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FACTORS FOR THE DESIGN OF AN INTEGRATED REAL-TIME INFORMATION SYSTEM FOR PUBLIC COMMUTING IN SOUTH AFRICA

by

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DECLARATION

I, Aphiwe Hlophe, declare that the contents of this dissertation/thesis represent my own unaided work and that the dissertation/thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed:  **Date: 10/12/2021**

ABSTRACT

The South African public transport system experiences a myriad of challenges documented extensively in the literature, which result in poor service quality and decreased ridership. Public transportation challenges are also experienced globally. However, various countries across the world have implemented technological solutions within major cities to solve public transportation challenges. These technological solutions include establishing an integrated real-time information system (IRIS) to address the commuting needs of public transport commuters. This study explored the factors affecting the availability and accessibility of real-time information for public commuters in South Africa to understand the design requirements for an IRIS for public commuting services in the country.

The study adopted an inductive qualitative approach to provide in-depth insights into the research subject, using service design as a research strategy. Data for the study was collected through semi-structured interviews with public transport operators (PTO): PRASA, MyCiti Bus rapid transit (BRT), Golden Arrow, and Minibus taxis within the City of Cape Town (CoCT), and Co-design sessions with public commuters. Secondary data sources such as policy documents and other strategic planning documents relating to the public transport sector were reviewed to supplement the empirical data. Subsequently, data was analysed using content analysis and thematic analysis, identifying patterns and themes from data in different formats. Activity theory (AT) was applied to interpret the relationship between the commuters, PTOs and the envisioned IRIS.

The main research question encompasses the factors influencing the design of an IRIS for public commuting in South Africa. Findings from the study revealed that the key factors include upgrading existing infrastructure, adopting standardised processes to ensure uniformity in an integrated model, drafting policies that regulate PTOs participating in an IRIS, and acquiring and implementing technologies such as smart cards, vehicle sensors, open-access wireless networks, interactive maps and display screens at transport facilities. The technology factor is at the core of an IRIS as it supports the integration of various subsystems from the PTOs. The study also sought to understand the design requirements for an IRIS from the PTOs and the commuters' perspectives. The PTOs required more administrative functions to manage a fleet, drivers, customer reviews, payments, and update commuters on scheduled maintenance. The commuters mainly required functions to support their decision making on alternative routes and modes. These include electronic payments, multilingual travel information, search or filter travel information, live vehicle location, notifications through SMS, text to audio conversion and downloadable schedules for offline use.

This thesis also presents a conceptual design of the IRIS co-created with commuters to ideate the design requirements for the system. The research outputs are positioned to assist the South African Department of Transport to develop comprehensive policies, strategic plans and infrastructural development initiatives to implement an integrated public transport system.

Keywords: Real-time, Travel information, Integrated transport, Public commuting, Intelligent transport, ICT in transport, Sustainability.

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GLOSSARY

AT	Activity Theory
BRT	Bus Rapid Transit
CBD	Central Business District
CCTV	Closed-Circuit Television
CoCT	City Of Cape Town
CoJ	City of Johannesburg
DoT	Department of Transport
DSS	Decision Support System
HCI	Hosken Consolidated Investments
ICT	Information and Communication Technology
IRIS	Integrated Real-time Information system
IS	Information System
ITS	Intelligent Transport System
MIS	Management Information System
MSDF	Municipal Spatial Development Framework
POPI	The Protection of Personal Information Act
PTO	Public Transport Operator
SA	South Africa
SANRAL	South African Road Agency
SARCC	South African Rail Commuter Corporation
StatsSA	Statistics South Africa
TOD	Transit-Oriented Development

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CHAPTER ONE: INTRODUCTION

Historical spatial land use policies and escalating property prices in the city centre have led to many living farther from their workplaces, thus commuting long distances to and from work in South Africa (Moyo et al., 2021). According to Litman (2018), public transport reduces the dependence on automobiles in dense urban areas, and it is the most cost-effective way to access transportation in urban regions. However, numerous problems dog the South African public transportation system, leading to dysfunctional public commuting and inefficient transportation services. It is argued that most problems associated with the public transport system in South Africa mainly stem from lack of infrastructure development and maintenance, inaccessibility, government negligence, corruption, rising fuel prices, safety and pollution concerns, all of which have limited the potential of the system (Bronkhorst, 2019). According to a 2017 survey conducted by Statistics South Africa (StatsSA), only 34% of South African households possess a car, while 66% rely on taxis, buses, railways, and other public transportation modes (StatsSA, 2018). Despite the rolling out of infrastructure projects such as ReaVaya and MyCiti bus rapid transports by the government to reduce overcrowding and other traffic-related social problems of public commuting, the problem continues to exacerbate (Scorcia & Munoz-Raskin, 2019). The situation is such that the rapid bus transit in peak hours generate much-commuting traffic; thus, the inability to make real-time decisions on the current status and available alternative routes to take often leaves many stranded, which results in overcrowding of public transportation facilities (Teffo et al., 2019).

The public transport system is utilised by a large percentage of a country's population globally, and commuters rely on timeous information to access available public commuting options (Friman et al., 2020). Real-time information is described as available information on-demand within a very short timeframe, in a format accessible through analytical platforms to make informed decisions (Jony, 2016). Real-time information can be used in stock market trading to either decide on buying or selling shares; in clinical care to provide better treatment and make fast and accurate decisions on patients to promptly detect natural disasters, saving thousands of lives and resources; and in the defence forces where timely decision making can give an advantage in warfare. Access to real-time information is facilitated by using information systems designed to enable access and interaction of information on-demand in real-time (Jabbar et al., 2020). In essence, real-time information systems are designed to deliver accurate and instantaneous information for informed decisions, mainly in operations, process engineering, maintenance, and transportation (Zurawski, 2012). As advances in transportation technology grow, real-time information has become a vital need increasingly demanded by

public commuters to navigate their way and access available commuting options and connecting modes of transport (Ceder, 2020). According to Ramli et al. (2017), several countries in Europe, North America and some cities in Japan have implemented IRISs to improve the delivery of transport services, where commuters can access available options and plan for interconnecting trips.

IRISes are those capable of combining data sets from various sources to provide an aggregation of real-time information (Aziz et al., 2018). The public transport system, which consists of bus, train and taxi operators, can apply an IRIS to evaluate real-time traffic conditions, monitor destination routes, estimate time to destination, and change routes due to accidents, road congestion or natural disasters (Ceder, 2020). According to Gumbo and Moyo (2020), access to integrated real-time information for commuters can lead to radical transportation choice shifts, saving commuting time with timeous information, accessed remotely on mobile devices or at strategic transport facilities. Mthimkulu (2017) argues that the problems experienced by public commuters are further exacerbated due to the lack of integrated and timeous communication channels in place to inform commuters on the possible alternate mode of public transit available to them. Australia took the initiative with Yarra Tram Trackers real-time information system. “Adelaide Metro tram supplementary feeder bus stops information system and real-time departure countdown information at Adelaide’s SMART STOPs” are examples (Bachok et al., 2008:265). These real-time integrated information systems were implemented to address growing problems associated with public commuting and improve the experience of using public transportation (Zakwan et al., 2016).Lau and Wei Lok Ng (2015) reveal that in Hong Kong, integrated transport systems use real-time information, providing reliability, responsiveness, empathy, tangibility and connectivity between modes of transport, thus enhancing public commuters’ transportation experience. The study found that despite the overall improved customer experience, there remains a gap for assurance, described as a degree of safety from crime or harmful incidents within public commuting, a generic phenomenon to be constantly addressed.

The situation of the current public commuting in South Africa begs for an innovative intervention to address daily commuting experiences and associated problems. Recently, a smartphone-based app called Gauteng-on-the-move, based on android and apple operating systems aims to provide public commuters with static information to access timetables of different transport services in the City of Johannesburg (CoJ) (Das & Ngobeni, 2017). However, the mobile application provides static schedule information, which lacks real-time information that could inform commuters about possible delays, overcrowding in stations and bus stops, and alternative connection and commuting schedules needed to address some of

the major public commuting challenges in South Africa. Also, the mobile application is limited to only two mobile platforms and is dependent on the high consumption of mobile data, thereby restricting access and use by public commuters without large data bundles (Hawthrone & Grzybowksi, 2019). Drawing from the limitations of existing systems, this study will seek to address the nature of availability and accessibility of integrated real-time information for public commuting within South Africa. Therefore, the study will address the availability of real-time information accessible on multiple integrated platforms for public commuting in South Africa to mitigate the problems associated with real-time decision making within the South African public transportation system.

1.1 Background to Research Problem

The lack of real-time information on commuting options means opting for overcrowded transportation to avoid being stranded, often leaving commuters vulnerable to criminal acts, a situation that presents a major concern to public commuters (Luke & Hyens, 2020). Therefore, it can be argued that the lack of integrated real-time information on available public commuting routes has partly contributed to the unpleasant and unsafe nature of public commuting in South Africa. The effect of real-time information on public commuting is that commuters are often left stranded in peak hour traffic and subsequently fail to arrive at work when due. Also, a study conducted by Gobind (2018) shows that time taken commuting can contribute to workplace fatigue and reduced concentration. Jevinger & Persson (2019) argues that the absence of real-time information on public commuting modes inconveniences public commuters who are also subjected to unsavoury conditions and extensive delays. It is further argued that the prolonged delays also result in students missing out on school time and elderly citizens being subjected to long queues and uncomfortable trips with an adverse effect on their health. Moreover, Peña Cepeda et al. (2018) state that physically challenged people have been identified as one group that experiences social exclusion due to their reduced mobility. Having access to information can help them identify transport modes and suitable conditions, thus providing comfort for people with disabilities when commuting.

The challenges above, experienced by public commuters, could negatively impact service delivery, trigger negative perceptions and, in turn, influence future use and negative perception of public transportation. Gobind (2018) posits that in public transportation, negative emotions caused by service failures can be aggravated by the passengers' feelings of not controlling their options and experience using public transportation. The authors further argue that poor service quality can result in loss of ridership turnover for the transport sector, which will reduce the budget reinvestment into providing better infrastructure. The apparent dissatisfaction with

public transportation services leads to a decline in ridership, which results in low revenue and a poor rating of government service delivery (Niemand & Chauke, 2017). Therefore, the dearth of reliability and safety of public transportation facilities for public commuters in South Africa begs for an effective and innovative intervention (Gumbo & Moyo, 2020). The debilitating public transport system, if not adequately addressed, can negatively impact means of livelihood, delivery of efficient public services, provision of social activities, employment growth, and education, with an adverse effect on the wellbeing of the citizenry (Van Amen et al., 2017).

The problem of public transportation in South Africa is perennial. Thus, it is pertinent to empower commuters to make informed decisions based on real-time information on the status of different modes of alternative public transportation routes that can be explored. As the regulator of public transportation services for commuters, the government must access innovative ways of addressing these incessant problems associated with public commuting (Niemand & Chauke, 2017). It has been argued that the South African public transport system, consisting of minibus taxis, trains and buses, is not integrated. They operate in silos, thus creating a highly dysfunctional transportation system (Luke & Hyens, 2017). As such, the lack of IRIS of operators plying public commuting routes cripples the ability of commuters to plan their trips, make informed decisions on connecting routes, take alternative courses, and make possible lifesaving decisions during their commuting time.

As highlighted above, one of the major challenges public commuters face in South Africa is the absence of real-time information to decide on the best possible options while using public transportation facilities. Shange and Harmacek (2017) thus argue that the lack of an integrated public transport system is a source of concern and frustration for public commuters to make decisions on available modes of transport. A country of South Africa's size needs to make provisions for an IRIS to aid and promote public commuting in this present age. Hassan et al. (2017)'s description of the lack of an integrated public transportation system and its implication is captured by the argument below:

"Poor quality public transportation has led to the investigation of intelligent communication systems to improve the public transportation system, through integration, and the challenges and opportunities that may result from this integration. South Africa is lacking in this regard, as a result, has led to the increased traffic congestion, increased travel time, delay as well as increased mortality rates due to road accidents and poor communication between the road users" (Hassan et al., 2017:729).

The gap in literature highlighted by Hassan et al. (2017) above relates that real-time information for public commuting has not been sufficiently explored in research. Liao et al. (2020) also declare that only a few studies have explored the impact of real-time information systems on public transport ridership and their potential role in improving the user experience. Similarly, the need to fill the gap in knowledge on accessible real-time information on public commuting systems in South Africa is emphasised by Shange and Harmacek (2017:76) arguing that, "transport integration is needed between the modes of transport to ensure a successful public transport system that can also be enjoyed by the poor". It is thus evident that there is a need for research to focus on the provision of an inclusive and IRIS for public commuters to make decisions on an alternative mode of transport and routes has been established. This study is significant for addressing the effects of traffic-related social problems such as overcrowding, delays and traffic jams and more, with adverse consequences and implications on public commuters.

1.2 Research Problem

South African public commuters often experience heavy traffic-induced social problems such as delays, overcrowding, and heavy traffic jams, leaving them stranded and susceptible to criminal activities. The situation is pervasive because the South African public transport system currently lacks an IRIS for public commuters to make decisions on alternative modes or routes of commuting (Klopp et al., 2019). The lack of real-time information on alternative modes and routes of public transportation hampers commuters' ability to make informed decisions, subjecting them to a constant state of vulnerability and high levels of perpetual discomfort (Lionjanga & Venter, 2018). Consequently, the unavailability of integrated real-time commuting information systems is a disadvantage, which may escalate dissatisfaction levels and frustration among public commuters, with adverse implications on the transportation system and economy at large (Thomas, 2016).

1.3 Aim of the Study

This study aimed to explore factors affecting the availability and accessibility of real-time information for public commuters in South Africa to understand the design requirements for an integrated real-time information system for public commuting services in the country.

1.4 Objectives

In order to investigate the issues surrounding the availability of real-time information for public commuting options, the following objectives are set to understand the subject matter better and develop innovative ways of addressing the research problem. The research objectives pursued to answer the research questions are:

1. To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.

2. To determine the available public-commuting information channels in South Africa.

3. To determine the real-time information required for public commuting in South Africa.

4. To identify design requirements for an IRIS for public commuting in South Africa.

1.5 Research Questions

The overarching research questions for the study are formulated as follows:

RQ1:What are the factors influencing the design of an IRIS for public commuting in South Africa?

- **SRQ1:** What are the challenges affecting the provision of real-time information for public commuting decision making in South Africa?

- **SRQ2:** What are the accessible information dissemination channels for public commuting in South Africa?

- **SRQ3:** What are the real-time information needs of public transport commuters in South Africa?

- **SRQ4:** What are the design requirements for an IRIS for public commuting in South Africa?

1.6 Ethical Considerations

Conducting research requires honesty and integrity to protect the rights of participants (Burns & Grove, 1993). The research needs to respect people's rights to anonymity, informed consent, and confidentiality. The data collected from participants should be used for academic purposes and only for the research. In qualitative research, ethical concerns become more salient, especially when conducting face to face interviews where participants express their feelings (Arifin, 2018). Participants should be briefed regarding the aim and objectives of a study so they can consent to participate through signed letters of consent. Participation should be voluntary because individuals are free to withdraw at any point in time. This research remained ethical in its approach in that it put appropriate measures in place to mitigate the possibilities of physical or psychological risks to participants. Ethical clearance was obtained from the Cape Peninsula University of Technology to ensure that this research is conducted by its ethical standards. The ethical considerations of this research are further discussed next.

a) Informed Consent

Participants exercise their right to participate in research through a mutual trust agreement. This arrangement is honoured through informed consent (Orb et al., 2001). Although the organisation's permission was requested for this study to access potential interviewees from the PTOs, yet individual respondents were required to sign a letter of informed consent to be part of the interview process. This letter highlighted the nature of this research so individuals can make an informed decision as to whether they want to participate. The participants were not compensated for being part of this study, which reduced the possibility of biased answers. The interviews took place at a location preferred by each participant, so they feel at ease with an environment they are familiar with. The co-design session also required that each stakeholder sign a consent letter before participating in the workshop.

b) Confidentiality and anonymity

Confidentiality means that the participants are known to the researcher, but their identity will not be disclosed in reporting the results. On the other hand, anonymity requires that even the researcher does not know the respondents. This is a common requirement in survey research. However, in this research, the participants were reassured confidentially that their answers from interviews would be treated as confidential. This is very important to ensure that interviewees feel safe and express their true feelings without the fear of being persecuted (Burns & Grove, 1993). The results from the data collected were used for academic purposes only and not shared with any third parties. Pseudo names were used to maintain the confidentiality of the interviewee's real identities. The data collected in the co-design session

ensured anonymity since the respondents were not required to provide personal information during the workshop.

c) Potential for harm

This research did not pose any harm or abuse, both physically and psychologically, to its participants, nor was the environment or any animal harmed. The researcher recorded truthful information from the participants. The researcher understands the potential emotional distress in qualitative research where interviewees express their feelings, and therefore, a heightened level of sensitivity was taken, especially when dealing with a vulnerable group of people. To create a calm atmosphere during the data collection process, participants could refuse to answer questions they are not conformable with.

1.7 Research Assumption

The research assumes existing modes of information systems available to public commuters in South Africa, where information provided is static and exists in silos with limited accessibility. The research is proposed on the premise that there is no existing, fully integrated public transport system in South Africa capable of providing seamless access to real-time information on the status of different modes of public transportation for all categories of public commuters in South Africa at all times.

1.8 Delineation of the Study

While sea and air transportation can also be considered public commuting, this research focuses only on intracity public commuting on road and rail, excluding the air and sea modes of transportation. The research is delineated to public commuters and transportation agencies operating in the CoCT.

The research will be conducted in Cape Town. Therefore the identified challenges of real-time information cannot be generalised to all public commuters residing in cities located in other provinces due to contextual factors.

Nevertheless, the system can be adapted to all South African provinces due to the similarities in commuting structures and the stakeholders' operations.

1.9 Significance of the Study

- This research will provide insights into factors affecting real-time information for public commuting in South Africa and associated problems affecting the public transport system in the country.

- This research will provide design concepts, which can be further developed and implemented to provide real-time information to improve the public commuting experience in South Africa.

- This research will assist the South African Department of Transport to develop more robust policies towards better integration of the transportation system nationwide and complement the vision of building and actualising smarter cities in South Africa.

1.10 Organisation of the Thesis

This chapter introduces the entire study, from the first to the last chapter. The structure of this thesis is as follows:

- **Chapter one:** This chapter introduces the study and provides the background to the study.

- **Chapter two:** This chapter provides an analytical summary of the literature related to this study.

- **Chapter three:** This chapter outlines the methodology used to collect and analyse the data in this study and justifies their selection.

- **Chapter four:** This chapter analyses the data collected using the methods outlined in chapter three.

- **Chapter five:** This chapter maps the findings to the components of Activity Theory.

- **Chapter six:** This chapter discusses the study's findings with the support of existing literature.

- **Chapter seven:** This chapter presents the main conclusions arising from this study.

- **References:** This section provides a list of literature and materials used in the study.
- **Appendices:** This section contains the following attached Appendices:
    - Co-design session outline
    - Co-design questions
    - Interview Outline
    - Interview transcripts
    - Data worksheets
    - Individual letter of consent
    - Organisational letters of consent
    - Ethics certificate

1.11 Chapter Summary

This chapter states the research problem, the study's aim and objectives, and the research questions derived to address the problem. It also introduces the topic then provides the background of the study. Furthermore, in this chapter, the author justifies the research by showing its significance for both research and practice

CHAPTER TWO: LITERATURE REVIEW

This chapter provides an overview of the literature regarding the key concepts of the study and a review of related works by other researchers. Specifically, the following aspects are covered:

i. Public transportation
ii. Public transportation in South Africa
iii. ICT in transportation
iv. Integrated transportation
v. Information Systems
vi. Intelligent Transport systems
vii. Smart Cities
viii. The theory underpinning the study
ix. Related work on Real-time information systems

2.1 Public Transportation

The rapid population growth in most major cities around the world has seen an increased number of commuters using public transport as a cost-effective means to access social activities (Ceder, 2020). Although public transportation does not offer the level of convenience found in private car transportation, it has become the essential link that moves the population within cities and between regions globally (Poliak et al., 2017). The public transport system is responsible for moving passengers, including vulnerable groups such as students and seniors, to schools, healthcare facilities, and workplaces. Public transportation can be operated at local, regional and interregional traffic. Public transportation can be operated on land, water or air (Dziekan, 2008). The definition and application of public transportation vary greatly within across the world. Developing countries might have a unique definition compared to developed countries.

2.1.1 Air Transport

Air transport is a mode of commuting where passengers are the most integrated through the shared access to terminal facilities and airports (Ilmu, 2018). The great advantage of air transport is its speed. Hence, the costs associated with air transport are still relatively higher than sea and land transport. The use of air transport gained popularity during the 20th century, both for freight and passengers (Button, 2008). Air transport for freight is advisable when moving perishable or high-economic value goods. In terms of passenger travel, it is the most

convenient choice among long-distance travellers such as tourists (Darmawan, 2012). Air passengers could either be moving domestically from one local region to another or internationally between multiple countries (Spasojevic et al., 2018). In both developing and developed countries, air transport and freight are still seen as the most convenient and most costly modes of transport. Its integration is based on the central governance from civil aviation regulatory organisations, which determine the standards of operation of airlines.

2.1.2 Sea Transport

Sea transportation has high terminal expenses since ports of entry facilities are among the costliest to build and keep operational (Esmer, 2018). Sea transportation accounts for more than 90% of the global importers and exporters courier network (Sophister, 2016). The advantage of this type of transport is moving large quantities of materials compared to land and air transport (Micoo et al., 2003). However, this mode of transport is slower and can further be delayed by a few days to months based on weather conditions (Chen et al., 2018). Isaksson (2018) states that delays are counted in days in sea transport and (2019) states that delays are counted in days in sea transport and, unlike flights, ships are often off schedule. Although sea transportation remains ideal for long distances and large international loads, there are instances where passengers move between countries using this mode of transport as it is the most economical type of transport.

2.1.3 Land Transport

Land transportation is the oldest and most flexible accessible type of transport. Unlike air and sea transport, ground transport is used for shorter distances and is relatively cheaper. However, this form of transportation can prove expensive in developing countries where inland infrastructure may not be up to standard (Graham, 2005). Land transport includes modes such as rail, taxi, and buses. These modes are used for commuting on local trips. According to Sun et al. (2016), due to the rapid economic development of society, it is increasingly more important for people to travel. The most common ways to travel are by highway and rail transport, and taking advantage of these modes promotes the growth of the national economies as the economy and transportation complement each other. There is a demand for land transport policies that are both financially and environmentally sustainable to reduce the growing public transport subsidies and reliance on private vehicles (Sun et al., 2016).

2.2 Public Transportation in South Africa

Public transportation is comprised of all transport modes in which the commuters do not travel using their vehicles. In this study, the term public transportation refers to the land transport system. Thus, only Bus and Rail transport and Taxis are the key focus areas.

2.2.1 Public Bus Service

The South African public bus service is divided into a public and private model of operations. Bus rapid transit system (BRT) would be such an example of contracted bus operators whilst the various Municipalities provide their own public bus service, with both being regulated by the provincial government (Thomas, 2016). The South African government launched various (BRT) projects in different cities across the country in line with the hosting of the 2010 soccer world cup; an example of such services is the MyCiti bus system currently operational in Cape Town; Rea-Vaya used in Johannesburg and the people-mover in Durban (Mmari & Markon, 2017). Although these modernised means of bus transportation have been adopted to everyday commuting, the service is still limited to suburban areas, whilst accessibility in townships where a large population of public commuters reside is low due to costs involved in maintaining such routes (Piek, 2017). Lionjanga and Venter (2018) argue that for BRT systems to deliver pro-poor outcomes, there needs to be an enhancement of accessibility in poverty populations to connect workers to job opportunities and social benefits such as education and healthcare. Besides the challenges associated with accessibility, there are benefits realised through BRT services: dedicated lanes separated from other traffic, efficient fare collection, attractive stations and distinctive system identity (Gupta et al., 2014). According to Jennings (2015), countries like Colombia, Mexico, Indonesia and Nigeria have reduced cost, improved mobility options to poor areas, reduced travel time and reduced waiting times compared to South Africa, where the BRT services have failed to improve the livelihood of commuters partly due to limited coverage and pricing scheme.

In comparison to the BRT service, Municipal buses are more conventional and accommodate all classes of citizens, making them more inclusive but less reliable due to the lack of maintenance of the vehicles (Gobind et al., 2015). Each municipality manages its public bus system, like the Ethekwini Municipalities, which has its Durban metro bus service, while CoCT commuters use the Golden Arrow bus service (Bannister, 2017). Whilst each city would source and manage its bus service, the fares are usually kept at affordable rates as the public bus services often become prone to strikes and arson attacks from dissatisfied protestors (Rink, 2016). Hence, the public metro buses are less developed in terms of infrastructure and vehicle

standards. This can be attributed to the fact that the municipality does not make enough revenue from the services to re-invest in better infrastructure (Walters & Manamela, 2016).

A study conducted in the Western Cape found a high level of dissatisfaction with the conventional bus services compared to the local MyCiti BRT service. The research compared driver compliance, vehicle overloading, vehicle comfort, vehicle safety, and driver-customer care (Behrens et al., 2018). The BRT systems such as MyCiti have a technological edge over the conventional bus services by providing travel information at terminals; however, this information is based on static estimations and is only accessible once the commuter has reached the terminal (Prayogi, 2015). It has been argued that the services of conventional buses can be significantly improved through the accessibility of real-time information on available modes and routes of public transport. The provision of real-time information on public commuting platforms will address the problem of static and unreliable information on the printed time schedules provided by municipal bus services and static travel information at BRT terminals (Noursalehi & Koutsopoulos, 2016).

2.2.2 Railway Transport Service

The Metrorail service in South Africa regulated by PRASA offers a more affordable alternative to commuters. According to StatsSA (2018), railway commuting is most common in the Western Cape, attributed to the high volume of road traffic in urban areas like Cape Town. Unfortunately, trains are unreliable due to a lack of structured scheduling, where trains often do not pitch at the scheduled time (Mtizi, 2017). Notwithstanding, South African commuters' perception of fares is satisfactory. The areas of concern remain the safety on trains and in the stations; breakdown of trains; inadequate operational times; and the cleanliness of trains, contributing to mounting dissatisfaction with the train services (Heyns & Luke, 2018). Conradie et al. (2015) state that railway service has become a convenient commuting choice due to competitive travelling fees. However, the service quality is deteriorating due to the provider's inability to cater for the number of commuters at peak hours, which results in overcrowded vehicles that force people to risk their lives by standing against doorways just to reach their destination.

The punctuality of the trains is a major cause of constant dissatisfaction amongst commuters who rely on the services, often resorting to protests when the trains do not arrive on the scheduled time and exposing commuters to dangers of vandalism and arson (Tripathi & Borrion, 2016). Mangogna and Gray (2015) also state that passengers use punctuality to measure the reliability of trains, and in South Africa, 84.5 % of the trains reach the final

destination within the international margin of 5 minutes. This is low compared to European operators who have an average of 95% punctuality. Investing in building modern and integrated high-speed railway systems similar to those operating in Europe, East Asia, and North America, according to Michniak (2016), will improve the reputation of the service and reduce the issues associated with punctuality. High-speed railway systems for outer city routes, combined with an effective information dissemination source, reduce the issues associated with punctuality and overcrowding, as pointed out by (Dlodlo 2015). In South Africa, the Gautrain is an example of a high-speed railway system launched in 2006. The service is operational in the CoJ, and accessibility is limited to certain areas (Niemand & Chauke, 2017). Though observation shows that such infrastructure improves the reliability of the train service, yet commuters find themselves having to pay significantly higher fees for such facilities. Despite the services provided by the Gautrain, there are still instances of delays, albeit it has better reliability than the city metro rail that is often plagued by high delay incidents.

The current metro railway service provides digital and printed schedules for commuters. It is difficult to make decisions based on this information, which is often unreliable and contain inaccurate estimates. The digital information provided on the status of the train schedule is only accessible on arrival at the main stations, leaving many stranded, queuing and converging on the next available option leading to overcrowding (Mathabatha, 2016).

2.2.3 Mini-bus Taxis Service

The Mini-bus taxi industry in South Africa is the most widely used and easily accessible means of public commuting (Piek, 2017). Although the industry is regulated by the Provincial Regulating Entity (PRE), it is largely unstructured and uncoordinated with other modes of transport (Vilakazi & Govender, 2014). According to Bickford and Weakley (2015), minibus taxi commuters often experience inconveniences due to the unstructured nature of the industry, lack of schedules, and timed trips resulting in drivers making irregular stops to pick up passengers and causing delays and overcrowding on roadsides. Nevertheless, commuters often prefer this mode of transport, because of the convenience of arriving closer to their homes or workplaces. However, due to a lack of information on real-time taxi scheduling and availability of space, , passengers often board the taxis with no available seats with dangerous implications for their safety out of desperation for the relative proximity to the destination offered by the taxis (Mhlanga, 2017).

The taxi industry is prone to resist change, as it still operates exclusively through traditional means of fare collection by the conductor when the trip commences (Piek, 2017). Lionjanga

and Venter (2018) state that travelling fees in taxis are route-based and often inflated depending on-peak and off-peak hours, compared to other modes of transport that offer weekly, monthly or yearly tickets purchases. Despite the many challenges of the minibus taxi industry, Kgwedi and Krygsman (2017) argue against the minibus-taxi industry's negative perception, stating that it is an opportunity to transform minibuses into an effectively scheduled public transport system innovatively. The authors also emphasise a need for firm policies that regulate the taxi industry to address commuter interests, safety, traffic congestion, branding of the city, and to ensure a balance of taxi supply and demand. The transformation of the minibus taxi service into a structured system will assist passengers and drivers with inconvenient trip planning and provide safety for commuters since the industry is notorious for incidents of route related violence and crime (Road Safety Annual Report, 2017).

Henama and Sifolo (2017) assert that a structured minibus taxi industry can lay the foundation for technological advancement with information-driven systems, similar to Uber and Taxify services. Furthermore, a system can be created where drivers and potential passengers can conveniently communicate locations with themselves while also providing potential passengers with information about the availability of seats in approaching vehicles. Such a system can only be realised by providing a real-time information mechanism operating on innovative ICT tools.

2.3 ICT in Transportation

Advancements of ICT in transportation, including electronic fare collection, electronic roadside signs, vehicular location services, CCTV and remote camera surveillance, mobile transport applications, and the use of interconnected internet devices have brought about developments in public transportation systems all over the world, albeit a significant gap still exists in South Africa (Bashingi et al., 2016). Recent ICT developments in the transportation sector have improved driver assistant functions such as vehicle guidance systems, vehicle automation, intelligent warning systems and safety mechanism, together with visibility improvement systems, amongst others (Polzin, 2016). Agarwal and Alam (2018) argue that despite the world's rapid urbanisation with ICT innovations reaching new heights, implementing ICT solutions in transport systems has been happening slowly due to the lack of sensor-enabled connected networks in towns and cities to facilitate seamless exchange. The argument has been made that the South African transport system can integrate ICT with road transportation and socio-economic functions effectively in cities to contribute towards sustainable road transportation (Feikie et al., 2017). Although ICT can positively impact transport systems,

Makino et al. (2018) argue that some countries that have implemented ICT solutions within their public transport systems still experience challenges relating to uncoordinated, complex, and silo systems, lack of knowledge about deployment strategy, and lack of a master plan to maintain such complex systems.

2.3.1 Smart Cards

Smart cards are an innovative and time-saving ticketing method (Puhe, 2014). They provide a seamless travel experience. Their usage makes it easier for passengers to top up balances and conveniently transfer between modes of transportation (Pelletier et al., 2011). This method of smart-ticketing has improved public transportation systems as it replaces the conventional paper-based ticketing system. Smart cards facilitate electronic fare collection with advanced systems that can be analysed to understand commuter travel patterns and passenger flow (Li et al., 2018). A study conducted in Finland revealed that smart cards make it easier for passengers to board vehicles. However, there are still concerns regarding the safety and costs associated with digital payment methods (Bashingi et al., 2016). Privacy is also a big concern with smart cards, as commuters may feel that their movements are being tracked. The costs associated with implementing smart card technologies are a big challenge for the transport agencies as card readers, and other forms of expensive computer equipment need to be purchased and installed on vehicles and stations.

2.3.2 GPS Navigation and Tracking

ICT has also provided the transport industry with a Global positioning system (GPS) that provides PTOs with tools to monitor and control operations and manage their fleet efficiently (Peraković et al., 2017). Vehicles equipped with GPS receivers can continuously calculate their three-dimensional location and velocity anywhere in the world and in any weather. According to Asad et al. (1998), Another term for this technology is “Advanced vehicle location” and has the following benefits for the commuter and operator:

- Improves performance through efficient dispatching and scheduling.
- Enables on-time response to service disruption.
- Improves the safety of drivers and passengers.
- Monitors and controls driver habits.
- Crucial in planning functions that determine the selection of routes and stops.

Vehicle tracking using GPS is gaining quick popularity among fleet owners as the technology becomes more affordable and available (Begashaw, 2018). In general, GPS vehicle tracking

uses a satellite system to monitor a vehicle's time and location data. This data is then sent to a dispatching centre via a cellular signal. The dispatch centre's data can be integrated to display all of the organisation's vehicles on a single screen, including their position, stop information, speed, and direction. In a complex environment, automated dispatch systems may use the transportation network's GPS data and current manifest information to dispatch a trip to the vehicle that is best suitable for the trip (Greenfeld, 2000).

2.3.3 Closed-Circuit Television (CCTV) Surveillance

CCTV cameras found in almost all parts of life can act as a deterrent to crime, capture suspicious behaviour, and assist prosecution if an offence occurs (Ashby, 2017). Although CCTV imagery is reflective as a security feature, it does raise concerns for the privacy of individuals who are going about their normal daily functions. Therefore, CCTV has to be managed appropriately to respect people's rights. According to Piza et al. (2019), installing cameras is not a solution to crime. However, it can be used with other interventions to act swiftly before a situation becomes volatile. The use of CCTV in transportation traces its routes to the aviation sector, where cameras are installed inside and outside the cockpit to monitor the cockpit door and passenger cabin (Kurdi, 2014). There has been a widespread adaptation of CCTV inside buses or carriages of trains. CCTV can be set up with networked IP cameras as part of a larger surveillance system that can be accessed remotely.

2.3.4 ICT Disruptions on Transport in South African

There is room for improvement for the South African public transport system in terms of adopting technology solutions that promote growth and sustainability (Ebrahim, 2019). According to Hershner (2017), the use of e-hailing services like Bolt and Uber has the potential to help reduce traffic congestion and make an impact on the economy while this is done. In recent years, these services have become the biggest form of transportation disruptions in the country and Africa as a whole. The combination of non-motorised vehicles and e-hailing services could solve the traffic-related issues experienced on the roads in South Africa. South Africa has a lot of unpaved roads, with roughly 30% of roads being paved and the quality of these roads also vary based on region (SANRAL,2020). Although e-tolls have been implemented to try and create revenue for roads maintenance, a large number of road users do not pay their tolls (Venter, 2018). Communities in rural and underdeveloped areas would not be able to utilize such services as e-hailing without proper road infrastructure. The use of (IoT) internet of things devices by car manufacturers like Ford has improved the means of handling traffic by those who rely on private vehicles, some of their modern cars come built with traffic alert systems that are crowdsourced and share information on current traffic congestions to other vehicles (Cosgrove, 2018).

2.4 Integrated Transportation

Integrated transport aims to provide a sustainable and effective transport system without degrading the ecological economy and social environment (Guzman et al., 2018). Integrated public transport systems help commuters to compare different routes and choose the best suitable mode of transport through comprehensive information systems (Aziz et al., 2018). Thus, integrating different transport modes reduces traffic congestion and provides commuters with convenience, efficiency, and affordable alternatives. Similarly, Feikie et al. (2016) state that integrated public transport combined with ICT can facilitate real-time information to commuters in South Africa to assist with the trip and route planning. Consequently, this will reduce traffic congestion as more people rely on public transport and less on unnecessary private vehicle commuting.

Integrating public transport systems involves collaboration between various entities. According to Poliak et al. (2018), these entities are the ministry of transport, governing regions, cities management, integrating organisation, railway transport carriers, suburban carriers, and carriers of urban public. A provincial plan is typically developed to highlight challenges in the existing systems to transform them into integrated systems, according to Chowdhury et al. (2018), who conducted a study that compared legislators and users' perceptions of services of an integrated system. The authors found that most legislators regard “network integration” as the most important feature in integrated public transport, while both users and legislators considered “fare and ticketing integration” a vital feature. Poliak et al. (2018) state that the integrating organisation, an independent entity, is tasked with ensuring no conflict of interest between the different components, as highlighted in figure 2.1.

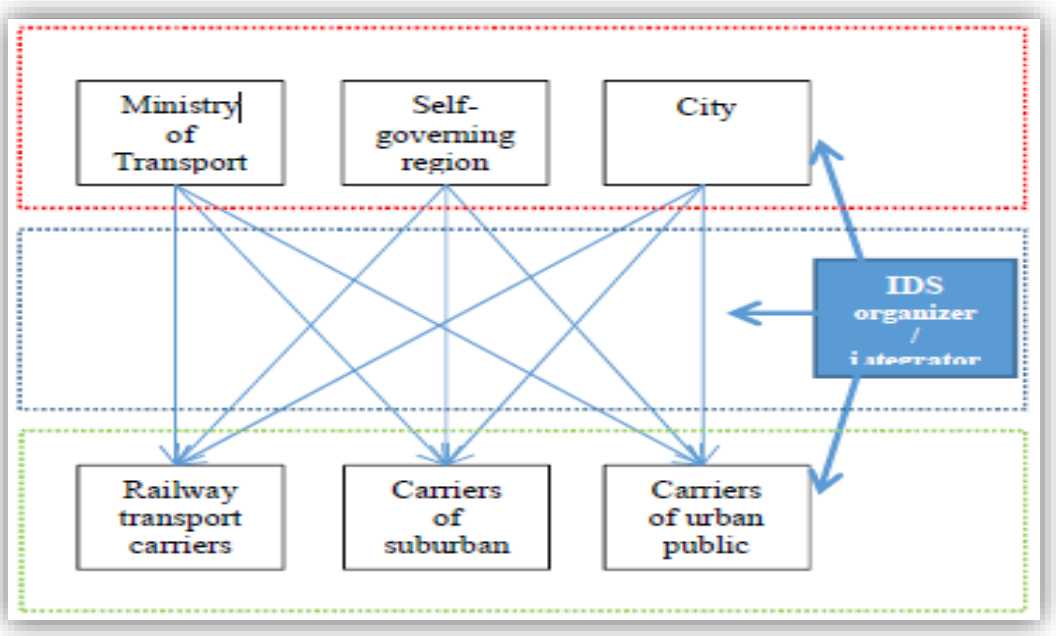

Figure 2.1 Three-level model for integration (Poliak et al., 2018:2)

Paulsson et al. (2018) state that network integration forms the basis for the collaboration of municipalities and PTOs. It facilitates partnership agreements on public transport priorities and builds common ground for interaction with transport providers operating tendered contracts. Mrníková et al. (2017) argue that non-integrated public transport systems cannot meet the customers changing needs, resulting in decreased ridership. Similarly, Poliak et al. (2018) also mention that some revenue may be lost due to the system's unmet needs. Consequently, the absence of an integrated public passenger transport system causes a dysfunctional problem, impacting commuters' travel times, trip comfort, travel costs, and access to information (Sumalee & Ho, 2018). This situation is mirrored through the South African public transport system, which is riddled with many problems related to the non-integration of the public transport system. The different types of public transport intermodal integration are as follows:

2.4.1 Operational Integration

Operational integration refers to synchronising the different transport modes through real-time information sharing and timetable coordination. This type of integration would be impossible without proper access to the timetable information for the various modes (Turner, 2014). Timetable coordination allows travellers to get information from the same source in a similar format, regardless of the mode choice. An example of such is a traveller not visiting different websites or station kiosks for information on each mode of transport (Veryard & Perkins, 2018). The internet has evolved to simplify the process of aggregating multi-modal information sharing. In the past, transport modes kept information separately. For example, rail commuters

would need to make telephonic calls to get bus schedules. However, distributing information amongst multiple modals has become easier with the newer telephonic and web-integrated information services (Tovey, 2012).

2.4.2 Organisational Integration

Organisational public transport integration involves adapting standards that remove barriers between the PTOs. This can be achieved by establishing an independent authority to coordinate the functions and cooperation of the various stakeholders (Saliara, 2014). According to Wagner (2018), the existence of an independent authority ensures that the contractual agreements of the different agencies serve the best interests of the public transport users. The responsibilities of this authority include tariff integration and fare revenue allocation, service planning and marketing activities. Four coordination categories are required for successful organisation integration: organisational, contractual, partnerships, and discursive (Metaxatos et al., 2017).Organisation: Changing organisational structures into standardised business processes. This can be achieved by merging entities into one or creating joint working groups between these entities; Contractual: This form of coordination ensures that the entities involved remain compliant through written agreements that result in a penalty if violated. Partnerships; This is coordination between entities that have no legally binding agreement, and such examples include operators sharing traveller information; Discursive: to achieve coordination through changing negative impressions and verbally emphasising the need for coordination.

2.4.3 Physical Integration

Physical integration ensures that stations and stops are designed to reduce friction between the access modes and the public transport services. (Veryard & Perkins, 2018). Physical Integration can also refer to the planning of stops, stations and transfer centres, their location and facilities, and their design (Saliara, 2014). The design of the facilities is mainly focused on safely coordinating the transfer of passengers without any conflicts between pedestrians and vehicles movement. As in all design cases, the public transport users' needs must be taken into consideration, since not all users are the same, the design must accommodate passengers with children, luggage mobility difficulties and regular daily commuters (Tovey, 2012).

2.5 Information Systems

An information system is described as a set of integrated components such as databases, networks, software, hardware and procedures that input, store, process and output data (

O'Brien & Marakas, 2017). Different organisations have used information systems to gain a competitive advantage in their operations industry (Hasan Al-Mamary et al., 2014). The major types of information systems are Management Information Systems, Transaction Processing Systems, Decision Support Systems and Executive Information Systems, each operates and serves a function at some level of the organisation's managing structure (Falih, 2018). Organisations have developed strategies around information systems to solve the complexities of globalisation and change in the economic and political structures (Abualloush et al., 2016). The use of computer-based information systems has improved the availability of information in large quantities, and this provides organisations with means of power, and a decision-maker can determine the best options at a tremendous speed or in real-time (Mukhopadhyay & Cooper, 1992). The real-time concept determines the speed at which the information is consumed and the currency and relevance.

2.5.1 Management Information Systems

Information can be viewed as an organisation's most valuable asset and must be managed efficiently and effectively. According to Hasselqvist et al. (2016), an MIS represents a form of information systems designed to help organisations operate economically, increase their growth potential and improve efficiency by supporting the decision making process. Management information systems (MIS) provide sound information about the past, present, and future to enable them to make the best possible decisions (Amuna et al., 2017). MIS produces periodic reports, special reports, and summarised reports (Asemi et al., 2011). Top and low-level management use these reports to make decisions that solve the firm's problems. Examples of MIS include Sales Management Systems and Human Resources systems. Unlike DSS, the MIS has used the firm's internal operations in strategic planning instead of supporting specific decisions. Traditionally, a MIS existed without computers, but it became more powerful with the use computers (Aggarwal, 2016)

2.5.2 Decision Support Systems

Decision support systems (DSS) are interactive computer-based systems that help decision-makers utilise data and models to solve semi-structured problems (O'Brien & Marakas, 2017). The outputs of a decision support system, such as data displays, statistical analyses, modelling results, and graphs, are intended to support the human judgment involved in making decisions (Arnott et al., 2019). Like other information systems, the decision support system comprises people, procedures, software, databases, and devices that support problem-solving through effective decision-making. The main use of a DSS is for informed decisions. Many organisations use decision support systems to improve decision-making at top levels of management in which unstructured and semi-structured problems are tackled. Structured

problems are repetitive and solved through well-documented processes. Unstructured problems are ad-hoc and non-standardised. There is no formula for a solution. (Hassan, 1999). Semi-structured problems fall somewhat between structured and unstructured problems. In contrast to the MIS, a DSS goes a step further by providing immediate support in solving problems. The DSS merely provides support rather than replace managerial decision making.

2.5.3 Real-time Information

The concept of “Real-time” in computer science can be defined as a reaction to events with minimal delay. It is the continuous feed of updated information in response to real-world events (Furht et al., 1991). According to Mačiulis et al. (2009), real-time information can be used in multiple aspects of life; health works can use it to diagnose patients, and environmentalists can use it to predict changes in pollution and water levels seismic shifts (Strong & Goemans, 2015). In sports, real-time data is used to monitor the performance of athletes during a particular match. Real-time information is important in a dynamic environment such as transportation. Travellers can be provided with real-time travel information to plan trips, and transport operators can efficiently manage operations through the real-time tracking of vehicles. Figure 2.2 shows the expected response time for real-time information on different applications.

