EXPLORING THE RELATIONSHIP BETWEEN INTELLIGENT TRANSPORT SYSTEM CAPABILITY AND BUSINESS AGILITY WITHIN THE BUS RAPID TRANSIT IN SOUTH AFRICA

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DECLARATION

I, **Lesego Nthite**, student number **200576906** hereby declare that this dissertation for DPhil Engineering Management at the University of Johannesburg is submitted by me and has not been previously submitted for a degree at this or any other institution and it is my own work. All reference materials contained in this research have been duly acknowledged.

DEDICATION

"He gives power to the weak and strength to the powerless. Even youths will become weak and tired, and young men will fall in exhaustion. But those who trust in the LORD will find new strength. They will soar high on wings like eagles. They will run and not grow weary. They will walk and not faint."

Isaiah 40:29-31

This dissertation is dedicated to the Lord God, who gave me the strength to complete this study against all odds. I also dedicate this dissertation to my late mother: Theodora Nompumelelo Nthite, my late father: Hosea Modikwe Nthite and my late sister: Lindiwe Nene Nthite, who would have worn the proudest smile on graduation day. Not forgetting my baby Onalerona "my gummy bear" for giving me hope for a better future.

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A number of people made great contributions that made a difference not only to this thesis but also to my own personal and professional development.

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ABSTRACT

More than 65% of South Africans use public transportation to access educational, business, and financial activity. Mobility of individuals and products, particularly in metropolitan areas, suffers from delays, unreliability, absence of safety and air pollution. On the other hand, mobility demand is increasing quicker than South Africa's accessible infrastructure. Public transport services are poor in general, but this picture is transforming a high-quality mass transit system using high-capacity buses along dedicated bus lanes by implementing the Bus Rapid Transit (BRT) system. The BRT system appeared as the leading mode of urban passenger transit in the first decade of the twenty-first century after a few pioneering applications in the later portion of the twentieth century.

In addition, Intelligent Transport System's (ITS) advantages motivate both advanced and developing nations, such as South Africa, to invest in these techniques rather than spending enormous quantities on expanding the transportation network. Various stakeholders in government, academia and industry are in the process of presenting a shared vision of this new strategy and first practical steps should be taken towards this objective. Intelligent transport system capacity can provide better and more inclusive public transportation facilities to commuters through enhanced reliability and accessibility; to operators through efficiency gains; and to customers and operators in terms of cost-effectiveness and service provision affordability. International experience shows that capacities of the ITS can boost transportation profits by as much as 10-15%.

Using vehicle tracking systems and pre-emption of traffic signals (to allow priority for BRT vehicles through traffic signals), reliability of public transport travel time can be enhanced through efficient scheduling and/or time adherence. Similarly, decreased passenger queues (and thus time delay) can be accomplished by using Electronic Fare Collection (EFC) to facilitate passenger fare payment. This research concentrated on assessing the capability of the ITS to make South Africa's BRT system agile. This study was driven by the observation that no research was undertaken in South Africa on the capability of the ITS and business agility, specifically research focusing on the BRT system. Municipalities in South Africa have embraced the BRT system to provide a secure, reliable, effective and affordable scheme for public transport. Compared to other modes of transport, busses are a safer choice. The purpose of the BRT system was to provide better public transport, operating systems and service.

The anticipated advantages of this system were significant, but there were some inherent obstacles to effective execution. These difficulties translate into longer travel time for the average commuter, which has an important impact on their transportation expenses. Furthermore, the accessibility of travel information for South Africa's BRT system remains a challenge. To achieve the primary goals and objectives of the systems, an intelligent transport system was incorporated to better manage the operations and activities of the bus rapid transit systems.

Strategic alignment between the BRT system and the intelligent transport system has been highlighted as one of the issues facing South Africa's transport sector. As such, a high-quality intelligent transport system delivery, which was also aligned with the BRT expectations, was a good way to illustrate the value of an intelligent transport system and the capability it produces for the BRT system.

South Africa's public transport sector consists of different modes of transportation such as taxis, buses, trains and the BRT system. An intelligent transportation system has the potential to improve service delivery levels. A central theme of the investigation was to comprehend the limitations and possibilities of South Africa's BRT system and the capability of the ITS. The study analysed the connection between the capability of an ITS and the agility of the BRT system as a competitive edge for excellence in South Africa's public transport industry. The research revealed stakeholders' status quo, views and attitudes about their experiences with South Africa's ITS capability and bus rapid system agility. In addition, the research explored whether the initial goals of the intelligent transport system were met in the bus rapid transit system.

Primary and secondary data such as questionnaires, observations, publications and prior research linked to intelligent transportation systems was used to gain a thorough knowledge of the BRT's intelligent transportation system and its operational management. The study conceptualised the ITS capacity in three dimensions namely: ITS infrastructure, ITS and business integration, as well as ITS innovation and guidance. In addition, the study further conceptualised two dimensions of business agility – market orientation agility and operational agility – of the BRT system. The background of both the ITS and the BRT system are also addressed. The nature of the study scope helped to identify whether the capability of ITSs influenced business agility within the South African BRT system. The information gathered was evaluated using the Statistical Package for Social Sciences (SPSS) with the help of Microsoft Excel using descriptive statistics, regression analysis, cross tabulation and chi-square testing. Tables, charts and maps were used to present this.

Qualitative data was evaluated using a thematic strategy. The research echoes the need for rapid public transportation systems to provide lessons to improve and adopt intelligent transportation technologies. The study's findings recognised numerous issues including the misalignment of capacities within a BRT system's organisations, as well as the limited use of intelligent transit system capabilities and business agility on the bus rapid transit system. The research verified that the notion of ITS in the South African transportation industry is still an evolving phenomenon. There is no prevalent understanding of ITS among transportation industry researchers and professionals, and there is still a lack of knowledge about the performance effects of ITS capabilities.

Although it can be discovered that ITS primarily leverages the amount of service that can be provided to the client and that they increase effectiveness in the back office, the wide range of ITS-services calls for an employee evaluation. The research makes actionable suggestions for South Africa's BRT system.

These suggestions are intended to support the development and enhancement of the ITS capability and business agility of BRT systems. The study suggests that South Africa's BRT system needs to build superior inner ITS capability to attain business agility effectively. As an end product, the study provided a structure for how the capacity of ITSs can ensure that the bus rapid transit becomes the most flexible public transport system in South Africa.

Key words: Intelligent transport systems capability, Operations, Sustainable transport, Traffic flow, Public transport, Bus Rapid Transit, Agility

ACRONYMS AND ABBREVIATIONS

ADAS	Advance Driver Assistance System
AFC	Automatic Fare Collection
AFPS	Automated Fare Payment System
APC	Automatic Passenger Counter
APTMS	Advanced Public Transport Management System
APTA	American Public Transportation Association
AVL	Automatic Vehicle Location
BRT	Bus Rapid Transit
CAD	Computer Aided Dispatch
CAS	Collision Avoidance System
CCTV	Closed Circuit Television
CITS	Cooperative Intelligent Transport Systems
DOT	Department of Transport
GITMP	Gauteng Integrated Transport Master Plan
GPS	Global Position System
HRM	Human Resource Management
IBL	Intermittent Bus Lane
IBM	International Business Machines
IDP	Integrated Development Plan
IT	Information Technology
ITDP	Institute for Transport and Development Policy
ITMP	Integrated Transport Master Plan
ITMS	Integrated Transport Management System
ITP	Integrated Transport Plan
ITS	Intelligent Transport System
LOS	Level of Service
MBL	Moving Bus Lane
MDT	Mobile Data Terminals

MITI	Ministry of International Trade and Industry
NCMC	National Common Mobility Card
NLTSF	National Land Transport Strategic Framework
NTMP	National Transport Master Plan
OCP	Optimal Control Problems
OCC	Operations Control Center
PDM	Passenger Demand Model
PLTF	Provincial Land Transport Framework
RSDF	Regional Spatial Development Framework
SANRAL	South African National Road Agency
SDF	Spatial Development Framework
SPSS	Statistical Package for Social Science
TMC	Traffic Management Center
TLP	Traffic Light Priority
TSP	Transit Signal Priority
UTC	The Urban Traffic Control system
VMS	Variable Message Sign

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DEFINITION OF TERMS

AFC – an automated fare collection system that consists of on-station (and complementary buses) to scan tickets and collect passenger revenue. It provides comprehensive passenger and revenue data.

APTMS – an advanced public transport management system consisting of on-bus units to track buses and provide automatic vehicle location for the OCC. This location information is also available for passenger information systems.

Bus Rapid Transit (BRT): A high quality bus based transit system that delivers fast, comfortable and cost effective urban mobility through the provision of segregated right of way infrastructure, rapid and frequent service, modern stations, on-board fare collections and high-tech vehicles (Rahim, 2013:54).

CCTV – a closed circuit television system enabling surveillance inside of stations through interfacing with the OCC

Corridor: A corridor is a broad geographical area that defines the general directional flow of traffic that may encompass a mix of streets, highways and public transport alignments (Ngoben, 2012:9).

Central Business District (CBD): The central business district is the traditional business core of a community, characterized by a relatively high concentration of business and administrative activity within a relatively small area (Cete et al., 2013:23).

Efficiency of transportation systems: The efficiency of transportation systems refers to the degree that transportation systems are comprehensive and integrated, so that individuals', short term decision support a strategic and long-term goals (Litman, 2013:6).

Integrated Transport Plan (ITP): An integrated transport plan is a document setting out how to integrate transport systems in order to increase accessibility for all people by giving priority to public transport, non-motorised transport and traffic safety (COJMM, 2015:88).

Intelligent transport systems: PIARC Committee on Intelligent Transport Systems (1999) defined intelligent transportation systems as the collection, processing, integration, supply and utilization of information through the application of computer, control and communications technologies to enable authorities, transportation professionals, operators and individual customers to make better informed decision (PIARC,1999:13).

Mode of transport: Mode refers to a particular form of travel i.e. walking, cycling, and travelling by bus, car, and carpool or by train.

PA system – Public Address systems on stations and in buses.

Public transport: Public Transportation includes all multiple occupancy vehicle services designed to transport customers on local and regional routes. It is transportation by van, bus, or rail or other conveyance, either privately or publicly owned, providing to the public general or special service (Rodriguez & Targa, 2004).

Transport mobility: Mobility is the degree of free flow movement of vehicles and pedestrians. It is the ability to move at an acceptable speed and travel time without undue interruption and at acceptable levels of comfort and safety.

Traffic management: Traffic management refers to various strategies that change travel behaviour (how, when, and where people travel) to increase the efficiency of transportation systems and achieve planning objectives (Ferguson & Erik, 1999).

UTC – The Urban Traffic Control system enabling prioritisation of traffic lights through interfacing with the OCC.

VMS – Variable message systems at stations and passenger information informing the public on general information as well as 'next bus's information.

CHAPTER ONE

THE RESEARCH PROBLEM AND ITS CONTEXT

1.1. Background

One needs to pose the question why South African cities have opted for BRT over other transport technologies? To respond to that question one would need to understand the current public transport operations and what they are responding to. The social engineering of apartheid deliberately implemented spatial planning and settlement initiatives that are characterized by:

- Establishment of dormitory townships.
- Little or no economic opportunity within easy proximity.
- Distance and cost are a challenge to access opportunities.
- Government subsidised services (bus and rail services) to promote cheap labour for the cities.
- Other transport needs are not considered or planned.

The consequences of the distorted spatial planning and the challenges that it posed for the majority of citizens perpetuates to this day. To fill the transport gap we have minibus taxi type services and small bus operators. However these services have proven to be unsafe, unreliable and supply driven as opposed to customer needs driven and they also tended to focus on peak service operations similar to the subsidised services. The rail system is the technology that is geared to mass transit, however the lack of investment over the decades requires high levels of investment and modernization, which initiatives commenced, but this will take many years to be efficient and effective, and remains the backbone of public transport in South Africa.

The network approach afforded by the BRT in particular provides a technology that ensures reliable, rapid and integrated technologies that address the travel and transport requirements of the entire city. It provides a response to reduce the effects of poor spatial planning while connecting the entire city in a much more cost effective and integrated manner. The service quality and access it affords reduces travel times and starts to reduce the effects of the apartheid spatial planning. The BRT technology and the trunk corridors provide a cost effective option that can integrate with other technologies such as rail, while it provides an opportunity, in the South African context, to draw in all current public transport service providers (taxi industry, small bus operators, subsidised bus operators, municipal bus operators) an opportunity to participate in the new BRT service operations.

It is also the catalyst to deliberately intensify land use initiatives that would redress the distorted spatial planning and creates opportunities for people and businesses to locate close to BRT corridors and stations. One of the main problems facing society today is the ever-increasing need for transport. The demand for transport has only been met by the development of new roads and other transport infrastructure.

Duke (2014), asserts that growth in the transport industry has gradually moved towards optimising the use of current equipment through careful planning, management and maintenance. The latter is made possible by implementing the ITS includes applying integrated computer-related methods to transport systems in order to improve transport and traffic efficiency and overall efficiency of the public transport system (Douglas, 2015). The mobility of people and products is compromised as a result of delays, unreliability, absence of safety and air pollution, particularly in metropolitan areas as shown on plate 1.1.

Plate 1.1. Traffic congestion on South African roads, Source: Douglas, 2015

Mobility demand is increasing more rapidly than the infrastructure available (Dirk & Erica, 2015). ITS design and implementation decreases traffic and number of accidents, resulting in reduced concentrations of vehicle emissions and increases quality of life. In addition, advantages of the ITS encourage both advanced and developing nations to invest in such systems rather, than spending enormous quantities on expanding the transport network. Various stakeholders in government, academia and industry are in the process of presenting a shared vision of this new strategy, and first practical steps should be taken towards this objective (Wiley & Sons, 2015). Growing congestion on highways along with concerns about air quality and long-term sustainability are an indication that change is inevitable, if towns in future decades are to satisfy the transport requirements of citizens.

Although the transportation industry has seen some beneficial changes, the sector continues to spread best practices, which is a general phenomenon illuminated by a lack of organisational agility owing to unreliable transportation scheme. Bharadwaj and Grover (2003) define organisational agility as the capacity of a company to compete and flourish in an unstable company setting through rapid detection and seizure of chances and threats. Organisational agility is considered a main competitive company enabler (Ganguly, Nilchiani, and Farr, 2009; Mathiassen and Pries-Heje, 2006). Business agility is now a king-maker because it is a main determinant of the success of a sustainable company as illustrated in figure 1.1.

Figure 1.1. Business agility compartments. Source: Bharadwaj and Grover (2003)

According to Bharadwaj and Sambamurthy (2005), agile organisations in their company settings are resilient to turbulent upheavals. They are also extremely adaptive to emerging possibilities and entrepreneurship in developing fresh business models or important competitive movements. In addition, agile companies outperform less agile companies as they continually produce competitive behavior (Ravichandran, 2018). The Bus Rapid Transit System (BRT) has been praised by many as the most flexible transport system in the South African (SA) transport sector. It rose from being the fourth biggest in a brief space of time to take second place in South Africa. According to Executive Director of Transport in the City of Johannesburg Lisa Seftel (2017), this accomplishment was accomplished through the use of the ITS, which made BRT more agile and gave it customer service velocity, which is very crucial in today's ever-changing technology setting. The fast networks of public transport that add to economic development, job creation and tourism include:

My Citi operates in Cape Town, Western Cape.
Rea Vaya in Johannesburg, Gauteng.
A Re Yeng (Let's go) in Pretoria, Gauteng.
Go George in George, Western Cape.
Harambee in Ekurhuleni, Gauteng.
Yarona in Rustenburg, North West.
GO! Durban in Durban, KwaZulu-Natal.

Road transport is behind the digital technology curve in South Africa. The country's safety issues, congestion and the need for effective traffic management led to the growth of the ITS in the 1990s. Since then, ITS demands and capabilities have increased rapidly. From early implementation of Variable Speed Limit (VSL) signs, Dynamic Message Signs (DMS) and e-tolls, to the next generation's tomorrow's sensor mesh, linked vehicles and self-driving cars, the list of ITS apps is increasing daily as vehicle-based transport technologies become the next promising area for digital technology advancement (Catherin, 2016). The main capability of the BRT intelligent transport system is data collection and dissemination of information, both for the management of the BRT scheme and for transit operators and travelers.

Traffic reports are now frequently featured on radio during peak traffic hours to assist drivers prevent congestion, however busses and taxis are unable to modify their paths owing to waiting at pre-ordained stops for commuters. The ITS monitors any incidents of unusual traffic congestion on the BRT feeder arteries and satellite monitoring of BRT busses. If delays are unavoidable, real-time passenger data systems can relay updated arrival times to digital signage at BRT stations or on the buses. Regular commuters may subscribe to obtain this data on their cell phones or on the internet via SMS. Passengers require data on bus routing or time schedules, and adherence to real-time schedules to help with their planning of public transport trips.

In order to guarantee that this information is reliable, precise and in real-time information, passenger information systems collect and interpret all passenger data from linked the ITS. Intelligent Transportation Systems, according to Piarc (2004), are systems that guarantee data collection, processing, integration and supply through the implementation of computer, control and communications techniques to allow transportation planners, operators and individual clients to create informed choices, i.e. smart transportation decisions. Referring to this observation, Andersen (2013) asserts that the ITS' overarching role is to enhance transportation system activities to promote the overall transport goals of mobility, security, reliability, efficiency, and environmental quality.

The merits of smart transport technologies have been demonstrated globally and as a developing country, South Africa has countless transport-related issues make it suitable for alternative smart transport systems (Steven, 2004). As many road networks lack the capacity to build additional highways, concerted attempts are being made to enhance the effectiveness of current facilities (Booyes et al., 2013). The BRT system was planned to play a leading role in transforming city-wide public transport into a scenario where it became the preferred mode of travel for most inhabitants and making a significant contribution to the countries' most effective growth as a whole. The features of BRT systems are as follows:

I. Segregated bus ways,

II. Rapid boarding and alighting,

III. Efficient fare collection,

IV. Comfortable and efficient shelters and stations,

V. Use of clean bus technologies not limited to any particular type,

VI. And flexibility in routing.

In an environment where companies were struggling to succeed, fickle customer tastes, and increasing uncertainty, managers recognised that the ITS was an important element in the capability of a BRT system to detect and react to market changes (Zhang, Zhao, Kumar, 2016). In the late 1970s, the first BRT system was set up in Curitiba, Brazil, and has now spread throughout the world to a few dozen cities. BRT is a word associated with bus transport schemes using accessible room on city arterial highways with dedicated bus routes. These systems use contemporary techniques to optimize flow, movement of passengers, ticketing and scheduling of buses. The effectiveness of the scheme and the large ability of transported passengers relies on the scheme as a whole and not necessarily on bus size, although articulated buses could be easily used when needed (Mabena, 2010).

South Africa is at a very critical point where officials are gaining traction and allocating resources to introduce fresh policies and projects that could possibly enhance government transport (Van Ryneveld, 2008). Positive outcomes can be achieved through the implementation of the ITS. By incorporating the ITS into the public transportation system, major factors influencing the quality and growth of public transportation such as reliability, security and comfort could be gradually addressed. Strategic alignment between BRT and ITS was one of the issues in South Africa's transport sector and that's why a high-quality ITS service – that is also aligned with the BRT expectations – is an efficient way to show how much value ITS generates for the BRT system. By demonstrating the value produced by the ITS, the argument that the system is merely a cost center that provides support for BRT policies is contradicted (Kulatilaka & Venkatraman, 2001). It is also evident that the greater the value, the more alignment between the ITS and the BRT system.

These BRT systems that achieve a greater degree of alignment with the ITS, are often associated with the transportation sector's excellent performance (Silvia et al., 2005). Research by Zhang, Zhao, Kumar (2016) also recognised the potential for the ITS to impact the BRT system's efficiency by creating alternatives to respond to change. Simultaneously, legacy systems may be inflexible or unresponsive to modify to the point where stiffness traps appear. Therefore, the intelligent transport system could become a limiting factor in the capability of BRT to respond to threats or possibilities. The primary reason behind individuals using their own vehicles to get to work is that public transport, such as trains and buses, has not always been reliable (Adewumi & Allopi, 2013). This has resulted in too many cars in the city, creating issues such as traffic jams and accidents.

The outcome was a productivity loss because of individuals arriving late for work. The BRT system offers a 'fast fix' solution to these issues of public transport. The South African Department of Transport (DOT) has made it clear that the BRT system was essential to the effectiveness of the public transport system in South Africa.

Local transportation cannot merely operate without a decent bus service that is available, affordable and appealing to a wide spectrum of individuals across society

(Adewumi & Allopi, 2013). The performance of the BRT's business agility depended on the ITS support for the completion of tasks by individuals, the specialisation of the company's internal capabilities, and the interaction of customers and partners in the design and delivery of the service (Sambamurthy et al., 2003; Mills & Margulies, 1980). There was a trend towards outsourcing various elements that affect the level of agility of the ITS. Examples include ITS infrastructure (e.g. cloud computing), applications (e.g. application service provisioning and software as a service) and complete business processes (business process outsourcing) to business network partners.

Such examples highlight the increasing significance of agility in partnerships. Most BRT businesses in the 21st century invested in the ITS to construct inner capabilities such as process effectiveness, knowledge management and enhancing relationships with providers, clients and company partners. The ITS has increasingly been seen as a source of competitive advantage and a critical enabler for business agility in the BRT system (Zhang, Zhao, Kumar, 2016).

A general agreement was reached that the ITS activates BRT agility by speeding up decision-making, facilitating communication, and reacting rapidly to altering market circumstances – offering adaptive organisational "wiring" and building digital alternatives (Sambamurthy et al., 2003). Researchers also observed that the ITS could hinder and sometimes impede the agility of the BRT system (Zhang P, Zhao K, Kumar 2016). For centuries, the ITS business value has been one of the top issues of BRT stakeholders. Numerous studies have recorded the beneficial impacts of the ITS capability on organisational performance, but understanding of the procedures through which such gains are accomplished remained restricted, owing to an absence of focus on the company setting (Suzuki et al., 2010). Therefore, such a connection remained topic of discussion in the ITS literature. The ITS was viewed by researchers and professionals as a competitive instrument (Zhang P, Zhao K, Kumar, 2016). There is still uncertainty surrounding current information on the ITS capability mechanisms affecting the efficiency of South Africa's BRT system.

1.2. RESEARCH PROBLEM AND ITS SIGNIFICANCE

Due to rises in population density, traffic congestion, related pollution and intensification of land use, there was pressure in the South African government to find efficient ways to move passengers, decrease travel time and in turn increase travel time and the number of stops. In order to enhance speed and service reliability, the BRT system was introduced in South Africa as an enhancement on the regular bus service. Many nations have embarked on BRT systems to make travelling for commuters more efficient and convenient. Smart transport systems were often seen as the solution to many transport issues. However, to ensure that the solutions of smart transportation systems are sustainable, they need to be implemented holistically, taking into account the operational, institutional and technical aspects (Rahim, 2014). The ITS introduces a set of difficulties not observed in most kinds of transport policies. The ITS places a heavy emphasis on activities that are not used by many transport departments.

Information systems, for example, pay more attention to maintaining credibility for the public and other consumers. The patronage numbers of the BRT systems in South Africa have stagnated for some time. Most studies conducted on the connection between the ITS capability and business agility relates to organisations in large countries. No study has been performed on ITS capability and business agility in South Africa, specifically BRT research. The need for an adequate level of business agility to respond proactively or reactively to uncertain internal and external occurrences and possibilities is increasingly felt by managers (Nuzzolo & Comi, 2016). The overall research problem is that the ITS has not properly resolved the operational difficulties in terms of enhanced mobility, security, reliability, effectiveness and quality of the environment. Estimating the effect of the ITS capability is not simple. Limited practical experience results from the reality that the ITS is still a fairly new field in South Africa. Current expectations are based primarily on exercises for modeling.

By demonstrating the value produced by the ITS capabilities, the argument that the ITS capacities were merely a cost center that provided support for BRT policies was contradicted (Kulatilaka & Venkatraman, 2001). It was also evident that the greater the value, the more ITS capabilities and BRT agility were aligned with each other. These BRT systems achieved a greater degree of alignment have often been connected with excellence in performance (Silvia et al., 2005). There have been distinct studies demonstrating both beneficial and negative effects in the performance of the BRT system in relation to the ITS capability. Nuzzolo & Comi A, (2016) showed a substantial beneficial impact of the ITS skills on the agility of the BRT systems in their assessment. Another favorable strategy was released in the Harvard Business Review (2008), in which Mcafee expressed that investments in certain techniques gave a competitive edge as competitors not only matched the movements, but used technology to create more effective ones.

Despite these problems, the BRT's planning and execution was often seen as an engineering issue concentrated on providing segregated BRT transportation methods, procurement of state-of-the-art vehicles, and complicated ITS applications (Galliers, 2007). The main focus was on the BRT's "hardware" rather than the market and facilities that are the most significant criteria for planning and design, or the critical shifts in institutional and governance and the political and technical champions needed to effectively plan, implement and operate BRT systems (Giuliano & O'Brien, 2004). Past studies on the connection between the ITS capability and BRT agility has usually been in favor of the ITS capability being an enabler or enhancer of BRT agility.

Nuzzolo & Comi (2016) discovered the ITS to be a BRT agility enabler. Some scientists have observed that the capabilities of the ITS may weaken the agility of the BRT systems. Galliers (2007) observed that inflexible legacy systems and rigid ITS architects restricted the BRT agility. In general, the ITS was regarded an enabler of the agility for a company. A typical assumption was that a BRT system would be more agile with higher ITS capability. It was not unusual, though, that the ITS also hindered organisational agility and at times even impeded it. This clarified why the ITS capabilities in many BRT businesses hampered business agility. Insufficient agility levels, for example due to unreliable service, have numerous adverse impacts on their company performance.

The ITS capabilities enabling company agility gave the BRT system a competitive benefit by shortening travel time from point A to point B. For instance, the BRT system uses the ITS capabilities to enhance their efficiency (McAfee et al., 2004). The study focus investigated and analysed the connection between the ITS capacity and BRT agility as a competitive edge within the South African transport industry.

1.3. The aim and objectives of the research

In view of the problems discussed and outlined with respect to intelligent transport system in the South African BRT system above, the research aim and objectives are outlined as follows:

1.3.1. Aim of the research

The objective of the research is to determine, by means of a comprehensive literature review what functional or critical factors will ensure Business agility within the BRT in South Africa. The study evaluates the impact of the introduction of intelligent transport system on the efficiency of management and operations of the BRT system in South Africa. These factors will further more be utilised to compile a framework that will align ITS capability with the BRT in South Africa.

1.3.2. Specific objectives of the research

Research on the ITS capability in South Africa has been restricted. The increasing interest and investment in the ITS warrants a closer look at the industry and the potential advantages to the BRT system in South Africa. In South Africa, the aim of the ITS was to take advantage of appropriate technology to generate intelligent vehicles and users. One significant effect integrating automated transport system into public road transport enables communication with ground stations to obtain road scheduling traffic circumstances. However, the ITS was expected to optimise the efficiency of the BRT network and further enhance the efficiency of travel times – leading to modifications in travel behavior that could decrease externalities such as unreliability and congestion (Pendyala & Bhat, 2012).

The primary goal of this thesis was to explore whether the ITS capability benefits the agility of South African BRT systems. This study seeks to foster higher knowledge or insight into the aspects of BRT agility, ITS capabilities and the connection between ITS capabilities, business agility and results of business agility in relation to uncertain occurrences. As secondary objectives, the researcher aims to enhance the understanding and importance of successful ITS and BRT alignment in South Africa towards Business agility and Performance.

The study offered testable proposals that could be used by other BRT stakeholders to create justifiable causal explanations and research. Given the primary goal of the abovementioned study goal, the Research particular goals are described as follows:

I. To determine the complementarity of the ITS capability and business agility in the South African BRT industry;
II. To measure the extent of the ITS capability;
III. To examine the relationship between the ITS capability and BRT agility.

IV. To present a functional and a credible framework model to improve relational and systems integration efficiency

1.4. Research questions

Several questions need to be answered before this main question is addressed. To facilitate the research objectives, the following research questions will seek to determine:

I. To what extent has the introduction of the ITS been able to make the BRT system in South Africa agile?
II. Does the ITS capability impede/enhance customer-market orientation agility within the BRT?
III. Does the ITS capability impede/enhance operational agility within the BRT?
IV. Does the ITS Infrastructure capability enhance/weaken the BRT agility?
V. Does the ITS business capability enhance/weaken the BRT agility?
VI. Does the ITS innovation capability enhance/weaken the BRT agility?

To address the specific questions for the research, hypothesis was formulated to understand the relationship between the ITS capability within the BRT agility in South Africa.

1.5. Hypothesis

The paper tested the hypotheses that high ITS capability increases agility in market orientation, allowing the BRT to be agile and flexible in South Africa to satisfy business requirements. The author further evaluated the ITS capability hypotheses to improve operational agility, allowing the South African BRT to rapidly reconfigure its inner company procedures to react to market modifications. The hypothesis that will be addressed by the research will be as follows:

"Uptake of ITS capability by BRT in South Africa can be facilitated by a high quality transit service with reduced in-vehicle time and safe operation"

Hypothesis 1: ITS capability is correlated with market orientation agility in the BRT (The greater the ITS capability, the higher the market orientation agility in the BRT)

Hypothesis 2: ITS capability is correlated with operational agility in the BRT (The greater the ITS capability, the higher the operational agility in the BRT)

To realise the values presented above, a research methodology was designed. The process of designing the research is discussed in the following section.

1.6. Research process and methodology

Foster (2007) outline the research structure and describe research as a process that starts with a problem within the researcher's general area of interest. It then follows a progress to the development of a plan, a review of related research findings, predicting and defining the potential outcome of the process and then starting and eventually concluding the actual research process. Cooper, et al, (2011) define business research as a systematic inquiry whose objective is to provide the information that will allow managerial decisions to be solved. While Sekaran (2000), describes business research as a systematic and organised effort to investigate a specific problem that needs a solution. Mouton (2001), views business research as how to solve real organisational problems. The researcher supports all the above definitions around business research and views business research as a mind-set change of the employees working for the organisation.

The traditional way of doing business often resulted in employees transferring work issues to managers and supervisors rather than solutions to problems. Business research intends to change such a paradigm. Research is therefore a systematic process of collecting, analysing, and interpreting information in order to increase understanding and knowledge of a specific phenomenon, Kruger (2001). This thesis utilised research tools, methods and reasoning in an attempt to answer research questions and as such develop the approach as proposed in Figure 1.1- Research construct model. The paradigm used for this paper was a phenomenological paradigm because the emphasis is on data quality and debt. The phenomenological paradigm focuses on understanding human behaviour from the participants' own frame of reference (Collis & Hussey, 2003). Most of the information gathered was qualitative data.

The purpose of the thesis was resolved in this regard through desk research. To define the fundamental theories, the desk research started with BRT-related textbooks. In addition, papers in publications discuss applicability, benefits and disadvantages, and restriction of the BRT system's intelligent transport system. Using primary and secondary information such as questionnaires, observations, publications and prior research linked to smart transport systems was used to gain an in-depth knowledge of the BRT's smart transport system's operational leadership.

The information collected was evaluated using the Statistical Package for Social Sciences (SPSS) with the help of Microsoft Excel using descriptive statistics, regression analysis, cross tabulation and chi-square testing. Tables, charts, and maps were used to present this. Qualitative data was evaluated using a thematic strategy. The research echoes the need for fast public transportation systems to provide lessons to improve and adopt smart transportation technologies. As an end product, the study provided a structure on how to integrate ITS in the context of Bus Rapid Transit Systems. The area and scope of the research, and steps required for the process that will be utilised for the study will focus on what is required in terms of the research question as indicated below:

Step 1: Exploratory study as a separate first stage with the objective to define the research questions and to develop the research project.

Step 2: Descriptive study utilising a comprehensive survey determining the, who, what, where and when in terms of Intelligent Transport System Capability.

Step 3: Literature study of the South African transport system, main dimensions the BRT system (Operation agility and operations Agility) and the Intelligent Transport system Critical Factors (ITS infrastructure capability, ITS innovation capability, ITS and Business capability) as defined in the descriptive study.

Step 4: Survey questionnaire consisting of valid items, via feedback from stakeholders, process owners, managers, custodians, administrators related to the BRT and ITS.

Step 5: Evaluation of content relevancy, validity, and reliability and descriptive statistics of the main model dimensions and Critical Factors contributing to BRT agility.

Step 6: Evaluation of content relevancy, validity, reliability, and descriptive statistic's analysis of priority factors-items and occurrence factor-items contributing to BRT agility.

Step 7: Performing the necessary statistical analysis and reports on BRT status findings.

Step 8: Organisation analysis and testing of the hypothesis.

Step 9: Finalisation of the thesis.

The study used a deductive strategy where current literature was used to define what data is needed from participants and to develop a set of hypotheses on the conceptual model of the study. These hypotheses were tested through a quantitative study using information collected. The investigative tool was the suitable research methodology for this study. Because the unit of analysis was at an industry level that meant face-to-face interviews proved to be difficult to conduct for this type of survey, the questionnaire approach is therefore more practical and provided data within a short space of time, bearing in mind that the research was conducted during the festive season.

The study conceptualised three-dimensional ITS capacity (ITS infrastructure, ITS & business development and ITS innovation & orientation) and further conceptualised two dimensional business agility (market orientation agility and operational agility) – see Figure 1.2. Outlines the research construct model, enabling the research to answer the research question.

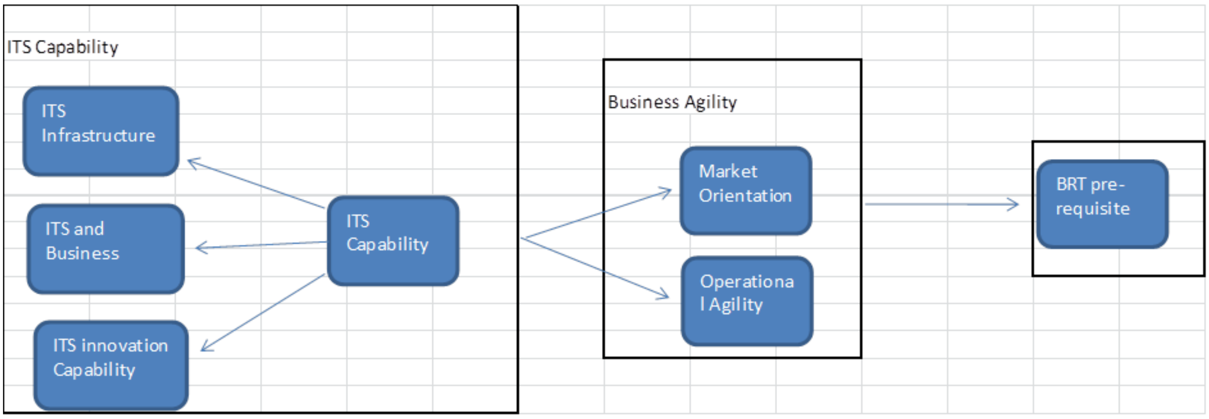

Figure 1.2- Research construct model, source: author (2016)

A fixed, non-experimental strategy was used in the research design. It also embraced the cross-sectional method of studies with the unit of analysis at the level of the sector. Correlation assessment was considered more practical and a suitable method for testing the connection between autonomous and dependent variables. Confirmation of the hypothesis was endorsed by a field study carried out on the basis of a quantitative study.

The desk research findings assisted with the design of the questionnaire. The questionnaire were circulated to all sampled South African BRT system stakeholders. The approach to phenomenology engaged the fundamental assumptions about problems that are affected, perceived and felt by respondents (Saunders et al., 2000). The questionnaire implemented in the study used a five-point Likert, which was deemed suitable for clear response determination. The information acquired was analysed using the SPSS program of statistical analysis. The purpose of the study was to find out whether the research question was agreed or disagreed. Finally, in the context of the impact on the hypothesis, the findings of the study and evaluation were discussed and a framework model was developed.

1.7. Chapter layout of research

The thesis is designed to allow logical arguments from defining the problem to proposing a scientific solution based on statistical as well as theoretical valid results. The dissertation is structured into five chapters.

Chapter one, the introductory chapter encapsulates the context, motivations, research questions and the scope of the study along with an outline of the dissertation. This is an introduction to the dilemma faced by the BRT in South Africa in ensuring it remains agile at all times. This chapter identify and highlight research questions, the scope and focus of this the research.

Chapter Two looks at the theoretical background to this topic's key problems. The consulted literature offers a background to urban transportation and sustainable urban transportation and examines other BRT technologies from both South Africa and around the globe, analysing system achievements and failures in distinct environments.

This section analysed the background of public transportation in South Africa and especially the growth of the BRT and the ITS as a whole. The literature also examines the connection between the capacity of the ITS and agility of BRT.

Chapter Three presents and justifies selected and applied research methods used in the study. The chapter further presents the research hypotheses, research strategy and design

Chapter Four provides the information collected for this research study to be analysed. Data on the on the ITS capability impacts on the BRT system agility are provided and conclusions were drawn on the effect in South Africa. Furthermore, the chapter describes results using frequencies, descriptive and inferential statistics

Chapter Five presents a critical analysis of research results in the context of strategic objectives of BRT systems. The analysis is presented with supporting literature; additionally, it provides an overall discussion of Intelligent Transport System within the South African BRT. The research explains the application of the analysis tools, and factor analysis. It also provides a comprehensive analysis of results of all critical factors identified, researched, analysed and evaluated.

Chapter Six presents the main findings of the research, drawing conclusions and suggestions for future research on BRT projects. Actionable recommendations are suggested and further research recommended.

1.8. Scope of the research

This research investigated the ITS implemented for the BRT systems in South Africa. The study covered both the ITS which have already been implemented and those which were under implementation. This study considered the current the ITS from the viewpoint of the technology only. The study did not cover any ITS implementations in the taxi industry and commuter bus operators such as municipal buses and Putco), nor the commuter rail network and Gautrain. A multitude of other factors not associated with information or communication also influence mobility and one's sense of assurance while traveling and, thus, were not addressed in this thesis. Examples included aspects of the built environment such as accessibility, lighting, station design, landscaping, cleanliness and maintenance, all of which influence both the perceptions and reality of safety and security of a BRT.

Based on the dynamic capabilities perspective and the view of a hierarchy of capabilities, this research proposed a model to examine how the ITS capabilities affect BRT agility in the South African transport context. The research was limited to the transport industry in South Africa focusing specifically on the BRT system. Therefore the findings from the literature review were limited to South African BRT industry. This dissertation focused on the public transport industry and explored the theory that the ITS capability enhance/weaken the BRT agility within the South African Public Transport within which the research context is based. The research confirmed whether ITS capability and BRT agility are the contributing positively to the transport industry in South Africa.

1.9. Significance of the research

The study attempts to explore whether the use of the ITS improved the running of the BRT system. It was undertaken to evaluate the impact of the challenge on the operations and management of the Bus Rapid Transport in South Africa. The aim is to evaluate the functioning with the ultimate goal of making general consideration on the usefulness of ITS. The findings of this study are likely to add to the existing literature on the operational management of BRT through intelligent transport system, as it investigates not only users of the system, but nonusers experience as well. Additionally, this study on the BRT is a qualitative study and is concerned with the opinions and experiences of stakeholders in order to provide an account of the social and economic effect of intelligent transport system in the BRT. Since this study on the BRT was intended to verify whether the aims pertaining to the implementation of the system were achieved the findings are significant for the following reasons.

It was anticipated that the BRT would provide a solution to the problems of the existing transport system. The findings of this study will add to existing literature on transport geography as it investigates not only users of the system, but non-users experiences which have been investigated. Additionally, this study on the BRT system is a qualitative study and is concerned with the opinions and experiences of stakeholders in order to provide an account of the social and economic effect of the South African BRT system.

1.10. Contribution of the study

The importance of the study is mainly to compile a comprehensive framework, and road map that form the basis of optimisation models to ensure Business agility within the BRT. This research provided the BRT industry in South Africa, research community, central and local government and transport operators with up to date insight into current ITS research and applications. This enabled decision makers and others to move towards applications with a greater understanding and confidence and to promote the research and development necessary for future deployment. This research promoted an understanding of effects of ITS adoption on the performance of a BRT system.

This research has assisted interested groups and individuals who:

- Would like to improve their understanding of ITS in relation to the BRT in South Africa
- Seek to understand the implications of ITS for the operation of the BRT in South Africa
- Seek to understand the perspective on, role in, and investment approach for ITS
- Are considering investing in ITS themselves.

This research had relevance and contributions for both the scientific community and the business community. This approach yielded an explanation of how, why, and when the ITS was related to BRT agility (performance) from the perspective of multiple varying views of causality and methods for argumentation.

The managerial contribution of this research project was to provide managers insight into the event types that can cause a need for agility, the conditions under which ITS can support a BRT's sensing, responding and learning and also the potential personal and structure frictions and rigidities, which might hamper business legality performance. The results provided managers with objective insights, trade-offs and building blocks for designing and managing IT'S as a means for business agility. This study provided a framework and issues of importance which could assist in building strategies and assessing internal capabilities.

The study helped decision makers and practitioners understand the most difficult issues in the challenging environments of developing cities, issues that are rarely addressed in the literature. The study proved to be a useful tool for those contemplating new BRT systems because added to the body of knowledge that has up to now focused on the "hard" engineering aspects of BRT. The industry gained invaluable knowledge on the link between the ITS capability and BRT agility.

1.11. Limitations of the study

The study evaluates the impact of the introduction of the ITS on a BRT along certain traffic routes and not all the networks such as taxis, buses, private vehicles, trains and pedestrians in South African municipalities.

1.12. Chapter summary

This chapter introduced the theme. It outlined the background of the study with respect to the South African BRT system and the ITS. It defines the research statement of the problem, the aim, objectives, research questions, scope, and significance of the research, the limitations and the definition of terms. It has also presented the scope and limitation of the research. The next chapter addresses the literature review anchoring this study.

CHAPTER TWO

LITERATURE STUDY

2.1. Introduction

The theoretical framework comprises of four components to fulfill the objective of the dissertation. It begins with an introduction to the transport sector. Second, the subject of technology implementation is presented, followed by an ITS research, fields and functions of their applications. The theoretical framework concludes with a review of present performance measurement methods in the design, execution and use of measurement stages as well as a summary of prevalent pitfalls in performance measurement. This section provides literature on the study region, South Africa with regard to municipal areas, transportation condition, South African BRT features, policy outlook and associated legislation, and business agility. This literature research provides a discussion on urban transport and highlights the use of the capacity of the ITS within the BRT system worldwide and locally (South Africa).

The aim of undertaking this literature review was to promote a thorough assessment of data gathered from the BRT stakeholders' experiences and views with the aim of interpreting the study results. Due to the dearth of apartheid literature in South African cities, data over ten years of age was needed. In order to alleviate many of the environmental, financial and social issues encountered in metropolitan areas that are evident in both advanced and developing nations, it is essential for each city to have an effective public transport system. This chapter is organized into three major parts. The first chapter offers a transport geography theoretical framework. Transport's role in developing countries development and transport problems is discussed. The development of the South African public transport system and the challenges and opposition in the South African context to the application of the BRT system will be examined. This review of literature will start with an examination of the role of transport in the geography discipline.

2.2. Bus Rapid Transit system

2.2.1. Defining Bus Rapid Transit

The word "BRT" arose from its implementation in North America and Europe. However, the same concept was also expressed through distinct names around the globe. With many road networks having little capacity to build more highways, concerted attempts are being made to enhance the effectiveness of current facilities (Booyes et al., 2013). While the conditions may differ from country to country, the same fundamental premise is being pursued: a high-quality, car-competitive, accessible transportation service. In this section, the word "BRT" will be used to define these kinds of systems in general. It was acknowledged, however, that the concept and term will certainly continue to develop (Rahim, 2014). Perhaps BRT's main focus on the customer was the most obvious distinction between BRT and other transportation facilities.

BRT systems are designed for speed, comfort, convenience, cost and security depending on the customer's requirements rather than for a particular technology. In reality, BRT is a set of traits of best practice from a range of alternatives for mass transit. This system therefore included examples from different mass transit applications to present a set of system features that best suits customer expectations (Deng & Nelson, 2013). While BRT uses rubber tire vehicles, with standard urban bus systems, it has little in common. The extent to which the above characteristics are effectively used within a system will be dictated by local conditions.

Small and medium-sized cities may discover that it was not possible to accomplish all of these characteristics within the limitations of budget and capability. Nevertheless, first satisfying customer demands was a premise that all cities should follow in building a successful transit service, regardless of local conditions. Today, cities seeking cost-effective transit alternatives are progressively using the BRT concept. As new experiments in BRT emerge, the state of the art in BRT will undoubtedly continue to evolve. However, the customer focus of BRT will remain a defining characteristic. High-quality BRT systems developers in cities such as Bogotá, Curitiba, and Ottawa astutely noted that the ultimate goal was to transport individuals rather than vehicles quickly, effectively, and cost-effectively (Deng & Nelson, 2013). BRT is a high-quality bus-based transportation system that provides quick, comfortable and cost-effective urban mobility by delivering rapid and frequent service of segregated right-of-way infrastructure and marketing and customer service excellence.

The BRT is a municipal project directed at enhancing public transport, decreasing public road congestion, enhancing the environment and generating employment. Busses run along specific paths to ensure service speed, while the stations are intended to be spacious and welcoming. High-quality infrastructure, effective activities, advanced technology, marketing excellence and customer service are elements that make up the BRT concept. Shongwe (2007:2) describes the Bus Rapid Transit System (BRT) as a flexible, rubber-tired fast transit mode that combines stations, cars, facilities, running methods and smart transport system components into an integrated system with a powerful positive identity that evokes a distinctive image. One innovative strategy is the use of buses, rather than light and/or heavy rail, in an integrated, well-defended system. Bus Rapid Transit (BRT) is a contemporary urban passenger transport system with a constantly increasing worldwide significance owing to evidence of the ability to implement mass transportation capacity rapidly and at low-to-moderate costs.

Perhaps the most comprehensive and concentrated definition of what BRT intends to be is the one that addresses it "as a rubber-tired rapid transit service that incorporates stations, vehicles, running ways, a flexible working schedule, and technology into a high-quality, customer-focused, regular, fast, reliable, convenient and cost-effective service" (Canadian Urban Transit Association 2004). Specifically, BRT refers to schemes that apply rail-like infrastructure and operations to bus services in anticipation of services that may include elevated service levels, segregated traffic rights, station-like platforms, high-quality facilities, and smart transport systems for a fraction of fixed rail costs (Currie & Delbosc 2011).

This cautious phrase implies that "BRT is not necessarily transformation as such, but a means of conversion" (Mejia-Dugand et al., 2013). A combination of infrastructure and service-oriented components which, in theory, bridge the best that light rail and buses have to deliver together is the prerequisite for the formation of mass transit systems capable of reacting to rapidly changing mobility requirements with a powerful favorable identity which evokes a distinctive picture (Levinson et al., 2003). BRT applications are intended to suit the markets they serve and their physical environment and can be applied in a multitude of environments and kinds incrementally. Due to the inherent flexibility benefits of rubber-tired buses, for example, unlike rail systems, the same vehicle that operates as a line-haul carrier can also morph into a neighborhood feeder BRT is also suitable for many lower density regions (Cervero & Kang 2011). However, BRT's huge potential could be used at its highest pace in congested metropolitan settings where more costly modal alternatives such as light rail could not provide appropriate mass transit services to road users.

Bus Rapid Transit System is therefore a homogeneous system of facilities, services and amenities that has the ability to become a much more competitive alternative to car oriented mobility than standard busses, to the extent that it can redefine a city's very identity. Cervero (2010) claims that the BRT system is an incrementally improved mode of transportation, offering quicker, more passenger-friendly service. This is accomplished in various ways, including improving infrastructure, road use of vehicles and stops / stations; using cleaner, quieter and lighter vehicles; and combining ITS techniques. A BRT system's objectives are comparable to other fast transit systems ' objectives. The service must be quick, offering passengers with reduced travel times. Other BRT service objectives, however, can provide a significant rapid transit service.

2.2.2. Bus Rapid Transit (BRT) background

Rapid motorisation and increasing ownership of vehicles are becoming increasingly important contributing factors to the traffic congestion encountered in cities around the globe, particularly in developing nations. This phenomenon required the need for innovative sustainable alternatives that encourage urban public transport. One such innovation is the development of BRT systems that have gained popularity in Latin America, Asia, and gradually in Africa over the years. The BRT was intended to play a leading role in transforming city-wide public transport into a position where it became the preferred mode of travel for most residents and made a significant contribution to the city's most effective growth as a whole.

While some city officials succeeded in implementing it, others failed because of economic, political, regulatory, and institutional difficulties. According to Rahim (2014), communities are looking for fresh and innovative solutions to tackling increased urban congestion and related pollution while offering efficient and effective transport alternatives. It is expensive and disruptive to add more roads and is not always an environmentally sound strategy. However, light rail rapid transit systems, which are of concern to many groups, involve substantial original capital investment and may not be an effective solution to all urban transport issues.

Transit busses provide an important transport service in metropolitan areas, but are often regarded as slow and unreliable. It is essential to realise that a well-known globally implemented transport system is the BRT system. (Mabena, 2010). With no less than forty BRT systems now working in Latin America, North America, Europe, Australasia and Asia, the BRT systems are gaining popularity around the globe. More than eighty systems, including those in London and New York City, are in the planning phase. Most of the structures are components of a new city development and redevelopment global trend called transport-oriented development (TOD). This is based on successful South America initiatives that began in the 1970s in Brazil. The system emerged as a necessary alternative for countries to decrease traffic emissions, especially the rising number of private cars. It provided a cost-effective alternative for metropolitan traffic, complementing the rail network with one tenth of the construction cost of a rail scheme. Successful BRT systems have enhanced travel times in these cities in Bogota and Brazil, decreased the amount of accidents and contributed to enhanced air quality.

The main distinction between a bus system and a BRT system is the latter works on dedicated bus lanes. A regular, faster and congestion-free ride is available to passengers. In the late 1970s, the first BRT system was set up in Curitiba, Brazil, and has now spread throughout the world to a few dozen cities. These systems use advanced techniques to optimise flow, movement of passengers, ticketing, scheduling of buses. The effectiveness of the system and the large capability of transported passengers depends on the system as a whole and not necessarily on the bus size, although articulated buses could easily be used when required. BRT is a customer-oriented high-quality transit that provides effective, low-cost and rapid urban mobility.

It is possible to implement these systems at a fraction of the cost of elevated or underground rail systems. Such systems have the following features: segregated bus routes, rapid boarding and lighting, effective fare collection, comfortable and effective shelters and stations, use of clean bus technologies, and flexibility in routing. Such systems considerably improve the ability of current bus systems and can be deployed over a relatively brief time period of 1-2 years. Traveling by bus becomes more common when lanes and entire corridors are devoted to bus use.

However, BRT is a very demanding transportation alternative that could alter the balance of a city's entire transportation network. This is because, in favor of bus facilities, BRT would reorient something as restricted and valuable as the provision of road space. This will clearly have a serious impact on the remainder of road traffic if a crucial modal change is not accomplished. Using the ITS has become the system's essential component.

2.2.3. Components of a BRT system

BRT systems vary from city to city because the design of the system depends on the requirements of the city's commuters, road networks, patterns, routes and, whether the city councils in which the BRT is accessible, have policies in place and accessible economic resources (Cabrera, 2010:12). BRT systems literature indicates that while systems may vary in design, route and size, the fundamental elements of BRT systems in each city are comparable.

BRT technologies could vary from BRT-Lite's to full-service BRT technologies depending on the variables listed above by Cabrera (2010) (Thole & Samus, 2009:23). A complete BRT system is ranked as the highest of BRT systems. The minimum features of a full BRT system are a designated bus route that is generally located in the center of the road (medium lanes), an integrated network of routes and corridors, enhanced safe stations, level access, pre-board fare collection, fare and physical integration between routes, corridors and feeder facilities, and limited entry to prescribed operators within a range of conditions.

Plate 2.1. Illustrates seven elements that that are discovered on some of today's most effective BRT systems. These include Exclusivity of Running Way, Advanced Bus Technologies, Improved Fleet Management Technology, Distinctive Aesthetics or Amenities, Faster Fare Collection and Boarding, Integrating Transit Development with Land-Use Policy and Innovative Project Delivery Methods. An enhanced BRT system that reflects full rapid transit objectives would include all of the elements stated above while a low cost, basic BRT system would have some of the features. However, the challenge now lies in the fact of developing a BRT system that meets transit objectives without sacrificing the quality of any of the features mentioned above.

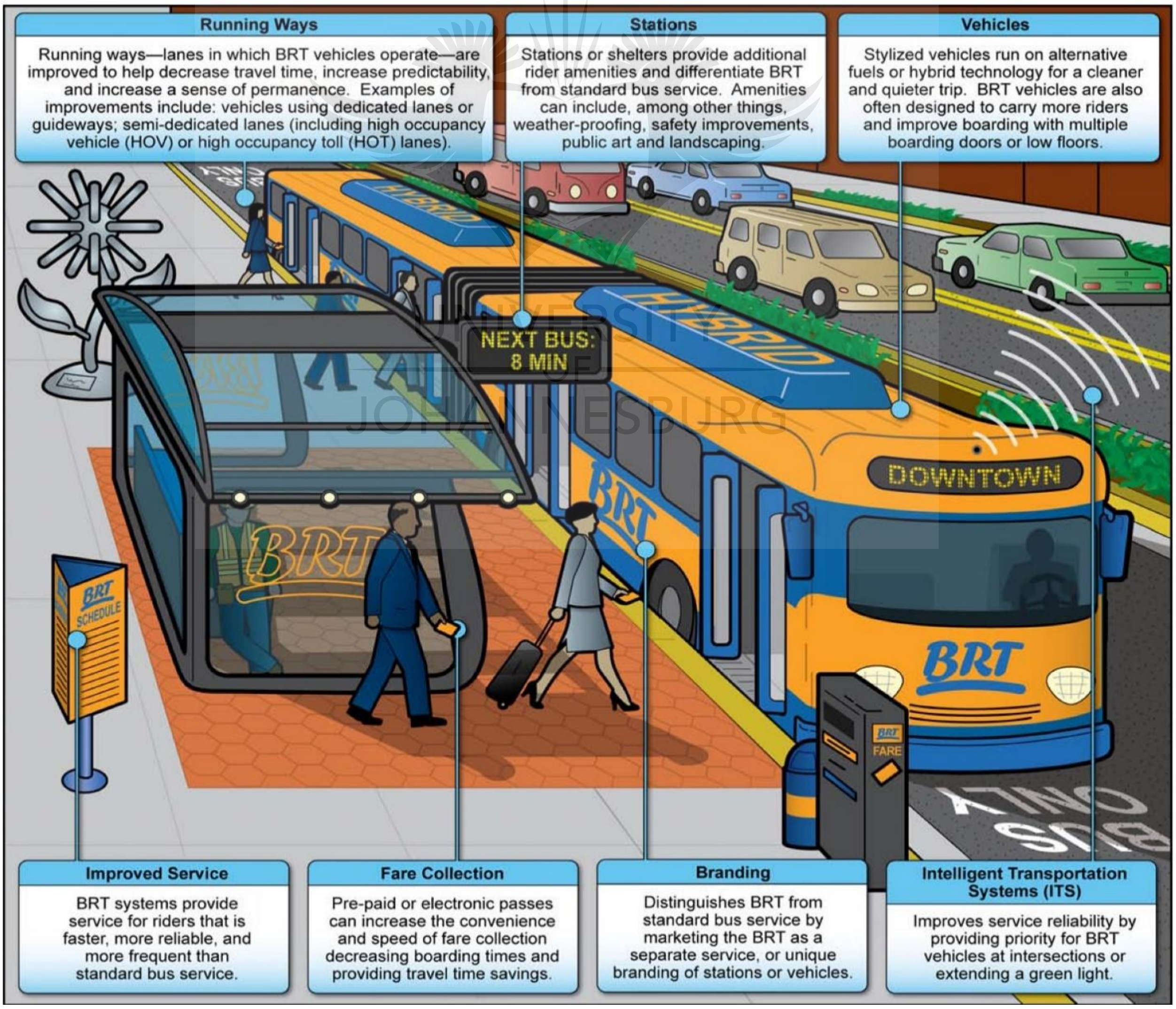

Figure 2.1: characteristics of bus rapid transit (BRT) system. Source: Naidoo (2011)

In the context of Naidoo (2011), the BRT was intended to tackle traditional bus services' sources of delay and be an appealing passenger service. Today, cities seeking cost-effective transit alternatives are progressively using the BRT concept. The state of the art in BRT will certainly continue to develop as fresh experiments in BRT arise. However, the client focus of BRT will probably remain its defining feature. The history of BRT lies in a number of past attempts to enhance the customer's transportation experience. As Wright (2002) indicated, the primary features of BRT systems are segregated bus lanes, fast boarding and lighting, clean, safe and comfortable stations and terminals, efficient pre-board fare collection, effective bus operator licensing and regulatory systems, clear and prominent signage and real-time information displays, intersection transit prioritisation, modal integration

With all the enabling features in mind, authors such as Thara (2015) give credit to BRT systems for enriching the lives of customers. Zhou (2011) also commends the BRT system for low prices, quick building cycle, and flexible development. These advantages are often the interests of lawmakers and decision-makers. This makes BRT a transport development strategy that cannot be overlooked by modern economies. Wright (2002) further uses the Curitiba system as an example of BRT which comprised the following main characteristics: simple route structure, frequent service at all times of the day, headway-based as opposed to time-point schedules, less regular stops, level boarding & lighting, color-coded buses & stations, exclusive lanes, higher-capacity buses, multi-door boarding and lighting, off-vehicle fare payment.

