all the stakeholders. Ruckus Wireless would also be convenient for commuters as it provides outdoor Wi-Fi which can be used by commuters waiting for vehicles at bus stations and bus stops.

e) Real-time information provision technologies: Mobile applications, websites and Variable message signs can be used to provide real time to passengers, and also allow them to inquire about arrival and departure times and would increase the use of the public transportation system (Ferris, Watkins and Borning, 2010; Park, Yang and Yi, 2011) . Availability of up to date information would improve reliability, convenience and reduce waiting times for public transportation system. The use of VMS would be suitable for use at bus stations and taxi ranks, while mobile applications would also be better to get the information to as many people in a very short time.

f) Internet Of Things technology was mentioned by one respondent, though this is an emerging technology it has the possibility to transform everyday through different networks interconnected to operate in various environments, this making it possible for them to be used in vehicles.

4.3.3 Challenges Likely To Be Encountered In Incorporating ICT Solutions Into The Public Transportation System

This section looks at the challenges likely to be faced by the different stakeholders of the public transportation system. Respondents 1, 5, 6, 8, 11, 12, 13 and 14 indicated that lack of skill to install, competence and the need to train personnel and passengers will be a challenge. Respondents 1, 4,8,11, 13 and 15 brought up acceptance of these technologies and resistance to change and adaptation by users and owners may be faced. Respondents 9, 13, 14 and 15 indicated that ICT awareness and literacy among the public transportation users will also be a challenging issue. Respondents 2,3,5 7,10,12,13 and 14 indicated that incorporation of ICT solutions into the public transportation system will face financial challenges. Respondents 3, 6, 7 indicated that problems with the infrastructure and network or internet coverage are likely to be a challenge. Respondents 4 indicated vandalism and theft of devices by users is also

likely to be faced. Respondents 3, 7 and 13 indicated that political will and government and public sector cooperation.

Considerations need to be factored on for challenges in the process if ICT solutions are to be incorporated into the public transportation system. As discussed in chapter 1, challenges are likely to be encountered at different stages of the integration process, the data collected also shows that, political will may be faced as a challenge as the public transportation system is government controlled but run by private companies and individuals. For these to be implemented, the government, at the provincial level will have to make decisions to do so.

Skills and competence are needed for the integration process to be fully operational. Firstly skills needed to install electronic devices, skills to maintain them during operation, skills for drivers and other personnel to operate these devices after installation, without having to bring in new people to work with these technologies.

Resistance to these technologies and applications by stakeholders may also be encountered. So before integration, it should be ensured that the stakeholders would accept these technologies and use them, and whether people are willing to adapt to the new public transportation system after integration. It would mean no improvement to the system if these technologies are put in place and then blindsided by people who they were meant for.

The public should have the ability and knowledge to use the applications and devices once they are in place. Education and awareness of ICT solutions should be promoted to the public because these are some of the challenges that can be faced by the system.

Most stakeholders may face financial challenges for ICTs to be successfully integrated into the public transportation system; Owners will have to buy and install these technologies; passengers will need finances to purchase devices compatible with some technologies and to mobile data. The government, will have to invest financially on the rollout of the integration.

Another major challenge is the infrastructure; Even though some ICT solutions can work with the current infrastructure, it needs to be expanded to support other technologies and for efficiency.

One factor that has to be considered is the probable chances of theft and vandalism of devices, especially those placed in public areas with no enough security.

4.3.4 Areas Of The Public Transportation System Mostly Need Improvement Through ICT Solutions

This section looks at various areas of the public transportation system and their need for improvement using ICT solutions.

4.3.4.1 Fleet / vehicle management

Respondents 1,2,5,6,7,8,9,10,13,14 indicated that the area of fleet and vehicle management mostly needed improvement using ICTs. This would ensure that vehicles are in roadworthy conditions, tracking of vehicle movement, validity of permits, control and of vehicles.

4.3.4.2 Customer service

Respondents 1,3,6,8,9,11,13 and 15 said that customer services need improvement in order to allow owners to communicate with users and provide their services and information through ICT and have the capacity to supply public transportation meeting the user demand and on time.

4.3.4.3 Driver and personnel management

Respondents 1,4,5,7,11,12,13 and 15 indicated that ICT solutions will best be suited for driver and personnel management. This would include monitoring of vehicles, how drivers behave and treat customers and speed used and the routes they operate on.

4.3.4.4 Human resources

Respondents 1 and 13 indicated that human resources need improvement in terms of personnel skills and competence.

The responses received about the areas of public transportation which needed improvement shows that the four stated areas, all need improvement; Fleet management, Customer service, driver and personnel management have shown the need to be improved. Most respondents did not feel the need to improve human resources through ICT solutions. Human resources in this case being all the other personnel in public transportation operations.

Fleet management through ICTs would ensure roadworthiness of vehicles, manage vehicle movement and would improve the efficiency of the transportation system.

ICT solutions would also improve customer service. The provision of real-time information, electronic ticketing systems and CCTV surveillance would improve the services currently offered to public transportation users and most likely attract more people to use the system.

ICT solutions can also be used to manage drivers and other personnel. Monitoring driver behaviour, movements, and speed through ICT are possible by using monitoring technologies. This can prevent illegal taxi operation activities, drivers driving in unauthorised routes.

4.3.5 Potential Benefits And Opportunities Of Using ICTs To Improve the Public Transport System

The section investigates the possible benefits and opportunities of using ICTs in order to improve the public transportation system. Respondent 1 indicated that more passengers will be involved in the public transportation system. Respondents 3 and 14 indicated that using ICTs will create sustainable job opportunities for people. Respondents 1 and 11 indicated improved driver and passenger safety would be a benefit of using ICTs. Respondents 3, 13 and 14 indicated that ICTs will improve accessibility to real-time information. However respondents2, 4, 6, 7, 8, 9, 12, 13 and 14 indicated that opportunities for efficiency and reliability in the public transportation system will arise from using ICTs. Respondents 2,5,10,11 and 14 indicated that ICTs will provide opportunities for improved management of the public transportation vehicles. Respondents 7, 12 and 15 indicated that ICTs may provide an opportunity to attract more customers.

For ICT solutions to significantly improve the public transportation system, there should be positive impacts they bring to the system. The benefits cited by respondents include involvement of passengers into the public transportation system, creation of sustainable job opportunities, improved driver and passenger safety, improved accessibility, efficiency, the reliability of the public transportation system, improved management of public transportation vehicles and attraction of more people to use the public transportation system.

