Mapping the Spaces In-between: How ICT can assist in providing a safer and more efficient commuter experience for all.

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Abstract

Contemporary societies are facing rapid growth, urbanization and migration into the form of urban cities and environments. This requires the ever-expanding need for urban infrastructures to facilitate growing populations, communities and economies within cities. A vital elements within modern urban environments is the need for different forms of urban mobility in order to facilitate the movement and flow of people, goods and communication networks.

Within the realm of urban mobility is the important aspect of public transport infrastructures as a system of creating more sustainable and equitable mobility for people within urban environments. Within cities of the global South, such as Cape Town, greater public transport systems are highly reliant on non-motorized transport (NMT) systems. This is due to issues of affordability, efficiency and spatial proximity of large portions of the population in relation to public transport facilities. Therefore, a substantial amount of urban mobility is facilitated by walking as a mode of transport.

However, public transport within Cape Town are impacted by issues of personal safety. This is most visible in the Cape Town central business district (CBD). There is a lack of knowledge, design and planning around how people move within the city, and how NMT systems are used within the greater public transport domain. Issues of personal safety become the dominant focus for NMT and human-scale mobility within the city centre. This research examines these issues in more detail.

In order to gain deeper knowledge around the experiences of NMT users within the CBD – a qualitative method of research was applied. The research used a gender-sensitive lens in order to gain an understanding as to how gender roles contribute to issues of personal safety and issues of mobility within the urban environment. The objective was to demonstrate the intersection of issues of personal safety within mobility and within space.

The research is used as a foundation for creating a mobile phone App prototype. The design is based on user-generated data to create a tool that can help commuters find the safest human-scale mobility routes within the CBD. This tool demonstrates how ICT (information and communication technology) systems can be used to create safer mobility infrastructures and networks. The prototype relies on user-generated data that creates a platform for citizens to become planners in their everyday transport navigations. Thus the research also explores how technology and user-generated data can inform planning and urban management. This resulted in a tool that enables a cyclical system that blends the knowledge of the user and planner in the co-productive design of space and mobility infrastructures.

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Acronyms and Abbreviations

NMT - Non-Motorized Transport
CBD - Central Business District
BRT - Bus Rapid Transport
IRT - Integrated Rapid Transit
SDF - Spatial Development Framework
IPTNP - Integrated Public Transport Network Plan
NHTS - National Household Travel Survey
CITP - Cape Town Integrated Transport Plan
CCID - Central City Improvement District
WIMT - Where is My Transport
ICT - Information and Communication Technologies
APP - Application
API - Application programming interface
GPS - Global Positioning System

Chapter 1: Context

1.1 Background

Urban infrastructure and urban mobility have become highly complex and essential systems within cities at global and local levels. Cities and their citizens have become highly dependent on infrastructural systems for the movement and flow of goods, people and communication networks. However, there is a deeper need for the examination and discussion around the social and mobility experiences that are present within everyday urban lives. This argument becomes manifested in the lens of the urban networks of public transport infrastructures, technology and communication infrastructures and the inter-related webs of these systems. Such urban networks are associated with social and spatial systems that influence the contemporary forms of urban 'moblities'. This deal with understanding how urban moblities are equally bound by social factors and influences of user experiences – that move beyond the physical and spatial boundaries of urban infrastructure landscapes (Da´vila, et al.2013; Graham, 2010).

Such social aspects within urban mobility have been highlighted as issues of equality of accessibility, affordability and freedom of movement. However, this study expands these social aspects to unpack accessibility and equality of mobility further. This is done within the realm of public and pedestrian safety, fears and vulnerability within urban mobility and the urban environment. Issues of human-scale mobility and non-motorized transport (NMT) are highlighted as a vital aspect in the greater public transport network and in the functions of urban mobility and contemporary urban lives (UN Habitat, 2013).

This study is entrenched in the current trends and systems visible within the City of Cape Town and the associated social, spatial and infrastructural elements present within the urban environment. The global trend of rapid urbanization is visible within Cape Town through natural population growth and in-migration. The City of Cape Town has a current total population of 3 740 025. The population growth between 1999 and 2007 was at 36, 4% and the estimate population growth per annum was 3% from 2010 (Dorrington, 2005; Cape Town Spatial Development Framework, 2012).

The global rapid urbanization trends have created positive effects for urban environments through urban-based productive economies with the intention of creating sustained positive standards of urban living. However, the other face of urbanization is that of the increase of crime, congestion and socio-economic inequalities and spatial divides.

With the increase of urbanization and the expansion of populations and communities, is the deeper and more complex need for urban support systems. These support systems include the need for more space, land, resources, technologies and infrastructures to facilitate modern society. The need for infrastructure includes that of water, waste and electricity. Furthermore the most significant infrastructural systems within this study is that of information and communication technologies (ICT) and the public transport mobilities of non motorized transport (NMT).