2.2.4. Barriers to BRT

BRT's track record offers a compelling case for more cities to consider it a transit priority when measured in terms of financial, environmental and social advantages. However, there are still several obstacles as a fresh idea that have prevented wider spread of BRT (Jennings, 2015). These obstacles specifically include:

- Political will
- Existing operators
- Institutional biases
- Lack of information
- Institutional capacity
- Technical capacity
- Financing
- Geographical / physical limitations.

The most significant ingredient in making BRT system successful is by far political will. Overcoming opposition from specific interest organisations and overall inertia against change is often an insurmountable barrier for mayors and other authorities. Rail and automotive lobby groups can create a strong political argument against the application of BRT systems. However, the political benefits can be excellent for those government officials who have made a dedication to BRT systems. In cities like Curitiba and Bogotá, the political leaders behind the BRT systems have left a lasting legacy to their cities, and these representatives have been rewarded with enormous popularity and achievement in the process.

While cars can account for less than 15 percent of the transport mode's share of a growing city, owners of such cars are the most important socio-political grouping. It may seem that the concept of prioritizing road space to public transport is contrary to private car owners ' interests. However, separating public transit vehicles from other traffic can often enhance personal vehicle circumstances (Jennings, 2015). Since public transit vehicles stop more frequently, separating these vehicles from mixed traffic can effectively enhance flows for all. Existing transit operators may also be a significant political obstacle to the application of BRT systems. Such operators may be quite skeptical about any change, particularly when the change may have consequences for their own profitability and even viability. The current operators took to violent road protests in cities like Johannesburg to counter the growth of the BRT system. Likewise, through recall attempts and intense lobbying, private transit operators have put pressure on political authorities in other cities. It should be observed, however, that there may be more perception of the risk to current operators than actual.

An efficient outreach effort with the operators can assist dissipate unfounded concerns in most instances. By improving profitability and better working conditions, existing operators can benefit significantly from BRT. Within the suggested BRT system, current operators can compete efficiently to win operational concessions. A barrier to BRT implementation may also be represented by professional staff within municipal agencies. Such employees often do not use public transportation as the main means of transport. Rather, municipal representatives are part of an elite of the middle class that has the purchasing power to purchase a personal car. Often, therefore, the experts responsible for planning and developing public transit systems do not use public transit. This absence of familiarity with the requirements and realities of transit users can lead to less than optimal design of public transit.

Such employees may also unwittingly offer individual motorised travel financing and design preference as this mode is the one they are most acquainted with. Despite the increase of worldwide data networks, an absence of understanding of alternatives such as BRT continues a very true obstacle. The lengthy period between the growth of the system in Curitiba and the realisation of BRT by other cities is proof of this data shortfall. BRT's awareness has increased significantly in recent years through the help of global agencies and non-governmental organisations. Visits of African and Asian city officials to Bogotá helped catalyze fresh BRT initiatives. However, many developing cities still lack fundamental data about understanding BRT's potential. The absence of information on BRT at the municipal level is often directly related to the absence of ability for human resources.

Many significant developing cities ' transport departments have to deal with a broad range of problems with only a handful of employees. Locally lacking institutional and technical capacity inhibits agencies ' ability to consider BRT even when there is general awareness of the chance. Financing is typically less of a BRT issue than other alternatives for mass transit. First, BRT is a comparatively low-cost alternative within most developing cities' financing ability. Second, BRT's operational cost efficiency implies that many regional and multi-lateral organisations are quite prepared to fund such projects.

The absence of continuing operational subsidies with BRT, unlike other alternatives, means that project sustainability can often be guaranteed at local level. Different local circumstances, such as urban, geographic and topographic variables, may also pose obstacles to the application of BRT. Extremely tight roads and steep mountains, for example, can present difficulties in design. Overall, however, each of these problems has technical alternatives. Local circumstances involve local alternatives, making each BRT project unique in the end. The provision of public transportation facilities in many developing world cities often does little to meet the population's travel requirements, especially low-income citizens (Palmer, 1997; Wright, 2004).

In developing world cities, road-based public transport is distinguished by a multitude of informal and formal vans, mini-busses and full-size buses (Wright, 2004), and facilities are usually poor and often considered insufficient. Standards of safety, safety, comfort, convenience, regularity, punctuality (where schedules apply), reliability and speed are often small, and low revenues also lead to issues with tariffs being affordable (Behrens et al., 2004; Eugenia, undated; Fouracre et al, 1999; Iles, 2005; Palmer et al, 1997; Wright, 2004). According to Iles (2005), the general public is also dissatisfied with the quality of public transport facilities in many developing countries. Wright (2004) defines the following shortcomings in the present facilities that usually complain about by public transport clients;

- Inconvenience in terms of location of stations and frequency of services;
- Failure to service key origins and destinations;
- Fear of crime at stations and within public transport vehicles;
- Lack of safety in terms of driver ability and roadworthiness of public transport vehicles;
- Service is much slower than private vehicles, especially when public transport vehicles make frequent stops;
- Overloading of vehicles makes ride uncomfortable;
- Public transport can be relatively expensive for some developing-nation households;
- Poor-quality or non-existent in1frastructure (e.g., lack of shelters, unclean vehicles, etc.);
- Lack of organized system structure and accompanying maps and information make the systems difficult to use; and
- Low status of public transit services (Wright, 2004).

As stated previously, urban poor rely / depend strongly on public transportation for accessibility and mobility in most developing world cities (Kwakye et al., 1997; Sohail, 2005), and where there is a lack of accessible, appropriate, affordable, secure, reliable public transportation; there is an adverse effect on the livelihoods of the poor (i.e. a significant on their livelihood strategies) and hence on their livelihoods.

2.2.5. The benefits of BRT

In addition to affecting how the BRT system itself performs, BRT system elements also have positive benefits to the user, on the public transport system as a whole, and the communities in which BRT systems operate. The five key benefits of implementing BRT include: additional ridership, cost effectiveness and operating efficiencies as well as increases in transit-supportive land development, and environmental quality (Diaz et al., 2004; Diaz, 2009; NBRTI, undated; VMC, 2006). BRT has been widely regarded as ‘‘one of the most wide-spread urban public transportation revolutions’’ of recent decades (Jiang et al. 2012; Levinson et al. 2003). This is because BRT is a mass transit choice with considerable advantages in terms of its implementation merits but also because of its vast potential to eventually benefit in a variety of ways the urban environment for which it has been chosen.

Wright and Hook (2007) and Hensher (1999) support the perspective that BRT is a quickly growing transportation mode around the globe due to its 1) low price, 2) operational flexibility, 3) fast execution, and 4) high efficiency (i.e. reliability / speed) and effect (i.e. user satisfaction / environmental advantages). BRT system components also have beneficial advantages for the consumer, the public transport system and the communities in which BRT systems work, in relation to influencing how the BRT system conducts itself. Based on a research by the Canadian Urban Transit Association (2004), Hensher and Golob (2008) also report the potential for increased patronage and capacity, the potential for incremental execution and the induction of land use modifications as BRT benefits over other mass transit systems. It's been well documented, though. BRT systems are more flexible compared to other types of mass transit.

The fact that BRT systems have the potential to use the same operating infrastructure that could have been already in place for light rail transit systems and, at the same time, allow conventional bus services to access certain BRT infrastructure sections to facilitate interconnection and performance enhancement (Deng & Nelson, 2011). This underlines the interoperability dynamics of this mode. The BRT system's benefit over a minibus taxi is the operation of longer busses on dedicated bus routes, providing passengers with a regular, quicker, safer and congestion-free ride (Hensher, Stopher & Bullock, 2003). Rapid transit is not a mode of transportation; it is a means or mass transportation system providing a quicker service than the options available, mostly at an average speed of 50km/h or more and with a specific right of way (Iles, 2005).

The BRT system is operating successfully around the world (International Association of Public Transport [UITP] 2010) in cities such as Lagos, São Paulo, Johannesburg, Curitiba, Bogota, Beijing, Los Angeles and Taipei and continues to show that with functional and successful implementation, it can become a quality mass transit system (Adebambo & Adebayo 2009), and can serve daily travel needs at affordable rate to commuters (UITP 2010). However, the challenge lies in the fundamental development of an affordable BRT system that will not only meet transit objectives, but will do so without sacrificing service quality and commuter satisfaction.

Because BRT vehicles are rubber tired, they can operate in a wide range of environments without forcing transfers or requiring expensive running way construction over the entire range of their operation. Through this flexibility, BRT can serve a geographic range much wider than that in which dedicated BRT guideways do exist (Levinson et al., 2002). BRT can also be introduced in conjunction with a multitude of travel demand management policies, such as charging congestion or calming traffic. In addition, BRT can be more adaptable than any rail-based system to cope with changing travel patterns and is quicker to construct. An efficient system of public transit can support the advancement of a city towards social equality, financial prosperity, and sustainability of the environment.

Cities can prevent the many negative costs associated with uncontrolled growth by leapfrogging past a car-dependent development route that eventually disrupts urban coherence and a sense of community. However, there are multiplier effects beyond these advantages that can further boost BRT's importance to a municipality. BRT, for instance, can result in lower government expenses connected with vehicle emissions and accidents. Such effects include expenses that are borne by the health care system, police, and the judiciary. In turn, municipal resources can be directed to other fields such as preventive health care, education, and nutrition by decreasing these expenses (Jennings, 2015)

2.2.6. Features of BRT

Clearly, BRTs will be a main component of the future public transport networks in South Africa, but cities need to discover their own best fit and pursue multimodal, budgetary bound, sustainable plans. It is time for South African cities to have an extra tailored BRT resolution as a safe, tidy, and inexpensive option. Based on the knowledge that BRT plays a part in South African mobility (and will continue to do so), it is essential to better comprehend how BRT works in the South African context and what sort of subsidization would be required as these systems grow (Wright, 2004).

In most developing world cities, the urban poor rely/depend heavily on public transport for accessibility and mobility, and where there is a lack of accessible, adequate, affordable, safe, reliable public transport;

- There is a negative impact on the poor’s livelihoods and therefore on their household incomes;
- The poor are unable to accumulate human, physical, financial, and social assets to break out of the poverty cycle; and
- The poor are kept physically, socially and economically isolated and trapped in poverty (Booth et al., 2000; Diaz et al., 2007).

There is therefore an urgent need in many developing world cities to improve public transport for the advantage of the poor (Fox, 2000). Wright (2004) argues that BRT seeks to tackle present service deficiencies by offering a fast, high-quality, safe and secure transit alternative resulting from: Reduced travel times;

- Improved reliability;
- Upgraded human amenities;
- Improved safety and security;

- Improved identity and a quality image;
- Improved accessibility; and
- Increased capacity.

In short, BRT system elements contribute to transit objectives/ transit system performance, including reducing travel times, improving reliability, providing identity and a quality image, improving safety and security, increasing capacity and enhancing accessibility (Diaz et al., 2004; Diaz., 2009). Therefore, BRT has a lot to offer for cities in developing countries. Most importantly, BRT's enhanced accessibility and high-quality service can benefit the urban poor significantly (Fox, 2000). BRT components may differ from project to project, but the entire system should have high speed, convenience, security and reliability (Jarzab et al., 2002). Running way, stations, cars, fare collection, service pattern and identity and branding are some fundamental components (Levinson et al., 2003 & Miller, 2009). BRT's vital characteristic is running way. Running is influenced by speed, reliability, price, image and identity.

Types include:

- On-street running way, such as an exclusive lane for buses either on the curb side or on median side of the carriageway, and
- Off-street running way, such as a freeway or expressway bus lane, at-grade transit way, and grade-separated transit way or busway (Diaz & Hinebaugh, 2009).

Running Ways BRT vehicles operate primarily in exclusive transit-ways or dedicated bus lanes. Vehicles may also operate in general traffic. Three types of busways, including exclusive busways, dedicated lanes and mixed traffic.

Stations BRT stations, ranging from enhanced shelters to large transit centers. Sufficient shelter from inclement weather, seating, customer information, appropriate lighting and ample platform space for boarding, alighting and waiting are the minimum requirements.

Vehicles Quiet, high-capacity vehicles use clean fuels to protect the environment. The ideal BRT vehicle has a level of passenger comfort, is visually attractive, and is environmentally friendly.

Services High-frequency service. The integration of local and express service can reduce long distance travel times. A variety of service alternatives, including all stops route(s), limited stop service, feeder services.

Route Structure BRT uses simple, often color-coded routes.

Fare collection Pre-boarding fare collection. They allow multiple door boarding, reducing time in stations. Multi-door boarding for customers with pre-paid fare media.

Intelligent Transport System Applications of ITS technologies include automatic vehicle location (AVL) systems, passenger information systems, and traffic signal preference at intersections. A collection of computer and communication technologies that can enhance the convenience, safety and reliability of a BRT service.

The station is a particularly essential element in the BRT system as the link between the passenger and the BRT system (Kittelson & Associates Inc. and Herbert S. Levinson Transportation Consultants, 2007). For a BRT system, both station locations and spacing should be planned so that passengers can easily access stations without walking excessive distances. Vehicles on a BRT system have a measurable impact on speed, capacity, environment and comfort (Levinson et al., 2003; Arias et al., 2007 & Kittelson & Associates Inc. et al., 2007; Diaz and Hinebaugh, 2009).

Striking-looking vehicles are important because users spend much of their time on the system within them, and they are also highly visible to potential customers (Levinson et al., 2003; Diaz and Hinebaug, 2009). Fare payment has a large influence on dwell time and speed of buses. Fare structure and fare collection processes are two basic aspects of BRT fare policies (Levinson et al., 2003). Fare collection can occur either onboard or off-board. Off-board fare collection is superior to onboard fare collection because it reduces passenger service time while boarding and alighting, and therefore station dwells time, bus travel time and operating costs (Jennings. 2015).

On-board fare collection, however, can operate well at low-volume and off-peak stations. BRT service design should be simple to understand and readable and should reflect the transportation requirements of a city. Depending on traveling demand and type of service, service frequency differs with the city. Levinson (2003), however, stated that the duration of the journey should not exceed two hours of round trip travel time. It is important to create BRT distinctive in order to improve ridership. BRT should have its own identity and image. Branding is a way of distinguishing BRT service from other facilities. A combination of different characteristics must be correctly scheduled for any city.

2.3. Business Agility

2.3.1. Defining Business Agility

Write (2004) defines agility as "the capacity to effectively alter the position of the body and involves the inclusion of isolated motion abilities by combining balance, coordination, speed, reflexes, strength, and endurance. The Free Dictionary defines Agility as "the ability to move quickly and easily." Write (2004) defines business agility as an organisation’s capacity to quickly adapt in productive and cost-effective ways to market and environmental modifications. Wieland et al, (2012) describes business agility as the capacity of the organisation to react quickly to change by adjusting its original setup. Business agility is the capability and the capacity to anticipate market dynamics, adapt to them and accelerate changes faster than the rate in the rest of the market to create economic value and help the organisation in performance (Overby et al., 2006).

(Wageeh A Nafel., 2016) note that although agility refers to the speed at which firms can detect and respond to the global business environment threats or opportunities, a true test of agility and its implications for performance lies in how easily and quickly firms can revise their behaviors based on unfolding marketplace events.

More recently a number of researchers have analysed how ITS can enable BRT agility and the way in which agility can be incorporated in the development of information systems (Sambamurthy et al., 2003; Desouza 2006). Dealing with change has always been an important issue in organisations. In areas where change is rather predictable and the response can be engineered upfront, organisations need to be flexible. Volberda and Rutges (1999) define flexibility as “the degree to which an organisation has a variety of actual and potential managerial capabilities, and the speed at which they can be activated, to increase the control capacity of management and improve the controllability of the organisation”. Another definition of organisational flexibility is the organisation’s ability to adjust its internal structures and processes in response to changes in the environment (Reed & Blunsdon, 1998).

Volberda (1998) distinguishes three types of flexibility: operational flexibility (referring to reactive routines to familiar changes that are based upon existing structures or goals of the organisation), structural flexibility (referring to the capacity of the management to adapt its decision and communication processes within a given structure as well as the rapidity by which this can be accomplished) and strategic flexibility (referring to the capacity of the management to react to unstructured non-routine unfamiliar changes that have far-reaching consequences and need quick response). Nafel (2016) observe that the boundary between flexibility and agility is blurred.

Flexibility is defined as a predetermined response to predictable events with relative low to medium rates of change, while agility entails an innovative response to unpredictable events with relatively high rates of change. Flexibility is focused on single systems (e.g. manufacturing), while agility is focused on groups of systems (such as a supply chain or business network) (Whadhwa & Rao, 2003). The overlap between flexibility and agility could be described as strategic flexibility. Agility can be seen to envelop and extend the concept of strategic flexibility (Overby et al., 2006). Agility is needed when the required changes were not envisioned when the organisational processes and systems were established. As a result, more radical and innovative change is required such as modularizing or re-engineering existing processes and systems, building new systems and competencies or acquiring these via external partners.

Only organisations that can quickly and easily deal with this can be called agile. Agility and its capabilities cannot be achieved overnight. It should be built into the long-range planning of the organisation and mechanisms are required to maintain it over time (Nafel., 2016). Even though much has been said and written on agility, a consensus on a definition of business agility has not yet emerged. Webster's dictionary defines agility as "nimbleness", "the power of moving quickly and easily" and "the ability to think and draw conclusions.

2.3.2. The relevance of business agility

The global business environment today is characterized by uncertainty, turbulent and volatile markets and most importantly increasing customer demands. The firm's ability to sense and respond to market threats and opportunities with speed and surprise has become essential for the survival of 21st-century organisations (Pan, Chen, & Hsieh, 2007).

The turbulent business environment requires firms that can adapt to change. Organisations must be agile and be able to handle extreme changes, survive unprecedented threats, and capitalize on emerging business opportunities (Wageeh A Nafel., 2016). The global business environment today is characterised by uncertainty, turbulent and volatile markets and most importantly increasing customer demands. Firm's ability to sense and respond to market threats and opportunities with speed and surprise has become essential for the survival of 21st-century organisations (Pan, Chen, & Hsieh, 2007). The turbulent business environment requires firms that can adapt to change. Organisations must be agile and be able to handle extreme changes, survive unprecedented threats, and capitalize on emerging business opportunities (Prahalad, 2009). Ravichandran, (2018) emphasizes the importance of organisation agility by stating that firms which have developed business agility capabilities would be ahead of other organisations which have not been able to develop such capabilities. The capability of sensing and responding is important in addressing the opportunities and threats with speed and surprise.

Tseng and Lin (2011) argued that Business agility is a winning strategy for becoming a global leader in an increasingly competitive market of fast changing customer requirements". Dyer & Ericksen (2006) emphasize the importance of organisational agility by stating that firms which have developed business agility capabilities would be ahead of other organisations which have not been able to develop such capabilities. The capability of sensing and responding is important in addressing the opportunities and threats with speed and surprise. Ravichandran (2018) argued that business agility is a winning strategy for becoming a global leader in an increasingly competitive market of fast changing customer requirements". An agile organisation is not only "flexible" to cater for unforeseen changes but also geared to respond and adapt to unpredictable changes rapidly and efficiently (Van Oosterhout et al., 2006).

Knowledge management and learning capability through data collection and analysis are part of an agile organisation's character. Quick deployment of solutions in responding to changes is fundamental to agile organisations. Various surveys have noted the importance and relevance of business agility the most notable one is that of McKinsey Quarterly (2006) global survey of executives, about 90% of responders stated that agility is either extremely or very important to business performance and 91% think that the importance of agility and speed has increased in the past five years (The McKinsey Quarterly, 2006). Dyer & Ericksen (2006) argues that agility has increasingly become crucial for survival, prosperity and has a significant role in a turbulent business environment. An agile organisation is not only "flexible" to cater to unforeseen changes but also geared to respond and adapt to unpredictable changes rapidly and efficiently (Van Oosterhout et al., 2006). Knowledge management and learning capability through data collection and analysis are part of an agile organisation's character.

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There's general agreement that agility is crucial in for survival in a turbulent business environment. The ability to sense and respond is confirmed as paramount. Dealing with change has always been a critical issue in organisations. In areas where change is rather predictable and the response can be engineered upfront, organisations need to be flexible. Volberda & Rutges (1999) define flexibility as ‘the degree to which an organisation has a variety of actual and potential managerial capabilities, and the speed at which they can be activated, to increase the control capacity of management and improve the controllability of the organisation (Volberda & Rutges, 1999). Another definition of organisational flexibility is the organisation's ability to adjust its internal structures and processes in response to changes in the environment (Reed & Blunsdon, 1998).

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2.4. The Success and Failures of BRT Systems Globally

A number of BRT systems have been developed globally of which only five case studies have been reviewed for this study namely Brazil, Columbia, Nigeria, India and Los Angeles. These countries were chosen because of their experiences regarding the use of BRT. The effect of the BRT systems in these different contexts, as well as their different structures, will be analyzed. The concept of BRT first originated in 1937 in Chicago. However, the full BRT was only implemented in 1974 in Curitiba, Brazil (Wright and Hook 2007). According to Wright and Hook (2007) to address these issues, the construction of a rail-based metro system was considered however, an alternative had to be sought due to the lack of funds (Wright & Hook 2007). Public transport prior to the implementation of the BRT system was unregulated, dominated by private sector operators and failed to meet consumer needs (Wright & Hook 2007).

In order to find a cheaper form of transport, the BRT system was developed (Wright & Hook 2007). The structure of the Curitiba BRT consists of long-haul bus routes and feeder routes. Feeder routes which are found in the city center consist of circular routes which are serviced by minibuses (Pienaar, Krynauw and Period 2005). Buses are color coded so that they are easily identifiable. The red buses are line haul routes, orange buses are feeder buses and green buses are used for ring routes (Pienaar et al 2005). Another feature of the Curitiba system is that fares are fixed. Passengers do not need to pay more when they need to transfer from one bus to another along their route (Pienaar et al 2005). " Same level boarding combined with pre-boarding fare payment results in typical dwell time of no more than 15-19 seconds at a stop" (Wirasinghe, Kattan, Rahman, Hubbell, Thilakarathe and Anowar 2013:11).

Another area that uses the BRT system in Bogotá, Columbia. The TransMilenio is Bogotá's own BRT system. Prior to the implementation of the BRT system, Bogotá's public transport consisted of buses and minibuses. Some of the major problems with the buses were poor ventilation, the buses were old, trips took more than an hour and there were no defined bus stops. Buses occupied a low percentage of the roadway network, which resulted in more people using private vehicles. Drivers collected fares which were time-consuming and subsequently increasing travel time (Leal & Bertini, 2003). Bogotá used the Curitiba model to fashion its' own system. According to the BRT Planning Guide (Wright & Hook, 2007:24), the "Bogotá system has transformed the perception of BRT around the world". Because of the success of the TransMilenio many countries have tried to replicate the BRT model in their own countries.

The TransMilenio which was launched in the year 2000 and similar to the Curitiba model, in that it has dedicated bus-ways, elevated stations, level boarding facilities, a smart card fare collection and wide vehicle doors which in combination, allow for ease of passengers boarding buses (Czegledy, 2004; Replogle and Kodransky 2010). Stations have passenger overpasses and sidewalks along with bikeways that feed into most stations along the route (Pacetti & Trittipo 2010). These features allow for ease of passenger flow into and out of the station. The Bogotá system consists of 400 feeder buses which transport passengers from outside the city. This system integrates pedestrian and bicycle paths from low-income areas into its system (Replogle & Kodransky, 2010).

The cost of the BRT system is relatively cheap compared to the construction of other forms of public transportation, the Bogotá system costs 5.5 million dollars per kilometer (Replogle and Kodransky 2010). "Some two dozen civic plazas, pocket parks, and recreational facilities lie within a half kilometer of busway stops" (Pacetti & Trittipo, 2010). These developments had an added advantage for the system, as 70 percent of BRT users were able to reach the stations on foot or by bicycle and this could be one of the reasons for the high ridership numbers recorded in Bogotá (Pacetti & Trittipo, 2010). The implementation of the TransMilenio has many advantages for Bogotá as it attempted to address problems were experienced with the previous transport system. Some of the major advantages include reduced travel time, reduced pollution and a reduced number of accidents (Pacetti & Trittipo 2010, Wirasinghe et al., 2013). The TransMilenio also has high customer satisfaction and this has resulted in high volumes of commuters using the system (Wirasinghe et al., 2013).

High volumes of commuters resulted in the TransMilenio being able to operate without a financial subsidy (Wirasinghe et al 2013). The operators of the old bus system were involved in the planning process of the BRT, and when the new system was implemented, these operators were afforded the opportunity to purchase buses in the new system. This obviated the problem of employee protests (Leal & Bertini 2003). Some of the notable successes of the TransMilenio is that “It decreased the average travel time by 32%, increased property values along the main line by 15-20%, enhanced tax revenues, created jobs, and improved the health and safety of the community” (Turner, Kooshian and Winkelman, 2012). The number of commuters has increased to “1 750 000 passengers daily”, by 2011 (Turner et al 2012). The TransMilenio system in Bogotá works well because of a peak-period traffic restraint scheme, which places a restriction on vehicles traveling into the city. During the week there is a restriction of 40 percent of vehicles coming into the city in the morning between 06:00 and 09:00 and in the evening between 16:30 and 17:30 (Wright & Fulton, 2005).

“Car restrictions are implemented through parking restrictions and a program that only permits peak-hour vehicle use on certain days, which is based on one’s license plate” (Wright & Hook, 2007). Another measure that is in place to promote the use of public transport is the car-free Sunday initiative (Replogle et al., 2010). Bogotá has the largest and most successful car-free weekday (Wright and Hook 2007). The system includes a 300km of new cycle way and pedestrian and public spaces have been upgraded (Wright & Hook, 2007). The proposal of the BRT system in Bogotá was initially met with resistance from bus companies that feared the loss of business, as a measure to address this they were incorporated into the system (Turner et al., 2012). Fifty-nine of the sixty-four companies became shareholders of the bidding companies in Bogotá (Turner et al. 2012). In addition, open dialogue with transport companies was held so that these bus companies could be included in the reallocation of routes (Turner et al. 2012).

A similar approach was used in the implementation of the Rea Vaya system in Johannesburg, however, in Johannesburg, there is still resentment from the Taxi Industry towards the Rea Vaya system. TransMilenio SA (South America) operates the control center which is equipped with 12 workstations, which allow planning and real-time supervision of bus operations (Turner et al. 2012). Each bus contains a global positioning system which reports the location of the bus every six seconds with a two-meter precision (Gwilliam, 2002; Turner et al., 2012). Nigeria is = another country that uses the BRT system. Lagos, Nigeria's capital, is one of the many developing countries that have implemented the BRT system. The BRT system was the first system to be developed in Sub-Saharan Africa. Lagos is one of the wealthier areas in Nigeria and experiences great traffic congestion due to poor urban planning in certain areas. This has resulted in Nigerians using private cars to travel to the city. In 2008 the BRT was launched in Lagos, which uses a 'BRT Lite' system (Cavero, 2013). Before the BRT was implemented, taxis, Danfoss (small vans, which hold 15 people), midi-buses and scooters were used for longer journeys, whilst for local journeys, motorcycles and taxis were used (Mobereola, 2009).

A widespread problem experienced before the introduction of the Nigerian BRT was long and unreliable journey times. The practice of vehicles not leaving until full and the lack of transport penetration into residential areas meant that public transport journeys were long and uncertain (Mobereola, 2009). The Nigerian BRT system consists of a 22km route and makes use of dedicated lanes that are located on state and federal roadways (Mobereola, 2009). The route runs from the city center into the outer areas of Lagos which consist of designated lanes, of which 65 percent of the system is completely separated from traffic, whilst 20 percent of the system is separated by bus lanes, which are marked in paint and the remaining 15 percent operates in mixed traffic (Mobereola, 2009). One of the advantages of this type of lane is that it has reduced traffic congestion caused by broken down vehicles that occur in bus lanes.

In addition, broken vehicles could be easily towed away as lanes are not continuous and approaching BRT buses may also avoid the blockage by going around (Mobereola 2009). In addition to the introduction of the Lag bus, the government introduced a corporate taxi scheme (Filani, 2012). This has helped with the integration of the different modes of transport in Nigeria. The Lagos BRT system shares similar features with other BRT systems from across the globe such as improved stations and off-board fare collection while operating from 06:00 to 22:00 during weekdays (Mobereola, 2009). With regard to public participation, the Lagos Metropolitan Area Transport Authority (LAMATA) launched a community engagement strategy, which allowed the community to be involved in the BRT system and essentially gave the community a sense of ownership (Mobereola 2009).

Groups of people from the community were identified (Mobereola, 2009). "When each group was consulted the scheme was explained as a means of solving their problems rather than those problems identified by others" (Mobereola, 2009). The Lagos BRT was advertised within the corridor in newspapers and on radio and television. "Television advertisements educated the public on the system, as well as how to use the system" (Mobereola, 2009).

Discussions and road shows were held with the community and a customer relations management line was set up for customer complaints. A live television program was launched to address some of the issues with the BRT system and creating awareness of the project during its construction phase which helped to decrease resistance towards the system (Mobereola, 2009). A number of positive benefits for Nigeria have been identified, as a result of the Lagos BRT. Mobereola (2009) states that the success of the Nigerian BRT system is as a result of a holistic approach, which has reorganized the entire bus industry in Nigeria. In addition, to the restructuring of the bus industry, the BRT has reduced travel times and fares. Although queues of approximately 200 people have been recorded the average queuing time was only ten minutes (Mobereola, 2009). The reduced travel time was as a result of the increase in speed from less than 15km/hour to 25km/hour (Mobereola, 2009). The Lag bus has also encouraged economic development and employs 2000 workers as well as reduced carbon emissions (Filani 2012).

Another country that experienced success from the launch of the BRT is India. India has launched a number of BRT systems; the first BRT system in India was launched on the 14 October 2009 (Replogle and Kodransky 2010). This system uses dedicated bus lanes, with its stations a short distance from main intersections (Unfcc 2014). Ahmadabad has introduced ‘square-about’ to overcome the problem of turning in narrow streets. The square about is similar to a round-about but has two phase traffic signals (Kost 2010). The Ahmadabad planners tried to build cycle tracks parallel to the BRT lanes; however, this created challenges for the city because of the uneven road surface (Kost 2009). Cycle tracks are found at the lower elevation in the street which results in rainwater collecting in these tracks and are being used by hawkers and as parking bays (Kost 2009). Maintenance checks of the buses are conducted daily and drivers who fail to maintain their buses or who violate any of the standards that are in place are fined. Janmarg is also one of the first BRT buses in India to use a GPS which relays real-time information to passengers (Kost 2009). Some of the successes of this system include faster speeds, environmental benefits, combating congestion and the development of infrastructure around the system.

Ahmadabad has seen a reduction in motorcycle use by 20-22 percent, the survey conducted in Ahmadabad, also shows that 65 percent of people who use the Janmarg walk to and from the bus station (Unfccc, 2014). Infrastructural success includes the widening of roads, which has resulted in the development of bridges which connects the city. Part of the corridor passes through vacant former mill lands that now are being developed. This includes new housing and shopping areas for the urban poor. Old diesel buses have been replaced with compressed natural gas buses. The routes of these buses now operate as feeder services for Janmarg. (Unfccc, 2014). The Los Angeles BRT system is one of the many BRT systems found in the United States. Los Angeles has a ‘BRT- Lite’ system which was developed as a way to improve bus services in the area. The Orange line BRT was only launched in 2005 on an abandoned railroad corridor (Niles and Jerram 1999; Wirasinghe et al., 2013).

“It is operated by the Los Angeles County Metropolitan Transportation Authority (METRO) and connects the San Fernando Valley to the west” (Vincent and Callaghan 2007:3). The Orange Line BRT system is very efficient as it uses a signal priority system which allows buses to have a longer green phase or even shortening the red phase. This signal priority can result in up to ten seconds of additional green time when a bus is at an intersection (Deng & Nelson 2011; Levinson et al., 2003). The BRT system operates in 28 corridors and covers a distance of 450 Miles (Deng et al., 2011). The Metro Orange line is a dedicated busway that is operated by the Los Angeles Metropolitan Transportation Authority (Thole & Samus 2009). The Orange line full-service BRT features include: off board fare payment, headway-based schedules, Community centered stations that are spaced approximately a mile apart, bicycle parking and wheelchair access on to the bus (Deng & Nelson, 2011; Thole & Samus, 2009).

The route for the Orange line occurs on the rail system map. Stations have ticket vending machines that allow for off-board fare payment that reduces boarding time (Deng & Nelson, 2011). The Los Angeles BRT stations have attractive canopies; stations also have real-time bus arrival information available for commuters (Deng & Nelson, 2011). Los Angeles Metro is the third largest transit agency in the United States with approximately 495 million annual commutes (Niles & Jerram, 1999). This BRT system is environmentally friendly as it is powered by natural gas. Some facilities found are onboard video monitors, spacing for two bikes, two wheelchairs and three extra wide doors (Deng & Nelson, 2011). The total cost of the Los Angeles Orange Line was approximately $350 Million (Niles and Jerram 1999). “The agency serves a 1 688 square miles area with a population of 11 million” (Niles & Jerram, 1999).

Some of the advantages of the Orange line BRT system are that it operates seven days a week 22 hours a day; the system has reduced waiting times for commuters, reduced traffic and accidents on roads (Vincent & Callaghan, 2007). “The Orange line connects to the Metro Rapid Ventura Line and numerous local bus lines (Vincent & Callaghan, 2007). The above discussion of the BRT in five countries around the world provides a backdrop against which this study is located. The literature has shown that the early developments of BRT systems have resulted as part of a solution to some of the common transport problems in many of the world’s urban areas today. It is argued that the BRT system is a cheap and reliable system and from the case studies outlined, it is evident that there are benefits in developing such a system in countries were transport problems prevail. One of the catalytic effects of such a system is land development. The advent of the BRT system has given rise to land development along the BRT route in certain countries.

2.5. Intelligent Transport System (ITS)

2.5.1. Defining the ITS

The term ITS is used to describe the application of ICT and its related infrastructure (Giannopoulos, 2009). In other words, it is the integration of communication and control systems that help authorities, operators and individual people to be informed better and support decision making (European Commission Extra Consortium for DG Energy and Transport, 2001).

The components of the Intelligent Transport System are not novel, but most of them have been established in the transport sector over the years. What is new regarding ITS is the vision of integrating an array of systems to provide real-time information in order to improve business operations, monitoring and information sharing among different stakeholders in the transport chain (Crainic et al., 2009). Giannopoulos (2009) found in his review of the development of ITS over the last 15 years that ITS are indeed main facilitators of information sharing in transportation, but he also points out that the intelligence part of ITS needs to be improved drastically. He claims that the biggest challenge in the field of ITS is related to the question of how the vast amount of raw data can be converted into useful information and made available to the relevant parties irrespective of their size.

Although the benefits of the ITS are widely recognized by transport companies, authorities and logistics providers, some factors impede the commercial expansion of the system (Ecorys Transport, 2005; Giannopoulos, 2009). These impeding factors are:

- The lack of interoperability, harmonization, standardization
- The relatively high initial investments required
- The lack of knowledge of impacts for different stakeholders
- The lack of economies of scale/critical mass required

The latter three go well in line with the impeding factors of new technologies found by Rogers (1995). ITS can be defined as holistic, control, information and communication upgrade to classical transport and traffic systems, which enables a significant improvement in performance, traffic flows, the efficiency of passenger and goods transportation; safety and security of transport, ensures more comfortable traveling for passengers, reduces pollution (See figure 2). The ITS have been introduced to take full advantage of the existing public transportation infrastructure, and to enhance its efficiency, effectiveness, and attractiveness. Intelligent Transportation System technology can be defined as the application of information technology to surface transportation in order to achieve enhanced safety and mobility while reducing the environmental impact of transportation.

According to Piarc (2004), intelligent transportation systems are systems that ensure the collection, processing, integration, and supply of information through the application of computer, control and communications technologies to enable transportation planners, operators and individual customers to make informed, i.e. intelligent transport decisions. In reference to this observation, Andersen (2013) claimed that the overarching function of the ITS is to improve the operations of transport systems to support the general transport objectives of mobility, safety, reliability, effectiveness, efficiency, and environmental quality. The ITS applies advanced technologies of electronics, communications, computers, control, and sensing and detecting in all kinds of the transportation system in order to improve safety, efficiency and service, and traffic situation through transmitting real-time information. Globally, ITS development has been driven largely by Government policy in the United States, while the technology has evolved generally under the leadership of private developers in Western Europe.

The rationale for governmental leadership in formulating ITS policies is to avoid duplication in structural investments and to enable systematic management of ITS services to evolve. The ITS and related information technology solutions for transport infrastructures are becoming a key means of boosting urban mobility. While Intelligent Transport System is often promoted, no unified definition of Intelligent Transport System prevails. Client agencies or countries in much of the world are apt to adopt definitions that accord with their specific purposes or objectives.

ITS in different cities have been implemented according to the physical infrastructure and the policy environment in each place, including their state of urban development and their level of readiness to accept and use ITS services. While similar problems prevail in each place, they have been dealt with in diverse ways. Table 2.1. Illustrates how different ITS representative organisations and countries have adopted various ITS definitions. Leading ITS countries such as the United States, Japan and some in Europe primarily focus on vehicle-oriented safety and efficiency, while later ITS adopters (among them, China and Indonesia) have tended to develop ITS to mitigate traffic congestion.

Organisation	**Definition**
European Union	Applications of information and communication technology to transport
European Road Transport Telematics Implementation Coordination Organisation	A system that integrates information and communication technology with transport infrastructure, vehicles and the user
ITS United Kingdom	A combination of information and telecommunications technology that enables provision of online information in all areas of public and private administration
European Telecommunications Standards Institute	Telematics and all types of communications in vehicles, between vehicles, and between vehicles and fixed locations; not restricted to road transport
ITS Japan	A system that capitalizes on leading-edge information technology to support the comfortable and efficient transportation of people and goods, anticipating a “quantum leap” in safety, efficiency and comfort
ITS Canada	Applications of advanced and emerging technologies (computers, sensors, controls, communications and electronic devices) in transportation systems to save lives, time, money, energy and the environment
Republic of Korea	A transportation system that (a) improves efficiency and safety through automated systems management; (b) provides transportation data through services that integrate such state-of-the-art technologies as electric control and communication with vehicles and other transport facilities

Malaysia	Applications of advanced and emerging technologies (computers, sensors, controls, communications and electronic devices) in

Table 2.1. Leading countries ITS Definition, Source: ITS for sustainable mobility, UNECE

The ITS is a multibillion-rand industry, which has evolved globally, with the challenge South Africa faces being far bigger than one discipline can handle, which is why international and local organisations have been integrated into this country's ITS project. The public sector has been evaluating ITS solutions at the national level to enhance traffic flow and is eager to advance some of the promising projects from pilot stage to full implementation stage. A critical challenge is not simply to build infrastructure but to build intelligence and management systems into it. Countries like the United stated, Japan and a number of countries in Europe, have led the way in a field that has become known as the ITS. Kulmala and Pajunen-Muhonen (1999) suggest that the term broadly describes any intelligent intervention in the transportation industry, specifically the road transportation industry.

Initially, these countries applied ITS for simple traffic control (e.g. traffic light coordination) and later Electronic Toll Collection (ETC), but it has since evolved to include real-time electronic ticketing and automated fare collection, in-vehicle navigation and route guidance, real-time public transportation information distribution, monitoring and active control of traffic flow and even vehicles that intercommunicate to prevent accidents (Khosa, 2002). As could be expected, every region decided on a different approach has led to various incompatible standards and systems which is seen as a major impediment to large scale implementation of ITS. Because of its dependence on wireless communications, electronic sensing, and computer-based data aggregation and visualization, successful deployment and maintenance of Intelligent Transport System are heavily dependent on advanced, and expansive technology and Information Technology (IT) (Brand, 1993).

Currently, the main drives for ITS adoption are safety, efficiency, and environmental impact reduction. Intelligent Transport System is the use of Information Communication Technology in transport systems. ITS is used to describe a wide array of transport system elements that use technology to measure, communicate and analyses events such as smartcard transactions, bus tracking, CCTV, mobile apps and more. Within the context of BRT systems, Intelligent Transport System is typically used for:

- Advanced management of operations
- Passenger information
- Automatic fare collection
- Reporting and forward planning

BRT systems typically utilize a wide array of technologies, equipment, and software. These are used at various scales by different users such as passengers, frontline staff or back-office personnel. It must be emphasized that the ITS is not primarily about the monitoring of service delivery but is fundamentally about the proactive management of BRT systems. It also needs to be stated that it can come at a high cost if not properly done. According to Chosi (2008:43), ITS support the operation of integrated transport networks, the control of vehicles operating on the networks, and the efficient planning of operations, (including individual journey planning and fleet logistics). It includes a wide range of user support functions, from simple information alerts through to highly sophisticated control systems (Andersen et al., 2010).

ITS involve the application of advanced technologies and proven management techniques to relieve congestion, enhance safety, provide services to travelers, and assist transportation system operators in implementing suitable traffic management strategies. ITS focuses on increasing the efficiency of existing transportation infrastructure, which enhances the overall system performance and reduces the need to add capacity (e.g., travel lanes). Efficiency is achieved by providing services and information to travelers so they can (and will) make better travel decisions and to transportation system operators so they can better manage the system. ITS are ideal of public transport planning, operations management and customer service applications that are enabled by advanced information and communications technologies. They act to enhance the effectiveness, efficiency, and usability of the public transport service offer to the benefit of public transport authorities, operators and passengers.

ITS involve customised, situation-specific applications to address specific functions (Zhang, Zhao, Kumar., 2016). They utilize a mixture of proprietary and generic technologies for that purpose. They utilise multiple data sources, mostly in real time, and enable a direct effect on outcomes which are usually not possible without the ITS application. The main application areas in a conventional fixed route, fixed schedule urban passenger transport are:

- Operations Management;
- Driver Aids Fare Collection;
- Traveler Information;
- Traffic Management;
- Security.

2.5.2. Intelligent Transport System Background

"We sleep in a society fine obsessed on science and technology, during which hardly anyone is aware of something concerning science and technology"

Carl Sagan, Scientist, and writer, 1934-1996

South Africa was a late starter in terms of ITS deployment and only received the necessary impetus through projects related to the FIFA Soccer World Cup in 2010. This also holds true for municipalities, where a number of key projects were launched leading up to the World Cup event.

However, due to fast track deployment as well lack of structured policy, ITS architecture and strategic frameworks at National or regional level, the true benefits of ITS deployment are probably not fully exploited at this point. An important driver of ITS systems is the benefits that accrue due to the integration of infrastructure, various ITS output as well as coordinated activities on an institutional level. Digitalization has improved the performance, quality, and productivity of many sectors, from education to health care, and including the transport system. Digitalization is expected to contribute to the economic, social, and environmental sustainability of the functions of our societies (OECD, 2014). Digitalization of the transport system is manifested in the ITS. Figure 2.2. Details advanced technologies, e.g. Internet, wireless communications, sensing systems and computational technologies improve every aspect of transportation, all modes of transport, and covering both passengers and goods.

Technologies such as automated passenger counters (APC) and automated vehicle location (AVL) systems may allow public transport operators to better balance supply and demand, improve schedule adherence, providing a more reliable service, improve fleet management and consequently reduce operating costs. Electronic fare cards provide a reduction on dwell time and make fare payment easier and more convenient, also reducing losses from fare evasion. Traveler information services can ease trip planning and provide important real-time information to travelers, regarding for example schedules or delays. ITS integrate telecommunications, electronics and information technologies with transport engineering in order to plan, design, operate, maintain and manage transport systems.

The application of information and communication technologies to the road transport sector and its interfaces with other modes of transport will make a significant contribution to improving environmental performance, efficiency, including energy efficiency, safety and security of road transport, including the transport of dangerous goods, public security and passenger and freight mobility, whilst at the same time ensuring the functioning of the internal market as well as increased levels of competitiveness and employment. Figure 2.2. Illustrates the ITS network overview which aims to streamline the operation of vehicles that manages vehicle traffic, assists drivers with safety and other information, along with provisioning of convenience applications for passengers and road safety.

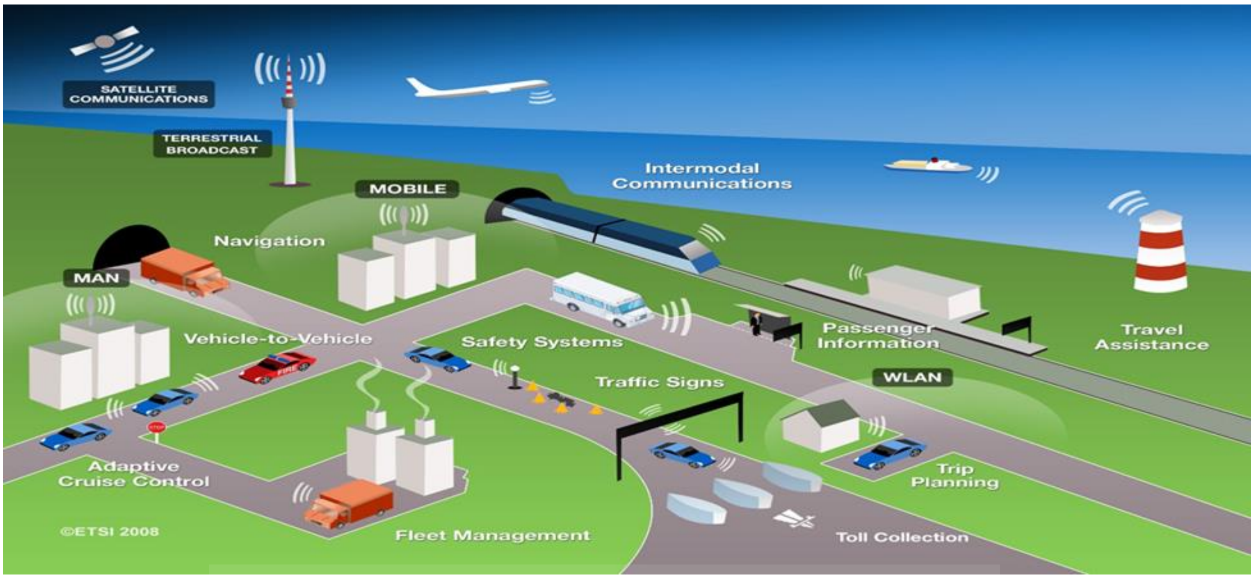

Figure 2.2. ITS network overview, Source: Garcia, (2004).

Signal priority systems can reduce travel time by reducing the amount of time that public transport vehicles lose on signalized intersections and consequently provide a faster trip. On the case of demand-responsive public transport, AVL and automatic dispatch may increase productivity and reduce passenger travel time (Giuliano and O'Brien, 2004). Building enough new roads or new lanes to meet increasing transport demand is becoming impossible, especially in urban areas where more capacity is needed. By applying the latest technological advances to transport systems, ITS can address the increasing demand for road transport by improving quality, safety, and effective capacity of the existing infrastructure (Garcia, 2004).

The main objectives of ITS may be summarized on 3 items: increase safety, reduce congestion, and contribute to energy saving and environment protection. The association between these three is obvious if there's no congestion on roads the traffic will flow smoothly, without problems of security and without a waste of energy like the one that occurs in congestion situations. Hamed Benouar (2011) says it with a simple sentence, "The goal of Intelligent Transport System within the BRT is to improve mobility, create better accessibility and enhance safety while meeting stringent environmental requirements (Benouar, 2001)". On the same paper, he also writes about the benefits of deploying ITS systems in the BRT, which can be associated with their objectives too. He says that there are many different ITS benefits and that these can be classified in four different terms: reduction in crashes and their severity, reduction in delay and travel time, throughput increase, and reduction in maintenance and operation costs.

The implementation of Intelligent Transport System has 6 main objectives (or benefits) that can be well defined:

- Improving safety on the roads, by reducing the risk of having traffic accidents (reduction of potential crashes);
- Improving mobility on the whole network with the reduction of delays and travel times;

- Optimize the use of the existing infrastructures, improving their efficiency;
- Increase productivity by saving on the costs;
- Energy saving and environment protection;
- Achieving customer's satisfaction. (Mitretek Systems, 2001)

The merits of ITS have been proven worldwide and as a developing country, South Africa has numerous transport related problems that are ideal candidates for ITS solutions (Steven, 2004). With many road networks reaching capacity with little space to build more roads, concerted efforts are being made to improve the efficiency of existing infrastructure (Booyes et al., 2013). Intelligent Transport System presents a crucial breakthrough by changing approaches and trends in transport and traffic research and technology aiming to solve escalating problems of congestions, pollution, transport efficiency, safety and security of passengers and goods (see figure 2.2). This is also proved by numerous programs and projects related to ITS all over the world, the introduction of new study programs on ITS and foundations of ITS associations at the national and global level.

ITS replaced previously used concept for transport problem solving, which had already been exploited. Increasing transport-related problems in all major cities, centers or airports, raise the need for innovative approaches and new solutions. Technological advances with vehicles, fare systems, and communications systems have played a key role in advancing the state of art public transport. ITS, such as automated vehicle location (AVL) and real-time information displays have done much too dramatically improve operational efficiency and customer service. Technology also conjures up images of modernity and sophistication which help to sell project concepts to both political officials and the public (See figure 2.2). At the same time, technology should not supplant the operational design. Instead, technological choices should simply follow from the customer requirements that have been prescribed by the demand analysis and desired operational characteristics (Nuzzolo A, Comi A., 2016). The ITS is a recent field in science and as such it demonstrates rapid development (Peirce, Lappin, 2003). ITS are being developed by various parties including system developers, car manufacturers and scientists worldwide (Humanist, 2004).

The contribution of various groups including engineers, psychologists, ergonomists and lawyers is also apparent. The importance of the development of ITS within the BRT lies mainly on the fact that their contribution in many of today's problems, which have resulted from the mobility growth, is anticipated to be substantial. To minimize the negative impact associated with disintegrated transport infrastructure, the intelligent transport system has been implemented to improve the efficiency of transport infrastructure. In view of the positive components of Intelligent Transport System in ensuring mobility, safety, reliability, effectiveness, and efficiency as a prelude to integrated transport, the need for ITS is becoming more and more important (Copley, 2010). ITS were invented to improve transportation systems operations, by increasing productivity, improving safety, reducing travel time and costs and saving energy.

Such systems also open up significant opportunities for new services for drivers, travelers, as well as infrastructure providers. Intelligent Transport System is an umbrella term that cannot be limited to a certain number of systems and applications. There is no commonly accepted taxonomy of ITS, as there are hundreds of systems and applications, each of them designed for a very specific purpose, as well as, a growing number of new devices, or, devices under development. However, attempting to categorize it, we could distinguish the Intelligent Transport System into two wide groups: intelligent infrastructure and intelligent vehicles. Intelligent infrastructure includes systems and applications designed for road and transportation infrastructure, such as loop detectors, electronic toll collection (ETC) and variable message signs (VMS).

The term "intelligent vehicles", on the other hand, refers to in-vehicle systems and applications, such as satellite navigation devices, intelligent speed adaptation (ISA), adaptive cruise control (ACC), forward collision warning (FCW), pedestrian detection systems (PDS) and lane departure warning (LDW). Besides the measurable benefits, many other advances can also be noticed, including new business opportunities, an increase of employment; improvement of regional/urban/national technology status, etc. Among common users and stakeholders, the following groups can be recognized: end users, network operators, system owners (stakeholders), service providers, tour operators, local authorities, civil government. In 1991, the concept of ITS emerged when transportation professionals recognized that electronic technologies could begin to play a significant role in optimizing surface transportation, and the United States (U.S.) Congress legislated the national ITS program.

Since then, computer, communication, and sensor technologies have improved dramatically, and ITS technologies have emerged in highway and public transit jurisdictions worldwide. Intelligent Transport System is being identified as a domain of high potential to tackle the many challenges facing the Transport sector both within each of the modes and (most importantly) in creating interfaces and integration across the modes. In fact, besides infrastructure, the ITS is considered as the single most important "factor" that can be used to effect cooperation among the various modes of transport and create a seamless transportation system across Europe.

Today, there is also an important and numerous stakeholder community which is either providing or utilizing ITS applications and services and the sector provides for a substantial contribution to economic and social development. Deployment of ITS systems and services has so far been largely "unimodal" in scope and extent leaving the wider "cross-modal" application of current systems behind, and further development to be sought for in the future. Also, the development and application of unimodal ITS applications are seen by many as still incomplete and not widespread enough to cover in a comprehensive way the totality of potential applications and market uptake. Achieving "critical mass" for self-sufficiency and sustainability of integrated ITS applications is currently still a goal to be achieved in many cases. The ITS can be used to support other public transport planning and business process functions for conventional public transport.

They can also be used to support the unique needs of the operators and users of demand-responsive public transport. Public transport ITS systems often interact with the ITS systems that support other urban transport modes (e.g. commuter rail, metro). In general, the Intelligent Transport System comprised of many sub-systems and technologies, many of which support more than one application. For example, Area Traffic Control (ATC) “smart” traffic signal systems can provide support to public transport priority or automatic public transport vehicle location applications. Examples include aspects of the built environment such as accessibility, lighting, station design, landscaping, cleanliness, and maintenance, all of which influence both the perceptions and reality of safety and security. Innovation will help to make transport more sustainable, which means efficient, clean, safe and seamless. New infrastructure cannot solve all transport problems of congestion and emissions. The ITS apply information and communication technologies to transport. Computers, electronics, satellites, and sensors are playing an increasingly important role in the transport systems. The main innovation is the integration of existing technologies to create new services.

Intelligent Transport System as such are instruments that can be used for different purposes under different conditions. However, these new tools and the data collection and processing upon which they are built bring their own challenges, unclear maps and schedules, unclean and ill-maintained vehicles and uncomfortable rides have all too frequently been the norm for those who utilize public transport in developing cities. The road urban transport sector now faces the challenge of exploring uses of the Intelligent Transport System in the BRT systems.