ICTs such as CCTV surveillance, tracking and cameras in vehicles and stations will improve passenger safety and security. These technologies will be essential for safety issues currently experienced in the public transportation system to be dissolved. The

hijacking of vehicles, loss of goods and money by passengers, robberies that occur at bus stops can be investigated and resolved and vehicles and goods discovered quicker by law enforcement and other relevant authorities.

More personnel may have to be employed for integration of ICTs in the public transportation system, this will create job employment opportunities for technical personnel by owners and the government to handle the integration.

Public transportation will be more accessible to the public if ICTs were to be integrated into the system. Provision of real time information to the public will even attract more people who previously had no access to public transportation to use it.

The above benefits will lead to improved efficiency and reliability of the public transportation system.

4.3.6 How ICT- based Demand-Responsive Bus and Taxi Schemes Would Help the Owners and the Public

This section looks at whether ICT based demand-responsive schemes for buses and taxis would help the passengers and owners of the public transportation system. Respondents had differing views on the ways demand-based scheme would affect the main stakeholders (passengers and the transportation service providers). Respondent 1 indicated that demand-responsive schemes would be viable for smaller vehicles such as taxis. Respondent 2 and 11 indicated that these schemes would eliminate the low occupancy of vehicles and dead mileage, leading to better customer service. Respondent 1, 5 and 13 indicated that these schemes will not be profitable for owners, but would maybe work in areas of high demand. Respondent 9 indicated that these would happy passengers and a more reliable public transportation system. Respondent 10 indicated that it would give an indication of the current state and allow for prediction. Respondent 12 and 14 indicated that it would allow owners to allocate enough vehicles for certain times and allow the public to plan their daily trips. Respondent 13 indicated demand based schemes are far-fetched for the province and can help in exclusive cases such as events and accidents. Respondent 15 indicated that these schemes would lead to less waiting time by passengers and a more effective public transportation system.

ICT based demand responsive schemes for taxis and buses as a solution to dead mileage and long waiting times are a viable solution to look at, but they may not be

suitable for the Free State. Dispersing taxis to meet every passenger's demand may be a financial burden to the owners, while for bus services, dead mileage will not affect their profits as there are subsidized by the government.

Demand responsive schemes, may increase dead mileage or decrease it. If a vehicle is dispersed due to a few people who showed demand, it will still record less occupancy, meanwhile when vehicles are dispersed only due to passengers' indication of demand, it will prevent vehicles driving around and going back to the station without any passengers.

These schemes may help owners in managing their fleet, dispensing vehicles and allocating them to routes according to demand indicated by the public.

These schemes seem likely to be useful to passengers than owners. Advantage Passengers will have the advantage of having vehicles made available to them whenever they want to take a trip.

4.3.7 ICT Infrastructure

In this section, respondents were asked whether the ICT infrastructure in the Free State province is adequate to support the integration of ICTs into the public transportation system. Respondent 1 indicated that most integration can happen with the existing infrastructure. Respondents 4,6,7,8,11,12,13,14 and 15 indicated that the infrastructure is not enough. Respondents 9 and 10 indicated that the infrastructure is enough to support integration. Respondents 1,3,5 did not respond to this section.

Most respondents to this section indicated that the ICT infrastructure in the province is not enough. A previous study by Maritz and Maponya, 2010 inferred that there is poor ICT infrastructure in rural areas of South Africa. But Mthethwa (2015) indicated that there is enough infrastructure and internet connectivity in the Free State province and also mentioned that it is better to source the infrastructure that we have rather than duplicating the infrastructure (Mthetwa 2015).

Integration does not mean something entirely new has to be created. Some ICTs can work with the available infrastructure but provision must be made in future to improve the infrastructure to support advancing technologies and applications. The existing infrastructure can be upgraded to be compatible with the technologies.

4.3.8 Ways To Improve Awareness And Use Of ICT by the Public

This section was for respondents to indicate ways of improving ICT awareness to the public. Respondents 1,3, 5, 9, 11 and 14 indicated education and training will improve ICT awareness and respondents 2,4,7,8,11,12 and 13 indicated that marketing and advertisements through different platforms will improve ICT awareness. However, respondents 2, 13 and 15 indicated that provision of free connectivity and cheaper devices would also improve awareness.

People need to be taught about ICT, this will raise awareness to these technologies which some of the people already use but do not know what ICT is. ICT education alone will not be sufficient because there are people in the community who use public transportation regularly but do not know how to read or write. Basic education and community outreach programs would lead to a knowledgeable community, making it possible for some people to access and use these technologies without struggling. Training of public transportation drivers and other operations personnel on how to operate and handle devices will also improve awareness. Connectivity also needs to be improved and internet access provided at affordable to the public.

4.3.9 Provision of Real-time Information to the Passengers

The section asked respondents for ways of providing real-time information to existing and potential public transportation users. Respondents 1, 2, 3,7,8, 11, 12, 14 and 15 indicated creation and use of systems or websites and applications providing real-time information. Respondents 2 and 4 also indicated the provision of wireless connectivity to enable access to mobile applications. Respondents7, 9 and 12 indicated the provision of screens at bus stops and stations and the use of digital television. Respondent 7 also indicated the use of bulk SMS to disseminate information while respondent 13 indicated that public transportation service providers should link their IT systems to bus stations and stops.

Most respondents indicated that there is a way service providers can provide real time information to passengers and potential passengers. From this information, it can be gathered that real-time information provision is not a far-fetched idea. Smartphone applications can be used to provide the public with real-time information and would be ideal as most people have cellphones. Other ways of providing real-time include the use of websites which can also be accessed via cell phones.

The most efficient real-time information provision would be mostly achieved through mobile devices other than other electronic devices such as screens in bus stations and on buses. Stationary devices will be providing information only at certain points.

4.3.10 Consideration And Comments Relevant To Using ICTs To Improve Public Transportation

This section requested any comments or considerations from the respondents in their different capacities with regards to using ICTs to improve public transportation. The respondents' views are presented in the Table 4.11 below.

Table 4.11: Respondents' comments on using ICTs to improve public transportation.