The need for public transport infrastructures has become paramount within urbanized environments in order to move citizen around the city to facilitate employment opportunities, increase equal accessibility to social facilities, social networks, social identities, community sharing and to create flourishing societies within the public realm (UN Habitiat, 2013; Graham 2010; Swilling, 2006).
Therefore this study is centred on the importance of NMT systems within the greater urban moblity networks and how human-scale experiences of mobility are influenced by social and spatial factors.

1.2 Public Transport in Cape Town

The City of Cape Town has a series of public transport systems within the urban landscape. These public transport systems include infrastructures such as the Metrorail and Bus Rapid Transit (BRT) systems such as the MyCiTi and Greyhound bus facilities. The city also has a highly used public transport system that is less institutionally 'formalized' in the form of mini-cab taxi and private taxi systems. Within these transport systems is the presence – however limited, of non-motorized transport (NMT) elements such as cycling and pedestrian mobility (CTSDF, 2012).

All of these public transport systems are present within the Cape Town Metropolitan area, as well as in the Cape Town Central Business District (CBD). The CBD presents a dominant presence of all these systems which are integrated within the urban environment. The transport routes and road networks that facilitate the entry into the CBD are predominantly through the south-east corridor of the city. As a result of this movement system, the CBD becomes a meeting point or mobility hub for these different modes of transport (See Figure 1 on the following page).

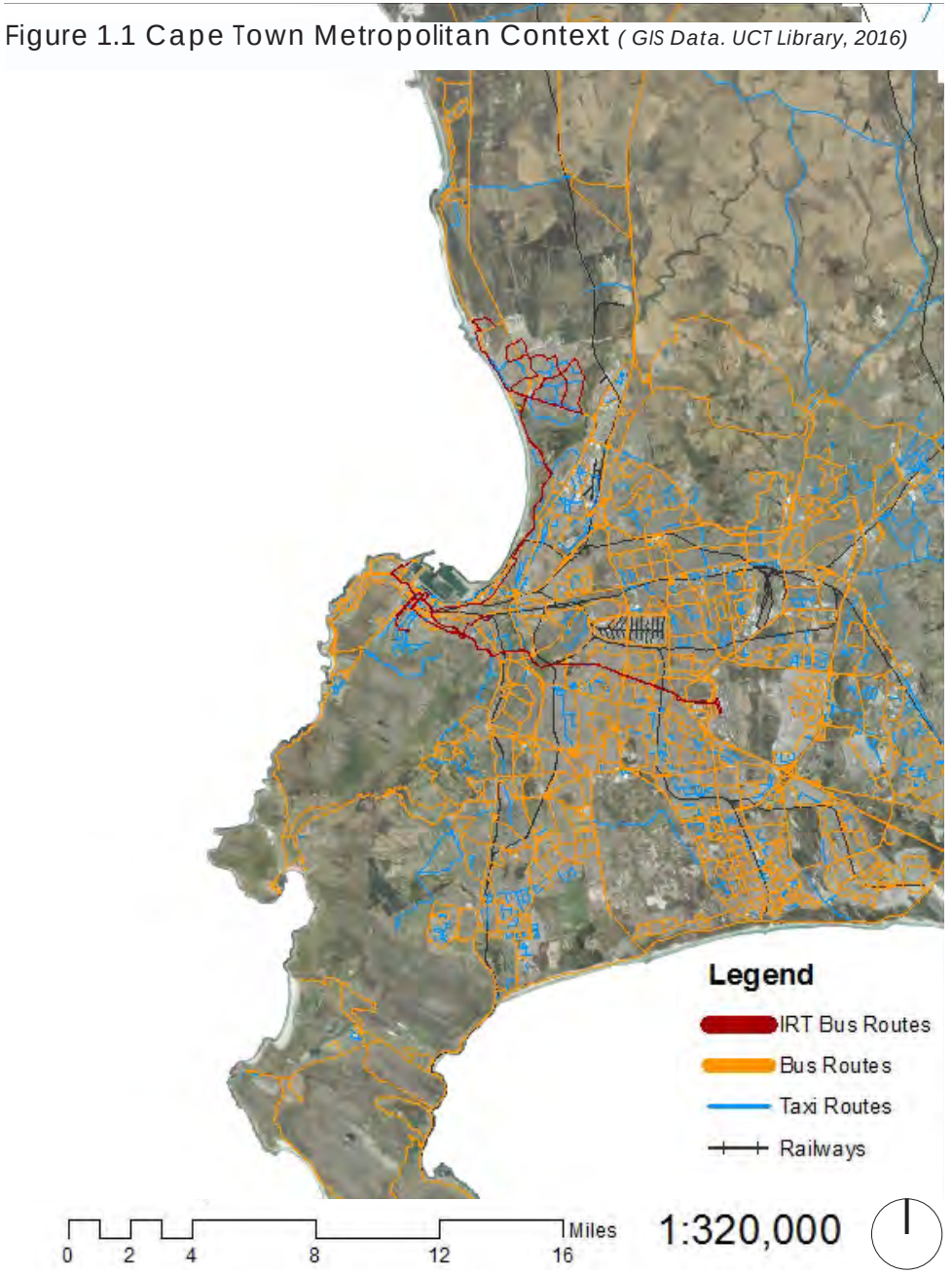
The City of Cape Town promotes a mobility model that is centred on the integration of public transport systems. This integrated urban mobility model is being implemented through the design and expansion of the MyCiTi BRT systems that were initiated within the city centre. This BRT system is supported by the design of Integrated Rapid Transit (IRT) zones and road networks within the CBD which act as linkage system between the Rail and BRT systems.