2.5.3. History of ITS

The development of the Intelligent Transport System is varied in various countries due to advances in telecommunication technologies. The major developments on Intelligent Transport System were made in Europe, the U.S., and Japan and it went through three phases. The phases consisted of the preparation stage, feasibility study and product development (Kanoungo, 2015). The first phase of the ITS began in the 1970s and 80s where several European companies were developing more complex systems that broadcasted messages that only cars affected by the message could receive.

In the United States, government-sponsored in-vehicle navigation and route guidance system - ERGS was the initial stage of a larger research and development effort called the Intelligent Transport System (Nowacki, 2012). In 1973 the Ministry of International Trade and Industry (MITI) in Japan funded the Comprehensive Automobile Control System (CACS). These systems shared a common emphasis on a route guidance and were based on central processing systems with huge central computers and communications systems. Due to limitations, these systems never resulted in practical application (Nowacki, 2012). The second phase of ITS development focused on the establishment of conditions to develop an ITS system. The feasibility study made efforts for research and development for the practical use of ITS.

An example of the ITS developed at this stage was Prometheus which in 1986 was initiated as part of the EUREKA program, a pan-European initiative aimed at improving the competitive strength of Europe by stimulating development in such areas as information technology, telecommunications, robotics, and transport technology (Takaaki, 2014). In Japan, work on the RACS project, which formed the basis for the current car navigation system, began in 1984. In 1985, a second-generation traffic management system was installed in Australia. This was known as the TRACS (Nowacki, 2012). In 1989 in the USA the Mobility 2000 group was formed and this led to the formation of IVHS (Intelligent Vehicle Highway Systems) in America in 1990, whose function was to act as a Federal Advisory Committee for the US Department of Transportation. IVHS program was defined as an integral part, became law in order to develop —a national intermodal transport system that is economically sound, to provide the foundation for the nation to compete in the global economy, and to move people and goods in an energy-efficient manner‖ (Allen et al., 2000).

The third phase began in 1994 when the practical applications of earlier programs were seen and understood in intermodal terms rather than simply in terms of automobile traffic. ITS have started to gain recognition as critical elements in the national and international overall information technology hierarchy. At this stage, ITS receive attention so that it can be used in other modes of transport (Sharma, 2015). As a result of this, in 1994 the IVHS program (USA) was renamed the ITS indicating that besides car traffic, other modes of transportation receive attention and during the first world congress in Paris, the term - ITS was accepted (Levitha et al., 2015). The ITS Japan established in 1994 promoted research, development and implementation of ITS in cooperation with five related national ministries in Japan and serves as the primary contact for ITS-related activities throughout the Asia Pacific region. ITS Japan is Part of a Global Advanced Information and Telecommunications Society (Takaaki, 2014). Figure 3.4 shows the phases of the evolution of the development of the ITS. Such barriers may in turn act as impediments to public and private services, leisure activities, and employment, and education, potentially generating long-term social impacts.

ITS offers the chance to mitigate some these concerns and barriers, especially those related to information provision, personalized service, and timely communication and response. To understand perceptions of transportation and resultant behavior, the whole journey point of view is vital, as the most “uncertain” segment in the trip chain can influence the entire trip in terms of mode, path/route, destination, frequency of travel, and even decision of whether or not to travel. Information is essential to travelers, especially about unfamiliar situations or unforeseen circumstances. A lack of maps or service information in public transport reinforces a sense of unfamiliarity and erodes the ability to plan journeys “safely”, and timely and accurate information about delays and connections help to decrease passenger anxiety (Stafford & Peterson, 2004). Transport improvements undoubtedly promote economic growth and social development by increasing mobility and improving accessibility to people, resources and markets. There have, however, been some concerns about the effect of improved transport systems on sustainable development (Hillman, 2001).

Several impacts of traffic and transport and associated costs can be distinguished, such as social, economic and environmental impacts, for both current and future generations. Sustainable urban transport development can only be achieved if the full account is taken in all aspects (Zeitgeist, 2005). Smith (1993) argues that the increasingly competitive and unstable global business environment is compelling organisations to be flexible and have the ability to sense and seize market opportunities. Flexibility is required for firms to adapt to changes, as and when they occur. Thus to proactively predict and respond to future changes, has become a firm's competitive advantage. For long times business environments were relatively stable with changes taking place incrementally (Kidd, 2000). When a radical change occurred, the pace tended to remain relatively slow and was not quickly followed by other significant changes.

In these relatively stable environments organisations were not urged to be adaptive or pro-active to respond with speed to internal and external events and to make the organisation agile (Bharadwaj & Sambamurthy, 2005). Those conflicting results can be attributable to incomplete or inappropriate measures of success and quality of the ITS delivery It is a known fact that the investment done by the organisation in Intelligent Transport System is substantial. However, the attempts to measure their success and quality have been a few (Sedera et al., 2001); Knowles et al., 2000) since the implications from enterprise systems are difficult to measure. This also makes it difficult to show ITS success. For vulnerable social groups such as elderly and disabled persons, access to information may be the deciding factor in whether to travel (Waara, 2013). Familiarity with an area or activity, including using public transportation or transportation mode, is associated with greater feelings of assurance.

The ability to confidently find one's way around is vital to such perceptions (Crime Concern, 1997). ITS offers the possibility to gain a sense of familiarity, e.g. via access to maps and directions. A multitude of other factors not associated with information or communication also influences mobility and one's sense of assurance while traveling and, thus, are not addressed in this thesis. According to operational BRT sites around the world, all of them are applying some amount of ITS technologies. The most popular ITS technologies include vehicle tracking, transit signal priority, and electronic fare payment and traveler information at the station/stop.

Traffic signal prioritization technologies are utilized as an active transit schedule adherence tool. Electronic fare payment is one of the popular technologies in BRT operations, which helps reduce travel times and increase passenger convenience. Today, the ITS is a part of the core business especially in the BRT, (De Sutter, 2004). Considering this fact, the biggest challenge for and ITS department is to ensure an efficient and effective ITS delivery owing how much is at an acceptable quality level for the BRT. This requires finding a constant way of measuring the quality by using appropriate methods and tools and also by making the necessary adjustments on time in case of deviations in order to keep the same quality level.

2.5.3.1. The Urban Setting and its Development Challenges

The world is industrialising and urbanising on a global scale that follows consistent patterns. Some 54 percent of the world's population lives in urban areas, creating many challenges related to urban living1. The United Nations has projected that two-thirds of the world's population will be urban by 2050 – or an increase of 2.5 billion to current urban communities. One in eight people currently lives in one of the 28 so-called mega-cities that hold over 10 million inhabitants. Many high-growth urban areas can be found in the developing countries of Africa. Most African countries are confronted with complex issues in planning to meet a range of challenges in providing adequate infrastructure for water supply, sanitation, energy, transportation, as well as public services for their emerging mega-cities. These future mega-cities will be confronted with a host of challenges linked to housing, safety employment, and the delivery of public services including urban mobility.

Urban mobility is expected to worsen during the 21st century in developing countries with increased car ownership, and due to the projected rapid expansion of urban perimeters in under-planned agglomerations. This will cause additional traffic congestion which can be expected to result in additional costs to motorists, as well as increased air and noise pollution, stress, and losses to traffic accidents. Moreover, insufficient mobility between places of residence and of economic activity could further penalize and marginalize the poorer segment of the population, limiting their development prospect4. Inadequate public transport systems compound the problem of urban sprawl and traffic congestion by further encouraging private vehicle ownership and usage. In this context, ICT can play a key role in improving the delivery and efficiency of infrastructure for sustainable development in urban areas.

ICT can support the implementation of smart power grids, better water management, effective early warning systems in case of natural disasters and better transport infrastructure, also called ITS. This is owed to important innovations and their commercialization in a number of areas including sensing, detection and transmission equipment, innovations in data storage and processing that allow the rapid and continuous exploitation of "big data"" in urban contexts, improvements and declining costs in geo-positioning systems and of course the advent of mobile telephony (including mobile broadband). These modern technologies and their applications to infrastructure can greatly enhance the efficiency and sustainability of infrastructure services, not least in the field of transport. However, reaping the sustainable development benefits from these technologies require new holistic approaches that may involve government agencies working in very different areas. In the case of ITS, transport and ICT authorities will need to enhance their cooperation.

2.5.4. ITS capability

ITS capability is a firm's ability to acquire, deploy, combine, and reconfigure ITS resources in support and enhancement of business strategies and work processes (Zhang, Zhao, Kumar, 2016). ITS capability is critical for a BRT to realise business value and sustain competitive advantage.

2.5.4.1. ITS Infrastructure capability

McKay and Brockway (1989) defined ITS infrastructure as the enabling foundation of shared ITS capabilities upon which the entire business depends on. The foundation is standardized and shared by business functions within the organisation, and utilized different organisational applications. Byrd and Turner (2000) provide a much clearer and detailed definition of ITS Infrastructure by stating the following:

"ÏTS Infrastructure is the shared ITS resources consisting of a technical physical base of hardware, software, communications technologies, data, and core applications and a human component of skills, expertise, competencies, commitments, values, norms, and knowledge that combine to create IT services that are typically unique to an organisation. These ITS services provide a foundation for communications interchange across the entire organisation and for the development and implementation of present and future business applications."

Broadbent et al (1999) define ITS infrastructure as a foundation of budgeted ITS capability, which is shared throughout the organisation in the form of dependable services, which is centrally controlled and coordinated. They also identified two aspects of Intelligent Transport System Infrastructure namely: technical Intelligent Transport System Infrastructure and human Intelligent Transport System Infrastructure. Based on the above definitions, it can be concluded that ITS infrastructure has two dimensions that are related but distinct: a (i) technical ITS infrastructure and an (ii) human ITS infrastructure. The technical ITS infrastructure consists of applications, data, and technology configurations.

While the human ITS infrastructure deals with the knowledge and capabilities required to effectively manage ITS resources in an organisation. (Zhang, Zhao, Kumar, 2016) Nuzzolo and Comi (2016) found that ITS infrastructure capabilities have a positive impact on other capabilities around customer, process, and performance management. Similarly, Dove. (2001) show that technical capabilities involved in the integration or modularity of ITS infrastructure mediate the link between IT skills capabilities and competitive advantage. Therefore, while there may be many examples of technical, managerial or human resources that fit within the definition of ITS capabilities, researchers are increasing of the view that such capabilities are interrelated (See figure 2.3.). The ITS expertise in South African has not developed to a greater degree for easy and immediate implementation.

Although there are low bases for the deployment such as those mentioned in the previous paragraph, there is a need for quick training and skills acquisition for the deployment of ITS.

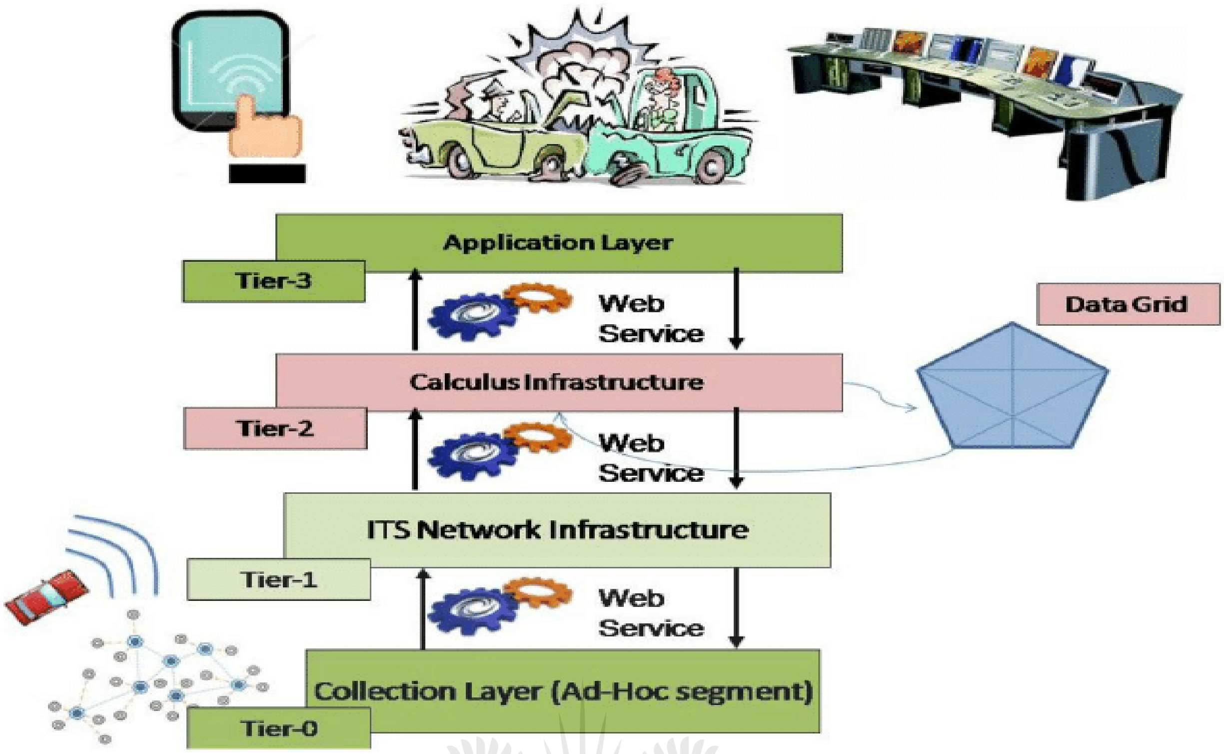

Figure 2.3. ITS infrastructure capability, Source: Zhang, Zhao, Kumar (2016).

The skills that currently exist are in urban areas, and the CCTV's that already exists creates a good screen monitoring base which should be augmented by the other technical expertise, and operational skills to understand Intelligent Transport System in its totality. Educational institutions should be directed towards this expertise, or the current computer lessons should be tweaked to form a base for laying over ITS operational expertise. Infrastructure-focused ITS are embedded within the transport network and include equipment such as dynamic signage, traffic lights, and in-road sensing devices (Zhang P, Zhao K, Ram L Kumar., 2016). They help to ensure the availability and quality of the transport infrastructure and can be used to manage traffic flow, enable payments for network use, and detect incidents and hazardous weather conditions. As such, managerial capabilities affect the design of a flexible ITS infrastructure using hardware, software, networking, and ITS skill-based resources to minimize the downside risk of rigidity traps that might otherwise damage or restrict agility.

Set of functions enabling fast and precise problem identification, streamlining the solution through interventions of operation and corrective maintenance, triggering the charge and eventually affecting the activation of contingency plans. The infrastructure allows critical systems, such as power supply, to operate at distance. Examples of equipment that can be monitored: turnstiles, automatic doors, vehicles, internal data networks, generators, air conditioners, computers, servers, and others.

Another important function that can be added is the monitoring of external agents that can cause hazards or interference in the operation of the transport system, such as weather conditions such as rain and lightning, flooding of roads and stations as well as communication technologies. Communication technologies are widely used in ITS systems. Most buses now have at least one method of communicating to the outside world, be it by the driver's cell phone or via a WLAN antenna. Communications technologies are evolving rapidly, and it would be futile to list the best communication method for each application. The quantity of all data packets to be transferred and the amount of time in which the transfer must take place must be considered when choosing a communication method (Zhang P, Zhao K, Ram L Kumar., 2016).

Flexibility is required for firms to adapt to changes, as and when they occur. Thus to proactively predict and respond to future changes, has become a firm's competitive advantage. For long times business environments were relatively stable with changes taking place incrementally (Kidd, 2000). When a radical change occurred, the pace tended to remain relatively slow and was not quickly followed by other significant changes. In these relatively stable environments organisations were not urged to be adaptive or pro-active to respond with speed to internal and external events and to make the organisation agile (Bharadwaj & Sambamurthy, 2005). Those conflicting results can be attributable to incomplete or inappropriate measures of success and quality of the ITS delivery. It is a known fact that the investment done by the organisations in ITS is substantial.

However, the attempts to measure their success and quality have been a few (Sedera et al., 2001); Knowles et al., 2000) since the implications from enterprise systems are difficult to measure. This also makes it difficult to show ITS success. For vulnerable social groups such as elderly and disabled persons, access to information may be the deciding factor in whether to travel (Waara, 2013). Familiarity with an area or activity, including using public transportation or transportation mode, is associated with greater feelings of assurance. The ability to confidently find one's way around is vital to such perceptions (Crime Concern, 1997). ITS offers the possibility to gain a sense of familiarity, e.g. via access to maps and directions. A multitude of other factors not associated with information or communication also influences mobility and one's sense of assurance while traveling and, thus, are not addressed in this thesis. According to operational BRT sites around the world, all of them are applying some amount of ITS technologies.

The most popular ITS technologies include vehicle tracking, transit signal priority, and electronic fare payment and traveler information at the station/stop. Traffic signal prioritization technologies are utilized as an active transit schedule adherence tool. Electronic fare payment is one of the popular technologies in BRT operations, which helps reduce travel times and increase passenger convenience. Today, the ITS is a part of the core business especially in the Bus Rapid Transit (BRT), (De Sutter, 2004). Considering this fact, the biggest challenge for and ITS department is to ensure an efficient and effective ITS delivery owing how much is at an acceptable quality level for the BRT. This requires finding a constant way of measuring the quality by using appropriate methods and tools and also by making the necessary adjustments on time in case of deviations in order to keep the same quality level.

2.5.4.1.1. The Importance of ITS Infrastructure capability

Weill et al, (1999); Weill et al, (2002) defines ITS infrastructure capability as the integrated set of reliable IT infrastructure services available to support existing applications and new initiatives in organisations. Broadbent et al, (1999) conceptualize ITS infrastructure capabilities like the ability:

- To provide data and information to users with the appropriate levels of accuracy, timeliness, reliability, security, and confidentiality;
- To provide universal connectivity and access with adequate reach and range; and,
- To tailor the infrastructure to emerging business needs and directions.

Although the main government focus is public transport, it needs to be mentioned that most (public) transport in South Africa is road based. Moreover, the current indications point to further growth of road-based public transport. It is, therefore, important to invest in infrastructure and systems that can make use of the available infrastructure in the most efficient way. The National Department of Transport understands ITS systems are one of the ways to improve the safety and efficiency of a road system. Plans to investigate possibilities have been verbalized. Zhang P, Zhao K, Ram L Kumar (2016) definition is consistent with Marchand, Kettinger, and Rollins (2000) conceptualization about information technology practices.

ITS infrastructure capability is seen as a fundamental differentiator in the competitive performance of firms (McKenney, 1995) and is a potential core competence that is difficult to imitate requiring a fusion of human and technical (Barney, 1991). Intelligent Transport System facilitates electronic commerce via the development of virtual value chains and critical to globally competing for firms (Clemons et al, 1989; Neo, 1991) for providing connectivity and integration. Zhang P, Zhao K, Ram L Kumar (2016) state that globally integrated infrastructure provides a platform to generate digital options that enhance the reach and richness of the firm's knowledge and its processes and assist the firm in accessing, synthesizing, and exploiting knowledge. Nuzzolo and Comi, (2016) argue that globally integrated infrastructure enables firms to cope with frequent or unexpected rapid changes in dealing with disruption in supply or fluctuations in demand and making necessary internal adjustments.

Intelligent Transport System infrastructure capability can be a significant barrier or enabler in changing business processes (Grover et al, 1993; Wastell et al, 1994) and ITS infrastructure services such as firm-wide applications, databases, and common systems are essential to quickly implement extensive, innovative, and radical process changes and best support demand-side initiatives (Broadbent et al, 1999; Weill et al, 2002). Zhang, Zhao, Kumar (2016) argue that ITS capabilities have a positive impact on the quality of organisational processes and the development of digital process capabilities. Intelligent Transport System capability offers the appropriate support for process management by providing the reach and connectivity to design and manage processes that connect the BRT organisation with its customers, suppliers, and other significant business partners (Davenport 1993).

Further, an elevated level of ITS capability enables firms to design metrics and analytics to provide visibility into the real-time performance of various processes, the integration between the various processes, and advance warnings about performance degradation in processes (Kalakota et al. 2003). Finally, a high level of ITS infrastructure capability enables faster and more responsive redesign and reconfiguration of processes in response to changes in business conditions. There is also a general agreement that ITS infrastructure capability alone is not adequate without ITS and business integration which is as the synergy between the ITS and business activities (Zhang, Zhao, Kumar, 2016). The availability of a modern information system for collecting and processing data on the parameters of passenger flows, even in real time, makes it possible to manage the transport resources at hand more efficiently. Operational and statistical information on passenger flows allows to a) control and regulate the dispatch process, according to a scheduled transportation service, b) estimate the average bus waiting time at the stations, and, c) analyse the dynamics of passenger traffic during rush hours and count the number of passengers transported.

The data received on passenger traffic during the trips facilitate creating a passenger demand model that can be used for transportation planning (schedules). In addition to this model, the initial data allow to build a predictive model of passengers flow along a route and occupation of the vehicle; this model allows maintaining the transport quality within a determined range. In summary, ITS infrastructure capability is confirmed by the literature review as an essential element of ITS capability as it consists of applications, data, technology configurations, and human technical skills.

2.5.4.2. Intelligent Transport System and business integration capability

The ITS is anticipated to be one of the pioneering technology that would enable the vision of smart cities. Connected and Autonomous vehicles along with smart infrastructure facilities can drastically change the way we commute. Appropriately designed and operated BRT systems offer an innovative approach to providing a high-quality transport service, comparable to a rail service but at a relatively low cost and short implementation time. In common with other forms of mass transit, a full-featured BRT has the potential to offer significant effects on land development. Although the resource-based view is successful at explaining how capabilities to shape firm performance, the theory has been criticized for failing to identify how capabilities might perform under varying environmental conditions (Nuzzolo & Comi, 2016).

The theory of dynamic capabilities attempts to address this oversight by noting that the performance implications of a firm's capabilities may be conditional on the environment. For example, as conditions become more volatile, a firm may find itself straddled with capabilities that are best suited to a stable market but that are less than ideal in a volatile market. Similarly, a firm that devotes a great deal of time, money, and effort to creating ITS capabilities that allow it to react quickly to change may see little return on its investment in a stable market when change is rare or largely predictable. Intelligent Transport System is not homogenous and therefore ITS integration emphasizes on IT business partnership and synergy.

Partnership and synergy between ITS and business managers lead to effective ITS–business joint decision-making, more strategic applications, and greater buy-in and, thus, produces a better implementation (Weill and Ross, 2004). Figure 2.4. Presents the integrated bus management system. It includes the stakeholders as well as the interrelationship between them.

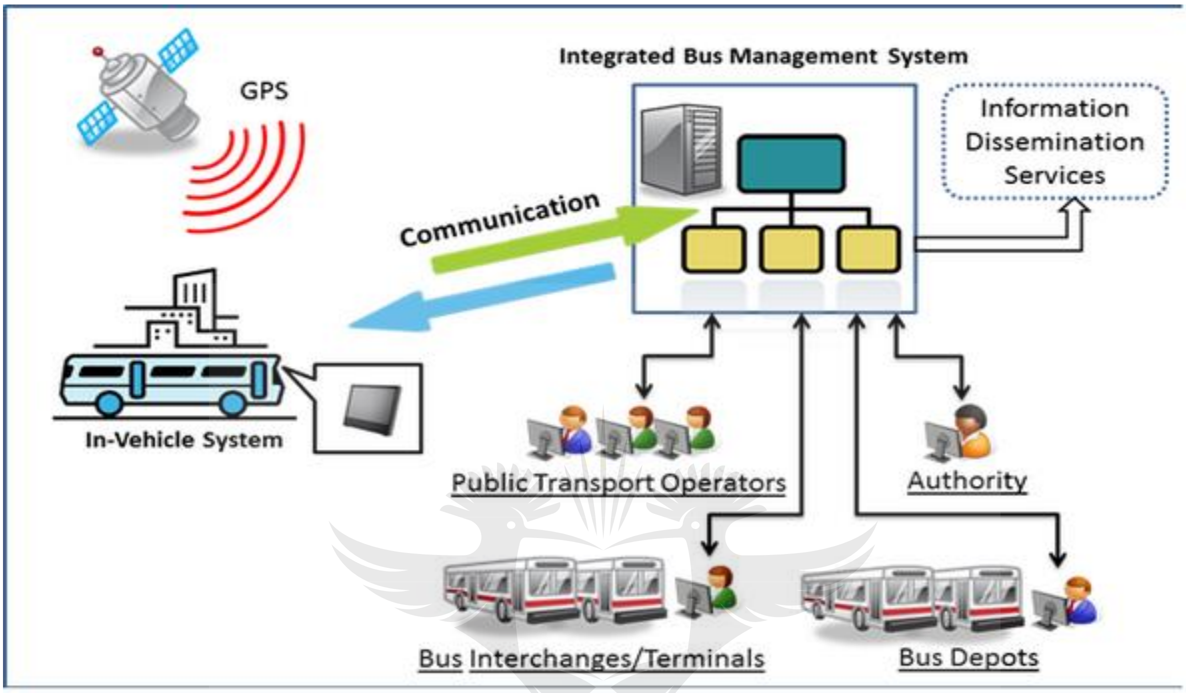

Figure 2.4. Integrated bus management system, Source: Zhang et al. (2016)

Integrated Bus Management systems allow bus companies to track and manage their bus fleets and provides valuable information to bus riders. Bus companies can monitor in real-time the speed and location of each bus in their fleet and view live streaming video from video-enabled black boxes positioned in various locations within the buses in an integrated manner (See figure 2.4. Integrated bus management system). Zhang P et al. (2016) argues that close interaction and collaboration between Intelligent Transport System and business foster a mutual respect and trust over time that encourages sharing and exchange of knowledge between ITS and line managers. ITS are increasing in popularity as a method of improving the safety and efficiency of the transport system.

Dealing with change has always been a critical issue in organisations. In areas where change is rather predictable and the response can be engineered upfront, organisations need to be flexible. Volberda and Rutges (1999) define flexibility as 'the degree to which an organisation has a variety of actual and potential managerial capabilities, and the speed at which they can be activated, to increase the control capacity of management and improve the controllability of the organisation' (Volberda & Rutges, 1999). Another definition of organisational flexibility is the organisation's ability to adjust its internal structures and processes in response to changes in the environment (Reed & Blunsdon, 1998).

Volberda (1998) distinguishes three types of flexibility: operational flexibility (referring to reactive routines to familiar changes that are based upon existing structures or goals of the organisation), structural flexibility (referring to the capacity of the management to adapt its decision and communication processes within a given structure as well as the rapidity by which this can be accomplished) and strategic flexibility (referring to the capacity of the management to react to unstructured non-routine unfamiliar changes that have far-reaching consequences and need quick response). Zhang P et al. (2016) observe that the boundary between flexibility and agility is blurred. Flexibility is defined as a predetermined response to predictable events with relative low to medium rates of change, while agility entails an innovative response to unpredictable events with relatively high rates of change.

Flexibility is focused on single systems (e.g. manufacturing), while agility is focused on groups of systems (such as a supply chain or business network) (Whadhwa and Rao, 2003). The overlap between flexibility and agility could be described as strategic flexibility. Agility can be seen to envelop and extend the concept of strategic flexibility (Overby et al., 2006). Agility is needed when the required changes were not envisioned when the organisational processes and systems were established. As a result, more radical and innovative change is required such as modularizing or re-engineering existing processes and systems, building new systems and competencies or acquiring these via external partners. Only organisations that can quickly and easily deal with this can be called agile. Agility and its capabilities cannot be achieved overnight. It should be built into the long-range planning of the organisation and mechanisms are required to maintain it over time (Ashrafi et al., 2006).

In most cities congestion is increasing, the public demand for mobility and improved safety is increasing and the construction of new roads is constrained by increasingly limited public funds and conservation issues. To increase the level of service on roads without constructing additional capacity, traffic management and traveller services are required to optimize the productivity of existing road capacity. Despite the widely espoused anecdotal evidence of the benefits of ITS, ITS projects must compete with conventional road projects for funding at the local, regional and national levels of government. The application of an Intelligent Transportation System is always preceded by the identification of a determined problem that the Intelligent Transport System is supposed to solve, minimize, or simply aid in the way it is dealt with.

As the ITS moves into deployment, the advantages of carrying out comprehensive impact and performance assessments are significant, since such assessments can validate initial assumptions and provide data to influence future deployment, both locally and within the ITS community more generally (Nuzzolo & Comi, 2016). The importance of having Performance Assessment on ITS projects is to understand if the objectives and initial assumptions are being met if the system is performing according to the intended objectives (Stevens, 2004).

The importance of transportation in global trade has increased significantly in the last decades. Cost pressure, rising customer demand for sophisticated BRT services, sustainability and security as well as safety issues have boosted the need for more efficient, effective and differentiated transport operations. ITS were found to have the potential to address these challenges in the transport chain. However, due to the novelty of the technology both ITS developers and users face huge uncertainty about the performance impacts of Intelligent Transport System within the BRT. Evaluating Intelligent Transport System in the BRT before the rollout based on concrete measures is likely to reduce the uncertainty involved in ITS developments and enhance the adoption rate of the new technology. In the public sector where various modes of transport such as the taxi, metro bus, metro rail, Gautrain and the BRT operates, ITS present opportunities for improving Level of Service (LOS) delivery (Zhang P et al. 2016).

Zhang et al. (2016) state that synergy between the ITS and business activities ensures speedy, effective and efficient translation of innovative responses that require radical changes to and re-engineering of business processes and information systems. ITS for users employ technology (such as smartphones and GPS-enabled devices) to improve convenience and journey efficiency for drivers and other users. They can reduce the barriers to switching transport modes and provide real-time and forecast information. For example, smartphone apps are available that use GPS and 3D maps to work out how efficiently a motorist is driving and provide advice on improving that efficiency. Integration encourages knowledge sharing between ITS and Business and that may lead to superior customer services. Considering this fact, the biggest challenge for and ITS department is to ensure an efficient and effective ITS delivery owing how much is at an acceptable quality level for the BRT.

This requires finding a constant way of measuring the BRT performance by using appropriate methods and tools and also by making the necessary adjustments on time in case of deviations in order to keep the same quality level. By measuring different components, like customer satisfaction, availability and service quality and then consolidating these measures to one, a total quality picture of the ITS delivery within the BRT may be retrieved. Zhang P et al. (2016) asserts the importance of Intelligent Transport System and Business Integration by stating that it facilitates informal and improvised decision making, especially in a turbulent environment. A close collaboration between Intelligent Transport System and Business enables a firm's processes to be responsive and flexible (Ferdows et al, 2004; McAfee 2004).

2.5.4.3. Intelligent Transport System innovation and orientation

ITS innovation in an enterprise is about using technology in new ways, where the result is a more efficient organisation and an improved integration between technology initiatives and business goals. Rouse (2011). ITS innovation can take many forms, for instance, it can be used to turn business processes into automated ITS functions, develop applications that open new markets, or implement desktop virtualization to increase manageability and cut hardware costs (Rouse 2011).

Sambamurthy et al, (2003) conceptualize ITS Innovation into two types first ITS exploration and ITS exploitation. The ITS contribute much to the efficient operation of BRT services and to the convenience and support of those who use these. ITS exploration capability is the ability of a firm to devote requisite resources and managerial time in making sense of different information technologies, experimenting with the promising ones to learn about their functionalities, and selecting the few technologies that are likely to impact the current and future operational capabilities. Moreover, in a paper on ITS, Pacione (2009) argues that compared to rail systems, the advantageous flexibility and decentralization of bus operations also result in a lack of system visibility and permanence that contributes to public perceptions of unreliability and disorganisation. Traffic congestion, urban sprawl, central city decline, and air pollution are all problems associated with excessive dependence on automobiles. Increasing recognition of the need for high-quality transit service to alleviate these conditions has fuelled the growing demand for Bus services throughout South Africa.

In most developing countries, an increase in urbanization has resulted in both environmental and social challenges. Notwithstanding a rash of recent technological innovations in areas such as web services, utility computing, and service-oriented architectures, a question remains as to whether an absence of agility or adaptiveness is primarily a technology rigidity issue or whether there are broader ITS managerial issues that allow inflexible ITS to persist and agility in turn to suffer. The ITS industry is characterized by a rapid pace of innovation, firms must manage their attention to current and emerging technologies, understand their potential value for business operations, and select promising technologies. (Sambamurthy et al, 2003). ITS exploration capability is the ability of a firm to devote requisite resources and managerial time in making sense of different information technologies, experimenting with the promising ones to learn about their functionalities, and selecting the few technologies that are likely to impact the current and future operational capabilities.

ITS exploitation capability refers to the ability of a firm utilize its existing ITS resources in improving existing processes or creating new ones. ITS exploitation is associated with the ability of a firm to manage its portfolio of ITS assets, leverage them and reuse them in different business activities and integrate the technologies with the business processes. Lu & Ramamurthy (2011) defines ITS Innovation as a proactive ITS stance and supports Sambamurthy et al, (2003) definition by stating that proactive ITS stance is characterized by a firm that always searches for ways to explore or exploit its resources to create or capitalize on business opportunities. Intelligent Transport System governance has identified the risks of ineffective ITS management whether in the form of weak cost control or project oversight, ineffective strategic planning, mistrusting end-user relationships or a lack of standards – factors that can result in ITS rigidity. As such, it could be argued that agility is as much a managerial issue as a technical issue for ITS flexibility is only truly useful when firms know how and when to take advantage of the options that a flexible ITS infrastructure has to offer.

This idea of performance is attributable to a duality of capabilities is echoed in the literature on the resource-based view where research finds that differences in performance are less a result of hardware or software resources alone – resources that are increasingly open to replication – but how well they are combined with non-ITS resources such as tacit knowledge to create distinct capabilities that can support a firm's strategic goals. Zhang et al., (2016) argue that a firm is likely to make better sense of a major ITS innovation and fully consider its potential fit to the firm and, thus, is able to identify, select, and pursue ITS innovations. In addition, the firm is able to anticipate and sense relevant changes due to advances in Intelligent Transport System and the opportunities created by emerging technologies (Weill & Ross, 2004). ITS opportunity orientation enables the firm to quickly identify and select opportunities with ITS innovations to address changing information needs that are in line with changing business strategy (Galliers, 2007).

Intelligent Transport System Innovation also enables continual learning and renewal. Augmented learning leads to an ability to quickly reconfigure processes in response to changes (Haeckel, 1999). ITS Innovation can be a proactive partner in the innovation process and permit dynamic reconfiguring and continuous transformation in changing environments (Agarwal and Sambamurthy, 2002). An organisation that has ITS innovation can manage the adoption, assimilation, and implementation of new ITS innovation initiatives and, thus, avoid falling into lock-in technology rigidity (Swanson and Ramiller, 2004). Sambamurthy et al (2003) Argue that ITS competence – an inside-out capability signifying "a firm's capacity for ITS-based innovation by virtue of the available ITS resources and the ability to convert ITS assets and services into strategic applications" – is a critical factor behind the range and intensity of competitive actions in a firm.

Where ITS infrastructure can flex in response to a change in the market or where technical skills can adapt to an urgent business need, a firm is more likely to realise increased agility. ITS innovation & orientation is an essential element of ITS capability as it refers to the ability to identify, select, and pursue ITS innovations. In short, ITS capability captures the cohesion shared by the three dimensions. A firm with high degrees of ITS capability should, therefore, be expected to contain each of the three ITS capability dimensions. Lu & Ramamurthy (2011) ITS exploitation capability refers to the ability of a firm utilize its existing ITS resources in improving existing processes or creating new ones. ITS exploitation is associated with the ability of a firm to manage the portfolio of ITS assets, leverage them and reuse them in different business activities, and integrate the technologies with the business processes.

Ramamurthy et al 1996, defines ITS Innovation as a proactive ITS stance and supports Sumbarthy (2003) definition by stating that proactive ITS stance is characterized by a firm that always searches for ways to explore or exploit its resources to create or capitalize on business opportunities. Swanson and Ramiller (2004) argue that a firm is likely to make better sense of a major ITS innovation and fully consider its potential fit to the firm and, thus, is able to mindfully identify, select, and pursue ITS innovations.

Fichman (2004) firms capable of comprehending the uncertainty about the benefits of using the innovation and the irreversibility in the costs of deployment, and it prudently avoids a herd-like mentality while examining the potential of a new IT innovation. In addition, the firm is able to anticipate and sense relevant changes due to advances in Intelligent Transport System and the opportunities created by emerging technologies (Weill & Ross2004). As such, a proactive ITS stance enables the firm to quickly identify and select opportunities with ITS innovations to address changing information needs that are in line with changing business strategy (Galliers, 2007). A proactive ITS stance also enables continual learning and renewal. Augmented learning leads to an ability to quickly reconfigure processes in response to changes (Haeckel, 1999). Intelligent Transport System becomes a proactive partner in the innovation process and permits dynamic reconfiguring on the fly and continuous transformation in changing environments (Agarwal & Sambamurthy, 2002). The firm with a proactive ITS stance can mindfully manage the adoption, assimilation, and implementation of a new ITS innovation and, thus, avoid falling into lock-in technology rigidity (Swanson & Ramiller, 2004). The firm can also identify the appropriate opportunity to reconfigure and reuse its existing ITS resources.

While early studies about the business value of ITS examined the direct connections between ITS resources and firm performance, Zhang et al., (2016) proposed a theory of ITS complementarities to argue that the initial effects of ITS should occur at the level of organisational processes that use the ITS resources. Finally, perception latency is the time it takes to perceive the outcome of the actions taken. Organisations with lower levels of latency will be more agile than organisations with higher levels of latency. Time agile companies can seize opportunities and gain advantages through their ability to reconfigure processes and organisational resources faster than competitors. They can reduce the barriers to switching transport modes and provide real-time and forecast information. For example, smartphone apps are available that use GPS and 3D maps to work out how efficiently a motorist is driving and provide advice on improving that efficiency.

ITS innovation in an organisation is about using technology in new ways, where the result is a more efficient organisation and an improved integration between technology initiatives and business goals. ITS innovation can take many forms. For instance, it can be used to turn business processes into automated ITS functions, develop applications that open new markets or implement desktop virtualization to increase manageability and cut hardware costs. Since the ITS industry is characterized by a rapid pace of innovation, firms must manage their attention to current and emerging technologies, understand their potential value for business operations, and select promising technologies (Nuzzolo & Comi, 2016).

2.5.5. Chapter Summary

Through the literature review, it was established that there are different perspectives regarding an intelligent transport system for advanced public transport management. From the related literature reviewed, quoted and analyzed in this chapter, it is considered that the operation and management of the public transport systems through intelligent transport are subject to various factors and characteristics of the ITS system design and the development and policies of various transportation institutions. Most of the authors have publicized how ITS are important as a new tool for operating and managing public and private transport. The subsequent chapter deals with data analysis, interpretation, and presentation of research findings pertaining to this study.

CHAPTER THREE

REVIEW OF CASE STUDY AREA- SOUTH AFRICA

3.1. Introduction

Transport plays a vital role in the social and economic facets of society. This is no different for South Africa. There is a strong interaction between land-use patterns, the economy, and transportation systems. Moreover, there are also negative impacts related to transportation. South Africa is a big country with a diverse physical environment. The country's total land area amounts to 1 219 912 square kilometers. South Africa's physical geography is dominated by one physical feature: a massive escarpment that runs right around the subcontinent, dividing a thin coastal strip from a huge plateau. This escarpment is clearest in the East, where it is marked by the spectacular Drakensberg Mountains (Ballard, 1998).

3.2. Land use patterns in South Africa

South Africa is still trapped in the legacy of racially segregated human-settlement policies. The apartheid government introduced legislation that preserved white supremacy, such as the Group Area Acts (No. 41 of 1950 and No. 36 of 1966), which directed population groups into specific urban spaces separated by buffer zones of open land. Whites were allocated large central areas, while blacks were displaced to townships on the periphery of cities. The apartheid system not only segregated races, but also entrenched inequality in the different forms of housing, geographical location, environmental landscape and in the distribution of facilities (Spinks, 2001). Post-1994 low-cost housing projects continue to be provided on the outskirts of cities, where land is cheaper and more accessible. Although locating human settlements on the edge of cities is a cheaper option, it is costly in the long run.

The government has to provide public transport operating subsidies, and poor households spend high proportions of their disposable income on public transport. Major cities in South Africa face a number of challenges, as urbanization and the fragmentation of households (resulting in more, smaller households) increase pressure on urban services and infrastructure. In order to meet the enormous service delivery demands, cities need to make efficient use of scarce resources. Land and land-use planning are key factors in effectively managing the inevitable progress of urbanization. The future of cities and their sustainability depend on decisions that are taken now in preparation for this growth. As a result of urban growth, service delivery pressure affects different sectors within cities, especially transportation and human settlements. The demand for transport is driven by the need for people to reach locations where activities take place, including the workplace, schools, hospitals, and clinics.

Therefore, effective land-use planning is vital, as it determines where major facilities and human settlements are located, how far people should travel to access such facilities, and what households and government spend on transport. Currently, in South Africa, these two sectors (public transport and housing) and land-use patterns face various challenges. The current public transport system is expensive, inefficient, ineffective and inaccessible, while coordination is lacking between land-use patterns and transport planning. Rising urbanisation and poverty levels, which increase the demand for housing, especially in the cities, are affecting human settlements.

Other challenges are related to the shaping of South African urban settlements by the apartheid regime, which resulted in spatial separation of residential areas according to class and race and promoted social isolation (DoHS, 1997). In urban areas, the demand for houses and for suitable land on which to build housing is increasing, but well-located land is scarce, costly and in some cases not owned by the government. Therefore, most low-cost housing projects tend to be developed in semi-urban areas, where land is cheaper, readily available and can be accessed with relative ease. Given the relative scarcity and cost of land in urban areas, cities need to make the most efficient use of this resource once it becomes available.

3.3. Transport demand in South Africa

The demand for transport is driven by the need for people to reach locations where activities take place, including the workplace, schools, hospitals, and clinics. Table 1.3 provides a breakdown of the main reasons for transport use, by settlement type. Choking congestion and pollution is a daily reality in most South African cities. Traffic volumes are growing at seven percent a year. There has been a massive increase in the use of cars to get to work. Between 1997 and 2004, the national percentage of people who used cars rose from 30% to 45%. In Gauteng, the figure is 55% (NHTS, 2003). Mobility patterns of South African inhabitants are dependent on the level of income. While most of the urban rich are car owners, the urban poor depend on public transport. Moreover, a fair share of the population cannot afford any type of transport. Nevertheless, the urban poor aim to own private vehicles as soon as possible.

Apparently, many households, with an income of only R4 000 per month, purchase a vehicle. According to Neil (2007), Passenger Demand Modelling represents one perspective of the metropolitan or regional transport system. The supply side represents the other perspective in terms of infrastructure and flow-dependent costs and travel times. The whole transport system is part of a region in which people live, work, and engage in leisure activities. The development of land use patterns and location of activities strongly determine travel demands in terms of trip generation and attraction and rely on transport systems that provide accessibility (Motos, 2007).

3.4. South African Transport Background

According to Beer et al. (2005), transportation is the driving force behind economic development worldwide. Newman (1999) explained that as the standard of living increases, there is even more demand for transportation capital and transportation infrastructure. He further argues that transport infrastructure can be a powerful catalyst, providing the building blocks for development that ensure growth, easy communication, and flexibility in commuting. Behrens (2002) suggested that the capital required in making a transition to improved transportation and flexibility in travel time i.e. origin and destination journey is investing in mass transit and smart management. Public transport plays a major role in uplifting South African and other global economies (DoT, 2011; Vilchis, Tovar & Flores, 2010). Its efficiency and effectiveness have developmental effects in the lives of the country's citizens. Public transport requires among other things the political will by the government as well as adequate resources such as funding and skills (technical & managerial).

According to the Department of Transport (1996), the South African transportation system is inadequate to meet the basic accessibility needs (to get to work, health care, schools, shops) in many developing rural and urban areas. Hence measures are needed to bring the South African transport system on par with the rest of its global counterparts such as Brazil, Chile, and India. Moreover, according to Pillay and Seedat (2007), the government engaged in the Action Plan in 12 of the major cities with the aim to integrate the 2010 Public Transport Infrastructure and Systems. These BRT projects also rely on parliamentary transport infrastructure grant which is often limited in supply and subject to bureaucratic hurdles. With that said, van der Merwe in Oxford (2013) also warns about the fragmented nature of public transport roll-out programs. The fragmentation stems from issues such as industry uncertainty, lack of buy-in by stakeholders, funding models and resource allocation. Contrary to what is being experienced, the White Paper on transport was developed in order to support the goals of the Reconstruction and Development Program (RDP) for meeting basic needs, growing the economy, developing human resources, and democratizing decision making. According to the DoT (1996), the following were fundamental issues which the White Paper sought to address:

- To enable customers requiring transport for people or goods to access the transport system in ways which best satisfy their chosen criteria.
- To improve the safety, security, reliability, quality, and speed of transporting goods and people (these are deemed to have reached unacceptable levels).
- To improve South Africa's competitiveness and that of its transport infrastructure and operations through greater effectiveness and efficiency to better meet the needs of different customer groups, both locally and globally.
- To invest in infrastructure or transport systems in ways which satisfy social, economic, or strategic investment criteria (hence the development of projects such as the BRT and Gautrain).
- To achieve the transport objectives in a manner which is economically and environmentally sustainable, and minimizes negative side effects.

Despite the above intentions, the South African public transport system is characterized by complex and often robust relationships among its stakeholders. The key stakeholders in this industry range from government, government agencies (for rail, road, air & sea transport), operators (corporate & SMMEs) as well as commuters (who are more often than not captive users) of services. Amidst the challenges experienced within this industry, the department of transport has continued with the implementation of an integrated public transport system (Holtzhausen & Abrahamson, 2011). This system is meant and believed to be complementary in nature and promotes inter-modal and intramodal competition (DoT, 2011). The implementation of an integrated public transport system does not come without problems (Holtzhausen & Abrahamson, 2011). The government sometimes finds it difficult to regulate industry participants so much that the enforcement thereof often results in violent altercations (Pikoli, 2015).

Moreover, there could be a contracting system which encourages intermodal competition for public transport contracts. For instance, when certain public transport projects such as BRT are being rolled out, these seldom occur without robust contestations from those whose turf and livelihood seem threatened. It is, however, worth indicating that commuters become the hardest hit by the endless contestations and disintegrated public transport system which is contrary to what the DoT has promised (DoT, 2011). It is important to note that the South African government, like in any other developing countries has a social and economic mandate to improve the quality of life of its citizens. One better way of realizing this is through quality and efficient public transport system. Over time, government and other stakeholders have expanded the harbors, airports, airplane fleet, rail lines and rail rolling stock, introduced rail technology train project, i.e. the Gautrain and bus rapid transit (BRT) project named Rea Vaya and Areyeng (in Johannesburg & Tshwane, respectively). There are also other BRT projects being rolled out in the cities of provinces such as Eastern, Western Cape, Limpopo, and North West.

The main idea behind the introduction of these projects is to allow the country to have world-class integrated public transport which can contribute positively towards the economy and the lives of citizens (Holtzhausen & Abrahamson, 2011; DoT, 2011; Oxford, 2013). All these projects were received with ambivalent reactions from various stakeholders (Moosajee, 2009). For instance, some politicians have regarded the Gautrain and the BRT's as groundbreaking public transport projects while others labeled them as "white elephants" which are meant to benefit the elite few (Bickford, 2013).

Small operators such as those who operated minibus taxis viewed BRT projects an attack on their turfs and threats towards their livelihood. On the other hand, government and commuters regarded the BRT as the realisation of the historic economic and social mission. Despite all the contrasting views, a public transport system should always take a user-centered approach. In this study, the significance of BRT as a public transport strategy will be explored and its characteristics will be analysed against those of BOS.

Mobility and transportation are the engines to the economic growth of a country. Unfortunately, this engine shows the signs of the times (i.e. congestion, accessibility and road safety problems), since it is often designed without much consideration for the increasing population of a country, especially in the developing world. Now, in nearly all urban areas in South Africa, the common signs of an ineffective traffic and transport (management) system can be experienced: traffic jams during peak hours, little or no use of public transport by the affluent population group, unreliable and unsafe trains and taxis, and unsatisfied customers. Many researchers worldwide are looking for opportunities to improve the situation by implementing technology in the transportation field. The demographics of South Africa indicate large and cosmopolitan metropolitan areas and its population is defined by a long history of local and international migration. Figure 3.1. Presents the total South African population by province.

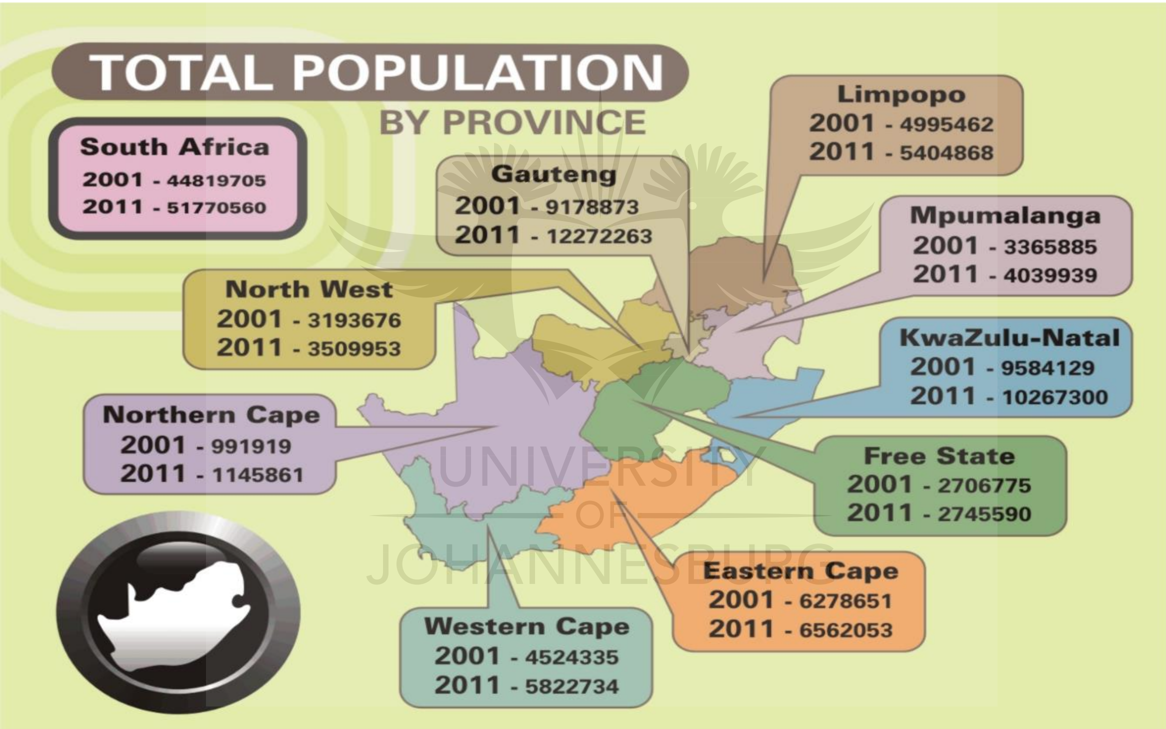

Figure 3.1: RSA total population. Source (STATSSA. 2011)

Gauteng is the most densely populated region in South Africa followed by Kwa-Zulu Natal, while Northern Cape is the least dense of all cities in South Africa. According to Statistics South Africa, the population of South Africa is approximately 57,943,723 million people (StatsSa.org, 2011) and like many developing countries, South Africa experiences traffic congestion, pollution, and overcrowding. Recent studies have shown that South Africa‘s population is increasing by about 2 percent a year.

An increase in population will result in an increase in urban problems pertaining to traffic, pollution, and overpopulation (Mabena, 2010). Figure 3.2 shows the population growth of the South Africa from 2009 to 2018 as presented by Stats SA 2018.

Figure 3.2: Population growth of the South Africa, Source: Stats SA 2018

From figure 3.2. It is evident that South Africa is not meeting the demands of commuters with respect to public transport as the supply is always insufficient for the growing population of the nation. Nearly two decades after the publication of the White Paper on National Transport Policy in 1996, passenger transport in South Africa still suffers from inefficiencies and is not adequately focused on the customer. The levels of reliability, predictability, comfort, and safety are still poor in certain areas. Accessibility to services and universal access are also a challenge. A transportation system is a significant structuring element of South Africa. The Integrated Transport Plan (ITP) of South Africa (2013) focuses on three main elements of land transportation, of which two, namely public and private transportation mainly influence the development of South Africa.

As demonstrated in the South African ITP, the predominant modes of transport used by South African residents to commute from home to work are the private motor-vehicle (13.7%) and minibus-taxi (41.6%). Other modes of transport used by South African residents, excluding walking, include the train (4.4%) and bus (10.2%) (Statssa, 2013). According to the National Household Travel Survey (NHTS) of 2003 and that of 2013, the passenger transport system is not sustainable under the current operating and management practices. The low profitability levels negatively impact on the capacity of private operators to adequately maintain and recapitalize their fleets. Unhealthy competition among modes also distracts from the spirit of partnership in the passenger transport sector. This, in turn, results in an unfortunate downward cycle of poor quality services, minimal investment in services, poor market perception, and an increase in the use of private vehicles.

Former Transport Minister Dipuo Peters said the fact that the Stats SA survey indicated that there was an increase from 10.9 percent to 14.4 percent of all commuters who walked more than 15 minutes to get transport, meant there should be an improvement of infrastructure, operations, and land-use planning, to improve the transport system.

The minibus-taxis account for 75% of the public transport system in South Africa. The demand for daily work related to commuting is 42.8% of the total population of South Africa (Tracey et al., 2013). Demand for excess public transport offers 16% and this obliges many people to use private vehicles for journeys to work on a daily basis. The local authorities came out with several strategies to ease transportation in South Africa including integrated network plan as illustrated in figure 3.1. Nationally, eleven percent (10,5%) of households identified lack of buses as their main transport related problem, with the majority of complaints coming from those residing in Gauteng (12,5%), Western Cape (12,0%), KwaZulu-Natal (11,8%) and Eastern Cape (11,6%). In Gauteng, about 52, 6% of households that used train services indicated that they were not satisfied with the distance between the train station and their home. In Western Cape, slightly more than four out of ten mentioned this as a problem. Nationally, 44, 7% of households were dissatisfied with the level of crowding in buses.

They were also dissatisfied with the facilities at bus stops, such as toilets and offices. Other problems that were not as important nationally, but for which there were significant percentages of provincial complaints, included (National Household Travel Survey, 2013):

- Lack of taxis at specific times
- No buses at specific times/late at night
- Taxis are too far
- Congestion: Gauteng (6, 3%) and Western Cape (6, 2%)
- Crime: Western Cape (8, 9%)
- No taxis available: Northern Cape (6, 2%) and Limpopo (3, 6%)

More than 21 years into the democratic era, South Africa's dreams of efficient, affordable and integrated public transportation systems remain deferred. A bleak and underwhelming picture is painted of captured users involuntarily using services that are lacking safety, services that are costly and services that are inaccessible for various reasons. Congestion on South Africa's road networks has peaked with nowhere to redirect car users for alternative transit. From an institutional perspective, public transport policies and plans –although directive – miss the necessary targets and densities to operate efficient and effective systems. The need for solutions that bring a direct positive impact on the South African public transport system is at a critical junction (Mthimkulu, 2015).

With an obligatory need to address the issues around inadequate public transport systems as well as an overwhelming requirement to upgrade systems to attract and sustain world events, major South African cities have sought to implement public transport systems and networks that are internationally recognized and promised to directly impact the issues at hand while meeting the objectives set out in policy (Walters, 2014). With some of the present systems being on the back burner and having minimal upgrades, new infrastructure has been developed to fulfill the demand for mass transit in line with accelerated urban growth and international best practice.