RESPONDENTS	CONSIDERATIONS SUGGESTED
1	• Real-time information would have a huge impact on the public transportation system. • The real-time information system must be very accurate
2	• Choose ICT service providers that can provide end-to-end capabilities as multiple service providers add complexity • Look at revenue share options with the ICT service provider to minimize the up-front implementation costs. • Find ways to monetize the infrastructure by providing additional "paid-for" content.
4	• Staff needs to be properly trained in using the equipment • Staff also needs a refreshing course every 6-12 months.
5	• Most public transportation users are illiterate • Making information available and bringing awareness to commuters could be achieved through ICT.
7	• Government departments of transport, communication and technology should work together in developing an ICT system that will improve public transportation.
9	• ICT should be made available to all people in different languages so that people can all understand
11	• Operator and provider management • Being able to track routes and operations • Being able to always be informed and being where you are supposed to be • Client safety and well-being

Table 4.11 Continued

12	• Improve efficiency
13	• ICT is highly essential, but first demand for ICT need to be created. • Remove fear of crime and create a safe environment for ICT • Provide free devices and public networking
14	• Awareness should be made • Get infrastructure • Safety
15	• It will help in improving the Free State province's public transportation state. • It will contribute towards a green city initiative by getting more people using public transportation and leaving their cars at home.

The general comments made by respondents on this section varied based on the respondent's position, i.e. transportation owners, passengers, planners and people in the ICT industry had different views but mostly indicate the importance of ICT. ICT is essential and will be helpful in improving the efficiency of the public transportation system provided people are educated first on ICT, awareness and demand for ICT solutions are created and the infrastructure is improved to support ICT.

4.3.11 Summary

The data above was gathered using qualitative data gathering method in order to gain a deep, intense and holistic overview of ICT solutions and the public transportation system (Gray, 2014). From the above results, it is evident that ICT solutions can be used to improve the public transportation system but various factors need to be considered.

The study on stakeholders of both the public transportation system and the ICT industry shows that ICT solutions are needed in the Free State public transportation system. Qualitative and quantitative data discussed above abridges the ICT need of the public transportation system from the stakeholder's perspectives.

It is evident that Information Communication Technologies are needed by the Free Sate public transportation system but for successful implementation some possible challenges have to be addressed beforehand.

The fact that the system have different private companies and individuals as owners will make integration difficult as they individually manage and the decision to integrate ICTs into their services will have to be made by them willingly unless it's a legislative decision by the government.

More people use taxis compared to buses, the integration of ICT solutions into the public transportation system should provide solutions which will cater for the taxi industry.

The relationship between age, occupation, current public transportation usage, satisfaction with the current public taxi services, internet access, computer literacy and likeliness to use public transportation after ICT integration is linear and 55% accurate. This means that the variables influence possibilities of using public transportation in future. The possibilities will be influenced by human behaviour and opinions, which are crucial key elements for successful adoption and use of ICTs in the public transportation system.

CHAPTER 5: DEVELOPMENT AND COMPARISON OF GUIDELINES

5.1 Introduction

This chapter aims at developing guidelines for ICT integration into the public transportation systems based on the literature review, case studies, theoretical framework, data gathered and the legislations. After a guideline is developed it will be compared to how other countries and cities managed to successfully integrate ICT into their public transportation systems. Guidelines are important as they assist with highlighting important factors to consider before ICT integration.

5.2 Guidelines

5.2.1 Formulation of a public transportation authority

The public transportation system in the Free State needs a public transportation authority to deal with all matters concerning the system. This would specifically ease the administrative process and coordination of the integration process. Having a public transportation authority will also mean clear duties and responsibilities of each stakeholder would be clearly stipulated. For homogenous representation of all the stakeholders, the authority should have representatives from the public sector dealing with public transportation and the private sector.

5.2.2 Reduction of political involvement and interference

As politics influence most public transportation decisions made, less political involvement in the process of ICT integration would speed up the process. These political procedures normally takes a lot of time from the planning, authorisation and implementation stages. Less political involvement and more involvement by experts in Transportation and ICT would result in better-informed decisions making by people dealing with the operations on a daily basis, resulting in a quicker implementation process.

5.2.3 ICT education and awareness

Lack of education and ICT awareness are possible factors that could hinder the integration and adoption of ICTs by the community. These challenges have to be addressed before implementation especially in rural areas. Teaching people the basics to ICT and creating awareness through outreach programmes and advertising should be done before use of ICT. Due to basic or minimal ICT knowledge, successful integration can be achieved by creating and using the simplest by efficient

technologies and devices. Creating awareness and encouraging the public to use ICTs will also increase accessibility to these technologies which are hindered by lack of knowledge or information.

5.2.4 Financing

Public transportation providers, in the case of the Free State, taxi owners solely deal with their expenses as businesses, while buses have the assistance of government through subsidiary schemes. Public transportation companies and owners should not solely deal with financial implications of integrating ICT solutions onto their vehicles. Technologies and devices used are costly, therefore for purchase, installation and maintenance costs of devices and other ICT components, a government subsidiary scheme should be introduced.

5.2.5 Sustainability of ICTs

ICT used should be sustainable, i.e. for successful integration of ICT in the public transportation system, sustainability of these technologies should be taken into account and factors such as public transportation and ICT infrastructure, technologies used and financial sustainability to people involved especially public transportation vehicle owners and regular users. Plans should be available for management of technologies, especially devices to be used communally, once in place so they can be used for longer periods of time. All integration plans and the technologies deployed should be able to accommodate any future developments.

5.2.6 ICT Infrastructure

It is necessary to upgrade the ICT infrastructure in the province as the existing infrastructure is not enough. The existing infrastructure has the ability to support most technologies but as new technologies are discovered regularly, in future if the infrastructure remains unchanged It will not be able to support new technologies.

5.2.7 Security

Types of security concerns surrounding ICT integration include vandalism, theft and misuse of devices and information security regarding personal information used in online bookings, payments and on applications. A single secure platform managed by a single entity, used for all public transportation transactions, bookings should be used for data safety reasons. For devices there should be full-time security services and insurance covers in place for damages and theft. Personal security of users against

internet crimes should be assured. Devices placed in public spaces such as bus ranks and stops should also be monitored.

5.2.8 Physical conditions of vehicles

Not all technologies, especially devices will be suitable for all the vehicles used for public transportation, buses and taxis vary in sizes, carrying capacity, chair sizes, spaces between seats etc. Suitably fitting devices for the different makes of vehicles should be deployed. An in-depth assessment of the available vehicles and types and sizes of screens and either devices should be carried out before installation. For advanced in-vehicle technologies such as screens, the physical state, size, internal space of the vehicle matters and the ICTs should not destruct the users and drivers in any way and cause safety concerns or discomfort.

5.2.9 Intermodal integration

ICTs deployed should be used on all the available modes of public transportation, i.e. should be able to accommodate taxis and buses equally for seamless travel.