The Cape Town MyCiTi BRT systems was proposed in 2007 with the first bus system being implemented in 2010 as a function of the FIFA World Cup held in Cape Town. This was followed by an expansion of the BRT system in 2013 which included the proposal for the four envisaged phases for the BRT roll-out. As part of the FIFA world Cup the city also implemented a pedestrian-friendly 'fan walk' route from the CBD to the Green Point Stadium. This pedestrian-friendly 'fan walk' is paired with the design of a bridge crossing the Buitengracht Street. The 'fan walk' represents the planning decisions towards promoting a form of NMT mobility within the city.
The current MyCiTi BRT system includes a central Civic Centre station placed near the foreshore, which is within close proximity to the MetroRail Stations, the CBD Greyhound main station and the CBD taxi rank. The MyCiTi BRT systems has expanded routes to the Cape Town International Airport, Century City, Khayelitsha and along the coast from Hout Bay to Atlantis in the West Coast (Cape Town Comprehensive Transport Plan, 2013).

The design and implementation of the MyCiTi is the tool with which the City of Cape Town has attempted to promote its goal and vision of promoting integrated public transport infrastructure for the city that creates more equitable transport for all citizens. Figure 1.1 demonstrates the movement patterns of the public transport sytems within Cape Town. It indicates the nature of access into the CBD from the East through a series of major arterieal roads which include BRT and IRT movement systems.

This chapter provides for a basic understanding of the current public transport systems within Cape Town and the CBD. Further analysis of the CBD case study and associated transport systems will be expanded on in Chapter 4, as a background to the research findings.

Figure 1.1 Cape Town Metropolitan Context *(GIS Data. UCT Library, 2016)*



1.3 Problem statement

The study resides in the notion that transport infrastructures and urban mobility go beyond that of the physical structures, design and spatial systems placed within the urban environment. The concept of urban mobility and how citizens use, function, experiences and relate to public transport infrastructures and the urban environment is also influenced by social, political and institutional factors. Therefore concepts surrounding equal accessibility and freedom of movement are embedded within the physical and spatial infrastructures, but also highly influenced by social aspects such as: gender, socio-economic status, spatial location, proximity and individual experiences of safety and vulnerability within the urban mobility network (Da´vila, et al. 2013).

These social influences and their effects on mobility often become invisible within the greater transport infrastructure and urban mobility systems. This is most noticeable within the realm of Non-Motorized Transport (NMT) system and their function within the greater transport network. Mobility systems at a human-scale - such as pedestrian linkage systems between different modes of transport – are vulnerable to issues of personal safety, victimization, crime and social fears within the public space. These factors exponentially limit the commuter's ability to move freely within the urban environment. This becomes a discussion on how urban mobility, equality of accessibility and freedom of movement become dictated by personal experiences of safety and vulnerability within the urban environment. This deals with the social, spatial and socio-spatial elements that affect human-scale mobility within the city. These issues of commuter safety are limiting the use, function and optimization of the greater public transport and mobility systems.The concept of safety in mobility as a relationship is analysed through a gender sensitive lens in order to highlight social issues of gender inequality, safety, freedom of movement and accessibility in urban mobility.

The other aspect within this study is focussed on our current technology-based and technology dependant societies and the presence of ICT systems within our social networks. The argument is that communities and cities have the option of innovative technology tools at their disposal – yet there is a lack of use, promotion and implementation of such ICT systems and their integration into the urban landscapes (Hemment & Towsend, 2013). There is a lack of understanding as to how ICT systems can be used as tools to help users or citizens within the urban environment. This in turn informs how ICT systems can be used within planning, spatial development, knowledge production, coproduction and urban management.

1.3.1 Main Research Question

1. How can ICT assist in providing a safer and more efficient commuter experience for all?

1.3.2 Subsidiary Research Questions

2. How do public transport systems and NMT systems function within the Cape Town CBD, through the lens of gender-sensitive commuter safety experiences?

3. How can user-generated data and ICT system be used as urban management and planning tools to provide for safer urban mobility structures within the urban environment?

1.4 Objectives

This dissertation aims to examine the relationship between ICT, safety and mobility by, firstly, exploring barriers to safety in public transport, and secondly, examining the potential for use of ICT in enhancing safety. The output of this research is a set of criteria and mobile phone App prototype that relies on user-generated data to map and rate the safest pedestrian-based movement routes that link public transport systems within the Cape Town CBD. This is through the objective of creating a deeper understanding as to how citizens use and experience public transport and non-motorized transport (NMT) systems within the urban environment.