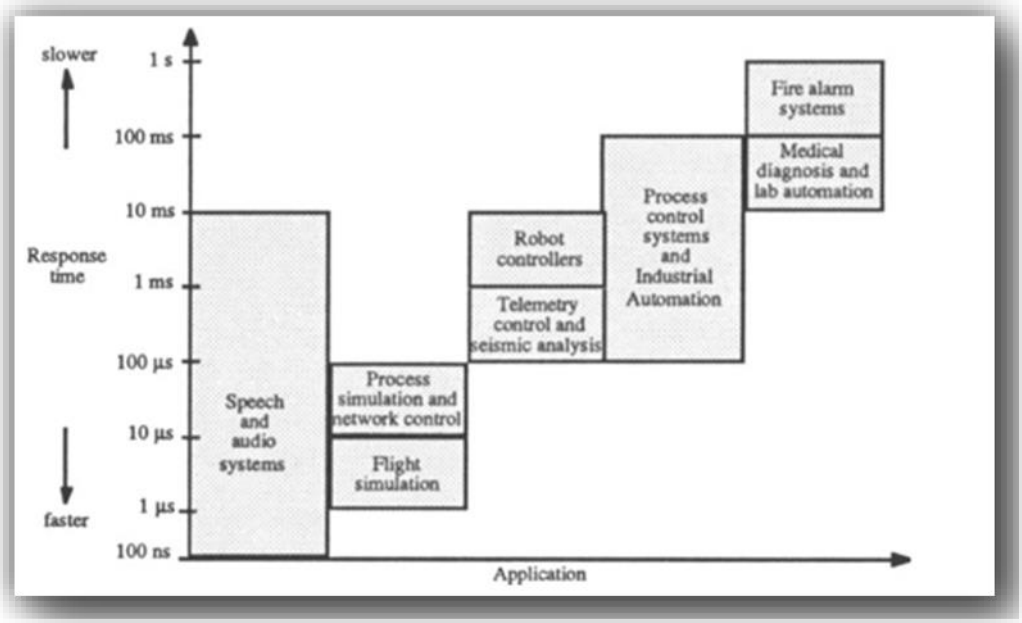

Figure 2.2 Real-time response times in applications (B Furht, 1991:2)

Two techniques can be used to collect real-time information for transportation: 1. Through embedding sensors in vehicles and roadside units, which started in 1998, 2. using mobile location services on phones, started in 2003 (Singh et al., 2014). The shift towards digital economies requires real-time processing and dissemination of information to keep up with customers' expectations of immediate responses and resolutions. Such services as airline reservations, online banking, real-time stock prices, and real-time order status alerts have become a norm.

2.5.3.1 Real-time Information Systems

Real-time information systems are systems in which the correctness of a certain computation is measured by the time taken to execute it. Such systems are critical in an industrialised nation's technological infrastructure. The real-time aspect is seen in telecommunications, manufacturing, railroad switching, aviation systems, and other mission-critical systems. According to Shin and Ramanathan (1994), The value of information in Real-time information systems can be classified into three categories:

- Hard – Not meeting the deadline can have severe consequences.
- Firm – Not meeting the deadline is not catastrophic, but the value of the information is rendered useless after the deadline.
- Soft – The value of the Information decreases when the deadline is missed but is still useful.

A deadline is a given time after a triggering event by which a response has to be completed. According to Burns and Wellings (2001), the differentiating factors between real-time and non-real-time systems are timing: Real-time systems are required to deliver correct results within a specified period; Interrupt driven: Real-time systems respond to events that arise as interrupt signals; Specialized hardware: Real-time systems often require some kind of specialised electronic hardware such as sensor devices; Unpredictability: Real-time systems are unpredictable as they respond to changes in their environments. These systems are expected to be fault-tolerant since there is a high level of risk for industries that rely on them. Although not always the case, in some instances, a failure can result in death or injury to the user and others (Vilakazi & Govender, 2014)

2.6 Intelligent Transport Systems

The advanced use of information and communication technology (ICT) in transportation is commonly referred to as Intelligent Transportation Systems (ITS). Intelligent Transportation System refers to implementing various advanced communication, sensors, and computing technologies in infrastructure and vehicles to improve efficiency, safety, convenience, and travel comfort (Abejide et al., 2018). ITS relies on integrating people, roads and vehicles through state-of-the-art ICT technologies. Sochor (2012) states that technologies commonly found in ITS include maps, journey planners, location-based services and real-time information about transportation options and conditions.

The rollout of an affective ITS will require a framework called a physical architecture that defines all the system's core functions and their interoperability independent of the technologies that will be deployed (Andersen & Sutcliffe, 2000). Physical architecture defines the rules to be followed from ITS implementation. An example is Figure 2.3, developed for the USA

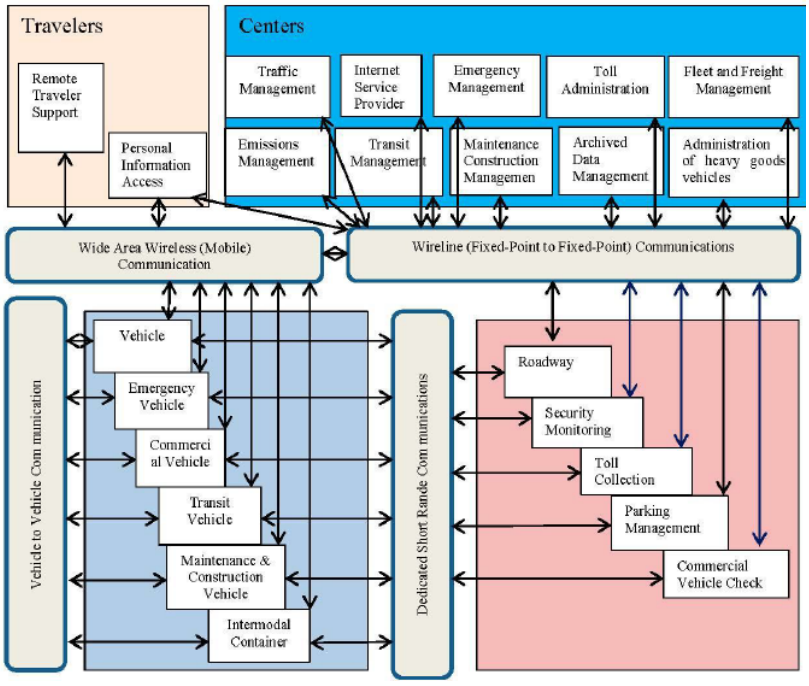

Figure 2.3 Shows ITS physical architecture (Stawiarska & Sobczak, 2018:5)

The ITS architecture forms part of the systems design and development lifecycle phases. Lack of architecture can result in incompatibilities between core system components, increased costs of upgrades and complications in introducing or adjusting to new technologies (Fernandez et al., 2016). Current ITS architectures integrate road traffic carriers well, but there

are growing calls for future ITS solutions that reduce discrimination against people with disabilities (Mandžuka,2015). Such examples are sensor-enabled glasses for blind people with a voice interface linked to a traveller information system that relays voice notifications on available modes of transport (Sochor, 2012).

2.6.1 Travel Information

The provision of public transport information services can help commuters make decisions on routes, modes, travel time, wait time and departure times. With the advancements in technology, this information can be provided in real-time, making it more relevant and reliable (Liao & Chen, 2015). Numerous travel information services on the Web are often used complementarily to improve travel information's adaptability, completeness, and personalisation (Kem et al., 2017). The idea of Integrated traveller information improves on the exploits of these web resources to construct travel solutions tailored to travellers' needs (Meng, 2016). Travel information is disseminated through various mediums such as smartphones, onboard displays, digital message signs, loudspeakers at the stops and mobile phones using SMS (Bachok et al., 2008). The preferred medium is determined by four user situations that refer to stages of a trip: pre-trip, at a stop, during the trip (onboard) and before return. For example, a user already at a station would prefer to consume travel information through displays and speakers at stops instead of receiving an SMS on a smartphone (Beul-Leusmann et al., 2013).

2.6.2 Traffic Management

The increase in the number of vehicles in towns across the world has affected traffic flow and has contributed to the increased pollution through vehicle carbon emissions (Rath, 2018). Traffic management can be described as an approach to managing the demand and supply of a traffic network within space and time (Jonkers & Gorris, 2015). The approach uses sensors located on vehicles and high speed secured wireless communication networks to send and receive data from a central database. This data can be related to traffic incident data, images, videos, traffic analytics data, and period-wise traffic reports (Gade, 2019).

2.6.3 Electronic Toll Collection (ETC)

Electronic toll collection began in the eighties by countries such as the USA and France, although during that era, the traditional stop and go approach was used and required human intervention to effectively bill vehicles as they passed a tollgate (Coronado Mondragon et al., 2012). Newer approaches to ETC are fully automated with the aid of roadside units that collect data from sensors onboard vehicles using short-range communication network technologies

(Randriamasy et al., 2018). According to Rota and Simic (2016), the modern ETC system allows free traffic flow since data is passed automatically while the vehicle passes the roadside unit. For instance, when the unit detects a vehicle in range, it auto bills the driver and automatically opens the bar, allowing the vehicle to pass through the tollgate.

2.7 Smart Cities

The term smart city is used to conceptualise an environment where traditional networks and services are combined in efficient and sustainable use of ICT to improve the city's services. Smart cities are deemed to be greener, safer, faster, and friendlier, boasting of components that include smart infrastructure, smart transportation, smart energy, smart health care, and smart technology (Mohan, 2016). Meijer and Bolívar (2016) state that the smart city concept can be categorised into three different types: smart cities as cities using smart technologies (technological focus), smart cities as cities with smart people (human resource focus), and smart cities as cities with smart collaboration (governance focus). It is argued that smart cities can be a catalyst for economic growth by enhancing the provision of quality government services, enabling local development, and harnessing emerging technologies such as big data and (IoT) internet of things to enhance services (Lim et al., 2018).

Big data is the huge volume of structured and unstructured data that is so large and complex that it is difficult to manage and process using traditional database and software tools (Oussous et al., 2018). In comparison, IoT is a network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, enabling these objects to collect and exchange data (Liu, 2018). Big data and IoT are commonly used in concert, particularly in smart cities where networked devices generate different forms of unstructured data, as illustrated in figure 2.4. Therefore, big data technologies are required for processing, storage, and analytical purposes (Sun et al., 2016).

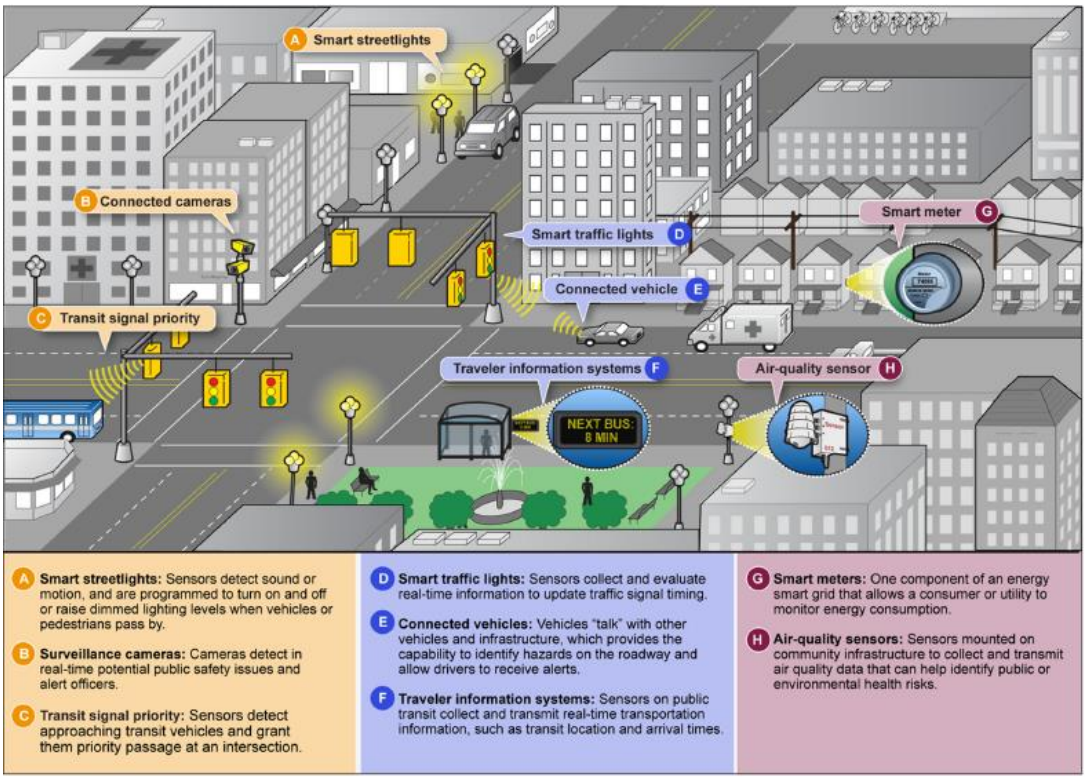

Figure 2.4 IoT in smart communities (Takeoka & Reddick, 2016:4)

One of the biggest challenges in smart cities is to securely manage these large volumes of data as there is a high risk of leakage and over-collection (Li et al., 2016). When transitioning towards smarter cities, the primary focus is to educate users rather than primarily focusing on improving infrastructure, buildings, and vehicles. Educated users are less likely to resist the change that comes with moving from traditional to smarter cities (Moustaka et al., 2018). Shelton and Lodato (2018) also state` that smart citizens (educated users) are less likely to be unwilling to develop smart cities as they better understand mitigating the risks involved, such as protecting themselves against internet threats. Smart cities form a foundation for implementing effective transportation systems based on dynamic ICT capabilities in many leading countries like Australia, Canada, the United States of America (USA), Japan, and some European countries (Angelidou, 2016).

2.8 Theory Underpinning the Study

Research on information systems has grown to include many different views on how organisations and individuals implement, use, and interpret technology (Halawi & Mccarthy, 2006). The impact of developing and using Information systems is even discussed in sociology, economics, and psychology. Theories in information systems research are used to advance knowledge in a given field. There are theories for analysis, explaining, predicting;

and theories for design and action (Trux et al., 2006). Theory simplifies the process of making sense of complex and sometimes contradictory real-world phenomena by serving as a lens through which we concentrate and magnify certain objects while reducing the focus on things that are regarded as "noise". According to Collins and Stockton (2018), a theory is a big concept with a high degree of explanatory power that organises many other thoughts. Applying theory to IT artefacts offers a richer understanding of complex phenomena that enable researchers to base their arguments and place their research in the proper context (Lim et al., 2013). A variety of theories have been developed to underpin IS research. Activity theory is one of the newer developments in theory. The building blocks of the theory are discussed below.

2.8.1 Activity Theory

An activity is a type of doing that is directed at a specific object. Activities are distinguished from one another by their objectives. An activity is triggered by the need to transform the object into an outcome (Scanlon & Issroff, 2005). Activity theory (AT) is a social-technical theoretical framework that is used to underpin Information Systems (IS) studies (Iyamu, 2020). This research seeks to understand the design requirements for an IRIS for public commuters. Thus, activity theory was employed to guide this IS-based research. Activity theory is used to analyse and better understand human activities by using tools and artefacts (Moawad et al., 2013). The activity theory is key in supporting qualitative and interpretative research, according to Hashim and Jones (2014). The activity theory focuses on the analysis of the individual in pursuance of their activity and objective using mediating tools and artefacts. Figure 2.5 shows the activity theory model with its components:

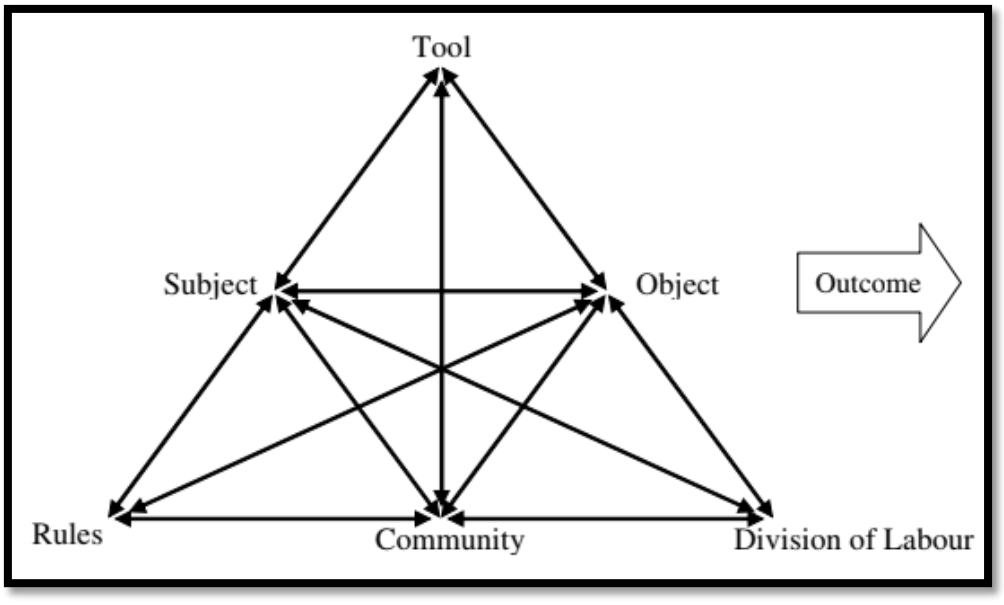

Figure 2.5 Activity theory model (Engeström, 1987:78)

The basic unit of analysis for activity theory is an activity system, which involves a group of people or a community that shares a common purpose (object) and uses instruments called a "tool" to transform the object into an outcome. The relationships between the components in the activity system are driven by "rules" which define behavioural constraints. The "division of labour" describes the separation of duties between different community members, the level of division can be determined by the power to make decisions (Hardman, 2007). There are multiple cases in which The AT framework has been applied successfully to qualitative studies (Bandara, 2018). At Deakin University, a student applied the theory to their PhD, the research focused on "investigating the Effects of Online Professional Development on the Integration of Technology in Schools" (Riverin, 2006). Boitshwarelo (2007), also applied AT to his PhD research for Deakin University. It aimed to "investigate the possibilities, issues and challenges involved in ICT implementation for teacher professional development secondary schools in Botswana". The third example of a study that applied AT successfully was conducted by Clark (2006) using the AT framework. The study focused on education in the primary school classroom in Australia. For each case described above, the data was presented and summarised. In the end, the data were analysed using the AT framework. Similarly, this research used AT as a lens for analysing the qualitative data collected. Table 2.1 below presents a general description of the AT components as outlined by Pearson (2009).

Table 2.1 AT components descriptions

AT component	Description
Subjects	The subjects are the people being studied. The subjects perform a series of tasks to achieve an overall objective. Examples can include workers, students, elderly.
Tools	The Tools are the instruments used by the subjects in performing their tasks. These can include software, hardware, databases.
Rules	The rules govern the boundaries at which the actors are constrained in their execution of the tasks; examples of these can be policies, standards and legislations .

Division of Labour	.The division of labour shows the different roles and responsibilities placed on the stakeholders in the activity system. These may include contractors, local governments, national governments
Community	The community is the social environment in which the activity takes place. The community is made up of members who share similar interests. Some examples of these are organisations, educational institutions, hospitals
Object	The objective components represent the goal of the subjects in their use of the tools to perform the activity**.**
Outcome	The outcome can be seen as the result produced after the activity has been completed

2.9 Related Work on Real-time Information Systems

South Korea's real-time information system has made it the world leader in Intelligent Transportation Systems (Lee et al., 2016). South Koreas Expressway Management Systems collects traffic information via Vehicle Detection Systems installed on roadside units. The features of this system include Real-time traffic information, advanced public transit, electronic fare collection and a Closed Circuit Camera deployed every 2-3 km (Singh et al., 2014). Information is collected and stored at South Korea's National Transport Information Centre, and relevant real-time data is distributed to commuters in various formats. In the United Kingdom, a real-time project called MIRA provides vehicles with a military-grade architecture that ensures persistent uptime. MIRA technology can provide a reliable method for controlling complex transport systems (Hasegawa, 2015). The Netherlands is also among the list of countries that have implemented real-time information systems for public integrated commuting. The MOTUS (Mobility and Tourism in Urban Scenarios) provides information services to public commuters to choose the best mobility solution. However, this system is tailored for tourists and is only accessible around inner-city areas (Bruglieri et al., 2015). MOTUS is seen to improve safety through road incidents reports. However, it limits mobility to inner-city areas and does not include commuters who travel to townships and rural areas. MOTUS also lacks electronic fee collection and does not reduce carbon emissions through traffic management and reducing the number of cars on the road.

2.10 Chapter Summary

The literature review provided an insight into the challenges that affect the South African public transport system. The research further highlights how developing countries have addressed this issue by implementing technological solutions. The chapter provides more detail regarding integration and the role of information systems in general. The next chapter outlines the research process and the research methods best suited for this kind of research.

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter provides insights into the research process and explains the terms associated with research methodology. The terms discussed in this chapter are the research philosophy, approach, design, and it concludes with the research strategy that explains the population sample, sampling technique, data collection instruments, and data analysis method. An appropriate research methodology is used to achieve the objectives of the study.

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3.1 Research Philosophy

Research philosophy is a belief about how data on a phenomenon should be gathered, analysed and used (Chowdhury, 2014). The choice of philosophy is the starting point in the research process. The research philosophy adopted contains important assumptions about how one views the world (Creswell, 2009). In other terms, the way you think will affect how you do your research. Cohen et al. (2017) also state that research is started from assumptions. This means that different researchers may have different assumptions about the nature of existence and knowledge acquisition (Saunders et al., 2007). The research philosophy can be divided into two dimensions: ontological and epistemological. Ontology is the study of existence and the nature of reality. This philosophical stance determines the researcher's questions about how the world is structured or how the social actors interact (Alvesson & Sköldberg, 2009).

On the other hand, Epistemology is a theory of knowledge concerning beliefs about how knowledge is created or acquired. According to Pascale (2010), "this includes the nature, sources, and limits of knowledge". Figure 3.1 shows the building blocks of the research process.

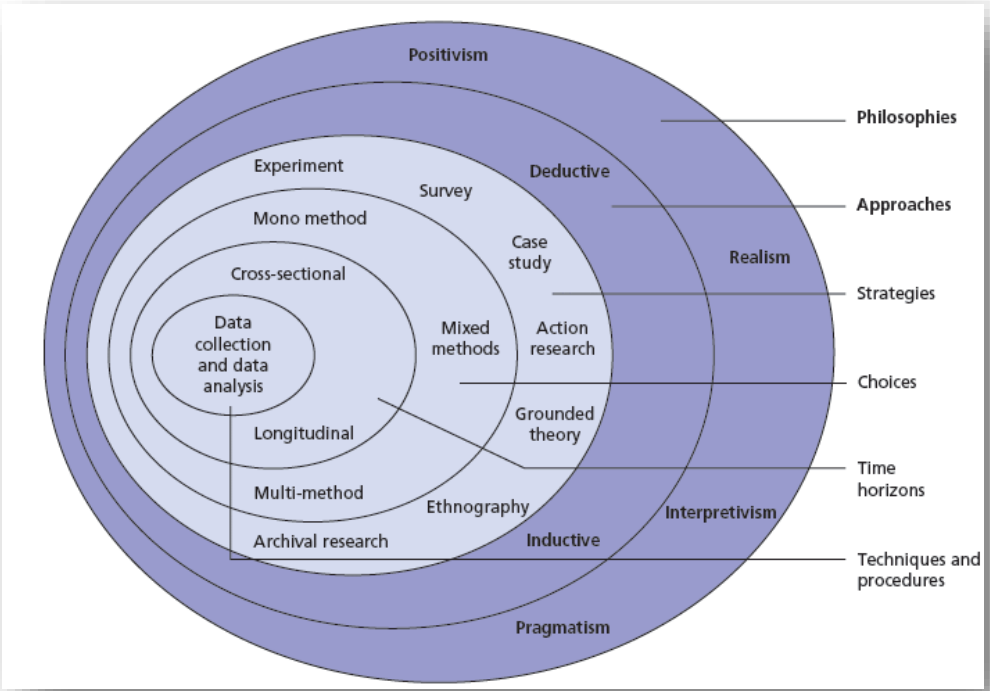

Figure 3.1 The research onion. (Saunders et al., 2009:109)

There are different philosophical perspectives to research; the objectivist and subjective research perspectives. Objectivists believe that laws of the natural world exist and, through a scientific investigation, can be discovered and measured against a hypothesis (Crotty, 1998). According to Boland (1985), the subjectivist research perspective believes that existence is based on people's personal experiences, and each individual has their definition of truth. This is also referred to as an interpretivist approach to research instead of objectivism, which follows a positivist approach. A philosophical review is an important aspect of the research process as it exposes the researcher to other possibilities, which can lead to enhanced research skills and improve confidence that they have chosen an appropriate methodology (Holden, 2004). These research philosophies, ontology and epistemology, are further discussed next.

3.1.1 Ontology

This study adopts the subjective ontological stance because it seeks to understand the phenomenon through the interaction and interpretation of human elements. Ontology can be defined as the study of being (Crotty, 1998). It is concerned with the nature of existence and the various interpretations of reality from the perspective of social beings (Guba & Lincolin, 1994). Saunders et al. (2007) define ontology as concerned with the nature of reality and researchers' assumptions about how the world operates. In other terms, ontology identifies

reality as a social construct that can be explored and created through human interactions and meaningful actions. This study adopts the constructivism stance to reality. It hence employs qualitative instruments to understand individuals' social experiences and identify factors that otherwise could not be easily exposed or described through metrics and statistics, nor generalised across entire populations (Bisman & Highfield, 2012).

3.1.2 Epistemology

This is a branch of philosophy that studies knowledge or knowing and helps answer questions like "what is knowledge" and "How do we know what we claim to know?", Epistemology is also "concerned with providing a philosophical grounding for deciding what kinds of knowledge are possible and how we can ensure that they are both adequate and legitimate" (Ahmed, 2008). So, this philosophical dimension pertains to the nature of knowledge (Creswell, 2009). This study adopts the interpretive perspective, which enabled the researcher to understand better the factors affecting the availability and accessibility of real-time information for public commuting in South Africa.

The interpretive epistemology maintains that humans create knowledge as they interpret their experiences of and in the world; this contrasts with the objectivist notion that knowledge exists independent of social beings and is discovered (Trochim, 2006). In other terms, the interpretative researcher is concerned with the in-depth analysis of actions, behaviours and words to interpret the world. According to knowledge Delanty and Strydom (2010), the interpretative researcher applies qualitative techniques to gather rich, in-depth experiences and interacts with participants instead of positivist researchers who rely more on numbers. Hence, this justifies the study's qualitative stance.

3.2 Research Approach

The study explores the factors affecting the availability and accessibility of real-time information for public commuters in South Africa to understand the design requirements for an IRIS for public commuting services in South Africa. This requires in-depth descriptions and explanations, and therefore, an inductive approach will allow the researcher to better understand participants' perceptions. Research approaches outline the assumptions that influence our data collection methods, analysis, and interpretation (Creswell, 2011). Based on a researcher’s beliefs, they could adopt qualitative, quantitative or mixed methods as approaches. According to Thorne (2000), qualitative researchers believe truth is subjective and based on individuals' experiences. Therefore, as seen in Figure 3.2, qualitative research

is known to be inductive since a theory is formulated from the social experiences of individuals or groups (Burney & Saleem, 2008).

In contrast, quantitative studies are deductive and aim to confirm an existing theory using scientific methods. Quantitative researchers believe that truth exists independent of social actors and can be discovered using methods applied in natural sciences (Kivunja et al., 2017). As illustrated in Figure 3.2 deductive approach aims to confirm an existing theory.

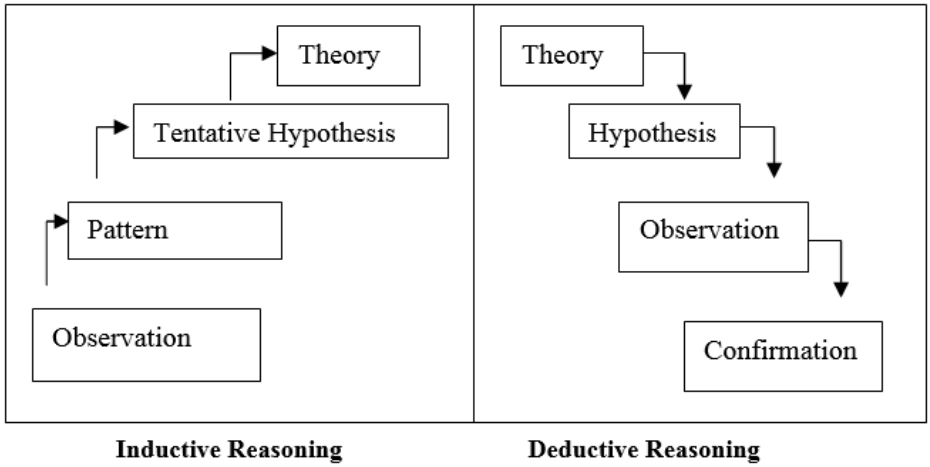

Figure 3.2 Shows inductive vs deductive reasoning (Trochim & Donnelly, 2006:17)

The deductive approach is the opposite of the inductive approach because it begins with an existing theory and then tests its implications with data (Woiceshyn & Daellenbach, 2018). It moves from general to specific. The common methods used with the deductive approach are questionnaires and surveys. Deductive research can also be called quantitative as it seeks to test an existing theory through numerical and statistical data (Goswami, 2010). Deductive reasoning has its origins in the natural sciences, where positivist epistemology is adopted (Strauss and Corbin, 1990).

In contrast, the researcher collects empirical data inductively and looks for patterns to formulate a hypothesis and theory (Goswami, 2010). The research moves from specific to general. The common methods used in this research are focused groups, individual interviews and observation. Inductive research is also qualitative since it derives a theory by discovering social actors' experiences (Hyde, 2000). Inductive reasoning is common in social science studies that adopt interpretive epistemology (Burney & Saleem, 2008). The interview data collected from this study will be analysed to understand better the nature of the problem. Hence, a qualitative inductive reasoning process was followed to acquire new knowledge.

3.3 Research Methodology

The three main research methodologies are qualitative, quantitative, and mixed methods (Creswell, 2003). The objectives and research questions determine the methodology used. The researcher's philosophical beliefs can determine the method adopted for a study (Glogowska, 2011). Quantitative methods are used by researchers who believe that reality exists independently from its social actors. These researchers believe in an objective ontology and rely on numbers to test a theory (Creswell & Plano Clark, 2011). This can also be referred to as a deductive approach to research.

Conversely, qualitative methods are more aligned to the subjective dimension of ontology, which states that reality is created through social interactions (Fetterman, 2009). Therefore, qualitative methods are adopted in such studies to understand the perspectives of different individuals and their views on the nature of existence. This research approach is referred to as inductive reasoning, where the researcher collects data and formulates a generic theory from the individual experiences of social beings. According to Wium and Louw (2018), the mixed method draws from the strengths of both quantitative and qualitative methods. It incorporates both single and multiple realities. In terms of nature knowing, the mixed method is neutral and accepts that knowledge is intersubjective. These research methods are discussed in detail next.

3.3.1 Qualitative Research Methodology

Qualitative research relies on inductive reasoning to interpret the meanings extracted from data (Thorne, 2000). Qualitative researchers are interested in people's experiences and look for deep understanding from the people's perspective rather than statistical analysis (Haradhan, 2018). In other words, the focus becomes more on words rather than numbers. Qualitative research is not explanatory since it builds on new theories (Thorne, 2000). The objective of qualitative research is exploratory and descriptive. Its exploratory nature allows a researcher to explain the participants' experiences concerning the theoretical assumptions of the study (Mouton, 1996). The exploratory nature of qualitative research allows the reader to understand the experience, the distinct nature of the phenomenon or programme and its impact on people.

According to Kielmann et al. (2012:9), “qualitative research is humanistic because it focuses on the personal, subjective, and experiential basis of knowledge and practice. It is holistic because it seeks to situate the meaning of particular behaviours and ways of doing things in a given context (as opposed to isolating these as a quantitative researcher would)".In

qualitative research, the data collection methods enable the researcher to be part of the same environment as the participants (Ospina, 2011). Qualitative research applies to studies that relate to information systems. Researchers use sources such as observations, case studies, design efforts, interviews, and archival materials to investigate people and their experience with the systems they use (Conboy et al., 2012). This study aimed to explore factors affecting the availability and accessibility of real-time information for public commuters in South Africa, The qualitative component of this study involved undertaking in-depth interviews with IT managers of transport operators. In this case, semi-structured interviews were used.

Considering the above, the researcher used a qualitative research method to investigate multiple realities relating to the design factors of a real-time information system for public commuters in South Africa. This is consistent with the subjective ontology of the researcher and the epistemological assumptions of knowledge creation as opposed to discovery. Unlike quantitative research, qualitative research uses less structured and non-structured methods to answer 'why' and 'how' a particular phenomenon exists rather than 'what' and 'how much' (Kielmann et al., 2012). Qualitative data can be triangulated for cross verification from two or more secondary sources such as books, websites, and documentary materials, which is referred to as triangulation and provides a validation mechanism similar to that of quantitative data (Aspers & Corte, 2019). This study used a combination of semi-structured interviews and document reviews.

3.3.2 Quantitative Research

According to Creswell (1994), Quantitative research is an objective approach to investigating an identified problem, by testing it against an existing theory, using numbers and statistical techniques, the results of which are typically presented in tables and graphs. The goal of quantitative methods is to gather numerical data and generalize it across groups of people or to explain a particular phenomenon. In other terms, quantitative researchers focus on comparing the relationship between two variables (independent variable and a dependent outcome). This makes quantitative research descriptive when seeking to establish associations between variables or experimental when determining causality (Crotty,1998). This is in contrast with qualitative research which is exploratory and aims to explain the experiences of the participants in relation to the theoretical assumptions. The structure of a quantitative design is based around the adaptation of the scientific method, quantitative researchers believe that reality is objective and there is just one single reality, their epistemological view is one of knowledge discovery as opposed to constructionism (Crotty, 1998). Quantitative research uses methods such as surveys, to collect Structured data from a

larger sample size of randomly selected respondents (MacDonald& Headlam,1999). Quantitative research follows a deductive reasoning approach, the researcher begins by formulating a hypothesis and then collects data that can be analysed to prove the hypothesis true or false (McGregor,2018). This study will be inductive by nature and hence will not employ a quantitative research method as the focus is on individual experiences of a smaller sample of participants and their experiences with the phenomenon being studied.

3.4 Research Strategy

A research strategy is a plan of how the researcher will research to achieve set goals and answer the research questions (Saunders et al., 2009). The different research strategies are: "Experiment, Survey, Case study, Action research, Grounded theory, Ethnography and Archival research" (Saunders et al., 2009). From the various strategies mentioned above, this research adopted service design as a commonly used strategy in studies relating to information systems. It is also best suited to exploratory and inductive research. This section will further discuss the rationale for the chosen strategy.

3.4.1 Service Design

Service designers use the 'Double Diamond' model. The first diamond deals with understanding the problem, and the second diamond represents the creation of a solution (Burns et al., 2006). As shown in Figure 3.3, the service design process is divided into four phases: Discover phase, Define phase, Develop phase and Deliver phase. In the Discover phase, the aim is to understand the problem by observing, reading, and engaging with stakeholders. The define phase clarifies and focuses on the real problem to solve. Several possible solutions are designed and iteratively developed into prototypes in the development phase. While in the ‘deliver’ phase, the focused solution is deployed, feedback is gathered, and the project is finalised (Strode, 2016).

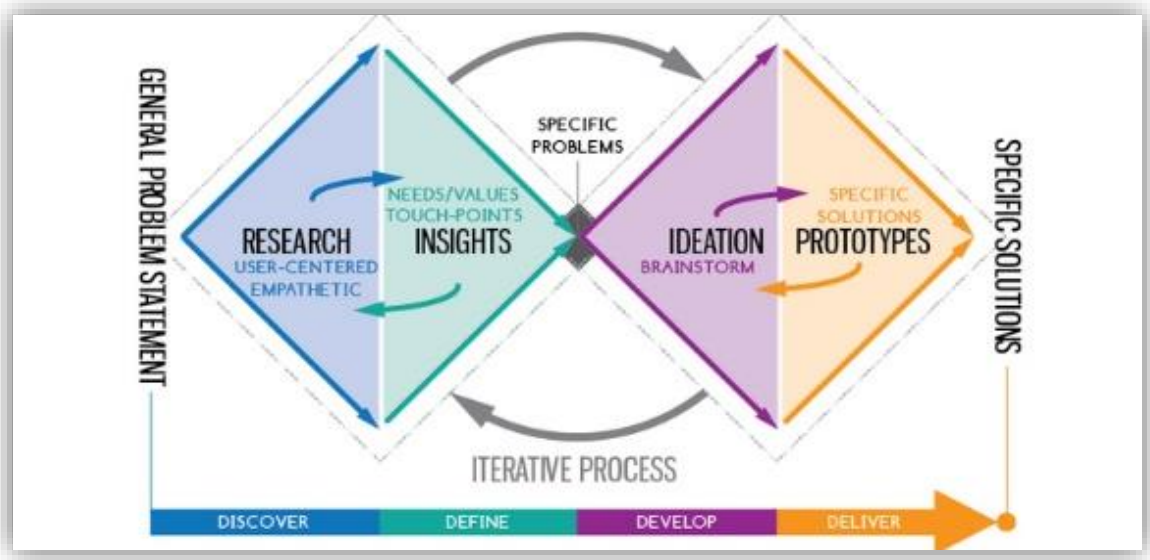

Figure 3.3 Service design process (adapted from Strode, 2016:492)

According to Costa et al. (2018), the phases of service design can be applied individually or wholly in research, where the scope of the study drives the stages at which the service design process is applied. Thus, for this research, the research covered discover and define phases of the first diamond and the ideation for design requirements within the second phase of the diamond, to fulfil the study's aim to explore factors affecting the provision and availability of real-time information for public commuters in South Africa. The research scope is limited to understanding the design requirements for an IRIS for public commuting services in South Africa.

The rationale for using a service design strategy in this research was to include public transport commuters in the co-creation of an IRIS that will improve the delivery of public transport services in South Africa. Public participation allows for increased commuter acceptance and support, which is essential to reduce resistance and incidents of vandalism.

3.4.1 Participatory Research

The participatory research approach is new in social sciences and an alternative to conventional social sciences research (Bergold, 2012). Participatory research uses qualitative tools and enables the researcher to be engaged directly with people to co-create knowledge about themselves to bring change in the world (Amaya &Yeates, 2014). in this approach, the people involved in the study are referred to as participants rather than subjects. According to Adelman (1993), the main premise of participation involves stakeholders who seek practical

solutions to concerns and issues in all aspects of the research process. Participatory research is a democratic process to creating new knowledge and views stakeholders as co-researchers who combine theoretical and practical knowledge to solve a problem (Koch & Kralik, 2006).

The participation happens through workshop sessions where a representative from the project's various stakeholders is invited to be part of the decision-making process. In the context of this research, the stakeholders were the PTOs and the commuters, who are the community well experienced in using the public transport system and can bring effective solutions. The participatory approach is adopted with a service design strategy to provide a tailored service for a particular community. Service design is a customer-centric approach to designing a new service or improving existing ones. In most cases, the services are improved to harness the value of digital technologies (Katzan, 2011).

3.5 Research Design

A research design can be used to test the hypotheses and answer key research questions. It can be exploratory, descriptive, explanatory, or, in some instances, a combination of the above (Saunders et al., 2007). This research is exploratory because it seeks knowledge concerning factors surrounding the provision of real-time information for public commuting in South Africa. Exploratory research design applies to studies that seek to collect rich empirical data to understand a phenomenon that is not well known (Probert, 2006). Therefore, the study used semi-structured interviews to collect data from PTOs as this technique allowed the researcher to gain rich data on a phenomenon that is not well understood. The co-design sessions were employed to gain an in-depth understating of the experiences of commuters about the research topic. Moreover, secondary data sources were considered by reviewing the documentation and policies of the PTOs.

3.6 Population and Sampling

A population can be defined as a group of individuals who have the characteristics required by the researcher. An individual is a person that is a member of a population (Murphy, 2016). The target population for this research is public commuting stakeholders in the Western Cape. These include public commuters and transport operators. There are two sampling methods: non-probability and probability sampling (Zikmund, 2002). Figure 3.4 below shows the steps in the sampling process:

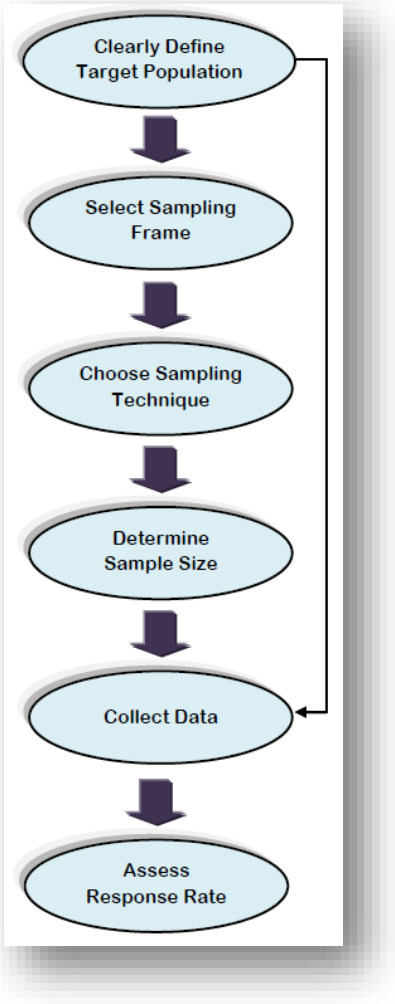

Figure 3.4 Sampling process steps (Taherdoost, 2016:19)

The sample size was derived from the Western Cape population, focusing on the Cape Town metropolitan region. This research adopted qualitative techniques and data collection instruments such as interviews and document reviews, influencing the sample size. Interpretive studies collect rich insights from data, and therefore the sample sizes are normally smaller than that of positivist research projects. Working with smaller sample sizes is advantageous because it costs less and saves more time than collecting information from large respondents.

Therefore, this research adopted a non-probability sampling method to conveniently select participants who knew the studied topic. This included 18 participants. The sample comprises the transport operators (PRASA, Golden arrow, MyCITI, Taxi Association) employees and selected public transport commuters. Therefore, the observation units will be an IT professional and manager at each of the four identified transport operators and ten public commuters. The different sampling methods are further discussed next:

3.6.1 Non-Probability Sampling

Non-probability sampling involves selecting respondents based on assumptions regarding the population of interest, forming the selection criteria (Yin, 2003). The main characteristic of non-probability sampling is that samples are selected based on subjective judgement rather than a random selection of probabilistic sampling methods. This sampling method is less costly and uses a smaller sample size. It is commonly used in exploratory research with a qualitative approach to help the researcher understand a population (Mohsin, 2016). Schreuder (2001) outlines some of the most widely used non-probability sampling techniques, such as convenience sampling, purposive sampling, snowball sampling, and volunteer sampling. A convenience sample is when participants are selected because they are readily and easily available. This sampling technique is less expansive, least expensive, least time-consuming, and most convenient. However, it has some disadvantages, such as Selection bias, sample not being representative, making it inappropriate for descriptive or explanatory studies (Vehovar et al., 2016). Purposive sampling, also known as judgmental, involves the selection of units such as people, events, and data based on their ability to provide information on the topic being studied (Malhotra & Birks, 2006). This sampling technique is ideal for exploratory research that aims for subjectivity over an objective epistemology.

The disadvantage of using this technique is that it does not allow generalisation (Zikmund, 2002). A snowball sampling technique is best suited for research in which the research participants are hard to reach. This uses smaller cases to encourage other cases to participate in the study (Davis, 2005). Snowballing is best suitable for studies requiring participants from closed or secret societies, whilst volunteer sampling is a form of self-selection in which the participants choose to participate in the research independently. This ensures a higher level of commitment and improves attendance since participants willingly participate out of interest rather than being approached by the researcher. The disadvantage to volunteer sampling is that there are prospects of being self-biased about a particular topic being studied. Considering the above-mentioned sampling techniques, this research found convenience sampling as the best appropriate to be adopted as the study follows a qualitative approach with an exploratory design. The participants were approached based on their interactions with public commuting services in South Africa.

3.6.2 Probability Sampling

Probability sampling is a technique of selecting respondents of a study that ensures that every member of the population has an equal chance of being selected. This is also referred to as random sampling method and reduces the prospects of bias against individuals in a population (Burns & Grove, 2001). The different types of probability sampling methods are random sampling, stratified sampling, systematic sampling, and cluster sampling (Wu Suen et al., 2014). This sampling method is not the preferred choice for this research due to it being costly and time-consuming. There are some advantages to using probability sampling such as better representation, reduced systematic errors, minimising the chance of bias and the sample drawn can be generalised to the population (Mohsin,2016). This makes probability sampling best suited for studies that are deductive in nature. Hence an alternative sampling method was adopted for this research.

3.7 Data Collection

Various data collection techniques exist in research. The choice of instruments used is based on whether the research is qualitative or quantitative. Quantitative research favours the use of surveys such as questionnaires to collect data, and qualitative studies are more inclined to interviews and participant observation (Yin, 1994). Information systems-related research studies require data collection techniques that focus on human interactions and place the researcher in the same environment as the participants brainstorm or engage on ideas that create solutions (Kaplan & Maxwell, 1994). Therefore, the main data collection techniques used in this research were semi-structured interviews and co-design sessions to aid the process of co-creation. Secondary data sources such as documents were reviewed to triangulate the data (Gallivan, 1997).