5.2.10 Accessibility of ICTs

ICTs should be accessible to all public transportation users and potential users, the following should be considered:

- Simple and easy to use technologies such as SMS and USSD.
- Location of devices should cater for elderly and special needs members of the public.
- Should be affordable.
- Accessible from any place.

5.2.11 ICT integration policy for public transportation

The new public transportation authority should formulate with the involvement of the public, public transportation service providers, ICT and transportation planning experts, a policy to follow through the whole process introducing and integrating ICTs into the public transportation system. The policy should have clear goals, responsibilities and timelines as it will act as a guideline to all the stakeholders and will be used for accountability purposes.

5.3 Comparison between Developed Guidelines and Existing Guidelines

Literature review and case studies show that implementation in other cities such as

5.3.1 Public transportation authorities

Transportation authorities have positively impacted the development of public transportation systems, the transformation of public transportation systems were spearheaded by transportation authorities in cities such as Cape Town and London.

5.3.2 Political involvement

Politicians are involved in decision-making and sometimes are given more power, which hinders developments if for political agendas they do not support some proposed developments. Political leaders are mostly involved in the passing legislation and policies and seeing to it that they are implemented with no involvement and interfering with the technical decisions made.

5.3.3 Education and awareness

ICT education and awareness have played a huge part in ICT integration worldwide, for example, before use of ICTs, in Yorkshire a training programme was initiated to educate the public on using platforms such as journey planners, buying tickets online and booking trips, therefore increasing the number of people that know about and can use ICT for public transportation,

5.3.4 Finances

Fully established public transportation companies, also had to adapt to the demand of ICT in the 1st world by integration technologies into their services whereas in other places involvement of the government, financial institutions and internet service providers such as cellular network companies have helped in the success of operations such as smart cards and M-pesa.

5.3.5 Sustainability

Some countries used in the case studies started with basic technologies such as magnetic cards as a method of ticketing and payment and as these technologies advance time and again they adapt to the latest technologies in order to keep them sustainable. The same should apply to the case of the Free State, start with appropriate and adequate technologies to fit the current needs and conception level but as ICTs become operational in the public transportation system, they should be regularly updated to latest versions of the technologies

5.3.6 ICT Infrastructure

Most of the places studied in the case studies are more developed than the Free State province and already have the best ICT infrastructure and internet coverage in the

world. The countries already have ITS systems in place with combinations of APTS categories such as Fleet Management Systems, Traveller Information Systems and Electronic Payment Systems which require stable and reliable infrastructure. Some countries, such as Kenya are in the same or lesser developed state as the Free State but are able to utilise technologies requiring basic infrastructure.

5.3.7 Security

Security ICT technologies such as CCTV monitoring and tracking of vehicles are some of the technologies used in public transportation in other countries. For the safety of public transportation platforms, ICT infrastructure and devices are under surveillance at all times. For data safety, secure smart cards with microchips are used to prevent unauthorised people from accessing public transportation users' data.

5.3.8 Physical conditions of vehicles

Different types of vehicles are used for public transportation in other countries. Trains and buses mostly used in these countries have internal structures to accommodate screens of different sizes without obscuring the drivers or passengers in any way. Even though the types of vehicles used in other countries differ from those used in South Africa may differ, the same ideas for devices may be adopted but altered to meet the structures of minibus taxis and buses used in the Free State.

5.3.9 Intermodal integration

A single online platform for all modes of public transportation, electronic tickets are also used for different modes of public transportation, passengers use one card to pay for trains and buses, paying for an entire multi-modal trip at once. Electronic fare payment systems and smart cards used in other places can be used for all modes of public transportation passengers are willing to use.

5.3.10 Accessibility

Basic taxis and the use of conventional cell phones such as the M-pesa system in Kenya. The vehicles currently being used for public transportation will not need to be removed from the roads for new once to support ICTs. The technologies used such as social networks, SMS, USSD and M-pesa are easy to use and accessible as they can be used by children and elderly people. Devices such as on street ticketing machines, information display screens are also placed where they can be easily accessed by anyone. The user friendliness and affordability of most technologies have made them accessible to all public transportation users.

5.3.11 ICT integration policy

Well-formulated and organised policies and strategies for public transportation development from case studies included policies on using ICTs in the public transportation system. A provincial policy based only on ICT integration in the public transportation will be ideal as its main purpose would be dealing with the specific task of ICT integration in public transportation.

5.4 Summary

The inclusion of all stakeholders in all tasks will reduce possible violation of policies by some of the stakeholders and it is the duty of all stakeholders to properly use ICTs and see that the devices and infrastructure are properly managed and regularly maintained to meet the needs and expectations of the users.

In the end, ICT technologies adopted and implemented should be effective enough in the public transportation system and result in efficiency and visible improvement in the system. Results should be indicated by reduced waiting times, availability of real-time information, and lastly a significant increase in a number of people using public transportation and less private vehicles on the roads. Following the developed guidelines and considering factors mentioned by the guidelines should help decision makers and other public transportation stakeholders to start planning for ICT integration and eventually implementation.

CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This study was aimed at investigating ICT solutions for public transportation improvement in the Free State, which included assessing possible challenges and opportunities that could arise from ICT solutions in public transportation. The study investigated existing legislation and policies on public transportation development and ICT to assess whether implementation of ICT and public transportation integration based policies has been possible in the Free State province, future implementation plans and progress of such plans if available.

The study also highlighted the developing use of ICT in public transportation systems worldwide, therefore raising awareness to the non-existence of such developments in the Free State public transportation system.

This study is important as it lays a foundation to future considerations for ICT integration into the public transportation system for all stakeholders. Through the methodology used it brings insights on the ICT needs of the public into light. Stakeholders will be able to make decisions regarding the problems they want to solve in the system and the types of technologies they may use. It will also help ICT companies and inventors interested in creating applications or devices for use in public transportation.

This, as the final chapter offers recommendations and conclusions based on the theoretical chapters and findings of this study.

6.2 Summary Based on Objectives of the Study

The aim of the study, which was to investigate ICT solutions to evaluate whether the Free State public transportation system is ready to support possible ICT solutions and what could be the possible challenges encountered in incorporating ICT solutions in the public transportation system, was subdivided into the following objectives;

1. **Finding out the ICT needs in the public transportation system.**

   Through questionnaire and interview data gathering techniques, the needs of the public transportation systems were identified.