1.5 Structure of the study

- Chapter One provides the background to the study and the current state of public transport in Cape Town. The chapter also provides the problem statement for this study and the associated primary and subsidiary research questions.

- Chapter Two provides an in depth literature review of all the discourse related to the study. This deals with creating an understanding of public transport infrastructures and social elements within urban mobility. This deals with issues of accessibility, personal safety and freedom of movement at a human-scale mobility lens. The chapter also un-packs information and communication technology (ICT) systems and their value in creating safer and more efficient urban mobility systems through the tools that technology provides.

- Chapter Three includes the methods, techniques and ethical positionality applied to the study. This deals with un-packing the qualitative and quantitative methods used in capturing primary data and knowledge. This chapter deals with gaining insight into the experiences and opinions of individuals that take public transport systems within the case study area. This information was obtained through semi-structured questionnaires, structured surveys and fieldwork observations.

- Chapter Four is the expansion and analysis of the findings. This chapter also includes a background study of the site and the current public transport trends and infrastructures. It deals with highlighting the themes and issues that were expressed by the research participants regarding urban mobility and personal safety in mobility. The chapter also highlights the research participant's opinions towards the desired criteria for the mobile App prototype. The information gained within this chapter was used to inform the design, analysis and planning for Chapter 5.

- Chapter 5 provides an analysis of the Cape Town Central Business District through the lens of pedestrian mobility and personal safety. This analysis, paired within information gained in Chapter 4, is used to create the mobile phone App prototype.

The chapter also provides the technical information that would support the App prototype; namely the associated Application Programming Interface (API) and the associated App database systems. These elements provide a practical example of how user-generated data can be used as a tool within Information and Communication technology (ICT) systems.

• Chapter 6 provides information regarding how the App prototype and user-generated data un-packed in Chapter 5 can be used as a tool for urban management and future transport and safety planning. This chapter also puts forwards recommendations as to how such ICT system can be better integrated into planning tools for public transport implementation in the future.

Chapter 2: Literature Review

2.1 Understanding Urban Infrastructures

When considering urban mobility infrastructure systems and networks there is a common understanding surrounding the physical, structural and design elements that create cities and their infrastructure systems. However, through deeper analysis it becomes clear that infrastructures go beyond the structural embodiment and become deeply defined by social understanding, use and context specific social experiences (Graham & Marvin, 2001; Simone, 2005).
According to Graham (2010) mobility and transport infrastructure is largely 'invisible' until it fails. Then it becomes highly visible. This deals with how infrastructures such as water, sewage, electricity and transportation networks are vital to the survival of urban environments. Therefore when these system fail, societies become aware of how fundamental their presence is in the function of urban communities, structures and economies.

However, we can further unpack this issue of the invisible and visible, by considering elements within infrastructure that fail due to their invisibility in the systems to begin with. This argument deals with how within our urban infrastructure systems – namely transport networks – there are social paradigms that gain little attention within the greater system. This argument deals not only with systems within transport infrastructure, but also with that of technology or ICTS infrastructures and their function within cities. The idea here is that transport infrastructure is often viewed as a hard infrastructural system – based

in the physical, structural and visible design within the built environment. This deals with the road networks, bridges, drainage systems, electricity wires and water pipes. These visible elements contribute to our social understanding of how infrastructural systems are working, how these are having a functional and positive effect on how people move, work and live within cities. However, it is the invisible transport infrastructures that so often get ignored; such as the social and individual experiences and needs that surround the infrastructural system. It also includes how some societies are segregated from such infrastructural systems, or how social factors inform how some groups of individuals are not granted equal access and opportunity to the infrastructural working of their urban environment (Pieterse, E. Ed. 2010; Gandy, 2005).

This deals with questions of how and why people use and experience, not only public transport infrastructure, but elements of human 'mobility' within an urban environment. Within this topic of invisible or 'soft' mobility infrastructure, is that of how other forms of infrastructure such as ICTS can and do contribute to this invisible infrastructure dichotomy. There is a need to bring these 'invisible' infrastructures to the forefront in order for our urban environment networks to function through equal accessibility and sustainability (Graham, 2010; Simone, 2010).

This concept of the invisible social structures within mobility infrastructure is to be explored through applying a gendered lens to public transport systems in the Global South and more specifically within the Central Business District of Cape Town. The argument deals with how the mobility and safety needs and requirements of women and other minority groups have been made invisible within this infrastructure system (UN Habitat, 2013; Da´vila, et al.2013). We can argue how this invisibility of gender based issues in public transport is, to an extent a reflection of society as whole. Through unpacking some appropriate gender based theory and applying it to the case study of the Cape Town CBD, we can begin to understand how infrastructure has limited its abilities to create socially fair and sustainable cities by not considering the keys issues facing women. This gendered lens of analysis is used to then highlight mobility issues facing all users – it is not used as a theoretical ideology to separate, juxtapose or excluded, but to be able to view from other, intersecting angles (Brand, 2013: 17-22; Levy, 2013: 23).