3.7.1 Interviews

Interviews are understood to be a method of collecting new qualitative information through face-to-face or telephonic interactions. Interviews are more engaging for most people regardless of the level of education, as the interviewer ensures that the interviewee understands the questions being asked. This is essential in instances where individuals cannot read or write. The response rate for interviews is much higher than that of a questionnaire since participants are less likely to be reluctant to answer questions in an interview. The other benefit of using this data collection method is that interviewers can often clarify ambiguous and confusing questions during the interview. However, interviews require much planning around people's schedules and can be costly in travelling to the interview venue. According to

Coughlan (2009), an interview can be structured, unstructured or semi-structured. In a structured interview, the researcher asks a fixed set of questions, nothing more than what is on paper (Leedy & Ormrod, 2001).

As the name suggests, unstructured interviews are of an informal discussion, and no standard set of questions is asked. Instead, the researcher pursues points of interest as the interview flows. Semi-structured interviews are those in-depth interviews where the respondent must answer present open-ended questions. Researchers may omit questions in the interview following the flow of the conversation (Coughlan, 2009). This research used semi-structured interviews. The rationale is that interviews provide an opportunity to initiate relationships with the respondents as co-researchers and help gain insights into the problems affecting the provision of real-time information for public commuting in South Africa. The stakeholders interviewed are IT professionals and senior management employees at each of the PTOs in Cape Town. Data collected during interviews were stored in encrypted devices and password protected for cross-checking and data analysis.

3.7.2 Document Review

This data collection method is used to gather data from existing sources that have been published by other authors (Smith, 2011). The use of secondary data is common in social science research to compare current results to past experiences. Secondary data can be very useful when the researcher cannot access participants or if participants are accessible but are not willing to reveal certain information (Johnston, 2014). This could be information relating to an organisation's planning, policies, procedures or government legislation. Common secondary data sources include books, journals, reports, data archives, internet articles, and statistical censuses (Smith, 2011). This research used secondary data in document reviews from the different transport operators to supplement the data collected from interviews. This is essential if a particular organisation's employees are inaccessible to provide primary data for this research. Using multiple data sources in qualitative research can also be referred to as triangulation (Patton, 1999). Triangulation assists in getting a comprehensive understanding of the phenomena.

3.7.3 Co-design

According to Ricci and Scataglini (2019), co-design involves people from different backgrounds. This could be researchers in specific fields, experts, non-experts, decision-makers and professionals from different backgrounds, and groups of stakeholders that collaborate in the design process. Co-design promotes creative thinking so participants and

researchers can work together to develop ideas for possible design solutions to improve the phenomenon being studied (Sanders& Stappers, 2008). Co-design and participatory research approaches bring diverse groups together to solve socio-technical issues affecting sectors such as health, education, transportation, and technology (Halvorsrud et al., 2016). To better understand these areas of knowledge, the researcher needed the perspectives of individuals who have experience within those industries (Goodyear-Smith et al., 2015). Using co-design techniques improves creativity, a customer-centric focus, cooperation between disciplines, and encouraging innovation (Steen-Manschot & De Koning, 2011). This researcher used a co-design session with public commuters as co-creators. The participants were required to brainstorm ideas onto post-it notes and a whiteboard. The data generated was then be captured on encrypted electronic spreadsheets for analysis. The rationale for adopting co-design as a technique is to understand the design requirements for an IRIS to be used in future research projects. The data collected during the co-design sessions were stored in encrypted devices and password protected for cross-checking and data analysis.

3.7.4 Questionnaires

A questionnaire can be defined as a printed self-report form designed to gather information in a form of written responses of the subjects. The information obtained from questionnaires is less has less depth than that of an interview (Berrios & Lucca,2006). Questionnaires require less energy to distribute and offer a high level of anonymity since subjects seldom provide personal information unless it is a specific requirement to do so (Rubin & ER, 2009). The questions can either be open-ended, closed-ended or a combination of both. The data becomes a lot easier to compare if the questions are closed-ended however there is less depth in responses. quantitative research makes use of questionnaires as a technique that provides structure to the way information is gathered and categorized (Kabir,2014). The researcher does not have to interact with the subjects of the study with this data collection tool, making it easier to distribute through channels such as internet links. Questionnaires are often designed for statistical analysis purposes but in some cases can be applied in qualitative. This research will not use questionnaires as they do not adequately capture human feelings, thoughts and behaviour in a manner or form required by this research.

3.8 Data Analysis

This study employed both thematic and content analysis as methods for data analysis. The data was gathered through semi-structured interviews with PTOs, and the document reviews employed thematic analysis. At the same time, the content analysis was applied to the data

from the co-design sessions with commuters. Data analysis is a very crucial component in the research process. It can be defined as a process whereby researchers search for patterns in data to extract information that can be shared with others (Flick, 2014). The data analysis process occurs in three stages. The data is first organised, then summarised into categories, and lastly, patterns and themes are identified (Patton, 1987). The data analysis process differentiates qualitative from quantitative research. Researchers focus on descriptions, words, and feelings in qualitative studies instead of focusing on numbers in quantitative research (Merriam, 1998). This research follows an exploratory design that seeks an in-depth understanding of an unknown phenomenon and therefore adopts a qualitative approach to data analysis. Content analysis as a method of data analysis for this research will be further discussed next.

3.8.1 Content Analysis

Content analysis is a qualitative research method that can extract patterns or themes from data in the form of text, images, video, audio, and symbolic matter (Leedy & Ormrod, 2001). Although content analysis can be qualitative or quantitative, it is commonly used for qualitative data analysis. White and Marsh (2006) state that content analysis is important to social sciences research to provide comprehensive answers to the research questions. Content analysis can be used in an inductive or deductive approach (Elo & Kynga¨s, 2007). The authors state further that if there is little knowledge about a phenomenon, then an inductive approach to content analysis is adopted. An inductive data-driven approach moves from the specific to the general. Individual instances are observed and combined into a broader whole or a general argument (Strauss & Corbin, 1990). According to Hsieh and Shannon (2005), The qualitative content analysis comprises these seven steps:

Step 1. Preparing the data: Since content analysis allows for capturing data in various forms of media such as text and audio, the data will first be transformed into a textual format.

Step 2. Identifying themes of analysis: The content was then categorised into themes with words or phrases that follow the study's objectives.

Step 3. Develop a coding scheme: Keywords from primary data were used to generate sub-categories and coding schemes for analysis.

Step 4. Test the coding scheme on existing data: literature was reviewed to compare with original ideas.

Step 5. Coding all the text: After all the coding protocol had been consistently recorded as described in the previous stages, the coding process was applied to the data systematically.

Step 6. Evaluate the consistency of the coding: The data set was validated to ensure that it is reliable by going through the steps from the beginning to find out if any detail may have been left out.

Step 7. Present the result: The final step of the analysis was to explore data properties to identify the dimensions, patterns and relationships that exist and to support it through literature and developed codes. The components of activity theory were used as a lens for analysing the data.

The main advantage of content analysis is that it helps present data in a reduced and simplified manner that speaks to the study's objectives while producing results that can be measured further using quantitative techniques (Langkos, 2015). Content analysis was used to analyse the data gathered from the co-design session with public transport commuters.

3.8.2 Thematic Analysis

Thematic analysis is primarily used in qualitative studies to help researchers determine people's opinions, beliefs and experiences (Caulfield, 2019). This analysis is usually applied to text like interview transcripts where researchers look for patterns classify them into broader themes. According to Braun & Clarke (2006), thematic analysis can be defined as a foundational method for identifying, analysing and reporting patterns within qualitative data to derive themes. This analysis method is flexible and easier to learn even by researchers who are not familiar with qualitative methods. The process followed when conducting a thematic analysis can be as follows:

Step 1: Familiarising yourself with the data: this requires the researcher to immerse with the data by reading transcripts and start to think about the significance of the data analytically and critically.

Step 2: Generating initial codes: The researcher codes the data from transcripts into a codebook. Codes provide labels for the data and capture the principal meaning.

Step 3: Searching for themes: The codes are collated into potential themes through categories.

Step 4: Reviewing potential themes: In this step, the themes are quality-checked against the collated data to ensure that no relevant data has been omitted.

Step 5: Defining and naming themes: clear and concise definitions and the names of themes are produced.

Step 6: Producing the report: Final analysis of extracts relating to the research questions, objectives, and literature.

This study used thematic analysis on the data gathered through semi-structured interviews with PTOs, which allowed the researcher to capture and organise the data into patterns that provided meaning and answered the research questions.

3.9 Chapter Summary

This chapter outlines how this research was conducted, showing who the participants are, how they were selected, and the methods for data collection. The researcher used a qualitative, inductive approach to data collection and analysis. The research aimed to explore the factors affecting the availability and accessibility of real-time information for public commuters in South Africa to understand the design requirements for an IRIS for public commuting services in South Africa. Co-design was used as a main data collection method along with interviews. The data is further supplemented with secondary data sources.

CHAPTER FOUR: DATA COLLECTION AND DATA ANALYSIS

The chapter presents the analysis of the data collected from the participants and the analysis of policy documents applying the methods outlined in chapter three and the emergent findings. This research was conducted in Cape Town (refer to Figure 4.1 below), a city in the Western Cape Province of the Republic of South Africa. The CoCT, with a population of about 3.4 million and a local economy estimated to produce an output of some R40 billion, has a burdened transport infrastructure compared to other cities within the continental region (CoCT,2018). However, what the CoCT has in common with most cities in the African region is the large concentration of people commuting into the city centre for varying economic activities. Data were obtained from a co-design workshop with ten conveniently sampled participants of public transport commuters to determine the real-time information required for public commuting in South Africa. Interviews were conducted with the transport operators to understand the problems associated with providing real-time information for commuters to facilitate decision-making on alternative modes and routes of public commuting in South Africa. Ten policy documents were also analysed, and the primary data was collected to determine the strategic plans to develop an innovative public transportation system in Cape Town and South Africa.

Figure 4.1 Map of CoCT with general areas (Rayle, 2017:42)

The chapter is divided into six main sections. Sections one and two present the co-design and interviews processes, respectively. In the third section, the co-design, document review and interview data are analysed, and the initial corresponding emergent findings are highlighted and subsequently summarised under the relevant sections. The fourth section summarises these findings under the related research objectives and sub-questions. The fifth section outlines the findings through the lens of activity theory. Lastly, chapter six is concluded with a summary. The diagram below shows the flow of the sections in this chapter:

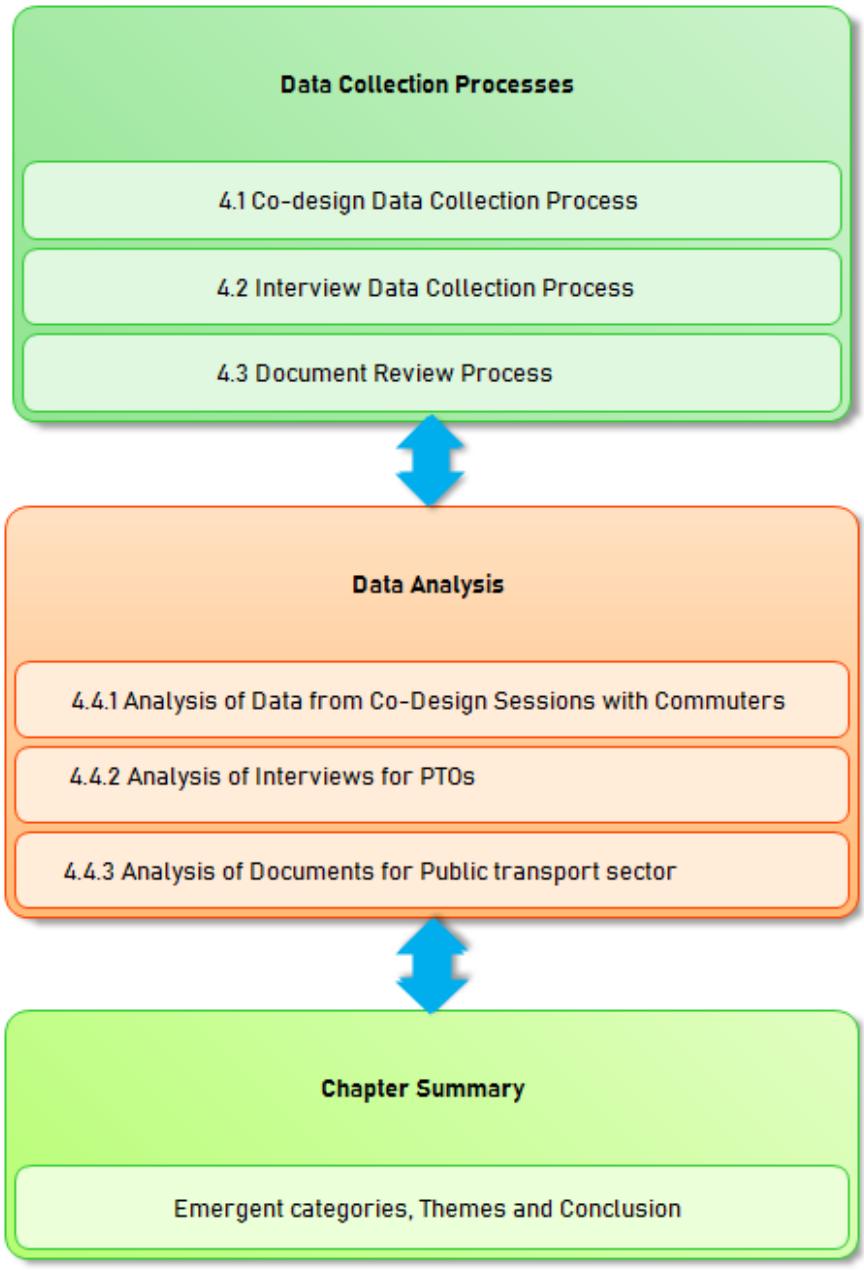

Figure 4.2 Diagram showing Chapter 4 outline

4.1 Co-design Data Collection Process

This section details one of the primary methods used in collecting data from participants of the study. Co-design design methods are primarily used to collect data from users who have experiences with the research subject. Therefore, it was appropriate to collect data from commuters of public transportation systems operating within the CoCT metropolis using the co-design method. The co-design sessions were designed to collect insightful data in response to research sub-questions 1.1) What are the challenges affecting the provision of real-time information for public commuting decision making in South Africa?; 1.2) What are the available information dissemination channels for public commuting in South Africa?; 1.3.) What are the real-time information needs of public transport commuters in South Africa? Research sub-question 1.4) What are the design requirements for an IRIS for public commuting in South Africa? The data collected from the co-design workshop complemented data from the semi-structured interviews and the document review data.

4.1.1 The Co-design Workshop Participants

Participants for the co-design workshop were identified and sampled based on the convenience sampling technique as described in chapter 3. The criteria below were used to select participants for the co-design workshop to select appropriate participants with the required knowledge and relevant information. The profile of the selected participants are illustrated in Table 4.1

I. Balance between Genders
II. Balance between active age groups
III. Balance between experienced and non-experienced commuters
IV. Inclusion of techno-savvy commuters
V. Inclusion of people that travel for different purposes (Work, School, Other)

Table 4.1 List of participants from the co-design workshop

Participant	Age	Gender	Group	Occupation status	Colour
P1	29	Female	A	Employed	Green
P2	21	Female	A	Student	Pink
P3	23	Male	A	Student	Blue
P4	26	Male	B	Work	Yellow
P5	19	Female	B	Student	Pink
P6	25	Female	B	Student	Blue
P7	46	Male	C	Work	White
P8	43	Male	C	Work	Yellow
P9	30	Female	C	Work	Green
P10	29	Male	C	Work	White

4.1.2 The Co-design Session with Commuters

The co-design sessions were divided into three groups, A, B, and C. Groups A and B consisted of 3 participants each, while Group C had 4 participants (See Table 4.1). The grouping of the participants allowed for a desirable number of persons in each group to stimulate effective communication and dialogue. The sessions were conducted physically and digitally. Groups A and B participated in a physical session, whilst group C was done remotely because the participants were at higher risk of Covid-19 infection. All the sessions were video-recorded, and the physical session was photographed for analysis purposes.

Regarding the anonymity of the participants, as outlined in the signed individual letters of consent, the photographs used in this document do not show their faces. The physical co-design session lasted 2 hours, 30 minutes and started with a brief introduction of the research project, the workshop objectives, followed by a short round of acquaintance as an ice-breaker to encourage the participants to feel comfortable (10 mins in total). Thereafter, the researcher explained the scope of the study, the activities involved in the workshop, and an opportunity for questions and answers. Participants were informed of their rights to participate and advised to withdraw their participation during or after the session was completed. Before the activities commenced, participants signed an informed consent document, thus consenting to participate in the study based on their own free will and understanding. The materials used in the co-design sessions are pictured in figure 4.3. The participants were each provided with

post-it notes of a specific colour, which helped the researcher identify responses once pinned to the whiteboard. Similarly, each question of the co-design was assigned a unique code which helped the research link the responses to the related question.

Figure 4.3 Materials used for co-design workshop

The data collection phase of the co-design session began with the researcher asking a series of questions, and the participants were required to provide individual responses on a post-it note. The participants would compare each other's responses before pinning them onto a whiteboard, as shown in figure 4.4. The themes are the nature of public transport, Information channels, information needs, and design requirements. These themes are aligned with the objectives of the study.

Figure 4.4 Picture showing a participant pinning a response.

Once all the responses were pinned onto the whiteboard, the participants were then given a 30-minute break for refreshments, and upon returning, the second phase of the session began. This phase involved a group task to co-create a conceptual design for the IRIS. A comprehensive outline for the physical co-design session is attached (Appendix A). The same process was adopted for the virtual session, with minor adjustments to suit the virtual environment.

4.2 Interview Data Collection Process: Public Transport Operators (PTOs)

Table 4.2 Shows description of PTOs

PTO	Description of operations
PRASA	PRASA is a South African state-owned enterprise responsible for the passenger rail services in the country.
MyCITI	MyCITI is a bus rapid transit service operating in the CoCT Municipality in South Africa.
Golden Arrow:	Golden Arrow Bus Services is the major bus service operator for the CoCT, South

	Africa, providing services throughout a large part of the CoCT.
Codeta:	Codeta is a Taxi association responsible for managing the routes within the CoCT Municipality.

Interviews were conducted as one of the primary data collection methods for the study. As illustrated in the previous chapter, selected participants were sampled based on the judgemental sampling technique. The interviewed participants chose a suitable date/time convenient for them within a period projected for the interviews. The interviews were conducted virtually using Microsoft teams. However, some participants preferred Microsoft to have them face to face at a venue of their choice. The interview questions were based on the research sub-questions aligned to the corresponding objectives. The interview schedule also comprised general questions targeted at the profile of the participants (See interview schedule attached in Appendix C). The questions were originally compiled in English. However, certain terms or phrases needed to be reiterated in a different language for the participants to better understand during the interviews. The interviews consisted of 8 participants, and Table 4.3 represents the profiles of the participants.

Table 4.3 Description of participants' profile

Participant	Title	Role	Stakeholder
R1	Operations Manager	Management Role	Taxi Association
R2	Communications	Co-ordinate route changes to taxi owners and other stakeholders	Taxi Association
R3	IT Manager	IT department as a senior technician	Prasa
R4	Operations Manager	Head of the department (Metrorail)	Prasa

R5	IT Manager	Managing IT infrastructure	Golden Arrow
R6	Line Manager	Manage the operation of different routes	Golden Arrow
R7	Manager	General Management and oversight of the organisation's operations.	MyCITI
R8	IT Administrator	Head IT infrastructure	MyCITI

All interviews were recorded using the MS teams desktop application. Each interviewee gave consent to be recorded. After each interview, the responses were transcribed manually onto a Microsoft word document, as shown in Appendix D. Once data was transcribed, the relevant responses were captured onto an excel spreadsheet for analysis (see appendix E). The interviews were carried out particularly to elucidate insights into research sub-questions 1.1) What challenges affect the provision of real-time information for public commuting decision making in South Africa?; 1.2) What are the available information dissemination channels for public commuting in South Africa?;1.3.) What are the real-time information needs of public transport commuters in South Africa? Research sub-question 1.4) What are the design requirements for an IRIS for public commuting in South Africa?

4.3 Document Review Process

Ten documents were reviewed. The documents were judged based on relevance to the subject matter and availability. The selected documents included strategic frameworks, reports and policies from CoCT on public transportation and those dealing with PTOs nationally. Summarily, the analysis process followed by the researcher to review these documents required familiarisation with the documents' texts firstly. Subsequently, the documents were further analysed by looking out for key terms and concepts relating to the subject of study, such as "Public transport"," Integration"," Infrastructure"," Development" and "Technology". Matching phrases were then highlighted for coding and categorisation. The highlighted texts were then summarised and transferred to an excel spreadsheet where codes and categories were assigned appropriate descriptive labels (see Appendix E). Table 4.4 below briefly describes the selected strategic plans, policy documents and reports reviewed

in this section, along with the authors and year of publication and purpose of commissioning the documents.

Table 4.4 Description of the Documents for Review

The following documents were reviewed:

Document	Document Title	Description	Author(s)
D1	The integrated transport development plan (2018-2023)	In this document, the CoCT outlines its plans for integrated delivery of intermodal and interoperable transport in Cape Town.	CoCT (2018)
D2	White Paper on National Transport Policy 2017	This document outlines a revised policy that originated from the 1980s and enabled a multimodal approach to public transportation, which enabled privately-owned minibus taxis to be legalised for commercial operations.	DoT (2017)
D3	Municipal Spatial Development Framework 2018	This document is required by law to translate the vision and strategy of the Integrated Development Plan (IDP) into a desired spatial form for the Municipality.	CoCT (2018)
D4	Transit-Oriented Development Strategic Framework 2016	This document provides insights on a policy that places public transport at the centre of urban development in Cape Town.	V Moonsamy and L Stolworthy (2016)
D5	The National Household Travel Survey (NHTS) 2020	The National Household Travel Survey (NHTS) 2020 reveals income groups of households and how much	StatSA (2020)

		they spend on services like public transport.	
D6	The South African National Roads Agency Limited (SANRAL) integrated report 2020.	This report presents the progress on road infrastructure development and maintenance by SANRAL	SANRAL (2020)
D7	Hosken Consolidated Investments (HCI annual report 2020)	Provides a performance report on HCI, the holding company for Golden arrow buses.	HCI (2020)
D8	PRASA corporate plan (2021-2023)	This document outlines the vision of PRASA to the positioning of rail as the backbone of public transport	PRASA (2021)
D9	South Africa's minibus Taxi Industry report 2020	This document provides a background on the minibus taxi industry in South Africa.	Ivo Vegter (2020)
D10	The MyCITI business plan 2015 (Revised)	This document contains the strategic plan for the MyCITI Bus project in Cape Town, which was implemented in 2010 as a newer, more efficient bus rapid service.	CoCT (2010)

4.4 Data Analysis

This section presents a report on the data collected from the participants using co-design sessions, document reviews and semi-structured interviews. The data were collated and analysed using the content analysis method as outlined in section 3.8.1. This technique was used to analyse data collected through co-design sessions and interviews. The process flow for carrying out qualitative content analysis is illustrated in Figure 4. 5

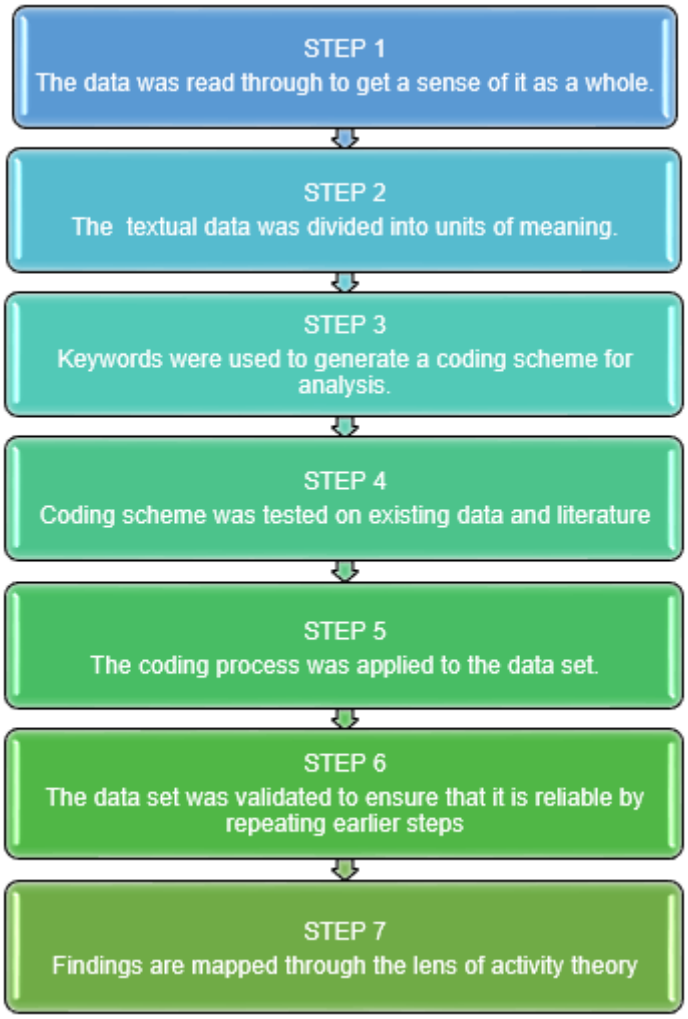

Figure 4.5 Process for content analysis of co-design (Adapted from Hsieh &Shannon, 2005)

4.4.1 Analysis of Data from Co-design Sessions

Groups A and B consisted of six participants each, including young professionals and two students. These participants are at low risk in terms of covid-19 and have no comorbidities; therefore, they could physically attend the session while adhering to Covid-19 health guidelines at all times. Group C consisted of 4 participants categorised as high risk to covid-19 and allowed to participate virtually. The participants received a pack of post-it notes and a set of questions. These were returned within two days using the Uber package service at the cost of the researcher. All data from the sessions were collated and entered into a Microsoft Excel sheet (See Appendix E). The participants' responses were coded, sorted and assigned appropriate categories to reveal the emergent patterns and findings. The descriptive analysis of responses from the co-design sessions are presented below in conjunction with the corresponding research sub-questions and related co-design questions:

Table 4.5 Mapping of Sub-questions and Co-design Questions

Subquestion	Co-design Questions
SRQ 1	**CDQ 1.1; CDQ 1.2; CDQ 1.3;**
SRQ 2	**CDQ 2.1; CDQ 2.2; CDQ 2.3; CDQ 2.4;**
SRQ 3	**CDQ 3.1; CDQ 3.2; CDQ 3.3;**
SRQ 4	**CDQ 4.1; CDQ 4.2; CDQ 4.3;**

SRQ 1: What are the challenges affecting the provision of real-time information for public commuting decision-making in South Africa?

CDQ 1.1 *How would you describe the state of public transportation in South Africa today?*

This question sought commuters' perception of the current public transportation system in South Africa to determine if the services provided are satisfactory to the users. The commuters identified a myriad of challenges the public transport system faces. There was an overwhelming consensus amongst the participants that the current public transport system is unreliable and unsafe. Out of the ten responses, there are (4) instances of concerns regarding safety (P1, P2, P4, P9) and another (4) pointing to the issue of unreliability (P1, P5, P7, P10). Other challenges mentioned are also closely related to the unreliability of services, such as punctuality and inconsistency in service quality. In response to the question on the state of public transportation in SA, P6 stated that "Using public transport in South Africa is a struggle as there is little maintenance." P8 identified "Bad customer service" as the overriding challenge facing public transportation in South Africa. P6 said, "Using public transport in South Africa is a struggle as there is little maintenance". Therefore, from the responses, it can be summarised that public transport services in SA are in a state of disrepair, jeopardy and decay, which requires urgent intervention.

Finding 1: *There is an overwhelming dissatisfaction among commuters about the safety and unreliability of the current public transport system in SA, with concerns such as punctuality, lack of maintenance, and bad services also voiced.*

CDQ 1.2 *In what situation or encounter can you recall where you most needed travel information on public transport service?*

The question was aimed at understanding the scenarios that commuters are faced with that would warrant the need for access to travel information. The scenarios experienced and described by the commuters are homogeneous for commuters who travel for relative purposes. For example, participants, P2, P3, P5, and P6 are students and recalled scenarios where they needed travel information to attend classes and partake in examinations punctually. P2 stated that “When I was going to write an exam, the taxi took too long to get to the taxi rank whereas I woke up on time” in another scenario experienced by P5 “There was a time when I had to wait 30 minutes for a bus as I did not make it in time for the previous one that had already left and this made me late for class. Therefore, I had to end up taking a taxi”.

The working-class participants also highlighted similar scenarios where they needed travel information for their commuting needs. P8 shared an experience of feeling stranded when leaving work after hours and not knowing which public transport was still available. Most participants indicated scenarios where they needed to make an alternative decision. For example, participant P4 said, “The time MyCITI buses were unavailable, as that was my primary mode of transport”. Similarly, P1 stated that “There was a time when taxis were on strike, and I needed to know if I should request an uber,” which are a very common occurrence, especially with the taxi mode of transport. The unreliability of the public transport system in SA necessitates commuters to be provided with real-time information that will decide how to plan their travel routes and trips to avoid delays.

Finding 2: *It revealed the need for real-time information on alternative modes, and during peak travel periods to school/work and return to home, which is often marred by delays and long queues.*

Finding 3: *A significant issue raised was strikes, which have become a growing trend of disruptions among SA’s public transport systems.*

CDQ 1.3 *In your opinion, why do these challenges faced by public commuters persist?*

The commuters were asked for their opinion on the persistent nature of public transport issues in SA. Most of the participants believe that the challenges persist because the stakeholders of the public transport system do not invest in the system. Participant P10 states that “The owners do not listen to the customers.” This points to the issue of operators not listening to customer complaints and voices regarding the challenges they face while commuting publicly. Similarly, according to P1, P6, and P7, commuters feel the public transport system has been neglected for quite some time which has largely contributed to the decay in the quality of

services. For example, P6 stated that "…people in charge or responsible for challenges aren't taking matters serious enough or aren't finding solutions to prevent these challenges from happening." While P1 pointed out that "This is because the owners are selfish and think for themselves only, trains whoever is in charge does not want to upgrade nor fix them, the busses it is because they are not familiar with technology to improve the situation." P5 simply states that the issues persist since there is "No Money" which points to the issue of lack of investment. Such is the magnitude of the perceived challenges that P4 believes there are too many challenges with the current system for the government to handle. The responses show that the government is overwhelmed by many challenges and requires innovative solutions. This will require significant investment from stakeholders to provide reliable and safe public transport services to the populace.

Finding 4: *Participants indicated varying concerns relating to the state of public commuting in SA, including lack of investment, engagement and accountability, in addition to the neglect of socio-traffic issues, which have further exacerbated the state of the public transport system in South Africa.*

SRQ2: What are the accessible information dissemination channels for public commuting in South Africa?

CDQ 2.1 *Do you currently have access to travel information on public transport services? If yes, how do you access it?*

This question aimed to establish how commuters are provided with travel information and understand how commuters access the information provided. Responses revealed some existing information dissemination channels for certain modes of commuting. According to participants P5, P6, and P8, bus services like MyCITI and Golden arrow use technology such as websites and mobile applications to provide information to commuters.

P5 indicates that "Yes, I do have access to travel information, the app is called Moya, and Golden arrow" which is more like a third party service that they share their travel information with to disseminate to commuters.P6 simply states that "Yes, I use the app for golden arrow bus and the Myciti app" and summarily P8 also states that "The website, app for MyCiti" are platforms they use to access travel information. P7 accesses travel information through display screens, stating, "…I use the information at the station." The taxi services do not seem to have any form of information channels as participant P10 who often uses this mode of transport, stated that "The taxis do not issue travel information". In contrast, participant P4 listed the Wego and Tajawal mobile applications as their primary source of travel information. Other

participants indicated that they still receive the travel information manually by calling the help desk or by word of mouth at stations.

Finding 5: *Responses point to multiple information dissemination channels operating in silos within the different transport systems.*

Finding 6: *Mobile applications and websites were indicated as the major sources of accessing travel information; word of mouth and the help desk were also mentioned as options.*

CDQ 2.2 *What mode of communication will be most suitable to use for your commuting needs?*

This question seeks to determine which communication medium commuters prefer to receive real-time travel information. The majority of the commuters (9 out of 10) indicated some kind of technology tool when asked which method they would prefer to receive travel information. In contrast, P3 is the only participant who simply stated that their preferred mode of communication was via "word of mouth," while the other commuters stated they prefer technological communication tools such as SMS, display boards, websites, and mobile applications. SMS and mobile applications were the most prominent preferred mode of communication for commuters. P10 indicated that "email" is their preferred mode of communicating travel information. This was an odd choice as the millennial participant would most likely be expected to prefer modern technology-driven modes such as mobile applications or websites.

Finding 7: *There was a general consensus on the need to receive travel information using a form of technological tool.*

CDQ 2.3 *Have you ever experienced any technological tools used to communicate travel information to commuters? Can you give examples of such tools?*

This question aimed to ascertain technological tools used by commuters to access travel information. Unlike CDQ 2.1, the emphasis here was on the technology being used. The majority of the participants have experienced some sort of technological tool to communicate travel information. Participant P5 stated that "Yes, there are apps used like Moya which I use for buses." Similarly, P8 indicated, "Yes, only for MyCiti there is an app," while P2 alluded to the fact that "Taxis have no tools, But buses have websites and applications. P7 specified

“Just information on screens,” which is some sort of digital display screen at stations. Besides the taxis, all the other modes use technology to provide travel information, so it was apparent that the commuters who normally use taxis could not name a technological tool used to access travel information.

Finding 8: *There is a split between respondents who have experienced using technological tools to communicate travel information amongst the participants.*

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Finding 9: *Technological tools experienced by commuters in communicating travel information include websites and mobile applications.*

CDQ 2.4 *Have you experienced any challenges while using such a system?*

This question seeks to understand the participants’ experiences with the various technological tools indicated in CDQ 2.3. Some of the challenges affecting these tools include outdated schedules and dysfunctional features. For example, participant P2 stated that “The problem I have is that the website is not always working or providing updated information”. Although some of the modes of commuting use technological tools for disseminating information, commuters are still provided with outdated information through websites and mobile applications. On the other hand, Participants P3 and P8 declared that they did not experience challenges using technological tools, with P8 stating that “The My Citi app works.”

In contrast, other responses were “not applicable” for those commuters who may not have experienced technological tools for communicating travel information. P3, who in their previous responses, stated that they preferred traditional means of getting travel information such as in-person and through word of mouth, responded by simply stating “No.” This was expected as this question would not apply to them.

Finding 10: *The majority agree that the existing information dissemination channels are non-functional and outdated.*

SRQ3: What are the real-time information needs of public transport commuters in South Africa?

CDQ 3.1 *What are the specific types of travel information you like to receive?*

The commuters are currently being provided with a variety of travel information. This question aims to ascertain the travel information needs of commuters. Participants were required to list travel information needs to answer this question, and many indicated more than one. As reflected in Table 4.6, the number of passengers on board seemed to be the most popular travel information required. Other top travel information needs are traffic congestion, delays, strikes, and accidents. The responses categorized as “Other” are not considered crucial in influencing decision-making under normal circumstances. For example, participant P4 stated that vehicles “Must have aircon” and “Must be clean,” from a travel information point of view, this would be hard to track and is less likely to influence the choice of commuting mode, unlike the rest of the information needs. Being in an overcrowded vehicle seems to be a common worry for most participants; hence it is the most recurring response.

Table 4.6 Shows commuter information needs

no	Information needs	Participants choice
1	Number of passengers	5
2	Traffic congestion	4
3	Delays	3
4	Other	3
5	Strikes	3
6	Accidents	2
7	Alternative modes	2
8	Alternative routes	1
9	Arrive time	1
10	Departure time	1
11	Distance between stops	1
12	Schedules	1
13	Estimated trip time	1
14	Fares	1

Finding 11: *Top on the commuter information needs for transportation systems includes the number of passengers on the vehicle; information on traffic congestion; Delays; Strikes, and Accidents. Other relevant commuter information needs for transportation systems mentioned include alternative routes; arrival time;*

Finding 12: *Commuters want to know about the number of passengers in a vehicle in order to make an alternative decision.*

CDQ 3.2 *In what way will the provision of real-time travel information affect your commuting activities?*

The concept of an IRIS was introduced to the commuters to understand the perceived influence on their commuting activities. Access to real-time travel information as perceived by the participants can improve the quality of service in the transport system, improve the safety of the public transport system, influence mode shifts through alternative decision-making and improve the trust in the overall public transport system. In terms of improving the quality of service, P9 agreed that "The quality of the service will be better" while P2, who is a student, responded that "The information will help in many ways, the passengers will be kept up to date on what's happening, and if there is traffic we can notify our lectures that we are running late because of a traffic jam or accident." P5 believed that "Safer travelling as a passenger and more trust in the transport service" will be achievable. Similarly, P7 commented that the transport system would be more transparent, thereby improving the trust between commuters and operators. Concerning influencing mode shifts, Participant P1 stated that "It would improve because the driver would know if there were a traffic jam or strike and take an alternate route to be earlier at the destination." The remaining response includes better trip planning, as highlighted by P6, who commented that "It would improve because I would be on time and know when to bring more money and where to get off." The responses indicate that the IRIS would positively impact the participants' daily commuting needs.

Finding 13: *There is consensus that real-time travel information will provide commuters with real-time information central to making alternative decisions on traffic-related incidents.*

Finding 14: *There is a general view that real-time travel information will enhance trust in the transport system and improve the commuting experience.*

CDQ 3.3 *How often would you like to receive the travel information?*

This question was a follow-up to question 3.2, and all participants specified intervals in which they would like real-time travel information updates. The majority of the commuters specified that 1-hour intervals would be convenient for them to receive real-time updates, while others mentioned that 30-minute updates would be best suitable for them. Participant P5 stated that "I would like to be updated every 30 minutes since problems are constantly forming on the roads such as traffic and accidents," while participant P8 simply stated that they would like to receive the updates "Very fast." Although the commuters have certain preferences regarding

real-time updates, the information would still be in its current form, whether an update is received after an hour or not.

Finding 15: *Commuters would like to receive updates and periodic notifications on real-time travel information every 30 minutes to an hour.*

SRQ4: What are the real-time information needs of public transport commuters in South Africa?

CDQ 4.1 *What is your understanding of IRIS for public commuting? How do you think this will benefit commuters?*

The commuters were asked the question above to determine their knowledge of integrated real-time information systems and their impact on their commuting activities. Out of the 10 participants, only two indicated that they do not understand IRISs for public commuting. Commenting on the benefit of IRIS for public commuting, P1 mentioned, “There are integrated sources of information for common decisions that would work for passengers,” while P10 stated, “The transport system will operate better as one.” Similar to P10, participant P2 agreed that “They are able to work together to create a better transport system” P5 also demonstrated a good understanding of the system by responding that “Integrated is basically sub-systems brought together into one whole system like buses, trains, and taxis for various ways to travel.” Even though a few of the participants did not fully grasp the concept of IRIS in the initial question, they later went on to mention that such a system would ultimately benefit the public transport system.

Finding 16: *Commuters have a general understanding of the concept of an IRIS for public commuting.*

Finding 17: *Responses suggest that an IRIS will provide collaborative information sharing from multiple sources accessible for public commuting in SA.*

CDQ 4.2 *What type of information about each mode of transport system would you specifically want to be made available to commuters? (List).*

Commuters were required to list specific pieces of travel information they would like to receive per the mode of the transport system. The responses to this question are tabulated to provide

the reader with a visual representation of the travel information commuters indicated per the choice of the transport system. These tables are numbered 4.7, 4.8 and 4.9 below:

Table 4.7 List of commuter information needs by mode choice: Taxi

no	Information needs	Participants choice
1	Taxi - Arrive time	3
2	Taxi - Number of passengers	3
3	Taxi - is it hygienic to travel in	2
4	Taxi - Accident reports and traffic congestion	1

Table 4.8 List of commuter information needs by mode choice: Bus

no	Information needs	Participants choice
1	Bus - Delay	3
2	Bus - Number of passengers	2
3	Bus - Departure time	2
4	Bus - Next stop time	2

Table 4.9 List of commuter information needs by mode choice: Train

no	Information needs	Participants choice
1	Train - Delay	3
2	Train - Next stop	3
3	Trains - is it safe to travel at the time	1
4	Train - arrive time	1

Finding 18: *Top of the commuter information needs for taxis is the number of passengers in the taxi and arrival time. Other mentioned information needs include cleanliness, accidents, and traffic congestion reports.*

Finding 19: *Top on the commuter information needs for buses is information about delays. Others include departure time and next stop time.*

Finding 20: *Top on the commuter information needs for trains is about delays and next stop. Others mentioned include safety report and arrival time.*

CDQ 4.3 *In what format would you like to receive real-time travel information? What type of features would you want to see on such a system?*

This question was to ascertain the system requirements for an IRIS. The first part required commuters to specify their preferred format to receive real-time travel information, while the second part of the question required them to list specific features as a requirement for the system. The second part of this question was answered through the co-creation phase (section 4.4.1.1) of the co-design sessions in which commuters were asked to ideate the IRS conceptual design the researcher graphically represented. The main formats highlighted by the participants to receive real-time travel information are text and audio. In terms of the required features of the system, participants stipulated the need for application-based notifications on mobile devices, the ability to view and access real-time travel information at designated public areas, and audio speakers that announce travel information and real-time digital schedules at stations as provided at airports. Participant P1 indicated that “intercoms in trains or train stations” would be an ideal feature for them.

In comparison, participant P4 wants a feature to translate travel information into different languages. Other features include USSD technology enabling users with feature phones to tap into the service and receive travel information. Given the multilingual system operated by South Africa, participants agreed that the system should provide information in different local languages.

Finding 21: *Commuters majorly favoured real-time travel information delivery in textual format and audio delivered through technological platforms.*

Finding 22*: An important initial design requirement feature indicated by commuters is for the system to translate information into different languages, text-to-speech capabilities, and notifications.*

4.4.1.1 Co-creation Phase

The second phase of the co-design session (See appendix B) required commuters to design a mock-up of an envisioned IRIS for public commuting within their respective groups. The designs were first sketched on paper, and presentations were done between groups A and B to validate each other's designs. Group C had to submit their design after the session so the other groups could review their design. Then mock-ups were created using Balsamiq software to represent the final designs of the groups. A personal computer was provided to each group

on which only the group leaders could transfer their sketches into mock-ups due to social distancing protocols. Group C was required to submit a sketch as an alternative, and the researcher reproduced the design using the software. The mock-ups of Groups A, B, and C are as follows:

a) Co-creation with: Group A

Group A co-designed storyboards to illustrate the key points for a mobile-based version of the envisioned IRIS for public commuting. The mobile application named “MyRide” centred around digital payments linked to a smart card and a convenient search filter that allows a user to find travel information in real-time. The group concluded that the design in figure 4.6 best suits their needs as they are constantly on their mobile devices.

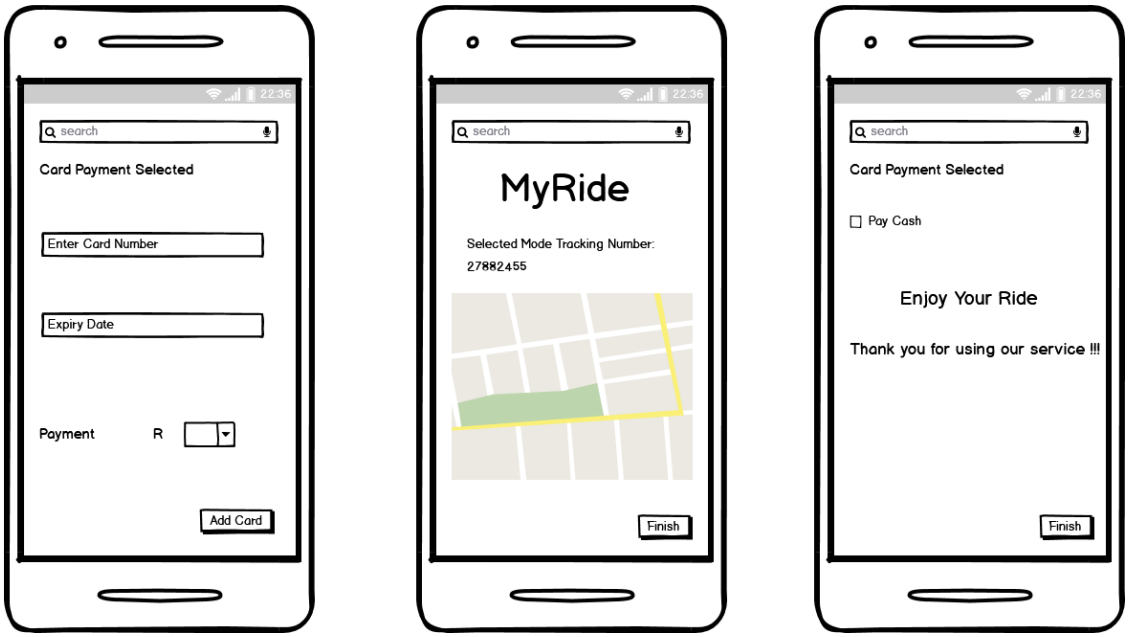

Figure 4.6 Group (A) Participants design of IRIS

The “MyRide” service features a real-time map of the selected modes or and commuters can track the vehicle on the map using the tracking reference number. The mobile device's built-in location tracking service can be powered by this design. The group also felt that it is important to have alternative payment mechanisms with provisions for commuters who prefer cash payments, which can be executed at the stations or through designated payment systems mounted in strategic locations. This design is convenient and creative for commuters to plan their journey and access alternative payment systems.

b) Co-creation with: Group B

This group produced a single view layout of the home page for the envisioned system. As seen in figure 4.7, the design features filtering inputs that allow the user to find the exact information they require from the system. This design is centred on translating output into different local languages and allows commuters to download timetables to their devices. To use the system, the commuter would need to provide a “departure point” and “destination point,” then specify the date and time to commute.