2. Identifying and defining key elements needed for successful use of ICTs in the public transportation system.

The following were identified as key factors in integrating ICT solutions into the public transportation system.

Computer literacy: For successful deployment, the public and other stakeholders need to have basic knowledge and understanding of computers and computer or mobile applications.

Political Will: Political leaders at different government spheres make final decisions and approval of policies, therefore

ICT infrastructure: Infrastructure determines connectivity, most ICT devices and technologies depend on internet connectivity to operate. Even though infrastructure is not enough in the Province, it can still support ICTs, therefore there is no need to get rid of the existing infrastructure, instead only an upgrade is needed.

Willingness to use: The public's willingness to use technologies will determine the success of the integration process.

Usability: The technologies to be integrated into the public transportation system should be usable by all people involved.

Finances: Affordability is the main concern when it comes to ICT, devices and internet connectivity are not easily affordable, therefore technologies proposed should be affordable to public transportation service providers and users.

Safety: ICT solutions in the system should be safe for all stakeholders. Internet security and privacy when using ICTs should be guaranteed. Relevant law enforcement authorities should be included in the process to protect ICT devices in public transportation platforms such as bus stops, taxi ranks and within the vehicles.

Driver Freedom: ICTs to be deployed should not compromise the freedom of drivers, but it should be noted that customer satisfaction and efficiency of the public transportation system are the main goals.

3. **Creating a theoretical framework of available parameters:**

An extensive literature review was carried out to conceptualise the process of integrating ICT solutions into the public transportation system and all factors to be taken into consideration. A theoretical framework was then developed based on previous theories on ICT and technology adoption and available parameters to help integrating ICT solutions in the public transportation system in the Free State province.

4. **Developing guidelines on how to incorporate ICT in the public transportation system in the Free State.**

From the primary data gathered, literature review and review of legislation, guidelines to assist in the integration of ICT solutions in public transportation in the Free State were developed.

5. **Comparing developed guidelines with those used in other provinces/cities and countries.**

Literature review, review of cases where ICT has been used in public transportation and review of legislation show that the success of ICT solutions in public transportation in other countries is based on organisation and cooperation between the stakeholders. There are specific authorities and boards formed for the sole purpose of public transportation, therefore making it easy to deal with integrating technologies without delays caused by political interference.

6.3 Findings

This section will combine the results to answer some of the research questions and aims of the study.

1. **Can ICT solve public transportation problems in the Free State province?**

ICTs have the potential to improve the public transportation system. Problems such as accessibility and reliability of public transportation as well as the lack of information can easily be solved by using ICTs. The review of cases also indicates that other countries and cities have been able to solve these problems and now have improved public transportation services.

2. **What are the challenges and opportunities of integrating ICT solutions into the public transportation system?**

A number of challenges and opportunities were identified in the study from both primary and secondary data. Possible challenges of include financial implications, people not knowing how to use the technologies, safety concerns and stakeholders' willingness to accept, use or authorise the integration process.

There are opportunities for the creation of ICT platforms such as websites, trip planning and other public transportation applications. The needs of the users can be considered by developers to create applications that can fulfil those specific needs. There are also opportunities for owners to improve their services, for ICT and public transportation service providers to collaborate and benefit socially and economically while improving the efficiency of the public transportation system.

3. **Which ICT solutions and applications can best serve the public transportation system in the Free State?**

Looking at the vast technologies and the factors which led to them being adopted and showing success for transport agencies, passengers and other cities, which can show best results when implemented in the Free State, considering the challenges that may be faced and the opportunities they are likely to bring.The majority of public transportation owners indicated that some of the technologies they would provide in

their vehicles were safety and security technologies while users needed ICTs for communication and convenience.

Cheaper technologies which can be affordable to the public and allow public transportation service providers to buy and install some devices in their vehicles will be ideal. Cheaper internet and data bundle prices are also needed to allow people to access the internet.

4. **What factors should be considered for successful integration of ICTs into the public transportation system?**

Key elements and crucial factors needed for the Province to successfully integrate ICTs into the public transportation system were also discovered. In the primary data gathering, the respondents indicated their needs, computer literacy, public transportation accessibility, current ways of communication and possible challenges. All these have to be considered and solutions are drawn as to how they can affect the integration process; i.e. How the needs can be solved, tackling computer literacy and awareness, improving accessibility and creating better ways of communication within the system.

Some respondents indicated the devices and applications they have access to and prefer using. These can be used as platforms or mediums for ICTs. Also to be considered are capabilities and limitations of public transportation vehicle owners' capabilities and limitations.

6.4 Recommendations

Based on the above conclusions, the following recommendations were made:

1. The public should be educated and made aware of ICT: Formal education for scholars and community outreach programs for out-of-school members of the public.
2. A public transportation body or authority should be established in order to run all public transportation matters and should include an ICT department which will deal with integrating ICT into the public transportation system.
3. The driver, the public transportation vehicle owner and the passenger should be involved in the decision-making process and feasibility studies before deploying ICTs in vehicles and public transportation stations and stops.

4. All stakeholders should be well informed and have all necessary information before implementation.
5. Existing devices and applications such as cell phones, SMS, USSD and social networks should be used. Other cheaper devices such as VMS can be an added advantage for considerations by service providers and owners with financial limitations especially looking at private taxi owners.
6. Provision of cheaper or free internet access to all people at
7. People take time to adopt and adapt to new technologies, therefore the ICT solutions to be used should be attractive to public transportation users, should also attract non-users to start using public transportation.

6.5 Recommendations for Further Studies

It was established in the study that technologies are always advancing and there is need to improve the efficiency of public transportation in the province. Therefore, there is need for case studies on the different towns and settlements within the Province's districts to assess the possibilities of ICT integration and success. There is also need for studies underpinning precise solutions through the use of advanced emerging technologies such as Internet of Things and Big Data as well as creation of applications as solutions. Extensive research on development of ICT technologies to help improve public transportation in the Free State, which will be suitable for the majority of the population is also suggested; this should include questions aiming at finding the types of mobile phones use for simpler suggestions regarding types of applications to integrate into the system.

6.6 Limitations of the Study

People's lack of interest in participating in questionnaire research and complete lack of ICT understanding by some respondents were some of the limitations to the study. Due to vehicle owners' need to protect their businesses and drivers' need to protect their jobs, they were biased when responding to some questions.