In order to understand urban mobility infrastructures we need to expand the different elements that encompass public transport infrastructure systems and networks. This deals with understanding how important and vital public transport infrastructures have become for human communities at a global and local scale. According to Graham (2010) we need to highlight and recognize the rapid urbanization of the planet through the ever-expanding growth in population and urban migration. This is expressed by the understanding that now, over 50 percent of our population lives in cities with a proposed increase to 75 percent by 2050. This informs not only our rapid consumption of space and natural resources, but the need for larger infrastructure networks to house and facilitate this growing urbanization. The movement of goods, people, money and information has become amplified by the need for speed and efficiency within today's society (Da´vila, et al. 2013; Graham & Marvin, 2001). As this demographic and spatial shift continues, people will beco-

me more reliant on sustainable and functioning system of infrastructure in order for the population to be contained within cities and urban environments. To support this migration into cities is the need for road and public transport infrastructure to create connectivity and energy flows to support our fast-paced society and economy. As populations increase that of housing and urban density becomes an integral factor in development within cities. With this comes the further need for functioning water, waste and sewage systems to remove expanding forms of human pollution. Our water reserves and limited natural resources become exhausted and stretched beyond their abilities as human consumption increases. This rapid urbanization places pressures on cities to invest substantial amounts of funding and planning into transport infrastructure and technology based connectivity (Graham: 2010).

With population increases and rapid urbanization acceleration within urban spaces there is also the broad social and economic need for connection, sharing and communication. This informs the expansion of ICTS and technology based infrastructure systems within our urban environments. Our global social and economic identity with consumerism and capitalism relies on the constant functioning and availability of digital functions. These technology systems are socially understood as invisible flows of energy that are socially assumed to be in perpetual use and readiness. We live in a modern urban world that must always be switched 'on' with little understanding for where the switch resides. It is due to this social understanding surrounding urban infrastructure as an 'invisible' experience. This is linked with how infrastructure is built - often lying below the built surface yet creating the most important foundation to the function of society and urban living. ICT infrastructures are also enmeshed and interwoven with the functioning of other vital urban infrastructures; such as electricity and public transport infrastructures (Graham & Marvin, 2001; Graham: 2010; Green, 2002).

Graham (2010) continues to argue that infrastructure networks and built systems have become socially and spatially considered as hidden, invisible and assumed aspects in the background of cities. According to Green (2002) technology infrastructures have become intrinsically entrenched in our modern society, to the point where technology has the potential ability to transform everyday social understandings of time and space.

There is a social understanding that these systems that have been put in place are a 'given' and have become naturalized and expected without deeper consideration. These infrastructure failures become visible through technical malfunctions, depletion in resource supply and access, extreme weather, war and violence and social disruptions. These issues become contributing factors in the failure of infrastructure systems which create visibly disrupted cities (Graham, 2010).

As our social systems become more multi-layered and complex, so must our urban and infrastructure systems follow suite. Within our social and infrastructural complexities is a further hierarchy of power and access. Urban infrastructure systems – both public transport and ICTS - no longer function and exist as separate entities; they have become interlinked with political, economic, social and design systems within the urban environment (Graham, 2010; Da´vila, et al.2013).

Urban infrastructural systems are created, funded and provided by the state, private organisation or institutional bodies. This informs the power relationship on the topic of accessibility to these urban infrastructures. Within in the Global South and South Africa there is often a lack of equal opportunity for all citizens to urban infrastructures such as housing, water, electricity and public transport. This is due to the historical, social and spatial manifestations of urban environments in South Africa. It is also due to the political, socio-economic and gendered hierarchies of power that create and inform unequally and socially segregated access to urban infrastructures (Pieterse, ed. 2010; Simone, 2005).

There is a call for the new 'infrastructural turn' which includes the need for critical social and scientific analysis and discussion surrounding urban infrastructure systems. This new thematic turn has brought about the consciousness that urban infrastructure is beyond that of a collection of technical elements and or 'things'. This further explains that urban infrastructure is a concept of collective influence and input including social, political and ecological elements (Simone, 2005). Graham (2010) explains that urban infrastructures are entirely comprised through political constructions which encompass "... congealed social interests." (13) This becomes an important statement when discussing infrastructure failure and inequality developing countries.

The debate around developing countries and urban infrastructure is strongly linked with that of failure, interruption and inequality. Graham (2010) and Silver (2015) argue that infrastructure failures are a reflection and reproduction of urban and social inequality within the Global South context. It is argued that there is a strong link between inequality, interruption and infrastructure failure within many developing countries. Areas of informal settlements and/or 'slums' will experience vastly different issues of infrastructure failure in comparison to that of 'middle class' settlements within the same geographic and social context. This indicates that within the realm of failed infrastructure is a multitude of different layers that inform these issues.

These factors within urban infrastructure include social, economic and geographic elements which will function differently depending on context specific influences and elements. Thus we can argue that when infrastructure fails it will be embodied not only in mechanical failure, but in the failure of social, economic and environmental elements.