The Gautrain rapid rail – connecting Gauteng's two economic hubs, Johannesburg and Pretoria and having a link to the airport as well as Bus Rapid Transit (BRT) systems which are present in 5 provinces in the country that have become the focus of public transport infrastructure to promote economic growth and the long-term sustainability of cities (Thomas, 2016). This level of transformation and the benefits that were acclaimed with the development of these systems has remained a debatable topic. The transportation industry in South Africa employs roughly 420,000 people, and trade union density is around 40% (Satawu, 2006). If minibus workers are excluded, the trade union density jumps to roughly 55% (Satawu, 2006). The national government has also prioritized transportation spending in recent years, as it views transportation as "the heartbeat of South Africa's economic growth and social development" (Department of Transport, 2013). Furthermore, the national expenditure on public transport grew between 2007/2008 and 2010/2011 "from R4.7 billion to R8.2 billion, at an average annual rate of 20.7 percent" (National Treasury, 2011). Thus, the transport sector has the potential to act as a catalyst for economic development and job provision and is an important sector of the South African economy.

Lucas (2011), in her studies of social exclusion in South Africa due to transport difficulties, summarizes the four key problems with transportation in the literature:"(I) low access to private vehicles and public transit services, (ii) affordability issues linked with high levels of reliance on the use of minibus taxis, (iii) the legacy of apartheid planning and new postapartheid housing development patterns, and (iv) over-reliance on walking and exposure to risk". This provides an indication of the continuing struggles faced by the majority of South Africans in relation to transportation infrastructure. Despite government initiatives such as the taxi recapitalization program (2006), the publication of two additional strategy documents in 2007, and the replacement of the 2000 National Land Transport Transition Act with the 2009 National Land Transport Act, significant challenges remain for South Africans in accessing reliable and affordable public transportation. To the list above could be added the question of multiple layers of government participating in the planning of transportation infrastructure, and the difficulties in coordination that arise. For example, the national government provides overall guidance through the Acts mentioned above, but municipalities are often responsible for the actual planning and delivery of services. In some cases, such as the Gautrain project, the provincial governments have also taken the lead, and arguably without properly including/consulting municipalities (Ungerer & Daweti, 2007).

A strong, well implemented and well operated public transport system is not far from the horizon of South Africa's future when the political will of those in power is aligned with the policies and plans that are present and documented. Transportation, although inundated by complex issues, has the possibility to affect many other disciplines and more especially, the economy of South Africa. The Bus BRT provides a slightly more optimistic perspective on the state of public transportation infrastructure development. The South African public transport system consists predominantly of rail and bus services that are subsidised by the government and the mini-bus taxi service which is unsubsidized. These do not work in an integrated fashion and compete with one another for commuters.

The principal project objective in South Africa is to upgrade the quality and performance level of the public transport system In South Africa, the apartheid government moved black people to outlying townships like Soweto, which meant the majority of the black population was forced to use public transport to get access to economic opportunities (Gail Jennings., 2015). Public transport gives residents increased freedom of movement as well as economic freedom- liberating them from apartheid spatial legacy characterized by informal settlements, poor schooling, and limited recreational spaces. Transportation allows economic development to occur because it's a basic prerequisite for anything human. Public Transport plays a critical role in the whole of RSA economy, contributing to poverty reduction by enabling the productive activities that create effective economic growth, and by providing poor people with access to economic opportunities and social services and a means of participating fully in society (Jennings, 2015). Transport improvements undoubtedly promote economic growth and social development by increasing mobility and improving accessibility to people, resources and markets. There have, however, been some concerns about the effect of (improved) transport systems on sustainable development.

Several impacts of traffic and transport and associated costs can be distinguished, such as social, economic and environmental impacts, for both current and future generations. Sustainable urban transport development can only be achieved if the full account is taken in all aspects (Zeitgeist, 2005). A review of literature on public transport quality indicates that service quality in the public transport sector reflects commuters' perceptions of the transport system's performance (Hensher et al. 2003; Wallis & Currie, 2008). In a journey, commuters generally have a choice between modes of transport, each with unique features interwoven with pros and cons (Garling, 2005). Customers' expectations and perceptions are paramount to service quality (Davidoff, 1994); they are not objective and may also not based on reality (Ungerer & Daweti, 2007). Service quality in the public transport sector can be measured in relationship with customer's expectations, perceptions, satisfaction, and attitude (Litman, 2008); it encompasses several topics such as comfort inside and outside of the vehicle, journey duration and the existence of infrastructural support systems (Currie, 2005).

A holistic approach to service quality improvement in the public transport system is required, particularly in the identification of customer's needs and priorities, including use of complaints and feedback to evaluate necessary service quality indicators (Dell'Olio, Ibeas & Cecin 2010). Public transport usually competes with other modes of transportation (Currie 2005) and will definitely be utilized if it can meet the expectations of the commuters, specifically if it can deliver the accessible, safe, affordable and reliable service it claims to provide (Stradling et al. 2007). Transport demand issues became additional widespread and severe than ever that in each industrial and developing countries alike. Fuel shortage square measure (temporarily) is not a drag however a general increase in road traffic and transport demand has resulted in congestion, delay, accidents, and environmental issues well on the far side what has been thought-about acceptable to this point(Jennings, 2015).

These issues haven't been restricted to the road and vehicular traffic alone. The economic process looks to possess generated levels of demand extraordinary the capability of most transport facilities. The demand for transport service is highly qualitative and differentiated. There is an entire vary of specific demands for transport that are differentiated by time of day, day of the week, journey purpose, style of shipment, the importance of speed and frequency, and so on. A transport service while not the attribute matching this differentiated demand may perhaps be useless. The demand for transport is derived; it's not associate finish in itself. With the possible exception of sightseeing, people travel in order to satisfy a need (work, leisure, education, health) at their destination. This is even a lot of - true of products movement. In order to grasp the demand for transport, we have a tendency to should perceive the means during which facilities to satisfy these human or industrial desires are distributed over a house, in both urban and regional content.

A good transport system widens the chance to satisfy these needs; a heavily or poorly connected system restricts choices and limits economic and social development. Over read of the characteristic of transport offer is that it's a service and not a decent. Therefore, it's uphill to stock it, as an example, to use it in times of higher demand.

3.5. Challenges Facing Transportation in South Africa

Transport and education are widely accepted as the two sectors which provide the highest returns, both economically and socially, for the development of a country (Copley, 2010). Thus, there is a need to efficiently and effectively develop the existing transportation network to secure the future growth of the Gauteng City-Region. Currently, the region is characterized by a lack of user-friendly, cost-effective and integrated transportation infrastructure. The result is a negative impact on economic activity, job creation and cost of living. The unnecessarily high costs of living is a burden borne especially by the most economically and geographically vulnerable residents of the region. It is important to recognize that transportation infrastructure is intimately linked to urban spatial planning and land use. For example, India has a very distinctive transportation system due to high urban densities, mixed land use patterns and the resultant spike in short trip demand. In cities like Delhi, for example, high density and mixed land use enables many to walk to their destinations or use non-motorized transportation (Tiwari, 2001).

In South Africa, however, there is little doubt that the legacy of spatial apartheid planning has significantly contributed to the many transportation challenges faced by her cities. In particular, past urban planning (or lack thereof) encouraged urban sprawl, low-density housing and a lack of mixed land use (Simon, 1992). Thus, South African cities are characterized by inadequate residential planning. This has placed upward pressure on private vehicle demand, resulting in increased automobile dependence and road congestion over time. The predict and provide method then creates a negative feedback loop for this, as more cars demand more (and wider) roads, which are then built and so the process evolves over time into an unsustainable situation.

3.6. South African transport policies

3.6.1. Background

This section provides a succinct overview of relevant policies divided into three categories, firstly policies relating to the planning of a transport system, secondly policies that inform the spatial analysis of a future public transport network and thirdly sustainability. Although the focus is on policy in this document, certain key planning documents and strategies have been included that are regarded as significant to the project. In one or two instances acts are mentioned that reflect relevant government policy. There has been much work conducted on the transport policy environment since the emergence of a democratic South Africa.

Walters (2012) account of public transport policy in South Africa provides a useful overview of what has transpired in the policy arena. From the White Paper on National Transport Policy, 1996 there was an explicit emphasis on prioritizing the needs of public transport and non-motorized users. There has been much work on understanding what this might entail and these sentiments have been better understood and reinforced in transport legislation and policy documents formulated over the past 16 years. The public transport strategy document produced by National Department of Transport in 2006 is indicative of the amount of work that has occurred in this area, and the recent improvements in public transport infrastructure and services can arguably be attributed to this effort. However, Walters (2012) analyses each mode, as well as the various operators of public transport, separately and critically discusses that policy for each mode of public transport has been developed in a silo which presents major challenges for the integration of systems spatially and operationally.

The lack of integration has clearly posed challenges at the local government level as highlighted by Moodley, Chetty, Reddy, and Simmer (2011) and Holtzhausen and Abrahamson (2011) in their accounts of developing integrated transport networks in Ethekwini Metropolitan Municipality and Cape Town Metropolitan Municipality respectively. Walters (2012) further argues that the complexity and lack of clarity around the relationship that the three spheres of government share regarding transport, as well as a distinct lack of sustainable funding mechanisms, pose great threats to the implementation of integrated public transport. The South African government has clearly focused on the development of public transport and less so on the NMT improvements that policy documents have called for.

A draft national NMT policy document was developed in 2007 and there is evidence of a growing focus on improving NMT conditions in South African cities. However, in-line with Walters (2012) comments, NMT policy development is largely occurring in a silo and thus runs the risk of further fracturing the transport environment. It is clear that there has been much progress made in terms of shifting policy away from a vehicle bias which focuses on the private vehicle owner and this is a shift in the right direction. However, there needs to be greater emphasis on integrating the policy development of various modes and their various operators.

South Africa as a developing country does not have the same level of transportation planning, across all spheres of government, as compared to developed countries, and more specifically North America. The lack of transportation policies are evident, and even more so the lack of non-motorised transportation policies, especially at provincial, district and local level as can been seen with the policies scrutinized in this section. The Municipal Systems Act (Act 32 of 2000), relevant to district and local municipalities does not specifically necessitate the compilation and approval of a transport plan.

It does, however, require the governing bodies to compile an Integrated Development Plan (IDP) and Spatial Development Framework (SDF) as part of the IDP. This framework should, however, include the development strategies and priorities of the city council, which should include transport developments (South Africa, 2000). The following transport policies were reviewed to give an overall view of the transport management systems:

- National Level
- Draft National Non-Motorized Transport Policy document, 2008, and a
- National Transport Master Plan, 2011 (NATMAP 2050).
- Provincial Level
- Provincial Spatial Development Framework, 2012 (PSDF).
- Local Level
- Spatial Development Framework, 2012

3.6.2. National Land Transport Strategic Framework

The National Land Transport Act (NLTA), (Act 5 of 2009) also provides the legal framework for the implementation of BRT's including negotiated 12-year contracts, the restructuring of existing public transport services, The National Land Transport Strategic Framework (NLTSF) is a legal requirement in terms of Clause 21 of the National Land Transport Act (No. 05 of 2009). It embodies the overarching, national five-year (2015 to 2020) land transport strategy, which gives guidance on transport planning and land transport delivery by the national government, provinces, and municipalities over the five year period. Strategies within 15 functional areas are outlined in terms of actions and outputs. The master plan for an intelligent integrated transport information hub strategy‘s plans are in line with the NLSTF and the strategy‘s development program would facilitate the achievement of the set strategic actions as outlined in the framework (Department of Transport, 2015).

The 2000 National Land Transport Transition Act provided for the creation of these bodies at the municipal level, and the 1996 White Paper identified fragmentation between different levels of government as a serious problem across the country. However, transport authorities have still not been created to tackle these important issues of integration and local ownership. In light of the slow movement to create transport authorities, Mostert (2011) argues that "*a special purpose agency should be created immediately to oversee the coordination of all formal public transport. This agency should be staffed by people who have a holistic view of public transport and who have a record of commitment to improving public transport*".

The contextual framework within which this NLTSF has been prepared is transport-related legislation and its associated policy. Strategies within 15 separate functional areas have been described in terms of outputs, and actions to achieve those outputs have also been included. The functional areas that are covered include the following:

- Public transport
- Land-use restructuring
- Roads
- Cross-border road transport
- Freight transport
- Inter-provincial transport
- Rural transport
- Traffic safety and enforcement
- Transport for persons with disabilities
- Non-motorized transport
- Transport and the environment
- Tourism and transport
- Transport and the 2010 World Cup
- Intermodal and integration of transport planning
- Conflict-resolution mechanisms.

3.6.3. National Transport Master Plan

The National Transport Master Plan for (2005-2050) provides an integrated mechanism for land use patterns and how people could effectively interact with various modes of transportation of people. It is a framework for transport systems planning, implementation, maintenance, operations, and investment as well as a monitoring tool for decisions for all modes. It is thus vital for the ITS interventions in traffic management to be in line with the NSDP principles and other planning regimes, including spatial planning (Department of Transport, 2010). The Transport Lekgotla (Convention) held on 08–09 April 2005 resolved that an “Integrated National Transport Plan” for South Africa should be developed. The then Integrated National Transport Plan (INTP) was later referred to the National Transport Master Plan (NATMAP). In the development of NATMAP (2050), it was necessary to identify and crystallize existing perennial problems and those which resulted from alternative socio-economic development strategies and to indicate how best these may be formulated, prioritized and implemented.

NATMAP (2050) goal is to develop a dynamic; long term and sustainable land use/multimodal transportation systems framework for the development of networks infrastructure facilities; interchange termini facilities and service delivery. The focus is that NATMAP (2050) should be demand responsive to national/provincial/district and /or any socioeconomic growth strategy, and/or any sectoral integrated spatial development plan. The application of strategic planning to transportation plans and problems are not n new phenomenon and/or development in long term planning. Provincial and municipal bus operators must be corporatized and all subsidized services must be provided in terms of tendered contracts that will be open to all road-based public transport operators, subject to the specifications of local transport plans.

Some parastatal and municipal bus services will achieve tendered contract status via the bridging mechanism of negotiated service contracts.

"Land transport planning must be integrated with land development and land use planning processes, and the integrated transport plans required by the National Land Transport Act (5 of 2009) are designed to give structure to the function of municipal planning mentioned in Part B of Schedule 4 to the Constitution, and must be accommodated in and form an essential part of integrated development plans, with due regard to legislation applicable to local government, and its integrated transport plan must form the transport component of the integrated development plan of the municipality" (Schoeman, 2010).

This provision, although very general and of a purely philosophical nature, should be read with the objectives as identified in the National Framework for Sustainable Development in South Africa (2008:10) that make provision for:

- Enhancing systems for integrated planning and implementation;
- Sustaining ecosystems and using natural resources efficiently;
- Economic development via investing in sustainable infrastructure;
- Creating sustainable human settlements, and
- Responding appropriately to emerging human development, economic and environmental challenges.

3.6.4. National Road Transport Act (no 93 of 2016)

The National Road Transport Act focuses on road safety of users and regulations for law enforcement. The implementation of this Act would ensure proper facilitation of intelligent transport technologies in terms of road safety operational standards and in promoting other intermediate means of transport such as bicycling, pedestrian safety measures and so forth. Conformity of these low-cost modes of transport would ensure smooth integration into the transport system as licensing and permits would be required for the movement of goods and passengers (Department of Transport, 2012).

The transport agency should be staffed by people who have a holistic view of public transport and who have a record of commitment to improving public transport". At the national level, this process could be similar to the one undertaken in the early 1990s with the National Transport Policy Forum (NTPF), which would include voices from government, organized labor, and other civil society organisations

3.6.5. Provincial transportation policies

The following provincial transport policies have been reviewed as they give an overall view of how ITS can be implemented for transportation management. At the provincial level, it might resemble the recently constituted body in Gauteng mentioned in the previous section of this research. This body includes government actors, organized labor, transport experts, and relevant private sector partners. At the municipal level, it would involve the creation of transport.

Authorities composed of local politicians and citizens. These authorities are crucial in terms of integrating local transport with other important infrastructure and services in the region, including health, education, and economic development. Transport authorities could then be consulted by provincial and national governments while planning important transport projects. Overall, this focus on integration and broader participation could facilitate a more inclusive, democratic, and equitable public transport system. It has the potential to allow each level of government to prioritize transport need.

3.6.6. Provincial Land Transport Frameworks

Clause 22 of the NLTTA requires each province to annually prepare a provincial land transport framework for a five-year period. The initial Provincial Land Transport Framework (PLTF) must serve to guide land transport in the province, including intra provincial, inter-provincial, and cross-border transport. Any subsequent provincial land transport frameworks must also include summaries of the local plans within the province. This entails that each province should have its own policies which will guide a smooth integration of intelligent systems in transport management.

3.6.7. Policy perspective on ITS

The underdevelopment of Intelligent Transport System is largely due to a lack of national co-ordination, as the main ITS deployment efforts have been at the metropolitan level but these have been hindered by institutional inconsistencies. These Municipal Authorities (and SANRAL) are deploying ITS technology in an institutional vacuum since the roles and responsibilities of the DoT have not been clarified to regulate and consolidate all institutional ITS technological requirements. The DoT acknowledged this deficiency in the Draft ITS Policy for South Africa which was drafted in 2008. This document proposed that the DoT would establish an ITS capacity which will play an advocacy, coordination and promotion role of Intelligent Transport System in the country.

This capacity will ideally be a line function, and be placed within a Branch that shall be decided by the Director-General. In the interim, the Director-General must identify a group of people or a line department, which will play this coordinating role until a line function has been established. As such, the Department of Transport would be key to motivating the allocation and provision of funding for implementation of ITS systems at a Metropolitan level. At a Regional level, the Department of Transport would be instrumental in setting up regional ITS Steering Committees, providing synergies between the various implementing authorities and ensuring a coordinated approach to ITS deployment. Unfortunately, this Draft ITS Policy was never officially adopted. While the National Land Transport Act (2009) promotes and provides for a much better aligned institutional dispensation for the planning, implementation, and management of transport functions in the country, the implementation of the ITS institutional structures and arrangements will, however, not be achieved in the short-term.

The NLTA also requires that the Minister of Transport must develop, establish and maintain a national information system with regard to land transport, based on sound business processes, and in collaboration with the provinces integrate that system with the information system kept by provinces. Transport plays a significant role in the social and economic development of any country, and the government has recognized transport as one of its five main priority areas for socioeconomic development. The effectiveness of the role played by transport is to a considerable extent dictated by the soundness of transport policy and the strategies utilized in implementing the policy. Public policy cannot be static but must be dynamic in nature. It must always be perceptive to the environment within which it operates. , therefore, needs to be reconsidered and if necessary, revised on a continuing basis. Most of the policies emerge from the National Department of Transport in the form of frameworks, plans, and legislation.

The Commuter Bus Industry The policy applicable to the commuter bus industry in the country is found in the White Paper on National Transport Policy of 1996 and in a number of other documents such as the Moving South Africa Strategy (MSA), the National Land Transport Transition Act of 2000 (NLTTA) as well as a Model Tender Document and the Heads of Agreement (HOA) between organized labor, the Department of Transport and the Southern African Bus Operators Association (SABOA) that regulates aspects of the tendering system. Part of the policy is also to be found in interim contracts with subsidized operators as an interim measure between the previous policy of lifelong operating rights and passenger subsidies, and the tender for contract system.

In this overview, I will not dwell on these matters as they have all been described in some detail at previous THREDBO. The official policy of the Department of Transport is that any bus service that requires a subsidy should be competitively tendered. Provision is also made for negotiated contracts. Especially for provincial and local government-owned bus companies as a once-off measure to enable such companies to recapitalize as well as prepare for the competitive regime.

At present, there are approximately 10 000 commuter buses (excluding municipal buses (+/- 1100)) of which approximately 7119 are included in the DoT subsidized system.

3.7. Bus Rapid Transit system in South Africa

3.7.1. Introduction

One of the more promising projects currently being implemented in South Africa is that of Bus Rapid Transit (BRT). There is much emphasis on developing BRT systems in South African cities as is indicated by Pillay and Seedat (2006) in their discussion of the National public transport strategy document. BRT is seen as the backbone to the IRPT networks which are required to be developed in the metropolitan municipalities. The motivation for transportation systems such as the BRT in South Africa is mainly their potential to connect the parts of the country’s fragmented cities. Geurs and Wee (2004) define accessibility as the extent to which land use and transport systems enable individuals to reach activities or a destination.

Inaccessibility results in social exclusion and diminished access to goods, services and employment opportunities. However, the BRT system in South Africa is intended to serve the larger purpose of restructuring cities, thus enhancing spatial justice in the country. Soja (2009) argues that access to goods and services by individuals or groups is crucial to creating “just spaces”. BRT systems in South Africa have not yet had the anticipated results of increasing accessibility to areas of opportunity, reducing poverty and promoting social cohesion (Rahim, 2014; Wits, 2014). According to Cervero (2013), while transit orientated development (TOD) should enhance pedestrian access to transportation, many factors need to be considered when investing in BRT. These include compact, mixed-use, pedestrian friendly development organized around a transit station. The predominantly mono-functional nature of township neighborhoods accompanied by relatively low densities surrounding the BRT stations mean that the factors discussed by Cervero do not exist. Thus, in considering BRT station precincts as potential TODs, neighborhood context is fundamental.

Currently, Johannesburg and Cape Town BRT systems are operational with Nelson Mandela Bay, Tshwane, Buffalo City, Rustenburg, and Polokwane are all in the process of implementing their systems. The confidence in BRT systems is high. This is despite the lack of robust empirical research to support the benefits in a South African context. There is a distinct lack of research which has been conducted on how the systems which are operating or performing relative to broader policy objectives. The Johannesburg Rea Vaya operator business plan has been modeled on successful BRT systems in Latin America, where they have almost identical situations to those in South Africa, with large numbers of minibus taxis and buses vying for passengers, and where both incumbent taxi and bus operators have become the new BRT operators. Rea Vaya BRT operators will be compensated on the basis of vehicle kilometers run, rather than the number of passengers carried, and consultation has been taking place with industry representatives – particularly the minibus taxi industry.

Maunganidze (2011) in his research on the Cape Town system is critical of the degree to which the Cape Town BRT service has been able to address travel needs of the poor. More research is required in this area to access the financial, land value and urban form and person travel impacts that the BRT systems are having. However, it seems that it is too late to impact on the decision making around the type of transport investment which will take place in cities. The City of Johannesburg started with the conceptualizing of its Bus Rapid Transit system in 2006 and named the system “Rea Vaya” which means “we are going”. The central feature of the BRT is that it approximates a rail network but the vehicles are on rubber tires. They run along dedicated road lanes, usually but not necessarily in the center if the road. Enclosed ticket stations make for safe and rapid movement of passengers on and off vehicles, and time-tabling ensures that even at off-peak times, nobody has to wait longer than 10 to 15 minutes for transport. According to the City of Johannesburg (2015), the Johannesburg Rea Vaya was modeled on the South American Bus Rapid transit systems, particularly the TransMileno of Bogota, Colombia.

A feature of the South American BRT systems is that the vehicles tend to be privately owned, largely because existing taxi and bus owners have been brought into the system as owners. The service is strictly regulated by a public authority, including regulation of the ticket prices, wages, and timetabling. Infrastructure, including depots, is entirely publicly owned. This is the model most closely being followed currently in South Africa, largely because of a desire to accommodate existing taxi and bus operators. The business model is one in which the fares collected from large volumes of passengers more than cover the operating costs, providing a reasonable rate of return for the owners (certainly a much higher rate of return than existing taxi and bus services). In every South American city where BRT has been introduced, passenger numbers have gone up, fares have been reduced, wages and working conditions have improved and operating profits have increased. In order to allow BRT's reaching its high levels of efficiency (less cost and higher reliability), safety and comfort for public transport users, it is essential to use advanced ITS. This is a concept that clearly relates to the evolution of transport services with the combined technologies of ITS.

Although Intelligent Transport System tools are being applied in BRT systems, technical references allowing for the systemization of the functionalities offered by Intelligent Transport System in the operation of BRT are not found. The main reason why more people use their own cars to go to work is that public transport, like trains and buses, are not always reliable. This leads to many cars in the cities, which cause problems like traffic jams and accidents. The result is a loss of productivity because people are late for work. Over the past eight years, the South African government has spent more than 130 billion rands on public transport projects in the country's main cities. The projects included the refurbishment of rail services and the establishment of a new rapid rail and Bus Rapid Transit (BRT) systems. This is a lot of money by any standards. As a percentage of the gross geographic product, South African cities devote about twice as much money to transport as other developing countries and as much as four times more than some regions of the world. The country should by now be celebrating the success of this investment. But sustaining the systems, especially the BRT systems, is proving to be difficult. Even high ranking government officials have expressed doubts about the way things are going.

The former MEC for transport in Gauteng province, Ismail Vadi, asked whether the government was getting value for money from the BRT systems. His concerns have been echoed by Joe Maswanganyi, the national minister of transport. Over the past 20 years, BRT's have been using the software, hardware, and communications technology to improve the service provided. These improvements have included better service reliability for passengers, better supervision of bus operations, improved scheduling, and timely passenger information about bus locations and travel times (Hickman, 2004). According to Giuliano and O'Brien, BRT funders and providers see ITS technology as a means for improving efficiency, increasing service quality, and ultimately attracting more choice riders. There have been many critiques directed at the traditional transport planning process and what it means for non-motorized and public transport users (Vasconcellos, 2003; Behrens, 2004; Behrens, 2006, Kane, 2002, Kane 2010).

These are the modes that are relied on by the poorer people in South Africa. Given that traditional approaches to transport planning focus on providing improved conditions for the vehicle, poorer peoples' travel needs are often not well understood and are neglected (Beherns, 2004). Vasconcellos (2003) provides a strong argument for the development of improved transport planning practices in the developing world which can begin to develop more equitable and socially just transport decisions. There is no doubt that this thinking has had a profound influence on the transport policy in South Africa as there is a clear policy focus on public transport and non-motorized transport users. However, transport planning practices have largely continued in a business as usual fashion through much of the post-apartheid era. It is encouraging that much attention has been placed on developing public transport in South African cities and that there is a shift in transport planning practices and outcomes which is beginning to occur.

However, there has been a critical response to the public transport projects, such as Gautrain and the My City bus system in Cape Town, questioning whether the investments are indeed targeting the poorer residents living in cities. There is much emphasis on developing BRT systems in South African cities as is indicated by Pillay and Seedat (2006) in their discussion of the National public transport strategy document. BRT is seen as the backbone to the IRPT networks which are required to be developed in the metropolitan municipalities. Currently, Johannesburg and Cape Town BRT systems are operational with Nelson Mandela Bay, Tshwane, Buffalo City, Rustenburg, and Polokwane are all in the process of implementing their systems. The confidence in BRT systems is high. This is despite the lack of robust empirical research to support the benefits in a South African context. There is a distinct lack of research which has been conducted on how the systems which are operating or performing relative to broader policy objectives.

Maunganidze (2011) in his research on the Cape Town system is critical of the degree to which the Cape Town BRT service has been able to address travel needs of the poor. More research is required in this area to access the financial, land value and urban form and person travel impacts that the BRT systems are having. However, it seems that it is too late to impact on the decision making around the type of transport investment which will take place in cities. The awarding of the 2010 (19th) FIFA World Cup event to South Africa stimulated an intense interest in improving the transport system in order to live up to the projected image of being a 'World Class African Cities'. At the national level, twelve cities were singled bent on receive additional support to upgrade and integrate all modes of transport in line with hosting this event. Nine of the twelve cities were host cities to World Cup events. Urban center, Cape Town and statesman Bay Metropole would want to accommodate the fans and tourists that will visit throughout the events.

The urban center system Rea Vaya was planned and enforced in time, but most of the bus systems in other cities (although also part of the legacy) are still becoming operational. The BRT in Cape Town is additionally functioning and it will be thought of to be Africa's second system. On the opposite hand, Nelson Mandela Bay opted for a mixed system which included some rapid bus (BRT) and conventional bus services.

Other cities were ready to create some enhancements to basic infrastructure and place Park and Ride systems in situ for the games. Almost all cities in the developing world are facing rapid urbanization and improvements in standards of living. This causes an even faster growth in the urban travel demand, particularly so for personal motorized modes of travel. This, in turn, has meant increased congestion, leading to deterioration in air quality and a growing incidence of accidents, both of which have severe negative health impacts. The significantly increased use of fossil fuels for transport also has negative implications for climate change and creates a foreign exchange and national security problems for developing and developed countries (Sambamurthy et al., 2003).

In the absence of a proportionate increase in road space, congestion is increasing, compromising the ability of cities to remain competitive and livable. In response, governments are increasingly looking at ways of improving public transport. Investments in Bus Rapid Transit (BRT) are an attempt to provide efficient and effective public transport services, often in places where no formal public transport currently exists. The most commonly adopted strategies to mitigate these problems worldwide have been improving public and non-motorized transport through a variety of management and operations strategies and infrastructure investments, as well as traffic management. The objective of this approach is to reduce personalized vehicle travel by offering more competitive, more sustainable and less intrusive travel alternatives, improved public and non-motorized transport. In addition to expanding the size and increasing the quality of their conventional road-based public transport systems, cities are also electing to invest in one or more forms of rapid transit, both road and rail-based.

BRT was initially proposed in the Department of Transport's Public Transport Strategy Action Plans of 2007 and constitutes a system of buses with dedicated lanes/tracks, and stations for individuals to access the service. It is a project that builds from success in Brazil with the BRT system and could be viewed as an example of South-South cooperation in the field of public transport. The Rea Vaya BRT system in Johannesburg is currently in operation, along with My Citi in Cape Town. Planning is also underway for further BRT systems in other cities, such as Tshwane. In Gauteng province, contrary to the Gautrain, the Rea Vaya connects residents of Soweto to the core of Johannesburg and does a better job of connecting people from historically segregated areas to their places of work. This is a positive step in terms of battling mobility-related exclusion for citizens who can access the stations.

In addition, it is much less expensive to build than rapid rail transit. Roughly R3bn rands has been spent on the first two phases of the Rea Vaya (City of Cape Town, 2012), compared to over R30bn on the Gautrain. One of the central challenges for the BRT system has been integrating and incorporating the minibus taxis. The Rea Vaya, for example, runs parallel to many of the previous taxi routes. As noted by Walters (2012): "Taxi owners and their drivers were (amongst others) concerned about their future earnings, the loss of revenue as their taxi vehicles had to be removed from the route, the potential job losses, the complexities associated with 'formal' business. This led to protracted negotiations and many acrimonious meetings".

This transition for the taxi industry needs to be negotiated over a long period of time and poses a substantial challenge for municipalities to proceed with the BRT implementation. Often each new section requires another set of negotiations with the taxi industry (Walters, 2012), and may result in fewer overall jobs in the transport sector. A second concern relates to a larger problem with public transport in the region—lack of overall integration and holistic thinking. In the case of the Gautrain and the Rea Vaya, the BRT system had to be implemented after the Gautrain was already a fait accompli.

Planners did not engage in deliberation and debate in advance of constructing the Gautrain but rather built it as a stand-alone project without considering how it might integrate with other modes of transportation, such as a BRT system. Mostert (2011:2) summarizes the problem as follows: There is no "Formal public transport is fragmented There is no integrated ticketing, scheduling, marketing or branding. Different operators offer different services under different sets of rules. Users do not perceive formal public transport to be a coherent product". After hearing sustained criticism on this front, the province of Gauteng recently announced the creation of a specialist steering committee that will develop a long-term integrated transport plan for the province.

The team was tasked with developing a five-year plan by January 2012, a 25-year plan by March 2013, and is composed of transport planning experts, academics, government officials, and the Policy Research Officer of the South African Transport and Allied Workers' Union (Department of Roads, 2011). Although the formation of this committee is a welcome and necessary development for the future of transportation in Gauteng, the fact that this is occurring after the construction the BRT remains troubling. Overall, the lack of integration and strategic thinking around multiple, and overlapping, forms of public transport is a fundamental problem in the country. Despite the BRT system having opportunities to be a catalytic system for commuting passengers, tensions endured during the initial phases of implementation in the different provinces due to MBT operators citing that the similar routes of the BRT with MBT was taking away customers from the latter which would affect their revenue.

As with other functional transit systems in various international cities, BRT systems in South Africa have been viewed positively by many, and have been welcomed with less hostility in the different cities as they have become a conduit for access and ultimately, economic growth. Similarly, the notion of universal access, safety, visibility of signage and information, frequency of the network and relative affordability have provided a positive perception for public transport where it has been lacking (White, 2009).

3.7.2. Components of Bus Rapid Transit in South Africa

The BRT Basics are a set of elements that were deemed essential to defining a corridor as BRT. These elements are critical in contributing to eliminating sources of a delay from congestion, conflicts with other vehicles, and passenger boarding and alighting, thus increasing efficiency and lowering operating cost. They are of critical importance in differentiating BRT from standard bus service. The elements that were observed for the BRT basics are as dedicated right of way, bus-way alignment, off-board fare collection, intersection treatment, and platform level boarding.

3.7.2.1. Dedicated Right of way

A dedicated right-of-way was observed as vital in ensuring that buses can move quickly and unimpeded by congestion. The Physical design of the lanes was observed on how they enforce right of way and thus, allowing for a free-flowing movement of the buses along the corridor. The right of way of the BRT buses was enforced through dedicated lanes that were separated from other vehicles through physical segregation and colorized road markings. 100% of the corridor lanes for trunk route have dedicated lanes that give BRT buses right of way. The dedicated lanes are not physically separated from the mixed traffic, but there is a physical barrier through separator blocks. The separator blocks installed do not prohibit the encroachment by private vehicles of the dedicated lanes and thus, causes delays for the buses. The dedicated lanes as presented on figure 3.1. Are highlighted through red road markings and separated from mixed traffic by means of landscaping median.

Plate 3.1. The dedicated lanes for the BRT, Source: http//www.ekhuruleni.org.za

3.7.2.2. Bus-way alignment

The busway is best located where conflicts with other traffic can be minimized, especially from turning movements from mixed-traffic lanes. In most cases, a busway in the central verge of a roadway encounters fewer conflicts with turning vehicles than those closer to the curb due to alleys and parking lots. The BRT was designed with tier 1 configuration, where two-way median-aligned busways were in the central verge of a two-way road. Plate 3.2. Illustrates the bus way in the trunk route, where the BRT lanes are indicated through the red markings. The busway alignment was designed not to affect the movement of the mixed traffic as there are dedicated lanes for the BRT. Through the median-aligned busways, the stations are located at the center of the busy-ways allowing for easy boarding at both directions.

Plate 3.2. Bus way in the trunk route, Source: City of Cape Town operations report 2018

3.7.2.3. Off-board fare collection

Off-board fare collection is vital at reducing travelers’ time and improving customer services. The system for off-board fare collection was observed in terms of its availability and functionality across the various stations located along the trunk routes. The BRT systems use an automated fare payment system where a smart magnetic store value card (this was a plastic card that has a magnetic strip on the back, the magnetic strip stores monetary value) is issued to commuters.

Hundred percent of the stations observed consist of off-board fare collection through turnstile-controlled machines, where commuters pass through a half-body turnstile upon entering the station where their ticket/smart card is verified and the fare is deducted. Plate 3.3. Illustrates an out a service turnstile at one of the South African BRT. This causes delays for commuters because they have to use fewer turnstiles. However, turnstile at some of the stations was not functional and was out of service and this created queues during peak hours as people had to wait to enter the stations and thus, increasing the traveling time of commuters.

Plate 3.3. Out a service turnstile, source: Author field data, 2018

3.7.2.4. Intersection treatment

Intersection represents a critical point along any BRT corridor. A poorly designed intersection or poorly timed signal phase can substantially reduce the system capacity. Where BRT vehicles operate in mixed traffic along an arterial street, intersection-specific running way improvements can still be developed through the development of bus bypass lanes and transit signal priority. The BRT operates in mixed traffic with dedicated lanes. Intersection treatment for the BRT is crucial for the smooth movement of buses along the routes and results in reduced travels time. There are no prohibited turns across the way of the buses, but there is a transit signal priority for intersection treatment. The transit signal priority was enforced through traffic signals.

The traffic signals for the intersection treatment in South Africa are not integrated with the control center of the BRT. This creates a challenge in acquiring up to date information on traffic signals that are not functional and the intersection where a bus is prohibited by other obstacles such as incidents or encroaching private vehicles and taxis.

Plate 3.4. BRT Traffic light intersection, source: Author field data, 2018

3.7.2.5. Service Planning

The introduction of BRT services often results in new challenges for the operations department or contractor of the transit agency. These challenges include coming up with new procedures to manage high-frequency routes, integrating new technology and information (from automated vehicle location and transit priority systems, for example) into operating procedures, and training supervision staff. Service planning focuses on the provision of measures that improve the operational and functionality of the BRT systems, such as the discussion between control centers versus road supervision service monitoring. The measures that were observed for service planning are multiple routes, express, limited and local services, control center and hours of operations.

The BRT is unique as a public transport system in terms of its flexibility with routing options. The ability of rubber-tired vehicles to change lanes and directions allows for a few potential routing variations. Multiple routes variations are important as they offer avoidance of unnecessary transfer for passengers and subsequent saving in travelers' time and are critical for the assessment of the available multiple routes for the BRT corridor. The BRT offers multiple routes on the same corridor. The trunk routes are serviced by complementary and feeder routes where small vehicles from residential areas provide access to transfer stations along the trunk route.

One of the most important ways that mass-transit systems increase operating speeds and reduce passenger travel times is by providing limited and express services. While local services stop at every station, limited services skip lower-demand stations and stop only at major stations that have higher passenger demand. Express services often collect passengers at stops at one end of the corridor, travel along much of the corridor without stopping, and drop passengers off at the other end.

3.7.2.6. Operations Control center

Operations control centers for BRT systems are increasingly becoming a requirement for a host of service improvements, such as avoiding bus bunching, monitoring bus operations, identifying problems, and rapidly responding to them. The addition of BRT service and infrastructure to a transit system often requires substantial changes to conventional control or communications center activities. The BRT infrastructure often has closed-circuit monitoring that requires a control center area for monitoring equipment and staff. Table presents the observations made in relation to the operations control center.

Items	Observation
Respond to incident in real-time	The systems respond to incidents in real-time as there are CCTV cameras along the routes to monitor the conditions and thus respond to any irregularity of the system.
Control the spacing of buses	The system does not control the spacing of buses.
Determine and respond to the maintenance status of all buses in the fleet	No respond to the maintenance status of the buses in the fleet as some of the variable message sign in the buses were not functional, indicating that the system was not aware of the maintenance status of any bus in the fleet.
Record passenger boarding and alighting's for future service adjustment	No passenger boarding recording and alighting future services adjustment through either increased/decreased headway for buses.
Use computer-aided dispatch (CAD)/ Automatic Vehicles Location for bus tracking and performance monitoring	Tracking of bus locations through Automatic Vehicles location and computer-aided dispatch where a dispatcher uses a two-way radio to call details to drivers. They are also able to view and understand the status off all units through communication with drivers.

Table 3.1. Control centre observations Source (Author field data, 2018)

3.7.2.7. Hours of operations

A viable transit service must be available to passengers for as many hours throughout the day and week as possible. Otherwise, passengers could end up stranded or may simply seek another mode. It is essential to have all-day service with extended hours, which, at a minimum, enable users to get into their communities very late at night, even if they then need to call home for a ride or take a taxi for a relatively short distance. The operational hours of the BRT Rea-Vaya are from 06h00 am in the morning until 07h00pm in the evening through the weekdays and weekends.

There are no late night services for commuters and this is an inconvenience for commuters who work late night shift as they have to find an alternative mode of transport to get to their destination. The headway (the waiting time between buses) is constant during peak (06h00-08h00am and 17h00-19h00pm) and off-peak hours (09h00am16h00pm), where buses pass through the station in an average of 5-10 minutes. This results in a service frequency of 12 buses every hour per station.

3.7.3. Assessment of the BRT program

It is too early to give a fair and comprehensive assessment of the program, however, a number of conclusions can be drawn:

- Implementation challenges BRT routes are embedded at grade into the urban fabric, presenting significant social, planning and engineering design challenges. Also extremely challenging has been the commitment that existing informal operators run the new operations – and forfeit their existing licenses. Most cities have struggled to implement successfully.

- Costs the cost of the program has been significantly higher than originally anticipated, including high ongoing operating deficits, although these are being lowered in some instances as experience builds.

- Suitability to context while there has been some reasonable positioning of BRT, a number of the projects were implemented on the township to downtown routes, which do not have the characteristics to which BRT is suited, while implementation of capital intensive dedicated roadways in small cities with minimal congestion has been inappropriate.

- Densification response While it is early to assess, there appears to be limited densification response as a result of the BRT projects (although most property sales along Cape Town's My Citi route do advertise proximity to the route prominently). Johannesburg is placing a strong emphasis on densification along its Phase 1C corridor now under construction, but finding difficulties in accommodating low-income housing on the route, other than around the Alexandra Township.

3.7.4. Benefits and costs of BRT in South Africa

The bus rapid transit system was initially implemented as a cost-effective measure to enable mass transit in cities. By correctly implementing BRT, a city creates a useful and economical alternative to a subway or elevated rail system which both cost more than BRT. Many cities profit from the system while maintaining reasonable fares for passengers. In addition, BRT is easy to maintain, quicker to implement, environmentally friendly, and reliable. Bus rapid transit is easy to maintain in that compared to metro systems, where the trains are confined to a track, the buses are able to adapt to shifting conditions more readily. For example, if a bus station was under construction and a detour was required, a bus could easily take a different route for a certain period of time.

A rail system, on the other hand, would not be able to do so and the entire rail line could be shut down. Bus rapid transit systems, in general, are also quicker to implement than traditional light rail or metro systems. Typically, dedicated lanes can be laid on top of existing roads. Conversely, rail systems require the laying of tracks for many kilometers which can involve clearing of land, relocation of residents and the complexity of maneuvering around existing roads, bridges, and other obstacles. A metro system requires miles of tunnels below a city which leads to a long implementation time period. A BRT is able to extend onto existing highways and roads creating a very seamless integration. If dedicated lanes are needed, additional lanes may have to be constructed or BRT can also travel with normal traffic when necessary. Pollution is also a growing social concern that has been addressed by the BRT system. Bus rapid transit, in general, lowers emissions.

Due to the unique operation of the BRT, buses can travel faster to their destination, lowering idling times as well as decreasing fuel consumption. The placement of the stops and the implementation of the dedicated bus lanes are responsible for this added benefit and are seen as the unique part of the BRT system. BRT systems represent a significant improvement compared to traditional metro transport systems. They use dedicated lanes and stations, modern buses, and smartcard payment systems to speed up public transport and give passengers a better quality service (table 3.1.). This comes at a price. BRT ticket prices are typically higher than Metrorail but are set to be competitive with the minibus-taxi offering. South Africa's BRT systems are currently transporting more than 120,000 passengers (one-way trips) every day. Surveys show that passengers generally prefer the comfort and speed of BRT to other modes like minibus-taxis. So, based on passenger numbers alone, BRT is not a failure.

Plate 3.5: South African BRT bus loading passengers at the station, source: Author field data, 2018

The system is proving to be unsustainably expensive for the South African government. But the BRT systems in the country's main cities, Johannesburg, Cape Town, and Tshwane, are performing worse financially than was expected. Between 2005 and 2016, a total of about R35.7 billion was allocated for the planning, design, and construction of integrated public transport networks countrywide. Costs are pushed up by the national government's commitment to bring minibus-taxi operators into the system in such a way that they are no worse off than before. This was partly driven by political pressure from taxi organisations, and partly to help bring an upgraded taxi industry into the formal transport network. Despite these extra costs, South Africa's spending on BRT systems is, per kilometer of busway, on par with many systems in Latin America and Asia. This suggests that the country has not overspent on infrastructure.

The problem is that fewer people than forecast are using the systems. Fare revenues are lower than expected. For example Rea Vaya, the BRT in the main economic hub of Johannesburg, as an example. Demand grew by about 6% a year on average in the five years to 2016. In 2016 Rea Vaya catered for about 50 000 passenger trips a day. This equates to about 1 100 daily boarding's per kilometer of busway, but it's far less than the average of 8 000 for comparable systems in Africa, Asia, and Latin America. The productivity of each bus is low. Travel distances are long because of apartheid spatial planning and low densities.

Seat turnover along the route is low and most passengers use the buses at peak times. The result is that Johannesburg and Cape Town have had to subsidies their BRT systems much more than planned. Subsidy expectations came from using some Latin American cities, which operate with zero subsidies, as a benchmark.

Planners expected fare revenues to cover direct operating costs. For Rea Vaya, the direct cost recovery ratio is only about 30% and for Cape Town's My Citi just over 40%. Subsidies in itself are not the problem. Subsidies for public transport are widely accepted as a way of making cities work better and protecting the environment. The issue is that South Africa's BRT subsidies are too high and haven't produced the desired results. One senses from the minister's comments that the government's appetite for subsidizing what is seen as underperforming systems is waning. Unless the entire public transport system makes a better impact, the program is likely to stall.

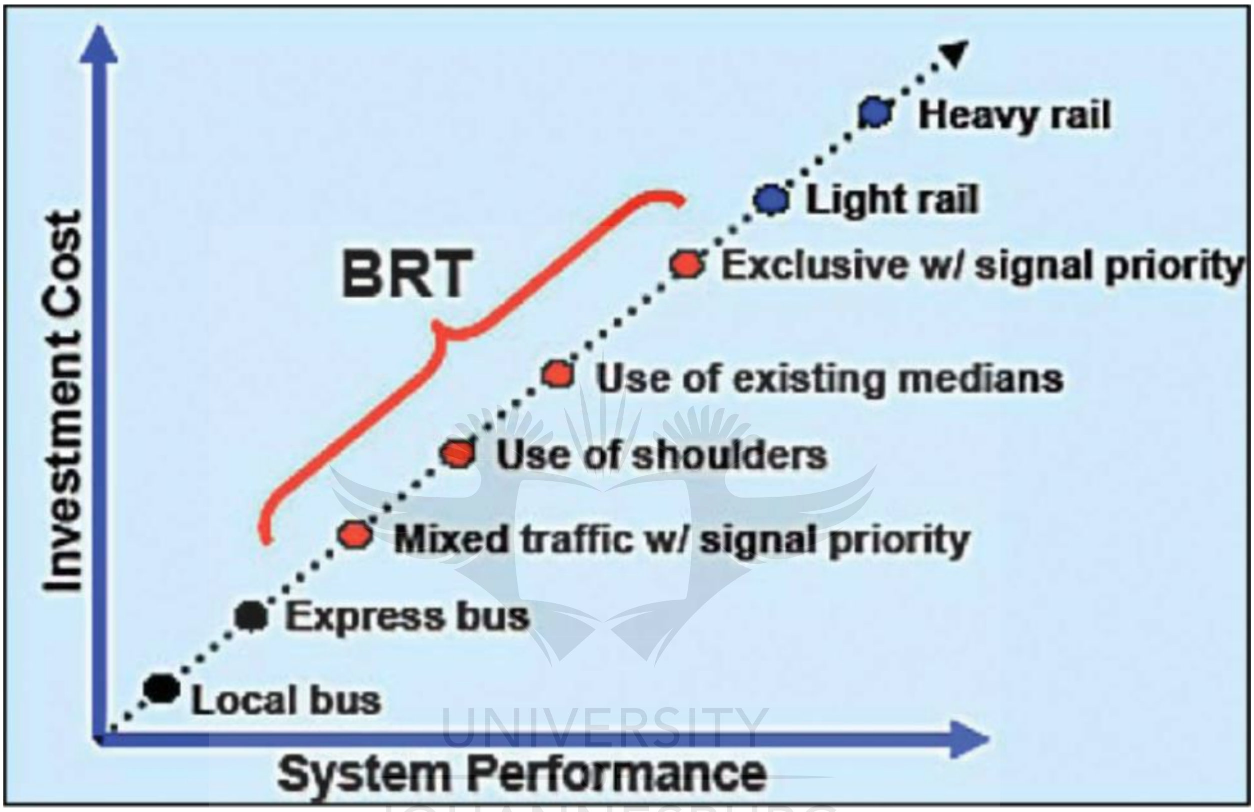

Figure 3.3. The spectrum of different BRT applications. (Cited in Cain et al., 2009)

A BRT system is an integrated package of rapid transit elements, which generally includes seven main components, as shown in Table 2 below. These elements work together to guarantee the efficiency and effectiveness of BRT systems. On the basis of busway type, which plays a pivotal role in determining the capital cost and overall performance, BRT systems can be divided into four groups: running in mixed traffic (with signal priority), using shoulder bus lanes, using median busways and using exclusive busways (Cain et al., 2009), as indicated in figure 3.3.

3.7.5. The role of BRT in the South African public transport

People have many reasons to be mobile, from day-to-day activities1 involving work, studies, and family life, to maintaining participation in society, hea1lth, and quality of life. Indeed, mobility is not only a characteristic of modern social life but also a precondition for it (Thomsen et al., 2005). The concept of mobility varies greatly between disciplines, from the movement between two points to social mobility between classes to the spread of ideas. One classification divides mobility into four general types of movement: personal, object, virtual (information), and imaginary (media) (Urry, 2000). When considering personal mobility, one finds a broad range of experiences and barriers such as demographic factors, accessibility, availability, affordability, safety/security concerns, lack of information, etc. Such barriers may in turn act as impediments to public and private services, leisure activities, employment, and education – potentially generating long-term social impacts.

Rapid population growth and urban expansion, together with a rampant increase in motorization, are overwhelming large cities in developing countries. Johannesburg, like many other, is facing significant urban mobility challenges that are too complex and sizable to be able to catch up with, despite the significant efforts being carried out. Local and national level governments are well aware of the challenges in Johannesburg (and in other South African cities) and have been implementing urban transport actions since the democratization of the country in the 1990s. This comprehensive response has included the introduction of policy changes, recapitalization of informal public transport providers, subsidization of public transport, and infrastructure investments across modes, with a special emphasis in rail and bus. The implementation of a Bus Rapid Transit (BRT) system in Johannesburg inspired by its success in Latin American cities (LACs) has been part of this response.

The experience from the initial stages of implementation of Rea Vaya (Johannesburg's BRT) is of critical importance since the city is expanding it and other South African cities are rolling out their own BRT systems using Johannesburg's BRT (and Cape Town's) as the model. As of 2015, Johannesburg had successfully implemented its two first Rea Vaya BRT corridors which work in a trunk and feeder approach similar to TransMilenio BRT in Bogota, Colombia. Stations have gotten international awards for architectural excellence in transit, and the buses are operating with the unprecedented involvement of the incumbent operators after a facilitated negotiation process, therefore meeting policy objectives of empowering these entrepreneurial groups to be part of a modernized business model. However, currently, Rea Vaya's ridership is significantly lower than initially estimated. Furthermore, while no operating subsidies were expected, these are now required to cover an important operating deficit. The lower-than-estimated ridership figures and fare box recovery ratio (i.e. the fraction of operating expenses covered through fares) of Rea Vaya are the result of a combination of different elements.

On one hand, Rea Vaya performance has been impacted by a combination of factors that are common in other cities of the developing world such as the presence of parallel informal services offering more convenient alternatives, a degree of lack of awareness by potential users on how to use and navigate the system, and instances of limited convenience for users to access and use the fare media, and, sometimes, an increase in the generalized transport cost of the trips with respect to the ex-ante situation. On the other hand, and as it is illustrated in this paper, there are other inherent factors that have to do with the structure of the urban form and mobility patterns in Johannesburg which are very different to the ones that Rea Vaya's LACs siblings have, and that partially prescribe the BRTs potential cover its operating costs from fare box revenue.

Public bodies are making transport data available for app developers, increasing transport efficiency. Benefits of smartphone Near Field Communication (NFC) include passenger convenience, lower sales and distribution costs, more flexibility, personalized communication with passengers and promotion of public transport. For the consumer, mobile technology allows travel time to be used productively and mobile ticketing will triple between 2013 and 2018. A journey may include more than one mode of transport. Research identifies four areas that can make public transport easier and more convenient (Daft 2014):

- Improving the quality and availability of information;
- Smart and integrated ticketing;
- Improved and reliable connections in multi-modal journeys;
- Safe, comfortable and easily accessible transport facilities, meeting the needs of passengers.
- An important part of this is making data available for an app and other developers; see- www.data.gov.za

While the need for operating subsidies is not a departure from current South African mass transit system operation funding practice (all other rail-based mass transit systems have historically been subsidized), these (and similar results in Cape Town, Pretoria and Nelson Mandela Bay) have triggered a profound discussion at both the national and local government levels about the robustness of the planning assumptions that triggered the implementation of BRT in South Africa. In this country, the implementation of BRT was originally advanced in the last decade based on, among other premises, an expectation that BRTs would be able to operate without subsidies based on LAC BRTs practice in the first decade of the 2000s (e.g. Colombia).

However, the first years of experience of BRT in South Africa have shown that fare revenue is not covering operating expenses and, therefore, its operation is also requiring a subsidy. Under the understanding that BRT does (and will continue to) have a role in South African mobility, local and national governments are working together to better understand how does BRT work in the South African context and what type of subsidization would be needed as these systems expand. Rapid transit systems provide high speed and reliability, as well as improved comfort and convenience to large numbers of travelers. They can also serve as a land development tool, inducing more sustainable development patterns. Metro and rail have been common rapid transit investment choices. BRT is becoming increasing popular in developing cities as it can provide high performance, capacity and levels/quality of service at costs affordable to them, and is usually more cost-effective than other, rail-based alternatives.

Pioneered first in Curitiba, BRT systems have been implemented worldwide, from a large number of Latin American cities to Asia, Europe, Oceania, and North America. The busiest BRT system, in Bogotá, Columbia, carries over 1.4 million daily trips, with line volumes exceeding 40,000 passengers per hour, both more than most metro systems.

BRT is seen as an appropriate solution to addressing mobility needs in an age of growing income, rising car ownership and use, and constrained fiscal resources. While BRT systems have proven successful in most cases, there are examples of those that have not done well, at least initially. Though they can be simpler and less costly than rail-based rapid transit, BRT systems have unique planning and implementation challenges which if not adequately addressed up-front can lead to less than successful outcomes (Kane 2010). The introduction of BRT systems often requires a need to migrate from a loosely organized public transport sector to one that is regulated and controlled. There is also the need to coordinate activities of the multiple agencies involved in planning, financing, implementing, and operating or regulating various aspects of the public transport system. There is also often the need to undertake new functions no institution has been doing. Apart from these issues, another unique challenge is that BRT systems often involve dedicating roadway space previously available to any vehicle to exclusive use by BRT services.

Even though most people traveling in virtually any developing city corridor are on public transport, this is perceived as interference with the "rights" of car owner/users, an influential societal group. Despite these challenges, planning, and implementation of BRT is too often seen as an engineering problem focused on the provision of segregated BRT transit ways, procurement of state-of-the-art vehicles and complex ITS applications. The primary focus is on BRT "hardware" rather than the market and the services which are the most important planning and design criteria, or the critical institutional and governance changes and political and technical champions necessary to get BRT successfully planned, implemented and operated. The public transport systems in all the case study cities shared the common need to migrate from a loosely organised bus transport sector to one that is regulated and controlled. The sector is dominated by private, largely informal, minibus services due to the significant deterioration in service coverage and quality or total collapse of the large, formally organised bus companies that previously existed in the respective cities.