6.7 Conclusions

It has been established throughout the study that ICT solutions are essential for public transportation improvement. The results indicated that there are inadequacies in the public transportation system, information needs and lack of ICTs. It also exposed a gap in the state of the province's public transportation when compared to those of other cities and countries. These absences can be solved through fundamental factors

such as, improving the ICT infrastructure in the province in order to improve connectivity. This would lead to improved information accessibility, therefore improved accessibility to public transportation. Also to be considered is bi-modality, or co-existence of old and new technologies that can all effectively solve public transportation problems and improve the public transportation system.

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APPENDICES

Appendix A: Request Letter

28 May 2015

TO WHOM IT MAY CONCERN

Re: **Ms Ndakhona Bashingi's Master of Technology studies**

This letter introduces Ms Ndakhona Bashingi, who is a Civil Engineering M-Tech student at the Central University of Technology, Free State. Ms Bashingi is busy with a research, which is aimed at investigating ICT solutions for improvement of the public transport system in the Free State.

This study requires her to carry out interviews and questionnaire research with public transportation operators, passengers, drivers and the general public in order to realize the current state and ICT needs of various stakeholders of the system. The research also aims at finding the challenges and possibilities of integrating ICTs into the public transport system and to realize this aim there is a need to carry out interviews with ICT service providers, transportation planners and operators.

All ethical considerations shall be duly observed in the study. This is inclusive of confidentiality of information and voluntary participation.

Should you have queries, please do not hesitate to contact the supervisor of the study, Dr. M. Mostafa. E-mail: mmostafa@cut.ac.za.

Thank you for the anticipated consideration of this request.

Kind regards

…….

DR M. MOSTAFA

Appendix B: Research Questionnaire

INVESTIGATING ICT SOLUTIONS FOR THE PUBLIC TRANSPORTATION SYSTEM IMPROVEMENT IN THE FREESTATE: OPPORTUNITIES AND CHALLENGES

Instructions:

Thank you for participating in this study. Your confidential response will help this research in terms of investigating how ICT solutions can be used to improve public transportation and assessing challenges and opportunities that may be faced.

I. Tick your answers. √
II. Do not make any inappropriate marks on the questionnaire.

Background information

AGE (YEARS)	GENDER	
	F	M
18 - 24		
25 - 30		
31 - 40		
41 - 50		
51- 60		
>60		

OCCUPATION	
Full- time worker	
Part- time worker	
Unemployed	
Student	
Other	

SECTION 1: Public transportation usage

Question 1

Do you use public transportation? Reasons for using or not using public transportation: (Choose 3 options in order of most influential reason)			
YES		NO	
Reasons for using public transport		**Reasons for not using public transport**	
Lack of private vehicle		Public transport not easily accessible	
Inability to drive		Safety reasons	
To avoid driving in traffic		Poor state of vehicles	
Environmental concerns		Lack of information	
Affordable		Behaviour of bus/ taxi drivers	
Reliable		Not convenient	
		Poor quality service	
		Unreliable	

Question 2

Rate your overall satisfaction with public transportation services on a 10point scale

Satisfaction with public transportation	
Taxi services	
Bus services	

Question 3

Is public transportation accessible?	
Not accessible	
Long walking distance to bus stop	
Long waiting time for taxi / bus	
Easily accessible	
Do not know where bus stop / station is	
Do not have information on public transportation	

SECTION 2: ICT AWARENESS

Question 4

Are you computer literate?		
YES	NO	
	Willing to learn	
	Not willing to learn	

Question 5

Do you have access to internet? If NO, tick reasons for lack of internet access			
Yes		No	
How often?		**I do not have access to internet because?**	
Daily		Do not need it	
Weekly		Expensive	
Monthly		Not interested	
		Willing to use if available	
Where?			
Home			
Work			
School			
Internet Cafe			

Question 6

Which of the following applications and devices do you prefer using?			
DEVICES		APPLICATIONS	
Computer		Computer games	
Mobile phones		Social networking	
Tablets		Internet browsing	
Camera		Radio and Television	
Telephone		Email communication	

Question 7

What can be done to improve ICT awareness in public transportation?	
Training drivers on ICT	
ICT education and community outreach	
Reduce prices of devices	
Cheaper and fast internet	
Reduced prices of mobile data	

SECTION 3: ICT NEEDS

Question 8

What type of information do you need before and during trip by public transport?	
Prices	
Bus stop location	
Maps and bus routes	
Travelling times	
Information on booking seats	
Distance and time left to next stop	

Question 9

If ICTs were to be integrated into the public transportation vehicles, how likely would you use their service? (Use a 10 point scale)

_____

Question 10

Do you think ICTs are relevant to be used in the public transportation system? Why?

_____

SECTION 4: DRIVERS AND PASSENGERS

Question 11

How passengers and driver communicate during trips (Tick where appropriate)	
Shouting to make announcements	
Pressing buzzer to request driver to stop	
Walk to the driver and ask him to stop	
Shout to get message to the driver	

Question 12

Which ICT devices are currently available in vehicles?	
None	
DVD player	
Music player	
Cell phone	
Map display screen	
GPS	
Vehicle destination display	

Question 13

What type of in-vehicle technologies will we be willing to use if installed on buses and taxis?

In – vehicle technologies	
Vehicle tracking device	
CCTV cameras	
Buzzers	
Map and route display screens	
Screens for video games and movies	
Wi –Fi	

SECTION 5: PUBLIC TRANSPORTATION OPERATORS

Question 14

Which of the following would you implement in the future?

Possibilities of future incorporation of ICT technologies and applications in public transport		
YES (Choose 5 options in order of possibility)		NO
Installing CCTV		
Installing screens for video games and music		
Installing available seat detectors		
Installing map and route display screens		
Placing information display screens at bus stops		
SMS notifications to passengers in cases of delays		
Provision of online ticket purchasing platform		
Online booking for seats		
Countdown timers for vehicle departure and arrival time at stations / rank		
Vehicle speed monitors		
Tracking devices in vehicles		
Installing buzzers for passengers to alert drivers to stop		
Provision of Bluetooth kits for drivers for communication on the road		
Provision of free Wi-Fi at bus ranks		

Question 15

What challenges are you likely to face in integrating ICTs to your services?