2.2 Urban Mobilities

Mobility has become an integral part of the modern world; of how societies function and how urban environments are planned, designed and built. It has become a requirement for contemporary societies. Globalization can be encapsulated by the rapid expansion of transport infrastructures and technology based communication infrastructures. Mobility has become to include not only the technical transport infrastructures, but the varying systems of how people move, function and experience urbanized environments. The UN Habitat Report (2013) argues how our global societies have escalated into an age of 'hyper-mobility' where travel is reaching further distances at faster speeds to facilitate our growing, expanding cities, societies and economies. This influences the need for more expan-

sive transport infrastructures that include road and rail to link different spaces and nodes. However, as urban populations increase at a vast rate, cities can no longer support social and economic needs of mobility and accessibility without sustainable public transport infrastructure models. Thus cities are becoming more involved in creating integrated transport systems in order to move more people in a faster and more economically and environmentally sustainable system.

Integrated transport systems are defined as mobility networks that support different modes and forms of transport; with a greater emphasis on creating equal accessibility through providing diverse and integrated public transport infrastructures. This is due to the fact that urban transport networks support both private and public needs. An integrated public transport network deals with linking urban nodes with fluid public transport system that promote accessibility and a freedom of movement (Integrated Public Transport Network Plan, 2014). On a structural level this deals with creating urban environments that include multiple mobility infrastructures such as: Rail, Bus Rapid Transport (BRT) and Non-motorized transport (NMT) systems such as pedestrian mobility and cycling. In the context of South Africa this includes the integration of more 'informal' mobility systems such as mini-cab taxi transport systems. An integrated transport system promotes the cohabitation of all these systems in order to create urban mobility systems that promote sustainability, equal accessibility and movement. This integrated model also relies on including social elements of safety, affordability, efficiency and equality of access for citizens (CITP, 2013; UN Habitat, 2013).

However, despite the visible increase of urban mobility systems and the promotion of integrated transport models, there are still considerable issues in the realm of equality, accessibility, freedom of movement and sustainable efficiency within public transport infrastructures. This issue resides in the lack of deeper understanding as to how public transport systems and public transport commuters function within urban environments.

The first argument is based in the need to understand that urban mobility has been transformed beyond that of the technicalities of the hard infrastructures. It can be argued that previous dominant conversations about transport infrastructure have been centred on cost, efficiency and speed. However, new elements have entered the conversation – including that of the importance of environmental sustainability, energy consumption and social inequality in mobility and transport.

As Da´vila et al. (2013) have argued; concepts around mobility have become based in user logistics and individual practice as an integral part in how transport infrastructures function. These user logistics comprise of a multitude of social dynamics such as accessibility, affordability, gender discrimination, socio-spatial segregation and user safety. This aids the paradigm of mobility and space with regards to understanding how societies relate with and move within their urban environments.

Furthermore it includes the understanding of demand-orientated needs being placed at the forefront of the urban mobility discussion. This includes examples of recognizing the need to promote and

design for walking, cycling as an important transport factor within integrated mobility systems (UN Habitat 2013: 30-32). The concept also includes the need for safety and efficiency within public transport infrastructures, integrated transport nodes and urban public spaces. A vastly important aspect in unpacking these arguments lies in the concept of accessibility – not only as a concept of accessibility in design, but accessibility in social systems.

2.2.1 Accessibility in Urban Mobility

The concept of accessibility has become a vital aspect in understanding how transport infrastructures function, and how they often fail to perform for minority groups or individuals within urban spaces. Accessibility is a dominant element within mobility and mobility infrastructure. However, accessibility needs to be understood beyond the measurement of connecting two different places through transport infrastructure. It has become a function that is entrenched in the social dimensions that influence ideas and practicalities in access. These social dimensions that influence the concept of accessibility include elements such as affordability, spatial proximity, socio-economic positionality, gender discrimination, social opportunity and personal safety. These elements can be considered as 'social accessibility' and is fundamental in understanding transport accessibility (Brand, 2014: 17 -22; Guy & Marvin; 1999).

'Social accessibility' includes elements such as an individual's ability to access employment opportunity, education opportunity and social amenities. This also includes the access to knowledge and technology as well as the ability to connect with society through communication networks and communal activities (Guy & Marvin; 1999). 'Social accessibility' is fundamental in allowing for citizens to participate in their cities, communities and urban fabric. This informs the discussion around concepts that 'social accessibility' and physical accessibility is at the crux of urban mobility. The UN Habitat (2013) report argues for the importance in understanding the current paradigm shift surrounding urban transport and transport policy. This is to move away from considering transport infrastructures and its expansion as the main goal in creating sustainable urban mobility systems within cities.

The argument is that transport planning has been centred on transport infrastructural expansion as the antidote to issues of urban mobility and inaccessibility. However this current understanding of transport and transport based infrastructure has at a global level, predominantly led to environmental degradation, social segregation and unsustainable projections. This is argued to be founded in the lack of understanding as to how and why people use transport, how societies move and function within an urban environment (2- 15). Thus it is argued that transport planning lacks the investigation into that fact that the vast majority of individuals do not take transport mainly to move from one place to another, but rather to make social connections, meet destinations and to obtain and facilitate general and practical needs and services for survival (Da´vila (ed.),2013; UN Habitiat, 2013).