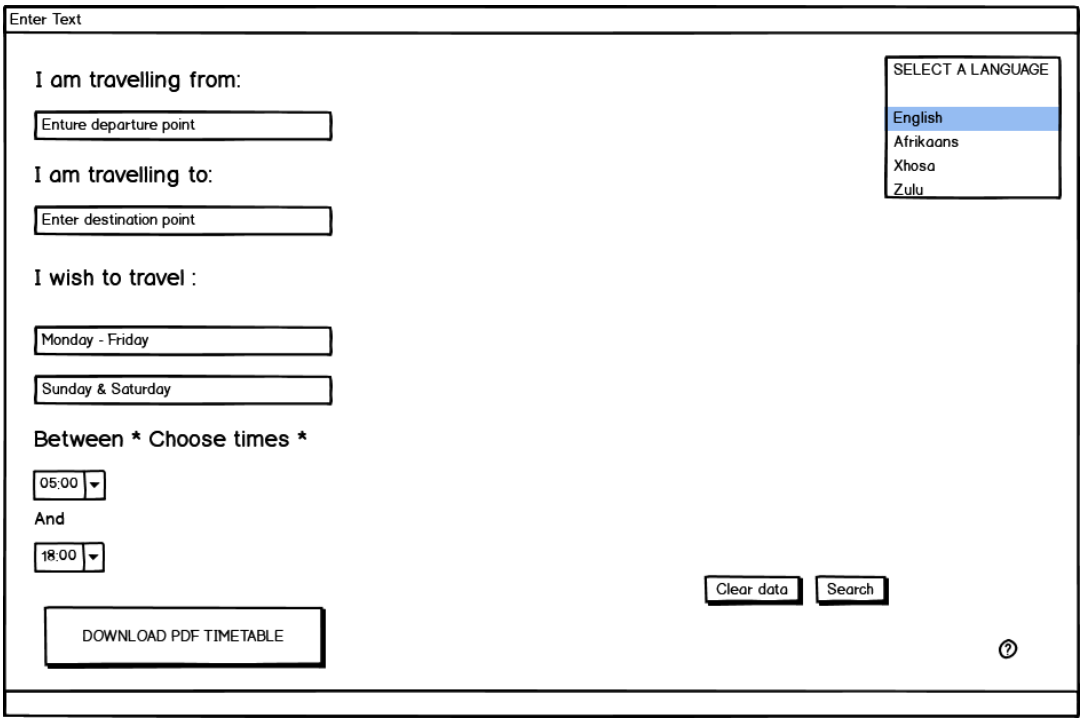

Figure 4.7 Group (B) Participants design of IRIS

The bottom right corner of the screen features a “help” button that connects users to a dedicated online support agent during technical difficulties. This design is very thoughtful and considers the challenges commuters may experience while interfacing with the system. The group did not specify the type of platform the design is based on. However, this concept could be best adaptable to tablet or desktop devices with higher resolution landscape orientations but can also feature on a mobile phone device with the correct configurations.

c) Co-creation with: Group C

This group produced a minimalistic landing page for the envisioned “Smart finder service” system. The interface requires the user to select a preferred commute mode and language. The “other” button allows users to choose from a wider variety of local languages not so familiar in the Cape Town region. As seen in the bottom left corner of figure 4.8, their group included a voice feature where the Information will be read out to the users instead of displaying plain text. This group features older participants; hence, ease of use and usability were key factors in their design.

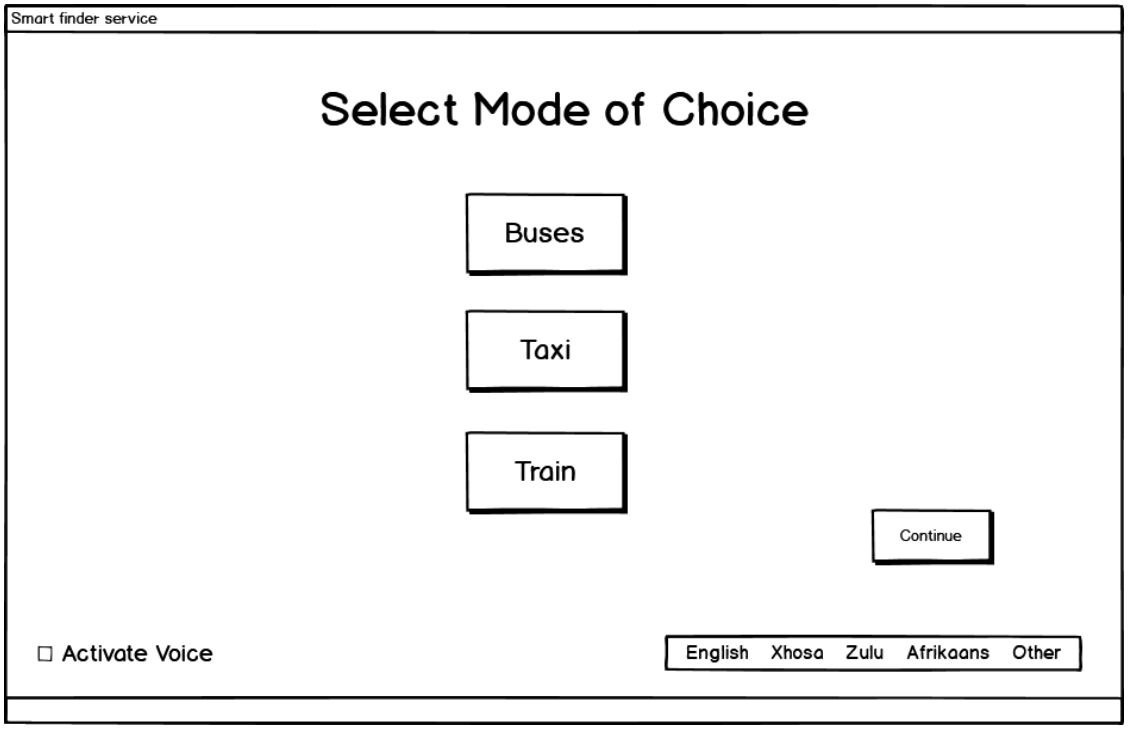

Figure 4.8 Group (C) Participants design of IRIS

This design can be interpreted as more of an initial loading screen where users will specify their preferences before continuing to the next screen to view the information. Such a design can be adapted to Group B's (figure 4.7) to provide an initial preloading screen as both designs are more landscape orientated.

The illustrations of the conceptual designs above provide the researcher with some insights into the design requirements of an IRIS from the perspective of the commuters who would be the system's potential users. The co-creation phase of the co-design sessions further expanded the responses of CDQ 4.3, which sought to ascertain the type of features commuters would require from an IRIS.

4.4.1.2 Summary of Co-design Findings

This section summarises the co-design findings in a tabular format with the co-responding to research sub-questions.

Table 4.10 Summary of co-design findings and the related research sub-questions

RQ: What factors influence the design of an IRIS for public commuting in South Africa?	
Findings	**SRQ**
Finding 1: There is an overwhelming dissatisfaction about the level of safety and unreliability of the current public transport system in SA amongst commuters, with concerns such as punctuality, lack of maintenance, and bad.	**SRQ1**: What are the challenges affecting the provision of real-time information for public commuting decision-making in South Africa?
Finding 2: There is a need for real-time information on alternative modes, and during peak travel periods to school/work and return home, which is often marred by delays and long queues.	
Finding 3: A significant issue raised was strikes, which have become a growing trend of disruptions among SA's public transport systems.	
Finding 4: Participants indicated varying concerns relating to the state of public commuting in SA, which includes lack of investment, engagement, and accountability, in addition to the neglect of socio-traffic issues, which have further exacerbated the state of the public transport system in South Africa.	
Finding 5: Responses point to multiple information dissemination channels operating in silos within the different transport systems.	**SRQ2**: What are the accessible information dissemination channels for public commuting in South Africa?
Finding 6: Mobile applications and websites were indicated as the major sources of accessing travel information; word of mouth and a help desk was also mentioned as options.	

Finding 7: There was a consensus on the need to receive travel information using a technological tool.	
Finding 8: There is a split between respondents who have experienced the use of technological tools for communication of travel information amongst the participants	
Finding 9: Technological tools experienced by commuters for communicating travel information includes websites and mobile applications.	
Finding 10: The majority of the commuters agree that the existing information dissemination channels are non-functional and outdated.	
Finding 11: Top on the commuter information needs for transportation systems includes the number of passengers on the vehicle; information on traffic congestion; delays; strikes, and accidents. Other relevant commuter information needs for transportation systems mentioned include alternative routes and arrival times.	**SRQ3**: What real-time information needs of public transport commuters in South Africa?
Finding 12: Commuters want to know about the number of passengers in a vehicle to make an alternative decision.	
Finding 13: There is a consensus that real-time travel information will provide commuters with real-time information central to making alternative decisions on traffic-related incidents.	
Finding 14: There is a general view that real-time travel information will enhance trust in the transport system and improve the commuting experience.	
Finding 15: Commuters would like to receive updated periodic notifications on real-time travel information every 30 minutes to an hour.	
Finding 16: Commuters have a general understanding of the concept of an IRIS for public commuting.	**SRQ4**: What are the design requirements for an IRIS for public commuting in South Africa?

Finding 17: Responses suggests that an IRIS will provide for collaborative information sharing from multiple sources accessible for public commuting in SA	
Finding 18: Top of the commuter information needs for taxis is the number of passengers in the taxi, and arrival time. Other mentioned information needs include cleanliness, accidents, and traffic congestion reports.	
Finding 19: Top on commuter information needs for buses is about delays. Others include departure time and next stop time.	
Finding 20: Top on commuter information needs for trains is about delays and next stop. Others mentioned include safety report and arrival time.	
Finding 21: Commuters majorly favour real-time travel information delivery in textual format and audio delivered through technological platforms.	
Finding 22: An important initial design requirement features indicated by commuters is for the system to translate information into different languages, text-to-speech capabilities, and notifications.	

4.4.2 Analysis of Interviews of PTO

In the following section, the interview responses from participants representing the transport agencies are discussed descriptively. Although organisations obtained consent to conduct interviews with the participants, the interview data were transcribed and coded, and categories were developed according to identified patterns. The section covers responses from participants R1 – R8 from the PTOs (Codeta, PRASA, Golden Arrow, MyCiti) based on the same set of interview questions. A thematic analysis process was applied to the interview data, and figure 4.9 illustrates the steps followed in the analysis process:

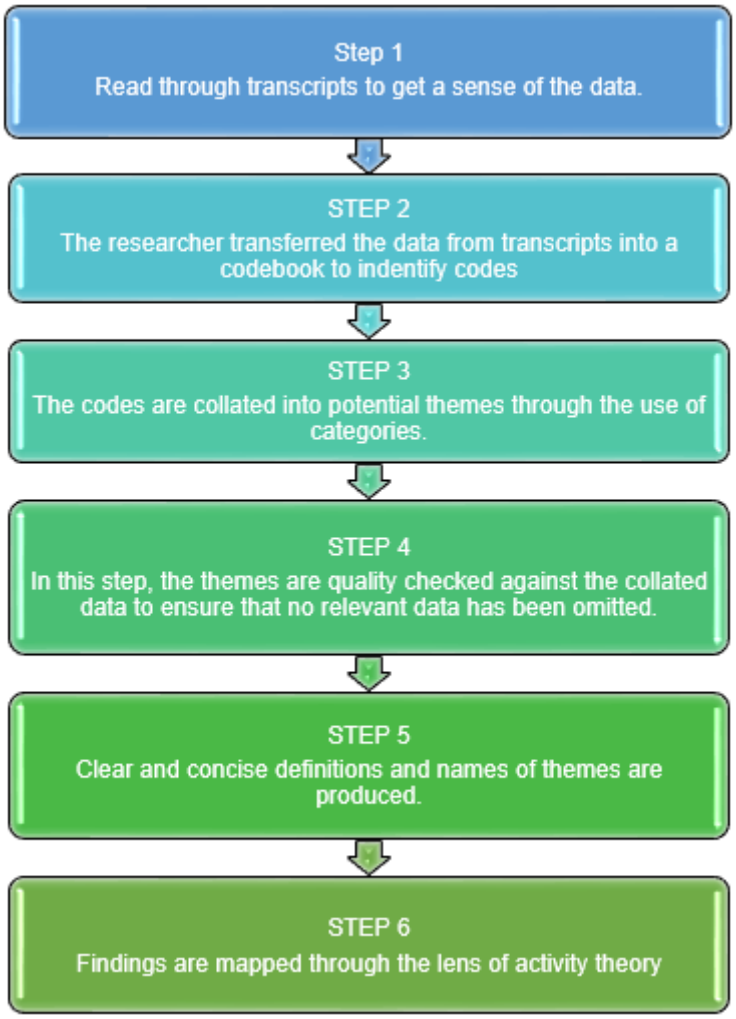

Figure 4.9 Process for thematic analysis of interviews (Adapted from Braun & Clarke, 2006)

Based on the responses of the 8 participants, findings were drawn and presented below corresponding responses to each interview question.

Table 4.11 Mapping of sub-questions and interview questions

Sub-question	Interview Questions
SRQ 1	**IQ 1.1; IQ 1.2; IQ 1.3; IQ 1.4; IQ 1.5;**
SRQ 2	**IQ 2.1; IQ 2.2; IQ 2.3;**
SRQ 3	**IQ 3.1; IQ 3.2;**
SRQ 4	**IQ 4.1; IQ 4.2; IQ 4.3; IQ 4.4; IQ 4.5;**

SRQ 1: What are the challenges affecting the provision of real-time information for public commuting decision-making in South Africa?

IQ 1.1: Can you provide an overview of the public transportation system in Cape Town?

This question targeted uncovering the state of the public transportation system in Cape Town from the participants' perspective. The responses to this question indicated varying problems associated with the public transport system in Cape Town. Respondents R2, R3, R4, and R7 all alluded to the seriousness of the Cape Town transport system problems. R3 pointed out that "It's decreasing in terms of effectiveness and becoming less preferred, the public transport system infrastructure is also a mess," which is reflective of the current situation where those with private vehicles are less likely to consider public transport.R6 supports this argument and can be quoted as stating "Public transport in the CoCT plays a crucial role in transporting people without private vehicles "Respondent R2 states that "I wouldn't say it's at its best; there is room for improvement." R6 and R8 point out that those looking for cost-effective communication still use the public transport system. R6 states that "…it is also an alternative for those who are saving costs and don't want to worry about parking". Some of the respondents did mention that safety is one of the problems, and traffic-related issues such as overcrowding were highlighted. There is a perception that the public transport system is in a state of decay and requires urgent interventions to address the decreasing ridership.

Finding 23: *Cape Town's public transport system experiences challenges such as safety, violence, degrading infrastructure, and other social traffic issues. However, it is cost-effective for public commuters, making it preferable to private commuting for most commuters.*

IQ 1.2: What is your knowledge of real-time information?

This question aimed to ascertain whether the PTOs employees understand the concept of real-time information and attempt to describe it in their own words. Three out of the eight respondents have some knowledge of real-time information. Respondents R2, R4, R6 indicate that they do not know what real-time information is, while R3 highlighted that "I understand that information received with fewer delays can help better communicate with passengers on time, especially regarding a delay." Similarly, R5 stated that "I know it's information that is sent out in a faster manner and periodically than normal information." Some respondents could not fully define what they knew about real-time information. However, they did indicate that they believe it can be useful in public transportation. For example, R8 simply states that "It's information that is used when travelling." At the same time, R1 highlights that "Real-time

information can be used. However, a study needs to be conducted on how we can reduce the number of vehicles that are going to be on the road" Respondent 7 also agreed that it could be used in terms of transportation. "Real-time information is useful for supporting commuters when making decisions." Most employees working in the IT department or related unit could describe the concept more accurately than managers.

Finding 24: *A good number of respondents have a basic understanding of real-time information, with some mentioning that it can improve decision-making within public transportation.*

IQ 1.3: How do you provide information for commuters using public transportation services?
The purpose of the question was to understand the available information channels to disseminate information to commuters. All respondents indicated that they do provide some kind of information for commuters but use different types of medium to disseminate to commuters. Some operators indicated using more than one tool to send out information. The taxis use manual means to communicate with commuters as stated by R1, "We provide information to commuters through printouts that are displayed inside the taxi" and R2 also complemented that "We do provide information in the form of a word to mouth, and some sort of advertising by the taxi rank, offices and inside vehicles". According to respondents R1, Taxis send out information relating to fare increases. R3 and R4 reported that the trains have an intern system that can send out SMS to customers, and information is shared on display screens at major stations. R5 and R6 indicated that Golden arrow provides routes and timetables primary on its website. MyCITI BRT seems to be the most sophisticated with mobile applications and web-based tools to provide commuters with a wide range of real-time information. There are various methods in which information is sent out to the commuters; these range from the very basic manual means used by the taxis to the technological tools used by MyCITI.

Finding 25: *The transport operators use multiple channels to provide commuters with travel information. These include SMS, printouts, display screens, websites, and mobile applications.*

IQ 1.4: What do you think are the challenges of providing real-time information for commuters?

This question covers the transport operators' opinions on possible challenges for providing real-time information. The responses were grouped into three main areas of concern as highlighted below:

a) **Lack of resources**: The lack of resources in the transport system is evident from the perspective of R7, who points out that not all commuters can afford devices to enable them to consume real-time information. Therefore, all commuters must be accommodated, “taking into account the different backgrounds of commuters to make diverse measures for all to access the information.” Similarly, R2 stated that “Most of our customers don’t have access to the technology to get the information; at the moment, we are doing it the best we know.” Evidently, one of the challenges of resources would be the ability to provide commuters with equal access to the information as indicated by R5: “The passengers must also have the proper devices to consume such information; otherwise, the system will be of no value.”

b) **Lack of standards**: Standards are crucial to an IRIS as they ensure consistency operationally. The respondents indicated that a major challenge was the lack of standardised processes from the PTOs. For example, R1 highlighted the concern that “…how will the information be sourced since each association has its own financing model?” When it comes to the taxis, each association has a specific fare for a route; this can be tricky when providing fare information in real-time to commuters. R6 also reported that “…we have challenges providing information as passengers want to access it in different ways”.

c) **Administration:** Regarding administrative challenges, R3 indicated that “Lack of human intervention has caused the system to be outdated in terms of information updates.” This means people are an integral part of the system, as pointed out by R8: “The data needs to be constantly kept up to date.” The management of infrastructure also needs intervention to operate at an optimum level, as highlighted by R4: “The system sometimes goes down, so network problems must be fixed.” This stresses the importance of having devoted administrators working round the clock on the system so that real-time information provided maintains its currency and relevance when important information updates are available as it relates to the travel information provided to commuters.

Finding 26: *Transport operators' provision of up-to-date travel information is hampered by a lack of resources such as technology tools required by commuters to receive real-time updates and stable network connectivity.*

Finding 27: *The provision of up-to-date travel information is affected by a lack of uniformity of standards as operators have unique business processes and commuters also expect tailored solutions.*

Finding 28: *Challenges of ineffective administrative processes and inadequate human resources are cited as inhibitors to providing up-to-date real-time information in the South African public transport system.*

IQ 1.5: How do you think real-time information can be made available for public commuters?

This question seeks to understand the PTOs' view on the best mode to disseminate real-time information for public commuting. Most respondents indicate that mobile is the best platform for disseminating information to commuters. R4 said, "It is easier for the passengers if they can use their phones to access information through mobile applications." Furthermore, R6 indicated that "Mobile is always the most convenient way to send them information," while R3 mentions that "...We support low-income individuals; SMS is still the preferred method, but it needs to be improved to provide current information." It is clear that the common preference between the different transport modes seems to be mobile applications and SMS. Other methods mentioned by R1 and R2 point to digital screens and speakers as the favourite choice to disseminate information to taxi commuters. The channels specified above are more digital. Mobile is very convenient as commuters are always moving with their mobile devices.

Finding 29: *It is apparent that the most convenient and accessible method to provide real-time information for commuters is through digital platforms.*

SRQ2: What are the accessible information dissemination channels for public commuting in South Africa?

IQ 2.1: How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles)

This question is designed to provide insight into the current measures to facilitate communication to commuters by the PTOs. Table 4.12 below shows the respondents comments:

Table 4.12 Comments on current methods of providing travel information

Respondent	Methods used to provide travel information
R1	Printouts at the rank.
R2	Verbally
R3	Printouts and digital screens
R4	We show the information at the station
R5	We provide commuters with schedule information on our website, and updates are posted to the Moovit app
R6	The commuters can search the company website
R7	Websites and using mobile
R8	We have a MyCiti web tool and application

Finding 30: *The PTOs provide travel information about routes, timelines, and availability of vehicles through various platforms such as websites and mobile applications, printouts, and digital displays.*

IQ 2.2: Do you use any technology to communicate information to commuters? If not, why? If yes, How is this done?

This question aimed to understand the technology PTOs use to conveniently disseminate travel information to commuters. The Taxis are the only mode of public transport that does not use technology to send out information to commuters. This is because the industry still operates a manual system. R1 mentioned that “At the moment, there is no technology. The industry is led by individuals who are not united, and when innovations get presented, everyone wants to know how they will gain.” Comparatively, R2 also stated that “No, there is a lack of technology resources from taxis and commuters.” Representatives of the other public transport operators, including buses and trains, stated that they do use technology to provide information. R3 and R4 mentioned that the trains have an internal system that can report on the status of trains, while some information regarding schedules can be found on the organisations’ websites. The public bus transport service, Golden Arrow, uses web-based tools to provide information for commuters, although the company does not have a customised application. They use a third-party application named Moovit to send out information. MyCiti

BRT employs a wide range of technologies to send out information. These include a customised mobile application, digital screens, and web-based tools. Even though PTOs use technological tools, the quality of the information these tools produce is outdated and not received in real-time.

Finding 31: *The majority of the PTOs use digital technology to disseminate information to commuters, excluding the taxi industry.*

IQ 2.3: What are your suggestions on how to improve the provision of traveller information to commuters by your organization?

This question was to determine the opinion of PTOs on improving the provision of up-to-date travel information for commuters. Table 4.13 below reflects the respondents' comments:

Table 4.13 Comments on suggestions on how to improve the provision of information

Respondent	Suggestions
R1	Use IT resources that are more efficient than manual systems
R2	Use a digital tool
R3	Invest in newer non-legacy systems to improve the effectiveness of information distribution.
R4	Use a faster and more reliable system to improve the existing systems and ensure that the people use them the way they were built to be used.
R5	Perhaps also have an internal application tailored for our organization as Moovit is a third-party platform that we use
R6	Find out how the commuters would like to receive the information and cater to their needs.
R7	We are very technology-driven as a BRT service. I wouldn't say there is much room to improve from how we already operate.
R8	Provide the community with access to data or WIFI in public

Finding 32: *The PTOs are all in agreement that innovative technology is the most efficient way to provide up-to-date travel information to commuters.*

SRQ3: What are the real-time information needs of public transport commuters in South Africa?

IQ 3.1: What type of information do you currently provide to public transport commuters?

This question aims to uncover the type of information PTOs disseminate to commuters. The information provided to commuters as specified by R1 is Information regarding changes in routes and fares. Complementarily, R2 stated that “Fare amounts and location of ranks” is what commuters are informed about.” R3 and R4 indicated that trains provide commuters with timetables, schedules, delays, and fare increases. On the other hand, the buses provide information about available routes, the distance between routes, time schedules, stops, and fares, as described by R5, R6, R7, and R8. The responses show that all PTOs currently provide travel information for commuters, which vary based on modes.

Finding 33*: The type of travel information transport operators can currently disseminate to commuters is limited to fare increases, timetable, station, routes, and commuting schedules.*

IQ 3.2: What do you think are the necessary travel information needs of public commuters?

The above question was targeted at determining what the preferred commuter travel information needs were from the perspective of the PTOs. Most of the respondents believed that information about the next available vehicle was what commuters were more concerned with. This sentiment was echoed by R1, who reported that “Commuters have different working hours, so most of the questions are like, will the taxis be available after hours?”. Similar to that comment above, R5 stated, “Commuters would generally want to know if the bus will arrive on time and when the next one is coming.” R7 also commented in agreement that “The commuter expect a regular feed of information relating to the next scheduled bus”. R3 and R4 specifically state that commuters prefer information about delays, time schedules, fare changes, and road incidents. At the same time, R8 indicates that “Being able to find stations and calculate estimate wait times” is one of the preferred information for commuters. There seems to be some overlap between what the public commuters provide to commuters and what they perceive to be the necessary travel information needs.

Finding 34*: The travel information preference of commuters according to transport operators includes the arrival of the next vehicle, which featured prominently, while information about incidents, delays, driver information, fare changes, and scheduling was also mentioned as important.*

SRQ4: What are the real-time information needs of public transport commuters in South Africa?

IQ 4.1: Do you think there is merit in sharing real-time travel information with other transport operators?

The question was purposed to investigate the perceived benefits of sharing real-time travel information amongst the different transport operators. The majority of the respondents indicated that sharing information with other operators would be beneficial. R7 believes it is a good idea since “It will certainly make it convenient for the commuters in terms of universal access to information.” Similarly, R4 pointed out that “It can be helpful for service delivery as transport operators. However, issues of privacy were also raised by R4, who commented that “…but privacy can be a big issue and extra security measures need to be put in place to protect confidential customer data between operators” R8 also raised similar concerns: “Depends on what the other parties plan to do with the information, could be privacy concerns.” R6 revealed that “…Change needs to be managed effectively to ensure all parties can work in cohesion.” The statement resonates with respondent 5’s comment about each party knowing their role in data coordination.

On the other hand, some respondents, particularly those in the taxi industry, raised concerns over unfair competition from such collaboration. For example, R1 indicated that “In terms of sharing information, it depends; taxis are currently leading in commuter numbers; so, this new system of sharing can put the competitors at an advantage of taking passengers.” R2 also made a similar assertion: “To be honest, the public will benefit, but for us, it can work against us because the person can choose other modes instead of using the taxi.” The wariness of information collaboration by transport operators raised by the previous respondents was also expressed by respondent R3 who stated that it might not be wise from the transport organisation’s point of view. It can give other stakeholders an upper hand. The responses show benefits associated with facilitating the sharing of information between the PTOs.

Finding 35*: Respondents concur that sharing information between PTOs will improve service delivery for commuters. However, there are concerns about data privacy and unfair competition between operators.*

IQ 4.2: How will you describe the benefits of an integrated traveller information system for commuters?

There is no doubt amongst the PTOs that an integrated traveller information system will benefit commuters. The ability to make alternative decisions is the main benefit mentioned by the respondents. R1 stated that “the commuters will gain from having multiple options to choose from.” Similarly, R2 indicated that “It can bring a lot of safety and make things much faster. For example, if it were an app, they would be able to find most routes and make decisions.” R3 and R6 expressed similar views that “Commuters will be able to decide early where to take transport and when a vehicle will be arriving late” the other possible benefits to commuters are improved safety and reliability. Expressing their opinions on other pertinent benefits, R8 believes that such a system will “improve security and safety for passengers and drivers,” while R4 indicated that the public transport system would be more efficient and reliable with integrated traveller information system. R7 believes “This will assist with traffic congestion as commuters will have diverse options,” therefore, there is no doubt between the respondents that this would benefit commuters. The overall responses indicated that an integrated system would help solve many of the challenges experienced by PTOs in providing quality services to their commuters.

Finding 36*: There is a consensus that commuters will benefit from an integrated system through improvement in decision making, safety, and reliability of the public transport system.*

IQ 4.3: Considering the current transportation system in CT, How well will an integrated real-time system work?

The PTOs currently operate in silos. Therefore, getting a buy into a new collaborative system would require mutual trust from all stakeholders to succeed. Respondent R1 voiced some scepticism that “This may create a platform for the government to control and formalise our current operations for their gain.” This is a relevant point since the taxi industry operates informally. Thus, establishing such a system will require formality and regulations, which might encounter resistance. R2 also commented that the system might experience challenges when initially launched. However, it can significantly improve passenger and driver safety in the long run.

In contrast, respondent R3 believes that the system may not have such a huge impact on influencing commuters' mode choices since commuters use the mode of transport that best suits their budgets. While R4 and R7 believe that there needs to be a better action plan

involving all stakeholders to reduce tension around the issue of competition for passengers, the current infrastructure also needs to be reviewed as stated by R6: “Proper infrastructure investments should be implemented to make this work in the current transportation system.” The statement implies that failure to invest in critical infrastructure hinders the system's optimum performance. Likewise, R5’s comment implied that the system could be successfully launched under current conditions. However, there needs to be accountability and proper administration to be maintained at the desired level. The respondent can be quoted stating, “Could be successful, but this depends on who will be liable for the administration and management of the system.” Regarding the current public transport system in Cape Town, R8 indicated that such a system might be what public transport needs to improve service quality.

Finding 37*: Respondents generally believe that change needs to be managed effectively to have a smooth transition from their current system to an IRIS.*

IQ 4.4: What desirable features should an IRIS provide for commuters and operators?

The question focused on the holistic features necessary for designing an IRIS from the perspective of the transport operators. Table 4.14 below highlights the design features of IRIS as captured by the respondents' comments:

Table 4.14 Desired features of an IRIS

Feature	Respondents choice
Fleet management	5
E-payments	4
Customer reviews	4
Driver Management	4
Update on maintenance	1
Arrive time estimates	1
Reports on incidents	1
CCTV	1
SMS Notifications	1
Seat reservation	1
Toll-free access	1

Finding 38*: The transport operators indicated fleet management; E-payments, customer reviews, and driver management as some of the most desired essential features in an IRIS, amongst others.*

IQ 4.5: What are the challenges such a system might encounter in the current climate?

The current transportation climate in SA segregates as routes are exclusive to certain modes or associations. In response, R1 stated that “The system may cause government interference in operations and place the taxi industry at a disadvantage through increased laws and regulations. Roads and other infrastructure will need to be upgraded first, and new routes must be created.” Seconding the need for better infrastructure, R2 believes that road conditions need to be prioritised before introducing such a system. The response can be quoted as “The most important challenge is infrastructure; there need to be improvements to the roads first.” An argument was made for a standardised process to administer and manage such a system. R3 and R7 stated that people are pivotal to the success of a system, and therefore proper training needs to be provided to administrators. R8 raised the importance of developing a revenue-sharing model that benefits all stakeholders equally, with R4 indicating that “There might be violence due to increased competition; other operators may feel an unfair advantage is given to others.” While R5 also raises a similar concern and states that “There could be tension between the different operators, particularly the taxi industry,” R6 revealed the need for standardised processes between stakeholders to maintain transparency. Implementing such a system would restructure the nature of public transportation, and therefore this needs to be a well-planned undertaking to minimise the risk posed by existing challenges.

Finding 39*: There are concerns raised about the effective administration and management of an integrated system to ensure equal opportunities and benefits are transparently presented to all relevant stakeholders.*

Finding 40: *Fear of conflicts, being in a position of disadvantage amongst operators, and the depleting current state of road infrastructure are major concerns highlighted that might derail the success of an* IRIS*.*

4.4.2.1 Summary of Interview Findings

This section summarises the interview findings in a tabular format with the corresponding research sub-questions.

Table 4.15 Summary of interview findings and the related research sub-questions

RQ: What factors influence the design of an IRIS for public commuting in South Africa?	
Findings	**SRQ**
Finding 23: Cape Town's public transport system experiences challenges such as safety, violence, degrading infrastructure, and other social traffic issues. However, it is cost-effective for public commuters, making it preferable to private commuting for most commuters.	**SRQ1**: What are the challenges affecting the provision of real-time information for public commuting decision-making in South Africa?
Finding 24: A good number of respondents have a basic understanding of real-time information, with some mentioning that it can improve decision-making within public transportation.	
Finding 26: Transport operators' provision of up-to-date travel information is hampered by a lack of resources such as technology tools required by commuters to receive real-time updates and stable network connectivity.	
Finding 27: The provision of up-to-date travel information is affected by a lack of uniformity of standards as operators have unique business processes and commuters also expect tailored solutions.	
Finding 28: Challenges of ineffective administrative processes and inadequate human resources are cited as inhibitors to providing up-to-date real-time information in the South African public transport system.	

Finding 25: The transport operators use multiple channels to provide commuters with travel information. These include SMS, printouts, display screens, websites, and mobile applications.	**SRQ2**: What are the accessible information dissemination channels for public commuting in South Africa?
Finding 28: Challenges of ineffective administrative processes and inadequate human resources are cited as inhibitors to providing up-to-date real-time information in the South African public transport system.	
Finding 29: It is apparent that the most convenient and accessible method to provide real-time information for commuters is through digital platforms.	
Finding 30: The PTOs provide travel information about routes, timelines, and availability of vehicles through various platforms such as websites and mobile applications, printouts, and digital displays.	
Finding 31: The majority of the PTOs use some kind of digital technology to disseminate information to commuters, excluding the taxi industry.	
Finding 32: The PTOs are all in agreement that innovative technology is the most efficient way to provide up-to-date travel information to commuters.	
Finding 33: The type of travel information transport operators can currently disseminate to commuters is limited to fare increases, timetable, station, routes, and commuting schedules.	**SRQ3**: What are the real-time information needs of public transport commuters in South Africa?
Finding 34: The travel information preference of commuters according to transport operators includes the arrival of the next vehicle, which featured prominently, while information about incidents, delays, driver information, fare changes, and scheduling was also mentioned as important.	

Finding 35: Respondents concur that sharing of information between PTOs will improve service delivery for commuters. However, there are concerns about data privacy and unfair competition between operators.	**SRQ4**: What are the design requirements for an IRIS for public commuting in South Africa?
Finding 36: There is a consensus that commuters benefit from an integrated system through improvement in decision-making, safety, and reliability of the public transport system.	
Finding 37: Respondents generally believe that change needs to be managed effectively to have a smooth transition from their current system to an IRIS.	
Finding 38: The transport operators indicated fleet management; E-payments, customer reviews, and driver management as some of the most desired features amongst others as essential in an IRIS.	
Finding 39: There are concerns about the effective administration and management of an integrated system to ensure equal opportunities and benefits are transparently presented to all relevant stakeholders.	
Finding 40: Fear of conflicts, being in a position of disadvantage amongst operators, and the depleting current state of road infrastructure are major concerns highlighted that might derail the success of an IRIS.	

4.4.3 Analysis of Document Review

This section provides an analysis of relevant policies guiding the operations of the different PTOs in CoCT through the systematic review of overarching policy documents, strategic plans, and government reports on the South African public transport sector. The analysis expounds on the activities, roles, and plans of major players within the public transport sector in South Africa, with particular focus on the implications on CoCT's public transport system. The document review was conducted to highlight the challenges acknowledged by governing bodies and establish the strategic plans and initiatives to deal with the challenges. Also, to review the impact of the implemented initiatives in practice and society, this data collection and analysis complemented the primary data collected from interviews and co-design sessions. The thematic analysis process in analysing the document is illustrated below in figure 4.10

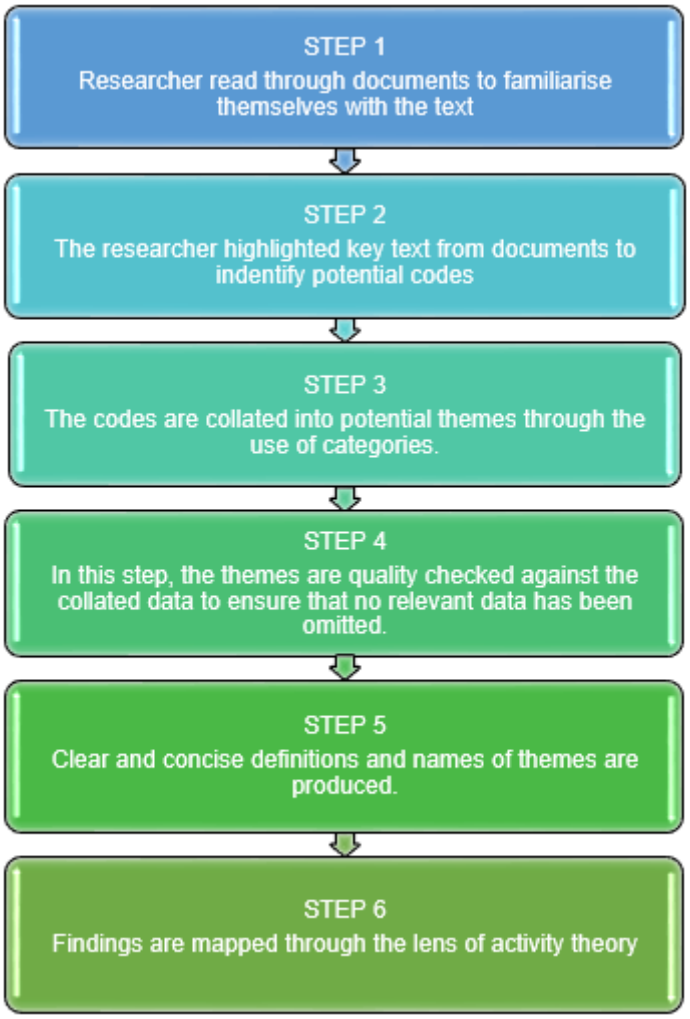

Figure 4.10 Process for thematic analysis of documents (Adapted from Dalglish et al., 2020)

4.3.3.1.1 D1: The Integrated Transport Development Plan (ITDP) 2018-2023

This document provides a framework for an integrated transport network within the CoCT to create a reliable and safe public transport system. The document highlights the main challenges of public transportation as:

"Flexibility and safety are the major challenges across the City, direct costs due to ticket fares are a main concern for the low-income group segment, and congestion is a concern specifically for high-income private transport users." (CoCT, 2018:146)

There are plans to address the ongoing issue of traffic congestion within the metro by installing a citywide transportation network by 2032, where different modes of public transportation will be integrated to form a unified system. According to the CoCT (2018), "it is projected that by the year 2023 The population of Cape Town will be roughly 5.6 million people, The morning rush-hour traffic is expected to increase by 46%, and 80% of Capetonians would be living within 500 meters of public transportation routes."

The implication of the numbers above is a reason for the CoCT to invest in sustainable public transport that people can trust to be effective, safe, and affordable. Hence, the ITDP aims to upgrade existing facilities and provide additional infrastructure to support the public transport system. The document also states that the addition of routes for services such as Rail and MyCITI can increase the capacity of the public transport system. Resultantly, it leads to an intermodal approach to public transport, which can drastically improve customer experience and reduce the number of private vehicles on the road.

Finding 41: *The CoCT acknowledges that an integrated transport system is required to address the traffic-related issues resulting from an increase in population and overreliance on private vehicles in their strategic plan for intermodal and interoperable transport in Cape Town.*

4.3.3.1.2 D2:The Revised White Paper on National Transport Policy (WPNTP) 2017

The government originally introduced the white paper on national transport policy in the late 1980s, which formally introduced the participation of minibus taxis in the public transport system. This was mainly done to expand the capacity of the public transport system to cope with the demand from people moving to and from inner-city areas. The policy also introduced a private-public partnership approach to municipal bus services. Today, an example of such

a partnership is between CoCT and Hosken Consolidated Investments, the holding company for Golden Arrow buses (HCI, 2020). This policy had implications for the PTOs. The legalisation of the taxi industry increased the competition for passengers between operators, and bus services were largely impacted as taxis operate informally. This led to the government being forced to subsidise the bus industry per passenger instead of channelling the funds towards infrastructure development (DoT, 2017). The mission, as stated in the document, is as follows:

"To promote a safe, reliable, effective, efficient, coordinated, integrated and environmentally friendly public transport system by developing norms and standards as well as regulations and legislation to guide the development of public transport for rural and urban passengers" (DoT, 2017:43).

The revised white paper on the national transport policy of 2017 addressed the issues around the earlier versions of the policy by increasing investments in rail infrastructure to support the congested road network, improving access to transport for the rural communities and people with disabilities, acquiring skills and expertise to implement policy proposals, and the monitoring and tracking of stakeholders by the DoT to ensure that policies and proposals are met at the implemented phase. The policy categorises the issues of public transport as follows:

Road infrastructure:

"There is insufficient funding to maintain the existing road infrastructure, which has resulted in a significant and growing road maintenance backlog nationwide. This issue must be rectified as the road network is a critical component of the economy, providing access and mobility, facilitating economic and social linkages, promoting economic development and stimulating exports" (DoT, 2017:43).

Rural transport:

"More attention needs to be given to rural public transport. The availability and quality of public transport in rural areas is deficient. Public transport policy must overcome the issues in rural transport of relatively poor connecting infrastructure in some provinces, large distances, sparsely populated regions, self-sustaining communities, dispersed demand and relatively low incomes to offer sufficient public transport services to rural areas." (DoT, 2017:45).

Public transport funding:

"Public transport remains inadequately funded. Specific funding issues still being a priority include the following:

• The absence of dedicated funding sources for public transport;
• Lack of clarity on how rural public transport projects should be funded;
• Inadequate funds to ensure the implementation of long-term plans;
• The funding of public transport operations through multiple sources and channels; and
• The major imbalance between spending on infrastructure (high spend) and operations
• (low spend). "

In conclusion, this revised policy aims at building an inclusive and abled public transport service accessible for people with reduced mobility and those living in rural areas. Such a policy would ensure that no one is left excluded socially and economically.

Finding 42:*The taxis operate informally, which has caused other PTOs to be unable to compete, and as a result, the government has resorted to subsidising those operators to keep their fares at affordable rates.*

4.3.3.1.3 D3:The Municipal Spatial Development Framework (MSDF) 2018

The MSDF framework of 2018 is an adaptation of the national land act of 2009 for the Cape Town Metro. It aims to address the issue of separate development resulting from the apartheid-era group areas act. This act divided people between races, and separate development was done in suburban areas as compared to township areas. Although there has been much reform in the post-apartheid era, the effects of its policies are still felt today as certain settlement areas and communities still do not have access to key transport infrastructure to participate in the economy. Among the issues highlighted above, the document highlights two major challenges facing the CoCTs existing network: affordability and congestion.

In terms of Affordability:

"17% of the population of Cape Town fall into the non-motorised transport (NMT) user group. This means that over 500 000 people do not have access to any transport mode other than walking or cycling due to their income constraints." (CoCT, 2018:33)

In terms of congestion:

"In 2013, the TomTom global traffic index suggested that Cape Town was the most congested city in South Africa, ranked 48th globally. The survey also revealed that motorists were spending an extra 35% of their time in traffic. Congestion comes at a great cost to the sustainability and efficiency of the city, not only in terms of the economic and social costs of time and money lost but also by generating pollution with its long-term effect on the environment." (CoCT, 2018:33)

The MSDFs objectives are to improve access to public transport infrastructure in these previously disadvantaged communities, such as Mitchells Plain and Khayelitsha, who are still very much reliant on public transports. These communities are most likely to spend more than 1 hour commuting to and from places of residence due to the distance of settlements to the city's economic hubs further exacerbated by an inefficient public transport system.

Finding 43: *The land planning in CoCT is such that the workforce lives further from the economic hub, resulting in longer walking distance and commuting times.*

4.3.3.1.4 D4:Transit-oriented Development (TOD) Framework 2016

The TOD is a broad framework at the core of the cape town public transport system development plan. The CoCT has adopted the TOD standard to draft its framework as it has been proven to work in cities such as San Diego, Washington, and some cities throughout America. The TOD Standard is aimed at guiding urban development stakeholders such as governments, developers and investors, planners and designers, sustainable development advocates, and interested citizens to evaluate projects at the planning or design phases to identify gaps and opportunities for improvement; guide policy and regulations relevant to urban planning, transportation planning, land use, urban design and parking" (CoCT, 2016:17) In the context of Cape Town, the aim is to use the train as a backbone to boost accessibility (CoCT, 2019). The framework positions public transport at the centre of development in communities, providing them with socio-economic benefits. The framework looks to address the following issues:

"1) Affordability - reduce the cost of public transport to commuters and the cost of providing public transport to the City. 2) Accessibility - facilitate equal access to social and economic activity through strategic urban development and the provision of safe public transport. 3)

Efficiency - provide an environment and level of service that reduces trip lengths and dependence on private vehicles. 4) Intensification & Densification - manage the desired form, composition and location of urban development conducive to affordable, accessible and efficient public transport." (CoCT, 2016:5)

Implementing the TOD framework will ultimately reduce the number of private vehicles and ensure that public transport is experienced as an inefficient and reliable form of commuting. The TOD requires quality train infrastructure to be in place to achieve compact, walkable, pedestrian-oriented communities. The TOD framework also helps to reduce the stress placed on the environment through carbon emissions from the number of vehicles on the roads during peak hours.