1. _____
2. _____
3. _____
4. _____
5. _____

Appendix C: Interview Guide

1. What problems are currently faced by the public transport system which can be solved by ICTs?
2. Which technologies and applications would best be suitable for use in the public transport system in Free State? Why those technologies?
3. Looking at the current situation of the system, what challenges are likely to be encountered in incorporating ICT solutions into the system?
4. Which of the following areas of the public transportation system mostly needs improvement by using ICT solutions? Why?
   a. Fleet / Vehicle management
   b. Customer service
   c. Driver and personnel management
   d. Human resources
5. What are the potential benefits or opportunities that can result from using ICTs to improve the public transport system, compared to the way the system is currently?
6. How would ICT based demand-responsive bus and taxi schemes help both the operators and the public?
7. Is the ICT infrastructure in the province enough to support integration of ICTs into the public transportation system?
8. To improve awareness and use of ICT by the public, what can be done?
9. How can bus service providers and operators provide real-time information to their clients and potential clients?
10. Are there any considerations you can comment on or identify that are relevant to using ICTs to improve public transportation?

Appendix D: Profiling of Interview respondents

Respondent	Capacity	Area Based
1	Public Transportation company representative	Free State
2	ICT expert – Vodacom	Gauteng
3	ICT expert – Project Isizwe	Tshwane
4	ICT expert – Leboa IT Solutions	Free State
5	Department of Transportation officer	Free State
6	Department of Transportation officer	Free State
7	Department of Transportation officer	Free State
8	MMM Transport planner	Free State
9	Public Transportation User	Free State
10	Transportation planning academic	Free State
11	Public Transportation User	Free State
12	Public Transportation User	Free State
13	Taxi owner	Free State
14	Taxi owner	Free State
15	Public transportation non-user	Free State

Appendix E: Data Analysis Tables

Age Group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-24	48	29.6	30.2	30.2
	25-30	34	21.0	21.4	51.6
	31-40	31	19.1	19.5	71.1
	41-50	31	19.1	19.5	90.6
	51-60	12	7.4	7.5	98.1
	> 60	3	1.9	1.9	100.0
	Total	159	98.1	100.0	
Missing	7	3	1.9		
Total		162	100.0		

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	71	43.8	44.9	44.9
	Male	87	53.7	55.1	100.0
	Total	158	97.5	100.0	
Missing	3	4	2.5		
Total		162	100.0		

Occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Full time worker	59	36.4	38.8	38.8
	Part time worker	14	8.6	9.2	48.0
	Unemployed	29	17.9	19.1	67.1
	Student	39	24.1	25.7	92.8
	Other	11	6.8	7.2	100.0
	Total	152	93.8	100.0	
Missing	6	10	6.2		
Total		162	100.0		

Public transportation usage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	113	69.8	70.2	70.2
	No	48	29.6	29.8	100.0
	Total	161	99.4	100.0	
Missing	3	1	.6		
Total		162	100.0		

Reasons for using public transportation

		Responses		Percent of Cases
		N	Percent	
Reasons for using public transportation	Lack of private vehicle	61	21.3%	45.9%
	Inability to drive	29	10.1%	21.8%
	To avoid driving in traffic	38	13.2%	28.6%
	Environmental concerns	25	8.7%	18.8%
	Affordable	79	27.5%	59.4%
	Reliable	55	19.2%	41.4%
Total		287	100.0%	215.8%

Reasons for not using public transportation

		Responses		Percent of Cases
		N	Percent	
Reasons For Not Using Public Transportation	Public transport not easily accessible	7	8.3%	15.9%
	Safety reasons	13	15.5%	29.5%
	Poor state of vehicles	11	13.1%	25.0%
	Lack of information	12	14.3%	27.3%
	Behaviour of bus/ taxi drivers	13	15.5%	29.5%
	Poor quality service	6	7.1%	13.6%
	Use private vehicle	6	7.1%	13.6%
	Not convenient	10	11.9%	22.7%
	Unreliable	3	3.6%	6.8%
	No Answer	3	3.6%	6.8%
Total		84	100.0%	190.9%

Satisfaction with taxi services

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20%	3	1.9	4.7	4.7
	30%	1	.6	1.6	6.3
	40%	2	1.2	3.1	9.4
	50%	11	6.8	17.2	26.6
	60%	6	3.7	9.4	35.9
	70%	6	3.7	9.4	45.3
	80%	13	8.0	20.3	65.6
	90%	5	3.1	7.8	73.4
	100%	17	10.5	26.6	100.0
	Total	64	39.5	100.0	
Missing	11	98	60.5		
Total		162	100.0		

Satisfaction with bus services

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20%	1	.6	2.0	2.0
	30%	5	3.1	10.2	12.2
	40%	1	.6	2.0	14.3
	50%	11	6.8	22.4	36.7
	60%	5	3.1	10.2	46.9
	70%	5	3.1	10.2	57.1
	80%	6	3.7	12.2	69.4
	90%	5	3.1	10.2	79.6
	100%	10	6.2	20.4	100.0
	Total	49	30.2	100.0	
Missing	11	113	69.8		
Total		162	100.0		

Internet Access

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	106	65.4	70.7	70.7
	No	44	27.2	29.3	100.0
	Total	150	92.6	100.0	
Missing	3	12	7.4		
Total		162	100.0		

Accessibility of public transportation

		Responses		Percent of Cases
		N	Percent	
Accessibility of public transportation	Not accessible	5	2.7%	3.1%
	Long walking distance to bus stop	26	14.0%	16.1%
	Long waiting time for taxis/ buses	41	22.0%	25.5%
	Easily accessible	91	48.9%	56.5%
	Do not know where bus stop/ station is	3	1.6%	1.9%
	Do not have information on public transportation	10	5.4%	6.2%
	No answer	10	5.4%	6.2%
Total		186	100.0%	115.5%

Computer literacy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	81	50.0	53.3	53.3
	No	71	43.8	46.7	100.0
	Total	152	93.8	100.0	
Missing	3	10	6.2		
Total		162	100.0		

Where people access internet

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Home	51	31.5	60.7	60.7
	Work	9	5.6	10.7	71.4
	School	13	8.0	15.5	86.9
	Internet Cafe	10	6.2	11.9	98.8
	Mobile	1	.6	1.2	100.0
	Total	84	51.9	100.0	
Missing	6	78	48.1		
Total		162	100.0		

Willingness to learn how to use computers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	55	34.0	82.1	82.1
	No	12	7.4	17.9	100.0
	Total	67	41.4	100.0	
Missing	3	95	58.6		
Total		162	100.0		

Frequency of internet access

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Daily	75	46.3	71.4	71.4
	Weekly	16	9.9	15.2	86.7
	Monthly	14	8.6	13.3	100.0
	Total	105	64.8	100.0	
Missing	4	57	35.2		
Total		162	100.0		