Within this social concept of mobility, the need for efficiency and speed are important factors; however they are also intrinsically paired with social needs of proximity, convenience, safety, accessibility

and a positive, healthy contributions to urban living and satisfaction. This informs the notion that "...mobility is thus properly viewed as a mean to the greater end of accessibility..."(2).
Thus it becomes important to view urban mobility more critically as the interlinking between people, space and the social and physical access to transport infrastructures. This requires thinking of accessibility as a series of interconnected elements that expand social, spatial, design and technology. Accessibility and urban mobility are encapsulated by the urban environment – through structure, design, form and function within a geographically defined urban landscape. This deals with where people live in relation to where economic and social nodes are spaced and how people move within these different spaces (UN Habitat, 2013; Brand, 2014:17).

Creating better accessibility also relies on the design and structure of the built environment. It deals with Land-use systems that promote mixed-use activities within urban nodes and the promotion of densification and active public spaces to promote a sense of place and identity. An urban environment that is densified, promotes a mix of activities and functions, not only will reduce the need for vast transport expansions; but it will promote accessibility, connectivity and the move towards more non-motorized forms of mobility. This urban form and design becomes that backbone for successful and sustainable, high-capacity public transport that integrates different modes of transport at intersecting multi-modal interchanges (UN Habitat, 2013; McFarlane & Graham (eds.), 2014).

Finally, accessibility as a lens of urban mobility is also made possible through the use of technology and information and communication technologies (ICT) systems to inform electronic connectivity and social connectivity. Technology infrastructure systems contribute to social accessibility and transport accessibility – our urbanized environments have been transformed by technology and communication infrastructures. Technology is a tool that allows for public transport infrastructures to function on a structural and engineering level. However, it is also used as tool to inform social communication and access to knowledge and opportunities (UN Habitat, 2013; Da´vila (ed.), 2013).

Within urban mobility it becomes clear that transport infrastructure needs to be designed through a sustainable model that includes and promotes technology as a tool for creating social accessibility and equality (Caicedo, 2013: 38-42).

It is important to note how urban mobility relies on such 'hard' infrastructures, design, structure and function within the urban built environment. However, urban mobility functions beyond the 'hardware' and the physical systems. It can be argued that the invisible systems within urban mobility place an integral role in the success and sustainability of urban public transport infrastructures. This deals with the social dimensions within mobility and accessibility in urban transport systems.

2.2.2 Social Components of Urban Mobility

Concepts around urban mobility cannot be further understood without applying the social dimensions of equal opportunity for accessibility, personal agency and freedom of movement. When consi-

dering the concept of accessibility and freedom of movement it is important to note that lack of accessibility, or separation from accessibility can also be influenced by social indicators. This can include socio-economic disparities that limit accessibility for specific groups of individuals due to affordability, proximity and spatial segregation. Other social components within this discussion include issues of inequality for gender and ethnicity, issues of safety and vulnerability, social risks and fears in transport. Issues of safety, design and pedestrian design in urban spaces are also contributing elements. These social dimensions are highly present in concepts around accessibility and urban mobility – they define how and why the transport infrastructures and urban environments fail or succeed. These elements are important in order for people to participant in civil society (UN Habitat, 2013; Levy, 2013: 23-27).

2.2.3 Affordability

Urban mobility and equal accessibility is also defined by the issues of affordability. Within developing countries, and therefore within the case study of Cape Town, issues of affordability contribute to the social accessibility to public transport systems and the sustainability of urban mobility. The need for social sustainable urban transport networks relies on the aspect of affordability. Often socially, economically and racially marginalized groups are placed at the periphery of cities – away from the urban centres, economic activity nodes and social facility resource clusters (Collin & Graham, (ed) 2014).

This requires for such communities to contribute a large portion of their income towards transportation. As a result, the issues of affordability becomes a contributing factor in social and economic systems of accessibility and freedom of movement (UN Habitat Report, 2013). According to the National Household Travel Survey Data Analysis (2013) in South Africa it was indicates that of the monthly household earnings, more than 60% of households earning R500 or less spend more than 20% of their monthly household income per capita on public transport. However, from the survey it indicated that 90% of households earning more than R6 000, spend less than 10% of their monthly household income per capita on public transport (33). This data indicates that socio-economically disadvantaged communities in South Africa are affected by higher transport cost due to the spatial location and monthly earnings. This in turn limits their accessibility status within urban mobility.

The concept deals with two systems that the concept and affordability and accessibility inform. Firstly, affordability is important in promoting social equality in the form of access and freedom of movement. Creating affordable public transport systems is integral in creating greater advantages for minority groups. This can be seen in reducing social burdens of inaccessibility to economic opportunities, social connectivity and access to social services. The focus of affordability is also a contributing factor in creating more inclusive forms of urban mobility – which in turn create a more sustainable, high-capacity transport infrastructure that is needed in urban environments (UN Habitat, 2013; Levy, 2013: 23).