Beginning in the 1980s, urban public transport in most developing cities underwent a major transformation, with the private sector assuming a much greater role as operators of minibuses or shared ride taxis. The advantages of minibuses are their agility in meeting market needs, ease of acquisition, viability without subsidies, and flexibility of schedules, stopping patterns, and even fares and routes. However, minibuses also have disadvantages, particularly in terms of the negative externalities (congestion, poor safety, and security, environmental impacts). Their numbers are often determined by political expediency (or even corruption) rather than real capacity needs and financial viability, making it difficult for operators to provide a minimally acceptable level and quality of service (Jarzab et al., 2002). These problems are unlikely to be addressed by market forces alone, but public regulation is often poorly enforced or non-extent. Implementation of a formal BRT system in a city that only has an informal public transport system operating without formal schedules, stops or even fixed fares require strong commitments; technical commitment to be able to determine what new types of public transport should be offered and political commitment to change the business model for providing it and get the funds and authority to actually implement.

As noted above, a large proportion of the population in most developing cities depends on the informal public transport sector, bus and or minibus for transport and employment. The high numbers directly affected, the owner/operators, rightly have enormous political power, which could be helpful in affecting change or become an insurmountable obstacle. The success of BRT with a powerful informal sector has been related to how well the BRT proponents dealt with it. More than 65% of South Africans use public transport for access to educational, commercial and economic activity. Traffic congestion, pollution, overcrowding and an increase in the number of road accidents, are some of the common problems experienced by growing cities, which results in an increase in the development and implementation of various modes of public transportation systems and more recently the implementation of Bus Rapid Transport (BRT) system in South Africa, as an alternative model of urban transport systems (Jennings., 2015). To date, 168 countries have implemented BRT systems as a means to alleviate transport problems in those countries.

Bus rapid transit (BRT) is a broad term given to a variety of transportation systems that, through improvements to infrastructure, vehicles, and schedule, attempt to use buses to provide a service that is of higher quality than an ordinary bus line(Jennings., 2015). The BRT was envisaged to play a leading role in transforming public transport within cities to a situation where it will become the preferred mode of travel for the majority of residents, and it will make a major contribution towards the most efficient development of the city as a whole. The department of transport has made it clear that the Bus Rapid Transit (BRT) system is crucial for the success of South African Transport system. Without a good bus service accessible, affordable and attractive to a broad range of people across society, local transport cannot simply work (Suzuki et al. 2010). BRT is designed to address the sources of delay of traditional bus services and to be an attractive service to passengers. The trend towards the implementation of public transport level of service improvement programs based on BRT technology that incorporates existing paratransit operations has been occurring dramatically in a number of cities around the world, particularly in Latin America (Schalekamp et al, 2009; Wright, 2004).

3.8. ITS in South African Bus Rapid Transit

3.8.1. Introduction

A wide variety of ITS technologies can be integrated into BRT systems to improve BRT system performance in terms of travel times, reliability, convenience, operational efficiency, safety, and security. ITS options include vehicle priority, operations, and maintenance management, operator communications, real-time passenger information, and safety and security systems. A high-tech control room monitors the buses and stations, ensuring that South African BRT matches world-class standards. The control room has real-time tracking of bus movements and staff can communicate with each driver, ensuring that buses run on time and quick solutions are found for any eventuality. Travel time reliability can be improved by smoothing the traffic flow, reducing the frequency and duration of incidents and by providing information on travel times and delays to the traveler.

With improved information and assurance of travel times, routes and modes, travelers have greater control over their travel choices. A potential negative impact of Intelligent Transport System is that with the intensive surveillance and data collection nature of some ITS applications, travelers may become more concerned about their privacy. ITS projects also have a greater technical risk due to the technical component – the equipment used must be effective and remain flexible to future advances in technology (Brand, 1993). Appropriately designed and operated BRT systems offer an innovative approach to providing a high-quality transport service, comparable to a rail service but at a relatively low cost and short implementation time. In common with other forms of mass transit, a full-featured BRT has the potential to offer significant effects on land development. It is not so long ago that smart card ticketing and at-stop visual real-time information was cutting edge technology.

The latest developments in Intelligent Transport S for public transport in cities, support operators and travelers by making services ever easier to operate and use. ITS for users employ technology (such as smartphones and GPS-enabled devices) to improve convenience and journey efficiency for drivers and other users (Nuzzolo & Comi, 2016). Recent research of Sengupta and Masini (2008) distinguish range and time as two dimensions that can be made agile. Range agility represents an organisation's ability to broaden (or shrink) specific aspects (range) of its capabilities (Sengupta & Masini, 2008). Adjustments in the range can be implemented based on internal options (for example, better integration in processes or strategic business units), and external options (for example, via alliances and partnerships). Range-agility provides firms with the ability to add variety to its products, routines, and practices, as well as to create and sustain webs of collaborative relationships with extended reach.

Time agility is the speed of response i.e. the time it takes to retool one's capabilities (Sengupta & Masini, 2008). At the heart of agility is the concept of speed and time – the capability of an organisation to rapidly execute decision making, operational cycles, and reconfiguration of corporate structures (Canter, 2000; Conner, 2000; Palethorpe, 2003). Time is relevant for various metrics, such as time to market of new products, time to process an order or service request, time to assemble virtual business network collaborations, and time to reconfigure organisational processes and systems. The time dimension can be divided into four components of latency (Verstraete, 2004). Decision latency is the time an organisation needs to decide on adequate actions. Action latency is the time needed to perform the envisioned actions. Impact latency is the time the environment needs to react. The growth of South Africa's economy is dependent on the successful delivery of a comprehensive and integrated transport system for the country (Mzansi Empowerment Network, 2011).

Interest in the intelligent system comes from problems caused by traffic congestion and synergy of new information technology for simulating real-time and communication networks. Intelligent Transportation System was designed for the urban, state or private road transport organisation (Mallik, 2014). This primarily consists of a hardware component to provide an integrated solution for the driver console unit, electronic ticking machine, passenger information system amid a vehicle tracking system. This further provides a single solution for monitoring vehicular schedules with the advent of modern technology such as; GPS, Wi-Fi, and GPRS.

The impact of the application of Intelligent Transport System in the BRT is therefore vital in improving the growth of public transportation system in South Africa. Technological aspects of a BRT cover (but not limited to) the following (Nuzzolo A, Comi A., 2016):

- Operations control center (OCC)
- Automated Public Transport System
- Automated vehicle technology
- Fare collection and verification system
- Traffic control signal
- Security
- Real-time information

These are further discussed below;

3.8.2. Advanced Transportation Management Systems (APTMS)

Advanced Transportation Management Systems (ATMS) operate with infrastructure fitted with vehicle detection systems, automatic vehicle identification, and CCTV to allow for real-time traffic data to be both sent and delivered through various service devices or facilities including Variable Message Sign (VMS), the World Wide Web or mobile devices. The data are transformed into various ITS services including Real-time Traffic Information, BIS, and ETCS. The BRT system consists of various infrastructure and technological segments and systems. The Automated Fare Collection (AFC) system integrated with the Advanced Public Transport Management Systems (APTMS) are the most advanced information technology applications and solutions in the BRT system which contributes to the management of fares and bus scheduling (See figure 3.3: Advanced Public Transport Systems).

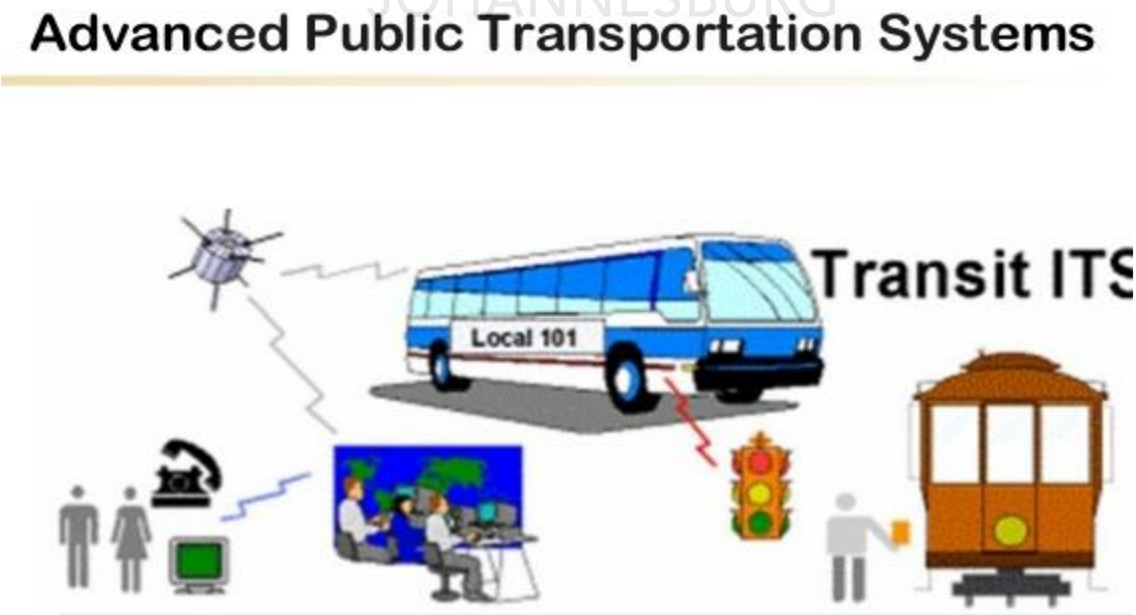

Figure 3.4. Advanced Public Transportation System, Source: ITDP, 2007

The diffusion of such information helps alleviate a range of environmental and congestion problems. Figure 3.4. Illustrates how most mega-cities have installed such ATMS technologies as traffic signals, CCTV and VMS in order to optimize their current transportation infrastructures.

It is very important that the BRT system's operational and functional performance are monitored continuously to identify any improvements, discrepancies, possible fraud and/or fare evasion, as well as the generation of statistical information for senior management and transport planning. It is not always possible to generate real time information, but the most important is the quality and the reliability of the information collected in any of the participating systems in the BRT System. The development and compilation of this information into strategic, managerial and operational reports are critical for the optimal operations of the BRT system. The reporting services will allow the BRT to obtain useful and actionable information about rider travel patterns, to quantify the extent and type of travel by patronage. All data and information should be consolidated through the intelligence of the back office application to ensure quality reports to all organisational levels in the BRT.

3.8.3. Automated Vehicle Technology

The cornerstone of a modern control system is an automated vehicle location [AVL] technology. This allows for the tracking of vehicles so that the control center can direct vehicle movements to avoid bunching, address changes in demand and respond to problems and emergencies [ITDP, 2007]. Global Positioning System [GPS] has become the preferred option for AVL, although care must be taken in which system is chosen and in understanding its limitations. An automated vehicle location (AVL) technology is applied to monitor the location of transit vehicles in real time through the use of GPS devices or other location-monitoring methods (See figure 3.5.).

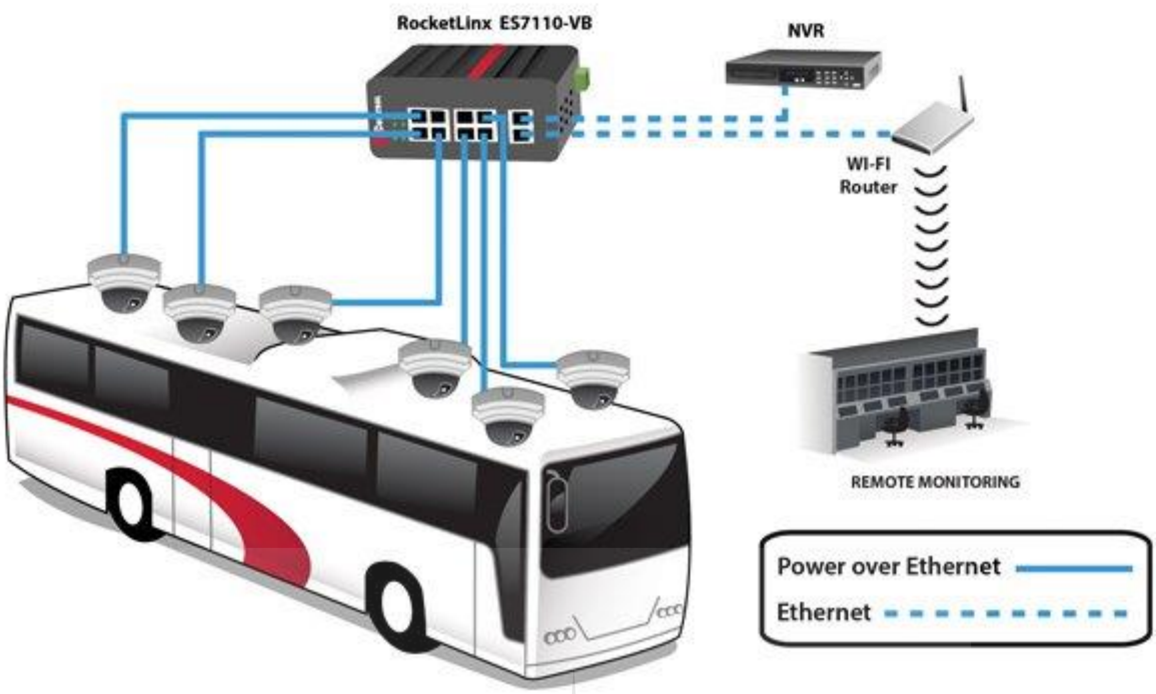

Figure 3.5: Automated Vehicle Location, Source: Bratislow, 2010

Information about the vehicle location is transmitted to a centralized control center in either raw data format or as processed data. Automatic vehicle location systems (sometimes referred to as automatic vehicle monitoring or automatic vehicle location and control systems) are computer-based vehicle tracking systems (Bratislow, 2010).

The use of automatic vehicle location into public transit allows for various functions to be improved such as the following:

- Improved system control. The system can be calibrated with greater ease to distribute service times and coverage adequately through the application of signal priority and control center and on-street supervision.
- Improved bus safety. In an emergency, the transit control center can relay vehicle location immediately to emergency response agencies.
- Improved quality of service. Passengers can be notified in real time of the location of the next bus and its expected arrival time.
- Improved system integration. Bus transfers can be better scheduled and controlled by knowing the location of each vehicle.

An AVL can be incorporated to provide enhanced vehicle monitoring, and quicker response to breakdowns and emergencies on vehicles (Yening, 2013).

It can also be integrated with transit signal priority, passenger information systems and APC system which can assist transportation agencies with information on stop arrivals and transit origin and destination data (Durake, 2015). Johannesburg initially experienced less of GPS signal within plus CBD because of interference by the tall buildings. The desire for motorists to be always connected has resulted in remarkable innovations in the realms of telecommunication and informatics, leading to the field of vehicle telematics, which can be loosely defined as the convergence of wireless communications, advanced vehicle tracking and in-vehicle Internet technologies to provide motorists with communication, information, safety and security services. However, no matter how accurate and information-rich these maps might be, they cannot independently provide the real-time detail required to avoid a collision.

Likewise, in-vehicle sensors alone are not the solution as they rely on line of sight. Cooperative Intelligent Vehicle Systems will fully integrate information from the roadway as well as other vehicles in the vicinity to provide advanced warning of any potential dangers ahead. Such systems also require a degree of co-operation by road authorities and vehicle manufacturers, particularly in the standardization of the information content. Traffic detectors, motorist's mobile devices and spatial detectors (license plate recognition, transponders, active & passive tags) are being integrated with GPS and radar capabilities to create so-called smart corridors, for enhanced roadside enforcement operations through improved screening and automated inspection/compliance checks at highway speeds.

3.8.4. Traffic Signal Control

Transit signal priority (TSP) is the process of altering traffic signal timing at intersections to give a priority to transit operations. TSP can be triggered by BRT vehicles operating in their own right-of-way or in mixed traffic along a street (known as ―mainline‖ priority) or operating in an auxiliary lane at an intersection (known as a ―queue jump) (Chen & Gary, 2014). With mainline TSP, the typical treatment is to extend the green signal or truncate the red signal to allow priority for BRT vehicles, thus reducing intersection delay. With a queue jump, the transit vehicle receives a separate green phase to go through the intersection before the adjacent through traffic (Kyoungho et al., 2015). There are two types of TSP that are beneficial to BRT operators such as:

- Unconditional priority, where a BRT vehicle would always have priority at a particular intersection,

- Conditional priority, where the BRT vehicle would receive priority at an intersection only if certain transit or traffic operating conditions are met, and TSP is typically applied when there are significant traffic congestion and bus delays along a roadway.

Travelers on a transportation network experience delays as a result of congestion, which is due either to traffic demand that exceeds capacity (recurring congestion) or due to the presence of incidents that reduce roadway capacity (non-recurring congestion). ITS improves the operational efficiency and capacity of the transportation network by improving traffic signal coordination, reducing the duration of incidents, providing transit priority, informing motorists of traffic problem areas, etc. The benefits can be manifested as an effective increase in capacity and reduced congestion, with the associated improvements in travel times, operating speeds and traveler delay. Traffic signal systems and the provision of coordinated traffic signal operation generally improve traffic operation on arterial roads by in the order of 10 to 30%, with the added inherent benefit of reducing rear-end collisions on the arterial by up to 35% during peak traffic periods.

However, research also indicates that the safety benefits of signal progression can vary significantly with corridor speed, level of congestion, signal spacing and the number of turning movements at access points. Vehicle actuated (VA) traffic signals reduce queues at isolated traffic signals where the arrival of vehicles is erratic and can be serviced on demand. Also, transit priority systems can yield up to 40% reduction in bus travel times. Delays, however, typically increase for cross street under coordinated operation and one should be careful that increases in operational efficiency on the arterial roads are not outweighed by delays on the side streets. The introduction of BRT will introduce changes that affect traffic signals technology, including the new dedicated busways, new turning movements and restrictions on right turns, and possible new priority treatments for the public –transport vehicle (ITDP, 2007).

If the existing technology is unable to cope with these changes, then ideally the opportunity should be taken to upgrade the technology and possibly even integrate traffic signal control into the central systems. South Africa and peak vehicle headways planned on the BRT Trunks are so frequent that signal prioritization is probably not feasible, although the appropriate synchronization of traffic lights and adjustment of phase lengths should be undertaken to ensure smooth public transport flow. The development of a BRT system can present a unique opportunity to upgrade the traffic signal technology along the same corridor. A new BRT system will imply several changes that will affect traffic signal technology.

Signal priority for BRT vehicles is the adjustment of traffic signals to give priority to a corridor with a BRT system over a corridor without one and to give priority to the BRT system over mixed traffic within the same corridor. Once equipment and techniques were developed to do this in a responsive way after the detection of BRT vehicles approaching an intersection, the expression “active signal priority” became the way to indicate this advance. Since then “passive signal priority” is used to indicate that such detection technology is not being applied (Nuzzolo & Comi, 2016). These changes include:

- New priority treatment for public transport vehicles;
- New exclusive lanes
- New restrictions on private vehicle turn

With new electronic signaling technology and software programs now available, an upgrade of the traffic signal system should be integrated into the BRT planning process. The appropriate synchronization of traffic lights often does not currently exist in developing cities.

A readjustment of phase lengths and synchronization should be undertaken with a special focus on a smooth public transport vehicle flow (see Plate 3.6. - traffic signal priority).

Plate 3.6. Traffic signal priority, Source: Bratislow, 2010

The basic technical platform to support connectivity and common functionality between the Rea Vaya ITS system and the JRA traffic control system is in place. This will facilitate the deployment of Traffic Signal Priority, which has not yet been developed.

3.8.5. Fare collection and verification

ITS offer new opportunities to improve customer service. Including more personalized payment options and potentially innovative pricing mechanisms. ITS also provide new ways of encouraging using compliance and help target enforcement (potentially automatically) when required. Pre-board fare collection and verification reduces the delays that accompany non-board fare collection, thereby improving system efficiency by reducing vehicle dwell times at stations and stops. It is particularly important at high volume stations (ITDP, 2007). It also removes the handling of cash from drivers and allows for better management of fare revenue. In South Africa, Johannesburg, Cape Town and Tshwane have opted for pre-board fare collection and verification.

Typically, a ticket office is provided at a station where passengers can purchase countless smartcards that can be uploaded with a variety of travel options. Provision is also made for single and double trip cards. According to Joubert (2014), passenger transit fare collection device is an automated way which bus passengers pay their fares, either on the bus, at the station or in advance. There are various methods of fare collection that use intelligent systems and they can be incorporated into public transport; and they include the following:

3.8.5.1. Fare media

What medium/media will be used to store fare information? Options include simple tickets, flash passes, magnetic stripe passes, magnetic stripe stored value cards, and smart cards (typically contactless). Each of these fare media has advantages and disadvantages, and the selection of a specific medium should consider the fare policy that is being implemented (Jacobs, 2004).

3.8.5.2. Sales/vending technology

Most rail-based transit systems employ some type of vending machine technology, but these are generally less common on bus systems, with agencies relying instead on cash fare and point-of-sale merchants to sell items such as monthly passes and multi-ride tickets. Given the higher-quality image and customer-friendly experience that is often one of the goals of BRT, introducing ticket vending machines at BRT stations may be very beneficial, even if these are not typically deployed at regular bus stops (Joseph, 2014).

Plate 3.7. Sales/vending technology, source Joseph, (2014)

3.8.5.3. Communications

Many state-of-the-art fare collection systems now require real-time communications for activities such as credit card verification and status monitoring. Particularly in an on-street environment, hard-wired communications may be expensive and difficult to maintain. So, consideration should be given to developing a secure wireless communications network to support the fare collection system (Rian, 2008).

3.8.5.4. Electronic fare payment

Transit managers across the country are exploring and adopting electronic fare payment System concepts. One of the major incentives for this shift is that transit operators want to decrease expenditures on fare collection and lessen the associated security risks connected with collecting large amounts of cash and tokens while providing greater convenience for transit riders (Darn, 2012). In addition, the regulations specify that the system should be EMV compliant. EMV is standard originally developed by Euro pay, master card, and visa to enable the interoperation of integrated chip cards in the payment environment. Passengers who have accounts can use a bank issued fare media [most likely a contract less smartcard] or, in the case of unbanked passengers, they can obtain pre-paid bank issued media from a participating bank or third party card issuer.

Plate 3.8: Smart Card for automated fare payment system, Source: Author field data, 2018

The EFC data structure will be loaded onto the bank issued fare media, which can then be used not only for transport but also for other purchases. The clearing and settlement of all payment transactions will take place through the National Payment System as currently utilized by the banks. This eliminates the need to transport a specific clearing house. Due to time pressures, JHB started operating with a manual paper ticketing system which is far from ideal. As (Pelletier, Trépanier and Morency 2011) stated, most of current fare collection systems are automated using new technologies like smart cards.

3.8.5.5. Automated Fare Payment Systems

This is a system or environment in which a card will be issued or used as a fundamental issue. Generally, cards will either be used in what is commonly referred to as an open (multiple card issuers and multiple service providers) or closed (a single card issuing organisation) system (Blake, 2009). Passengers swipe their cards at a gate or turnstile before entering the station waiting area and will swipe the card again when exiting the station. This allows for the deduction of the correct fare for the trip or combination of trips that are made on the system. It also provides important passenger origin-destination data for system planning. National Department of Transport (NDOT) has developed guidelines for integrated fare and ticketing systems. Regulation (government Gazzette2008), based on these guidelines, have been gazette for comment and detail the minimum principles for Electronic Fare Collection (EFC) system management in public transport.

Clearly, any public transport fare and ticketing system will need to comply with these regulations once published (Nuzzolo & Comi, 2016). The concept is well advanced in Europe, Asia and almost every metropolitan area in the United States and Canada such as New York, Washington, Chicago, Quebec, Montreal, etc. Comparing to other payment approaches for public transport fare collection (e.g. cash, prepayment (tickets, monthly passes, magnetic cards), smart cards are nominated in various aspects, including user convenience, vehicle delay, ease of monitoring payment, cost of equipment, fare deposit security and interoperability (Vuchic, 2005). Of course, every technology comes along with its drawbacks. In case of smart cards, (Bagchi and White, The potential of public transport smart card data 2005) for example, pointed out that the trip purpose or user assessment of service could not be analyzed merely by smart card data. However, many studies have been done in this area based on smart card data, since it seems a well-accepted approach in practice and provided the analysers with worthy information regarding passengers' trajectories (Nuzzolo & Comi, 2016). The fare collection system is another important component of BRT systems, directly affecting costs, ridership, boarding times and revenues Write (2005).

Fare collection systems have a significant impact on passengers' overall impressions of the system. There are several alternative methods available for fare collection, such as on-board, off-board, payment by cash, prepaid tickets, passes, magnetic stripe or smart cards. Each method has different boarding times, capital and operating costs associated with it. The more efficient systems (e.g., contactless smart card) may have higher capital costs. Fare collection and fare validation are critical for quality of service and financial stability of the BRT system. Nevertheless, less effort is often assigned for its preparation, procurement and supervision than the effort given for trunk vehicle operations. The BRT has troubles in the automated fare collection system since its inception. There are operational difficulties with fare collection systems, such as long queues for card acquisition, low throughput of the turnstiles' and loss of trips stored in the cards. There are also problems with the quality and integrity of data (sales validation). These problems resulted in some loss of confidence amongst customers in the system.

3.8.6. Real Time information

"All of the biggest technological interventions created by man- the airplane, the automobile, the computer- says little about intelligence, but speaks volumes about his laziness"

-Mark Kennedy, Politician 1957

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

The incorporation of travel information can also be provided in South Africa through mobile applications available on Google play, Application store and Blackberry World, social networks such as Twitter and direct telephone services from owners as it's already in use within the Netherlands. The information offered by 9292 includes maps, public transportation fares of all the available modes of public transportation (9292.nl, 2015). Passenger information, specifically information related to the transit service, takes many forms, including information needed before making a trip, during the trip and at the termination of a trip.

Figure 3.9. Information display via VMS, Source: 9292.nl, 2015

The VMS displays information regarding the approved schedule through appropriate media that can be accessed before making a trip. These help with trip planning and the ultimate decision to use the transit facility. The main sources of information need to be provided as follows:

- At stations or other points prior to boarding a transit vehicle. Relating primarily to vehicle arrival, these help instill rider confidence and comfort and can contribute to overall travel time competitiveness (e.g., a rider can do a quick errand if a vehicle arrival is several minutes away).

- On the vehicle, itself. Next-stop information, traffic updates and service disruption alerts can also instill confidence and comfort by helping passengers reach destinations and transfer connections most efficiently.

- At a termination point. Destination and transfer information can help manage rider expectations during and after the trip

Advanced traveler Information systems' main focus is the provision of real-time information to travelers, mainly drivers. They provide information on traffic situations, congestion levels, accidents and delays on a specific route the driver is traveling on (Ezell, 2010). ATIS has also been proven to be a factor affecting travel choice behavior of commuters (Sun et al., 2014). The incorporation of travel information can also be provided in South Africa through mobile applications available on Google play, Application store and Blackberry World, social networks such as Twitter and direct telephone services from owners as it's already in use within the Netherlands. The information offered by 9292 includes maps, public transportation fares of all the available modes of public transportation (9292.nl, 2015). Ideally one would envisage a transport system that enables people to make informed choices about when and how they travel.

Using technology to keep people informed both before and during the journey should be a central feature in the overall transport strategy and provides an essential tool to deliver better network efficiency and improved safety. Reduced delay and the provision of traveler information, particularly with respect to capacity reducing incidents, can have a significant impact on the reliability of a trip. The provision of traveler information with respect to trip duration, expected delays or arrival times and reasons for the delay has a significant impact on the quality of a trip and level of frustration. This is particularly important with respect to public transportation where commuters typically require information on:

- The current state of the network based on real-time information across all transport modes;
- Real-time public transport information, such as scheduled arrival and departure times
- Travel options and available services

Pre-trip information has traditionally been available to the traveling public through radio and television services. The accurate, reliable and relevant flow of information to travelers during a journey is equally important. The advent of the Internet created opportunities for public and private sector web-based journey planning and information services that are now maturing into real-time information sources in a way that could provide broader information. Real-time information on public transport services reduces passenger uncertainty and can assist passengers in making the best use of their waiting time (ITDP, 2007). Variable message signs can be used outside or inside stations and in vehicles. Real-time information is of less value where frequencies are very high, e.g. one or two minutes, but will still be of value in choosing between services and vehicles, in off-peak periods when frequencies are lower and in notifying passengers of incidents and possible delays. Information technology is changing all aspect of daily life.

Public transport has likewise benefited from the reach of information technologies as well as the continuing reduction in technology cost. Intelligent Transport system refers to a range of information technologies that provide more choices and better quality for the customer. Real-time information displays are one application of Intelligent Transport System that can alleviate concerns over the reliability of the service (Nuzzolo & Comi, 2016). Information on public transport vehicle location can be relayed via several technologies to displays at stations informing waiting passengers in the next available vehicle. Real-time information helps to reduce customer "waiting stress" which affects passengers who don't know when or if a particular route is going to arrive. By knowing the expected arrival time of a bus, the customer can mentally relax as well as potentially undertake another value-added activity to make the best use of time (Naess, 2006). Some systems, such as the Singapore MRT system, even place a real-time information display at the outside of the station. This allows customers to make best use of their time, as well as help, reduce stress and rushing.

A customer may see that they have several extra minutes prior to entering the closed station boundaries. BRT Real-time passenger information (RTPI) is being provided at the bus stations on multi-line displays. RTPI will also be provided on personal mobile devices. The effective rollout of RTPI has been delayed because of the reduced reliability of the AVM/GPS data. The technical systems and devices are in place but have not yet been launched. This is subject to the GPS reliability being resolved. The technical platform for PDA services is also in place. It remains to be activated, and this is likely to be done after the bus station RTPI system has been launched and stabilized. Active, or real-time priority techniques, change the actual traffic signal phasing when a BRT vehicle is observed to be approaching the intersection. The normal vehicle identification mechanism is to have a transponder detect the BRT vehicle prior to its arrival at the stop line.

If the BRT vehicle is detected during the green phase, and the green phase is nearing the yellow phase, then the green phase is extended. If the detection occurs during the red or the yellow interval, the green time is recalled more quickly than normal. Some general guidelines for applying phase extension or phase shortening include (Nuzzolo & Comi, 2016):

- The minimum side street green time is set based on the number of time pedestrians need to cross the road;
- The amount of green signal extension or advance should be up to a specific, set maximum;
- The BRT corridor green is not generally both advanced and extended in the same cycle.

The green times are likely to be most easily extended at intersections with light cross traffic.

3.8.7. Security

According to Winston (2009:89), security systems are needed to ensure safety with a CCTV surveillance device as well as alarms, both of which can be located both on board vehicles as well as off-board in stations or along with guideways. Amaru (2008) stated that surveillance devices are principally made up of closed-circuit television (CCTV) cameras, occasionally equipped with microphones. These enable a central dispatch and/or control center to remotely monitor vehicles, stations and guideways.

In addition to this, increased resolution of the recording can be triggered by an operator on board or remotely by central dispatch. According to Correlate (2006:48), alarms can include passenger-activated alarm strips or buttons on vehicles or in stations, and operator panic buttons including those found on mobile data terminals (MDTs) as part of real-time CAD/AVL communication systems. There are two types of panic alarms: overt and covert. Once activated, overt alarms can be heard by all passengers.

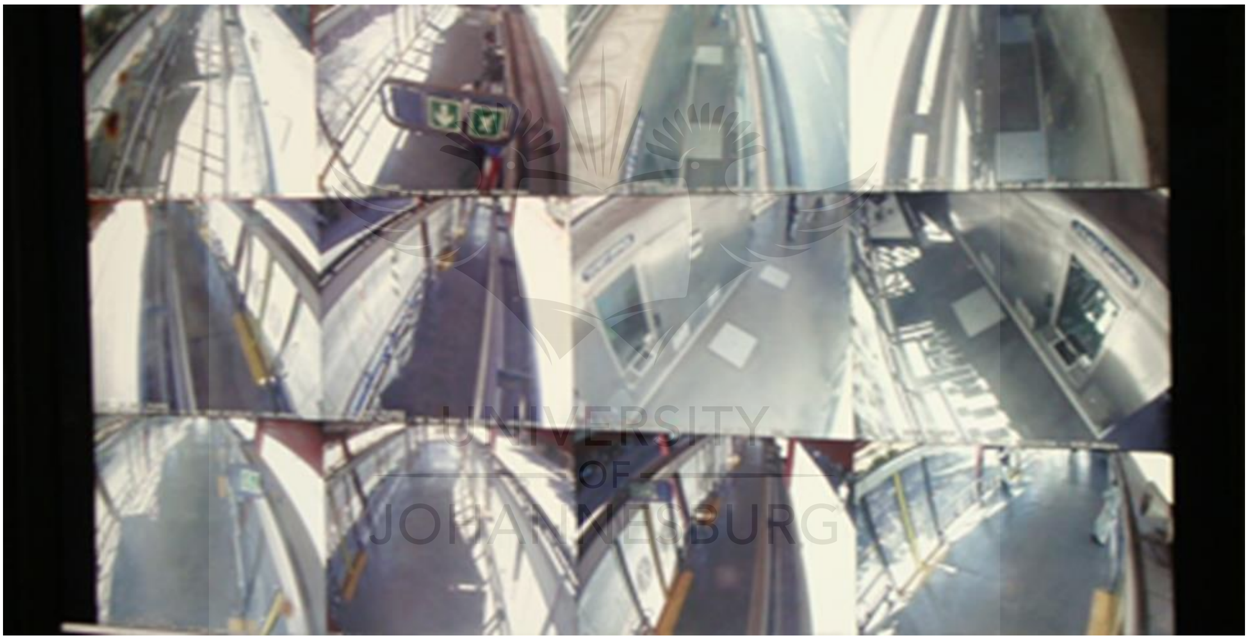

Plate 3.10. CCTV surveillance footage across various stations of the BRT. Source: Skoglund, 2012

This type of alarm is preferred in emergencies to alert all passengers to take immediate action (i.e., evacuate the bus). In contrast, the activation of covert alarms is known only to the operator and central dispatch. Integration to real-time CAD/AVL communications means that central dispatch is able to track the exact location and direction of travel of a bus requiring assistance and can identify what resources are accessible to the bus (law enforcement, emergency response, transit support staff and other buses. Figure 3.7 illustrates a typical example of a CCTV camera installation.

Monitoring of the transportation system and parking facilities for incidents and unusual conditions through CCTV cameras provides significant benefits to the users of these facilities in terms of personal security. Incident management and traffic management systems monitoring the roadways for unusual traffic conditions, transit management systems monitoring their vehicles and bus stops, and parking management monitoring parking facilities are a few other examples of where CCTV cameras are recommended for deployment. The monitoring of these video images through manned centers can provide quick response to motorists, transit patrons, pedestrians and cyclists in need of assistance. Advanced security camera systems and the availability of fast broadband wireless communication facilitates accurate automated site monitoring to the point where human intervention is only required in the form of armed response to a security incident.

The traffic conditions and planning associated with large events, such as sports matches, concerts or emergency incidents can be managed effectively with ITS technology through CCTV monitoring, electronic signage, traffic signal priority and liaison with police personnel on the street, all from a centralized control room. More sophisticated control rooms provide integrated facilities for all responsible authorities under one roof, with event management controlled from a Joint Operations Centre (JOC).

South Africa currently has some of the highest road accident fatality rates in the world. New technology provides an opportunity to increase the safety of drivers, vehicle occupants and other road users, including the more physically vulnerable sectors of society. ITS particularly supports the road safety agenda in three main ways

Network management techniques that help to tackle congestion described in Section 4 also provide safety benefits and vice versa

Camera technology linked to back-office systems support enforcement of road traffic legislation, including through safety cameras and CCTV, and also help enable prompt remedial action in the event of an accident.

In-vehicle ITS developments offer additional safety features to drivers, and there is potential for greater co-operation between vehicles and the road infrastructure to support safety and other objectives. In-vehicle ITS technologies fall into three broad categories known as Telematics, deploying technologies that:

- Support drivers by giving warnings and providing information. Dynamic route guidance systems that forewarn of real-time traffic conditions are reaching the mass market;
- Assist the driver and allow them to hand over specific elements of vehicle control ; and
- Can actually-override the driver and take control, particularly in emergency situations.

Some of these technologies are already available through several top-of-the-range vehicles but ultimately some level of telematics will be a standard feature in all makes and models. The more advanced and automated solutions are likely to contribute significantly to future targets for road safety. Insurance companies are exploring the potential of in-vehicle ITS devices to assess driver behavior, aid risk assessment and inform annual premium rates more generally. The security of passengers and staff on and around public transport services is vital, and this is particularly important issue in the South African context. From a technological point of view, security cameras at stations and along the route as well as emergency call boxes or buttons at stations that are linked to the control center and policing and security services can act as a deterrent to crime and allow for a rapid response to incidents. In South Africa, all implementing cities are installing security technology on their system. The communication system is the backbone of the landside information systems.

Rea Vaya have installed their own fibre optic cables along the running way and connecting the stations. This approach involved a higher capital expenditure upfront, but has low operating costs. As a private system, they have avoided call and data transmission charges. A 3rd party network is used for the GPS communication. All stations are covered by CCTV, which relays images by fibre-optic cable to the control centre. The CCTV images are used to support both general station management and for security (see figure 3.7- CCTV surveillance footage across various stations of the BRT).

3.8.7. Communication

To understand perceptions of transportation and resultant behavior, the whole journey point of view is vital, as the most “uncertain” segment in the trip chain can influence the entire trip in terms of mode, path/route, destination, frequency of travel, and even decision of whether or not to travel. What follow are some examples of factors that have been shown to influence perceptions of uncertainty/assurance while mobile and that can be associated with information and communication? Information is essential to travelers, especially about unfamiliar situations or unforeseen circumstances. In Gothenburg, real-time information for buses and trams has been found to increase travelers’ sense of assurance (Skoglund, 2012).

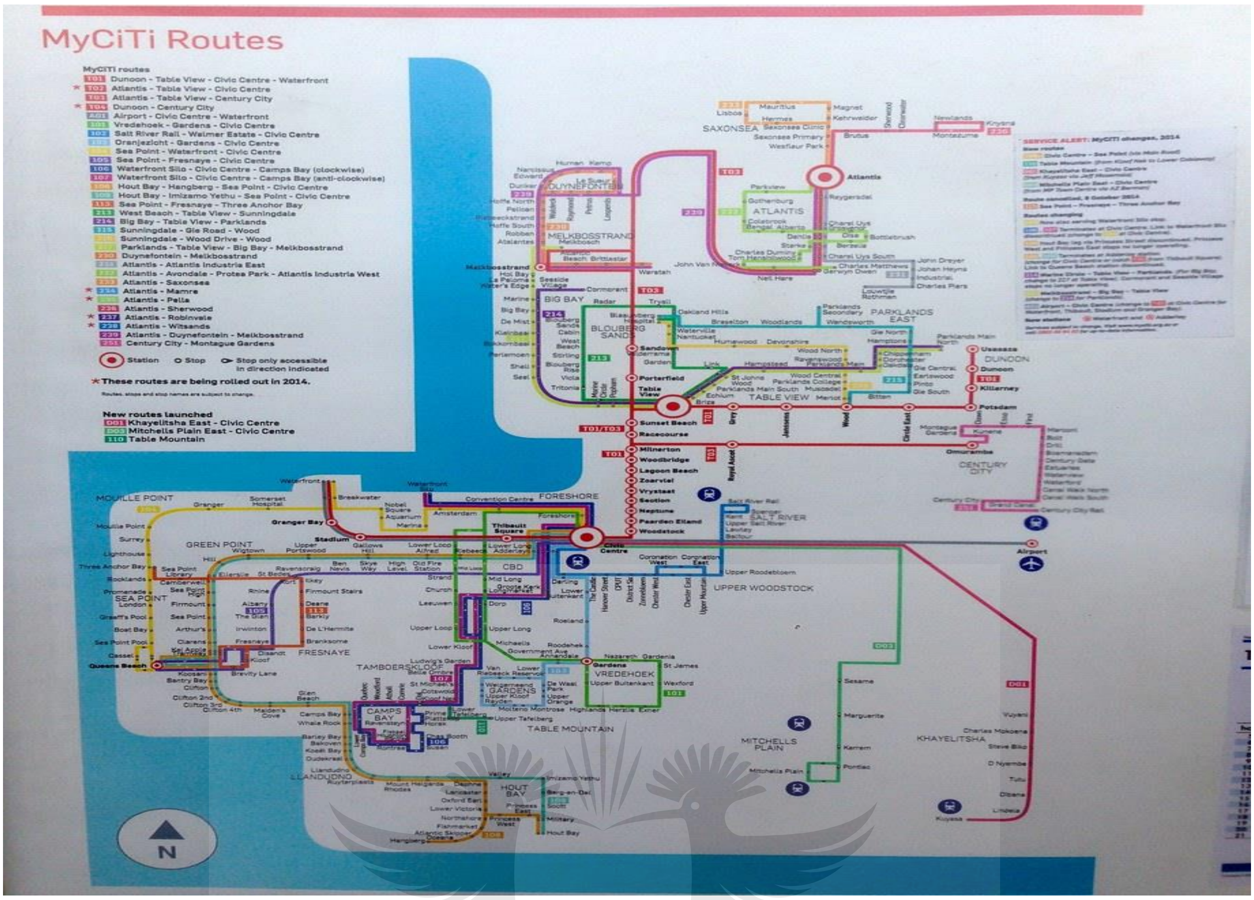

Plate 3.11: BRT route map, Source: Author field data, 2018

A lack of maps or service information in public transport reinforces a sense of unfamiliarity and erodes the ability to plan journeys “safely”, and timely and accurate information about delays and connections help to decrease passenger anxiety (Stafford and Pettersson, 2004). For vulnerable social groups such as elderly and disabled persons, access to information may be the deciding factor in whether or not to travel (Waara, 2013). Familiarity with an area or activity, including using public transportation or a particular transportation mode, is associated with greater feelings of assurance. The ability to confidently find one’s way around is vital to such perceptions (Crime Concern, 1997). ITS offers the possibility to gain a sense of familiarity, e.g. via access to maps and directions (See figure 3.7).

The ITS, or the advanced use of Information and Communication Technology (ICT) in the transportation context, offers new tools in the continual effort to develop an accessible, safe, and sustainable transportation system. However, ITS and therefore the knowledge assortment and process upon that it's designed bring their own challenges, as personal data and privacy are fundamentally intertwined. Individuals’ knowledge is habitually collected, from which one can infer a broad range of activities and lifestyle choices, and which may have implications over time or in other contexts. Perceptions of technology and knowledge use area unit contextual; what could also be thought-about acceptable or privacy-invasive in one scenario and for one purpose might not hold true for different persons, situations, or purposes. Concerns usually concentrate on aspects of namelessness, lack of knowledge or control, function creep, etc.

Furthermore, though individual, finish users area unit tormented by policies and technologies guiding knowledge assortment and process, they're seldom concerned in decision-making processes, offered realistic alternatives, or able to management their own knowledge. From this knowledge, one will infer a broad vary of activities and modus vivendi decisions, which can have implications once employed in real time, later in time, and/or in another context. Perceptions of technology and knowledge use are discourse and what is also thought about acceptable or privacy-invasive in one scenario and for one purpose might not hold true for different persons, situations, or functions. considerations over knowledge assortment and process typically target aspects of obscurity, lack of knowledge of data of info} regarding information use, lack of management, operate creep, etc. moreover, though individual, finish users are clearly plagued by policies and technologies guiding knowledge assortment and process, they're seldom concerned within the decision making processes, offered realistic alternatives, or able to management their own knowledge.

The success of some ITS applications depends on the activity response of travelers (Bristow et al., 1997). as an example, an alternate route recommendation displayed on a variable message sign can haven't any impact of assuaging congestion if travelers don't comprehend and bear upon the message. Mortal behavior is influenced by previous expertise, data of the network and therefore the behavior of different drivers, further because the convenience of the ITS instrumentality (Underwood and Gehring 1994). The ITS provides agencies and their customers a way to handle current urban issues, further as anticipate and address future demand through an intermodal, strategic approach to transportation. Communication can be broken down into two categories: live and deferred. Until recently, voice and data also were processed separately. Recent advances in digital technology have transformed voice (analogy) to another data transmission (digital). Figure 8 illustrates a bus fleet that uses cellular technology for positioning and voice (it.2) and Wi-Fi for deferred (heavy downloads) data (it.3). Please note that street-side passenger information signs can also be updated using cellular technology, since the data stream is relatively low (it.5). Using cellular technology for the bus stop display requires power only to the bus stop.

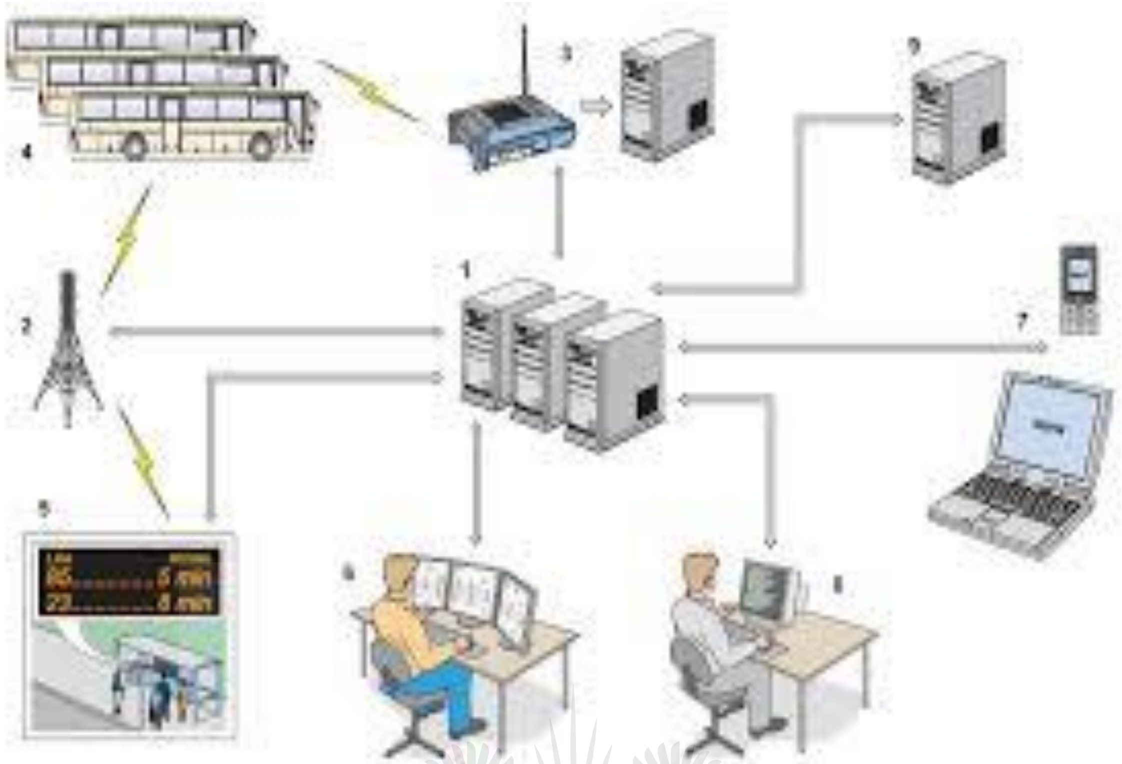

FIGURE 3.6. - Cellular Communications in a bus fleet. Source Skoglund, 2012

Communications technologies are inherent to most ITS systems. Communication technologies are therefore a means of achieving benefits from ITS systems. Until recently, communications technologies were not reliable, available or well integrated. ITS systems, therefore, relied on manual intervention. For example, first-generation automated passenger counters (APCs) required manual intervention on the bus to retrieve the data. Communications technologies now allow this data to be transmitted remotely without having to locate and immobilize the bus. The data automatically retrieved can also be remotely processed, and actions such as sending an e-mail to a concerned party can be done automatically. One typical application of this is fleet management. If a fault code appears on the bus powertrain, this code can be sent to the garage maintenance crew automatically. The maintenance crew can act on the code by performing a road call or by planning maintenance when the bus comes back to the depot (Nuzzolo A, Comi A., 2016).

3.8.9. Operations control centre (OCC)

Congested traffic conditions are often accompanied by a high incidence of rear-end and/or sideswipe collisions due to the prevalence of slow-moving, stop-and-go traffic.

The traffic management techniques associated with ITS can help to reduce the number of collisions in two ways (See figure 3.7), by:

- Improving operational efficiency and reducing congestion, which reduces overall collisions and improves safety.
- Clearing incidents as soon as possible and informing motorists of traffic conditions ahead, thereby reducing the likelihood of secondary collisions occurring in the congested traffic stream.

Network monitoring requires that monitoring devices be installed in strategic locations throughout the transportation network to measure and record traffic flow, travel times, accidents and other security incidents, monitor ITS field equipment as well as the effect of traffic congestion on the environment.

Figure 3.7: Traffic Management Centre (TMC), Source: Skoglund, 2012

The detectors and cameras should be connected to a Traffic Management Centre (TMC) where data can be stored and images viewed. The vehicle detectors could be used to automatically select traffic signal timings (real-time traffic responsive control) and to detect incidents on the expressways. Environmental sensors should also be installed to monitor the impact of traffic conditions on air quality. Network monitoring provides quantitative data from field detectors and qualitative data from video cameras. The use of temporary/portable CCTV equipment (using wireless communications) is important for those locations not adjacent to the fibre optic network. This multi-functional tool can significantly enhance the potential of an area by providing many positive benefits to road users at the selected sites (See figure 3.7):

- Major incidents and congestion are effectively monitored and managed. Rapid and accurate incident detection can provide significant reductions in delays due to incidents. In addition, the chances of secondary incidents or accidents occurring are reduced, providing significant improvements to road safety.
- A rapid overview of network conditions provides up-to-the-minute information for traffic management services and road users via the media.
- CCTV cameras support traffic management from the Traffic Management Centre, with online updating of signal timings in response to unforeseen events or incidents on the network (such as breakdowns and accidents).
- The system can be used for automated law enforcement
- Surveillance at public transport stops and facilities as well as along the routes will assist in creating a safe and secure environment

The results of the monitoring process must then be disseminated to the motoring public and the agencies that manage the transportation network, as appropriate. The information will enable transportation agencies to plan and respond to increased demand, traffic delays and congestion, incidents, special events, road works, and diversions as well as provide information on problems, network status and alternative routing options to the traveling public. The use of elements of an ITS for the control of a BRT system is an important part of BRT operation. The control technologies applied may vary, depending on the operating environment, physical constraints of the city, as well as budget limitations (Diaz & Schneck, 2000). Applications of ITS technologies include automatic vehicle location (AVL) systems, specialized bus signals, signal activation sensors and control systems for providing Transit Signal Priority (TSP) at signalized intersections and mixed roadway rights of way. Transit Signal Priority helps improve bus speeds, facilitates bus turns and reduces waiting times for buses crossing intersections.

It has been reported that this TSP works best when separation times between buses are over 4 minutes (Wright, 2005). The use of AVL also helps in conducting follow-up analyses of the collected vehicle data over time, in order to evaluate the overall service performance and to compare the scheduled and actual BRT vehicle running times. Centralized management and control of the BRT system afford many advantages to optimize system efficiencies and minimize costs:

- Immediate response to changes in customer demand;
- Immediate response to equipment failures, safety, and security problems;
- Efficient spacing between BRT vehicles and avoidance of vehicle "bunching";
- Automated system performance evaluation;
- Automated linkages between operations and revenue distribution;
- Efficient response to customer queries.

While not all system utilizes an automated control centre, it is increasingly becoming standard practice in high-quality systems. A cornerstone of a modern control system is automated vehicle location (AVL) technology which allows the tracking of a vehicle along the corridor. With the AVL the control centre can direct vehicle movements so as to avoid bunching, react swiftly to problems and emergencies, and allocate capacity resources in swift reply to changes in demand (Graeff, 2009). While the benefits seem clear, the cost of a real-time control system would seem prohibitive for a developing city. However, the cost of central control technologies has steadily decreased during the past few years (Write 2004). Thus, even cities in developing nations may now wish to consider the advantages of a central control system.

Operations Control Centre, (referred to as service information hub) monitors the in-service performance of buses, station, and all operational activities within a BRT system, so that problem areas negatively impacting on good customer service are dealt with at the appropriate level of authority and intervention.

Plate 3.12. BRT Operations Control Centre, source: World Bank 2009

The Operation Control Centre is the nerve centre of the BRT, in that it controls and manages the busses and stations on the route, and acts as the conduit between the busses, stations, other infrastructure and all the personnel working on of with the system (Hensher 2006). The specific monitoring responsibilities of the OCC include:

- To monitor in- service performance and to record in the daily log where service failures have occurred. Sufficient and accurate detail must be provided to ensure the case can be substantiated should the Contractor challenge the report (e.g. time, consequence of the failure, driver ID, and action taken by controller);
- That schedules are maintained through the drivers logging on in a timely manner to ensure the start of the trip is not delayed;
- The safe operation of services by managing incidents, accidents and security matters;
- Monitor congestion of passengers or vehicles at stations;
- Performance of drivers to ensure that service quality is upheld;
- The APTMS system provides the 'technology tools' for the OCC to track each bus in the system and monitor performance against the programmed bus schedules;

- During the whole driving shift, the driver is under the exclusive and direct control of the Bus Controller who has the authority, where necessary to instruct the driver to deviate from their programmed schedule. Where any service problems occur (incidents, bus breakdowns), the controller will intervene and manage the situation to remedy the problem. They will contact the BOC as required; and

- The APTMS system will advise the driver automatically when the driver is ahead or behind schedule. If the Controller notices that the driver is not self-monitoring his schedule or is running late, the Controller will contact the driver and instruct him accordingly.

Amongst others, the following ITS support systems are used to update real time performance of BRT service (Stations and Buses). The OCC applies a range of ITS tools for the managing and monitoring of the BRT operations (Levinson et al 2002; Hensher 2006). Several options exist to link buses and stations to with a central control office. In some instances a simple radio or mobile telephone system may suffice. However, increasingly Geographical Positioning Satellite (GPS) technology is providing an effective communication link (Figure 5- Sharing of system functionality by the OCC). GPS technology permits real time information on vehicle location and status.

Modern GPS systems can track vehicle movements with an accuracy of 2 to 20 metres, depending on the type of system and local conditions. GPS location technology combined with wireless communication system (GPRS) is utilized within the control system of BRT system (Levinson et al 2002; Hensher 2006). By using the GPS technology in conjunction with vehicle managing and tracking software and voice communication system, BRT is able to closely headways. A control centre operator will direct a driver to slow down or speed up depending on the location of other vehicles and the demand requested. Further, if a surge in demand occurs at a particular station, a new vehicle can be sent to alleviate crowding. The OCC systems run off an integrated platform i.e. the Delcan software platform. It is important to understand the relationships and interfaces between the various functional areas.

Some of the software components share functionality between the shared central software and the OCC whilst others have limited shared functionality – although the User Interface is provided by the Delcan software. The inter-relationship between the systems and the sharing of system functionality by the OCC is shown below (Figure 3.4)

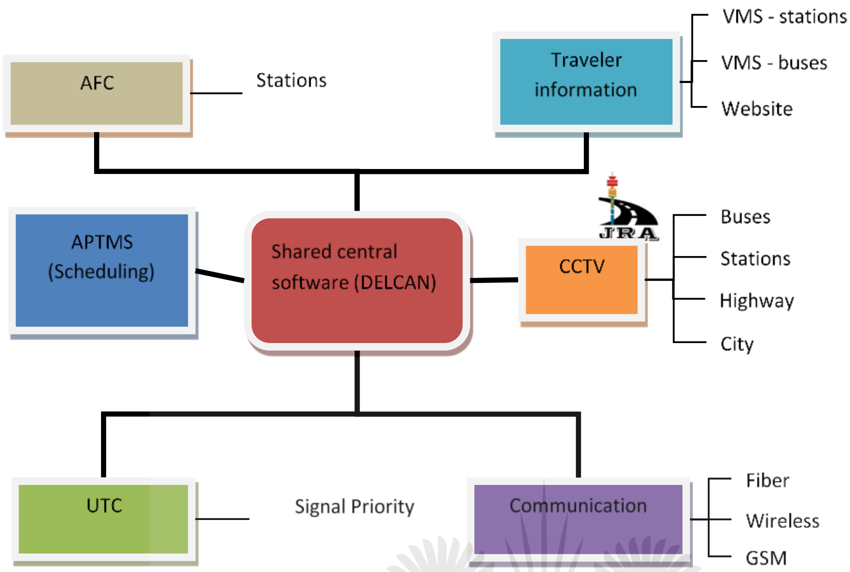

Figure 3.8. Sharing of system functionality by the OCC, Source: Hagel and Brown, 2001

During its daily activities, the OCC is able to liaise with relevant agencies to deal with operational and emergency situations effectively. A close relationship exists between RV and JRA as the latter manages the UTC system which manages traffic signals on the RV routes. Ready communication channels should exist with other agencies such as emergency units, to respond quickly and effectively to incidents. The OCC must have at hand current contact details for technical support and operational and maintenance issues as they arise. Liaison must be developed between other transport operators such as Gautrain, Metrorail as well as other bus operators such as Metro bus and Putco.