Devices preferred by respondents

		Responses		Percent of Cases
		N	Percent	
Devices preferred	Computer	69	29.7%	42.9%
	Mobile phone	94	40.5%	58.4%
	Tablets	37	15.9%	23.0%
	Telephone	16	6.9%	9.9%
	No Answer	16	6.9%	9.9%
Total		232	100.0%	144.1%

Applications preferred by respondents

		Responses		Percent of Cases
		N	Percent	
Applications preferred	Computer Games	14	6.0%	8.7%
	Social Networking	57	24.4%	35.4%
	Internet Browsing	30	12.8%	18.6%
	Radio and Television	38	16.2%	23.6%
	Email Communication	30	12.8%	18.6%
	No answer	65	27.8%	40.4%
Total		234	100.0%	145.3%

Reasons for lack of internet access

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Do not need it	1	.6	2.8	2.8
	Expensive	11	6.8	30.6	33.3
	Not interested	6	3.7	16.7	50.0
	Willing to use if available	18	11.1	50.0	100.0
	Total	36	22.2	100.0	
Missing	5	126	77.8		
Total		162	100.0		

Ways to improve ICT awareness

		Responses		Percent of Cases
		N	Percent	
Ways to improve ICT awareness	Training drivers on ICT	63	27.6%	38.9%
	ICT education and community outreach	57	25.0%	35.2%
	Reduce prices of devices	23	10.1%	14.2%
	Cheaper and faster internet	42	18.4%	25.9%
	Reduced prices of mobile data	36	15.8%	22.2%
	No Answer	7	3.1%	4.3%
Total		228	100.0%	140.7%

Type of information needed before travelling

		Responses		Percent of Cases
		N	Percent	
Information needed when travelling	Prices	103	42.6%	66.9%
	Bus stop location	22	9.1%	14.3%
	Maps and bus routes	23	9.5%	14.9%
	Travelling times	51	21.1%	33.1%
	Information on booking seats	2	0.8%	1.3%
	Distance and time left to next stop	31	12.8%	20.1%
	No Answer	10	4.1%	6.5%
Total		242	100.0%	157.1%

Likeliness to use public transportation after ICT integration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20%	1	.6	1.0	1.0
	40%	1	.6	1.0	2.0
	50%	9	5.6	9.0	11.0
	60%	9	5.6	9.0	20.0
	70%	13	8.0	13.0	33.0
	80%	31	19.1	31.0	64.0
	90%	10	6.2	10.0	74.0
	100%	26	16.0	26.0	100.0
	Total	100	61.7	100.0	
Missing	11	62	38.3		
Total		162	100.0		

Relevance of ICT solutions in public transport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	103	63.6	95.4	95.4
	No	5	3.1	4.6	100.0
	Total	108	66.7	100.0	
Missing	3	54	33.3		
Total		162	100.0		

Reasons why ICT are relevant in public transportation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Convenience	32	19.8	35.6	35.6
	Fleet Management	9	5.6	10.0	45.6
	Accessibility of Information	33	20.4	36.7	82.2
	Transport Accessibility	8	4.9	8.9	91.1
	Improved customer service	8	4.9	8.9	100.0
	Total	90	55.6	100.0	
Missing	6	72	44.4		
Total		162	100.0		

Current ways of communication

		Responses		Percent of Cases
		N	Percent	
How drivers and passengers communicate	Shouting to make announcements	46	24.3%	28.4%
	Pressing buzzer to request driver to stop	37	19.6%	22.8%
	Walk to the driver and ask him to stop	26	13.8%	16.0%
	Shout to get the message to the driver	65	34.4%	40.1%
	No Answer	15	7.9%	9.3%
Total		189	100.0%	116.7%

ICT Devices available in vehicles

		Responses		Percent of Cases
		N	Percent	
ICT devices available in vehicles	None	29	12.3%	17.9%
	DVD player	42	17.9%	25.9%
	Music player	77	32.8%	47.5%
	Cell phone	25	10.6%	15.4%
	Map display screen	5	2.1%	3.1%
	GPS	25	10.6%	15.4%
	Vehicle destination display	14	6.0%	8.6%
	No Answer	18	7.7%	11.1%
Total		235	100.0%	145.1%

In-Vehicle technologies respondents are willing to use

		Responses		Percent of Cases
		N	Percent	
In-Vehicle Technologies willing to use	Vehicle tracking device	61	24.9%	37.7%
	CCTV cameras	33	13.5%	20.4%
	Buzzers	35	14.3%	21.6%
	Map and route display screens	41	16.7%	25.3%
	Screens for video games and movies	10	4.1%	6.2%
	Wi-Fi	43	17.6%	26.5%
	No Answer	22	9.0%	13.6%
Total		245	100.0%	151.2%

Possibilities of future ICT integration into taxis

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	42	25.9	100.0	100.0
Missing	3	120	74.1		
Total		162	100.0		

Challenges likely to be encountered.

		Responses		Percent of Cases
		N	Percent	
Challenges likely to be faced	Financial challenges	32	31.1%	54.2%
	Literacy	18	17.5%	30.5%
	Vandalism	13	12.6%	22.0%
	Driver freedom compromised	16	15.5%	27.1%
	Safety/ Driver distraction	9	8.7%	15.3%
	Passenger's willingness to use ICTs	6	5.8%	10.2%
	Network coverage and device battery life	9	8.7%	15.3%
Total		103	100.0%	174.6%

Future ICTs owners are willing to incorporate in their services

		Responses		Percent of Cases
		N	Percent	
Future ICTs incorporated into services	Installing CCTV	14	7.3%	28.0%
	Installing screens for video games and music	12	6.2%	24.0%
	Installing available seat detectors	11	5.7%	22.0%
	Installing map and route display screens	16	8.3%	32.0%
	Placing information display screens at bus stops	13	6.7%	26.0%
	SMS notifications to passengers in cases of delays	13	6.7%	26.0%
	Provision of online ticket purchasing platform	12	6.2%	24.0%
	Online booking for seats	10	5.2%	20.0%
	Count down timers for vehicle departure and arrival time at stations / rank	5	2.6%	10.0%
	Vehicle speed monitors	20	10.4%	40.0%
	Tracking devices in vehicles	17	8.8%	34.0%
	Installing buzzers for passengers to alert drivers to stop	22	11.4%	44.0%
	Provision of Bluetooth kits for drivers for communication on the road	11	5.7%	22.0%
	Provision of free Wi-Fi at bus ranks	9	4.7%	18.0%
	No Answer	8	4.1%	16.0%
Total		193	100.0%	386.0%