Finding 44: *The public transport system is at the core of achieving social cohesion; hence, proper infrastructure for transport is necessary to uplift communities and enable them to participate actively in the economy.*

4.3.3.1.5 D5: The National Household Travel Survey (NHTS) 2020

This document presents the findings of a survey conducted nationality and aimed to ascertain the income groups of households within the different cities and the expenditure on services such as public transport. The focus was on the data about the CoCT, and according to the report, the low-income households survive on average of R3200 per month. The majority of these low-income earners live in townships where access to public transport is limited to specific modes, and often commuters walk long distances to stations. Figure 4.11 shows the income groups and the type of transport they depend on in peak hours.

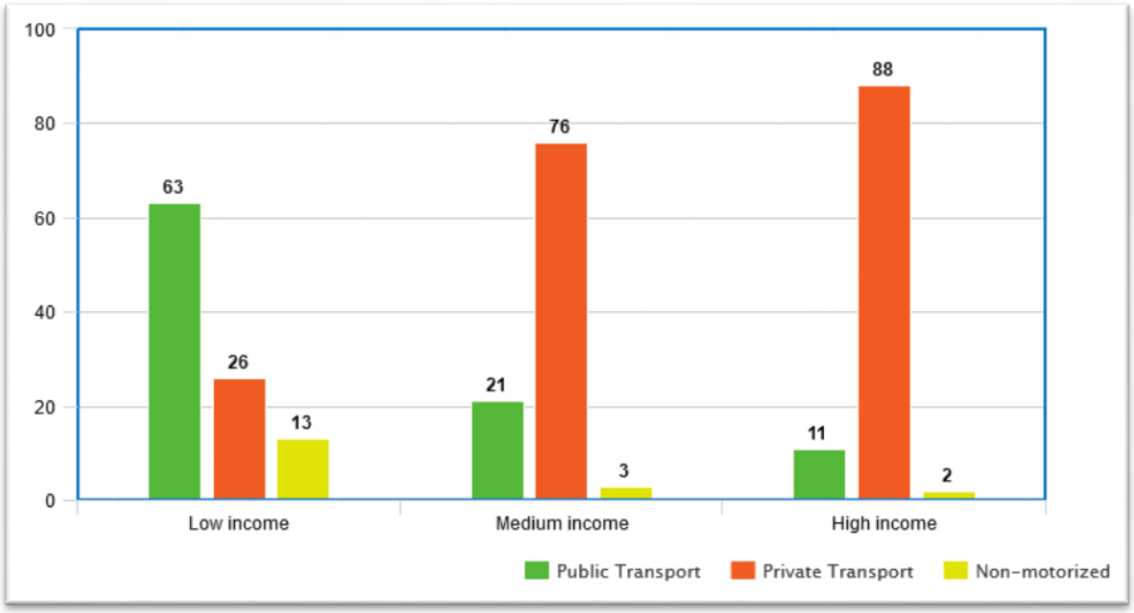

Figure 4.11 Peak period segment usage split by income groups % population (StatSA, 2018)

The income bracket of the households is often used as an indicator of users of private vehicles or public transport. The low-income households who survive just below the poverty line majorly use the public transport system. However, the middle class and higher-income households can afford to own at least one vehicle (StatSA, 2018). The public transport system is often seen as a zero option for the low-income bracket. Thus the unavailability of PTO services at any time often puts them in jeopardy.

Finding 45: *The public transport system in the CoCT predominantly caters to the low-income populace, with the middle and high-income earners often relying on private commuting.*

4.3.3.1.6 D6:The South African National Roads Agency Limited (SANRAL) Integrated Report 2020.

The South African public transport system consists of a rail and road network. The roads are maintained by the South African National Roads Agency (SANRAL) at a national level. The main responsibility of SANRAL is to ensure that roads are maintained, which requires ongoing expenditure. South Africa has a lot of unpaved roads, with 70% of the roads in provinces being gravel roads and access roads and an aggregate of about 30% of the roads paved. The quality of these roads tends to vary based on region and province. Therefore, SANRAL needs to clear the backlog on road construction, as this forms part of basic infrastructure and amenities available to communities. Ensuring roads are properly maintained timeously, which is one of the core responsibilities of SANRAL, improves the safety of all road users and reduces the

number of accidents. One of the visions outlined in the draft national road policy is an intelligent transport system that can assist in solving some of the problems experienced on the roads. These include environmental sustainability, safety, and security, together with traffic congestions. In a report by the DoT (2020), It was pointed out that the deployment of ITS can be a more cost-effective means of solving these problems rather than providing additional roads capacity as SANRAL is financially overstretched to meet some of its obligations of provided road capacity.

“I draw attention to note 44 to the financial statements, which indicate that the public entity has an accumulated loss of R14.85 billion and current assets do not cover current liabilities as of 31 March 2020. The Board is fully aware of the liquidity risk it faces in the short term and is actively engaging with the government to resolve the e-toll impasse…” (SANRAL, 2020:42)

This report states that SANRAL’s financial woes yield greater uncertainty and result from revenue loss from projects such as e-Tolls as motorists have become reluctant to pay.

Finding 46: *There is an acknowledgement that the road network* can lead to the deployment of ITS, which is a more cost-effective means to *alleviate the pressure placed on road networks during peak hours* rather than building additional roads capacity*.*

4.3.3.1.7 D7:Hosken Consolidated Investments (HCI) Report 2020

This document reports on the status of HCI which is the holding company contracted by the CoCT to maintain the Golden Arrow bus service. The subsidization of bus services through contracts between bus operators and the provincial government has brought stability in the business of providing scheduled bus services in recent times in CoCT (HCI, 2020). The Golden buses provide services in residential areas such as Hanover Park, Elsies River, Langa, Nyanga, Wynberg, Mitchell’s Plain, and Khayelitsha (PGWC, 2011). Although the Golden arrow bus network covers a wide range of routes, it has limited off-peak services on most of the routes. The service currently operates 1046 buses during peak hours, serving 1300 routes across metropolitan Cape Town (HCI, 2020). Most of their vehicles are single deckers with a loading capacity of approximately 65 passengers seated. Golden Arrow buses undergo regular rigorous maintenance to reduce the number of vehicle breakdowns in recent years. Some of the measures put in place include:

- Weekly mechanical defects check on electrical, body, and tyres.

- Buses are serviced at 15 000km intervals, below the supplier's recommended 20 000km intervals.
- Daily repairs of work on identified defects
- Roadworthiness checks are done at six-monthly intervals
- Extensive Fleet renewal – approximately 500 new buses added to the fleet since 2003

Although GABS has been accelerating its fleet renewal programme since 2003 to enhance its service quality, the current Golden Arrow buses are inaccessible to passengers with reduced mobilities (HCI, 2020). The bus service has been reported to face challenges around security at terminals and in vehicles, several incidents of commuters being robbed onboard by suspects who are masquerading as passengers. As quoted in this report, "A dramatic increase in armed robberies aimed at buses was experienced. After a series of high-level meetings, the authorities agreed to install cameras on buses and deploy a dedicated public transport police force. Additionally, GABS has begun to install drop-safes in buses for driver takings "(HCI,2020:18). As noted in the report, the company has a fightback strategy against these criminal elements and subsequently partnered with SAPS and local safety and security agencies. Also, more than 500 buses have been fitted with onboard electronic camera systems (HCI, 2020).

Finding 47: *Golden Arrow is the most accessible bus service in the CoCT. However, it is reported to have limitations of use for persons with mobility challenges, and it is faced with challenges of safety as passengers are susceptible to criminals masquerading as passengers.*

4.3.3.1.8 D8: PRASA Corporate Plan (2021-2023)

The commuter rail network in the CoCT consists of 97 stations, with daily services provided on 14 service lines and 227 train trips during peak times (PRASA, 2021). PRASA owns the railway service, which is faced with many challenges that make it incapable of providing a consistent level of service to commuters (DoT, 2020). The rail system lacks proper maintenance that further contributes to its deterioration. As a result, Metrorail who operates in CoCT is constrained because it needs to maintain infrastructure but cannot raise prices because its main customers are low-income commuters who often cannot afford alternative means of transportation. Most of the problems faced by PRASA and Metrorail are national problems and not specific to the CoCT. For example, cable theft often interrupts the signalling systems of trains nationally, which results in delays and cancellation of services. There is a general lack of trust in the rail system's operations, making it a low option for those who can

afford other modes of public transportation. PRASA is embarking on a rail operations recovery and modernization programme, which will make the service more attractive to all commuters by providing modernised trains and stations. This will significantly contribute to:
"

• Affordable Benefits: PRASA provides a public transport service at the lowest cost to South African households, i.e., lowest fares, thus increasing disposable household income.

• Congestion Management Benefits: PRASA has the potential of moving ±60,000 passengers an hour in one direction per corridor, and the modernisation programme will steer PRASA towards realizing this potential. In so doing, PRASA will reduce congestion, shorten travel times and reduce environmental degradation.

• Economic Development Benefits: The proximity to transit facilities positively affects residential property values and commercial activities due to increased travel opportunities.

• Additional Quantifiable Benefits: such as parking cost savings, infrastructure cost savings, fiscal impacts, labour market impacts, and income impacts. Commuter rail users save on parking costs in the city centres, and Park and Ride facilities offer safe parking at no additional cost to PRASA rail users.
" (PRASA, 2021:13)

The rail system needs to be modernised and integrated to form a sustainable public transport system. There has been an increase in security presence at the Cape Town station due to acts of arson and vandalism. A further investigation revealed that the CCTV cameras at the train station have not worked since 2015 (CoCT, 2018). PRASA needs to do more to improve the safety of commuters and expand its capability to provide for passengers with special needs as only limited stations are accessible to passengers who use wheelchairs (CoCT, 2018).

Finding 48: *Trains are the most affordable mode of transport. However, the services are marred by challenges such as delays, safety issues, and decay in infrastructure that have made the service less desirable to middle and higher-class commuters.*

4.3.3.1.9 D9:South Africa's Minibus Taxi Industry Report (2020)

The mini-bus taxi industry is a central part of the public transport system because the service is available during off-peak hours and is accessible in most residential areas. The CoCT estimates that around 332 407 daily trips are made by taxi (Vegter, 2020). Since there is no

set schedule or guide for taxis, the experience can be quite overwhelming for commuters who have never used the service before. Taxis normally fill the void for other modes that do not pitch on time. The taxi industry operates in an almost unregulated manner, making it hard to curb the spread of illegal operators (CoCT, 2018). More than 70% of the taxi routes in Cape Town are overtraded, and with a growing number of illegal operators, this often leads to violence and shootings that pose a threat to, often leads to violence and shootings that threaten the safety of innocent people bystanders (Vegter, 2020). The operators in this sector are the various taxi associations that oversee vehicles registered to operate within a particular route (Vegter, 2020). The vehicles are owned and maintained by different individuals who often respond unenthusiastically to efforts that could bring about reform. As part of the taxi recapitalisation:

"The government would pay taxi owners a 'scrapping allowance,' which would serve to remove older, unsafe taxis from the road, and which could then be used as a deposit for the purchase of new 18-seater (minibus) or 35-seater (minibus) vehicles. The taxi industry was majorly opposed to this programme resulting in violent protests and intimidation. This makes it difficult to integrate the taxis into the MyCiTi BRT project as initially planned (CoCT, 2018). it estimated that the taxi industry is made up of 200000 operators makes about R90billion in annual revenue, with little to no tax duties" (Vegter, 2020:11).

The government needs to find a means to levy taxi operators to reinvest into developing the sector's infrastructure. The issues of mini-bus taxis are experienced at a national level. Hence the South African government needs to provide more attractive incentives for taxi operators to buy into envisioned mechanisms of change.

Finding 49: *Taxis are the most widely used mode of transport, but the taxi industry is very informal, and this has led to the emergence of illegal operators who cause tension that spills over to acts of violence that endangers commuters. The industry is also known to resist initiatives from the government that aim to bring about reform.*

4.3.3.1.10 D10:The MyCITI Business Plan 2015

This document presents an updated version of the policy business plan on the MyCITI BRT project that was launched in 2010 leading up to the FIFA world cup. The services grew rapidly over the years after the launch and later became one of the more preferred options by passengers in most major routes serviced and within the CBD. The MyCITI Bus Rapid Transit (BRT) network is at the core of the CoCT's plan to integrate all modes of transportation (CoCT,

2018). Since its initial implementation, the service has grown by 44 stations and a network of 22 routes, with the total investment topping R10 billion. The initial phase of the BRT implementation was designed to complement the existing rail system in line with the planned shift towards an integrated public transport system (CoCT, 2018). BRT can be a catalyst for promoting the shift from private to public transport by providing a high quality of service. This position was supported by the integrated transport development plan, which stated that:

> "The vision for this BRT service is based on principles of quality, equity, security, sustainability, and integrity. This translates into design principles of universal access, passenger mobility, accessibility, modal integration, customer convenience, safety and security, sustainable transport, congestion management, the optimal use of scarce resources and transport that supports economic development." (MyCITI, 2015:5).

The MyCITI project was introduced as a safer and more technologically advanced bus service than its closest competitor Golden arrow. MyCITI uses smart cards to access facilities or board vehicles, thus reducing the possibility of criminals masquerading as passengers. MyCITI also provides for people with reduced mobility through partnerships with dial-a-ride service. Dial-a-Ride is a public transport service provided by the City for people with special needs who cannot use conventional public transport (MyCITI, 2015).

Finding 50: *MyCITI BRT is considered as an integral basis of the CoCT's vision for smart transportation services within the city. The services optimise safety and convenience through technology-based solutions designed to be* integrated into the multimodal public transport system.

4.3.3.1.11 Reasons for Policy Non-implementation

The policies outlined above are national and require all spheres of government to align towards achieving a common goal. The biggest obstacle for implementing the strategic plans and policies mentioned above is that rail transport can be the backbone of the public transport system, as mentioned in documents (1) and (3). However, the rail networks are managed nationally, and provincial governments have little control over them. If rail management is placed under the administration of local metropolitan regions, then there are possibilities for private-public partnerships investments projects to enhance the public transport system. The CoCT has requested jurisdiction over the local rail from the DoT, which is yet to be granted. Similarly, the road infrastructure is a mandate of SANRAL, tasked with building capacity and

maintaining existing roads at a national level. The other issue impacting the implementation of thesis policies is the financial hardships of the companies tasked with maintaining key infrastructure like the roads. As noted in Document (D7), failure to turn projects into revenue-generating streams means there is little liquidity in these companies' books.

4.4.3.2 Summary of Document Reviews Findings

Table 4.16 below summarises the findings extracted from the document reviews. The data supports the findings gathered from empirical data summarized in sections 4.4.1.2 and 4.4.2.1. The following conclusions can be drawn from the data:

Table 4.16 Document review findings and related SRQ

RQ: What factors influence the design of an IRIS for public commuting in South Africa?	
Findings	**SRQ**
Finding 41: The CoCT acknowledges that an integrated transport system is required to address the traffic-related issues resulting from an increase in population and overreliance on private vehicles in their strategic plan for intermodal and interoperable transport in Cape Town.	**SRQ1**: What are the challenges affecting the provision of real-time information for public commuting decision-making in South Africa?
Finding 42:The taxis operate informally, which has caused other PTOs to be unable to compete, and as a result, the government has resorted to subsidizing those operators to keep their fares at affordable rates.	
Finding 43:The land planning in CoCT is such that the workforce lives further from the economic hub, resulting in longer walking distance and commuting times.	
Finding 44: The public transport system is at the core of achieving social cohesion. Hence, proper infrastructure for transport is necessary to uplift communities and enable them to participate actively in the economy.	

Finding 45: The public transport system in the CoCT predominantly caters to the low-income populace, with the middle and high-income earners often relying on private commuting.	
Finding 46: There is an acknowledgement that the road network can lead to the deployment of ITS, which is a more cost-effective means to alleviate the pressure placed on road networks during peak hours rather than building additional roads capacity.	
Finding 47: Golden arrow is the most accessible bus service in the CoCT. However, it is reported to have limitations of use for persons with mobility challenges, and it is faced with challenges of safety as passengers are susceptible to criminals masquerading as passengers.	
Finding 48: Trains are the most affordable mode of transport. However, the services are marred by challenges such as delays, safety issues, and decay in infrastructure that have made the service less desirable to middle and higher-class commuters.	
Finding 49: Taxis are the most widely used mode of transport, but the taxi industry is very informal, and this has led to the emergence of illegal operators who cause tension that spills over to acts of violence that endangers commuters. The industry is also known to resist initiatives from the government that aim to bring about reform.	
Finding 50: MyCITI BRT is considered an integral basis of the CoCT's vision for smart transportation services within the city. The services optimise safety and convenience through technology-based solutions designed to integrate into the multimodal public transport system.	

4.5 Chapter summary

Table 4.17 Chapter 4: Emergent categories and themes

Categories	Themes
Public Transport Challenges	Public Transportation in South Africa
Infrastructure challenges	
Knowledge of Real-time	
Real-time decision making	
Challenges of real-time information	
Accessibility	Information Channels
Technology resources	
Systems maintenance	
Systems upgrade	
Mode of information	
Traveller information	Information Needs
Information frequency	
Change management	Integrated real-time information system
Data Privacy	
System requirements	
Operational challenges	
Integrated system	
Information sharing	

Chapter 4 provided the reader with a report of the findings from data collected through co-design, interviews, and document reviews. The findings summarised in (Tables 4.10, 4.15, and 4.16) provide insights into these four objectives; a) The challenges affecting the provision of real-time information for public commuting decision making in South Africa; b) information dissemination channels; c) real-time information needs of public transport commuters in South Africa and d) the design requirements for an IRIS for public commuting in South Africa. The challenges affecting the provision of real-time information were ascertained through all three data collection methods and the challenges majorly included infrastructure issues, traffic issues, safety and security concerns, and lack of investments.

The information on dissemination channels was collected primarily from the participants using co-design and interviews to find out what channels exist and the participants' experiences of them. The participant's responses varied, with some mentioning traditional means of information dissemination and others mentioning technology-based solutions such as mobile applications, websites, and display screens. The real-time information needs were also obtained through the use of both co-design and interviews. The participants mainly require information about routes, delays, overcrowding, alternative modes, and vehicle arrival time, to name a few.

The last objective was achieved through co-design and interviews; the co-design with commuters enabled interview brainstorming of ideas on possible concepts for the IRIS while the interviews with the PTOs staff allowed the researcher to understand what features they would expect from such a system. From the commuters' perspective, they require electronic payments, filtering of travel information, integrated travel information, and a multilingual interface. The PTOs require more administrative features such as employee management, fleet management, customer service, and electronic transactions. Based on the analysis and summary of the data in this chapter, 18 categories and four themes were generated, presented in table 4.16 above. The categories derived from this chapter are discussed in line with the research questions and objectives in the next chapter.

CHAPTER FIVE: INTERPRETATION OF FINDINGS

This chapter reveals the intrinsic meanings attached to the findings through the lens of the activity theory (AT) constructs, the theoretical framework underpinning this study. The application of AT is relevant for this study as it relates to the set of activities involved in actualising the provision of real-time information for public commuters in Cape Town.

The scope of activity theory was discussed in chapter 2, section 2.8. This theory was made famous by Engeström (1987), who demonstrated the relationships between activities by using triangles within triangles to connect a network of activities to achieve the desired outcome. The networked triangle represents the relationship between subjects, tools (Instruments), rules, division of labour, and objects that work together to realise the desired outcome. The diagram of the Engeström activity theory model is depicted in figure 5.1 for ease of reference. The findings of this study are presented below through the lens of activity theory to understand better the relationships within the network of activities designed to produce real-time travel information for public commuting in Cape Town:

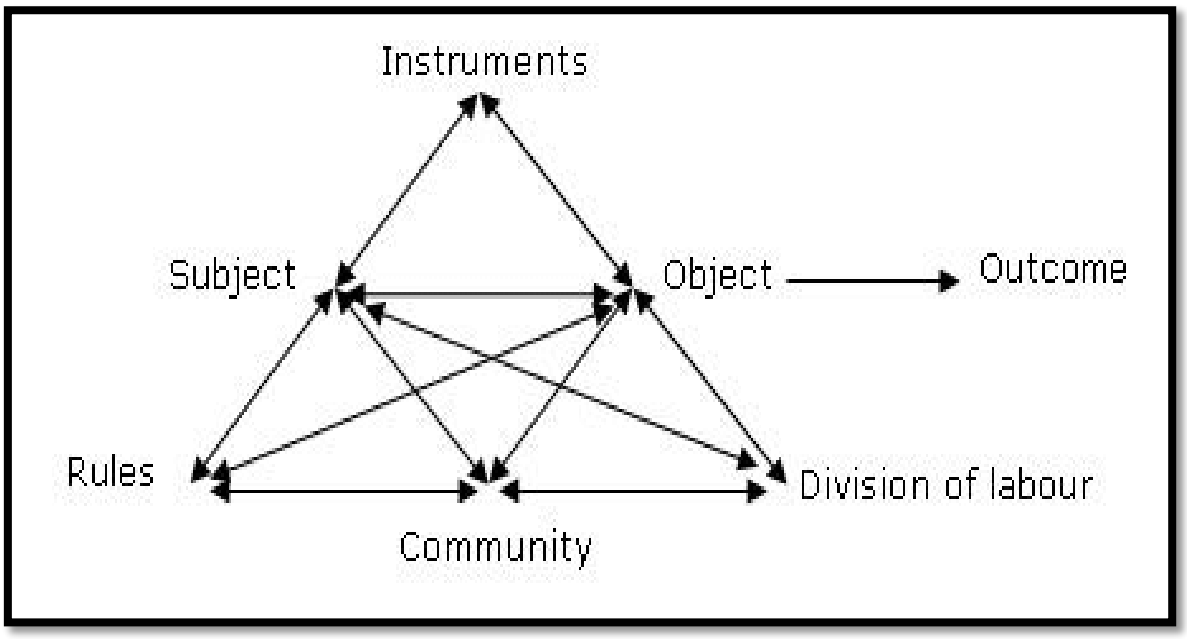

Figure 5.1 Activity theory diagram (adapted from Engestrom, 1987: 78)

5.1 Subjects

Activity Theory identifies the subject component as an individual or a group involved in an activity (Nunez, 2009). In the context of this research, the subjects defined at the micro-level include the public transport commuters who would be utilising the IRIS. At the same time, IT

specialists and operations managers of the PTOs are considered subjects at the macro level, interacting with the IRIS for administrative purposes. Each subject brings a diversity of experiences to the activity system. Through their interaction, subjects' perspectives change as they experience new ways of acting together. The findings relating to the subjects are expounded below based on a) perception of the public transport system and b) Travel information needs.

a) Perception of the Public Transport System

It is important to establish the subjects' perception of the South African public transport system. It lays the foundation for understanding the gaps that trigger the resultant activities that need to occur to produce the desired outcome. Findings indicated that "The public transport system is at the core of achieving social cohesion; hence, proper infrastructure for road and rail transport must be in place to uplift communities and enable them to participate in the economy." (Findings 44). The public commuters have a negative perception of the state of public transportation, as highlighted in Finding 1. The commuters, predominantly low-income earners, who cannot afford to own private vehicles often face negative experiences while travelling to work or school, as captured by Findings 45 and 3. Findings showed that participants from the PTOs also share the same negative sentiments regarding the public transport system in South Africa. In their view, there are several challenges that commuters have to face while using public transport. Finding 4 revealed that commuters' views about the"…varying concerns relating to the state of public commuting, which includes lack of investment, engagement, accountability, neglect of socio-traffic issues, have further exacerbated the state of the public transport system in South Africa".

Relatively, "The CoCT acknowledges that an integrated transport system is required to address the traffic-related issues resulting from an increase in population and overreliance on private vehicles in their strategic plan for intermodal and interoperable transport in Cape Town. (Finding 41). From the findings, it can be concluded that the subject displays an informed understanding and knowledge that the South African public transport system is faced with a myriad of challenges that require constructive intervention through a network of activities with impactful outcomes.

The findings on the subject's perception of the public transport system are summarised with the corresponding sources of data in table 5.1 below:

Table 5.1 List of findings on the perceptions of the public transport system

Findings	Methods	Themes
Finding 1: There is an overwhelming dissatisfaction amongst commuters about the level of safety and unreliability of the current public transport system in SA, with concerns such as punctuality, lack of maintenance and bad services also voiced.	Co-design	Public transportation in South Africa
Finding 3: A significant issue raised was strikes, which have become a growing trend of disruptions amongst SA's public transport systems.	Co-design	Public transportation in South Africa
Finding 4: Participants indicated varying concerns relating to public commuting, which includes lack of investment, engagement, accountability, neglect of socio-traffic issues, which have further exacerbated the state of the public transport system in South Africa.	Co-design	Public transportation in South Africa
Finding 23: The public transport system experiences safety, violence, degrading infrastructure, and other social traffic issues. However, it is cost-effective for public commuters who prefer it to private commuting.	Interviews	Public transportation in South Africa

Finding 41: The CoCT acknowledges that an integrated transport system is required to address the traffic-related issues resulting from an increase in population and overreliance on private vehicles in their strategic plan for intermodal and interoperable transport in Cape Town.	Document review	Public transportation in South Africa
Finding 45: The public transport system in the CoCT predominantly caters to the low-income populace, with the middle and high-income earners often relying on private commuting.	Document review	Public transportation in South Africa

b) Travel Information Needs

The subject's perception of travel information is an important aspect of the activity network, as it sets the tone for the desired features that will lead to the provision of real-time information for public commuting. The findings in this study revealed that overcrowding is the most influential factor commuters consider when making alternative decisions on modes, as succinctly captured by Findings 11 and 12. While the most disseminated piece of information by the PTOs is fare increases, according to Finding 33. commuters indicated their preference that travel information must be sent periodically through notifications, preferably between every 30 to 60 minutes intervals, as captured by Finding 15.

However, there is a gap between the travel information requirements of commuters and what is provided by the operators in practice, hence Finding 34 revealed that "The respondents believe the most preferred type of information for commuters is the arrival of the next vehicle, while information about incidents, delays, driver information, fare changes, and scheduling was also mentioned as important". Findings also revealed that the main information required per mode in the respective order is the number of taxis, possible delays for the buses, delay and next stop for the trains. From the subjects' point of view, it can be concluded that there is

a gap between the required travel information and the actual travel information provided. Regarding the network of activities, the subjects clearly demonstrate the desired travel information required, which provides the basis for the rationalisation and actualisation of the outcome.

The findings on the travel information needs are summarised with the corresponding sources of data in table 5.2 below:

Table 5.2 List of Findings on the Travel Information Needs

Findings	Methods	Themes
Finding 11: Top on the commuter information needs for an alternative decision on transportation modes includes the number of passengers on the vehicle; information on traffic congestion; Delays; Strikes and Accidents.	Co-design	Information needs
Finding 12: Commuters want to know about the number of passengers in a vehicle in order to make an alternative decision.	Co-design	Information needs
Finding 15: Participants would like to receive periodic notifications on real-time information ranging from an update within 30 minutes to every hour.	Co-design	Information needs
Finding 18: Top of the commuter information needs for taxis is the number of passengers in the taxis and arrival time. Other mentioned	Co-design	Information needs

information needs include cleanliness, accidents, and traffic congestion reports.		
Finding 19: Top of the commuter information needs for Buses is information about Delays. Others include Departure time, Next stop time.	Co-design	Information needs
Finding 20: Top of the commuter information needs for trains is delays and next stop. Others mentioned include safety report and arrival time.	Co-design	Information needs
Finding 33: The most disseminated information to commuters is fare increases. Other information provided to commuters includes timetables, stations, routes, and schedules.	Interviews	Information needs
Finding 34: The respondents believe that the most preferred type of information for commuters is the arrival of the next vehicle, while information about incidents, delays, driver information, fare changes, and scheduling were also mentioned as important.	Interviews	Information needs

5.2 Tools

The Tools within AT defines materials used by subjects to initiate the object. These tools can either transform behaviour or the social environment (Ditsa, 2011). This research identifies the tools as a technological component required for the actualisation of the object, including databases, servers, networks, application software, telematics, and other technology tools as required. The tools facilitate interaction between the subjects and their objectives and with other subjects. The extent to which the tool improves interaction is based on the subject's personal experience and the experience of those who created or maintained them. Therefore, the tools are looked at from two aspects a) existing information dissemination channels and b) preferred information dissemination channels.

a) Existing Information Dissemination Channels

There is a need to understand the existing information dissemination channels and their shortcomings to ascertain whether they aid or hinder achieving a desired outcome in the activity system. It was established that the commuters access travel information through several methods that vary based on the public transport mode. Taxis operate manually by making announcements verbally or displaying printouts in vehicles as captured by (Finding 31). While trains and buses use a combination of technology-based tools to disseminate information, these solutions include websites, display screens, mobile applications, as specified in (Findings 6,8,30). Commuters experience various challenges while interacting with these information channels. As stated in Finding 10,"…existing information dissemination channels are non-functional and outdated." The other limiting factor about the current tools is that they operate in silos, thus limiting commuters from conveniently accessing travel information in a unified platform, as related by Finding 5. It can be surmised that varying tools are used to communicate travel information between the subjects, i.e. PTOs and commuters, to provide the information required for travel purposes.

Nevertheless, much of the information provided and the channels are inadequate, as revealed by Finding 10: "Respondents are majorly in agreement that the existing information dissemination channels are non-functional and outdated." Subjects are wary of the inadequacy of existing communication channels, as it affects a key function of effective communication in the network of activities. The desired outcome of providing real-time travel information is unachievable by the moribund methods being used by some PTOs, jeopardising the objective of the activities if adequate use of technology is not employed.

The findings on existing information channels are summarised and presented together with the corresponding data sources in table 5.3 below:

Table 5.3 List of findings on the existing information channels

Findings	Methods	Themes
Finding 5: Participants indicated the availability of multiple existing information dissemination channels that are operating in silos.	Co-design	Information channels
Finding 6:Findings indicate that mobile applications and websites were the major sources of accessing travel information; word-of-mouth and help desk were also mentioned options.	Co-design	Information channels
Finding 8: There is a split between respondents who have experienced the use of technological tools for communication of travel information amongst the participants	Co-design	Information channels
Finding 9: Responses on technological tools used in communicating travel information includes websites and mobile applications	Co-design	Information channels
Finding 31: The majority of PTOs use some kind of digital technology to disseminate information to	Interviews	Information channels

commuters, excluding the taxi industry.		
Finding 25: There are multiple channels used to provide commuters with travel information, including SMS, printouts, display screens, websites, and mobile applications.	Interviews	Information channels
Finding 10: Participants majorly agree that the existing information dissemination channels are non-functional and outdated.	Co-design	Information channels
Finding 30: The PTOs provide travel information on routes, timelines, and availability of vehicles through various platforms such as websites and mobile applications, printouts and digital displays.	Interviews	Information channels

b) Preferred Information Dissemination Channels

This section will help understand user preferences better regarding information dissemination tools, and it can expose the gap by comparing it with what already exists. The commuters prefer to receive travel information through digital channels as this is convenient and makes information easily accessible for their commuting needs as per deductions from Findings 7 and 29. These digital channels include SMS, display screens, websites, and mobile applications, according to Finding 25. Similarly, it was indicated in Finding 32 that "The PTOs are all in agreement that innovative technology is the most efficient way to provide up-to-date travel information to commuters." The commuters also prefer information dissemination channels that provide integrated real-time information for improved sharing and collaboration between modes, as captured by Finding 16 and17. It was further established that using an integrated platform would improve the experience for commuters and allow public transport operators to better manage their staff, fleet, transactions, and overall operations. The

commuters also believe that information must be provided in various languages or rendered in text or audio, as revealed in Finding 21.

There is an understanding of the need to use technological tools to disseminate information using the right channels. Technology plays a key role in actualising the outcome by facilitating information sharing between the subjects and the object. In order to provide reliable real-time travel information for commuters, the integrated platform and communication channels must be built on cutting-edge technological innovation, which serves as the hub of the activity network. There is a gap as the current methods for information dissemination channels do not meet the needs of the commuters in providing information on current platforms, formats and in an integrated manner.

The findings on information dissemination channels are summarised in line with the corresponding data sources in table 5.4 below:

Table 5.4 List of findings on the preferred information dissemination channels

Findings	Methods	Themes
Finding 7: There was a consensus on the need to receive travel information using a technological tool.	Co-design	Information channels
Finding 16: The majority of the commuters have a general understanding of the concept of IRISs for public commuting.	Co-design	Integrated real-time information system
Finding 17: The participants' responses suggest that an IRIS will improve collaborative information sharing from multiple sources.	Co-design	Integrated real-time information system
Finding 21: Participants majorly favour the information	Co-design	Integrated real-time information system

delivery in a textual format, while others prefer audio.		
Finding 22: An important initial design requirement features indicated by commuters is for the system to translate information into different languages,text-to-speech capabilities and notifications.	Co-design	Integrated real-time information system
Finding 25: There are multiple channels used to provide commuters with travel information, including SMS, printouts, display screens, websites, and mobile applications.	Interview	Information channels
Finding 29: The respondents believe that the most convenient and accessible method to provide real-time information is through digital platforms	Interview	Information channels
Finding 32: The PTOs are all in agreement that innovative technology is the most efficient way to provide up-to-date travel information to commuters.	Interview	Information channels
Finding 34: The respondents believe that the most preferred type of information for commuters is the arrival of the next vehicle, while information about incidents, delays, driver information,	Interview	Information needs

fare changes, and scheduling were also mentioned as important.		
Finding 38: Respondents indicated fleet management; E-payments, customer reviews, and driver management as the most desired feature in an IRIS.	Interview	Integrated real-time information system

5.3 Rules

The rules in Activity Theory govern how the subjects of the community can apply them to either prevent or enable themselves to perform an activity. These rules can be implicitly or explicitly defined (Ditsa, 2011). As outlined in section 5.1, the subjects in this study are commuters at the micro-level and PTOs at the macro-level. Rules govern the subjects as they interact and use the tools highlighted in section 5.2. These rules are necessary for the activity system as they set the boundaries with which each stakeholder is expected to comply. For example, Finding 35 indicated that "Respondents concur that sharing information between PTOs will improve service delivery for commuters. However, there are concerns about data privacy and unfair competition between operators." Firstly, this points to the need for rules that govern how sensitive customer data is retrieved, used, and protected from threats in an integrated system. Secondly, rules are needed to ensure that any stakeholder does not monopolise the integrated system for personal gain.

Another issue about the rule that emerged in the findings is revenue sharing. In a futuristic integrated system that incorporates online payments, the revenue generated must be fairly distributed between the stakeholders in Finding 39. The rules must be developed to ensure standards and cohesion in the activity system concerning Finding 27. The rules would need to apply to all stakeholders, including the informal taxi industry, which has been operating with an advantage over other PTOs in the current system, as highlighted by Finding 42. Rules are important in the governance of subjects and major players in the network of activities. As it relates to the actualisation of the outcome, the CoCT must play a key role in establishing ground rules and policies that will govern the collaboration of the PTOs on the platform to ensure fair play and transparency.

It is particularly essential that all parties play strictly by the rules and oversight functions are put in place to curb the excesses of any PTO that might want to stray outside of the rule book, particularly the taxi minibuses, given the notoriety of their antecedents (Finding 42,49). For an integrated system to function optimally, all PTOs must adopt uniform standards in dealing with information and communication to ensure commuters have a uniform experience. Compliance with these standards and rules must be effectively applied and monitored to achieve the desired outcome with the activity system.

The findings relating to the rules in the activity system are summarised with the data sources in table 5.5 below:

Table 5.5 List of findings relating to the rules

Findings	Methods	Themes
Finding 27:The provision of travel information is also affected by a lack of standards as operators have unique business processes and commuters also expect tailored solutions.	Interviews	Public transportation in South Africa
Finding 35: Respondents concur that sharing of information between PTOs will improve service delivery for commuters. However, there are concerns about data privacy and unfair competition between operators.	Interviews	Integrated real-time information system
Finding 39: Respondents believe that proper training and a revenue-sharing model are key to maintaining cohesion in an integrated system.	Interviews	Integrated real-time information system

Finding 42: The informal manner in which taxis operate has resulted in other PTOs not being able to compete fairly, and as a result, the government has resorted to subsidizing those operators to keep their fares at affordable rates.	Document reviews	Public transportation in South Africa
Finding 49: Taxis are the most widely used mode of transport, but the taxi industry is very informal, and this has led to the emergence of illegal operators who cause tension that spills over to acts of violence that endangers commuters. The industry is also known to resist initiatives from the government that aim to bring about reform.	Document reviews	Public transportation in South Africa

5.4 Division of Labour

AT's division of labour describes the roles and responsibilities of subjects within a community, the power relations and bodies of authority maintaining compliance with the community's rules (Holt & Morris, 2015). There is a division of labour between the transport operators and the different government agencies within the local, provincial and national governments. The role of the government is to implement laws, regulations, policies and standards as outlined in section 5.3, while PTOs are expected to contribute towards the administration and provide support for the IRIS to ensure that the information remains current and up to date (Finding 28). Therefore, in terms of the activity system, each stakeholder within the network must fulfil their respective duties to achieve the desired outcome. For example, the rail network is managed nationally by PRASA, and the local spheres of government are tasked with managing the municipal contracted transport services.

The failure to effectively manage the rail infrastructure has a rollover effect on all local regions, and policies cannot be implemented in due course as the rail system can relieve the pressure placed on the road network (Finding 48). A similar finding was made during the document review of a report from SANRAL, tasked with the maintenance and building of road infrastructure. The report found that the company is financially indebted to provide additional road capacity at an acceptable rate and acknowledge that it would be cheaper to implement an ITS on existing roads that will efficiently manage people's movement during peak hours (Finding 46). The divisions in responsibilities and roles show that when multiple stakeholders are involved, rules must be adopted so that all parties can achieve a shared objective. An independent service provider may need to be appointed as a private-public partnership responsible for maintenance, support and training people to use IRIS. This is a required division of labour that will ensure that the IRIS is protected and interference from all spheres of government is reduced.

The findings relating to the Division of Labour are presented in a summary format in table 5.6 below:

Table 5.6 List of findings relating to division of labour

Findings	Methods	Themes
Finding 28: There are ineffective administrative processes and inadequate human resources in place to keep real-time information up to date.	Interviews	Public transportation in South Africa
Finding 48: Trains are the most affordable mode of transport. However, the services are marred by challenges such as delays, safety issues and decay in infrastructure that have made the service less desirable to middle and higher-class commuters.	Document review	Public transportation in South Africa

Finding 46: There is an acknowledgement that the road network can lead to the deployment of ITS, which is a more cost-effective means to alleviate the pressure placed on road networks during peak hours rather than building additional roads capacity.	Document review	Public transportation in South Africa

5.5 Community

The community can be defined as a social environment where the subjects participate in an activity. The members of this community serve a common purpose at some place or time (Engeström, 2000). The PTOs such as PRASA, Codeta, MyCITI BRT, and Golden Arrow buses are the key stakeholders operating in this community and interacting with the subjects. The use of an IRIS would improve how commuters and staff of the PTOs carry out their daily activities. For example, commuters who live further from the city would be informed in advance about the next available modes of public transport, so they do not walk long distances without knowing if they will find transport at the next station or not. This is in line with Finding 43. From the PTOs perspective, the implication of public transport system challenges on the social environment is also undesirable, where various criminal acts occur that put drivers and passengers a risk.

Finding 46 indicated that "The rail system can be used as a backbone to alleviate the pressure placed on road networks during peak hours.

However, the rail infrastructure is subjected to acts of theft and vandalism". This statement is also supported by Finding 48, that "Trains are the most affordable mode of transport. However, the services are marred by challenges such as delays, safety issues and infrastructural decay that have made the service less desirable to middle and higher class categories of commuters". Commuters of the bus operator, Golden Arrow, also experience similar challenges relating to onboard crime vehicles, as stated in finding 47. MyCITI BRT is a prime example of how the situation is improving as soon as the technology is introduced in public transport, with smart cards for checking into facilities and vehicles to reduce the number of criminals accessing the services illegally, as indicated by Finding 50. Hence CoCT believes that the BRT service is an integral part of creating an integrated transport network.

Finding (26) indicated that "The provision of travel information is affected by a lack of resources such as technology tools required by commuters to receive real-time updates and stable network connectivity," which points to infrastructural challenges that impact the members of this community. There is also much conflict within this social environment which often inconveniences commuters. This conflict occurs between operators and results from disputes over routes (Finding 40). Finding (49) further highlights this point: "Taxis are the most widely used mode of transport, but the taxi industry is very informal, and this has led to the emergence of illegal operators who cause tension that spills over to acts of violence endangering commuters."

The findings relating to the community are summarised and presented with the corresponding data sources in table 5.7 below:

Table 5.7 List of findings relating to the community

Findings	Methods	Themes
Finding 26:The provision of travel information is affected by a lack of resources such as technology tools required by commuters to receive real-time updates and stable network connectivity.	Interviews	Public transportation in South Africa
Finding 40: Findings reveal that fear of conflicts amongst operators and the depleting current state of road infrastructure are major concerns that might derail the success of an IRIS.	Interviews	Integrated real-time information system
Finding 43:The land planning in CoCT is such that the workforce lives further from the economic hub, resulting in longer walking distance and commuting times.	Document reviews	Public transportation in South Africa

Finding 46: There is an acknowledgement that the rail system in conjunction with the road network can lead to the deployment of ITS, which is a more cost-effective means to alleviate the pressure placed on road networks during peak hours, rather than building additional roads capacity.	Document reviews	Public transportation in South Africa
Finding 48: Trains are the most affordable mode of transport. However, the services are marred by challenges such as delays, safety issues and decay in infrastructure that have made the service less desirable to middle and higher classed categories of commuters.	Document reviews	Public transportation in South Africa
Finding 47: Golden Arrow is the most accessible bus service in the CoCT; however, it is reported to have limitations for persons with mobility challenges, and it is faced with safety challenges as passengers are susceptible to criminals masquerading as passengers.	Document reviews	Public transportation in South Africa
Finding 49: Taxis are the most widely used mode of transport, but the taxi industry is very informal, and this has	Document reviews	Public transportation in South Africa

led to the emergence of illegal operators who cause tension that spills over to acts of violence that endangers commuters. The industry is also known to resist initiatives from the government that aim to bring about reform.		
Finding 50: MyCITI BRT is considered an integral basis of the CoCT's vision for smart transportation services within the city. The services optimise safety and convenience through technology-based solutions designed to integrate into a multimodal public transport system.	Document reviews	Public transportation in South Africa

5.6 Object

The object can be defined as the immediate goal of the activity. The subjects in the activity system have specific goals that they aim to achieve by using tools. At a micro level, the aim is for the commuters to access real-time information that will assist them to make real-time decisions on the mode of public transport, as indicated by Finding 13,14,24. The aim is to provide commuters with improved service delivery at the macro level by providing real-time travel information, as implied by Finding 35. An IRIS is at the core of the activity system. It must be in operation for the subjects to fully realise their goals (Finding 17,41). The IRIS provides the real-time information required to achieve the objectives of the subjects as it aggregates the information into one platform that will allow them to make alternative decisions (36). Thus, there would be a contradiction in achieving the outcome without implementing an IRIS since not all the PTOs currently use technological tools to disseminate information to commuters, as highlighted by Finding 31. The object in this particular case is the IRIS, and the objective is for commuters to make informed decisions using the real-time information provided by the object.

The findings relating to the objectives are summarised and presented with the corresponding data sources in table 5.8 below:

Table 5.8 List of findings relating to the objectives

Findings	Methods	Themes
Finding 13: Participants indicated that the provision of real-time travel information will provide commuters with real-time updates to make alternative decisions on traffic-related incidents.	Co-design	Public transportation in South Africa
Finding 14: Participants were also believed that the provision of real-time travel information will enhance their trust in the system and improve the commuting experience.	Co-design	Public transportation in South Africa
Finding 24: Most of the respondents have a basic understanding of what real-time information is, with some mentioning that it can improve decision making within public transportation	Interviews	Public transportation in South Africa
Finding 17: The participants responses suggests that an IRIS will improve collaborative information sharing from multiple sources.	Co-design	Integrated real-time information system
Finding 41: The CoCT acknowledges that an integrated transport system is required to address the traffic-	Document reviews	Public transportation in South Africa

related issues resulting from an increase in population and overreliance on private vehicles in their strategic plan for intermodal and interoperable transport in Cape Town.		
Finding 36: Respondents indicated that commuters would benefit from an integrated system by improving the public transport system's decision-making, safety, and reliability.	Interviews	Integrated real-time information system
Finding 31: The majority of PTOs use some kind of digital technology to disseminate information to commuters, excluding the taxi industry.	Interviews	Information channels

5.7 Outcome

Activity Theory defines the outcome as the intended long-term goal of undertaking the activity. The result is positive if all activity system components are fully satisfied without contradiction, as highlighted in section 4.6.6. For this to be achieved, the subjects must be provided with tools that meet their needs; an IRIS that integrates all modes and provides real-time information about them would enable subjects at micro and macro levels to perform their objectives (Finding 41). The subjects and their use of the tools are governed by the rules, which also govern how the PTOs who are the stakeholders in the community conduct themselves as part of a larger integrated public transport system. The different spheres of government are responsible for the oversight of these rules and holding the community accountable for any violations at the local and national levels. The outcome for public transport in South Africa can either be positive or negative based on whether the other related activity components were fully satisfied (Finding 35). "Respondents concur that sharing information between PTOs will improve service delivery for commuters. However, there are concerns about data privacy and unfair competition between operators". This finding proves the point

made above using the rules component. If rules are not enforced in the activity system, expect a negative outcome. Finding (14) stated that "Participants were also of the view that providing real-time travel information will enhance their trust in the system and improve the commuting experience." This instills confidence in other potential public commuters who previously relied on private cars for their commuting activities (41).