3.8.10. Human Resource Management

The impact of human resource management on the performance of a company has come into limelight and as such it has become an area that requires paying more attention to in the field of (HRM). According to few studies, some human resource practices will have a positive impact on a company's performance while numerous researchers suggest that more conceptual and practical approach is important on these works (Delery & Shaw, 2001; Von Krogh, Ichijo, & Nonaka, 2000; Wright & Boswell, 2002). Although, recently employees in an organization are seen as the most important asset possessed by an organization however, their impact are felt by only a few organizations (Davenport & Pruzak, 2000; Schein, 2006; Syed-Ikhsan & Rowland, 2004).

3.8.10.1. Expertise

Specific qualities are required in terms of expertise and experience in order to manage the effective design and deployment of ITS technology, however, South Africa has a lack of ITS skills and an inability to retain existing expertise or experienced Engineers. It is therefore imperative that an ITS Strategy actively promotes the development of knowledge transfer through the appointment of specialized and appropriately experienced contractors or consultants. This entails a clear focus on the following activities:

3.8.10.2. Education

ITS is an interdisciplinary area of expertise with ITS practitioners coming from their original “mother disciplines” such as Civil (Traffic and Transportation), Electrical, IT and Communications Engineering. Until recently there has been no formal tertiary education for ITS, but this industry has subsequently grown into an area of specialization which led ITS South Africa to establish an ITS Centre of Excellence as a delivery mechanism. It is a virtual centre that encourages cooperation with local and international universities and technical universities to explore synergies around educational programs. As a result, several major South African universities are now offering postgraduate courses in ITS and undergraduate courses are being planned for the near future.

3.8.10.3. Training

Training is done to create change by initiating a new employee into the culture of the organization. It involves new employees acquiring new skills or improving their skills in order to implement change that is needed by an organization. Training is not sufficient enough to motivate work force. But, it is an important tool that an organization can use to achieve its long term goals (Laird, Holton III, & Naquin, 2003).

3.8.10.3.1. General training

It is necessary to identify training needs for staff involved at different levels in ITS projects, to inform a process of knowledge transfer and training. This will ensure the training services provided, and technology transfer program developed, will strengthen the capacity of the personnel, relating to the operation, maintenance and best practice for the entire ITS technical platform. An understanding of these systems, gained by ITS personnel through the training and knowledge transfer, will assist in developing this resource.

3.8.10.3.2. Training in specialist areas

ITS systems incorporate cutting edge technologies, which require the provision of training in specialist technical areas. A program of institutional strengthening would provide specialist, on-going training for operations personnel, but management and executives would also benefit from exchanges with international ITS experts and managers. Consideration must be given to knowledge transfer being entrenched in technology deployment contracts, such as through a formal exchange program, for Engineers and technicians, with International companies.

3.8.11. The link between Intelligent Transport System capability and BRT agility

There are many technologies and operational features that can be utilized when designing BRT systems. Some have been applied to standard bus systems to help make them more efficient. A BRT system typically is a combination of technologies, features, and land use that together make it effective and efficient. Currently, there are twenty-one (21) ITS technologies, which can be integrated into BRT systems that have been defined (Hagel and Brown, 2001).

3.8.11.1. Introduction

Intelligent Transport System is a major force driving the need for business agility and at the same time an important capability, which can hinder or enable a BRT's level of business agility. Over time, ITS have developed and matured significantly. ITS were relatively expensive in the early days of computing. Efficiency was the primary objective of shaping architecture while delivering relatively limited performance. Roles and relationships were tightly defined to optimize the use of scarce and expensive technology resources (Hagel and Brown, 2001). During the years ITS have become standardized and commoditized, leading to lower prices due to economies of scale. The literature provides t streams of research with different perspectives on the relationship between ITS capabilities and BRT agility (performance).

3.8.11.2. The role of ITS capability in the agility of the South African BRT

"How much does the Intelligent Transport System contribute to the BRT and how much does it help to keep the business running?"

Those questions have been discussed for years and no simple answer can be given due to difficulty in measuring quality. In a BRT, users need an ITS to be responsive to their individual need and to help them be more productive while management wants an ITS that is reliable, visible, secure and scalable so that their stakeholders could exploit the potential of ITS and use it to fulfil the business strategies. Zhang P et al. (2016) emphasizes that through the changes occurring in the perceived contribution of Intelligent Transport System to the BRT, Intelligent Transport System becomes not only a success factor for survival and prosperity but also an opportunity to differentiate and to achieve competitive advantage. This shows how much the Intelligent Transport System is crucial for the BRT. Today, in most of the municipalities the ITS is a part of the core business especially in the BRT, (De Sutter, 2004). Considering this fact, the biggest challenge for and ITS department is to ensure an efficient and effective ITS delivery owing how much is at an acceptable quality level for the BRT.

Strategic alignment between BRT and ITS has been one of the concerns in the transport industry in South Africa and that is why a high quality ITS delivery which is also aligned with BRT expectations is an effective way of showing how much value ITS generates for the BRT. A key Bus Rapid Transit (BRT) feature is data collection and information dissemination, both for the BRT system management as well as to transit operators and passengers. Traffic reports now feature regularly on the radio during peak traffic hours, to help motorists avoid congestion, but buses and taxis are unable to change their routes due to waiting commuters at preordained stops.

Intelligent Transport System monitors any incidents of abnormal traffic congestion on the Bus Rapid Transit system feeder arterials as well as satellite tracking of the BRT buses and, if delays are unavoidable, real-time passenger information systems can relay revised arrival times to electronic signage at the BRT stations or on the busses. Regular commuters could subscribe to receive this information by SMS on their cell phones or via the Internet. Passengers essentially require information on bus routing/timetables and real-time schedule adherence to assist in their public transport trip planning. Passenger information systems collate and interpret all the passenger data from the related ITS systems to ensure this information is reliable, accurate and in real-time information. By showing the value generated by ITS, the argument which postulates that ITS is nothing more than a cost centre providing a supporting role to BRT strategies Zhang P et al. (2016), is contradicted.

Since the introduction of the first Bus Rapid Transit in South Africa, ITS alignment has improved, but still, there remains a gab, which shows that ITS executives believe that they are more closely aligned to the BRT objectives than they perceive them to be (Economist business unit, 2008). Shortly it can be said that ITS is adding value to the BRT in South Africa by automating their existing business processes and making them more effective and efficient by reducing costs. At the same time, continuous monitoring of the quality of the ITS services ensures that this value is kept. According to Burg and Singleton (2005), Intelligent Transport System provides BRT with the ability to monitor their operations and quickly realign business processes enabling them to change the way of competition. ITS a recent field in science and as such it demonstrates rapid development (Peirce, Lappin, 2003). ITS are being developed by various parties including system developers, car manufacturers and scientists worldwide (Humanist, 2004).

The contribution of various groups including engineers, psychologists, ergonomists and lawyers is also apparent. The importance of the development of ITS within the BRT lies mainly on the fact that their contribution in many of today's problems, which have resulted from the mobility growth, is anticipated to be substantial. Generally, the invention of the BRT has enhanced people's everyday life, but their development and the resulting growth in mobility has been followed by negative consequences. More specifically, road safety, traffic, and environmental conditions are affected by that growth, for which conventional measures seem to be ineffective. ITS seem to be a promising direction towards providing an efficient solution for the reduction of those side-effects of mobility growth, thus setting new standards.

3.8.11.3. Intelligent Transport System and Bus Rapid Transit user

People have several reasons to be mobile, from daily activities involving work, studies, and family life, to maintaining participation in society, health, and quality of life. Indeed, quality isn't solely a characteristic of contemporary social life, however additionally a precondition for it (Thomsen et al., 2005). The construct of quality varies greatly between disciplines, from the movement between two points to social equality between categories to the unfolding of concepts.

One classification divides quality into four general sorts of movement: personal, object, virtual (information), and unreal (media) (Urry, 2000). ITS and services have nice potential to usually enhance individuals' daily, personal quality and transportation experiences. As an example, advancements in positioning and mobile systems allow more and more precise and continuous measurements of the locations and movements of people and objects over time. These pursuit and observation capabilities facilitate the gathering of position, movement and activity information, that allows more development of services and devices, for example, to supply data for pre- and on-trip coming up. Intelligent Transport System enhance and modify the top users' expertise and include:

- Information like maps, journey planners, push notifications, and period information;
- Monitoring via sensors and video police investigation (CCTV) systems;
- Positioning that permits navigation, personal alarms, and location-based services;
- Identification to form virtual signs and (geo) tags;
- Authorization via smartcards and RFID tags;
- Communication that's immediate and pervasive.

ITS for users use technology (such as smartphones and GPS-enabled devices) to boost convenience and journey potency for drivers and alternative users. They will cut back the barriers to shifting transport modes and supply period and forecast data. as an example, smartphone apps area unit obtainable that use GPS and 3D maps to figure out however efficiently expeditiously with potency a driver is driving and supply recommendation on up that efficiency. For the top users' daily quality and transportation experiences, such services will serve to boost one's sense of assurance by reducing uncertainty and facilitating coming up with and coping with unforeseen circumstances. However, these new tools and also the information assortment and process upon that they're engineered to bring their own challenges, as information amount and quality will increase, Associate in Nursing as data regarding a person is essentially tangled with an individual's privacy. Whereas people area unit going regarding their day, they're habitually tracked so as to gather the sought-after information that has become a market artefact.

From this information, one will infer a broad vary of activities and style decisions, which can have implications once utilized in real time, later in time, and/or in another context. Perceptions of technology and information use area unit discourse and what could also be thought-about acceptable or privacy-invasive in one scenario and for one purpose might not hold true for alternative persons, situations, or functions. considerations over information assortment and process usually specialize in aspects of namelessness, lack {of knowledge of data} regarding information use, lack of management, operate creep, etc. moreover, though individual, finish user's area unit clearly full of policies and technologies guiding information assortment and process, they're seldom concerned within the decision-making processes, offered realistic alternatives, or able to manage their own information.

Despite many opportunities for ITS services to enhance one's mobility, assurance, safety, security, the collection and use of position, movement and activity data also has potentially negative consequences, as the use of ICT in transportation and other contexts facilitates easier access to more information for people to use, but about them as well. The data generated and collected by various technologies increasingly fill in the once fragmented picture of one's movements and activities, especially as the personalization of services increases, e.g. via positioning and tracking behaviour. Such tensions within the realm of personal data and technology are not new and will not likely be resolved in the future as society and technology are continually co-evolving. The raised access to data and communication offered by ITS services (and ICT generally) will serve to scale back perceived risk and uncertainty by impartation a way of connectedness and management.

Information is especially important in unfamiliar locations and situations and can aid all transportation users, from those on the "front line" of transportation (professional drivers) in facilitating their work to vulnerable social groups, who often need information in order to decide whether to travel or not (Waara, 2013). The success of some ITS applications is dependent on the behavioural response of travellers (Bristow et al. 1997). For example, an alternative route recommendation displayed on a variable message sign will have no effect of alleviating congestion if travellers do not comprehend and act upon the message. Traveller behaviour is influenced by previous experience, knowledge of the network and the behaviour of other drivers, as well as the availability of the ITS equipment (Underwood and Gehring 1994).

3.8.11.4. ITS and BRT back office

ITS-enabled back-office solutions support traffic management and long term investment choices. They collect, mixture and store knowledge regarding the state and use of the network, to be used in a period of time operations further as designing and investment. As an example, the metropolis Joint Transport Operations Centre (JTOC, operated in partnership with metropolis Transport) permits network operators to regulate stoplight signals, variable speed, and message signs, and ramp metering in response to a period of time traffic conditions monitored through cameras and different sensors.

Note that whereas these six classes are helpful in considering our investment and roles in respect to ITS, they don't operate in strict isolation. Intelligent Transport System and knowledge assortment and process don't seem to be "silver bullets" in a position solve all issues via "complete and perfect" info. they're extra tools within the tool case that bring with them their own challenges associated with problems like privacy, lack of choice/control, and technological accessibility. Thus, efforts ought to be created to handle these new challenges, like technological mechanisms, personal actions, and user participation, and proactive structure policy and public legislation. However, these new tools and therefore the knowledge assortment and process upon that they're designed to bring their own challenges, as knowledge amount and quality will increase, and as info regarding a person are basically tangled with an individual's privacy.

Whereas pe1ople are going regarding their day, they're habitually caterpillar-tracked so as to gather the sought-after knowledge that has become a market trade goods. The evaluation process using back-office tools such as the operations control centre must incorporate driver behavioural factors, a variable that is much less prevalent in conventional road project evaluation. ITS for users use technology (such as smartphones and GPS-enabled devices) to enhance convenience and journey potency for drivers and different users. They can scale back the barriers to switch transport modes and supply period and forecast data. For example, smartphone apps are available that use GPS and 3D maps to work out how efficiently a motorist is driving and provide advice on improving that efficiency.

3.8.11.5. The ITS and BRT Vehicle

ITS technologies represent a great potential for further development of road transport, meanwhile the utilization of these technologies is currently limited by the fact that they represent, more or less, rather an information system, while the users, having been provided with the relevant information, have to decide themselves about their next step and are fully responsible for it. To take full advantage of the ITS potential to improve the security of the road traffic, it is necessary to consider also the question of reliable and secure cooperation of the ITS systems in vehicles and the ITS systems on the road network: any error while running either of the systems or while transmitting the information could result in putting in danger or even destroying human lives. Vehicle-installed ITS enable them to respond to driving conditions without driver input or control.

These solutions cover everything from cruise control to autonomous (or driverless) vehicles, with benefits ranging from increased safety to convenience and fuel and journey efficiencies. For example, ITS in some vehicles use radar and lasers to detect if a collision is likely to happen. They can alert the driver, pre-tension seatbelts and apply the brakes automatically if they determine that a collision is otherwise unavoidable. The application of ITS in BRT systems helps agencies to boost services by up the responsibility and potency of operations. Through information analysis, agencies will at present, within the Indian context, Intelligent Transport System includes a good sort of technologies with applications in navigation, traffic management, parking and surveillance.

Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) ITS use wireless networks to enable secure, real-time interactions between compatible vehicles and between vehicles and the network infrastructure. These solutions are also known as cooperative ITS (also referred to as C-ITS). For example, ITS technologies can provide real-time or near real-time information, collected by sensors, transport users, covering everything from traffic conditions and weather conditions to expected arrival times for public transport services and whether the services cater for wheelchair users. Over a previous couple of years, transport agencies are able to implement ITS technology at variable scales. Vehicle-installed ITS change them to reply to driving conditions while not driver input or management. These solutions cowl everything from the controller to autonomous (or driverless) vehicles, with advantages starting from increased safety to convenience and fuel and journey efficiencies.

For example, ITS in some vehicles use observation and ranging radiolocation measuring instrument measuring system measuring device and lasers to detect if a collision is probably going to happen. They can alert the motive force, pre-tension seatbelts and apply the brakes mechanically if they verify that a collision is otherwise inevitable. Automatic Vehicle Location System (AVLS) technology uses a combination of a Global Positioning System; receiver and a General Packet Radio Service (GPRS) communication module to transmit the location of a vehicle to the control centre, in real time (AFTEK 2011). This technology was at first utilized by the military and step by step found its means into freight and supply services, wherever drivers were monitored for an unexpected stoppage and route deviations. The solution helps the operators monitor drivers for unscheduled stoppages, deviations from routes, over-speeding, etc., which have adverse impacts on the delivery schedule as well as finances.

The same system was later custom-made to urban bus systems as some way for operators to watch these aspects that have an effect on operations additionally as finances. Since the monitoring requirements of urban bus service is much different from that of the freight industry, bus operators have not been able to take the full benefit of the application. For example, buses in urban areas have engorged streets that don't allow them to succeed in higher speeds; therefore the connection of report on over-speeding is proscribed. Similarly, each bus driver has to follow a specific schedule throughout the day. Since passengers move these routes, drivers don't deviate from the scheduled path unless directed by the traffic police or alternative authorities.

However, for the case of urban bus operations, AVLS can provide specific analyses, such as travel time monitoring between consecutive stops at various times of the day, schedule adherence, and driver behaviour analytics. Due to the limited market for ITS use in public transport, these analyses have not been explored adequately. Further, the shortcoming of bus operators to lift capital for advanced analytics solutions has conjointly prevented any breakthrough during this direction. As the simple movement, around urban areas, becomes more and more plagued by congestion, ITS applications become crucial in strengthening bus systems.

3.8.11.6. ITS and quality of BRT service

The concept of service quality has been broadly applied to the public transport system and defined as commuters' perception of how well a particular transport service meets or exceeds their expectation (Nandan & Geetika 2010). Service quality in the public transport sector can be measured in relationship with customer's expectations, perceptions, satisfaction, and attitude (Litman 2008); it encompasses several topics such as comfort inside and outside of the vehicle, journey duration and the existence of infrastructural support systems (Currie 2005). A holistic approach to service quality improvement in the public transport system is required, particularly in the identification of customer's needs and priorities, including use of complaints and feedback to evaluate necessary service quality indicators (Dell'Olio, Ibeas & Cecin 2010).

Initially, instruments to measure service quality were developed by market researchers to evaluate which service satisfies customers (Jiang, Kelin, and Carr, 2002, Afrial, 2009). In its relation to public service quality provided for by the government, Levine (1990) explains that public service products in a democratic country must at least fulfil three indicators: responsiveness, responsibility, and accountability. Albrect (1985) and Zemke (1990), on the other hand, view that public service quality is a result of interactions among three aspects, i.e. service systems established by organisations of service providers, human resources providing the service, marketing strategies, and customers or service users.

The three aspects are associated with one another, interrelated and linked together by an organisational culture directed to fulfil the needs of customers. On a different note, Gibson, Ivancevic, and Donelly (as quoted by Dwiyanto, 2005) include the dimension of time. In this case, public service performance consists of the aspects of production, quality, efficiency, flexibility, and satisfaction for short-term measurement; the aspects of competition and development for medium-term measurements; and the aspect of business continuity for long-term measurement. The quality of customer services is directly related to customer satisfaction, which will ultimately determine customer usage and long-term financial sustainability. Unfortunately, unclear maps and schedules, unclean and ill-maintained vehicles and uncomfortable rides have all too frequently been the norm for those who utilize public transport in developing cities.

Public transport and paratransit operators sometimes pay scant attention to customer service, assuming instead that their market is comprised of captive customers, who have no other option but to use their services. Such a predilection, though, can lead to a downward spiral, in which poor services push more commuters towards two-, three-, and four-wheeled motorized alternatives. In turn, the reduced ridership limits public transport revenues and further diminishes the quality of service, which in turn leads to further erosion of the passenger base. The impacts of poor customer service may not be immediately evident when the majority of users are “captive” riders who indeed have few other transport options. However in the medium and long term, as income increases, these captive riders will become discretionary riders. The discretionary riders are quite likely to switch to individual motorized transport as soon as it becomes financially feasible to do so (Reeves and Bednar, 1994).

Customer service is fundamental at each level of operation. Are drivers courteous, professional and well presented? Are the stations and vehicles clean, safe and secure? Does the morning commute a pleasant and relaxing experience or is it a hazardous and unfortunate trauma that must be endured? Are there opportunities for people to complain, receive information and be heard? Individually, factors such as driver behaviour, signage, and seat comfort may appear to be trivial measures, but their combined effect can be a significant determinant in public transport services long term viability. Customers normally don’t care about the type of engine propulsion technology, but they do care greatly about the simple customer service features that directly affect journey comfort, convenience, and safety. Despite this rather obvious observation, too many public transport developers devote their entire attention to the vehicle and engineering aspects of system design and forget about the customer service aspects. Quality products and services are expected for every product and service offered by organisations to customers.

According to Zeithmal, Parasuraman, and Berry (1990), “Excellent service pays off because it creates true customers; customers who are glad select a firm after the service experience, choose the firm again and sing praises to others”. Zeithml et al (1996) highlight that the sellers and not the buyer set the specifications and the framework of rules under which the buyer must purchase. Since the quality expression “Fitness for use” is general and ambiguous, it needs to be analysed before it can be used by the buyer to make a decision (H.C. Rosander1985). In addition, difficulties in measurement of customer expectation and perceptions and an ongoing debate on the differences between customer satisfaction and service quality also exist (Reeves and Bednar, 1994). By using importance-performance analysis, we can measure the conformity between the expected South African public service qualities (referred to as importance level) with the South African public service quality received by service users as of end users (referred to as performance level).

It is in such conformity that the study of South African service quality becomes one of the important factors to improve the service quality of mass transportation provided by the Government. Moreover, the service quality study is a part of a multidisciplinary social engineering study on South African mass rapid transit system that can be used as a model for other major cities. In the end, assessing the quality of public services and analysing the customer satisfaction rate, needs benchmarking of the rapid transportation system (Camp 1989, Keehley 1997, Spendolini 1992, Gilbert 2008). Thus, the efficiency and effectivity of transportation system in South Africa are expected to be obtained, and also it proves the government alignments to the public service reformation to the mass public transportation (Fitriati, 2009 and 2010). In a journey, commuters generally have a choice between modes of transport, each with unique features interwoven with pros and cons (Garling 2005). Customers' expectations and perceptions are paramount to service quality (Davidoff 1994); they are not objective and may also not based on reality.

Service quality in the public transport sector can be measured in relationship with customer’s expectations, perceptions, satisfaction, and attitude (Litman 2008); it encompasses several topics such as comfort inside and outside of the vehicle, journey duration and the existence of infrastructural support systems (Currie 2005). A holistic approach to service quality improvement in the public transport system is required, particularly in the identification of customer’s needs and priorities, including use of complaints and feedback to evaluate necessary service quality indicators (Dell’Olio, Ibeas & Cecin 2010). Public transport usually competes with other modes of transportation (Currie, 2005) and will be utilized if it can meet the expectations of the commuters, specifically if it can deliver the accessible, safe, affordable and reliable service it claims to provide (Stradling et al., 2007).

A review of literature on public transport quality indicates that service quality in the public transport sector reflects commuters' perceptions of the transport system's performance (Hensher et al. 2003; Wallis & Currie 2008). In a journey, commuters generally have a choice between modes of transport, each with unique features interwoven with pros and cons (Garling, 2005). Customers' expectations and perceptions are paramount to service quality (Davidoff, 1994); they are not objective and may also not based on reality (Ungerer & Daweti, 2007). If a customer expects a certain level of service and they perceive that an equal or higher level was delivered, they will most definitely be satisfied (Vavra, 1997); however, even when good service as measured by an objective standard is delivered and customers expected better service, they will be dissatisfied (Ungerer & Daweti, 2007). When considering personal mobility, one finds a broad range of experiences and barriers such as demographic factors, accessibility, availability, affordability, safety/security concerns, lack of information, etc.

3.8.11.7. Intelligent Transport System and Sustainable transport development

Urban areas are plagued by an increase in the level of pollution and even more so traffic congestion, which creates its own social, economic and environmental challenges (Beavon, 2001; Rodrigue, Comtois and Slack, 2006). Traffic congestion, pollution, overcrowding and an increase in the number of road accidents, are some of the common problems experienced by a growing city, which results in an increase in the development and implementation of various modes of public transportation systems and more recently the implementation of the BRT systems in developed and developing countries, as an alternative model of urban transport systems. Improvements in transportation systems have resulted in direct advancement of economic growth as well as increased in social developments, due to greater mobility and better accessibility to people, resources and the market place.

There is however a concern that improved transportation systems will have associated costs (economic, social and environment) for current and future generations, and that accounts for each of these entities is needed for sustainable transport development (Zuidgeest, 2005). As reported by Commission for Global Road Safety(June 2014), the global road deaths were between 750,000 to 880,000 in the year 1999 and estimated about 1.25 million deaths per year and the toll is increasing further. The World health Organisation (WHO) report (1999), showed that in the year 1990 road accidents as a cause of death or disability were the ninth most significant cause of death or disability and predicted that by 2020 this will move to sixth place. Without significant changes to the road transport systems, these dreadful figures are likely to increase significantly. Traditional driver training, infrastructure and safety improvements, may contribute to a certain extent to reduce the number of accidents but not enough to combat this menace.

ITS are the best solution to the problem. Safety is one of the principal driving forces behind the evolution, development, standardization, and implementation of ITS systems. Transport has a major impact on the quality of life in a city, its environment, and the economy. Transport Authorities globally are facing similar strategic challenges around worsening congestion, insufficient transport infrastructure, affordability constraints, increasing emissions and growing customer needs. To respond to this demanding environment, Transport Authorities can no longer depend solely on the traditional approach of building more infrastructure as this requires significant financial commitment as well as complex regulatory and environmental planning processes to manage. Consequently, Transport Authorities across the world are increasingly focusing on the use of demand management with schemes such as road user charging; and information and customer management techniques including enhanced traveller information services.

This broader application of Information Technology (IT) provides an opportunity to drive innovation in the provision of transportation systems and services. There is no doubt that technology is changing the way the world used to do business. Obliged by law to run to published timetables and to charge laid-down fares, buses cannot compete equally with the minibus-taxi, which generally runs where and when they wish. People waiting at bus stops readily board whichever mode stops first, something easy for the taxi to contrive. Bus drivers, earning union-negotiated wages, enjoy pension and medical funds. Provincial, metropolitan, and city authorities claim constantly – albeit unconvincingly – that the taxi situation is being regulated, but the taxi publicly repudiate the new provincial permit system, and they want the local Road Transportation Board, which declines to issue permits for roadworthy vehicles to be staffed with people more sympathetic to their cause (Pillay & Seedat, 2006).

Vanderschuren (2006) presented the following concept of integrating economic, social and environmental sustainability, as can be seen in Figure 3.5.

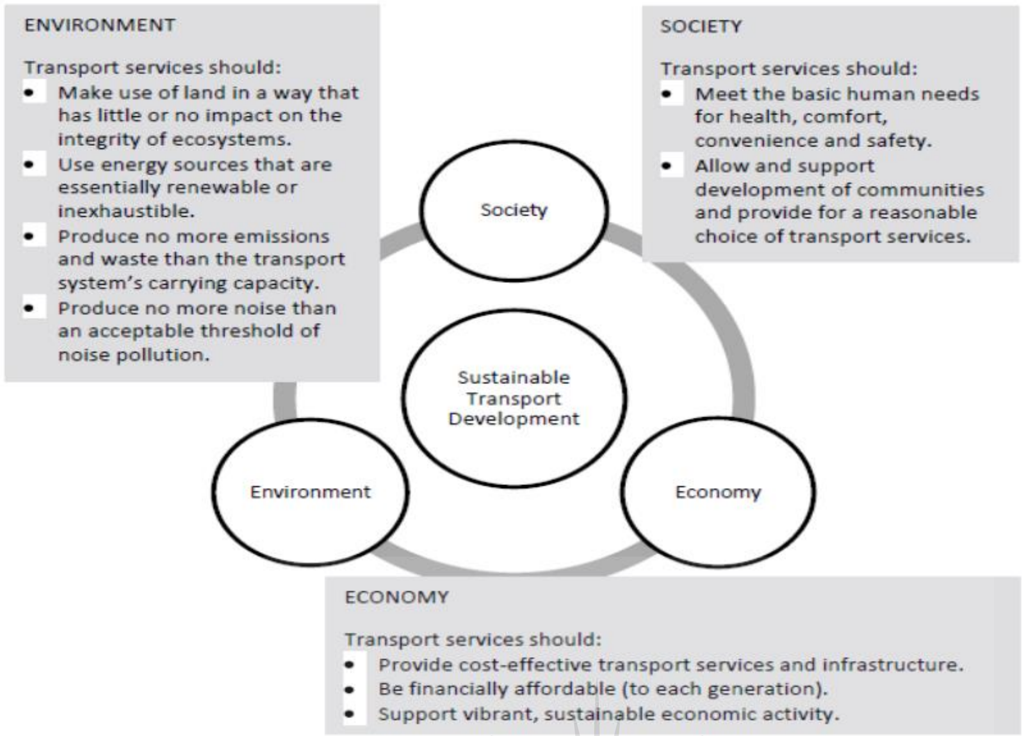

Figure 3.9: Concept of Sustainable Transport Development, Source: Vanderschuren, 2006

3.8.11.7.1. Economic Value

Sustainable development is an approach to economic planning that attempts to foster economic growth while preserving the quality of the environment for future generations (Basiago, 1999). The outcome of implementing the ITS is a sustainable public transportation system which in turn will result in maintaining a standard growth rate of wealth creation through evolving innovative job creation to empower human development in productivity, equity and reduction of biodegradation of the environment. Social development will result in a system which alleviates poverty through optimum resource usage, prioritised resource allocation equitable resource distribution. Sustainable development is an approach to economic planning that attempts to foster economic growth while preserving the quality of the environment for future generations (Basiago, 1999). The implementation of ITS resulting to Sustainable Public Transportation system will result to maintaining a standard growth rate of wealth creation through evolving innovative job creation to empower human development in productivity, equity and reduction of biodegradation of the environment.

Social development will result in a system which alleviates poverty through optimum resource usage, prioritised resource allocation equitable resource distribution. ITS deployment improves efficiency in the use of transport infrastructure, which yields economic dividends. Through delivering current accurate real-time information, ITS can help optimize the use of existing infrastructure and transportation systems. Another dividend from ITS implementation comes from improving efficiency in moving both people and freight, which tends to benefit overall economic activity and productivity. Standardised, integrated forms of co-operation between logistics and road traffic management can enhance the productivity of logistics and transport businesses. ITS technologies using freight tracking systems in coordination with the global positioning system or onboard monitoring help eliminate unnecessary mileage. The ITS solutions not only create economic value within the transport sector but also lead to the development of a range of front-to-back (or integrated) industries in such sectors as automobiles, electrical equipment, communication networks, software, and engineering.

ITS services and infrastructure are inconceivable without the coordination of elements from all those sources. In enhancing a national or a city transport network, Intelligent Transport System accelerates the growth of many related industries in a variety of ways. The jobs created tend to be of a skilled and high-quality caliber. In the United States, the Department of Transportation has forecast that 60,000 jobs will be created relating to the Intelligent Transport System over the next 20 years. ITS can also contribute to poverty reduction by improving the travel time and travel costs for poorer city dwellers, providing them with new economic opportunities in distant areas of their cities. This is an essential development contribution in large cities in developing countries where large sections of the populations are likely to live in peripheral slums that are remote from economic opportunities, typically situated in urban centers.

By reducing the time, the costs and the stress associated with travel time, Intelligent Transport System are likely to contribute to poverty alleviation by – among others-facilitating transit through public transport. Buses are often the mode of choice for urban transport by the poorest in the developing countries.

3.8.11.7.2. Environmental sustainability

Environmentally speaking, ITS deployment induces traffic efficiency and fluidity to grow, and encourages the use of public transport, resulting in reductions in CO2 emission and other air-borne pollutants such as small particles. Demand for emission reductions will spur the development of public or collective ITS services. Transportation generates a large share of the environmental burden of CO2 emissions (especially when counting the extraction of fossil fuels as a polluter in this sector). Data from 2012 from the International Energy Agency (IEA) suggests that transportation accounts for 22 percent of energy consumption related to CO2 emission, with 74 percent of total CO2 emissions in the sector coming from road traffic.

The transport sector is the most rapidly growing source of greenhouse gas emissions in South Africa, since congestion results in increased fuel consumption and, consequently, an increase in air pollution. Reductions in the environmental impact of motorized transportation are, therefore, usually measured in terms of reduction in CO^2 emission and fuel consumption and directly attributed to improvements in operational efficiency and reductions in travel delay that can be achieved through ITS initiatives. A strategy for a developmental green economy for Gauteng (Preliminary Report for the Gauteng Province Department of Economic Development – January 2010) proposes to:

- Promote low carbon transportation systems
- Remove subsidies for fossil fuel and penalize inefficiency (high fuel consumption)
- Establish a long-term strategic shift away from private car use and support for mass transit, public transport, rail, etc. (through an increase in quality, affordability, and availability of public transport and penalizing private car use).

The Lancet (one of the world's best known, oldest, and most respected general medical journals) has reported that air pollution is the second fastest growing causes of death in the world in 2010 3.2 million died prematurely due to air pollution, compared to 800,000 air pollution deaths reported in 2000. 2.1 Million Deaths were in Asia where car markets have exploded in the past ten years and where the large car is seen as a status symbol. The study found that it was specifically the type of air pollution caused by car and truck exhaust that are doing the most damage. Mandatory vehicle emission standards have been in place in many countries for a number of years but South Africa has only recently introduced emission specifications for new vehicles, which focus on a reduced carbon footprint.

Green ITS is deploying different measures that help reconcile economic growth with a sustainable transport system, by producing more energy efficient transportation systems, better use of existing road infrastructure and reduced CO^2 emissions. Internationally, Traffic and incident management systems have proven to be able to reduce fuel consumption by as much as 40 % and vehicle emissions by up to 50%. Exhaust emissions thus are a major source of pollution, and the level of particulate emissions in motor vehicle exhaust has a significant impact. Hence, exhaust emissions are a key target in attempts to reduce pollution, as the level of particulate emissions from motor vehicle exhausts is such a significant factor in air pollution.

According to the ITS development strategy of the Department of Transport in the Republic of Korea, ITS contribute to decreasing fuel consumption and greenhouse gas emissions by reducing traffic congestion and preventing motor vehicles from idling. Carbon emissions from transport are expected to decline by 12 percent by 2020. Furthermore, an annual CO2 reduction of 19,000 tonnes13 is anticipated when the Intelligent Transport System is implemented for 1,000 km of the national highway network. "High Pass", the electronic toll collection service on major roads, is also expected to achieve an annual reduction of 23,000 tones. Integrated ITS services that support individual vehicles can yield an estimated 15 percent reduction in carbon emissions. ITS services and technologies, including the Advanced Public Transportation System (APTS) in public transportation, enhance public transport punctuality and usability—a premise confirmed by the ITS development plan of the Republic of Korea. People's use of public transportation will likely increase relative to that of personally owned vehicles.

Black (2010) argued that the concept of sustainable transport development has various indicators which need to be accounted for, these are the effects on fossil fuel (petroleum), reserves, global atmosphere, local air quality, noise pollution, level of mobility, congestion rate and mortality rates (fatalities and crashes). The demise of public transportation in South Africa manifests itself in practically every public transportation study. There is a continuous debate on the current public transport system, the quality of service, the aging infrastructure, the rationalization processes, land use patterns, poor subsidy targeting, poor public transport planning, operation and regulations, and the need for an integrated public transportation system (Maunganidze, 2011). ICT can play a key role in improving the delivery and efficiency of infrastructure for sustainable development in urban areas. ICT can support the implementation of smart power grids, better water management, effective early warning systems in case of natural disasters and better transport infrastructure, also called ITS.

This is owed to important innovations and their commercialization in a number of areas including sensing, detection and transmission equipment, innovations in data storage and processing that allow the rapid and continuous exploitation of "big data"" in urban contexts, improvements and declining costs in geo-positioning systems and of course the advent of mobile telephony (including mobile broadband).

These new technologies and their applications to infrastructure can greatly enhance the efficiency and sustainability of infrastructure services, not least in the field of transport. However, reaping the sustainable development benefits from these technologies require new holistic approaches that may involve government agencies working in very different areas.

3.8.11.7.3. Society sustainability

Sustainable mobility "Satisfying the needs of the current generation without compromising the ability to satisfy the needs of future generations", WCED (1987) is, therefore, the mobility model that enables movement with minimal environmental and territorial impact. Positive changes in shape of world transport in 21 eyelids are accompanied by a number of negative consequences to which number growth of power consumption and negative influence on the environment, constantly growing delays of people and freights on all means of transport which are connected not so much with an objective lack of transport infrastructure capacities, how many with low level of transport streams organisation and management belong. Scales and the importance of these problems are estimated as strategic calls national and even continental scale.

All these negative consequences contradict the principles of sustainable development which the commission of the UN on a sustainable development defined as the social development, allowing to satisfy requirements of present generations, without causing thus damage to the opportunities left in inheritance to future generations for the satisfaction of their own requirements. The commission of the UN also defined various aspects of a sustainable development ensuring principles, among which major—the principles of territories sustainable development as the urbanization is one of the key factors influencing the development of the modern world. The sustainability of transport systems in large cities and metabolizes is determined by the stability of their constituent subsystems, as well as the stability of relationships between them. This stability is ensured, to a considerable extent, the quality of governance.

From a holistic viewpoint, ITS deployment is key to maximizing efficiency in traffic management. Among the greatest impacts of ITS services are the lightening of congestion and consequent shortening of travel durations. For example, in South Africa, ITS services have helped increase the average speed of traffic by 15 to 20 percent. Presenting real-time traffic information to drivers on the road is another way ITS can improve traffic outcome. Drivers, in general, intuitively avoid traffic jams and manage their speed rationally. With reduced congestion and improved traffic efficiency, public transportation (via rail, bus, and taxi) becomes ever more punctual and reliable, inducing rising public trust in, and use of, those services. Improved traffic efficiency also enables transportation managers to respond promptly to traffic incidents.

According to De Jongh and Venter (2005:69), the ever-increasing demand for limited road space requires innovative measures to maximize the use of existing road infrastructure and transportation management demand more proactive planners. Pen (2002:234) argued that ITS do not create new capacity, but rather makes more effective use of existing capacity. It encourages one to travel at more appropriate times, along with better selected routes by using more efficient modes of transport. Emergencies can be avoided by alerting drivers to potential hazards, which in turn further reduces congestion and preempts accidents. Banister (2005) highlights some of the objectives of sustainable transport and states that there should be a reduced need to travel. By placing facilities and services in close proximity to residential areas would result in people having to travel less.

The second objective of sustainable transport is to reduce the levels of car use and road freight in urban areas. The third objective of sustainable transport is to promote more energy efficient modes of travel for both passenger and freight and finally noise and vehicle emissions should be reduced at the source. In addition, there is a need to encourage a more efficient and environmentally sensitive use of vehicle stock. It is also important to improve the safety of pedestrians and all road users and to improve the attractiveness of cities for residents, workers, shoppers, and visitors.

3.9. Chapter summary

In this chapter the literature consulted for this study was presented as well as the theoretical framework on urban transport systems and the development of the BRT system globally and in South Africa. From the case studies presented in the literature review, it is evident that the BRT system has a number of benefits for both developing and developed countries. It is also evident that each country has its own unique setting and challenges. Like in South Africa the TransMilenio in Bogotá also experienced resistance from the local transport providers. In order to address the issue, local transport providers were incorporated into the BRT system. In South Africa however, the attempt to integrate the Taxi Industry has failed. The next chapter, Chapter four, discusses and justifies the methodology chosen for this study.

CHAPTER FOUR RESEARCH PROCESS AND METHODOLOGY USED IN COLLECTION OF PRIMARY DATA

4.1. Introduction

In Chapter 2 and 3, an in-depth discussion of the researched literature was conducted. The researched literature was analysed and critical factors pertaining to the different research areas were identified to be included in the proposed ITS framework. In this chapter the methodology that will be employed to conduct the research is discussed. It focuses on the research rationale, design, steps and methodology used to conduct the research. The utilisation of quantitative research methodologies, as well as inductive and deductive reasoning in the research process is discussed and includes specific steps to be performed to answer research questions. The purpose of the utilisation of expert opinions, research phases as well as structuring of questionnaires is identified. This chapter presents the methodological approach and design used in this study. This chapter dwells on the operationalization of variables and indicators and outlines the research strategy and techniques used.

This chapter describes and justifies the selection of the qualitative method of data collection as it is most appropriate for this study. The qualitative method involves the recording of actual events recording interviews, questionnaires, and discussions and observing behavior (Neuman, 2000). Additionally, qualitative research focuses on real-life experiences (Flowerdew & Martin, 2005). Qualitative data is unstructured compared to quantitative data (Flowerdew and Martin 2005). The chapter discusses the revised research questions which are guided by the insights gained from the literature review.

The advantage of a qualitative study is that it assists with the manner in which participants behave in their natural setting by describing the natural setting and what they think and feel about it (Henning, van Rensburg and Smith 2004; Flowerdew & Martin 2005). Qualitative methods in research are used to gain insight into the perceptions of participants (Creswell 1998, Kitchen and Tate, 2000; Flowerdew & Martin 2005). The Data Collection Methods and Sampling techniques employed are also elaborated on, with an indication of the aspects of reliability and validity of this research. The chapter concludes with the data analysis techniques used in this study.

4.2. Rationale for the Adoption of the Qualitative Research Design

There are two diverse ways of gathering data. Quantitative methods generally use numbers, are deductive and need an initial hypothesis (Bryman & Bell, 2007). Qualitative research does not necessarily need a hypothesis to start with. It focuses on fewer individuals and is based on words and observations. Qualitative research seeks to understand social reality rather than focusing on statistical analysis and it aims at providing a rich description of people and processes in their natural setting (Bryman & Bell, 2007).

The qualitative research design is deemed the most appropriate for this study, since qualitative researchers study phenomena in their natural settings, to make sense of and interpret social phenomena such as opinions, perceptions, interaction, and behavior (Creswell 1998, Kitchen and Tate, 2000, Flowerdew & Martin 2005). Most researchers who use a qualitative research design do so because of the flexibility and evolving nature of qualitative research (Strauss & Corbin, 2008). Qualitative research also enables researchers to delve beneath the surface and uncover the innermost experiences of participants (Strauss & Corbin, 2008).

This study makes use of qualitative research methods to gather information on the experiences, opinions, and perceptions of BRT stakeholders and to draw conclusions as to how ITS capability has influenced the use of the BRT system in South Africa. Given that this study will not focus on measurement and quantifying numerical data, the qualitative research method was deemed more appropriate than the quantitative research method. Although the qualitative method is most appropriate it has limitations (Creswell 1998). Some researchers argue that the qualitative researcher tends to be biased and may lead the participants during the research process (Flowerdew & Martin 2005). In order to collect data, it is necessary to identify research sites.

4.3. The notion of ITS

According to Patrick (2010), the notion of ITS and services refers to the integration of information and communication technologies with transport infrastructure to improve economic performance, safety, mobility, and environmental sustainability. An intelligent transport system applied to a bus rapid system in a mega city such as Johannesburg was aimed at exploring the usefulness of the system in managing and operating public transport in a fast-growing city where transport demand has been on the increase since 1994.

4.4. The gap analysis survey approach

A pre-understanding about the subject area was fostered by being exposed to experienced co-workers and by having personal communication with several employees at the Rea Vaya BRT. However, vast amounts of data needed to be gathered from other sources in order to be able to conduct the study

An ITS gap analysis survey approach was adopted for this study to evaluate the introduction of the system to manage the BRT in South Africa with respect to safety, reliability, comfort, and reduction in travel time. According to Georgia (2014), the analysis of the intelligent transport gap survey includes the operational management of Bus-Rapid Transport such as demand and supply and route planning. Hannes (2012:17) states that gap analysis aims to identify missing/necessary needs in a selected area in relation to what outcomes are desired. This study evaluates the gaps that exist within the operations and management of the BRT system utilizing intelligent transport system. This to demonstrate the extent to which the system can improve the management and operations of bus rapid transit in South Africa and the shortcomings of the system in terms of efficiency, safety, environmental quality, effectiveness, mobility and reliability which all talk to demand and supply of the BRT to resolve commuters' ease with transportation.

4.5. Background

The study investigated the role of Intelligent Transport System's capability on business agility more specifically in the South African Bus Rapid Transit system. The objective is to confirm (or not) that ITS capability and Business agility are pre-requisites of BRT performance excellence.

In chapter 1, one research question with six sub-questions was raised as follows:

What are the pre-requisites for the South African Bus Rapid Transit system performance excellence?

- To what extent has the introduction of Intelligent Transport System been able to make the Bus Rapid Transit in South Africa agile?
- Does Intelligent Transport System's capability impede/enhance customer-market orientation agility within the BRT?
- Does Intelligent Transport System capability impede/enhance operational agility within the BRT?
- Does Intelligent Transport System Infrastructure capability enhance/weaken the BRT agility?
- Does Intelligent Transport System business capability enhance/weaken the BRT agility?
- Does Intelligent Transport System innovation capability enhance/weaken the BRT agility?

The aim of the research design was to devise ways of obtaining information to be able to answer these questions and therefore be able to meet the research objectives specified in chapter 1.

In chapter 2, the findings in the review of the literature indicate there is a general consensus that Intelligent Transport System capability can enhance or impede Bus Rapid Transit system agility. In this process, data was collected in two parts (ITS capability and business agility) as per the conceptual model, including the transportation background as well as Intelligent Transport System Background.

- The first part (ITS capability) obtained information on ITS infrastructure, ITS Business Integration, ITS Orientation and Innovation
- The second part (business agility) data were obtained on Operational and Market Orientation agility.

The examination of the correlation was being based on numerous hypotheses derived from the conceptual model shown in figure 4.1. Research model.

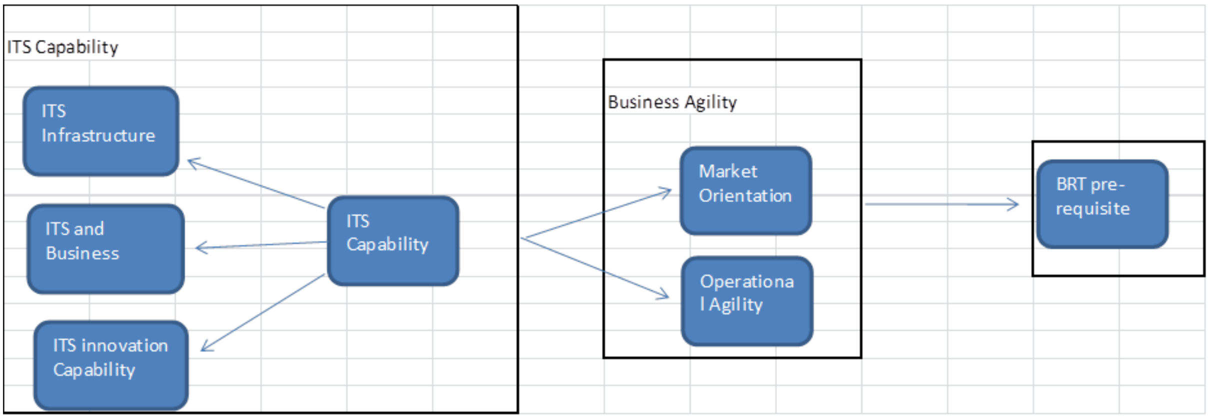

Figure 4.1: Research construct model, Source: Author (2016)

4.6. Hypothesis

As discussed in Chapter 2 the research model leads to two research hypotheses:

1.10.1. Market Orientation agility is an organisation's ability to quickly improve products or services according to the change of customers' preferences. In short, it is the ability to proactively predict future changes. ITS plays a role in providing the means to sense market trends and new customer requirements within a Bus Rapid Transit system.

Hypothesis 1: Intelligent Transport System's capability is correlated with Bus Rapid Transit system's market orientation agility

1.10.2. This agility highlights flexible and rapidly responding operations as a critical foundation for enabling fast and fluid translation of innovative initiatives in the face of changes (Lu & Ramamurthy, 2011). ITS capability can be a significant barrier or enabler in changing business processes thus affecting operational agility.

Hypothesis 2: Intelligent Transport System's capability is correlated with Bus Rapid Transit system's operational agility

There are two positives between the constructs as shown in table 4.1.

Independent Variable	Dependent Variable	Expected Correlation
ITS capability	Market orientation agility	Positive
ITS capability	Operational agility	Positive

Table 4.1: Relation of independent to dependent constructs, Source: Author Nthite 2019

4.7. Research strategy

The research used a deductive approach where current literature was used to identify what information is required from respondents, and to come up with numerous hypotheses centred on the research's conceptual model. These hypotheses are tested using data gathered through a quantitative survey. The appropriate research methodology for this research is the survey instrument. Owing to the fact that the unit of analysis will be on an industry level that means face to face interviews may prove to be difficult to conduct for this type of survey therefore the questionnaire approach was more practical and provided data within a short space of time bearing in mind the research was conducted during the festive season.

The research design used a fixed, non-experimental approach. It also adopted the cross-sectional research method with the unit of analyses being at the industry level. Correlation analysis technique was used, deemed to be more practical and an appropriate technique for testing the relationship between independent and dependent variables (Collis and Hussy, 2003). The data collected was mainly qualitative.

4.8. Research design

Research design is a plan or blueprint of the method employed by the researcher to accomplish his/her objective (Mouton, 2001). The research will take on the form of a quantitative empirical survey. According to Mouton (2001), empirical studies address the real-life problem by collecting new data or analysing existing data. The research was administered using a questionnaire. This method was preferred due to its geographical flexibility, elimination of interviewer bias, convenience to the respondent in terms of time and low associated cost (Fox et al, cited by Larson and Poist, 2004). The research was designed to use quantitative research method to collect primary data in a form of survey instrument with structured questionnaires congruent to the research's conceptual model and literature review.

4.8.1. Targeted Respondents

The target audience consists mainly of an officer to senior management from Operations management, Safety, Quality Control, Station management, Marketing Legal and ITS departments within the Bus Rapid Transit system in South Africa.

4.8.1.1. Population and sample size

A sampling size is influenced by several factors, including the estimated response rate bearing in mind the festive season, required number of responses, possible invalidated responses, sampling frame, the size of the industry, accessibility and time constraints (Hair et al., 2007). A hundred questionnaires were sent out. A return rate of 90% to 95% was anticipated, which would give a sampling size (responses) of between ninety and ninety-five completed questionnaires.

Bus Rapid Transit system is the fastest growing industry, but the industry size is still small in South Africa, therefore, it would have been very difficult to target a higher number of respondents. The survey questionnaire was administered via email and hand delivery.

4.9. Data collection methods

The study revolved around the fulfilment of the specific research objectives. This section highlights different techniques and tools that were adopted for the achievement of the objectives with respect to sampling, primary and secondary data collections methods as well as data analysis tools. The collected data consist of both primary and secondary data. Secondary data are data that were collected and documented previously, for a purpose other than the problem at hand. In contrast, primary data are data that are to be collected for the specific question that is to be analysed (Hox & Boeije, 2005).

4.9.1. Primary data collection

Primary data collection involved data observed or collected directly from first-hand information (Driscoll, 2011:123). Various primary data collection tools were employed for the description of the experiences that occurred. This was by extracting information on the use of intelligent transport system introduced to manage the BRT in South Africa.

4.9.1.1. Sampling frame

The selection of a proper sample is an obvious prerequisite to a sample survey. A sample is defined as a collection of units which in some part of a larger population and which is specially selected to represent the entire population (Jones, 2013:21).

4.9.1.2. Sampling Techniques

Both non-probability and probability sampling techniques were used for the study because it is accurate and reliable and easy to collect.

4.9.1.3. Non-probability sampling techniques

A non-probability sampling method was adopted for the selection of key-informant interviews which was purposive and an export-oriented selection.

4.9.1.3.1. Purposive sampling of Key-informants (KII)

The purposive sampling technique was used to identify key-informants for the survey. This is because they have a proper understating of how ITS is used within the South African Bus Rapid Transit systems. The organogram of various transport and land use planning institution was reviewed where official/authorities with the expertise related to transport planning were identified and sampled for the study. The motivation for purposive sampling is that key-informants have an inclusive understanding of the challenges and opportunities of operating the Bus Rapid Transit system using ITS. In this respect, informed techniques on the ITS routes gave a good account of the mode of operation of the system.

4.9.1.3.2. Probability sampling techniques

Probability sampling is a sampling technique where the chance of a unit/element being chosen into the sample is known (by its exact probability or by statistical estimates).

This technique was used to select the respondents. A systematic random sampling technique was adopted for selection of BRT system stakeholders.

4.10. Secondary data collection

The documentary searches were useful in attempting to obtain transport system inventory data. Thus, timetables and route maps of the Bus Rapid Transit systems provided useful information on ITS.

4.10.1. Literature review

The documentary searches were useful in attempting to obtain transport system inventory data. Thus, timetables and route maps of the Bus Rapid Transit systems provided useful information on ITS. A database such as EBSCOhost, Academic search complete, Master File Premier, and Newspaper sources, Jester, Direct of access journal and Google scholar were used to collect information. Various sites such as BRT website, National Department of Transport (NDOT) website, Arup and IBM company website were also visited to acquire more secondary data.

4.10.2. Major books consulted

Several textbooks were reviewed to enable a better understanding of the evolution, development, and designing of the capable intelligent transport system to improve the management of bus rapid transit systems around the world. A book titled *City competitiveness and improving urban subsystems* by Bulu Melish (2010), played a role in understanding how cities can improve public transport utilizing intelligent transport system. The book outlines the guidelines and parameters to be taken into consideration when a city is developing and implementing technological innovations.

Another book published in 2010 by Toy S. Lee entitled *ITS: smart and green explores the evolution of intelligent transport system into public transport*. The book explains how physical infrastructure, economic value, and policies of a country influence the type of intelligent transport system that will be implemented.

4.10.3. Relevant Journals

Various articles such as the one published by APTA (American Public Transportation Association) journal by Joseph Barr et al., in 2010 on implementing BRT intelligent transport system were read extensively. The articles provided insight into the crucial components to be considered when implementing an intelligent transport system such as the South African bus rapid transit.

4.10.4. Official documents

Official documents from the government department were reviewed. Among them are Berling's metropolis initiative and the Integrated Urban Governance was compiled by Micheal Abraham, which focuses on metropolis peer-review training. The report reviews how the BRT system can achieve operational excellence in all areas of operation, including roadways, stations, buses, depots, and ITS. It gave the author enlightenment on the challenges that were hindering the BRT in achieving excellence in operations of an intelligent transport system. Other documents which were Johannesburg City: transportation planning and management strategy (2014/2015), the Johannesburg IDP (2013/2014), RSDF (Regional spatial development framework) for regions (F, D, B, and C), to understand the impact of BRT systems on spatial development of the regions.

4.10.5. Integrated transport legislation

Relevant legislation, policies, and strategies on the role of transportation in planning reviewed to understand how policies on urban transportation impact on commuters' attitudes towards public transport. The Gauteng integrated transport master plan (ITMP25) was read to see how it integrates intelligent transport system with other modes of transport to improve information dissemination. The Gauteng Public Passenger Road Transport Act (No 7 of 2001) was reviewed to understand how public transport in Gauteng is governed and what the legal reference for implementing intelligent transport system into the public transport system was.

4.10.6. The use of maps

Secondary data sources such as maps were also sourced and used. They were used to describe the locating of the study area, as well as depicting the physical characteristics of the area, routes, and the BRT station location. Examples of the maps used for this research; integrated transport network for Johannesburg, integration of ITS map on safety, BRT route map to mention just a few.