The findings relating to the outcomes are summarised and presented with the corresponding data sources in table 5.9 below:

Table 5.9 List of findings relating to the outcomes

Findings	Methods	Themes
Finding 35: Respondents concur that sharing information between PTOs will improve service delivery for commuters. However, there are concerns about data privacy and unfair competition between operators.	Interviews	Integrated real-time information system
Finding 36: There is a consensus that commuters will benefit from an integrated system through improvement in the public transport system's decision-making, safety, and reliability.	Interviews	Integrated real-time information system
Finding 41: The CoCT acknowledges that an integrated transport system is required to address the traffic-related issues resulting from an increase in population and overreliance on private vehicles in their strategic plan for intermodal and	Document review	Public transportation in South Africa

interoperable transport in Cape Town		
Finding 14: There is a general view that real-time travel information will enhance trust in the transport system and improve the commuting experience.	Co-design	Public transportation in South Africa

5.8 Chapter Summary

In conclusion, The overall outcome for the public transport system is to improve the quality of service by providing an efficient, reliable and safe transport system for the subjects consisting of commuters and PTOs staff. The subjects who perceive the public transport system as riddled with challenges require innovative solutions to improve the current situation. The objective of the subjects is to make informed real-time decisions on alternative modes to the current dissemination tools that are too dysfunctional to meet the subjects' needs.

The IRIS is at the core of achieving this objective for the subjects, as it provides a platform in which all PTOs are internal stakeholders and are actively sharing travel information centrally. The IRIS requires rules to regulate the use of the IRIS by the community. The rules must be enforced by the different spheres of government, particularly the national and provincial transport departments.

CHAPTER SIX: DISCUSSION OF FINDINGS

This chapter presents the discussion of the findings in line with the literature's practical implication for the aim of the research. The research aimed to explore factors affecting the availability and accessibility of real-time information for public commuters in South Africa to understand the design requirements for an IRIS for public commuting services in South Africa. Chapter 4 provided a detailed account of the data collection and analysis processes. The main themes that emerged from the findings in the previous chapter are i. Status of Public transportation in South Africa, ii. Information Channels, iii. Information Needs, and iv. Integrated real-time information systems. This chapter will discuss these themes in line with the corresponding categories established from the data collected from document reviews, co-design, and interview sources. The findings are discussed with the corresponding research objectives of the study.

6.1 Theme 1: Public Transportation in South Africa

Objective 1: To understand the problems associated with real-time decision-making on alternative modes and routes of public commuting in South Africa.

6.1.1 Public Transport Challenges

Findings revealed existing challenges for public commuting in South Africa that affect both the commuters and operators. These challenges have also been documented extensively in the literature. According to the commuters who participated in this study, the public transport system is unsafe, unreliable, and often inconveniences commuters. These challenges are relatable to the findings of a study conducted by Shange and Harmacek (2017), who state that the public transport system in South Africa has many flaws that work to the disadvantage of commuters. These include discomfort, overcrowding, waiting time, and breakdowns. The author further highlighted that many traffic accidents occur due to reckless driving, unroadworthy vehicles, and poor road conditions. This is in line with a point raised by P6 in this study which indicated that "there is little maintenance that makes the public transport system undesirable." The study participants also highlighted that the PTOs are reluctant to listen to commuters' concerns regarding these challenges, which has reduced the quality of service and customer satisfaction.

This reluctance is further supplemented by Luke and Heyns (2019), who declare that the current perception of public transport is so low that most public transport users aim to buy a private vehicle as soon as they can afford it. PTOs also acknowledge that the transport system

they are part of has become an undesirable option for the commuters as R4 stated: "The public transport system in Cape Town is dysfunctional with much overcrowding and also lacks safety." Despite its challenges, it was noted by R7 that there is still a large number of people who depend on public transport, mainly the low-income who cannot afford to own private vehicles. The public operators also see ongoing tensions between operators or modes, especially in the minibus taxi industry, as a risk to commuter safety. Other challenges the operators indicated are poor infrastructure, traffic issues, overcrowding, and safety.

The challenges of the public transport system are also apparent in the documentation reviewed in this study. There have been policies and strategic plans published by CoCT and the PTOs to address public transportation issues. The documents point out the challenges: traffic congestion at peak hours due to overreliance on private motor vehicles, prolonged commute times due to poor special land planning redress, and criminal acts that endanger the safety of drivers and commuters. Despite having these policies in place, implementation is still lacking. According to Walter (2014), the failure of the transport policy implementation can be attributed to a lack of sufficient technological resources, ineffective management processes, and organisational cultures that impede rather than promote successful implementation.

There are overlapping views between the commuters' and operators' experiences with the challenges of the public transport system in South Africa, which warrant innovative solutions to address them. Implementing an IRIS could potentially address most of the challenges highlighted above, providing real-time information that would enable commuters to make informed choices on alternative modes.

6.1.2 Infrastructure Challenges

The public transport system faces infrastructure challenges ranging from degraded facilities, unroadworthy vehicles to degraded facilities, unroadworthy vehicles, and poor road conditions. The inadequate provision of public transport infrastructure has been reported to contribute to economic exclusion. Commuters who often live in the outskirts of urban areas are subjected to walking long distances to access transport services. According to the OECD (2017), there is a relationship between high-quality infrastructure and economic productivity since transport infrastructure plays a critical role in transitioning from a middle- to high-income economy. The integrated transport plan (2018) document analysed in this study acknowledges that the rail network can support heavily congested road transport. However, certain routes had to be closed in recent times due to acts of vandalism and arson that damaged key infrastructure. The provision of road infrastructure has also been lacking; with

only 30% of the country's roads paved, it means accessibility is limited to certain areas, and commuters are often subjected to walking long distances to access the nearest transport facilities (SANRAL, 2020).

The challenges reported in section 6.1.1 continue to persist because of poor infrastructure. P9 stated that "The operators need to invest into their infrastructure." The commuters believe that the public transport infrastructure has been neglected and there have been inadequate investment projects to improve the situation. Mthimkulu (2017) argues that the infrastructure issues emanate from years of spatial segregation and other roots of unequal infrastructure provision. The commuters also stated that this could be caused by a lack of accountability where budgets for infrastructure development projects are misused.

According to the literature, infrastructure must be properly planned, implemented, maintained, and managed to provide effective transport services, and increasing maintenance budgets can ensure that infrastructure reaches its designed lifespan (Joynt, 2019). A study conducted by Hanyurwumutima and Gumede (2021) found that the South African government has increased transport expenditure over the years in big metros such as CoCT and CoJ Ethekwini. Despite the said intervention, the expected economic growth has not been achieved. Providing adequate infrastructure to support the transportation sector should be a major priority for the government and other social infrastructure projects such as health and education.

There is a need to speed up the rollout of innovative technology tools to make the public transport system safer and more efficient, with ideal maintenance and working infrastructure conditions. IRIS can be implemented to deal with the efficient movement of people using existing road and rail infrastructure.

6.1.3 Knowledge of Real-time Information

The interview participants demonstrated different levels of understanding about their knowledge of real-time information. The majority of the participants who indicated that they have full knowledge of real-time communication have a background in IT. However, those at the operational level could not fully define the concept. The participants who have full knowledge of real-time information indicated how the concept could be adopted in the public transport industry to support decision making, reduce the number of vehicles and help communicate information to passengers, especially regarding possible delays.

For example, R3 stated that "I understand that its information is received with fewer delays…it can help to better communicate with passengers promptly, especially regarding a delay." The use of real-time information in public transport is later supported by participants in the co-design session who stated that its provision could improve decision making, allow commuters to make alternative decisions, enhance safety, and improve the overall trust in the public transport system. This is also supported by literature as Bruglieri et al. (2015) state that real-time information may decrease traffic congestion and air pollution within cities and improve accessibility for all citizens.

Access to mobile devices and internet connections influences commuters to explore mobile-based solutions for options to reduce travel time. Therefore, public transport facilities must be equipped with internet connections and technology infrastructure to raise awareness of real-time information (Hong et al., 2019). The commuters are more likely to embrace the usage of an IRIS once they are aware of the benefits provided by access to real-time information.

6.1.4 Real-time Decision-making

The commuters who participated in the co-design session indicated that real-time travel information would enable effective real-time decision-making. For example, those student participants indicated scenarios when they needed travel information to decide alternative modes on their way to school. The students have had experiences where they missed classes or even an exam due to their mode of transport either being delayed or inaccessible due to strikes. The working-class participants also highlighted similar occasions where they required real-time travel information while commuting to and from their places of work during odd hours of the day. P8: "Leaving work after hours and not knowing which public transport is still available." When only one mode of transport is available, the commuters are left inconvenienced and frustrated due to the unavailability of information on alternative options, standing in long queues resulting in late arrival to their destinations. In some instances, the commuters are left completely stranded, as stated by P6: "When I was leaving campus late, and the taxis to my area were finished. " The point above is buttressed with the argument that real-time travel information could assist in improving these experiences since commuters would be made aware of the possible alternative means of commuting to their destinations (Macedo et al., 2021).

Considering the challenges highlighted in 6.1.1, making an informed real-time decision could be the difference between getting to the destination on time, arriving late, and being safe. In some instances, the real-time decision you make may save your life from the dangers posed by violent protests in communities. Relative to the above statement, Rahman (2013) argues

that during dangerous situations, information becomes extremely crucial to reach the destination in time and the correct format to decide without any time delay. According to Friman et al. (2020), well-informed commuters feel comfortable and safer with real-time decision making, which improves personal safety at stations and during the trips, whereby commuters can identify available seats on each transport mode. In the face of covid-19, there are also many concerns around crowded spaces at public transport facilities, which exposes commuters to health risks (Tiikkaja & Viri, 2021). Considering the above, providing an IRIS will enable commuters to make better decisions in critical conditions that will improve their travel experiences in choice shifts, comfort, and safety.

6.1.5 Challenges of Real-time Information

The provision of real-time information is challenging under the current climate in South Africa as public PTOs do not have the human resources to provide information that is up to date. R4 highlights that "The system sometimes goes down, so network problems must be fixed." Currently, network connectivity issues impact system uptime, which is a big challenge since real-time communication requires a reliable, constant data feed. Also, the commuters' need to consume information from different devices, and compatibility issues are challenging the IRIS faced, as not all devices may be optimally supported initially. The incompatibility challenges are corroborated by Majrashi et al. (2020), who posited that It is not uncommon for people to possess a wide variety of devices to access a shared information space. It is important to consider the constraint of compatibility when designing such a system as IRIS to be as inclusive as possible for low-income commuters, who might likely not own a high-end compatible device. Similarly, Silva et al. (2018) state that integrating devices from different architectures is not easy, especially interoperability and communications. The author further posits that properly distributing resources can help increase processing power and data transfer speeds.

To overcome the challenge of compatibility, it would require incorporating diverse technological tools that allow for universal access to real-time information such as HTTPS, SMS, IoT, and USSD technology. By applying these technologies, a wider range of devices can be supported, including those who do not have access to expensive smart devices. Two classes of real-time information emerged from the literature (local travel information, personalised travel information). Local travel information is made for non-connected passengers at stations, while personalised travel information is received through connected mobile devices such as smartphones (Zargayouna et al., 2020). Therefore, the IRIS would

need to cater to both the localised and the personalised interfaces to accommodate diverse usage by the commuters.

6.2 Theme 2: Information Channels

Objective 2: To determine the available public commuting information channels in South Africa

6.2.1 Accessibility

Accessibility refers to how easily travel information is made available to commuters for each mode of public transport. Accessibility is important as it highlights the significance of an IRIS that can offer standardised access for real-time travel information. Yeboah et al. (2019) state that although digital sources have been provided for commuters to make travel information more accessible, they also tend to visit travel shops, information centres, together with using word-of-mouth by asking (inspectors, friends, relatives, other passengers). The findings of this study reveal that taxis still send out information to commuters through word of mouth, with P4 stating that" " Taxis have no tools, buses have websites and applications. "This can largely be attributed to the culture of resisting change within the industry." The most widely used mode of transport, according to StatsSA (2018), is the taxis.

In contrast, one of the ways to improve the commuter experience is by providing real-time travel information for commuters to plan around disruptions (Luke & Heyns, 2020). Other modes of public transport do have some travel information on their websites that commuters can download for offline use. However, this travel information is static and does not consider the dynamic nature of public transport in South Africa.

There are also third-party mobile applications for smartphones, such as Moovit and Wego, that provide periodically updated travel information for the various modes of transport. These solutions require a smart device and access to the internet, which is still a luxury to most commuters who constantly seek ways to reduce their commuting costs. However, the MyCITI bus service utilises an in-house mobile application to provide commuters with information on timetables, routes, and news alerts. This information dissemination method limits access to those commuters who cannot afford the costs of data (Hawthrone & Grzybowksi, 2019). Display screens at stations are another way of providing travel information to commuters. This information dissemination channel is commonly used at train stations and MyCITI, which eliminates the ability to make any concrete plan ahead.

6.2.2 Technology Resources

Technological resources are required to support the implementation of an IRIS for South African public commuters. The current situation is such that there is varying use of technology. R1 believes that "At the moment there is no technology. The industry is led by individuals who are not united, and when innovations get presented, everyone wants to know how they will gain." Gössling (2018) states that technology has considerable importance for transport systems as it provides access to travel information, trip planning tools, opportunities to share transport modes, compare and make payments, and ultimately improve safety through the communication of travel patterns. The other modes of transport do have some technological tools for commuters to access travel information from a device.

The most technologically advanced mode of transport is the MyCITI BRT service, which has various technological tools to provide information to commuters. These include a custom mobile application and display screens at stations. There are also third-party services such as Wego and Moovit that provide mobile applications for bus services like Golden arrow. The train services do not utilise advanced technology as commuters can only use a website to download timetables and schedules. However, Go-metro's third-party application can be downloaded for timetable and route information. The participants of this study agreed that the most suitable method to receive travel information is through technological tools, including websites, mobile applications, and display screens.

One of the suggestions made by participants from the interviews is that there is a need to implement citywide Wi-Fi connections so that commuters can have stable connectivity while using these technology tools and the IRIS. The use of interactive display screens at facilities is also required for commuters who prefer to receive local information; as P3 stated, they still prefer to receive travel information: "In-person." CCTV in vehicles is also important in the IRIS as a security feature currently adopted by bus services such as Golden Arrow (Gabs, 2020). The other important technological resource would be sensors onboard vehicles that enable check-in and checkout features and electronic payments through smart cards. The technology resources are at the core of the IRIS as they determine how travel information will be disseminated and form the basis for integration.

6.2.3 Systems Maintenance

Systems maintenance is a phase in systems development where changes or enhancements are made to a system to make it more useful in achieving user needs (Ralph & George, 2018). Part of the study's revelation is that commuters were dissatisfied with current information

dissemination channels and viewed them as incapable of meeting their commuting needs. Some of the problems experienced with information dissemination platforms include non-functional features, outdated information, and in many instances, the platforms are often unavailable. According to Sommerville (2016), there are three types of systems maintenance, 1. Corrective maintenance: Involves fixing day zero errors in code. This is an expensive type of maintenance as it can involve recoding several components in the system; 2. Adaptive maintenance' forces a system to evolve due to changing business processes, government policies, and other external factors beyond a company's control; 3. Perfective maintenance: is adding additional features and enhancing the system for the users. This type of maintenance is classified as routine and is not triggered by a fault or problem (Coronel et al., 2020).

From the reported experiences of the commuters, maintenance of the existing system is a perennial problem that keeps on affecting the ability of PTOs to deliver the quality and standard services expected of them. These problems with maintenance of the systems are likely associated with lack of resources, lack of prioritisation, lack of skilled workforce, corruption, and dereliction of duty, among others (DoT, 2020). To ensure that the envisioned system is properly maintained, a contracted third-party service provider needs to be responsible for maintenance and administrative services. This type of arrangement provides some degree of independence for the 'operator's duty to the system, and grounds for accountability and transparency, by eliminating government interference in the system's operations. This type of partnership is evident in the management of MYCiti BRT services, which has brought some measure of success in the reliability of operations, in direct contrast with PRASA services.

6.2.4 Systems Upgrade

Multiple information channels are currently in use today. They may need to reuse some of the components of these channels to create an improved integrated platform for commuters. As highlighted in section 5.2.2, the vehicles need to be fitted with sensors and technologies that enable the efficient dissemination of information. The government has a role in providing incentives or subsidies to encourage all PTOs to equip their vehicles with supporting technologies. Once the PTOs have gone digital, their existing systems need to be upgraded and standardised to participate in the IRIS. Currently, many of these existing systems are ineffective and are not being used to their full potential. R5 supports this claim and states that "The problem I have is that the website is not always working or providing updated information." Therefore, an upgrade is justifiable to either improve the usability or effectiveness of these systems. According to Mateen (2017), the reuse of existing systems will allow faster delivery of the new product. Quality is almost assured with system reuse as

these are a collection of components that have been tried and tested with industry standards. Due to system upgrading, the costs and time associated with developing a new solution will be greatly reduced.

Lowering upgrading costs and support through government intervention and subsidies will ensure that the PTOs do not inflate the prices of public transport commuting due to costs associated with a system upgrade and compatibility with IRIS.

6.2.5 Mode of Information

Some commuters indicated a preference for travel information to be sent directly to them through mobile applications, SMS, email, or made available on websites. According to Shonhe (2017), there has been a growth in the use of the internet and mobile technologies in all spheres of life. The commuters who participated in the study indicated a preference for information accessible on their smartphones.

However, some support receiving travel information in person at stations through information boards and display screens. For example, the trains use display screens at stations or send SMS to commuters about possible delays. This is a convenient medium for providing travel information to regular commuters without smart devices on route options.

The participants also suggested using speakers to disseminate travel information at stations. However, this may lead to noise pollution as the feature would need to be rolled out at old stations for each public transport mode. Nevertheless, a system that works similar to the airport system where real-life updates are displayed on screens and announcements are made intermittently on updates is more adaptable to suit the operation of the train and taxi services with a larger number of commuters.

Information on such a platform will be automatically synced with IRIS, where other users can remotely access the real-time changes and updates to travel information from other linked platforms. R2 mentions that "The best way is to use technology, but it has disadvantages because not everyone can use it." Zargayouna et al. (2020) supports this claim and argues that older commuters who are not familiar with digital tools may shy away from using technology-based modes of information dissemination. Therefore, there must be supplementary ways of disseminating information to commuters, even though technological channels are prioritised in a system like IRIS.

6.3 Theme 3: Information Needs

Objective 3: To determine the real-time information required for public commuting in South Africa.

6.3.1 Traveller Information

Travel information is important for daily commuting needs as it provides a basis for proper comparison between the transportation modes. Commuters tend to use travel information to plan trips and make the best choice for the expected speed, comfort, safety, and trip cost (Aderinola et al., 2020). This section discusses travel information based on two related categories emergent from the findings: 1.) The current travel information provided to commuters; 2.) Commuters travel information needs. The travel information mentioned by the participants in this study is similar to those reported in the literature. A comparison of the two aspects of travel information mentioned above is provided below to highlight the gaps in the provision of travel information that can be addressed by the design of an IRIS.

6.3.1.1 Current Travel Information Provided

The PTOs provide commuters with a diverse range of travel information. However, these tend to vary based on each mode of transport service. For example, the taxi industry is well known for being out-fashioned; hence, the only travel information provided to commuters is about potential fare increases. Below is a list of the travel information provided to commuters by the PTOs, which includes fare amount, timetables, and station information on top of the list:

- Fare amounts
- Timetables
- Location of Stations
- Schedules
- Delays
- Routes

From the above list, fare amount is the only travel information common to all the transport modes. This is no surprise that fare increases are given high priority as the PTOs are very profit-driven, and little attention is given to the interests of the commuters. P1 shared sentiments that support this claim about PTOs "The owners are selfish and think for themselves only…". In addition, the train service provided information about timetables, location of stations, schedules on display screens at major stations like the Cape Town station, and delays were communicated using SMS. While both Bus modes provided commuters with

timetables, location of stations, and route information, delays are only communicated by the MyCiti Bus mode. A study conducted by Deng and Chen (2021) found that PTOs provide commuters with static information on bus routes, departure timetables, and ticket prices in most cases.

Such information is often in contrast with commuters, who are more interested in real-time information on estimated bus arrival time, estimated travel time, road congestion, and crowding in vehicles. In order to achieve a fully optimised IRIS, commuters' information needs must be recognised as the core of the design requirements.

6.3.1.2 Commuter Travel Information Needs

There are some similarities between commuters' travel information requirements and what is provided currently by the PTOs. Information about delays, fares, schedules, and routes were both mentioned by the commuters and PTOs. Nevertheless, the order of priority differs sharply. Based on the list below extracted from table 4.5 showing commuters' preferred travel information needs, the commuters expressed the need for more information than what was currently provided to plan their trips effectively. The number of passengers onboard a vehicle appeared as the most required travel information. The position of the commuters was corroborated by Habib and Anik (2021), who suggested that priority placed on the number of passengers could be the result of people being conscious of confined and overcrowded spaces due to the threats posed by covid-19. Given that the study was conducted during the covid-19 pandemic, it is no surprise that commuters will be warier of the danger posed by confined spaces. However, it has always been argued that the issue of overcrowding has always been a dissatisfying factor with public transport as it reduces safety and comfort (Haywood et al., 2017).

- Number of passengers
- Traffic congestion
- Delays
- Other
- Strikes
- Accidents
- Alternative modes
- Alternative routes
- Arrive time
- Departure time
- Distance between stops

- Schedules
- Estimated trip time
- Fares

In contrast to what is currently provided, commuters indicated traffic-related incidents such as delays, accidents, strikes, and traffic congestion based on priority. The travel information such as fares and timetables ranked highest by PTOs, were given a low priority by commuters, who prioritised dynamic travel information to enable informed decision-making when planning trips. The prioritised information needs include alternative routes and modes, arrival and departure time, the distance between stops, and estimated trip time. The travel information needs categorised as "other" include the vehicle's condition, features such as aircon, hygiene, and points for free rides. These can be classified as nice to have features, but they are also acknowledged as possible influencers of mode choice, and hence they have been categorised as "Other." The list above corresponds to the literature. As stated by Hörold et al. (2016), commuters generally require information about the vehicle's location, load factor, departure and arrival time, vehicle eco-friendliness, and route.

In order to design an effective IRIS, the preferred travel information needs of commuters must be the highest priority as the system is primarily aimed at improving the experience of the commuters as opposed to boosting the profits for the PTOs.

6.3.2 Information Frequency

The frequency of travel information provided emerged as an important finding that developed from the analysis of data from the commuters. The commuters indicated their preference for the frequency of travel information updates. This preference varied from hourly to 30-minute intervals as a reasonable period to receive updates on travel information. However, it is important to note that real-time communication requires information to be updated in very short intervals (seconds) to maintain its current form in a changing environment (Lee, 2018). This concept will not necessarily change based on users' expectations. It is assumed that commuters are not fully aware of the dynamism of real-time information, as the information may have been updated several times before the time range stated. Therefore, it was presumed that the frequency of information alluded to by commuters is the expectation of how often they would like to receive travel information updates on their devices. This can be related to 'commuters' worry about being spammed with too much information from an automated system.

There is a need for a feature that allows commuters to choose different intervals for receiving notifications from the IRIS about the frequency of travel information provided. The notifications should have reasonable intervals similar to those indicated in this study. Zargayouna et al. (2020) found that overloading commuters with information lead to oversaturation, and passengers often end up ignoring important notifications while trying to find an itinerary of their own. The frequency and latency of real-time information available to commuters are key in designing and operating a practical integrated transport system in South Africa.

6.4 Theme 4: Integrated Real-time Information System

Objective 4: To identify design requirements for an IRIS for public commuting in South Africa.

6.4.1 Change management

When transitioning from an old system to a new one, there are bound to be some challenges along the way as it impacts organisational culture, and people tend to fear the unknown. There is often a risk of resistance to change from users and other relevant stakeholders (Ralph & George, 2018). Findings highlighted that PTOs believed trust is a major issue in achieving an integrated system, and concerns about the non-existence of mutual trust between the different operators and the government and the operators. The taxis had mentioned that such a system might cause the government to enforce regulations since they operate in an unstructured manner. The other issue is unfair competition between operators; there are fears that the envisioned system may give some modes of transport an advantage. R5 indicates that "There could be tension between the different operators, particularly the taxi industry." As some participants mentioned, these trust issues need to be clearly addressed by all parties as they may lead to conflict.

There is a need to maintain a visible and trustworthy partnership since some commuters are often loyal to a certain transport mode due to their personal experience. Building collective trust in an integrated system is important to project a positive image. Such commuters would be open to using alternative modes of transport partnering with their preferred option.

According to the literature, change can be effectively managed through a phased approach strategy (van Marrewijk, 2018). The phased approach allows pilot projects to run in parallel with existing systems, reducing the risk of failure as systems can be tested on a smaller scale and then slowly rolled out to a larger group of users (Ralph & George, 2018). This contrasts with the "big bang" approach, also referred to as the direct cut strategy.

The direct cut strategy is cost-effective since systems do not run in parallel. However, it is risky as failure can occur, and it is impossible to revert to the old system (Ralph & George, 2018). A phased approach could be adopted for the envisioned system, piloted and launched in one metropolitan region like the CoCT. Following the successful implementation of the planned integration of public transport systems by CoCT 2030, similar solutions can be rolled out later in other metropolitan areas in phases. This method will allow for adequate planning of resources to support the implementation in other metropoles and address teething problems before a countrywide adoption of IRIS.

6.4.2 Data Privacy

The protection of personal data is a major concern of PTOs since an integrated system will require data sharing of their operations and commuters. R8 indicated that PTOs should not have issues sharing their information, although this is dependent on "…what the other parties plan to do with the information, could be privacy concerns".

A data privacy issue presents a complex challenge within an integrated system, given that commuters can hold any party liable for sharing their data without consent. The Protection of Personal Information Act (POPI) is government legislation protecting the public from being victims of data misuse (Arthur, 2021). The act states that organisations are custodians of 'citizens' data and therefore are responsible for protecting personal information when storing and sharing. Applicable privacy policies must be considered when designing the system's features to accommodate all data compliance regulations and responsibilities and ensure compliance with the POPI Act.

It is the responsibility of the transport operators to secure customer data from unauthorised access. Users must be notified of changes to data policies at all times and allowed to decide without any form of coercion or deception. Kandeh et al. (2018) argue that the POPI Act is clear about what it requires; however, it is tricky for data management professionals to implement it due to a lack of formalised guidelines. The PTOs must have a dedicated person responsible for data governance, s and standardised guidelines must be adopted, developed, and shared between their data governance officer to ensure consistency in application. Data security is an integral aspect of designing integrated systems such as IRIS. It is vital to the system's operation to gain the commuters' confidence, the potential users. Security can be by encrypting confidential data from information security threats. These could be through hackers, masqueraders, or malicious software (Choi et al., 2018). There are also growing

concerns of threats targeting IoT device operating systems which need to be mitigated against as they pose a threat to data protection in an IRIS.

6.4.3 System Requirements

System requirements can be defined as features that users expect from a system (Gunawardhana, 2019). In the context of this study, users of the proposed IRIS are primarily commuters. However, the PTOs also have a vested interest in the system's operational capabilities. In section 4.4.1.1, participants of the co-design session co-created concepts outlining some of the features required from an IRIS. These features are highlighted below, together with suggested requirements of IRIS from the PTOs as well.

- Electronic integrated payments
- Multiple payments methods
- Translation of information between languages
- Search or filter travel information
- Live vehicle location on an interactive map
- Notifications through SMS
- Display information at screens
- Text to Audio conversion
- Download schedules for offline use.

These requirements would improve the customers' experience in terms of comfort, safety and trip planning. Most current information channels lack these features; for example, most transport modes still use the cash system for fare collection, despite electronic payments being safer and more convenient. The features of IRIS required by the PTOs are expected to provide better services for their customers through enhanced operational capacity. These features are vital for efficiently managing logistics, planning, scheduling, maintenance, and seamless information in an integrated system. The required features of IRIS from the PTOs perspective are presented as follows:

- Driver management features (Managing shifts, performance, incident reports, driver habits)
- Fleet management features (Vehicle location services, CCTV on-board)
- Customer reviews
- Seat reservation
- Toll-free access

- Update on maintenance status
- Electronic payments
- SMS notifications

From the list of required features of IRIS provided by both the commuters and PTOs, it can be concluded that there is a need for separate interfaces. The interfaces cater to commuters, the primary users, and the PTOs staff who would indirectly interact with the system while performing administrative functions. So, there is a need for the IRIS design to cater to these two classes of users—UI specifically for commuters with the different commuting options and related information. However, the independent operator contracted to manage the IRIS would use the same interface as the PTOs, with escalated permissions and management rights.

6.4.4 Operational Challenges

There are standards to be adopted to achieve operational synergy between the different operators for the IRIS to function as expected. R6 mentioned that PTOs require standards to be adopted." it will require the stakeholders involved to standardise their process." For example, a standardised method for handling payments using smart-card technology should be accepted by all the transport modes and across transport routes. Thus far, only MyCITI has adopted this payment method (MyCITI, 2015). Berner and Judge (2019) corroborated the requirement for interconnectivity standards and stated that standards could help improve compliance costs for organisations as regulatory demands for duplicate information in slightly different forms should be greatly reduced.

The current climate is too segregated to introduce the IRIS without addressing the stark differences in operating standards of the PTOs. It is well-known that taxis often fight for routes, scheduling, operation, and management controls. Therefore, to achieve integration, there has to be a shared revenue model that benefits all stakeholders equally. This will also reduce the possibility of conflicts over routes or customers.

Integrating divergent services in a system like IRIS entails commissioning a comprehensive action plan with a strategic initiative and mission of bringing all major players to a mutual agreement (Solecka & Zak, 2014). All parties must be educated on the benefits of IRIS. The intricacies of the complexity such a system will have on their operations must be exhaustively explained to the satisfaction of the relevant stakeholders.

The government also has a big role in regulating the IRIS to prevent conflict, abuse, and mismanagement from the stakeholders. Training will need to be provided as staff from the different modes of transport may have varying skills regarding the use of the IRIS and its supporting technologies, as R7 mentioned: "The training may need to be provided to users and administrators to use the system efficiently." The success of an IRIS post-implementation is only as good as the people who use it, and from an administrative point of view, the staff of PTOs must be trained to buy into and champion the initiative.

6.4.5 Information Sharing

In order to facilitate a collaborative transport system, the PTOs must be open to the concept of information sharing to achieve a functional IRIS. It has been argued that Information sharing enables automatic content discovery, reducing information overload, and ensuring that information is given to the correct person, at the right time, based on a user's preferences (Mahakata et al., 2017). Findings from the study established that better collaboration between the stakeholders exists when information is shared that benefits the end-users.

In relation, Al-Mulla et al. (2019) state that organisations become more efficient and effective when they share vital information, and those not privy to vital information often find it difficult to compete in an environment driven by ICT. Establishing a centralised platform is crucial for information sharing, drawing data from multiple sources that empower the effective use of information on the collaborative platform.

Regarding information sharing, P10 stated that "the transport system will operate better as one," while P1 agrees with this point by mentioning that "There are integrated sources of information for common decisions that would work for passengers." Despite the possibility of such collaboration, it also raises concerns over increased competition for passengers between the PTOs. The concern was expressly noted that some PTOs might acquire more benefits than others through increased ridership due to the centralisation of information. Thus, to ensure transparency, the impact of this shared information must be properly enumerated and conveyed to all parties involved to ensure equitable access and reduce favouritism. The collaborative information sharing effort's operational impact on PTO's operations must be periodically evaluated and adjustments made in line with fair competition and practices. Mahakata et al. (2017) state that information sharing platforms allow organisations' members to work together towards a common goal by focusing on their respective collaborative activities. Collaborative sharing offers a convenient option for commuters to access

information from different PTOs in one location to facilitate decision-making on alternative modes on an IRIS.

6.4.6 Integrated System

An integrated system, as it relates to public transportation, can be defined as one that combines a network of various modes, sectors, operators, and institutions into one entity to increase economic and social benefits (Sonar & Gaikwad, 2020). The integrated approach to public transportation is part of the vision of the CoCT as this can be seen in improving the situation with traffic congestion and overreliance on private vehicles within the city (CoCT, 2018). Findings reported 'participants' acknowledgement that an integrated system would improve the efficiency and reliability of the public transport system. P2 agrees that PTOs "…are able to work together to create a better transport system" when integrated. Given that the public transport system comprises multiple modes, an integrated system will enable commuters to make informed decisions when choosing a mode of transport best suited for their journey. For example, it was referenced that commuters are susceptible to criminal activities when stranded at stations. Thus an integrated system is imperative to enable commuters to make alternative plans on modes. The safety and security of commuters will improve due to the deconcentration of commuters from certain modes, which will also reduce traffic congestion when commuters make smarter decisions on commuting routes and time.

According to Schwedes and Hoor (2019), integrated transport can increase ridership as commuters' perception of the public transport system greatly improves. R5 supports this point: "It can help reduce the number of private cars in the city as more people will have confidence in an efficient modernised system." The efficiency of an integrated system also provides people with quicker access to economic hubs, which boosts economic activity for businesses and households (Yang et al., 2020). Implementing an integrated transportation system at the practical and policy level would result in a door-to-door service integrated transportation system. The realisation of mobility for all can be achieved, and it is consistent with the concept of transportation equity, which the UN stipulates as a fundamental right (Safitri et al., 2015). Similar to the previous author, a report by the European Commission found that if destinations were made fully accessible, demand for tourism services by passengers with reduced mobility could increase by over 40% since door-to-door services will improve accessibility (OECD, 2017).

An unintegrated public transport system inconveniences commuters in terms of travel time (connecting and timetables between PTOs are not synchronised), comfort (having to queue

for multiple tickets), costs (parallel fare amounts between same service providers), and information (the passenger faces a non-transparent system) (Mrníková et al., 2017).

In support of the potential impact of IRIS, Stawiarska and Sobczak (2018) concurred that an integrated system improves traffic conditions for drivers, passengers, and pedestrians and increases road traffic safety by 40–80 %. Based on the results of this study, it is clear that the concept of integration can potentially enhance confidence in the public transport system. Thus, it is important to incorporate the findings from this study to explore factors affecting the availability and accessibility of real-time information for public commuters in South Africa. Therefore, this study has explored the factors affecting the real-time information in SA to understand the design requirements for an IRIS for public commuting services in the country.

6.5 Chapter Summary

This chapter discussed the identified themes based on the research questions with the literature, the empirical data, and secondary data sources. The first theme discussed public transportation in South Africa. The empirical data and literature confirm that there are challenges relating to public transport, which often inconvenience commuters and leave them stranded at stations susceptible to criminal acts. There are also infrastructure challenges that hinder the delivery of transport services to previously disadvantaged groups in particular. The introduction of the IRIS was suggested as an innovative means to address these challenges since it provides access to real-time information both in literature and in the findings to influence mode shifts for commuters.

The second theme discussed was related to the information channels provided to commuters. It was noted in the empirical data that these channels are inadequate in meeting commuters' needs due to either having outdated information or inaccessible features. The findings revealed that commuters prefer technology-based information channels for convenience. However, not all can afford the technology associated with consuming real-time information. Therefore, an IRIS would need to factor in the diverse requirements of commuters and disseminate information in more than one mode.

The third theme discussed the information needs of participants, revealing overlapping similarities between the literature and the preferred information needs of participants in this study. The literature and empirical data found that the commuters have information needs relating to trip planning, including fare amounts, timetables, location of stations, schedules,

delays, routes, and traffic-related incidents. PTOs also require information to assist them in their daily operations and management of logistics.

The fourth and last theme delved into the design of an integrated real-time information system, and concerns about possible resistance to change were also highlighted in line with the literature. The literature also stressed the importance of phasing the new system into an existing environment to avoid fuelling tensions. The discussion also covered concerns about data privacy in an integrated shared platform, which requires regulation from the government, and, finally, the arguments and merits for integrated real-time information in South Africa were presented. The conclusion and recommendations for this research are presented in the next and final chapter.

CHAPTER SEVEN: CONCLUSION AND RECOMMENDATIONS

Chapter 7 presents answers to the research questions posed in section 1.5 to address the research problem in section 1.2. The factors for the design of IRIS is captured in section 7.2, and a conceptual design of the proposed IRIS is presented in 7.3. This chapter also outlines the research contributions in section 7.4. Recommendations for practice and further research are illustrated together with the limitation of the study in sections 7.5 and 7.6, respectively. Reflections on the researcher's experiences conclude the chapter in sections 7.7 and 7.8.

7.1 Summary of the Study

This section attempts to summarise the research by answering the main research question, divided into four sub-questions linked with the research objectives. Answers to the research questions are presented through the sub-questions, and the corresponding research objectives are addressed in the following subsections.

7.1.1 SRQ1: What are the challenges affecting the provision of real-time information for public commuting decision-making in South Africa?

This research question was posed to investigate the status of the public transport system in South Africa to understand the challenges that impact the provision of real-time information for public commuting purposes. The research findings of this study reveal that various challenges have besieged the development and advancement of the South African public transport system for years. The challenges with public transport include unreliability, unsafe and socio-traffic issues like congestions, overcrowding, and accidents. At the same time, infrastructure was in decay due to neglect and inadequate investment projects. The other challenges involved the awareness of the benefits realisable from real-time information, which not all the PTO participants could define.

Lastly, there is a challenge with providing real-time information in the current environment since the PTOs lack the human resources to keep the travel information up to date. The dynamics of establishing a stable network connection, supporting multiple user devices, and ensuring effective data management are other factors that contribute to these challenges of providing real-time information. These challenges impede the actualisation of an IRIS that facilitates real-time information for commuters. The answers provided sufficiently addressed the research objective: **To understand the problems associated with real-time decision-making on alternative modes and routes of public commuting in South Africa.**

7.1.2 SRQ2: What are the accessible information dissemination channels for public commuting in South Africa?

The question provided insight into the currently employed channels for providing travel information to commuters in South Africa. The current information channels available to public commuters include third-party services, mobile applications, display screens, information boards, and web-based tools. Findings reveal that some operators still use manual methods to disseminate information, such as word of mouth and helpdesks. All the PTOs operate in silos and produce static and periodically updated information distributed to commuters using different non-complementary channels.

The existing information dissemination channels were limited and dysfunctional due to a lack of system maintenance and outdated information. Inaccessible features, when needed, are the main issues described that make these information channels less desirable for commuters. There are suggestions from both PTOs and commuters for adopting technology-based tools to disseminate information.

Technology resources were reported as a critical requirement for the PTOs to participate in and implement integrated systems actively. Although the current information channels are ineffective in meeting commuters' needs for real-time travel information, certain existing channels can be upgraded and adopted in the IRIS. The answers provided to the question above addressed the objective: **To determine the available public commuting information channels in South Africa.**

7.1.3 SRQ3: What are the real-time information needs of public transport commuters in South Africa?

The question aimed to unveil commuters' real-time travel information to plan and make informed travel modes and alternative routes. Answers to the research question are categorised along with the information need and frequency of information provided. Findings indicated that currently, commuters are only provided with information relating to fare amounts, timetables, location of stations, schedules, delays, and routes. The real-time information needs of commuters who participated in this study reveal that there is a major demand for information on traffic-related incidents such as strikes, accidents, traffic congestion, and overcrowding, alternative modes, alternative routes, arrival time, departure time, the distance between stops, schedules, estimated trip time. Therefore, the IRIS must be designed to respond to such traffic-related incidences and report real-time to support commuters' informed decision-making. On the other hand, findings also indicated the frequency by which

commuters would like to receive notifications on real-time travel information at half to one-hour intervals.

Currently, commuters have to be actively searching for travel information on display screens, websites, and other forms of digital tools currently being used. At present, there is a gap in pushing travel information to devices in modes such as SMS, USSD, and HTTPS without spamming the users with too much information. However, to benefit from such a feature on IRIS, it requires that commuters have access to mobile devices to receive notifications on travel information at the preferred interval. Answers provided the necessary insight into the objective: **To determine the real-time information required for public commuting in South Africa.**

7.1.4 SRQ4: What are the design requirements for an IRIS for public commuting in South Africa?

The successful IRIS design depends on several factors uncovered through this research question. The identified requirements need to be satisfied for the system to be designed, implemented, and operated efficiently. The study reveals a need for different versions of the envisioned system as the commuters and operators have their list of expectations in terms of the functionality of the system.

The operators require more administrative functions such as managing drivers and fleet and customer reviews. Also, commuters require end-users functions that enable them to consume travel information, including searching information, multiple payments methods, support for multiple languages, live location of vehicles on interactive maps, and more. A comprehensive list of these requirements is captured in section 6.4.3 of the thesis. Although most of the requirements mentioned in this study were functional, there are also information security concerns from the PTOs regarding sharing data in an integrated system.

There is government legislation to protect personal information from misuse, so the envisioned system must comply. The role of government is crucial in regulating the envisioned system through laws and regulations that govern the interaction between stakeholders and the management of benefits. Thus, a formula on sharing of ridership, degree of collaborative information, payment, etc., will be factored into the IRIS design. There also needs to be a strategy for transitioning from the old system to the new (Design for Data transfer and integration) as users from the PTOs, and general commuters need to adjust and accept the new way of doing things.

The upgrading of existing road and rail infrastructure must be prioritised to realise the full potential of an IRIS. Besides convenience, the vehicles must be fitted with technologies that improve passengers' safety, such as CCTV cameras and smart cards to check-in facilities.

The answers highlighted reports on the requirements identified by both the PTOs and the commuters to fulfill the objective: **To identify design requirements for an IRIS for public commuting in South Africa.**

7.2 Factors for the Design of an IRIS

This research explored the factors for designing an IRIS for public commuting in South Africa. The factors are technical, operational, governance, infrastructure, and socio-economic nature. In this section, the factors obtained from the results of this study are presented in Table 7.1 using the components of AT as a lens.

Table 7.1 The factors for the design of an IRIS

AT component	Factors
Subjects: **(Commuters, Employees of PTOs)**	○ The commuters are the potential users of the IRIS, and therefore their information needs must be met to accept the system as part of their daily commute. ○ From the perspective of the PTOs, the IRIS must provide a convenient and accessible means for them to perform their daily administrative functions.
Tools: **(Software, Hardware, Databases, Protocols)**	○ IRIS must employ innovative and digital tools to disseminate information in real-time. ○ The information must be in a centralised repository and accessed through an integrated portal. ○ IRIS must incorporate such tools as websites, mobile applications, and display screens.

	○ Technology must support HTTP and IoT protocols to transmit data to a middleware. ○ The PTOs vehicles would have to be fitted with sensors that transmit real-time data about the vehicle to operate in the IRIS system. ○ The vehicles must be fitted with CCTV cameras to improve the aspect of security ○ Smart cards must be adopted to ensure legitimate commuters access facilities for safety reasons. ○ Roadside units should be installed on roads that pick up short-range signals on cars and track congestion on roads and vehicle data. ○ Electronic signs should be placed on busy roads to report incidents and possible congestion for drivers on a trip.
to Rules: **(Policies, Standards, Legislation)**	○ A revenue-sharing model must be developed and agreed to by all parties so that all PTOs are treated equally. ○ IRIS and the PTOs must be POPI-act-compliant to protect commuters' personal data. ○ Adopt uniform standards of operation between PTOs to ensure synergy in the system (e.g., accepting electronic payments on all modes).
Division of Labour:	○ An independent contractor must be appointed to maintain and administer the IRIS to ensure no

(Independent Contractor, Local government, National government)	participating stakeholders monopolise the system. o The national government must upgrade and maintain transport infrastructure and improve the quality of roads and rail networks to support IRS implementation. o The local government must ensure that municipal modes of transport are kept running through their regional private-public intervention and subsidy programmes.
To Community: **(Social environment, Resources, Accessibility)**	o The PTOs who operate in this community must have adequate resources to participate in the system (e.g., access to a stable network and infrastructure). o The commuters must access real-time travel information while onboard the modes, without subscribing to mobile data plans or owning expensive devices. o An effective change management plan must be in place to identify and mitigate the possibilities of conflicts by introducing the IRIS. o Training must be provided to employees of PTOs, so they accept the IRIS and do not see it as an additional load to their daily work duties.
Object: **(Objective)**	o The IRIS must disseminate current and relevant information for commuters to make informed decisions on routes and modes.