4.11. Questionnaire design

(Leedy 1997:192) recommends that "all questionnaire should be tested on a small population" to eliminate ambiguities and inconsistencies. The questionnaire was tested on a small sample of persons involved in the customer service environment. To fulfil the purpose of the research, a questionnaire was drawn up with a range of questions addressed to each of the main adjectives of the study, outlined above. The questionnaire went through a process of several reviews by the project partners and a draft of the questionnaire was piloted by each of the partners to ensure that questions are clear and unambiguous. The questionnaire together with a covering letter and instructions was sent to the selected sample (Yeung, Lee and Chan, 2003). A copy of the questionnaire, with a covering letter and instruction, are attached in Appendix 1.

The questionnaire was designed to support the objective of the investigation. Considerable effort was made to create the questionnaire with conceptually clear and concise statements. To ensure the accuracy of content validity and reliability, the questionnaire was developed using the process illustrated in Table 4.2 which is adapted from MNI study guide (2014).

Table 4.2: Questionnaire process, Source: MNI study guide (2014).

The questionnaire was designed to collect three sets of data and questions are designed based on the constructs of the conceptual model. The first set of questions

Item	Process
1	Initial considerations, including the purpose of the study and definition of the research question.
2	Clarification of concepts to be measured, including method of measurement.
3	Determine question types, format and sequence.
4	Draft questionnaire based on review of literature, variables and information needs, and consultation with supervisor to comment on the questionnaire design
5	Pre-testing (piloting) the questionnaire, using a small sample of the population to check for relevance, clarity and ambiguity.
6	Administering the questionnaire, i.e. Selecting the means of delivery and then implementing the data collection.

collects categorical data that provide demographic information. The second set is mainly to gather perceptions of respondents on Intelligent Transport System capability in their respective organisations. The third set of questions gathers data relating to business agility. It must be noted that all respondents were expected to answer both business agility and the ITS capability questions. The questions in table 5 formed the basis of the questionnaire. This information was gathered through numerous close-ended questions using a five-point Likert-type scales.

This set of questions uses scales developed by other researcher's Lu & Ramamurthy (2011) and the collected data is used in statistical analysis to test the two hypotheses listed above.

Table 4.3: Key questions per construct, Source: Author- Nthite 2018

4.12. Item Evaluation Process

Construct	Key Questions
ITS infrastructure capability	**Relative to other firms in your industry, please evaluate your organisation’s ITS infrastructure capability (1=poor, 5 excellent)**
	1. Data management services & architectures (e.g., databases, data warehousing, data availability, storage, accessibility, sharing etc.)
	2. Network communication services (e.g., connectivity, reliability, availability, LAN, WAN, etc.)
	3. Application portfolio & services (e.g., ERP, ASP, reusable software modules/components, emerging, technologies, etc.))
	4. ITS operations/services (e.g. hand-held devices for scanning, servers, large-scale processors, performance monitors, etc.)
ITS and business integration	**Evaluate your organisation’s ITS/ Business Integration by indicating to what extent do you agree with the following statements(1=strongly disagree, 5 = strongly agree)**
	1.Wedsfss seek to develop a clear vision regarding how ITS contributes to business value
	2.We have integrated business strategic planning and ITS planning
	3.We enable general management’s ability to understand value of ITS investments
	4. We have established an effective and flexible ITS planning process and developing a robust ITS plan.
ITS Innovation and Orientation	**Please indicate how well the following statements describe your organisation's ITS Innovation and orientation (1=strongly disagree, 5 = strongly agree)**
	1.We constantly keep current with new information technology innovations
	2.We are capable of and continue to experiment with new ITS as necessary
	3.We are capable of and continue to experiment with new ITS as necessary
	4.We constantly seek new ways to enhance the effectiveness of ITS use
	5.We constantly seek new ways of developing integration tools (e.g. API and web services)
Operational Agility	**Please evaluate how well your organisation performs or is positioned to perform the**

	following activities (1=strongly disagree, 5 = strongly agree)
	1.We fulfil demands for rapid-response, special requests of our customers whenever such demands arise; our customers have confidence in our ability
	2. We can quickly scale up or scale down our production/service levels to support fluctuations in demand from the market.
	3. Whenever there is a disruption we can quickly make necessary alternative arrangements and internal adjustments.
	4. Our Organisation's IS function is responsive to user service requests?
	5.We provide flexibility with regard to delivery options that fits our customer daily schedules in the best possible way
Market Orientation Agility	**Please indicate your agreement with the following questions (1=strongly disagree, 5 = strongly agree)**
	1. We are quick to make and implement appropriate decisions in the face of market/customer-changes.
	2.We constantly look for ways to reinvent/re engineer our organisation to better serve our market place
	3.We treat market-related changes and apparent chaos as opportunities to capitalize quickly
	4. We adopt new technologies to produce better, faster and cheaper products and services.

The item evaluation process will assist the researcher in determining which items to be included or excluded in the pool. Factors considered are; inter-item correlation, validity of items; internal consistency reliability; and item scale correlation.

Where:

4.12.1. Reliability tests the degree to which the instrument (questionnaire) measures the same every time it is used and is inversely related to random error and if the instrument (questionnaire) is reliable when the values are statistically comparable to the mean, variance within the limits of confidence intervals, and

4.12.2. Validity determining the extent to which the test measures what it was intended to.

It is noted that item discrimination is the correlation between item score and total score in the item battery and is calculated by using standard correlation.

4.13. Factor Analysis

Factor analyses describe the covariance relationship among the variables in terms of a few underlining, unobservable random quantities or factors. These variables within the group are highly correlated among themselves, but have relatively small correlation with variables in a different group. According to Pellisier (2007), factor analysis studies the interrelationship among variables, whereby large set of variables can be reduced to smaller sets of new variables that are more basic in meaning but contains most of the required information of the original set.

4.13.1. Overview of Factor Analysis

According to De Coster (2003) - Factor analysis is a collection of methods used to examine how underlying constructs influence the responses on a number of measured variables. Factor analyses are normally performed when examining the pattern of correlations (or covariance's) between the observed measures. When measures that are highly correlated (either positively or negatively) they are likely influenced by the same factors, while those that are relatively uncorrelated are likely influenced by different factors, Davis, Chase, Aqualiano (2003). De Coster, (2003), further states that there are basically two types of factor analysis: exploratory and confirmatory.

4.13.1.1. The Exploratory Factor Analysis (EFA) attempts to discover the nature of the constructs influencing a set of responses.

4.13.1.2. The Confirmatory factor analysis (CFA) tests whether a specified set of constructs is influencing responses in a predicted way.

The primary objectives of EFA are to determine:

- The number of common factors influencing a set of measures.
- The strength of the relationship between each factor and each observed measure.

Furthermore some common uses of EFA are to identify the nature of the constructs underlying responses in a specific content area. The Exploratory Factor Analysis (EFA) is utilised for this research and therefore the researcher will attempt to:

1. Identify the nature of the constructs underlying responses in a specific content area;
2. Determine what sets of items fit together in the questionnaire;
3. Demonstrate the dimensionality of a measurement scale;
4. Determine what features are most important when classifying a group of items, and
5. Generated factor scores representing values of the underlying constructs for use in other analyses

4.13.2. Operationalisation of constructs

The constructs for this study are measured using a five-point Likert (1932) type-scale. Likert type scales are very useful for measuring concepts such as attitude, perception, feeling, and opinion among others (Hair et al., 2007). The items used to operationalize the constructs of ITS Infrastructure, ITS Business Integration, ITS orientation and innovation, Operational agility and Market orientation agility are drawn from the work of Lu & Ramamurthy (2011) and Sambamurthy et al., (2003). Existing scales have been used for the questions measuring the five constructs because developing new scales requires specialized knowledge, therefore using of tried and tested scales are chosen to ensure validity and reliability in the measures (MNI, 2012). Table 4.3. Shows the number of constructs used for this research.

4.13.3. Research design matrix

Table 2.4 highlights how information was sourced corresponding to the research objectives outlined in chapter one and the expected outcomes

Research objectives	Corresponding Research questions	Data collection tools		Sampling methods	Data analysis and presentation tools	Outcome
		Primary data sources	**Secondary Data sources**			
To determine the complementarity of ITS capability and Business agility in the South African BRT industry;		Questionnaires	Books Journals ITMP RSDF IDP	Random Purposive Expert	SPSS Maps Pictures Tables Graphs	
To measure the extent of Intelligent Transport System (ITS) capability;	How reliable is the ITS in relation to managing the Bus Rapid Transit	Questionnaire KII	Books Journals Newspapers	Random Purposive	SPSS Maps Tables Graphs	Understanding of the impact of intelligent transport on safety of the BRT in RSA to users.
To explore the		Questionnaire KII Observation	Books Journals Newspapers	Random Purposive	SPSS Maps Tables Graphs	The degree of the reliability of the systems in managing BRT.

To determine the efficiency of the ITS in the management of the BRT Rea-vaya in the City of Johannesburg.	How do managers and commuters judge the reliability of ITS in managing Rea-vaya? How efficient is the ITS in the efficiency running of Rea-vaya in the City of Johannesburg ?	Questionnaires KII Observation	Books Journals RSDF IDP ITMP	Purposive	SPSS Tables Graphs	A understanding of the operations efficiency for intelligent transport system management in the BRT
To examine the relationship between Intelligent Transport System (ITS) capability and Bus Rapid Transit (BRT) agility.	To what extent has the introduction of Intelligent Transport System been able to make the Bus Rapid Transit in South Africa agile?	Questionnaires KII Observation	Books Journals Articles	Purposive	SPSS Tables Graphs	A understanding of the operations efficiency for intelligent transport system management in the BRT
To determine the level to which the introduction of ITS in Rea-vaya has reduced waiting times for commuters.	To what extent has the introduction of ITS in Rea-vaya been able to reduce waiting times for commuters?	Questionnaires KII Observation	Books Journals Articles	Random Purposive	Deductive Analysis Maps Tables	Improved strategies for managing the BRT through ITS

Table 4.4. Goal achievement matrix table, Source: Authors field data 2017

4.14. Data analysis method

Data was gathered and analysed using major methods of analysis namely, quantitative and qualitative data analysis.

This was done to present and analyse data gathered from secondary sources and primary data. The data was first processed, edited, coded where necessary and presented in the form of a table, graphs, cross tabulation, bar graphs, and pictures and then explained.

4.14.1. Quantitative data analysis

Quantitative analysis of the collected data was facilitated using the IBM SPSS (Statistical Packages for Social Sciences, version 20). This computer software was used to manage data, i.e. data entry and editing field data gathered using intercept surveys to analyse data statistically to present the findings in the form of tables and graphs i.e. pie chart, line graph, and bar graphs, to help draw a conclusion from the field data. This type of data analysis was chosen because it offers increased objectivity in data presentation and interpretation

4.14.2. Qualitative data analysis

Quantitative data that cannot be addressed through statistical techniques were derived, deduced, analysed and interpreted using qualitative analysis such as texts and interviews, observation, drawing inferences in order to discover meaningful patterns descriptive of managing and operating BRT through the use of ITS. The research design matrix table 2.3 was used to achieve this purpose.

4.14.3. The use of tables, graphs, and maps

Tables, graphs i.e. pie charts, line graphs, bar graphs, and maps were utilized to present visual graphical pictures of the gathered statistical data.

4.14.3.1. Tables

Field data that was gathered using questionnaires administered to commuters was orderly classified and then systematically presented in the form of tables. The reason for using tables is that data is presented in a simple manner that is simple to understand, brief, helpful in analysis and clarifies main characteristics of ITS data. Cross-tabulations were used to deepen the analysis of the various bus rapid transit systems across the nation and the world.

4.14.3.2. Graphs

Graphs of several types i.e. pie charts, line graphs, and bar graphs were used to present field data. Graphs were used as they present data in the form that is simple and economical.

4.14.3.3. Photographs

Photographs were used to illustrate the observation on the ground. The pictures depicted the existing characteristics of the Rea-Vaya systems with the region to station appearance, a commuter at the station, information display to commuters.

4.15. Reliability, validity, and objectivity

Every type of research has to be critically evaluated. Patton (2001) states that reliability and validity are important parts of every qualitative research. Thus, the following sections will analyse the master's thesis reliability, validity, and objectivity.

4.15.1 Reliability

The extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable.

Reliability describes if a study conducted under the same circumstances would give the same results. According to Yin (2008), the goal of reliability is to minimize errors and keep the study unbiased. Even though the term reliability is commonly used to test or evaluate quantitative research, it is most often likewise used for qualitative methods (Golafshani, 2003). Some authors are more specific about the term reliability and use 'dependability' as the corresponding term for qualitative research (Lincoln & Guba, 1985). When referring to the reliability of an interview study, it refers to the degree of consistency of the executed interviews (Kvale, 1996). Cronbach's alpha, α (or coefficient alpha), developed by Lee Cronbach in 1951, was used to measures reliability. Cronbach's alpha tests to see if multiple-question Likert scale surveys are reliable.

These questions measure latent variables — hidden or unobservable variables like a person's conscientiousness, neurosis or openness. These are very difficult to measure in real life. Cronbach's alpha will tell if the test designed is accurately measuring the variable of interest. Cronbach's alpha was computed by correlating the score for each scale item with the total score for each observation (usually individual survey respondents) and then comparing that to the variance for all individual item scores. The minimum acceptable value for Cronbach's alpha ca 0.70; below this value the internal consistency of the common range is low. Meanwhile, the maximum expected value is 0.90; above this value is perceived as redundancy or duplication. Cronbach's alpha coefficient is both an inherent property of the response pattern of the population studied, without a characteristic ladder itself; it is feasible, the alpha value changes depending on the population in the scale was applied.

4.15.2 Validity

According to Bryman and Bell (2007), there are two types of validity in qualitative research: internal validity and external validity. Internal validity refers to the match between the researchers' observations and the theoretical ideas they propose. External validity describes how findings can be generalized for other cases (Bryman & Bell, 2007). Although some qualitative researchers have argued that the term validity is not applicable to qualitative research, but at the same time, they have realised the need for some kind of qualifying check or measure for their research. For example, Creswell & Miller (2000) suggest that validity is affected by the researcher's perception of validity in the study and his/her choice of paradigm assumption.

As a result, many researchers have developed their own concepts of validity and have often generated or adopted what they consider to be more appropriate terms, such as, quality, rigor, and trustworthiness (Davies & Dodd, 2002; Lincoln & Guba, 1985; Mishler, 2000; Seale, 1999; Stenbacka, 2001). Wainer and Braun (1998) describe the validity in quantitative research as “construct validity”.

In this study, the construct was the initial concept, notion, question or hypothesis that determined which data was to be gathered and how it was to be gathered. They also assert that quantitative researchers actively cause or affect the interplay between construct and data in order to validate their investigation, usually by the application of a test or other process. In this sense, the involvement of the researchers (preliminary investigation) in the research process was used to increase the validity of a test.

4.15.3. Cronbach’s reliability analysis

According to SPSS – Cronbach's Alpha is not a statistical test and is technically a coefficient of reliability (or consistency). Alpha therefore measures internal consistency and indicates how closely related a set of items are grouped. SPSS results further indicate that a high value of Alpha is often used along with substantive arguments and possibly other statistical measures as evidence that the items measure an underlying (or latent) construct (Giliem, 2003). In summary Cronbach's Alpha can be written as a function of the number of test items and the average inter-correlation among the items.

SPSS further highlighted that when the number of items increases so will also Cronbach's Alpha increase. Also when the average inter-item correlation is low, Alpha will be low and that when the average inter-item correlation increases Cronbach's Alpha increases holding the number of items constant. Of importance is that Cronbach’s Alpha reliability coefficient normally ranges between 0 and 1. The closer Cronbach’s Alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale, (Cerny & Kaiser 1997). As a rule of thumb for Cronbach’s Alpha as provided by George and Mallery (2003) and cited by Gliem, J.A, and Giliem, R.R (2003) - Midwest Research to Practice Conference for Likert-Type Scales is when Cronbach’s Alpha is regarded as:

> .9 – Excellent, > .8 – Good, > .7 – Acceptable, > .6 – Questionable, > .5 – Poor, and < .5 – Unacceptable”.

In summary Cronbach's Alpha is used to rate the internal consistency (homogeneity) or the correlation of the items in a test. It is agreed by experts that test showing a strong internal consistency measurement should show only moderate correlation among items (.70 to 0.90). However, the following guidelines exist (1) when correlations between items are too low, then it is likely that they are measuring different traits and therefore should not all be included in a test, (2) If item correlation are too high, it is likely that some items are redundant and should be removed from the test, (Giliem,2003).

4.16. Chapter Summary

This chapter outlined the research methods that were adopted for the collection of relevant data required. This Chapter addressed the research methodology used for gathering and analysis of data. The use of specific research methodology and design as well as the design and structure of the questionnaire and the attributes of the target sample was explained. The utilisation of item and factor analysis for data interpretation was also discussed. It described the research approach, data collection instruments, sampling design and goal achievement matrix of the study required for the achievement of the research objectives outlined in chapter one. The chapter that follows discusses the literature review pertaining to this study. This chapter presented and justified the selection of the research methods used in this study. The qualitative methodology was used in this study. A description of the research sites and an explanation of the participants used in this study was given. The next chapter presents the finding.

In Chapter 3 the literature of the research process was discussed whilst Chapter 4 described the application and interpretation of the data analysis as applied in the research. Chapter 5 further will display an in-depth analysis and coverage of the item and factor analysis performed.

Statistical and descriptive results will be discussed in Chapter 5.

CHAPTER FIVE

FINDINGS AND ANALYSIS

5.1. Introduction

This chapter presents the results of the research findings relevant to the problem. The key research questions raised in Chapter 1 shall be guiding the analysis and presentation of data. This chapter presents the findings from the investigation into the Intelligent Transport System capabilities and Business agility within the Bus Rapid Transit system. The research findings in this chapter emanate from questionnaires to selected stakeholders of the BRT. The findings presented below to elucidate the views of the different stakeholders as well as the social and economic effect that Intelligent Transport System has had on the BRT. There were a hundred participants in the first segment of the data collection and as previously mentioned these participants were required to complete the questionnaire related to the BRT (see Appendix A). Ninety-eight completed questionnaires were returned completed.

5.1. Overall response

A total of hundred questionnaires were sent out using email and hand delivery. Of the one hundred, ninety-six completed and returned it. An overall completion rate of 96% - see figure 5.

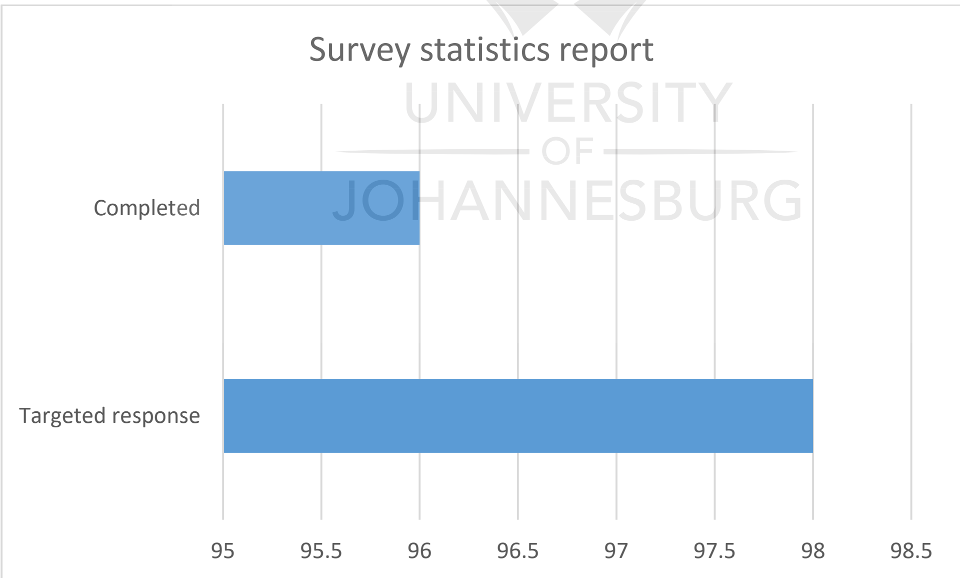

Figure 5.1: Survey Statistics, UJ Statkon 2018

5.2. Preparing and cleansing data for analysis

Before making use of the survey data, the following steps were taken to clean and check the data collected.

- Editing – examine data for completeness and consistency. Eight responses were started but not completed and some had a large number of responses missing. These were taken out from the statistical data analysis.
- Missing data – Five responses had some missing values for the scale items. As long as there were no more than four values missing within the scale measuring a construct, these were removed or omitted from the statistical analysis so that the results would be statistically relevant.
- Coding - numbers were assigned to categorical data such as organisation and functional role.
- Data transformation – The responses to the scales measuring the five constructs (ITS infrastructure capability, ITS & Business Integration, ITS Innovation & Orientation, Operational Agility and Market Orientation Agility) were averaged using the SPSS compute variable function. This was done in order to allow analysis to be performed at the construct level rather than on item level. See appendix B for further details.
- Using the SPSS compute variable function, a new categorical variable was created to differentiate responses from the sponsoring organisation and that of the industry players
- Outliers that showed inconsistent respondent replies were removed.

5.3. Checking for scale reliability

Cronbach's alpha is used when you have multiple Likert questions in a questionnaire that form a scale, to determine scale reliability (Hair et al, 2007). Cronbach's alpha measures the internal consistency meaning the degree to which the items that make up the scale are all measuring the same fundamental attribute. Cronbach's alpha (Cronbach, 1951). Cronbach's alpha determines the internal consistency or average correlation of items in a survey instrument to judge its reliability

5.3.1. Measurement scale analysis

Before the study constructs were used to analyse the relationship between the BRT and the intelligent transport system, it was necessary to evaluate their reliability and validity, ensuring that research instruments (questionnaires) used for this study have internal consistency, stability and are free form random (Alshehri, 2012). In addition, Giannakos (2014) indicates that internal consistency was related to the extent to which participants ‘responses are dependable and steady across construct variables of a single data gathering instrument.

For this reason, the measurement scales used for assessing the study objectives were tested for reliability and validity. The details of such statistical processes and results are given below.

5.3.1.1. Reliability analysis: Estimating internal consistency

A crucial feature of scientific research is the aspect of validity and reliability which Thiel (2014) mentioned that are closely interrelated. Reliability according to the author is the extent to which research variables are measured accurately using appropriate data capturing instruments; and how methodological approaches in research can be consistently repeated in other researches under similar context to arrive at same results. On the other hand, validity in research concerns the strength of a study both internally and externally. Internal validity indicates how well a researcher measures a purported relationship or effects between variables. Also, research is externally valid when it is possible to generalize its findings.

Cronbach‘s Alpha was used to perform reliability analysis (Cronbach, 1951). Internal consistency reliability analysis is an estimate of internal consistency associated with the scores that can be derived from the scale or composite score. Reliability analysis should be performed before commencing any advanced statistical analysis. It is significant to any study because without performing it, it is impossible to have any validity associated with the scores of the scales. Alshehri (2012) posits that high values of Cronbach‘s Alpha are desirable and signify the reliability of measures. A four-point-Likert scale measure of reliability was suggested by Hair, Black, Babin and Anderson (2014); (0.50 and below) low-reliability, (0.50 and below 0.70) high moderate-reliability (acceptable), (0.70 and below 0.90) high-reliability and excellent-reliability (0.90 and below 1.0).

Hair et al., (2014) view that a Cronbach‘s Alpha score of 0.70 and above is essential for acceptable internal reliability, whereas Pallant (2013) advocates for any internal reliability score value which is above 0.60. Additionally, Nadi (2012:103) recommends that all alpha values above 0.50 (acceptable) should be regarded as a true indicator of convergence and any values below 0.50 are unacceptable and should be discarded. The findings of the study showed that Cronbach‘s Alpha values for all the variables construct ranged between 0.67-0.89, for the questionnaires distributed to BRT stakeholders. A crucial feature of scientific research is the aspect of validity and reliability which Thiel (2014) mentioned that are closely interrelated. Reliability according to the author is the extent to which research variables are measured accurately using appropriate data capturing instruments; and how methodological approaches in research can be consistently repeated in other researches under similar context to arrive at same results. On the other hand, validity in research concerns the strength of a study both internally and externally. Internal validity indicates how well a researcher measures a purported relationship or effects between variables. Also, research is externally valid when it is possible to generalize its findings.

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Research objectives	**Number of items**	**Cronbach Alpha**	**Overall comment based on (based on Hair et al.'s, (2014) four degrees of reliability scale)**
To determine the complementarity of ITS capability and Business agility in the South African BRT industry;		0.85	High reliability
To measure the extent of Intelligent Transport System (ITS) capability;		0.67	High moderate reliability (acceptable)
To examine the relationship between Intelligent Transport System (ITS) and Bus Rapid Transit (BRT) agility.		0.87	High reliability

Table 5.1. Cronbach's Alpha Reliability results, Source: Author 2019

Thus, overall and in line with Nadis (2012) recommendations, the Cronbach's Alpha results for this study indicated that the study instrument for BRT Rea-Vaya commuters was reliable with all the values above 0.50- thus indicating proper internal construct reliability as shown in table 5.24.

5.3.2. Regression analysis

A regression analysis was conducted to elaborate on the various relationships that exist between ITS capability and the BRT agility. The analysed data indicated how ITS capability relates to the BRT system agility.

5.3.2.1. Regression analysis: summary for the influence of occupation status on the purpose of using BRT

The study hypothesized that ITS capability is correlated with market orientation agility in the BRT. At the conceptual level, ITS capability is expected to correlate with the rationale for BRT agility (Pienaar, Krynauw & Period, 2005). Because of the measurement criteria employed to measure successful BRT system, linear regression analysis was selected as an appropriate statistical procedure for investigating occupational status factors that influence the ITS' rationale on ensuring the BRT is agile. Results of the study presented in table 5.26 revealed that the independent variable explains about 86.4 of the dependent variable (roles of occupation status on the purpose of using the BRT), with the R-squared equal to 0.840.

The outcome of the ANOVA test confirmed the models best fit, which could predict a better outcome than using a mean with the ratio of improvement reached F=1187.423 and a significant value equal 0.000(p<.05).

Cronbach's alpha	Internal consistency
Alpha> or = 0.9	Excellent
0.9 > alpha >=0.8	Very Good
0.8 >alpha >=0.7	Good
0.7 >alpha>=0.6	Moderate
0.6>alpha>=0.5	Poor
0.5>alpha	Unacceptable

Table 5.2: Internal consistency. Adopted from Hair et al (2007)

The scales used in this investigation were tested for reliability against the classification values suggested by Hair et al, (2007). This grouping is shown in Table 5.3. While the actual measured values for the five constructs are shown in Table 5.4.

Construct	Cronbach's Alpha	Strength
ITS Infrastructure	.811	Very Good
ITS and Business Integration	.933	Excellent
ITS Innovation & Orientation	.922	Excellent
Market Orientation Agility	.923	Excellent
Operational Agility	.910	Excellent

Table 5.3: Actual Cronbach's Alpha . Source: Author 2019

Reliability was measured using the SPSS Cronbach's coefficient function. According to Hair et al, (2007). Cronbach's alpha measurement of 0.7 and higher is usually considered good. The reliability for the four constructs as illustrated in Table 7 (ITS & Business Integration, ITS Innovation & Orientation, Operational Agility and Market Orientation Agility) can be classified as excellent. Meanwhile, the reliability for the first construct (ITS Infrastructure capability) is rated a little lower than the four construct but still classified as very good.

5.4 Frequency analysis

The study of quantitatively describing the characteristics of a set of data is called descriptive statistics. Frequency Analysis is a part of descriptive statistics. In statistics, frequency is the number of times an event occurs. Frequency Analysis is an important area of statistics that deals with the number of occurrences (frequency) and analyses measures of central tendency, dispersion, percentiles. Used together, these tools of frequency analysis are extremely important for analysis and interpretation of any data at a glance.

Almost every sphere from scientific research to medical, climatic and geological studies, economic and policy decisions; business research and reporting use various forms of frequency analysis.

5.4.1. Rank in BRT organisation

In as much as the survey sample was aimed at ITS and BRT staff a large part of the respondents were in management or experts meaning they have both ITS and Business exposure or experience. It is encouraging to see that 17.7% of the respondents were Senior Management and 33.3% were management, but most importantly head of department accounted for 6.3% of the respondents and 10.4% supervisor, 29.2% Specialist and 3.1% officer. As depicted in figure 9 the aim was to get the views of ITS and BRT from different functional perspectives and more than 66% percent of the respondents were above the level of management and were of high ranking and therefore were expected to be knowledgeable about the information sought in this study. This further boosts the reliability of the responses.

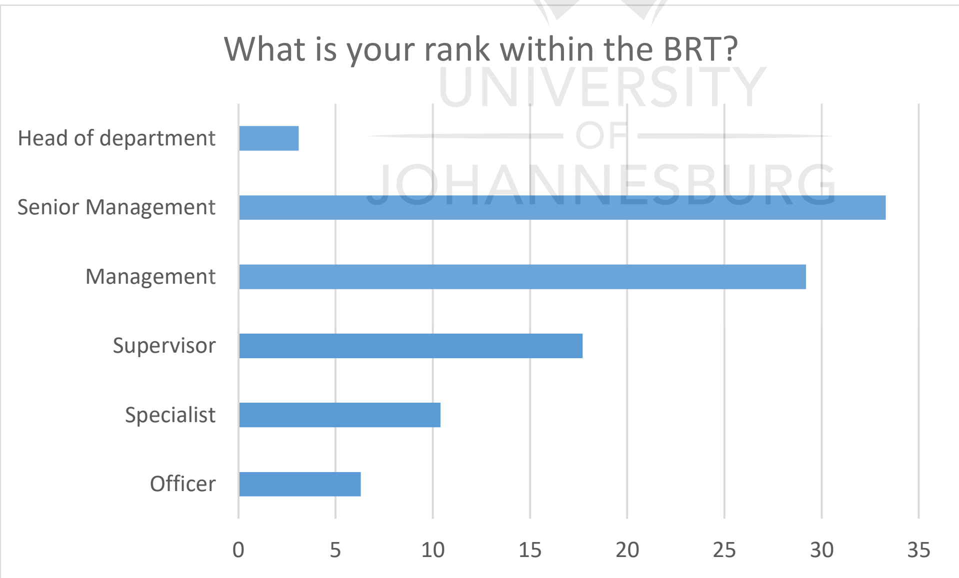

Figure 5.2: Rank within the BRT, Source: UJ Statkon 2018

5.4.2. Education level

Educational level and skills of an individual has implications on what they can afford because it plays a key role in determining their income level. It was necessary to determine the education level of respondents as shown in Figure 5.3 because the Intelligent Transport System in the BRT requires a certain level of education to use the system, although the system should be user friendly. ITS is a specialised field and requires a certain level of knowledge. This question was asked in order to ascertain the education/knowledge level of the respondents. The study found that most of the respondents had diploma/degree (37%) and honors (33%), which shows that the BRT has knowledgeable people with capabilities. 14% has Masters degrees while 11% have certificates, 5% have grade 12 and 1% has a doctorate.

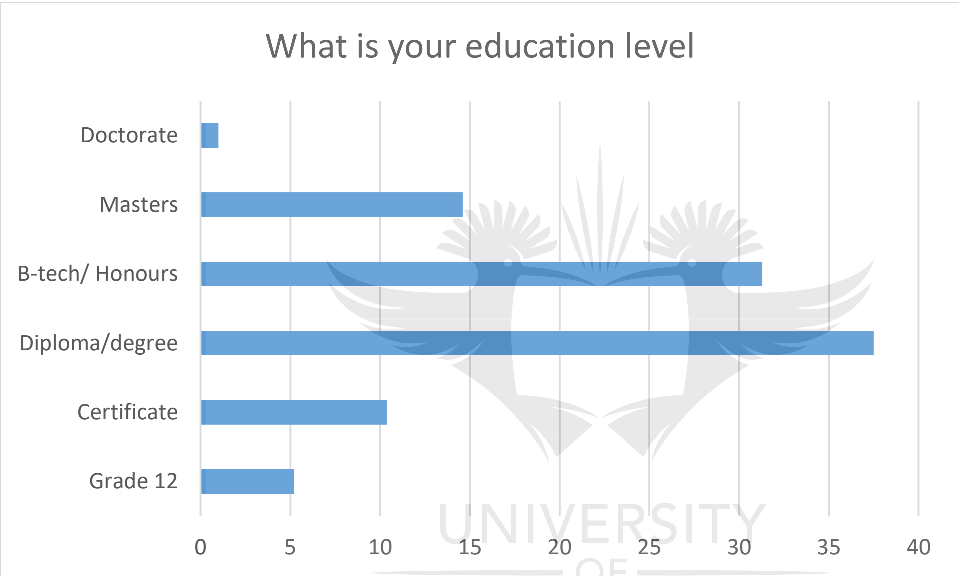

Figure 5.3- Education level, Source: UJ Statkon 2018

The study revealed that 44% of the respondents had some form of education from a higher institution. Education status is not in any way a criterion in determining the people who can access the public transport. It becomes a factor when most of them with tertiary education may have better job opportunities and as a result earn higher incomes. This influences the type of public transport that they can afford, as it was shown in figure 5.3.

5.4.3. Field of work

Response to this question gave the researcher an overall profile of the respondents. Majority of the respondents were from Safety (20%), Quality Control (25%) and Operations (33%). Intelligent Transport is a small department in the BRT as most functions are outsourced.

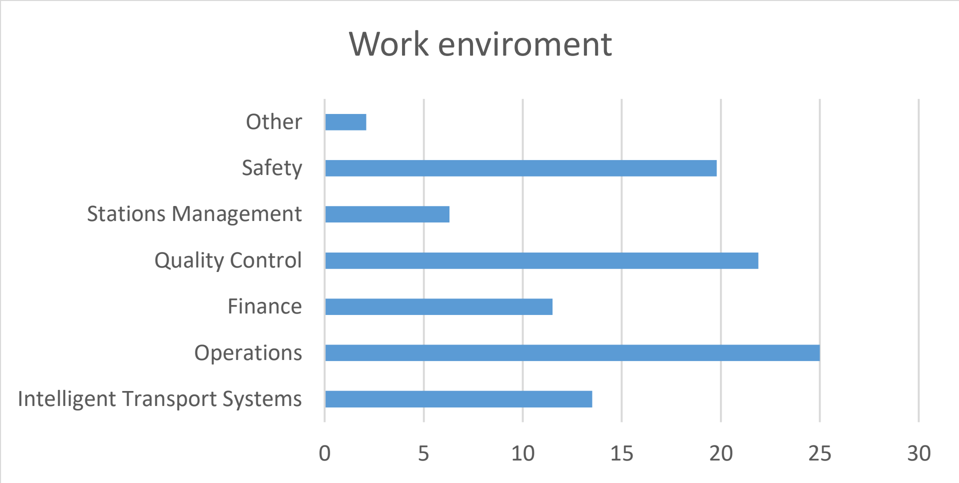

Figure 5.4- Work environment, Source: UJ Statkon 2018

5.5. Statistical data presentation and analysis

This section presents analyses and interprets data on relationships between the BRT in South Africa and the intelligent transport system. The analysis began with measurement scale analysis of the research instrument that was used in this study. Secondly, analysis was done in respect of determining the characteristics of ITS capability in bus rapid transport and how it affects performance.

5.6. Descriptive analysis

The author, typically is more interested in composite variables (construct) than the ten questions in a construct. In this case for example ten questions together were combined into one variable by averaging together all ten questions.

In this section descriptive analysis are performed on composite variable level however questions influencing the composite variable are referenced and the results of the questions are part of the appendices. The formation of composite variable as illustrated in table 9, was prepared in the following manner:

Composite Variable	ITS Capability
12 Questions: ITS Infrastructure Capability 11 Questions: ITS and Business Integration 8 Questions: ITS Orientation and Innovation 10 Questions: Marketing Orientation (Dependent Variable) 10 questions: Operational Agility(Dependent Variable)	ITS Infrastructure capability ITS and Business Integration ITS Capability**(Invariable)** ITS orientation and innovation

Table 5.4. Composite Variable, Source: UJ Statkon 2018

5.6.1. ITS Infrastructure capability

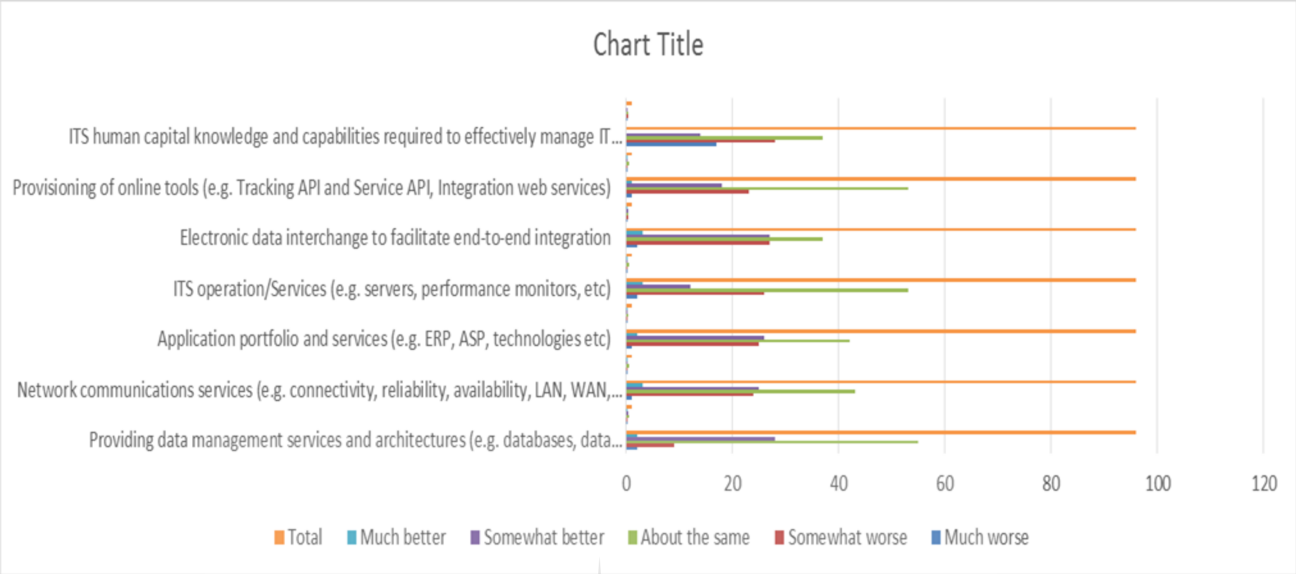

Figure 5.5: ITS Infrastructure capability, Source: Author- Nthite 2019

ITS & business integration is the ability of management to envision and exploit ITS resources to support and enhance business objectives. In figure 12 respondents were asked to evaluate their organisation's ITS and business Integration by indicating to what extent they agree with a list of statements. An overwhelming majority (45%) agreed that there's integration between ITS and Business as shown in appendix D, 29% percent strongly agreed with the statement that their organisation seeks to develop a clear vision regarding how ITS contributes to business value and 25% strongly agreed that IT managers are involved early in meetings for major business projects.

In summary, there is a strong agreement among respondents that their organisations' ITS and business is integrated this could also be driven by the fact that BRT is embedded or integrated with operations. The 21% of respondents who believe there is ITS and BRT Business integration can't be ignored because 21% percent is a large number.

5.6.2. ITS & Business Integration

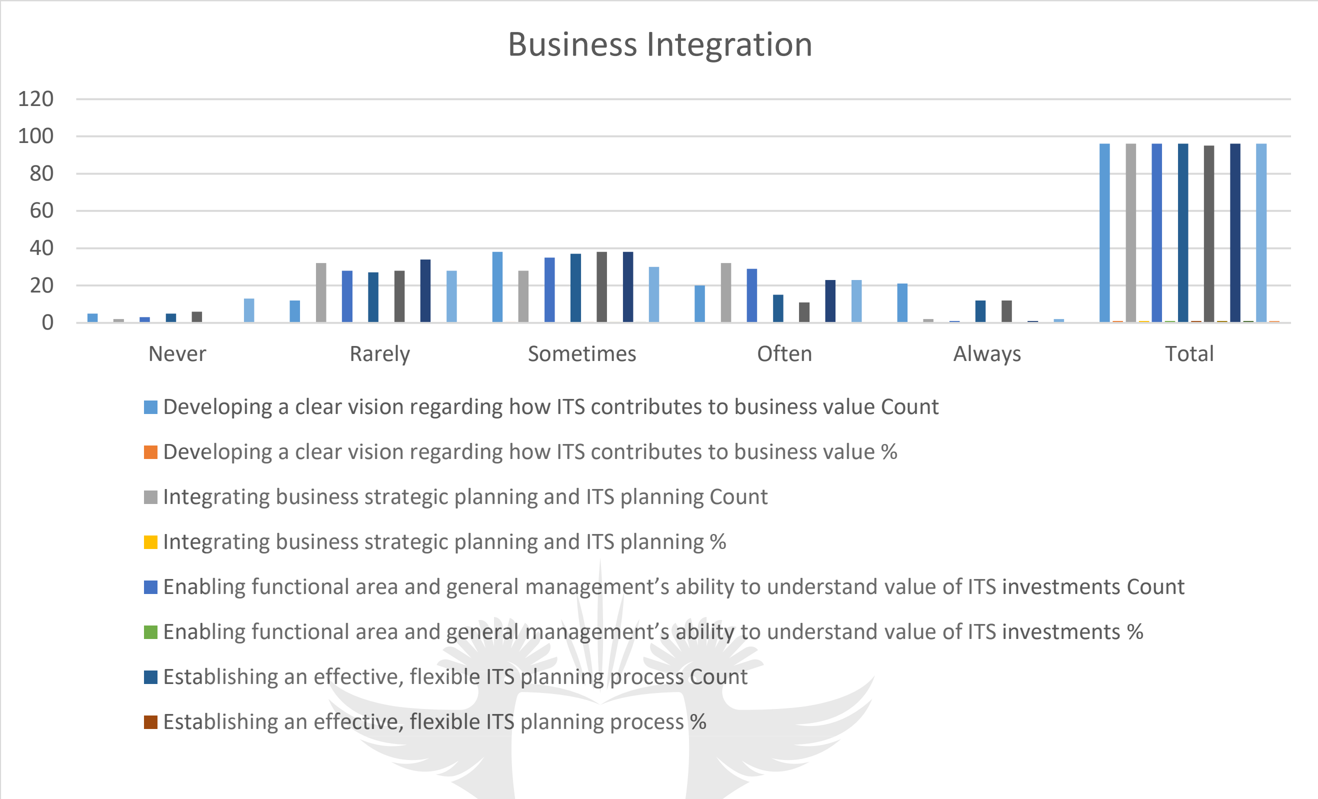

Figure 5.6: ITS & Business Integration, Source: Author- Nthite 2019

ITS & business integration is the ability of management to envision and exploit ITS resources to support and enhance business objectives. In figure 12 respondents were asked to evaluate their organisation's ITS and business Integration by indicating to what extent they agree with a list of statements. An overwhelming majority (45%) agreed that there's integration between ITS and Business as shown in appendix D, 29% percent strongly agreed with the statement that their organisation seeks to develop a clear vision regarding how ITS contributes to business value and 25% strongly agreed that IT managers are involved early in meetings for major business projects.

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5.6.3. ITS innovation and orientation

ITS innovation and orientation is a firm's ability to search for ways to embrace new ITS innovations or exploit existing ITS resources to address and create business opportunities. Respondents were asked to evaluate their ITS innovation and orientation capability in acquiring, assimilating, transforming, and exploiting ITS knowledge.

Figure 13 shows that a large number of respondents (43%) agree that they have very good capability whilst 7% strongly agree that their capability to embrace ITS innovations is not good. In Appendix E.

Fifty-one percent (51%) agreed with the statement that their organisations constantly seek new ways to enhance the effectiveness of ITS usage and when asked if their organisations have ready access to resources, including financial resources, to support innovation activities, 49% agreed with the statement.

In summary figure 13 shows there’s 14% of respondents who believe their organisation's capability of embracing new ITS innovation is poor. The majority of respondents is happy with their organisation’s capability of exploiting existing ITS resources to create new business opportunities.

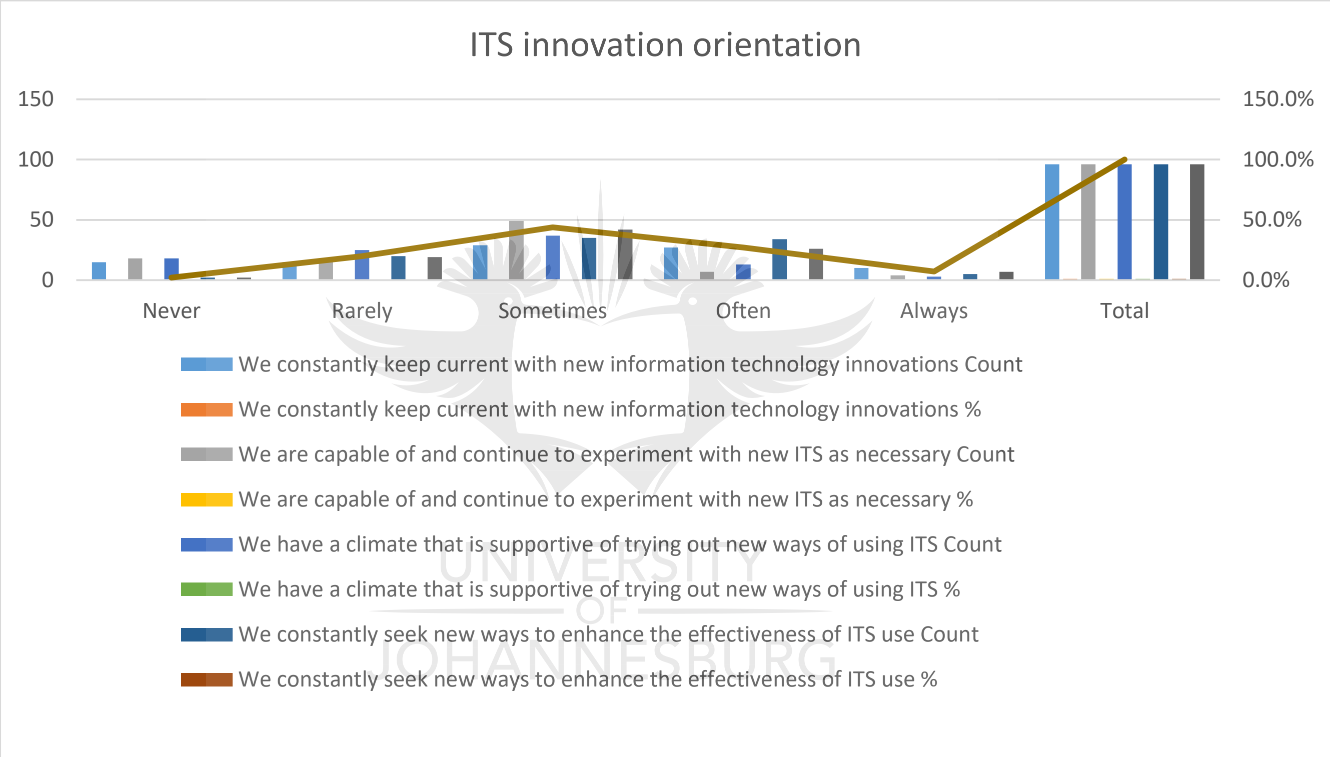

Figure 5.7: ITS Innovation & Orientation, Source: Author- Nthite 2019

5.6.4 Operational agility

Operational agility is a firm’s ability in its internal business processes to physically and rapidly cope with market demand or changes. Respondents were asked to evaluate how well their organisation performs or is positioned to perform a list of activities as shown in Appendix A.

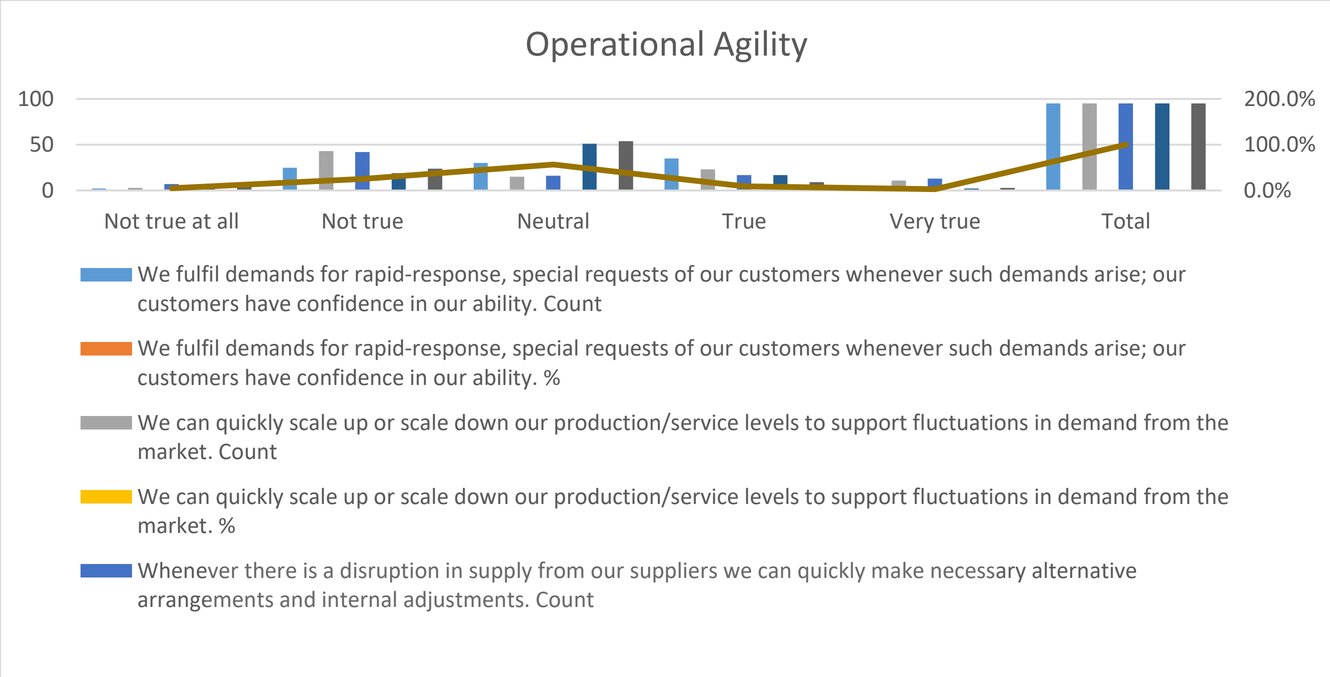

Figure 5.8: Operational Agility, Source: Author 2019

Figure 5.7 shows that most organisations have very good operational agility and whilst 30% were not sure of their organisation's agility and 23% percent did not believe that their organisations have a good operational agility, this is because respondents did not agree with some of the statements. The two highlighted questions very important facilitators of operational agility in the BRT industry and it is a disturbing fact.

5.6.5. Market orientation agility

Market orientation agility is a firm's ability to quickly respond and capitalize on changes through continuously monitoring and quickly improving products or services to address customer needs. Respondents were asked how well they agree with a list of questions indicated in appendix A.

The questions sought to understand how organisations align themselves with market requirements. In figure 15, 42% indicated that they have a good market orientation agility whilst 23% were not sure of their capability to align with market requirements. Twenty-one percent felt that their organisations do not have the ability for market orientation and 10% strongly agreed with the notion that their organisations can quickly respond to market changes. Appendix F shows the results of the detailed list of statements presented to respondents.

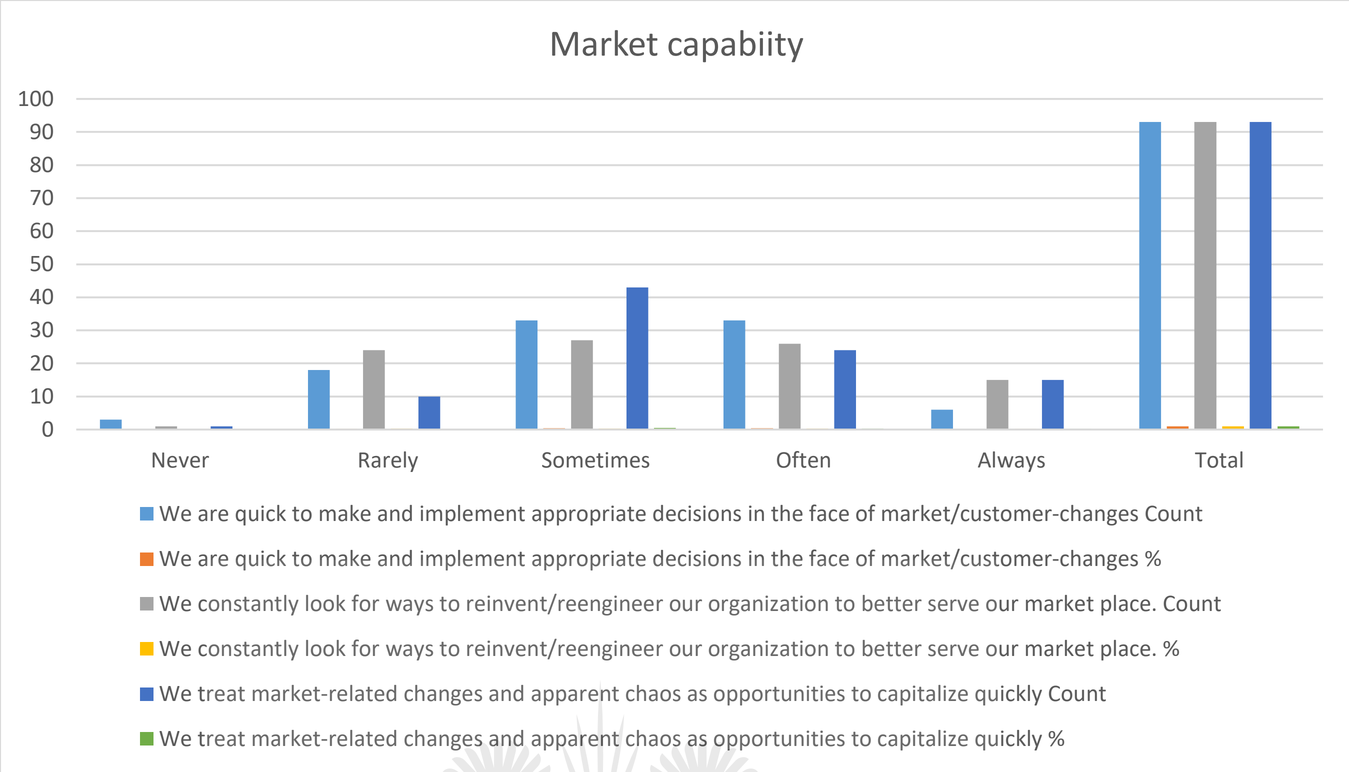

Figure 5.8: Market Orientation Agility, Source: Hair et al, 2007

5.7. Inferential data analysis

This section has discussed inferential statistics, which uses probability theory to draw conclusions (or inferences) about, or estimate parameters of the environment from which the sample data came. Four different aspects of inferential statistics are discussed; these are:

- Hypothesis testing, which is also called detection theory, attempts to choose one model from several postulated (or hypothesized) models of the physical system.
- Sampling theory, which deals with problems associated with selecting samples from some collection that is too large to be examined completely. These samples are selected in such a way that they are representative of the population.
- Estimation theory, which is concerned with making some prediction or estimate based on the available data.
- Regression analysis, which attempts to find a mathematical expression that best represents the collected data. In this chapter we only considered linear relationships

5.7.1. Research Hypothesis

According to (Hair et al, 2007) the purpose of using inferential statistics is to obtain information at the population level from the data gathered from the sample. The conceptual research model shown in figure 4 contains one independent variable (ITS capability) and two dependent variables (Market Orientation Agility and Operational Agility). In the research design, two hypotheses were presented.