	○ The PTOs must collaborate and share information that contributes to the repository and supports commuter decision-making in real-time. ○ IRIS must be designed to provide travel information accessible to diverse people, using innovative options like interactive screens with travel maps at strategic locations around the city.
Outcome: **(Benefit)**	○ Primarily real-time travel information on all available modes and routes must be accessible to commuters at all times. ○ Travel information notice must be available on supported devices depending on the frequency interval required by the user. ○ The real-time travel information provided must be useful for informed decision-making to help improve the safety of commuters and the reliability of the public transport system. ○ The use of the IRIS system must enhance the trust in the public transport system and improve the commuting experience.

7.3 Conceptual Design of IRIS (CityMoova)

This section presents the conceptual design of the IRIS called “CityMoova” proposed by this thesis, based on the requirements elucidated by the commuters and PTOs, together with other design factors identified in the literature. The findings of this study demonstrated the need for two interfaces of the IRIS. The user roles and needs connote that end-users view and access different features than the PTOs.

The end-users, the commuters, mainly read updates from the system in contrast to the PTOs who play an administrative role and need to modify, update, read and delete data from the IRIS. Therefore, the conceptual design presented below is divided into two sections based on the perceived interaction with the system by the two categories of end-users:

7.3.1 End-user Interface

The end-user view of the system is complex in an IRIS because end users have different expectations on how they receive data. As established in the study, users expect information in different formats like text, audio, and mediums such as SMS, websites, display screens, and mobile applications. The use of smartphone technology would be advantageous in IRIS, as smartphones have location services that can detect a user's current location to provide commuters with personalised services. Although smartphones have become increasingly popular, these devices are not always available to low-income groups who mostly rely on the public transport system. Therefore, the conceptual design considers diversity by including a USSD feature for older phones to enable such devices to obtain data from the IRIS. The mockup view labelled (6) depicts how this USSD technology would work on the phone. The features include but are not limited to:

- Login feature as seen in mockup labelled (1)
- Registration feature linked to social media services as seen on mockups (2 and 3)
- Homepage labelled (4) for users to search travel information, view maps, view stations, and get live updates
- Settings where users can manage personal account details, add payment methods, set notifications, agree to privacy policies, set language preferences, and sign out of the system.

Mobile devices connected to the IRIS can be advantageous since commuters are constantly on the move with their devices, and smartphones, in particular, come with built-in geo-location services that will allow IRIS to understand patterns of the commuter's movements. However, it must be acknowledged that not all people own supporting mobile devices, so options must be provided in the form of display screens mounted at stations, as seen in figure 6.2, together with an interactive travel map interface at strategic locations. Mockup number (1) illustrates the IRIS display screen for commuters shown in figure 7.1.

Figure 7.1 Mobile device view of IRIS

The Internet of Things (IoT) is an emerging technology that needs to be incorporated into the design of an IRIS. For example, a commuter who owns a smartwatch can link the device to the IRIS to receive updates on travel information, as depicted below in figure 7.2 mockup (2). Ultimately, the IRIS must disseminate information in a format rendered to IoT and other smart devices, accommodating the different platforms and screen resolutions.

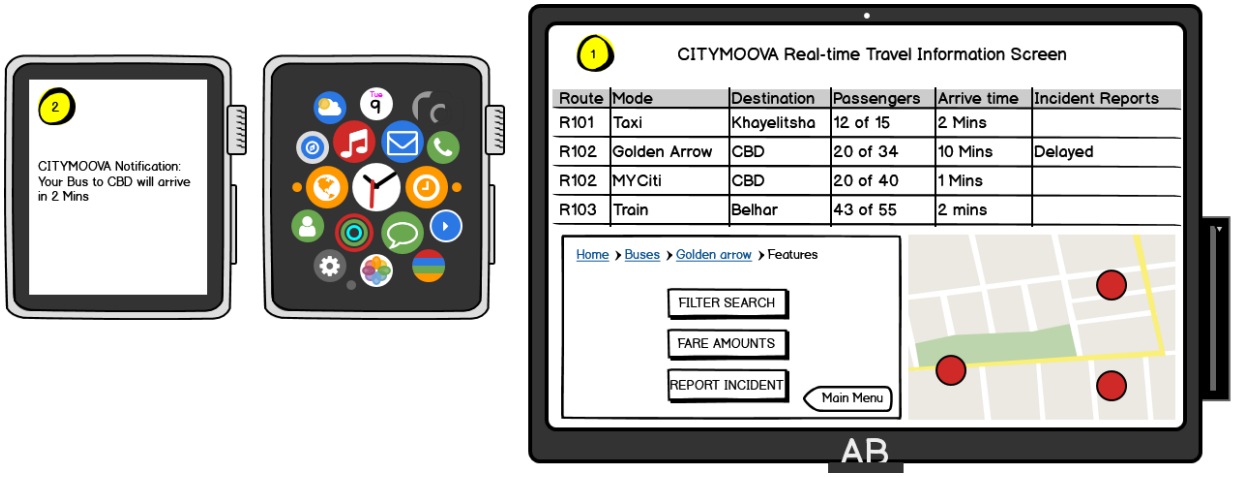

Figure 7.2 IoT devices on IRIS

The next section briefly outlines the administrator's view of the IRIS, capturing the importance of maintaining two views on the IRIS.

7.3.2 Administrator Interface

The second IRIS interface is designed as a web-based dashboard for PTOs, staff, and managers of the IRIS to support PTOs functionality and accessibility. Web-based solutions have platform independence. Therefore, administrators can run any compatible operating system of their choice to access the dashboard system through a web browser tool. It is a fact that security is a big concern on the web. Therefore, security mechanisms and protocols such as encryption, digital certificates, and multi-layered authentication must be put in place to minimise the threats posed by attackers. It is important to have an administration portal in any system that would allow administrators with requisite access to have a single view of the data. This view must be done in isolation to the end-user to ensure separation of duties. Only relevant users with permissions must access the system dashboard, and layers of permission must be implemented for security reasons and separation of duties.

Blockchain technology can also keep track of information and records for security and accountability purposes, thus dissuading any stakeholder from manipulating data and information. Figure 7.3 shows a preview of the PTOs staff user interface using a tabbed layout. As captured by the findings of this study, some of the features required by the PTOs from the IRIS include the following:

- Maintenance of customer data
- Ability to track company vehicles or fleet management

- Tracing transactions performed through E-payments
- View reports on driver habits or management of staff
- Edit, update or modify travel information when necessary

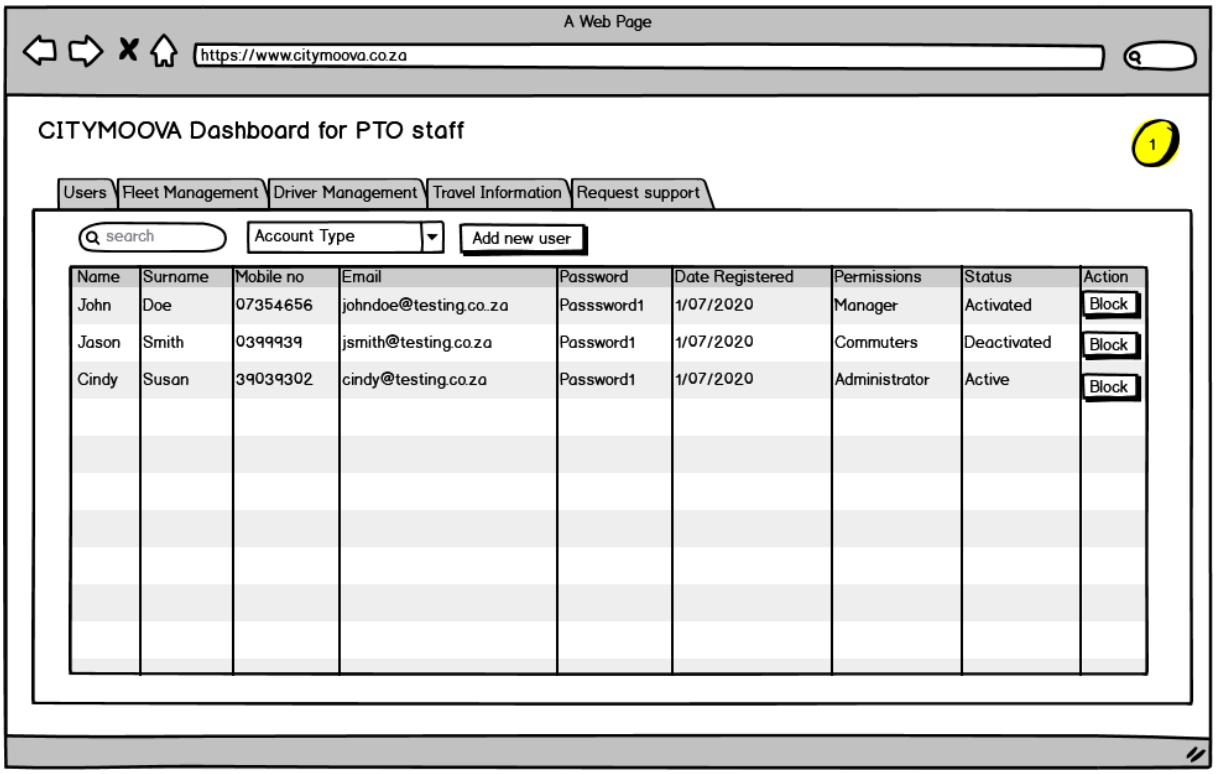

Figure 7.3 PTO staff dashboard for IRIS

What can be noted from figure 7.3 is that the functional requirements of the PTOs staff need to be controlled to ensure integrity in the system. Therefore, there is another separation of duties between the PTOs and the independent contracted organisation responsible for maintaining the IRIS. Although the PTOs have escalated permissions than those of the commuters, the top-level admin permissions of the IRIS should only be left to the independent contractor to reduce the risk of corruption, fraud or other forms of internal threats.

As seen in the tabs of figure 7.4 below, additional functions would be available to the contractor to perform admin tasks. For example, one of the requirements of the PTOs is to track transactions. However, giving all the PTOs direct access to the transaction logs is a big security concern; therefore, the contractor would be responsible for supporting the PTOs in that regard.

Due to separation of duties, The PTOs may not be given direct access to all the features they require, but they can be requested through the admin contractor. There is some overlap between the functions indicated by the tabs in figures 7.3 and 7.4. However, the contractor's interface would allow for extra functionality such as transactions, system preferences and security policies.

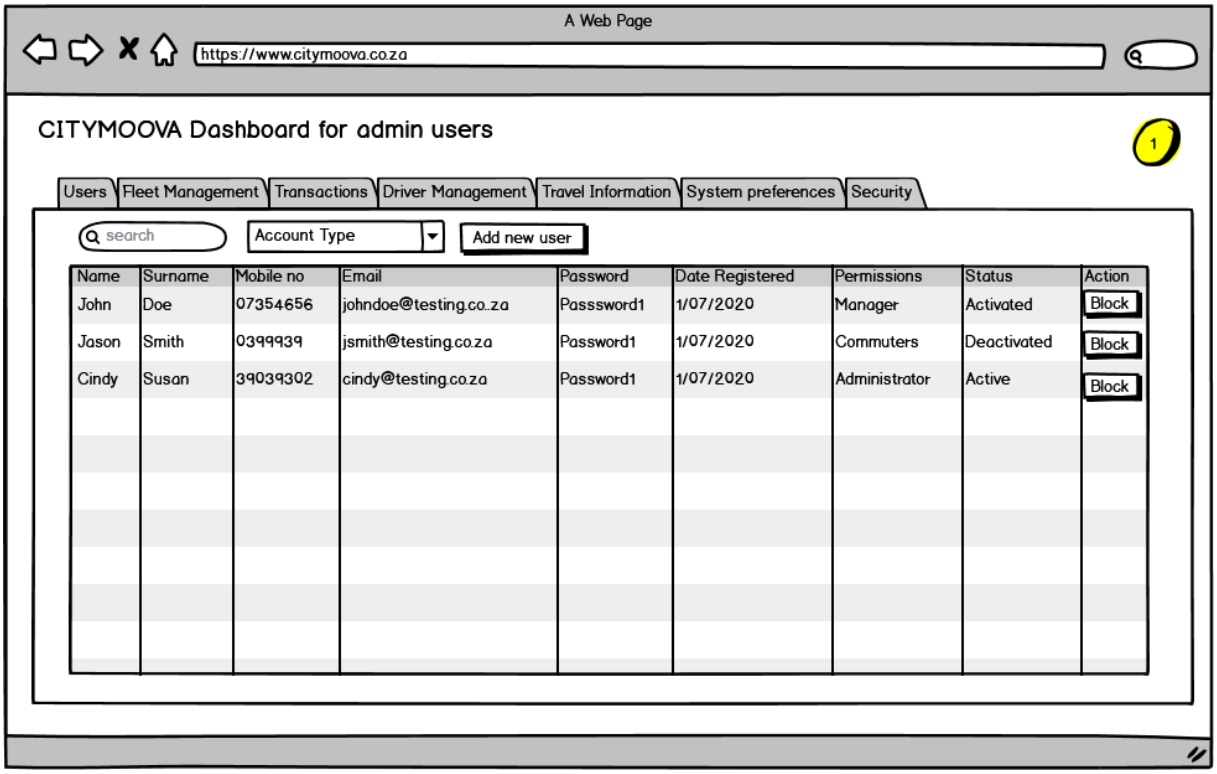

Figure 7.4 Independent contractor admin dashboard

The representations above depict the proposed IRIS system from an ideated conceptual point of view of the study. This does not represent the actual design of the system, which is beyond the scope of the study.

7.4 Research Contributions

This section focuses on the contributions of this thesis. The section is divided into three parts addressing contribution to theory, methodology, and practice.

Theoretical Contribution:

- This study contributes to the academic body of knowledge by providing findings on the nature of public transport in South Africa, The methods used to disseminate information, commuters' travel information needs, and the design requirements for an IRIS.

- This research will contribute to understanding factors for the design of an IRIS as outlined in section 7.3.

- This study will assist other researchers in developing frameworks for designing an IRIS for public commuting.

Methodological Contribution:

- The triangulation of data collection techniques, such as interviews, co-design and document reviews, helps capture different aspects of a phenomenon, particularly in IS research, where the social experiences of participants need to be well understood. The methodology of this study can be applied in other cities, provinces or even countries to understand the factors affecting the provision of real-time information for public commuting.

Practical Contribution:

- This research will contribute towards policies promoting advanced infrastructure development, improved public transport service delivery, and better associability for public commuters in South Africa.

- The conceptual designs produced by commuters in section 4.4.1.1 and the author's illustration of the IRIS in section 7.3 can be used as a basis for implementing or adapting to other designs.

7.5 Recommendations

The following recommendations inform the design and successful implementation of an operational IRIS system in South Africa.

Recommendations for Policy Implementation:

- The private partnership must be embraced as a third-party organisation contracted to provide administration, support, and maintenance services for the IRIS. This will foster accountability and limit collusion and system manipulation.
- There is a need for policies to be developed that support IRIS governance and standardise processes for PTOs operations, such as a unified payments system to bring about cohesion and reduce the possibilities of conflicts in an integrated environment.
- Investments from Public-Private partnerships must be solicited and acquired due to the magnitude of resources required to implement the IRIS. The government is not financially constrained to fund the system adequately to run efficiently.
- It is necessary to fast track the implementation of municipal spatial land redress policies to provide improved public transport facilities in previously disadvantaged communities due to the volume of users of the public transport system from these communities.

Recommendations for Infrastructure Development:

- There needs to be a massive investment in the upgrading and maintaining the transport infrastructure and integrating PTOs systems into the upgraded infrastructure to support the projected population growth by 2030 and realise the full potential of an IRIS.

- The rail network needs to be upgraded with modern facilities and infrastructure resources, as it plays a crucial role in supporting the road network, which falls under pressure during peak hours, to ensure optimal participation in an integrated system.

Recommendations for IRIS Implementation:

- The use of technological solutions within the transportation sector needs to be encouraged not just by PTOs but also by the government to create smarter cities that promote efficient service delivery to meet the citizens' needs.

- The implementation of this IRIS can be piloted in one of the major metros such as CoCT to understand the viability and promote acceptance from the general public before conducting an extended national rollout.

- A high powered planning committee comprising all relevant stakeholders must be commissioned to introduce, educate, and negotiate the governance conditions acceptable to all parties within the framework for designing and implementing the IRIS system.

- Sensitisation and re-skilling training should be provided for both staff and commuters through awareness programmes and usability to address the impact of resistance to change when transitioning from the old system to an integrated transport system powered by an IRIS.

7.6 Research Limitations

This research was conducted in Cape Town. Therefore, the identified challenges of real-time travel information cannot be generalised to all public commuters residing in cities located in other provinces due to contextual factors. Nevertheless, the system can be adapted to all South African provinces due to the similar commuting structure and the stakeholders' operations. A major limitation in the study was the unavailability of own city to participate in the interviews. The permission process was delayed and drawn out despite applying early enough; thus, the view of this significant stakeholder was not captured in this study.

The process of granting research study permission as stipulated by CoCT was six weeks, but the permission only came in November 2021, 7 months after the application was made and at the submission stage of the thesis. Therefore, it was impossible to schedule interviews within the time frame for final submission. Nevertheless, the document review provided some relevant information from the CoCT and government agencies' point of view through the policy and planning documents.

7.7 Future Research

This study investigated factors affecting the availability and accessibility of real-time information and design requirements for an IRIS. The following opportunities for further research exist:

- Developing a conceptual design for the IRIS based on the requirements gathered and validated with public transport commuters and operators.

- Modelling and implementing the system based on the identified requirements and factors and testing it with public transport commuters and government agencies.

- Developing a readiness framework for assessing the capability and capacity for implementing an IRIS in South Africa.

- Developing guidelines to implement data management procedures and standards to ensure compliance with the POPI Act for PTOs in an integrated system.

7.8 Reflection

Undertaking this research study has been an invaluable learning process. I have understood the challenges of research and the interactive nature of the research process. The co-design session was not difficult to get participants for; hence it was the first data collected in this study. The interviews were tricky and required patience as there was a greater need to work on people's schedules. Fortunately, teleconferencing tools enabled me to facilitate these interviews remotely. I learned from this the need to have backup plans in the eventuality that certain participating stakeholders do not pitch and that secondary data sources can be used with empirical data collection techniques to complete data from missing stakeholders.

My biggest challenge was coordinating the data collection process, which required me to send emails and make calls to people who, at times, were not helpful. However, this was overcome through social media and LinkedIn, which allowed me to reach out directly to people of interest. The responses from multiple stakeholders and secondary sources yielded rich data that I analysed from a theoretical framework perspective called Activity theory. This lesson taught me the importance of theoretical frameworks underpinning information systems research.

7.9 Conclusion

The study, through the literature, established the importance of providing real-time travel information for commuters to improve the travel experience and ridership in the public transport system, which is consistent with the research findings. The study explored the factors affecting the availability and accessibility of real-time information for public commuting purposes and understanding the design requirements for an IRIS for commuting services. The

underlying and dependent factors of design must be considered to achieve the vision of an integrated public transport system.

The themes identified in this study (see table 4.17) provide insights into the challenges of public transport, the information needs of commuters, information dissemination channels and design requirements for an IRIS. It was established throughout the study that the South African public transport system is faced with challenges, citing the problematic state of infrastructure, lack of technology and resources, among others. These challenges must be addressed to ensure the availability of adequate resources to support the IRIS.

Findings also revealed the necessity to implement a transparent revenue-sharing model for the IRIS so that all stakeholders can participate without the fear of unfair competition and conflict. Another factor highlighted is the need to standardise processes between the different modes to ensure a universal method of facilitating payments, schedules, and vehicle tracking.

Standardised processes will ensure synergy between the operators in the integrated system as they currently operate in silos, especially in the taxi industry that still lacks a formalised system of operation and technological tools to disseminate information.

The study also established that commuters have specific real-time information needs over and above those currently provided to them by the PTOs. The commuters are particularly concerned with receiving real-time travel information on strikes, accidents, traffic congestion, overcrowding, alternative modes and routes, arrival time, departure time, the distance between stops, schedules, and estimated trip time. This information should be provided through multiple channels such as SMS, websites, display screens, mobile applications and interactive travel maps. The participants of this study preferred a combination of these information channels as they allow access from a wider variety of portal devices and provide access to commuters who cannot afford smart devices.

Regarding the design requirements, the study also exposed the need for the proposed system to support multiple languages as South Africa has multiple indigenous languages. Other requirements include searching information, multiple payments methods, and support for multiple languages, live location of vehicles on interactive maps, and more. Findings unanimously suggested adopting technological tools for disseminating travel information, with the commuters' preference for update frequency and push notifications supported by the proposed system.

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APPENDICES

Appendix A: Co-design session outline

CO-DESIGN SESSION OUTLINE

Time	Activity
10:00 – 10:10	• Room Setup – Chairs and Tables with social distancing protocols • Catering and beverages setup (Coffee/Tea + Muffin) • Materials are given to participants
10:10 – 10:20	• Introduce the research project and outline the objectives
10:20 - 10:25	• Consent forms distribution and filling/signing
10:25 – 10:40	• Intros • Participants were divided into groups. • Explain service design and phases covered in the scope of this project.
10:40 – 11:30 (Discover Phase)	• Data is collected from participants (Interactive session, Q & A). • Take Pictures • Compile affinity Chart
30 minutes Break	
12:00 – 12:30 (Define Phase)	• Data collated and discussed. • Identify themes and patterns • Discuss the meaning of findings.
12:30 – 12:30 (Define Phase)	• Brainstorm requirements • Design conceptualization • Sketches • Prototyping
Concluding statement	**End of session**

WORKSHOP TOOLS AND MATERIALS:

- 2 Packs of post its
- Pens
- Markers
- A4 pages for prototyping/Sketches
- Laptop
- Video recorder
- Sanitizer

Appendix B: Co-design questions

#	QUESTIONS	GOAL	CODE
1.1	How would you describe the state of Public transportation in South Africa today?	Status of public transport system	A1
1.2	In what situation or encounter can you recall where you most needed travel information on public transport service?	Status of public transport system	A2
1.3	In your opinion, why do these challenges faced by public commuters persist?	Status of public transport system	A3
2.1	Do you currently have access to travel information on public transport services? If yes how do you access it? List	Information channels	A4
2.2	What mode of communication will be most suitable to use for your commuting needs?	Information channels	A5
2.3	Have you ever experienced any technological tools used to communicate travel information to commuters? Can you give examples of such tools?	Information channels	A6
2.4	Have you experienced any challenges while using such a system?	Information channels	A7
3.1	What are the specific type of travel information would you like to receive? (List)	Real-time information needs (Group discussion)	A8
3.2	In what way will the provision of real-time travel information affect your commuting activities (List)	Real-time information needs (Group discussion)	A9
3.3	How often would like to receive this information?	Real-time information needs	A10
4.1	What is your understanding of integrated real-time information system for public commuting? How do you think this will benefit commuters?	Design requirements	A11
4.2	What specific information would you like to be made available about each mode of transportation (List).	Design requirements	A12
4.3	In what format would you like to receive this information? (Audio, Text, Language). What type of features would you want to see on such a system? Infrastructure	Design requirements	A13

Appendix C: Interview outline

SEMI-STRUCTURED INTERVIEW SCHEDULE

1. Explain the ethical guidelines binding the research and obtain signed informed consent. (Start recording afterwards).

2. Introduce myself and outline the aims of the project to the interviewee
3. Determine the duration of the interview
4. Give the interviewee a chance to introduce themselves and what their role is in the organization.
5. Start with general questions.
6. Go deeper into the topic-specific question.

Appendix D: Interview transcripts

SEMI-STRUCTURED INTERVIEW 1

Date of Interview: 24 April 2021

Name of Interviewee: Respondent (R1)

Time: 15h00

	Interview Questions	
IQ1	Can you provide an overview of the public transportation system in Cape Town? The public transport system in cape town is faced with a few challenges since its combines government transport and privately owned transport like taxis, the government-owned transport is given an advantage over taxis.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
IQ2	What is your knowledge of real-time information? Real-time information can be used however a study needs to be conducted on how we can reduce the number of vehicles that gonna be on the road.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q3	How do you provide information for commuters using public transportation services?	**Objective 1:** To understand the problems associated with real-time decision making on alternative

	We provide information to commuters through printouts that are displayed inside the taxi, Information about fare increases.	modes and routes of public commuting in South Africa.
Q4	What do you think are the challenges of providing real-time information for commuters? There need to be more resources and how will the information be sourced since each association has its own financing model.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q5	How do you think real-time information can be made available for public commuters? Since we are living in a digital age, we need workshops and training for drivers to send out information more digitally, speakers in vehicles can be used to disseminate information.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q6	How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles) Through display printouts at the rank. We communicate mostly announcements that hardly change	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q7	Do you make use of any technology to send out information to commuters? If not WHY? If yes, How is this done? At the moment there is no technology. the industry is led by individuals who are not united and when innovations get presented everyone wants to know how they will gain.	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q8	What are your suggestions on how to improve the provision of traveler information to commuters by your organization? Use IT resources that are more efficient than manual systems	**Objective 2:** To determine the available public commuting information channels in South Africa.

Q9	What type of information is provided to commuters? Information regarding changes in routes and fare amount.	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q10	What do you think are the preferred travel information needs of commuters? Commuters have different working hours so most of the questions are will the taxis be available after hours.	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q11	Do you think there is merit in sharing real-time travel/commuting information with other transport agencies? In terms of sharing information it depends, taxis currently are leading in commuters numbers so this new system of sharing can put the competitors at an advantage of taking passengers	**Objective 4:** To determine the available public commuting information channels in South Africa.
Q12	How will you describe the benefits of an integrated traveler information system for commuters? The commuters will gain from having multiple options to choose from.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q13	Considering the current transportation system in CT, How well will an integrated real-time system work? This may create a platform for the government to control and formalize our current operations for their gain.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q14	What are the desirable features you think the system will need to provide for commuters and operators?	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

	Operators can track vehicle locations and driver habits and passengers can take alternative modes. Identifying quickest routers for drivers.	
Q15	What are the challenges such a system might encounter in the current climate? The system may cause government interference in operations and place the taxi industry at a disadvantage through increased laws and regulations. Roads and other infrastructure will need to be upgraded first and new routers must be created.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

SEMI-STRUCTURED INTERVIEW 2

Date of Interview: 25 April 2021

Name of Interviewee: Respondent (R2)

Time: 19h00

	Interview Questions	
IQ1	Can you provide an overview of the public transportation system in Cape Town? I wouldn't say it at its best, there is room for improvement	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
IQ2	What is your knowledge of real-time information? Not full knowledge.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q3	How do you provide information for commuters using public transportation services?	**Objective 1:** To understand the problems associated with real-time decision making on alternative

	We do provide information in the form of word to mouth. and some sort of advertising by the taxi rank, offices and in vehicles.	modes and routes of public commuting in South Africa.
Q4	What do you think are the challenges of providing real-time information for commuters? Most of our customers don't have access to the technology to get the information, at the moment we are doing it the best we know.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q5	How do you think real-time information can be made available for public commuters? The best way is to use technology but it has disadvantages because not everyone can use it.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q6	How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles) Verbally. The information we provide at the moment is very basic	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q7	Do you make use of any technology to send out information to commuters? If not WHY? If yes, How is this done? No, there is a lack of technology resources from taxis and commuters.	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q8	What are your suggestions on how to improve the provision of traveler information to commuters by your organization? Using a digital tool	**Objective 2:** To determine the available public commuting information channels in South Africa.

Q9	What type of information is provided to commuters? Fare amounts and location of ranks.	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q10	What do you think are the preferred travel information needs of commuters? Vehicle information and driver information in the event where there are problems and can be reported swiftly.	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q11	Do you think there is merit in sharing real-time travel/commuting information with other transport agencies? To be honest, the public will benefit but for us, it can work against us because the person can choose other modes instead of using the taxi.	**Objective 4:** To determine the available public commuting information channels in South Africa.
Q12	How will you describe the benefits of an integrated traveller information system for commuters? It can bring a lot of safety and make things much faster for example if it was an app there will be able to find most routes and make decisions.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q13	Considering the current transportation system in CT, How well will an integrated real-time system work? There are a lot of challenges but it will take time to trust it and get it right. It could gradually reduce the amount of conflict between owners, passengers, and drivers.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q14	What are the desirable features you think the system will need to provide for commuters and operators? The operators will have more control over their drivers and the commuter will be safer.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

Q15	What are the challenges such a system might encounter in the current climate? The most important challenge is infrastructure, there need to be improvements to the roads first.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

SEMI-STRUCTURED INTERVIEW 3

Date of Interview: 10 May 2021

Name of Interviewee: Respondent (R3)

Time: 15h00

	Interview Questions	
IQ1	Can you provide an overview of the public transportation system in Cape Town? It's decreasing in terms of effectiveness and becoming less preferred. The public transport system infrastructure is also a mess.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
IQ2	What is your knowledge of real-time information? I understand that its information is received with fewer delays.it Can help to better communicate with passengers in a timely manner specially regarding a delay.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q3	How do you provide information for commuters using public transportation services?	**Objective 1:** To understand the problems associated with real-time decision making on alternative

	We have an SMS system that notifies people when there are delays. And display screens at main stations like the Cape Town station	modes and routes of public commuting in South Africa.
Q4	What do you think are the challenges of providing real-time information for commuters? Lack of human intervention has caused the system to be outdated in terms of information updates.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q5	How do you think real-time information can be made available for public commuters? Since we support low-income individuals, SMS is still the preferred method but it needs to be improved to provide current information.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q6	How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles) Printouts and digital screens.Employees keep updating the system manually.	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q7	Do you make use of any technology to send out information to commuters? If not WHY? If yes, How is this done? Yes, we have an internal system	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q8	What are your suggestions on how to improve the provision of traveler information to commuters by your organization? Invest in newer systems that are not legacy to improve the effectiveness of information distribution.	**Objective 2:** To determine the available public commuting information channels in South Africa.

Q9	What type of information is provided to commuters? • Timetables • Fare increases	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q10	What do you think are the preferred travel information needs of commuters? • Delays • Time schedules	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q11	Do you think there is merit in sharing real-time travel/commuting information with other transport agencies? Since they are in competition it may not be a wise idea from the transport organizations point of view.it can give other stakeholders an upper hand	**Objective 4:** To determine the available public commuting information channels in South Africa.
Q12	How will you describe the benefits of an integrated traveler information system for commuters? People will be better informed about alternative modes of transport.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q13	Considering the current transportation system in CT, How well will an integrated real-time system work? It might not be received well since people are prone to take the same modes of transport that are economically viable to them.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q14	What are the desirable features you think the system will need to provide for commuters and operators?	**Objective 4:** To identify design requirements for an integrated

	• Fee collection • Update on maintenance • Track driver habits • Track employee shifts	real-time information system for public commuting in South Africa.
Q15	What are the challenges such a system might encounter in the current climate? • People will need training • Accountability needs to be improved	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

SEMI-STRUCTURED INTERVIEW 4

Date of Interview: 21 May 2021

Name of Interviewee: Respondent (R4)

Time: 16h10

	Interview Questions	
IQ1	Can you provide an overview of the public transportation system in Cape Town? The transport system in Cape Town is dysfunctional with a lot of overcrowding and also lacks safety.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
IQ2	What is your knowledge of real-time information? I don't know what real-time information is.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q3	How do you provide information for commuters using public transportation services? We use a system in the organization and send updates for display at stations.We can also send messages to mobile devices.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.

Q4	What do you think are the challenges of providing real-time information for commuters? The system sometimes go down so network problems must be fixed	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q5	How do you think real-time information can be made available for public commuters? It is easier for the passengers if they can use their phones to access information through mobile applications.	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q6	How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles) We show the information at the station.	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q7	Do you make use of any technology to send out information to commuters? If not WHY? If yes, How is this done? Yes,Website and company system.	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q8	What are your suggestions on how to improve the provision of traveler information to commuters by your organization? We need a system that is faster and more reliable,improve the existing systems and ensure that the people actually use them the way they were built to be used.	**Objective 2:** To determine the available public commuting information channels in South Africa.

Q9	What type of information is provided to commuters? • Train schedules • Trains arriving late	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q10	What do you think are the preferred travel information needs of commuters? • Incidents and delays • Fare changes • Delay durations	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q11	Do you think there is merit in sharing real-time travel/commuting information with other transport agencies? It can be helpful for service delivery as transport agencies but privacy can be a big issue and extra security measures need to be put in place to protect confidential customer data between agencies.	**Objective 4:** To determine the available public commuting information channels in South Africa.
Q12	How will you describe the benefits of an integrated traveler information system for commuters? The public transport system will be more efficient and relaible	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q13	Considering the current transportation system in CT, How well will an integrated real-time system work? There needs to be understanding from the various stakeholders to reduce tension caused by competition.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q14	What are the desirable features you think the system will need to provide for commuters and operators?	**Objective 4:** To identify design requirements for an integrated

	• Customer reviews • e-payments • route tracking • Vehicle location. • Fleet management.	real-time information system for public commuting in South Africa.
Q15	What are the challenges such a system might encounter in the current climate? There might be violence due to increased competition other agencies may feel an unfair advantage is given to others.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

SEMI-STRUCTURED INTERVIEW 5

Date of Interview: 14 May 2021

Name of Interviewee: Respondent (R5)

Time: 15h30

	Interview Questions	
IQ1	Can you provide an overview of the public transportation system in Cape Town? The Cape Town public transport system needs a plan to help address the traffic situation during peak hours	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
IQ2	What is your knowledge of real-time information? I know its information that is sent out in a faster manner and periodically than normal information	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q3	How do you provide information for commuters using public transportation services?	**Objective 1:** To understand the problems associated with real-time

	We have a feature on our website that helps people find information about bus schedules and also post updates on our social media platforms	decision making on alternative modes and routes of public commuting in South Africa.
Q4	What do you think are the challenges of providing real-time information for commuters? The passeengers must also have the proper devices to consume such information otherwise the system will be of no value	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q5	How do you think real-time information can be made available for public commuters? In manner which will allow everyone to access it like display at bus terminals	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q6	How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles) We provide commuters with schedule information on our webiste and updates are posted to the Moovit app	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q7	Do you make use of any technology to send out information to commuters? If not WHY? If yes, How is this done? Yes,We only make use of technology rather than prinout outs,infroamtion is sent to webpages and applications	**Objective 2:** To determine the available public commuting information channels in South Africa.

Q8	What are your suggestions on how to improve the provision of traveler information to commuters by your organization? Perhaps also have an internal application tailored for our orgnization as moovit is a third party platform that we use	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q9	What type of information is provided to commuters? • Directions • Routes •Fare	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q10	What do you think are the preferred travel information needs of commuters? Commuters would generally want to know if the bus will arrive on time and when the next one is coming.	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q11	Do you think there is merit in sharing real-time travel/commuting information with other transport agencies? It's a good idea,each party must know their role	**Objective 4:** To determine the available public commuting information channels in South Africa.
Q12	How will you describe the benefits of an integrated traveler information system for commuters? It can help reduce the number of private cars in the city as more people will have confidence in an effeient modernised system	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

Q13	Considering the current transportation system in CT, How well will an integrated real-time system work? Could be successful,But this depends on who will be laiuble for the administration and management of the system	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q14	What are the desirable features you think the system will need to provide for commuters and operators? •Arrive time estimates • Card payments • Reports on incidents	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q15	What are the challenges such a system might encounter in the current climate? There could be tension between the different operators,particulary the taxi industry	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

SEMI-STRUCTURED INTERVIEW 6

Date of Interview: 7 June 2021

Name of Interviewee: Respondent (R6)

Time: 15h00

	Interview Questions	
IQ1	Can you provide an overview of the public transportation system in Cape Town? Public transprot in the Coct plays a crucial role in transporting people without private veheciles,it also an alternative for those who are saving costs and don't want to worry about parking	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.

IQ2	What is your knowledge of real-time information? Not aware	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q3	How do you provide information for commuters using public transportation services? Commuters can find travel information on our website,we provide route and timetables	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q4	What do you think are the challenges of providing real-time information for commuters? In general, we have challenges providing information as passanegrs wanna access it in different ways	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q5	How do you think real-time information can be made available for public commuters? Mobile is always the most convient way to send them information	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q6	How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles) The commuters can search the compnay website	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q7	Do you make use of any technology to send out information to commuters? If not WHY? If yes, How is this done?	**Objective 2:** To determine the available public commuting information channels in South Africa.

	Yes,We have a web based tool and use an external Mobile app service called Moovit	
Q8	What are your suggestions on how to improve the provision of traveler information to commuters by your organization? Find out how the commuters would like receive the information and cater based on their needs.	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q9	What type of information is provided to commuters? •Available Lines • Distance between routes • Time Schedules	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q10	What do you think are the preferred travel information needs of commuters? The commuters generally are concered with time and delay issues and occasionaly notified when fare increases.	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q11	Do you think there is merit in sharing real-time travel/commuting information with other transport agencies? To an extent,However change needs to be managaed effectively to ensure all parties can work in cohesion	**Objective 4:** To determine the available public commuting information channels in South Africa.
Q12	How will you describe the benefits of an integrated traveler information system for commuters?	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

	Commuters will be able to decide early where to take transport and when a vehicle will be arriving late.	
Q13	Considering the current transportation system in CT, How well will an integrated real-time system work? Proper infrastructure investments should be implemented to make this work in the current transportation system	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q14	What are the desirable features you think the system will need to provide for commuters and operators? Electronic payments to reduce the risk due to crime and notifications about nearby transport services	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q15	What are the challenges such a system might encounter in the current climate? it will require the stakeholders involved to standardized their process	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

SEMI-STRUCTURED INTERVIEW 7

Date of Interview: 2 July 2021

Name of Interviewee: Respondent (R7)

Time: 18h00

	Interview Questions	
IQ1	Can you provide an overview of the public transportation system in Cape Town?	**Objective 1:** To understand the problems associated with real-time decision making on alternative

	The public transport system is experiences a lot of challenges including violence and traffic related issues	modes and routes of public commuting in South Africa.
IQ2	What is your knowledge of real-time information? Real-time information is useful for supporting commuters when making decision	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q3	How do you provide information for commuters using public transportation services? Information is provided thriugh various platforms wuch as stations and the MyCiti mobile app	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q4	What do you think are the challenges of providing real-time information for commuters? Taking into the different backgrounds of commuters in order to make diverse measures for all to access the information	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q5	How do you think real-time information can be made available for public commuters? We do provide real-time informatioin for our coummuters at stations	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q6	How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles) Websites and using mobile	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q7	Do you make use of any technology to send out information to commuters? If not WHY?	**Objective 2:** To determine the available public commuting information channels in South Africa.

	If yes, How is this done? Yes,Mobile and digital screens at stops	
Q8	What are your suggestions on how to improve the provision of traveler information to commuters by your organization? We are very technology driven as a BRT service,I wouldn't say there is much room to improve from how we already operate.	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q9	What type of information is provided to commuters? • Timetables • Routes • Stops • Stations	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q10	What do you think are the preferred travel information needs of commuters? The commuter expect a regular feed of information relating to the next scheduled bus.	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q11	Do you think there is merit in sharing real-time travel/commuting information with other transport agencies? It will certainly make it convient for the commuters in terms universal access to information	**Objective 4:** To determine the available public commuting information channels in South Africa.
Q12	How will you describe the benefits of an integrated traveler information system for commuters?	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

	This will assist with traffic congestion as commuters will have diverse options	
Q13	Considering the current transportation system in CT, How well will an integrated real-time system work? There needs to be proper endorsmnet from all stakeholders to avoid conflicts	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q14	What are the desirable features you think the system will need to provide for commuters and operators? • Integrated payments • Driver review • Passenger feedback	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q15	What are the challenges such a system might encounter in the current climate? The training may need to be provided to users and administrators so as to use the system effieciently	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

SEMI-STRUCTURED INTERVIEW 8

Date of Interview: 18 July 2021

Name of Interviewee: Respondent (R8)

Time: 15h00

	Interview Questions	
IQ1	Can you provide an overview of the public transportation system in Cape Town?	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.

	The public transport system mainly caters for low to middle income users but can sometimes be unreliable specially during strikes	
IQ2	What is your knowledge of real-time information? Its information that is used when travelling	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q3	How do you provide information for commuters using public transportation services? Through digital platforms	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q4	What do you think are the challenges of providing real-time information for commuters? The data needs to be constantly kept up to date	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q5	How do you think real-time information can be made available for public commuters? Mobile devices is the best way	**Objective 1:** To understand the problems associated with real-time decision making on alternative modes and routes of public commuting in South Africa.
Q6	How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles) We have a myciti web tool and appliation	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q7	Do you make use of any technology to send out information to commuters? If not WHY?	**Objective 2:** To determine the available public commuting information channels in South Africa.

	If yes, How is this done? Yes,we dislay information at stations and printout maps	
Q8	What are your suggestions on how to improve the provision of traveler information to commuters by your organization? Provide the community with acess to data or WIFI in public	**Objective 2:** To determine the available public commuting information channels in South Africa.
Q9	What type of information is provided to commuters? •Fare costs	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q10	What do you think are the preferred travel information needs of commuters? Being able to find stations and calculate estimate wait times	**Objective 3:** To determine the real-time information required for public commuting in South Africa.
Q11	Do you think there is merit in sharing real-time travel/commuting information with other transport agencies? Depends on what the other parties plan to do with the information,could be privacy concerns	**Objective 4:** To determine the available public commuting information channels in South Africa.
Q12	How will you describe the benefits of an integrated traveler information system for commuters? improved security and safety for passengers and drivers	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q13	Considering the current transportation system in CT, How well will an integrated real-time system work?	**Objective 4:** To identify design requirements for an integrated

	Customer satisfaction will be better as the service quality will be improved	real-time information system for public commuting in South Africa.
Q14	What are the desirable features you think the system will need to provide for commuters and operators? • CCTV • SMS Notifications • Seat reservation • Toll free access • Vehicle tracking	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.
Q15	What are the challenges such a system might encounter in the current climate? There needs to be equal revenue sharing strategy between the different agencies.	**Objective 4:** To identify design requirements for an integrated real-time information system for public commuting in South Africa.

Appendix E: Data Work Sheets

E1: Co-design Data sheets:

	A	B	C	D	E	F
1	**Participant**	**Question Code**	**Comments**	**Code**	**Category**	**Theme**
2	**RSQ 1**		**What are the challenges affecting the provision of real-time information for public commuting decision making in South Africa?**			
3						
4	CD 1.1		How would you describe the state of public transportation in South Africa today?			
5	P1	A1	Well I would say the state of transport system is good at some time and terrible at another simply because they fight themselves for stupid thinds causing passengers to be late. There is no security you can get robbed in the bus,jelously amongst self	•Unrelaible •Unsafe •Not punctual	**Challenges of public transport**	Public transportation in South Africa
6	P2	A1	The public transprot system has a positibe side and a negatie side,drivers treat people with respect but not all. negaitive side is that it is not safe for passengers in taxis and buses.	•Unsafe •Inconsistent	**Challenges of public transport**	Public transportation in South Africa
7	P3	A1	Fully functional, it works for me	Functional	**Challenges of public transport**	Public transportation in South Africa
8	P4	A1	Not Safe	Unsafe	**Challenges of public transport**	Public transportation in South Africa
9	P5	A1	Public transport is very unreliable at times for example, a taxi does not take you to your destination at your desired time.	•Unreliable •Not punctual	**Challenges of public transport**	Public transportation in South Africa
10	P6	A1	Using public transport in South Africa is a struggle as there is little maintained.	Lack of maintainace.	**Challenges of public transport**	Public transportation in South Africa
11	P7	A1	Can be unfeasible	unreliable	**Challenges of public transport**	Public transportation in South Africa
12	P8	A1	Bad customer service	Lack of support	**Challenges of public transport**	Public transportation in South Africa
13	P9	A1	Lacks security to keep us safe during peak	Unsafe	**Challenges of public transport**	Public transportation in South Africa
14	P10	A1	Sometimes can let you down when you in a hurry	Unreliable	**Challenges of public transport**	Public transportation in South Africa
15						
16	CD 1.2		In what situation or encounter can you recall where you most needed travel information on public transport service?			
17	P1	A2	There was a time when taxis were on strike and I needed to know if I should request an uber.	During Strike	Real-time decision making	Public transportation in South Africa
18	P2	A2	When I was going to write an exam but the taxi took too long to get to the taxi rank whereas I woke up on time	Going to school	Real-time decision making	Public transportation in South Africa
19	P3	A2	When I got lost trying to get to cape town campus at Bellville	Going to school	Real-time decision making	Public transportation in South Africa
20	P4	A2	The time My CITI buses were unavailable as its my primary mode of transport	Alternative option required	Real-time decision making	Public transportation in South Africa
21	P5	A2	There was a time when I had to wait 30 minutes fir a bus as I did not make it in time for the previous one that had already left and this made me late for class therefore I had to end up taking a taxi.	•Alternative option required •Going to school	Real-time decision making	Public transportation in South Africa
22	P6	A2	When I was leaving campus late and the taxis to my area were finish	•Alternative option required •Returning home	Real-time decision making	Public transportation in South Africa
23	P7	A2	Woke up late for work and needed the fastest mode of transport to work	•Going to work •fastest mode of transport	Real-time decision making	Public transportation in South Africa
24	P8	A2	Leaving work after hours and not knowing which public transport is still available	•Alternative option required •Returning home	Real-time decision making	Public transportation in South Africa
25	P9	A2	When private car would not start in the morning	Alternative option required	Real-time decision making	Public transportation in South Africa
26	P10	A2	When I got to the rank and the loading was full so I had to que and wait for the next one to finish loading.	•Alternative option required •Long waiting queue	Real-time decision making	Public transportation in South Africa
27						
28	CD 1.3		In your opinion, why do these challenges faced by public commuters persist?			
29	P1	A3	This is because the owners are selfish and think for themselves only, trains who ever is in charge does not want to upgrade nor fix them, the busses it is because they are not familiar with technology to improve the situation	•Owners neglect •lack of technology	Infrastructure challenges	Public transportation in South Africa
30	P2	A3	Still exist because the taxi managers and other translation managers do not listen to their passengers, even when there are complains about certain things they just don't list	•Lack of investment •Lack of engagement	Infrastructure challenges	Public transportation in South Africa
31	P3	A3	No challenges faced	Contended with current system	Infrastructure challenges	Public transportation in South Africa
32	P4	A3	Transport system in south Africa is plagued with too many challenges, trains have poor service and delay a lot, buses also are always affected by road accidents.	Too many social-traffic issues	Infrastructure challenges	Public transportation in South Africa
33	P5	A3	No Money	Lack of investment	Infrastructure challenges	Public transportation in South Africa
34	P6	A3	it still exists because people don't do anything about it, people in charge or responsible for challenges aren't taking matters serious enough or aren't finding solutions to prevent these challenges from happening.	•neglect •Lack of investment	Infrastructure challenges	Public transportation in South Africa
35	P7	A3	There is a lack of will from government to fix the problems	neglect	Infrastructure challenges	Public transportation in South Africa
36	P8	A3	No accountability	No accountability	Infrastructure challenges	Public transportation in South Africa
37	P9	A3	The operators need to invest into their infrastructure	Lack of investment	Infrastructure challenges	Public transportation in South Africa
38	P10	A3	The owners do not listen to the customers	Lack of engagement	Infrastructure challenges	Public transportation in South Africa
39						

	A	B	C	D	E	F
1	Participant	Question Code	Comments	Code	Category	Theme
2	RSQ 2		What are the accessible information dissemination channels for public commuting in South Africa?			
3						
4	2.1	CD 2.1	Do you currently have access to travel information on public transport services? If yes how do you access it?			
5	P1	A4	Yes,by word to mouth	word to mouth	Accessibility	Information channels
6	P2	A4	Yes we get information while taking the bus like what time the next bus will arrive at the stop	word to mouth	Accessibility	Information channels
7	P3	A4	Yes,Help desk	Help desk	Accessibility	Information channels
8	P4	A4	Yes, tajawal app and wego app	Mobile application	Accessibility	Information channels
9	P5	A4	Yes,I do have acess to travel information,the app is called Moya and Golden arrow	Mobile application	Accessibility	Information channels
10	P6	A4	Yes,I use the app for golden arrow bus and the Myciti app	Mobile application	Accessibility	Information channels
11	P7	A4	Yes,I use infromation at the station	Station	Accessibility	Information channels
12	P8	A4	The website,app for MyCiti	•Webiste • Mobile application	Accessibility	Information channels
13	P9	A4	Download the schedules from the website using phone.	Website	Accessibility	Information channels
14	P10	A4	The taxis do not issue travell infromation	No access	Accessibility	Information channels
15						
16	2.2	CD 2.2	What mode of communication will be most suitable to use for your commuting needs?			
17	P1	A5	Boards at rank with travel information or website	•Information Boards •Websites	Mode of information	Information channels
18	P2	A5	Display on poster at the rank would be good way to give out information	Information Boards	Mode of information	Information channels
19	P3	A5	In person	word to mouth	Mode of information	Information channels
20	P4	A5	Mobile app and website	•Mobile application • Website	Mode of information	Information channels
21	P5	A5	Display at station	Information Boards	Mode of information	Information channels
22	P6	A5	SMS,APP,display screen and mobile notification	•SMS •Mobile application •Information screen	Mode of information	Information channels
23	P7	A5	via mobile/SMS	•SMS •Mobile application •Information screen	Mode of information	Information channels
24	P8	A5	Through the website	Website	Mode of information	Information channels
25	P9	A5	Using email	Email	Mode of information	Information channels
26	P10	A5	At the station on boards	Information Boards	Mode of information	Information channels
27						
28	2.3	CD 2.3	Have you ever experienced any technological tools used to communicate travel information to commuters? Can you give examples of such tools?			
29	P1	A6	None	No	technology resources	Information channels
30	P2	A6	Taxis have no tools, Buses have websites and application	Yes	technology resources	Information channels
31	P3	A6	Yes, Website Mycotic	Yes	technology resources	Information channels
32	P4	A6	Yes, Websites	Yes	technology resources	Information channels
33	P5	A6	Yes, There are apps that are used like Moya which I se for buses	Yes	technology resources	Information channels
34	P6	A6	Yes, Notifications from an application	Yes	technology resources	Information channels
35	P7	A6	Just information on screens	No	technology resources	Information channels
36	P8	A6	Yes, Only for MyCiti there is an app	Yes	technology resources	Information channels
37	P9	A6	I'm not aware of any	No	technology resources	Information channels
38	P10	A6	None	No	technology resources	Information channels
39					technology resources	Information channels
40	2.4	CD 2.4	Have you experienced any challenges while using such a system?			
41	P1	A7	For golden arrow there is a website but it is not working	Not functional	Systems maintance	Information channels
42	P2	A7	The problem I have is that the website is not always working or providing updated information	Outdated	Systems maintance	Information channels
43	P3	A7	No	Functional	Systems maintance	Information channels
44	P4	A7	Website is not working	Not functional	Systems maintance	Information channels
45	P5	A7	The golden arrow bus website does not work	Not functional	Systems maintance	Information channels
46	P6	A7	The website is there but is not currently working.	Not functional	Systems maintance	Information channels
47	P7	A7	No	Not applicable	Systems maintance	Information channels
48	P8	A7	The My Citi app works	Functional	Systems maintance	Information channels
49	P9	A7	Not applicable	Not applicable	Systems maintance	Information channels
50	P10	A7	No	Not applicable	Systems maintance	Information channels
51						

	A	B	C	D	E	F
1	**Participant**	**Question Code**	**Comments**	**Code**	**Category**	**Theme**
2	**RSQ 3**		**What are the real-time information needs of public transport commuters in South Africa?**			
3						
4	CD 3.1		What are the specific types of travel information you like to receive?			
5	P1	A8	I would like to know about traffic jams, Accidents on route, is the transport available and time its leaving.	•Traffic congestion •Accidents •Departure time	Traveller information	Information needs
6	P2	A8	For drivers to let us know about strikes when they are running late, when there is a problem with the vehicle when there is an accident or traffic on route	Strikes Delays Traffic congestion	Traveller information	Information needs
7	P3	A8	Relevant	Other	Traveller information	Information needs
8	P4	A8	Bus must be clean Not overcrowded Must have aircon	•Other •Overcrowding	Traveller information	Information needs
9	P5	A8	Time schedules Future strikes Prices and fares Amount of Passengers The route it taken Distance between pick up destination points	•Schedules •Strikes •Fares •Amount passengers •Alternative routes •Distance between stops	Traveller information	Information needs
10	P6	A8	The number of people on a vehicle Notification on strike Time that will be points for free rides New services Loyalty	•Amount of passengers •Strikes •Other	Traveller information	Information needs
11	P7	A8	Traffic congestion Time of arrive at destination Reports on delays	•Traffic congestion •Arrive time •Delays	Traveller information	Information needs
12	P8	A8	Amount of people at station estimated time at trip Available modes	Amount of passengers Estimated trip time Alternative modes	Traveller information	Information needs
13	P9	A8	Crime in area Traffic reports Accident in routes	•Safety •Traffic congestion •Accidents	Traveller information	Information needs
14	P10	A8	I would like to know how many people are in the transport And if the transport will be late Other transport in area	•Amount of passengers •Delays •Alternative modes	Traveller information	Information needs
15						
16	CD 3.2		In what way will the provision of real-time travel information affect your commuting activities?			
17	P1	A9	It would improve because the driver would know if there is a traffic jam or strike and take an alternate route to be earlier at the destination.	Alternative decision	Real-time decision making	Public transportation in South Africa
18	P2	A9	The information will help in many ways, the passengers will be kept up to date on what's happening and if there is traffic we are able to notify our lectures that we are running late because of a traffic jam or accident.	•Realtime update; •Quick notification	Real-time decision making	Public transportation in South Africa
19	P3	A9	Improve the travelling	Improved commuting experience	Real-time decision making	Public transportation in South Africa
20	P4	A9	Id stop using private car	Improved trust in system	Real-time decision making	Public transportation in South Africa
21	P5	A9	Safe travelling as a passenger and more trust in the transport service	•enhance Safety; •Trust in system	Real-time decision making	Public transportation in South Africa
22	P6	A9	It would improve because I would be on time and id know to bring more money and where to get off.	Improved decision making	Real-time decision making	Public transportation in South Africa
23	P7	A9	Improve decisions made and the system will be more transparent	•Improved decision making; •Trust in system	Real-time decision making	Public transportation in South Africa
24	P8	A9	Id stop using private car	Improved trust in system	Real-time decision making	Public transportation in South Africa
25	P9	A9	The quality of the service will be better	Improved commuting experience	Real-time decision making	Public transportation in South Africa
26	P10	A9	Drivers will be able get there fasters and Passengers will be more informed.	•Improved commuting experience: •Realtime update.	Real-time decision making	Public transportation in South Africa

28	CD 3.3		How often would like to receive this information?			
29	P1	A10	Need to be updated every 30 minutes or an Hour	60	Information frequency	Information needs
30	P2	A10	Should be updated envy 30 minutes or an hour so we remain updated	30	Information frequency	Information needs
31	P3	A10	When Necessary	1	Information frequency	Information needs
32	P4	A10	Every 1 hour and 30 minutes	60,3	Information frequency	Information needs
33	P5	A10	I would like to be updated every 30 minutes since problems are constantly forming on the roads such as traffic and	30	Information frequency	Information needs
34	P6	A10	Every 30 minutes or 1 hour time schedules	60,3	Information frequency	Information needs
35	P7	A10	Every 30 Minutes	30	Information frequency	Information needs
36	P8	A10	Very fast	1	Information frequency	Information needs
37	P9	A10	Every 1 hour intervals	60	Information frequency	Information needs
38	P10	A10	Every 1 Hour	60	Information frequency	Information needs
39				60	Information frequency	Information needs
40						
41						
42						

	A	B	C	D	E	F
1	**Participant**	**Question Code**	**Comments**	**Code**	**Category**	**Theme**
2	**RSQ 4**		**What are the design requirements for an integrated real-time information system for public commuting in South Africa?**			
3						
4	CD 4.1		What is your understanding of integrated real-time information systems for public commuting? How do you think this will benefit commuters?			
5	P1	A11	There are integrated sources of information for common decisions that would work for passengers	Multiple sources	Information sharing	Integrated real-time information system
6	P2	A11	They are able to work together to create a better transport system	Colloborative platform	Information sharing	Integrated real-time information system
7	P3	A11	Coming from different sources	Multiple sources	Information sharing	Integrated real-time information system
8	P4	A11	The integration is good for people to work in teams	Colloborative platform	Information sharing	Integrated real-time information system
9	P5	A11	Integrated is basically sub-systems brought together into one whole system like buses trains and taxis for various ways to travel	Colloborative platform	Information sharing	Integrated real-time information system
10	P6	A11	No, I don't understand the system that they use	No knowledge	Information sharing	Integrated real-time information system
11	P7	A11	Integration is things that work together	Colloborative platform	Information sharing	Integrated real-time information system
12	P8	A11	Merging things into one system like train, bus and taxi	Colloborative platform	Information sharing	Integrated real-time information system
13	P9	A11	I don't understand fully	No knowledge	Information sharing	Integrated real-time information system
14	P10	A11	The transport system will operate better as one	Colloborative platform	Information sharing	Integrated real-time information system
15						
16	CD 4.2		What type of information about each mode of transport system would you specifically want to be made available to commuters?			
17	P1	A12	Taxi- accident reports and traffic jams Bus - route and arrive time Train - alerts when its late or if it will stop		Traveller information	Information needs
18	P2	A12	Taxi- what time it will get there Bus - when its running late Train - speaker that tells you which station is next stop		Traveller information	Information needs
19	P3	A12	Train - arrive time Bus - Departure time		Traveller information	Information needs
20	P4	A12	Minibus - amount of people Taxis - is it clean MyCITI - is there aircon		Traveller information	Information needs
21	P5	A12	Bus - number of passengers Taxi - is it hygienic to travel in Trains - is it safe to travel at the time		Traveller information	Information needs
22	P6	A12	All modes - Number of passengers		Traveller information	Information needs
23	P7	A12	Bus - is it loading passengers Taxi - number of passengers Trains - reason for stopping		Traveller information	Information needs
24	P8	A12	Myciti - Delay Train -Delay Taxi - Arrive time		Traveller information	Information needs
25	P9	A12	Bus - Next stop time Train - Running late Taxi - What time it will be here		Traveller information	Information needs
26	P10	A12	Taxi - Amount of people		Traveller information	Information needs

28	CD 4.3		In what format would you like to receive this information?. What type of features would you want to see on such a system?			
29	P1	A13	USSD Go to website intercom in trains or train stations	USSD	system requirements	Integrated real-time information system
30	P2	A13	For taxis,buses and trains to announce using speaker that they will be arriving at certain station	Audio	system requirements	Integrated real-time information system
31	P3	A13	Text message and paper printouts	Text	system requirements	Integrated real-time information system
32	P4	A13	Audio in different languages	•PA system in Multilingual Languages •options	system requirements	Integrated real-time information system
33	P5	A13	I would like to receive Text message	Text	system requirements	Integrated real-time information system
34	P6	A13	Text message Audio Notifications App USSD	Text, Audio	system requirements	Integrated real-time information system
35	P7	A13	SMS APP	Text	system requirements	Integrated real-time information system
36	P8	A13	Text Voice Speakers	Audio, Text	system requirements	Integrated real-time information system
37	P9	A13	Screens at station Text App	Text	system requirements	Integrated real-time information system
38	P10	A13	I would like an SMS to my phone	Text	system requirements	Integrated real-time information system

E2: Interview Data sheets:

	A	B	C	D	E	F
1	Participant		Comments	Code	Category	Theme
2	RSQ 1		What are the challenges affecting the provision of real-time information for public commuting decision making in South Africa?			
3						
4	IQ 1.1		Can you provide an overview of the public transportation system in Cape Town?			
5	R1	Answer:	The public transport system in cape town is faced with a few challenges since its combines government transport and privately owned transport like taxis, the government-owned transport is given an advantage over taxis	unfair competitiion between prvt and public Conflict between stakeholders	Challenges of public transport	Public transportation in South Africa
6	R2	Answer:	I wouldn't say it at its best, there is room for improvement	Not good,Room for improvement	Challenges of public transport	Public transportation in South Africa
7	R3	Answer:	It's decreasing in terms of effectiveness and becoming less preferred. The public transport system infrastructure is also a mess.	inffective system, undersireable option, Poor Infrastucture	Challenges of public transport	Public transportation in South Africa
8	R4	Answer:	The transport system in Cape Town is dysfunctional with a lot of overcrowding and also lacks safety.	Unsafe,, overcrowded Dysfucntional system	Challenges of public transport	Public transportation in South Africa
9	R5	Answer:	The Cape Town public transport system needs a plan to help address the traffic situation during peak hours	Requires improvement plan	Challenges of public transport	Public transportation in South Africa
10	R6	Answer:	Public transprot in the Coct plays a crucial role in transporting people without private veheciles,it also an alternative for those who are saving costs and don't want to worry about parking	Provides alternative option to private Cost effective	Challenges of public transport	Public transportation in South Africa
11	R7	Answer:	The public transport system is experiences a lot of challenges including violence and traffic related issues	Violence problems ,Traffic issues	Challenges of public transport	Public transportation in South Africa
12	R8	Answer:	The public transport system mainly caters for low to middle income users but can sometimes be unreliable specially during strikes	Unreliable Cost effective	Challenges of public transport	Public transportation in South Africa
13						
14	IQ 1.2		What is your knowledge of real-time information?			
15	R1	Answer:	Real-time information can be used however a study needs to be conducted on how we can reduce the number of vehicle	Partial knowledge	Knowledge of Real-time	Public transportation in South Africa
16	R2	Answer:	Not full knowledge	No knowledge	Knowledge of Real-time	Public transportation in South Africa
17	R3	Answer:	I understand that its information is received with fewer delays.Can help to better communicate with passengers in a timely manner specially regarding a delay.	Information on demand travel information	Knowledge of Real-time	Public transportation in South Africa
18	R4	Answer:	I don't know what real-time information is.	No knowledge	Knowledge of Real-time	Public transportation in South Africa
19	R5	Answer:	I know its information that is sent out in a faster manner and periodically than normal information	Information on demand	Knowledge of Real-time	Public transportation in South Africa
20	R6	Answer:	Not aware	No knowledge	Knowledge of Real-time	Public transportation in South Africa
21	R7	Answer:	Real-time information is useful for supporting commuters when making decisions	Supports decision making Travel information	Knowledge of Real-time	Public transportation in South Africa
22	R8	Answer:	Its information that is used when travelling	Travel information	Knowledge of Real-time	Public transportation in South Africa
23						
24	IQ 1.3		How do you provide information for commuters using public transportation services?			
25	R1	Answer:	We provide information to commuters through printouts that are displayed inside the taxi, Information about fare increases.	Printouts,fare increases	Information sources	Information channels
26	R2	Answer:	We do provide information in the form of word to mouth. and some sort of advertising by the taxi rank, offices and in vehicles.	Verbal and print	Information sources	Information channels
27	R3	Answer:	We have an SMS system that notifies people when there are delays. And display screens at main stations like the Cape Town station	SMS and display	Information sources	Information channels
28	R4	Answer:	We use a system in the organization and send updates for display at stations.We can also send messages to mobile devices.	System and SMS	Information sources	Information channels
29	R5	Answer:	We have a feature on our website that helps people find information about bus schedules and also post updates on our social media platforms	Website	Information sources	Information channels
30	R6	Answer:	Commuters can find travel information on our website,we provide route and timetables	Website	Information sources	Information channels
31	R7	Answer:	Information is provided thriugh various platforms wuch as stations and the MyCiti mobile app	Mobile app and other	Information sources	Information channels
32	R8	Answer:	Through digital platforms	Multiple platforms	Information sources	Information channels

	A	B	C	D	E	F
34	IQ 1.4		**What do you think are the challenges of providing real-time information for commuters?**		challenges of real-time information	Public transportation in South Africa
35	R1	Answer:	There need to be more resources and how will the information be sourced since each association has its own financing model.	lack of standards	challenges of real-time information	Public transportation in South Africa
36	R2	Answer:	Most of our customers don't have access to the technology to get the information, at the moment we are doing it the best we know.	No access to technology	challenges of real-time information	Public transportation in South Africa
37	R3	Answer:	Lack of human intervention has caused the system to be outdated in terms of information updates.	Lack of management, outdated system	challenges of real-time information	Public transportation in South Africa
38	R4	Answer:	The system sometimes go down so network problems must be fixed	Connectivity issues	challenges of real-time information	Public transportation in South Africa
39	R5	Answer:	The passeengers must also have the proper devices to consume such information otherwise the system will be of no value	compatibility of device	challenges of real-time information	Public transportation in South Africa
40	R6	Answer:	In general, we have challenges providing information as passanegrs wanna access it in different ways	providing information on mutiple plaforms	challenges of real-time information	Public transportation in South Africa
41	R7	Answer:	Taking into the different backgrounds of commuters in order to make diverse measures for all to access the information	Lack of standards	challenges of real-time information	Public transportation in South Africa
42	R8	Answer:	The data needs to be constantly kept up to date	updating data	challenges of real-time information	Public transportation in South Africa
43						
44	IQ 1.5		**How do you think real-time information can be made available for public commuters?**			
45	R1	Answer:	Since we living in a digital age, we need workshops and training for drivers to send out information more digitally, speakers in vehicles can be used to disseminate information.	Digitally and Speakers	Mode of information	Information channels
46	R2	Answer:	The best way is to use technology but it has disadvantages because not everyone can use it.	Digitally	Mode of information	Information channels
47	R3	Answer:	Since we support low-income individuals, SMS is still the preferred method but it needs to be improved to provide current information.	SMS notifications	Mode of information	Information channels
48	R4	Answer:	It is easier for the passengers if they can use their phones to access information through mobile applications.	Mobile phones	Mode of information	Information channels
49	R5	Answer:	In manner which will allow everyone to access it like display at bus terminals	Display screen	Mode of information	Information channels
50	R6	Answer:	Mobile is always the most convient way to send them information	Mobile phones	Mode of information	Information channels
51	R7	Answer:	We do provide real-time informatioin for our coummuters at stations	Display screens	Mode of information	Information channels
52	R8	Answer:	Mobile devices is the best way	Mobile phones	Mode of information	Information channels

	A	B	C	D	E	F
1	Participant		Comments	Code	Category	Theme
2						
3	RSQ 2		What are the accessible information dissemination channels for public commuting in South Africa?			
4						
5	IQ 2.1		How do you provide commuters with necessary travel information? (Routes, timelines, available vehicles) ?			
6	R1	Answer:	Through display printouts at the rank.	Printouts	technology resources	Information channels
7	R2	Answer:	Verbally	Verbal	technology resources	Information channels
8	R3	Answer:	Printouts and digital screens.Employees keep updating the system manually.	Prinouts Display screen	technology resources	Information channels
9	R4	Answer:	We show the information at the station.	Display screen	technology resources	Information channels
10	R5	Answer:	We provide commuters with schedule information on our webiste and updates are posted to the Moovit app	Website Mobile application	technology resources	Information channels
11	R6	Answer:	The commuters can search the compnay website	Website	technology resources	Information channels
12	R7	Answer:	Websites and using mobile	Website Mobile application	technology resources	Information channels
13	R8	Answer:	We have a myciti web tool and appliation	Website Mobile application	technology resources	Information channels
14	IQ 2.2		Do you make use of any technology to send out information to commuters? If not WHY? If yes, How is this done?			
15	R1	Answer:	At the moment there is no technology. the industry is led by individuals who are not united and when innovations get presented everyone wants to know how they will gain.	Lack of technology resources Lack of innovation	technology resources	Information channels
16	R2	Answer:	No, there is a lack of technology resources from taxis and commuters.	Lack of technology resources	technology resources	Information channels
17	R3	Answer:	Yes, we have an internal system	Internal system	technology resources	Information channels
18	R4	Answer:	Yes,Website and company system.	Website Internal system	technology resources	Information channels
19	R5	Answer:	Yes,We only make use of technology rather than prinout outs,infroamtion is sent to webpages and applications	Multiple technology tools	technology resources	Information channels
20	R6	Answer:	Yes,We have a web based tool and use an external Mobile app service called Moovit	Multiple technology tools	technology resources	Information channels
21	R7	Answer:	Yes,Mobile and digital screens at stops	Mobile IoT Devices/display screens	technology resources	Information channels
22	R8	Answer:	Yes,we dislay information at stations and printout maps	Mobile IoT Devices	technology resources	Information channels
23	IQ 2.3		What are your suggestions on how to improve the provision of traveler information to commuters by your organization?			
24	R1	Answer:	Use IT resources that are more efficient than manual systems	Innovative IT tools	technology resources	Information channels
25	R2	Answer:	Using a digital tool	Innovative IT tools	technology resources	Information channels
26	R3	Answer:	Invest in newer systems that are not legacy to improve the effectiveness of information distribution.	Innovative IT tools; Improve information distribution;	Systems upgrade	Information channels
27	R4	Answer:	We need a system that is faster and more reliable,improve the existing systems and ensure that the people actually use them the way they were built to be used.	Faster and reliable systems; Improve information system; Promote awareness of information usage	Systems upgrade	Information channels
28	R5	Answer:	Perhaps also have an internal application tailored for our orgnization as moovit is a third party platform that we use	Customized information platform	Systems upgrade	Information channels
29	R6	Answer:	Find out how the commuters would like receive the information and cater based on their needs.	Identify information needs	Systems upgrade	Information channels
30	R7	Answer:	We are very technology driven as a BRT service,I wouldn't say there is much room to improve from how we already operate.	Effective technology use	technology resources	Information channels
31	R8	Answer:	Provide the community with acess to data or WIFI in public	Access to internet and connectivity	technology resources	Information channels

RQ1 | RQ2 | RQ3 | RQ4 | General

	Participant		Comments	Code	Category	Theme
2						
3	RSQ 3		What are the real-time information needs of public transport commuters in South Africa?			
4						
5	IQ 3.1		What type of information is provided to commuters?			
6	R1	Answer:	Information regarding changes in routes and fare amount.	information on services	Traveller information	Information needs
7	R2	Answer:	Fare amounts and location of ranks.	information on services	Traveller information	Information needs
8	R3	Answer:	•Timetables •Fare increases	information on services	Traveller information	Information needs
9	R4	Answer:	•Train schedules •Trains arriving late	information on services	Traveller information	Information needs
10	R5	Answer:	• Directions • Routes •Fare	information on services	Traveller information	Information needs
11	R6	Answer:	•Available Lines • Distance between routes • Time Schedules	information on services	Traveller information	Information needs
12	R7	Answer:	• Timetables • Routes • Stops • Stations	information on services	Traveller information	Information needs
13	R8	Answer:	•Fare costs	information on services	Traveller information	Information needs
14	IQ 3.2		What do you think are the preferred travel information needs of commuters?			
15	R1	Answer:	Commuters have different working hours so most of the questions are will the taxis be available after hours.	Available vehicles	Traveller information	Information needs
16	R2	Answer:	Vehicle information and driver information in the event where there are problems and can be reported swiftly.	Vehicle information; Driver information	Traveller information	Information needs
17	R3	Answer:	•Delays •Time schedules	Incidents and delays Scheduling	Traveller information	Information needs
18	R4	Answer:	•Incidents and delays •Fare changes •Delay durations	Incidents and delays; Fare changes	Traveller information	Information needs
19	R5	Answer:	Commuters would generally want to know if the bus will arrive on time and when the next one is coming.	Scheduling; Available vehicle	Traveller information	Information needs
20	R6	Answer:	The commuters generally are concered with time and delay issues and occasionaly notified when fare increases.	Incidents and delays fare changes	Traveller information	Information needs
21	R7	Answer:	The commuter expect a regular feed of information relating to the next scheduled bus.	Scheduling	Traveller information	Information needs
22	R8	Answer:	Being able to find stations and calculate estimate wait times	Navigation; Scheduling	Traveller information	Information needs
23						

	A	B	C	D	E	F
1	**Participant**		**Comments**	**Code**	**Category**	**Theme**
2						
3	**RSQ 4**		**What are the design requirements for an integrated real-time information system for public commuting in South Africa?**			
4						
5	**IQ 4.1**		**Do you think there is merit in sharing real-time travel information with other transport agencies?**			
6	R1	Answer:	In terms of sharing information it depends, taxis currently are leading in commuters numbers so this new system of sharing can put the competitors at an advantage of taking passengers	Increased competition for customers	**Information sharing**	Integrated real-time information system
7	R2	Answer:	To be honest, the public will benefit but for us, it can work against us because the person can choose other modes instead of using the taxi.	Availability of alternative modes	**Information sharing**	Integrated real-time information system
8	R3	Answer:	Since they are in competition it may not be a wise idea from the transport organizations point of view.it can give other stakeholders an upper hand	Increased competition for customers	**Information sharing**	Integrated real-time information system
9	R4	Answer:	It can be helpful for service delivery as transport agencies but privacy can be a big issue and extra security measures need to be put in place to protect confidential customer data between agencies.	Improves service delivery; Need to address privacy concerns	**Data Privacy; Information benefit**	Integrated real-time information system
10	R5	Answer:	It's a good idea,each party must know their role	requires adeqate knowledge	**Information sharing**	Integrated real-time information system
11	R6	Answer:	To an extent,However change needs to be managaed effectively to ensure all parties can work in cohesion	Needs Proper Management	**Information sharing**	Integrated real-time information system
12	R7	Answer:	It will certainly make it convient for the commuters in terms universal access to information	Convenience for commuters; information accessibility	**Information sharing**	Integrated real-time information system
13	R8	Answer:	Depends on what the other parties plan to do with the information,could be privacy concerns	Need to address privacy concerns	**Data Privacy**	Integrated real-time information system
14						
15	**IQ 4.2**		**How will you describe the benefits of an integrated traveler information system for commuters?**			
16	R1	Answer:	The commuters will gain from having multiple options to choose from.	Multiple options	**Integrated system**	Integrated real-time information system
17	R2	Answer:	It can bring a lot of safety and make things much faster for example if it was an app there will be able to find most routes and make decisions.	Multiple options and improved Safety; informed decision making	**Integrated system**	Integrated real-time information system
18	R3	Answer:	People will be better informed about alternative modes of transport.	Multiple options	**Integrated system**	Integrated real-time information system
19	R4	Answer:	The public transport system will be more efficient and relaible	improved efficency and reliability	**Integrated system**	Integrated real-time information system
20	R5	Answer:	It can help reduce the number of private cars in the city as more people will have confidence in an effeient modernised system	improved efficency and reliability; enhances confidence in system; Reduces volume of traffic	**Integrated system**	Integrated real-time information system
21	R6	Answer:	Commuters will be able to decide early where to take transport and when a vehicle will be arriving late.	Multiple options; informed decision making	**Integrated system**	Integrated real-time information system
22	R7	Answer:	This will assist with traffic congestion as commuters will have diverse options	Multiple options; Reduces volume of traffic	**Integrated system**	Integrated real-time information system
23	R8	Answer:	improved security and safety for passengers and drivers	improved Safety and security	**Integrated system**	Integrated real-time information system
24						
25	**IQ 4.3**		**Considering the current transportation system in CT, How well will an integrated real-time system work?**			
26	R1	Answer:	This may create a platform for the government to control and formalize our current operations for their gain.	Trust issues	**Change management**	Integrated real-time information system
27	R2	Answer:	There are a lot of challenges but it will take time to trust it and get it right. It could gradually reduce the amount of conflict between owners, passengers, and drivers.	Trust issues; Reduce conflict	**Change management**	Integrated real-time information system
28	R3	Answer:	It might not be received well since people are prone to take the same modes of transport that are economically viable to them.	Economical challenges	**Change management**	Integrated real-time information system
29	R4	Answer:	There needs to be understanding from the various stakeholders to reduce tension caused by competition.	Trust issues; Possibility of conflict	**Change management**	Integrated real-time information system
30	R5	Answer:	Could be successful,But this depends on who will be laiuble for the administration and management of the system	Proper Management	**Change management**	Integrated real-time information system
31	R6	Answer:	Proper infrastructure investments should be implemented to make this work in the current transportation system	Infrastructure investment	**Change management**	Integrated real-time information system
32	R7	Answer:	There needs to be proper endorsmnet from all stakeholders to avoid conflicts	Stakeholder agreement	**Change management**	Integrated real-time information system
33	R8	Answer:	Customer satisfaction will be better as the service quality will be improved	Improved quality of service	**Change management**	Integrated real-time information system

	A	B	C	D	E	F
34						
35	**IQ 4.4**		**What desirable features should an integrated real-time information system provide for commuters and operators?**			
36		R1 Answer:	Operators can track vehicle locations and driver habits and passengers can take alternative modes. Identifying quickest routers for drivers.	Driver Management Fleet managemnt	system requirements	Integrated real-time information system
37		R2 Answer:	The operators will have more control over their drivers and the commuter will be safer.	Driver Management	system requirements	Integrated real-time information system
38		R3 Answer:	•Fee collection •Update on maintenance •Track driver habits •Track employee shifts	Driver Management E-payements Update on maintenance Fleet management	system requirements	Integrated real-time information system
39		R4 Answer:	•Customer reviews •e-payments •route tracking •Vehicle location. •Fleet management.	Customer reviews E-payements Fleet managemnt	system requirements	Integrated real-time information system
40		R5 Answer:	•Arrive time estimates • Card payments • Reports on incidents	Arrive time estimates Reports on incidents E-payements	system requirements	Integrated real-time information system
41		R6 Answer:	Electronic payments to reduce the risk due to crime and notifications about nearby transport services	E-payements	system requirements	Integrated real-time information system
42		R7 Answer:	• Integrated payments • Driver review • Passenger feedback	E-payements Customer reviews Fleet management	system requirements	Integrated real-time information system
43		R8 Answer:	• CCTV • SMS Notifications • Seat reservation • Toll free access • Vehicle tracking	CCTV SMS Notifications Seat reservation Toll-free access Fleet management	system requirements	Integrated real-time information system
44	**IQ 4.5**		**What are the challenges such a system might encounter in the current climate?**			
45		R1 Answer:	The system may cause government interference in operations and place the taxi industry at a disadvantage through increased laws and regulations. Roads and other infrastructure will need to be upgraded first and new routers must be created.	stigent laws and regulations; infrastructure	operational challenges Infrastructre challenges	Integrated real-time information system, Public transportation in South Africa
46		R2 Answer:	The most important challenge is infrastructure, there need to be improvements to the roads first.	Infrastructure	infrastructure challenges	Public transportation in South Africa
47		R3 Answer:	•People will need training •Accountability needs to be improved	training required; management	operational challenges	Integrated real-time information system
48		R4 Answer:	There might be violence due to increased competition other agencies may feel an unfair advantage is given to others.	completion conflict	operational challenges	Integrated real-time information system
49		R5 Answer:	There could be tension between the different operators,particulary the taxi industry	competion conflict	operational challenegs	Integrated real-time information system
50		R6 Answer:	it will require the stakeholders involved to standardized their process	standardization of platform/process	operational challenegs	Integrated real-time information system
51		R7 Answer:	The training may need to be provided to users and administrators so as to use the system effieciently	training required	operational challenegs	Integrated real-time information system
52		R8 Answer:	There needs to be equal revenue sharing strategy between the different agencies.	Revenue sharing model	operational challenegs	Integrated real-time information system

Appendix F: Individual letter of consent

FACULTY OF INFORMATICS AND DESIGN

Individual Consent for Research Participation

Title of the study: **Factors for the design of an integrated real-time information system for public commuting in South Africa.**

Name of researcher: Aphiwe Hlophe
Contact details: email: aphiwe24@yahoo.com.sg

Name of mentor: APRF Justine Olawande Daramola
Contact details: email: daramolaj@cput.ac.za

Name of mentor: MR Ayodeji Afolayan
Contact details: email: afolayana@cput.ac.za

Purpose of the Study: The aim of this study is to explore factors affecting the provision of real-time information for public commuters in South Africa to design an integrated real-time information system for accessing real-time information on public commuting in South Africa.

Participation: My participation will be through co-design workshops.

Confidentiality: I have received assurance from the researcher that the information I will share will remain strictly confidential unless noted below. I understand that the contents will be used only to design an integrated real-time information system for public commuting in South Africa and that my confidentiality will be protected through the use of pseudo names.

Anonymity: The subjects of this research will remain nameless, and responses will not be linked back to them. If photos or videos are used in the recording, then the participants' faces will be blanked out.

Conservation of data: The data collected will be kept securely on a password protected smartphone and then later backed up onto an encrypted folder on a desktop. The recordings will be preserved purely for audit purposes, and only the investigator will be able to decrypt the storage locations of the data.

Voluntary Participation: I am under no obligation to participate, and if I choose to participate, I can withdraw from the study at any time and/or refuse to answer any questions without suffering any negative consequences. If I choose to withdraw, all data gathered until the time of withdrawal will be destroyed.

Additional consent: I make the following stipulations (please tick as appropriate):

	In thesis	**In research publications**	**Both**	**Neither**
My image may be used:				
My name may be used:				
My exact words may be used:				
Any other (stipulate):				

Acceptance: I, (print name)_____

agree to participate in the above research study conducted by Aphiwe Hlophe of the Faculty of Informatics and Design at the Cape Peninsula University of Technology, which research is under the supervision of APRF Justine Olawande Daramola

If I have any questions about the study, I may contact the researcher or the supervisor. If I have any questions regarding the ethical conduct of this study, I may contact the secretary of the Faculty Research Ethics Committee at 021 469 1012 or email naidoove@cput.ac.za.

Participant's signature: _____ Date: _____

Researcher's signature: _____ Date: _____

Appendix G: Organizational letters of consent

prasa
PASSENGER RAIL AGENCY OF SOUTH AFRICA

Umjantshi House
30 Wolmarans Str.
BRAAMFONTEIN
2001

Private Bag X101
Braamfontein, 2107
T +2711013 1667

www.prasa.com

I Walter Thabethe in my capacity as ICT Manager at PRASA give consent in principle to allow Aphiwe Hlophe, a student at the Cape Peninsula University of Technology, to collect data in this company as part of his/her M Tech (IT) research. The student has explained to me the nature of his/her research and the nature of the data to be collected.

This consent in no way commits any individual staff member to participate in the research, and it is expected that the student will get explicit consent from any participants. I reserve the right to withdraw this permission at some future time.

In addition, the company's name may or may not be used as indicated below. (Tick as appropriate.)

	Thesis	Conference paper	Journal article	Research poster
Yes	✓			
No				

Walter Thabethe *05/05/2021*

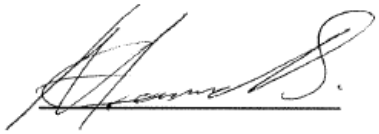
Cape Peninsula
University of Technology

I __Mogamat Essa Davids_____, in my capacity as Chief Operating Officer_____ at _Kidrogen(Pty)Ltd_____ give consent in principle to allow Aphiwe Hlophe, a student at the Cape Peninsula University of Technology, to collect data in this company as part of his/her M Tech (IT) research. The student has explained to me the nature of his/her research and the nature of the data to be collected.

This consent in no way commits any individual staff member to participate in the research, and it is expected that the student will get explicit consent from any participants. I reserve the right to withdraw this permission at some future time.

In addition, the company's name may or may not be used as indicated below. (Tick as appropriate.)

	Thesis	Conference paper	Journal article	Research poster
Yes	×			
No				



ME DAVIDS

07 October2021

since 1861

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Bus Enquiries/Busnavrae/Inkcukacha
Ngebhasi: 0800 65 64 63
Reg No. 1992/001234/07

TO WHOM IT MAY CONCERN

I F. E. Meyer, in my capacity as Chief Executive Officer at Golden Arrow Bus Services give consent in principle to allow Aphiwe Hlophe, a student at the Cape Peninsula University of Technology, to collect data in this company as part of his/her M Tech (IT) research. The student has explained to me the nature of his/her research and the nature of the data to be collected.

This consent in no way commits any individual staff member to participate in the research, and it is expected that the student will get explicit consent from any participants. I reserve the right to withdraw this permission at some future time.

In addition, the company's name may or may not be used as indicated below. (Tick as appropriate.)

	Thesis	Conference paper	Journal article	Research poster
Yes	✓			
No		X	X	X

FRANCOIS E MEYER

4 May 20201
Date

I M.Ndamase, in my capacity as Operations Manager at CODETA Taxi Ass give consent in principle to allow Aphiwe Hlophe, a student at the Cape Peninsula University of Technology, to collect data in this company as part of his/her M Tech (IT) research. The student has explained to me the nature of his/her research and the nature of the data to be collected.

This consent in no way commits any individual staff member to participate in the research, and it is expected that the student will get explicit consent from any participants. I reserve the right to withdraw this permission at some future time.

In addition, the company's name may or may not be used as indicated below. (Tick as appropriate.)

	Thesis	Conference paper	Journal article	Research poster
Yes	✓	✓	✓	✓
No				

Signature

24/08/2020

Date

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Date	: 22 October 2021
To	: Director: Policy & Strategy
Reference	: PSRR - 0347

Research Approval Request

In terms of the City of Cape Town System of Delegations (March 2019) - Part 29, No 1 Subsection 4, 5 and 6 "Research:

(4) To consider any request for the commissioning of an organizational wide research report in the City and to approve or refuse such a request.

(5) To grant authority to external parties that wish to conduct research within the City of Cape Town and/or publish the results thereof.

(6) To after consultation with the relevant Executive Director: grant permission to employees of the City of Cape Town to conduct research, surveys etc. related to their studies, within the relevant directorate

The Director: Policy & Strategy is hereby requested to consider, in terms of sub-section 5, the request received from

Name	: Aphiwe Hlophe
Designation	: Master's candidate
Affiliation	: Cape Peninsula University of Technology
Research Title	: "Factors for the design of an integrated real-time information system for public commuting in South Africa"

Taking into account the recommendations below (see Annexure for detailed review):

Recommendations

That the CCT via the Director: Policy & Strategy grants permission to Aphiwe Hlophe, in his capacity as a Master's candidate in the Faculty of Informatics and Design at Cape Peninsula University of Technology (CPUT) to conduct research subject to the following conditions:

- All National, Provincial and CCT COVID-19 pandemic response requirements are to be adhered to at all times in the implementation of the research project, including the co-design session with transport commuters;
- No face-to-face interviews to be arranged;
- The willingness and/or availability of individual CCT staff members to participate in the research study, in a voluntary capacity;
- Adherence to the scope and scale of the study, as submitted;
- A maximum of 4 officials to be interviewed in a once-off session virtually; must adhere to all regulations;
- The researcher to contact the following CCT officials who will advise on who will participate in the study:
  - Manager: Public Transports Systems, Haniefa Gaibe at Haniefa.Gaibe@capetown.gov.za ;
  - Director: Information Systems and Technology (IS&T) Directorate, Omeshnee Naidoo at Omeshnee.naidoo@capetown.gov.za .
- City officials and their inputs to be anonymised and the conditions of anonymity be adhered to in the research report;
- The use of direct quotations in the report to be verified and authorised in writing by the relevant City officials, even in cases where paraphrased, anonymised and not quoted directly ;
- Clear acknowledgement in the research report that the views of the participants is not regarded as official CCT policy;
- All City data and information used in the study to be acknowledge and correctly referenced;

Appendix H: Ethics certificate

Cape Peninsula University of Technology

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80 Roeland Street, Vredehoek, Cape Town 8001

Office of the Research Ethics Committee	Faculty of Informatics and Design

20 May 2020

Ethics approval is granted to Mr Aphiwe Hlophe, student number 217036406, for research activities related to the MTech: Information Technology at the Faculty of Informatics and Design, Cape Peninsula University of Technology (CPUT).

Title of thesis:	Factors for the design of an integrated real-time information system for public commuting in South Africa

Comments

Research activities are restricted to those detailed in the research proposal.
Data collection permission is required from the relevant organisations involved in this study.

Signed: Faculty Research Ethics Committee	20 May 2020 Date

Appendix I: Turnitin Digitial Receipt

turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Aphiwe Hlophe
Assignment title:	Final Thesis: Aphiwe Hlophe
Submission title:	Thesis chapters
File name:	217036406_Aphiwe_Hlophe_Thesis__final__edited.docx
File size:	2.81M
Page count:	193
Word count:	54,667
Character count:	313,999
Submission date:	08-Dec-2021 06:55PM (UTC+0200)
Submission ID:	1722186740

CHAPTER 1: INTRODUCTION

Gentrification and escalating property prices in the city centre have led to many living further from their workplaces, thus commuting long distances to and from work in South Africa (Tamuka Moyo et al., 2021). According to Litman (2018), public transport reduces the dependence on automobiles in dense urban areas, and it is the most cost-effective way to access transportation in urban regions. However, the South African public transportation system is clogged by numerous problems, leading to dysfunctional public commuting and inefficient transportation services. It is argued that most problems associated with the public transport system in South Africa mainly stem from lack of infrastructure development and maintenance, inaccessibility, government negligence, corruption, rising fuel prices, safety and pollution concerns, all of which have limited the potential of the system (Bronkhorst, 2019). According to a 2017 survey conducted by Statistics South Africa (StatsSA), only 34% of South African households possess a car, while 68% rely on taxis, buses, railways, and other public transportation modes (StatsSA, 2018). Despite the rolling out of infrastructure projects such as Rea Vaya and MyCiti bus rapid transports by the government to reduce overcrowding and other traffic-related social problems of public commuting, the problem continues to exacerbate (Socreta & Munoz-Raskin, 2018). The situation is such that the rapid bus transit in peak hours generate much-commuting traffic; thus, the inability to make real-time decisions on the current status and available alternative routes to take often leaves many stranded, which results in overcrowding of public transportation facilities (Tefilo et al., 2018)

The public transport system is utilised by a large percentage of a country's population globally, and commuters rely on timeous information to access available public commuting options (Friman et al., 2020). Real-time information is described as available information on-demand within a very short timeframe, in a format accessible through analytical platforms to make informed decisions (Jiang, 2019). Real-time information can be used in stock market trading to either decide on buying or selling shares; in clinical care to provide better treatment and make fast and accurate decisions on patients to promptly detect natural disasters, saving thousands of lives and resources; and in the defence forces where timely decision making can give an advantage in warfare. Access to real-time information is facilitated by using information

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