Data collected from the survey will be used to test whether these hypotheses hold true or not.

Hypothesis H1

H0: ITS capability do not correlate with BRT market orientation agility

H1: ITS capability correlate with BRT market orientation agility

Hypothesis H2

H0: ITS capability do not correlate with BRT operational agility

H1: ITS capability correlate with BRT operational agility

The two hypotheses, test the relationship between the dependent and independent variables but does not necessarily mean that one variable is causing the other that means the tests is not that of a causal relationship.

5.7.2. Preliminary analysis for correlation

One of the pre-requisites of performing correlation analysis is the use of the scatterplot. Scatterplot is a very useful tool in checking relationship between two variables. Scatter diagram visually shows the relationship between two variables. (Hair et al 2007)

The relationship is based on the concepts of:

Nature of relationship – linear or non-linear,

Direction – positive or negative, and

Strength of association – weak or strong.

Hypothesis 1

There is a positive relationship between BRT Market orientation agility and ITS capability. The nature of the relationship between the two variables is linear.

The direction of the relation is positive. The strength of association is not too strong, but it is between high and strong because the association is significant.

Hypothesis 2

There is a positive relationship between BRT Operational agility and ITS capability. The nature of the relationship between the two variables is linear.

The strength of association is not too strong, but it is strong and closely associated compared to Hypothesis 2. In summary, the above finding proves that a positive relationship exists between the variables and most importantly the nature of the relationship is linear which means correlation analysis may be applied.

The strength of the relationship is good. The findings support the following hypothesis:

H1: ITS capability correlates with market orientation agility

H2: ITS capability correlates with operational agility

Both alternative hypotheses in this regard are rejected. This paves a way for further analysis using correlation analysis owing to the fact that the nature of the relationship is linear of both hypotheses, therefore, the correlation analysis is applicable.

5.7.3. Correlation analysis

The conceptual model contains two dependent (BRT market agility and BRT operational agility) variables and one independent variable (ITS capability), which means it is possible to analyse the hypotheses using the correlation analysis technique. Correlation analysis is used to assess the strength of the relationship between two variables (Hair et al, 2007). Furthermore, a correlation analysis is used to quantitatively assess or define the strength of correlation between variables (Hair et al, 2007).

The relationship is based on the concepts of:

Presence of relationship – measured by the concept of statistical significance,

Strength of association – measuring the association between two variables.

Correlations					
		Market_cap_ agility Market capitalisation agility	infrastruc_ cap_f Infrastructure capability: factors 1 and 2 combined	Innovation Innovation	Bus integration Business integration
Pearson Correlation	Market_cap_ agility Market capitalisation agility	1.000	0.558	0.592	0.765
	infrastruc_cap_f Infrastructure capability: factors 1 and 2 combined	0.558	1.000	0.746	0.582
	innovation Innovation	0.592	0.746	1.000	0.683

	Bus integration Business integration	0.765	0.582	0.683	1.000
Sig. (1-tailed)	Market_cap_agility Market capitalisation agility		0.000	0.000	0.000
	infrastruc_cap_f Infrastructure capability: factors 1 and 2 combined	0.000		0.000	0.000
	innovation Innovation	0.000	0.000		0.000
	Bus integration Business integration	0.000	0.000	0.000	
N	market_cap_agility Market capitalisation agility	93	93	93	93
	infrastruc_cap_f Infrastructure capability: factors 1 and 2 combined	93	96	96	96
	innovation Innovation	93	96	96	96
	Bus integration Business integration	93	96	96	96

Table 5.5. Correlation analysis, Source: Author- Nthite 2019

5.7.3.1. Statistical Significance

'*Statistical significance means you are very sure the results of your statistical analysis are reliable*' (Hair et al, 2007, p: 357).

According to (Hair et al, 2007) the typical guideline to be considered statistically significant, the probability value must be <0.05 that may mean there is less than 5% chance of wrongfully rejecting the null hypothesis.

5.7.3.2. Strength of Association

The strength of association measures the association between two variables using a correlation coefficient. (Hair et al, 2007).The rule of thumb values for measuring the strength of association are given in Table 11.

Coefficient Range	Strength of Association
+-0.91 - +-1.00	Very Strong
+-0.71 - +-0.90	High
+-0.41 - +-0.70	Moderate
+-0.21 - +-0.40	Small but definite relationship
+- 0.00 - +-0.20	Slight, almost negligible
*Assumes correlation coefficient is statistically significant	

Table 5.6: Strength of Association (Adapted from Hair et al, 2007)

5.7.4. Results of correlation analysis

Bearing in mind the above concepts and results of scatter diagram the correlation analysis carried out on the two dependent and one independent variable produced the results shown in table 12.

Correlation Results			
	ITS capability	Operational Agility	Market Orientation Agility
ITS capability	1		
Operational Agility	**.908**	1	
Market Orientation Agility	**.761**	**.732**	1

Table 5.6: Correlation Result, Author 2019

The results show that:

H1: There is a high positive correlation between BRT Market orientation agility and ITS capability, with the correlation coefficient being 0.761. This confirms the findings that is, the higher the level of ITS capability, the higher the level of BRT Market orientation agility. The correlation is statistically significant and, therefore, the null hypothesis is rejected. The first hypothesis (H1) is accepted.

H2: There is a high correlation between BRT operational agility and ITS capability. The correlation coefficient is 0.908. This also confirms the findings that is an increase in ITS capability is correlated with increases in BRT operational agility. The statistical significance is excellent and, therefore, the null hypothesis is rejected. Thus, the second hypothesis (H2) is accepted.

Hypothesis	Relations	Predicted Sign	Results
H1	Direct effects: ITS capability→ BRT Market orientation agility	**+**	Positive
H2	Direct effects: ITS capability →BRT Operational agility	**+**	Positive

Table 5.7: Summary of Hypotheses and Results, Source: Nthite (Author) 2019

5.6.4 Chapter Summary

This chapter has analysed, presented, and interpreted data on Intelligent Transport System capability and Bus Rapid Transit agility. The majority of respondents have shown a good understanding of their organisation's ITS capability and believe they have well ITS capability (ITS infrastructure, ITS innovation & orientation and ITS & business integration and business agility (operational agility and market orientation). However, a low percentage believes that ITS capability and BRT business agility is poor in their respective municipalities.

This chapter has identified a number of concerns, through gap analysis and the most critical being the lowest level of ITS capability and BRT business agility in the South African BRT compared to industry players. Secondly the data revealed that BRT have a high level of ITS capability and business agility compared to other public transport in South Africa. It has been proven that an increase in ITS capability in the BRT is positively correlated with an increase on its business agility and therefore by implication a BRT's ability to quickly respond to market changes is correlated with the level of the BRT's ITS capability, the ability in its internal business processes to physically and rapidly cope with market demand or changes is correlated with the level of ITS capability.

CHAPTER SIX

DISCUSSION OF FINDINGS

6.1 Introduction

This chapter presents an analysis and discussion of the findings of this study. The study was set out to explore the relationship between business agility and ITS capability in the BRT industry in South Africa with an objective of confirming business agility and ITS capability as pre-conditions of partaking in the BRT industry. In chapter 2, the study provided empirical evidence through a thorough examination of the literature on the complementarity of ITS capability and BRT business agility. This assisted in understanding the relationship between ITS capability and BRT business agility. Results of the thorough examination of the literature review confirmed that ITS capability enables business agility but is it really true in the South African context? Well, the study explores the premise that ITS capability enables both operational and market orientation agility in South Africa's BRT industry. The study sought to answer the research questions:

- Does ITS capability impede/enhance BRT market orientation agility?
- Does ITS capability impede/enhance BRT operational agility?

The research conceptualizes the multidimensional construct (ITS capability) as a higher level general construct that encapsulates the cohesion among the three dimensions (ITS Infrastructure, ITS & Business Integration, and ITS Innovation & Orientation). This conceptualization emphasizes the inter-correlation among the three dimensions, which means the three ITS capability dimensions together enables business agility. This is evident in the data analysis process as all three dimensions correlate at a coefficient of an average .656 which indicate a strong inter-relationship among the dimensions. Business agility is dimensioned into operational agility and market

6.2. ITS capability and market orientation agility

With regard to the first research question, the study found that ITS capability enhances market orientation agility, with the correlation coefficient being 0.761. It is evident from the results that ITS capability enables market orientation agility in the South African BRT industry. The finding is congruent with literature review findings which concluded that ITS capability enables market orientation agility. The findings confirm that ITS capability enables market orientation agility in the BRT industry in South Africa that is BRT firms use ITS capability in building or enhancing market intelligence to detect market opportunities and attend to customer requirements.

The BRT industry is evolving rapidly and customers have increasing service expectations, especially concerning delivery solutions, therefore, market orientation agility is essential in sensing market changes in order to meet customer demands. The use of ITS capability such as big AVMs is paramount in detecting customer trends and profiling customers.

This view is supported by Sambamurthy et al, (2003) when they state that business intelligence or analytics tools are utilized by firms to sense and react to market threats and opportunities in turbulent and competitive markets. ITS capability bring in a synergy between ITS and business which ensures speedy, effective and efficient translation of innovative responses that require radical changes to and re-engineering of business processes and information systems(Ramamurthy et al., 2011). The findings resonate well with Weill and Ross (2004) assertion that firms with good ITS capability are able to anticipate and sense relevant changes due to advances in ITS and the opportunities created by emerging technologies. One could argue that BRT agencies with low ITS capability are likely to have low market orientation agility this is further supported by McKenney (1995) when the state that ITS capability is a fundamental differentiator in the competitive performance of firms, therefore, BRT managers need to pay greater attention to developing their ITS capability to successfully sense and seize market opportunities.

6.3. ITS capability and operational agility

With regard to the second question, the study found that ITS capability is highly correlated with operational agility, with the correlation coefficient being 0.908 which indicate a close relationship between ITS capability and operational agility. The finding is consistent with literature review finding which concluded that ITS capability enables operational agility. The finding confirms that firms with a high level of operational agility are able to offer customers flexibility with regard to when and where there's unexpected changes or improvements in the operation and options that fit their daily schedules in the best possible way. This view is supported by Zhu (2004) when the state that the impact of ITS capability in the BRT is that, the high level of ITS capability positively contribute to operational agility as it allows spontaneous reconfiguration of operational capabilities.

The finding further confirms that ITS is a key element of the BRT value chain as it provides vertical and horizontal integration capability to firms, thus enabling system integration with various suppliers and ultimately with customers. This is supported by Tsai et al, (2013) as they assert that back-end ITS capability supports the entire value chain by coordinating all activities, when all participants in the value chain, ranging from suppliers to customers, interact with one another through these technologies such as web services. In the BRT industry, the operational capability is about becoming fully technological automated from end to end. Many respondents felt that their organisations provide one or more of Slack's et al, (2007) operational objectives (speed, dependability, flexibility, quality, and cost), which is important for the BRT industry.

The finding confirms that ITS capability enables firms to have flexible and rapidly responding operations as a critical foundation for enabling fast and fluid translation of innovative initiatives Hammer (2004). The finding further confirms the role of ITS capability during times of uncertainty as to the capability to automate business processes rapidly, react to unplanned business events autonomously and cost-effectively, enabling business operations to move with greater flexibility and speed. (Bharadwaj, 1998; Dove, 2001; Kohli, 1990; Kotler, 2008).

Overall, it is supposed that the BRT industry is digitized and, therefore, ITS capability have a complementary relationship with operational capability because Intelligent Transport System is a business platform in digitized economies (Sambamurthy et al., 2003).

6.4. Preconditions of performance excellence in the BRT industry

With regard to the main objective of confirming (or not) that business agility and ITS capability are pre-conditions of partaking in the BRT industry, the overall findings indicate that ITS capability has a significant influence on operational agility and market orientation agility. It can, therefore, be concluded that an organisation with low levels of agility and ITS capability may find it hard to survive in the BRT industry as it is a digitized economy characterized by increasingly competitive and turbulent global business environment with rapid market and customer demand, thus business agility and ITS capability are confirmed as pre-conditions of partaking in the BRT industry. The outcome of the literature review which concluded that ITS enables business agility further support this finding that ITS and business agility are the pre-conditions of partaking in the BRT industry.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATION

7.1. Conclusion

As indicated in the literature reviewed, the South African BRT draws on successful examples from countries in South America, Asia, North America, and Europe, where excellent and affordable BRT systems have been established (CoCT, 2006; CoCT, 2008; CoCT, 2010b). However, contextual differences need to be recognized and taken into account. What may be appropriate in one case may not be workable or acceptable in another. Therefore, as local public transport problems and needs, as well as local realities, may differ drastically from those in other case cities, BRT solutions need to be tailored so that they can work within the South African environment or under South African conditions (i.e., under existing demographic, economic, environmental, physical (or urban form), social, and political conditions) (Iles, 2005).

For example, one of the critical success factors of the South African BRT System is considered to be the effort to define a form of BRT that meets local user needs, is appropriate to the context in which it is placed, and is affordable and deliverable in the broadest sense (Mobereola, 2009). Part of the reasons for conducting this study was to establish a set of actionable recommendations that BRT firms can implement to increase the level of ITS capability and business agility. Business agility appears in various literature streams. It started in the manufacturing literature in the early nineteen-nineties and was later extended to supply chain management, marketing, strategy and information systems. In this dissertation, a multi-disciplinary perspective was developed on the relationship between ITS capabilities, BRT agility, and business agility performance, based on concepts across multiple streams of research.

There were two tensions related to the concept of business agility. From the one side, there were three streams of literature with different perspectives on the relationship between ITS capabilities and BRT agility (performance). One stream claims that Intelligent Transport System is a necessary condition for higher levels of BRT agility performance. The second stream claims that Intelligent Transport System contributes to higher levels of BRT agility performance under certain conditions and for certain events. The third stream of literature claims that ITS does not really matter in achieving superior BRT agility performance. This literature stream criticizes the degree to which ITS can bring sustainable benefits, due to its rigidity and complexity.

The term of office in the South African government in is five years. The deployment of the ITS is a long process, and the effects cannot be measured in a period equal to that of the government term. However, in order to bring ITS deployment, the funding mechanisms and the political commitment that should go with it, there is a need for the assessment period to be aligned.

It is true that the period of assessment and the tenure of government may not necessarily coincide, and the minister or ministers to whom the responsibility was placed and by whom political commitment is given, may be replaced or transferred. It is also acknowledged that the time of review (five years) there may not be sufficient information or date to make substantial decisions and policy changes. This time frame, however, will coincide with the government’s time framing.

The empirical results provided evidence that the relationship is mediated by sensing, responding and learning capabilities. At first, the evidence seemed to support the theory that some BRT agencies found a hampering effect of ITS on business agility. A closer look at the ITS-agility relationship is revealed, however, that ITS can contribute to higher levels of business agility performance under the conditions of higher levels of architecture maturity (i.e. more standardization and data sharing), high levels of data quality, strong alignment between business and ITS capabilities and alignment among sensing, responding and learning. These conditions explain why a lot of BRT agencies still have difficulties organizing ITS as a means to enhance business agility. On the other side, there is a tension in the applicability of the business agility concept to the service industry. The concept of business agility originated from the manufacturing industry. As such, one can question the degree to which business agility applies to the service industry. There are a number of fundamental differences between service organisations and manufacturing firms, such as the intangible and perishable nature of the output and the closeness of the consumer to the producer (Mills & Margulies, 1980).

The BRT industry is one of the fast growing sectors in South Africa and ITS is the driver of this growth. Technology is playing an important role in the value chain of the industry as it provides end-to-end integration. As noted by Carr (2003) Technology on its own cannot provide a competitive advantage in the industry. The outcome of the debate on the use of technology points to the exploitation of technology capability by business could lead to a competitive advantage. These differences have implications for the relationship and role of ITS capabilities on business agility and BRT agility performance. In BRT industries people use time as an input to deploy knowledge assets, collaboration assets, and process-engagement to create productivity (effectiveness), performance improvement (potential) and sustainability. ITS are expensive and due to their complexity will not necessarily provide the required solutions and efficiencies.

Typically the output of the BRT is: information, service, attention, advice, experiences, and/or discussion ("intangible goods"). The quality of most services depends to a large extent on the quality of the individual that provides the service. Service employees can be seen as “mini-factories” (Mills & Margulies, 1980). Therefore, in the delivery of services, ITS support for agility refers mainly to the empowerment of individual people in their service delivery process. A comparative study of the commonalities and differences between manufacturing firms and service organisations, in relation to the role of ITS capabilities and the effects of sensing, responding and learning on business agility performance, would be a worthwhile addition to the body of knowledge.

This dissertation urges the BRT to change their organisational design, processes, culture and supporting ITS according to the paradigm of sensing, responding and learning as a means to confront customer requirements, but potentially consequential internal and external events.

Besides the well-known requirement of alignment between business and Intelligent Transport System, this dissertation supplements it with alignment among sensing, responding and learning as two prerequisites for higher levels of BRT agility performance. Increasingly, ITS can support BRT and individuals with more advanced sensing, quick response to new events and learning from previous events. The processing power of ITS continues to increase. The ITS is continually evolving to be more standardized, open, modularized and mobile. Via communication technologies, people and machines are connected on a global scale. Intelligence and processing power moves to the local user and becomes accessible any place any time. Intelligent agent software supports decision making while social networks and communities provide a source of intelligence.

BRT's collect increasingly detailed information about their employees, customers, and partners. One of the biggest challenges for firms is how to make sense out of this huge amount of information (i.e. deal with sensing overload), translate it into a local response and learn from it on a global scale. Personal and organisational biases and rigidities can blur this sense-making process. BRT's and individuals need to be aware of their biases and open to changing their mental models. To thrive in increasingly competitive and turbulent business environment organisations must be agile and have the ability to sense and seize market opportunities. Agile organisations are resilient to turbulent business environments and also highly adaptive to emerging opportunities. Intelligent Transport System is increasingly seen as a source of competitive advantage and a critical business agility enabler. The role of ITS capability in the BRT industry is important as it supports the entire value chain.

The survey results have also shown that the BRT has moderate degrees of ITS capability and business agility compared to its peers in the public transport industry. The literature review and the research findings have concluded that agility and ITS capability is crucial for BRT's survival. The loss of market share in recent years and limited funding from the National Department of Transport (NDOT) may be attributed to the weakness of ITS capability and business agility. The empirical research of this dissertation gives support to the fact that ITS capabilities can support BRT agility, but only to a certain extent and under the condition that sensing, responding and learning of ITS are aligned with each other, and business capabilities are aligned with ITS capabilities among the different layers of the architecture. The research also indicates how ITS capabilities can mitigate sensing overload by supporting human data processing capabilities and human decision making.

The empirical research reveals that social capital is an important moderating variable in the relationship between ITS capabilities and BRT agility. Social capital can mitigate the lack of ITS agility that exists in many organisations by overcoming information system boundaries and rigidities via human relationships. The results of the five constructs show a good picture of respondents' BRT agility and ITS capability, but there are still respondents who disagreed with some of the statements put to them.

The BRT industry is about moving passengers from one point to another and requires continuous market orientation and operational agility. Finally, an important outcome from the literature review is that prior research relating to ITS and BRT agility has also supported the relationship between the ITS capability and business agility some investigations established an enabling role of the ITS, while others discovered a disabling effect of ITS on agility. Even more importantly, the ability to manage the organisational portfolio of processes, including reconfiguring them for continued effectiveness, designing and utilizing appropriate metrics and controls, and applying them as strategic options, has emerged as an organisational imperative (Kalakota et al. 2003; Robinson et al. 2000). Information technologies are considered to be a significant enabler of process management (Davenport, 1994; 2000).

Shortly it can be said that ITS is adding value to the BRT in South Africa by automating their existing business processes and making them more effective and efficient by reducing costs, however this can be improved. At the same time, continuous monitoring of the quality of the ITS services ensures that this value is kept. According to Burg and Singleton (2005), ITS provides BRT with the ability to monitor their operations and quickly realign business processes enabling them to change the way of competition. The following framework was therefore recommended to ensure BRT produces high performance level, thereby making it the most agile public transport system. The general idea was to collect vast amounts of data from various sources (cell phones, cameras, social media, etc.) and analyse and use that data to help with planning, rerouting of traffic, providing commuters with real-time updates, and to create a system that is constantly being optimized based on current and future (predictive analysis) conditions.

Keeping in touch and knowing what the customer requires is important for ensuring customers are satisfied at all times (Market orientation agility). Efficiency changes can easily be made in the planning and design phase at low cost. The challenge is that the availability of data on which decisions can be made is often limited. This approach is more reliant on surveys of current public transport demand, modelling and the data of other operational cities by which certain performance parameters can be benchmarked. A full efficiency review should be carried out before the Operational and Business Plans are finalized. During the planning phase, it is important to ensure that performance management is done on internal as well as external stakeholders with a clear understanding of KPI's, 3rd party SLA and asset management.

7.2. Proposed guidelines for effective implementation of ITS in South African public transport system

ITS as an established route to resolve, or at least minimize traffic problems should be developed on strategies based on the geographic, cultural, socio-economic and environmental background to integrate the various components of ITS into an interrelated system; using location-based broadcast protocol based on repetition coding as first proposed by Xu et al,(2004). The growth of ITS will be facilitated by the ever-improving electronic technology, improved and more accessible internet connectivity. The development of the internet and wireless communication, especially mobile phones revolutionized communication (Maritz and Maponya, 2010). Internet connectivity has become the spine to implement ITS 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). From the recommended ITS Strategic Plan Framework as shown in Figure 8.1, the efficient improvement of the South African BRT system can be achieved in the four (4) phases as indicated. The gradual implementation of this process in a step by step process will result in BRT performance excellence.

7.3. Becoming an ITS driven organization

The following activities can be performed by an organisation that aims to be ITS-driven:

- Build strong ITS Infrastructure capability by strengthening technology architecture, data management service, application portfolios and general ITS services.
- Enforce data and process integration to be embedded in ITS infrastructure capability
- With the BRT industry characterized by rapid market change and customer demands it may be beneficial for the organisation to build and ITS Innovation and Orientation capability, in order to be able to search for new opportunities or develop product features.
- Develop integration of ITS and business through collaboration and partnership
- Strengthen ITS capability so that the organisation can be an active participant in the entire value chain
- Build integrated, end-to-end integration tools that provide real-time visibility and movement of data, customers, and staff
- Build internal ITS capacity in the form of human resources and cut down on outsourcing

7.4. Strengthen Business agility

Performing the following activities could lead to business agility being strengthened:

• Strengthen the capability to provide flexibility with regard to route deviation

• Strengthen the capability to rapidly cope with customer requirements and moreover rapidly cope with radical unexpected schedule changes to scale up or scale down operational levels in responding to customer requirement.

• Adopt or Strengthen Slack's et al, (2007) operational objectives to achieve the operational goals of speed, dependability, flexibility, quality and cost to effectively provide a service to the customer and manage interactions with customers, suppliers, and other important stakeholders in the value chain

Figure 7.1. Illustrates the interconnection of smart mobility and ITS and how it supports the concept of reliability, efficiency, sustainability and effectiveness in a BRT system. However, many challenges could be encountered just to mention a few; insufficient funds to promote development, acceptance of new/modern technological change, familiarization and adapting to global technological changes. These challenges can be overcome through government budget on strategic infrastructure funding to improve the road transportation system by building new roads where necessary, rehabilitation as well as the incorporation of Modern Technology i.e. ITS into the design, construction, and maintenance of road infrastructure by employing other fields of study and expertise in job creation.

7.5. Recommended model

The recommended model in figure 7.1., highlights the opportunity for the South African government to address many of the challenges they're currently facing by improving their transportation system. Having a more efficient and far-reaching BRT system can have a positive impact on the environment, the economy, and general quality of life. The majority of the focus was on creating an efficient Intelligent Transportation System (ITS).

Figure 7.1. Illustrates the visual depiction of what that system would look like. This model was developed on the base of infrastructure that includes not only multi-modal connected conveyance but also automated traffic signals, tolls and fare collection.

The general idea was to (starting at the bottom) collect vast amounts of data from various sources (cell phones, cameras, social media, etc.) and analyse and use that data to help with planning, rerouting of traffic, providing commuters with real-time updates, and to create a system that is constantly being optimized based on current and future (predictive analysis) conditions (Market Orientation). Data integration drives the system, incorporating weather and traffic data, linking emergency services data as well as information from government agencies. Smart services offer different benefits, from vehicle locating systems, to route diversion alerts (Operational Agility).

A central operations control centre can tie together the BRT with real-time and updated data, handling passenger information, traffic signals, incident management and vehicle health monitoring. City planners can track data records and area-wise people movement and use this information to build models whereby public transportation gets deployed in areas of maximum people movement to ensure better connectivity.

At the heart of this ITS system would be an operations control center where all of the government agencies (traffic management, police, fire, etc.) would be tapping into and sharing the same data (ITS Capability). Today, their data is not centralized which makes for difficult planning. While there are several technology solutions, every city has its specific complexities and problems. The challenge lies in finding the best fit for a city that addresses all key goals of BRT—a convenient, green, safe, connected solution. Technology can also be very effectively leveraged in the planning stage to arrive at the elements and framework that an optimised BRT system should incorporate. Application of the framework presented in figure 8.1, will enable the BRT to be more agile.

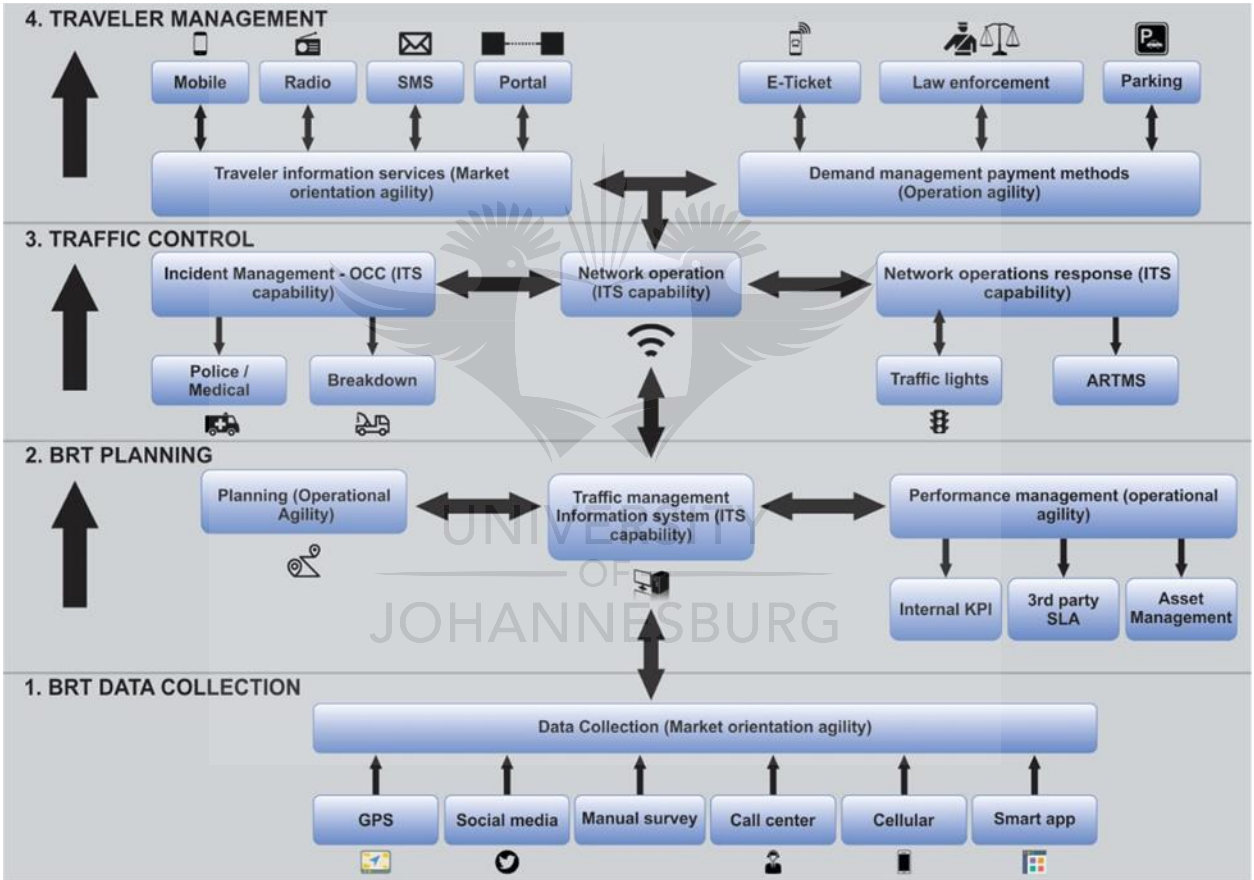

Figure 7.1. Recommended Model, Source: Nthite (author) 2019

The adoption of location and information-based technologies into vehicles (Navigation and GPS Tracker System), infrastructure design and construction, traffic data management and traveller information service will foster dramatically great improvements in the safe and efficient mobility of people and freight in the South African Public Transportation Sector. Figure 7.1 above shows a strategic plan for incubating ITS in South Africa. Most ITS services within the BRT are outsourced, therefore contract management is important. Updated schedules and all operational activities should be made available to all relevant stakeholders with weekly feedback on performance (including preventative and corrective action on all non-conformances). Information obtained from the analysis of existing BRT systems can be used to calculate Key Performance Indicators (KPIs) for benchmarking against other BRT systems or routes. Once the review process of data collection, data analysis, and KPI formulation are complete, the business and operational plans can be updated

In South Africa, incident response takes the form of multi-agency co-operation in order to identify an incident, dispatch the required vehicles, arrive on and secure the scene, attend to the specific nature of the incident and react as necessary prior re-opening the roadway. These activities go hand in hand with ITS and, hence, the need to ensure that ITS architecture is able to integrate with IMS architecture is critical. Efficiency changes for cities with currently operating systems are more complex and more expensive to implement than if they had been implemented before operations started, but the changes have the advantage of being based on more reliable data. This approach requires the collection and analysis of detailed operational data, the implementation of timetable changes and liaison with the VOCs to implement these changes. Careful management of passenger expectations during the implementation of changes is also important. A full system operational efficiency review should be carried out annually, or more regularly if needed.

Network monitoring requires that monitoring devices be installed in strategic locations throughout the BRT network to measure and record traffic flows, travel times, accidents and other security incidents, monitor ITS field equipment as well as the effect of traffic congestion on the environment. The detectors and cameras can be connected to a Traffic Management Centre (TMC) where data can be stored and images viewed. The vehicle detectors could be used to automatically select traffic signal timings (real-time traffic responsive control) and detection of incidents.

7.6. Development of an integrated ITS architecture

An ITS Architecture is the definitive framework that will guide the deployment of Intelligent Transportation Systems. The ITS Architecture spans all ITS activities and provides a means of detecting gaps, overlaps, and inconsistencies between the application and standards. The Logical and Physical Architecture provides a starting point for the standards development activities by identifying the applicable architecture flows and data flows to be standardized in the National ITS Architecture and the way in which the information is exchanged across those interfaces.

In an attempt to define the various aspects that need to be included in an ITS architecture, Figure 8.3 includes a graphical overview. In the figure, three distinct layers emerge. At the most elementary level (bottom), the hardware platform can be found. The hardware layer is connected to the network layer. This layer is responsible for receiving, processing and dissemination of information. The network layer communicates, via a limited number of systems, to the platform layer. The various applications tap into the platform layer and will use the disseminated information.

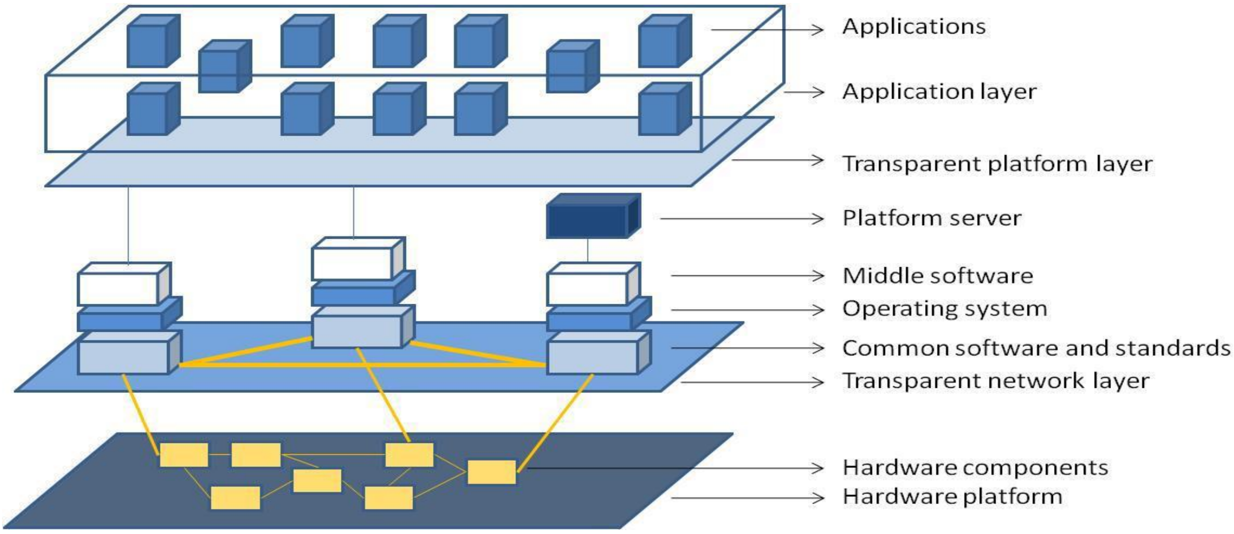

Figure 8.2. ITS architecture framework, Source: Nthite 2019

7.6.1. Hardware Layer

The Hardware platform defines and standardizes the various hardware components needed within the ITS architecture. The hardware components can be linked if required. However, not all hardware components need to be connected. Examples of hardware components that need to be connected/integrated are computer network cabling and computer hardware. An example of a hardware component that does not have to be integrated with the components mentioned previously, is vehicle counting loops.

7.6.2. Transparent network layer

The transparent network layer can be seen as the operating layer within the ITS architecture. Data is collected (received from data generation applications), processed and translated into useful traffic information. Common software and standards are used to create transparency to support information needs. Regarding standards, Europe has developed a common traffic information language standard called DATEX. DATEX is a standardized data and exchange specification, according to ISO rules.

This common traffic information language makes it possible to exchange information between regions and counties. The operating system and middle software will also have to be defined and standardized. Finally, the transparent network layer is supported by a platform sever.

7.6.3. Platform Layer

At the top end of the architecture, the platform layer can be found. This layer communicates directly with the transparent network layer. Furthermore, this communication happens in two directions. Firstly, various ITS applications that are bundled in the application layer collect data, such as traffic counts, video imaging and GPS (Geographical Positioning System) information. On the other hand, the platform layer receives the processed information generated by the transparent network layer.

The information received is in the standardized communication language standard. The platform layer communicates with the application in the application layer. Full or partial access to information can be provided, depending on the application needs and status. An overview of the various applications that could be included in the application layer can be found in Figure 8.2.

7.7. Research limitations

The study has a few limitations. The author would have preferred to have had a higher response rate for the sample and this limitation should have been avoided by conducting semi-structured interviews in support of the quantitative method. Using qualitative could have enabled further discussion and insight presenting lighter into the subject. The size of the BRT industry in South Africa is small and this in itself is a limitation. This affects the ability to generalize the results to a wider population of firms outside of the BRT industry. In the design of the data analysis, the author should have used control variables such as organisational size, age and financial in order to test whether ITS capability and business agility can be affected by these control variables.

7.8. Future Research

Firstly, technology is only one piece of the puzzle in achieving business agility. Future research should extend this research and examine how other elements such as culture, structure, process, governance, people, organisation age, transformation capability, organisation size, and employees' average age, financial stability, education level of employees and bureaucratic processes or policies. This view is supported by Weill et al, (2002) when they state that customer base, organisation's brand, core competence, infrastructure, and employees' ability to change are an integrated group of resources that is critical to agility.

Secondly, future research can be conducted to investigate how a company could and should develop superior ITS capability as an interaction and fusion of technologies, people, structure, and processes (Garud et al, 2006; Weill et al, 2002, Lu and Ramamurthy, 2011). Finally, research should be conducted to investigate how a firm could develop superior ITS capability that will support strategies in public transport as a whole, in South Africa.

7.8. Chapter summary

This chapter presented the overall conclusion of the study as well as the recommendation for an agile BRT system in South Africa. The model was proposed was discussed as well as the technical layers related to it. Future research was proposed in order to add to the body of knowledge.

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Annexure A

Questionnaire

01 October 2018

Dear sir/madam

I am carrying out a survey to gather information for my dissertation that I need to complete as part of University of Johannesburg D-Phil Engineering studies.

The research aims to investigate and analyses the link between ITS capability and Business Agility within the South African BRT industry. The research will test if ITS capability enhance/impede business agility in the BRT. I value your opinion to continually contribute to the academic literature. Therefore, I would be grateful if you participate in this survey. It should take no longer than 10 minutes of your time. All feedback will remain anonymous and all information gathered is kept confidential. Kindly return the completed questionnaire to me on or before 1 December 2018.

Should you have any queries or comments regarding this survey, please feel free to contact me at Lesegonthite@yahoo.com .

Best regards

Lesego Nthite

PLEASE ANSWER THE FOLLOWING QUESTIONS BY CROSSING (×) THE RELEVANT BLOCK OR WRITING DOWN YOUR ANSWER IN THE SPACE PROVIDED.

EXAMPLE of how to complete this questionnaire:

Do you use the BRT?

Male	1
Female	2 (×)

Section A – Background information

This section of the questionnaire refers to background or biographical information. Although we are aware of the sensitivity of the questions in this section, the information will allow us to compare groups of respondents. Once again, we assure you that your response will remain anonymous. Your co-operation is appreciated.

1. Question one: What field of work are you in?

ITS	1
Operations	2
Finance	3
Quality Control	4
Station Management	5
IT	6
Other	7

If Other, Please specify____

2. Question two: What is your education level?

Grade 12	1
Certificate	2
Diploma/Degree	3
B-Tech/Honours	4
Masters	5
Doctorate	6

3. Question three: Gender?

Male	
Female	

4. Question four: What is your work rank?

Officer	1
Specialist	2
Supervisor	3
Management	4
Senior management	5
Head of department	6
Other	7

5. Age (in complete years)

6. Ethnicity

Black	1
White	2

Coloured	3
Indian or Asian	4

Section B: ITS Infrastructure Capability

Please evaluate your organisation's ITS infrastructure capability in the following areas on a 1-5 scale (1= much worse, 5= much better).

	1.much worse	2.somewhat worse	3.about the same	4.somewhat better	5.much better
1. Data management services & architectures (e.g., databases, data warehousing, data `availability, storage, accessibility, sharing etc.)					
2. Network communication services (e.g., connectivity, reliability, availability, LAN, WAN, etc.)					
3.Application portfolio & services (e.g., ERP, ASP, reusable software modules/components, Emerging, technologies, et c.)					

4. ITS operations/services (e.g. hand-held devices for scanning, servers, large-scale processors, performance monitors, etc.)					
5.Electronic data interchange to facilitate end-to-end integration					
6.Provisioning of Online Tools(e.g. Shipping list API, Tracking API, Rates and Services API, Integration web services)					
7.ITS Human capital knowledge and capabilities required to effectively manage IT resources in the organisation					

Section C: ITS/ Business Integration

Please evaluate your organisation's ITS management capability in responding to the following on a 1 to 5 scale (1 = never, 5 = always).

	1.Never	2.Rarely	3. Sometimes	4.Often	5.Always
Developing a clear vision regarding how ITS contributes to business value					
Integrating business strategic planning and ITS planning					
Enabling functional area and general management's					

ability to understand value of ITS investments					
Establishing an effective and flexible ITS planning process and developing a robust ITS plan.					
Involvement in business process planning and optimization activities					
ITS provides all operational information with regards to business					

Section C: ITS Innovation

Relative to other firms in your industry, please evaluate your capability in acquiring, assimilating, transforming, and exploiting IT knowledge in the following areas on a 1 to 5 scale (1 = Never, 5 = Always).

	1.Never	2.Rarely	3.Sometimes	4.Often	5.Always
We constantly keep current with new information technology innovations					
We are capable of and continue to experiment with new IT as necessary					
We have a climate that is supportive of trying out new ways of using IT					
We constantly seek new ways to enhance the effectiveness of IT use					
We constantly seek new ways of developing integration					

tools(e.g. API and web services)					

Section D: Operational Agility

Relative to your competitors, please indicate on a 1 to 5 scale (1 = not at all true; 5 = very true) how well your organisation performs or is positioned to perform the following activities.

	1.not true at all	2.Not True	3.Neutral	4.True	5.Very True
We fulfil demands for rapid-response, special requests of our customers whenever such demands arise; our customers have confidence in our ability.					
We can quickly scale up or scale down our production/service levels to support fluctuations in demand from the market					
Whenever there is a disruption in supply from our suppliers we can quickly make necessary alternative arrangements and internal adjustments					
We provide flexibility with regard to when and where parcels can be delivered					
We provide flexibility with regard to delivery options that fits our customer daily schedules in the best possible way					

Section E: Market Capitalizing Agility

Please evaluate your organisation's Market Capitalization Agility in responding to the following on a 1 to 5 scale (1 = never, 5 = always).

	1.Never	2.Rarely	3.Sometimes	4.Often	5.Always
We are quick to make and implement appropriate decisions in the face of market/customer-changes.					
We constantly look for ways to reinvent/reengineer our organisation to better serve our market place					
We treat market-related changes and apparent chaos as opportunities to capitalize quickly					

Section F: Other Variables- Organisational context

Approximately how many years has your company been in business? _________Years.

Please indicate the approximate number of Fulltime Equivalent Employees (FTE): ________

IS context and IS decision:

Number of years the IS function in your organisation been formally in place: _________Years.

Please indicate the approximate number of Full-time Equivalent Employees (FTE) in IS function: ________

On average, what is the approximate ratio of the IT budget to your firm's annual sales? _______%

Appendix 1

```
* Encoding: UTF-8.
GET FILE='C:\data\statkon\projects2019\nthite4433\sav\Nthite4433.sav'.

comment *Correct g5 values which are out of range.
recode g5 (101, 160=100).

compute infrastruc_cap_f1=mean(b3,b2,b4).
compute infrastruc_cap_f2=mean(b6,b7,b5). /*b1 crossloads.
compute infrastruc_cap_f=mean(b3,b2,b4,b6,b7,b5).

compute innovation=mean(c1,c2,c3,c4,c5).

compute bus_integration=mean(d1,d2,d3,d4,d5,d6,d7).

compute op_agility=mean(e1,e2,e3,e4,e5).
compute market_cap_agility=mean(f1,f2,f3).

variable labels
 infrastruc_cap_f1 'Infrastructure capability: factor 1'
 infrastruc_cap_f2 'Infrastructure capability: factor 2'
 infrastruc_cap_f 'Infrastructure capability: factors 1 and 2 combined'
 innovation 'Innovation'
 bus_integration 'Business integration'
 op_agility 'Operational agility'
 market_cap_agility 'Market capitalisation agility'.

missing values A1specify (' ').

COMMENT *ANALYSIS STARTS HERE.

correlations variables=infrastruc_cap_f1  infrastruc_cap_f2 infrastruc_cap_f innovation  bus_integration  op_agility  market_cap_agility.
```

Appendix 2

Correlations

		infrastruc_cap_f1 Infrastructure capability: factor 1	infrastruc_cap_f2 Infrastructure capability: factor 2	infrastruc_cap_f Infrastructure capability: factors 1 and 2 combined	innovation Innovation	bus_integration Business integration	op_agility Operational agility	market_cap_agility Market capitalisation agility
infrastruc_cap_f1 Infrastructure capability: factor 1	Pearson Correlation	1	0,551	0,882	0,655	0,478	0,432	0,450
	Sig. (2-tailed)		0,000	0,000	0,000	0,000	0,000	0,000
	N	96	96	96	96	96	95	93
infrastruc_cap_f2 Infrastructure capability: factor 2	Pearson Correlation	0,551	1	0,880	0,659	0,548	0,566	0,538
	Sig. (2-tailed)	0,000		0,000	0,000	0,000	0,000	0,000
	N	96	96	96	96	96	95	93
infrastruc_cap_f Infrastructure capability: factors 1 and 2 combined	Pearson Correlation	0,882	0,880	1	0,746	0,582	0,566	0,558
	Sig. (2-tailed)	0,000	0,000		0,000	0,000	0,000	0,000
	N	96	96	96	96	96	95	93
innovation Innovation	Pearson Correlation	0,655	0,659	0,746	1	0,683	0,661	0,592
	Sig. (2-tailed)	0,000	0,000	0,000		0,000	0,000	0,000
	N	96	96	96	96	96	95	93
bus_integration Business integration	Pearson Correlation	0,478	0,548	0,582	0,683	1	0,709	0,765
	Sig. (2-tailed)	0,000	0,000	0,000	0,000		0,000	0,000
	N	96	96	96	96	96	95	93
op_agility Operational agility	Pearson Correlation	0,432	0,566	0,566	0,661	0,709	1	0,731
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000		0,000
	N	95	95	95	95	95	95	93
market_cap_agility Market capitalisation agility	Pearson Correlation	0,450	0,538	0,558	0,592	0,765	0,731	1
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	
	N	93	93	93	93	93	93	93

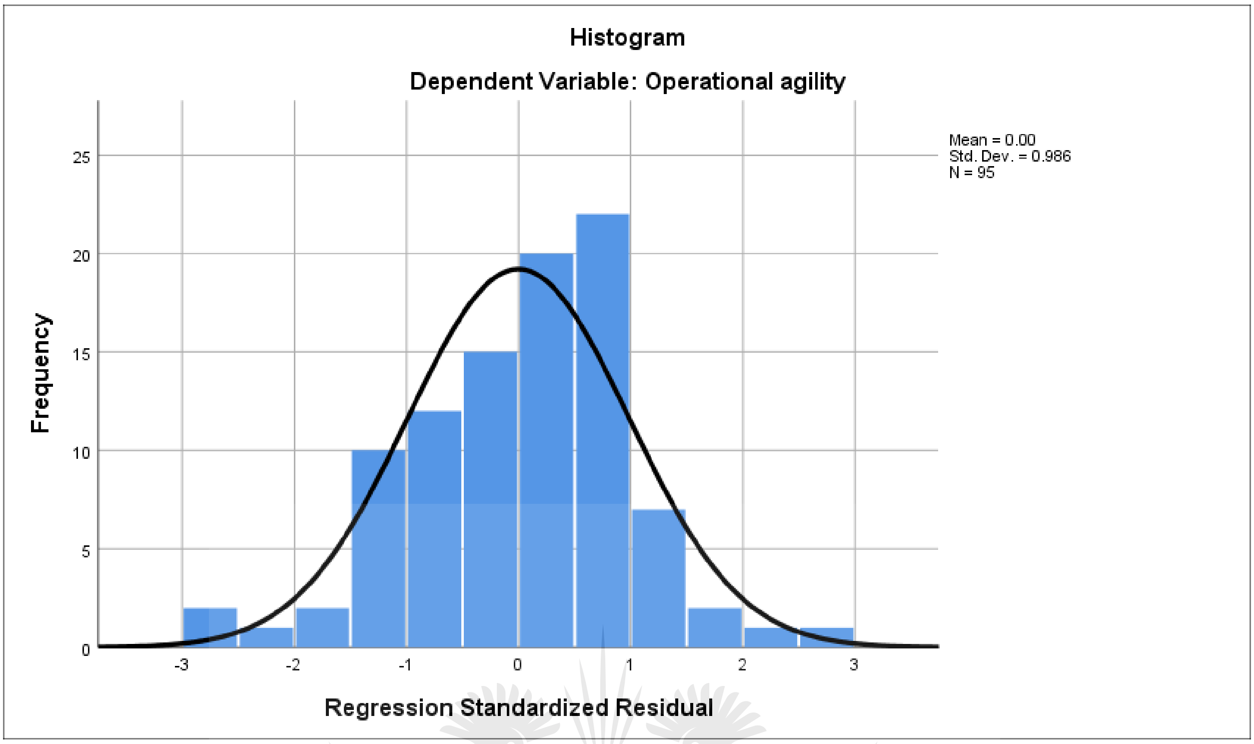
nonpar correlations /variables=infrastruc_cap_f1 infrastruc_cap_f2 infrastruc_cap_f innovation bus_integration op_agility market_cap_agility.

Appendix 3

Correlations

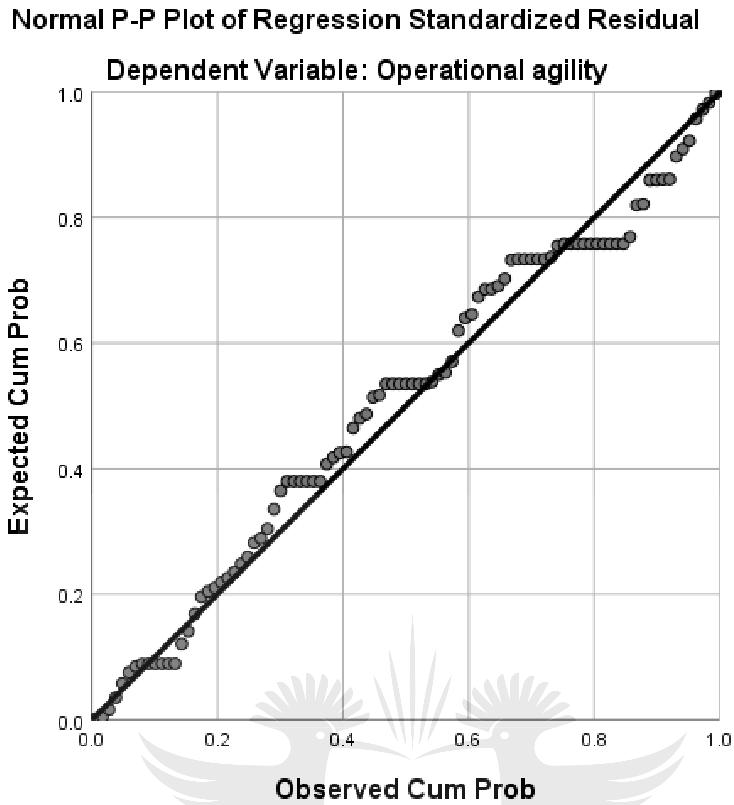
			infrastruc_cap_f1 Infrastructure capability: factor 1	infrastruc_cap_f2 Infrastructure capability: factor 2	infrastruc_cap_f Infrastructure capability: factors 1 and 2 combined	innovation Innovation	bus_integration Business integration	op_agility Operational agility	market_cap_agility Market capitalisation agility
Spearman's rho	infrastruc_cap_f1 Infrastructure capability: factor 1	Correlation Coefficient	1,000	0,533	0,861	0,648	0,523	0,458	0,454
		Sig. (2-tailed)		0,000	0,000	0,000	0,000	0,000	0,000
		N	96	96	96	96	96	95	93
	infrastruc_cap_f2 Infrastructure capability: factor 2	Correlation Coefficient	0,533	1,000	0,874	0,652	0,507	0,547	0,504
		Sig. (2-tailed)	0,000		0,000	0,000	0,000	0,000	0,000
		N	96	96	96	96	96	95	93
	infrastruc_cap_f Infrastructure capability: factors 1 and 2 combined	Correlation Coefficient	0,861	0,874	1,000	0,750	0,579	0,569	0,524
		Sig. (2-tailed)	0,000	0,000		0,000	0,000	0,000	0,000
		N	96	96	96	96	96	95	93
	innovation Innovation	Correlation Coefficient	0,648	0,652	0,750	1,000	0,714	0,658	0,613
		Sig. (2-tailed)	0,000	0,000	0,000		0,000	0,000	0,000
		N	96	96	96	96	96	95	93
	bus_integration Business integration	Correlation Coefficient	0,523	0,507	0,579	0,714	1,000	0,698	0,743
		Sig. (2-tailed)	0,000	0,000	0,000	0,000		0,000	0,000
		N	96	96	96	96	96	95	93
	op_agility Operational agility	Correlation Coefficient	0,458	0,547	0,569	0,658	0,698	1,000	0,712
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000		0,000
		N	95	95	95	95	95	95	93
	market_cap_agility Market capitalisation agility	Correlation Coefficient	0,454	0,504	0,524	0,613	0,743	0,712	1,000
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	
		N	93	93	93	93	93	93	93

Appendix 4



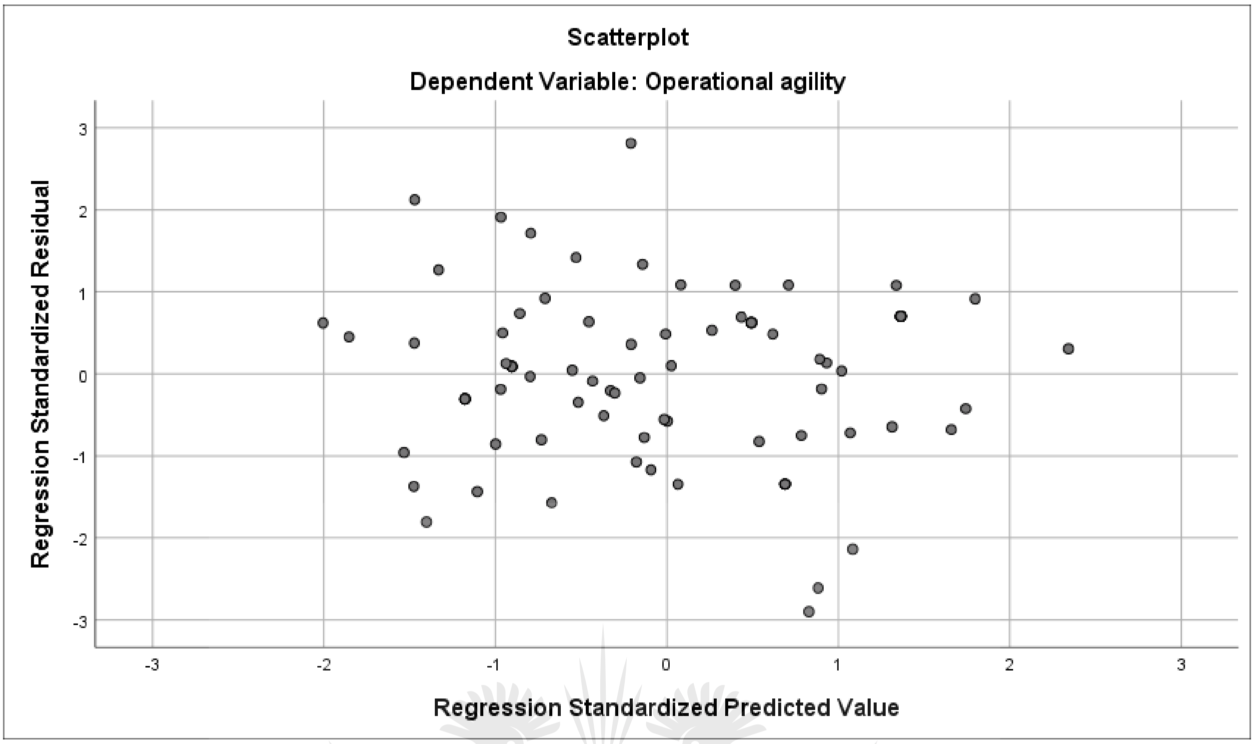
Histogram
Dependent Variable: Operational agility
Mean = 0.00
Std. Dev. = 0.986
N = 95
Frequency
0
5
10
15
20
25
-3
-2
-1
0
1
2
3
Regression Standardized Residual

Appendix 4



Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Operational agility
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0

Appendix 5


Scatterplot
Dependent Variable: Operational agility
Regression Standardized Residual
3
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2
3
Regression Standardized Predicted Value