The second aspect within the topic of affordability is that of promoting for alternative modes of transport, namely that of non-motorized transport systems (NMT). According to the UN Habitat Report (2013:

208) an important part in facilitating for affordable public transport can be achieved through the promotion of NMT systems. Within developing countries and cities such as Cape Town a large percentage of low-income citizens use walking as a mode of transport. This is due to affordability, proximity and necessity. According to the 2013 National Household Travel Survey (NHTS) the statistical number of classified 'workers' (aged 15 and above) in South Africa that rely on public transport to get to work is 40%. Within in this survey it is demonstrated that within their public transport mobility walking contributes 21, 1%. This indicates that a large amount of urban mobility in South Africa relies on NMT systems - such as 'walking all the way' and walking as a mobility linkage to different modes of public transport. The information is at a national level, however it can be interpreted to be a foundational trend for the general elements of urban mobility found within South African communities at large (NHTS, 2013).

Therefore it can be argued that transport policies need to promote and design for NMT systems, not only as a tool for dealing with affordability and accessibility, but also as a way to promote more integrated mobility networks. Promoting NMT systems is also a low-cost initiative within the hard transport infrastructure systems within cities. The lens of affordability is important in not only highlighting socio-economic issues of accessibility, but also how social systems and decisions influence how urban mobilities function. The argument of promoting for NMT systems in relation to mobility, safety and urban design of public space will be later unpacked and expanded on.

2.2.4 Social Vulnerabilities in Urban Mobility

An important aspect within the discussion of accessibility and urban mobility lies in that of the social inequalities and vulnerabilities that occur within public transport systems and associated urban environments. When considering vulnerable groups within society it is based on gender, age, ethnicity and disability. As argued in the UN Habitat Report (2013) it is important to understand how social vulnerabilities affect the functioning of urban mobility, networks and technologies. Therefore it is argued that urban mobility and transport infrastructure can be improved by better understanding how social minorities deal with accessibility and mobility with urban spaces (115). The nature of this research focusses on the gendered lens within urban mobility (Levy: 24, 2013; Brand, 2013: 17-20).
This informs the following argument which uncovers the different social vulnerabilities that affect accessibility in urban mobility.

2.2.5 Gender & Mobility

Societies are at a global and local level gendered. This deals with how men and women are assigned different social roles that dictate behaviour and create systems of privilege and oppression within different physical spaces. Gender based issues are visible within the topic of transport and urban mobility due to the differences in women's commuter patterns, safety vulnerability and accessibility in relation to that of men's. This argument is most dominant within developing countries where such gendered differences are more visible. It is argued then that on average women in developing countries have a commuter patterns that is based in 'chain trips' which implies

making multiple trips to different destinations through the use of different forms of public transportation (UN Habitat Report, 2013: 116).

The female commuter pattern is also influenced by factors of affordability, proximity, efficiency and safety. Through qualitative research, Heinrichs & Bernet (2014) have highlighted that the urban public transport system does not include the options that many female commuters require. These include the need for multi-purpose systems of mobility for women and children. It is argued that in general most working male commuters move from A to B in a linear fashion; from home to their place of work. In contrast it is argued that female commuters at large experience more multi-purpose or 'diver trips' to provide for the functioning of their families. This includes activities such as food shopping, sending their children to school on their way to work and then later when returning from work.

These 'diver trips' or 'chain trips' are often not facilitated by the public transport routes provided and the departing and leaving times designated by the system. These multi-purpose trips require the use of different modes of transport that tap into different areas within a region or city. It also requires a syncing of these different modes of transport in order to facilitate the alternative times and routes that the commuter patterns of woman must fit into. It can therefore be argued that the nature of these commuter trips will be facilitated by the use of walking of NMT systems in order to reach specific destinations, move within urban public spaces and within integrated transport systems. Within the commuter patterns of women there is a distinct issue regarding safety, vulnerability and isolation. These issues occur not only on different forms of public transport infrastructures, but in the urban spaces around them and in-between them.
As argued by Levy (2013: 23-27) it is clear by the different movement patterns of men and women that mobility is a result of a societal gendered division of labour – this informs the requirement for different transport needs. However, in the current public transport model at large the different gendered needs are unequally and unevenly balanced (Da´vila (ed.), 2013).

2.2.6 Gendered Lens

The argument of applying a gendered lens to urban mobility is influenced by the concepts and theories found in feminist work in gender and social issues. These theories create a foundation in understanding how social vulnerabilities within urban mobility are generated. This becomes visible in how minority groups experiences issues of safety and vulnerability within transport networks and urban environments. The theories imply that society is already fraught with social inequalities and systems of privilege and of oppression that are often found in gender dynamics. McIntosh (1995) argues on the topic of male privilege that is present within contemporary society. It deals with a series of "…invisible packages of unearned assets…" that are assigned to the male gender at large; most prominently found in white homonormative males and their privileges (77). This theory translates into the topic of urban mobility when considering issues of accessibility, safety and freedom of movement. Socially constructed gender privileges that manifest in our societies affect how women and men have different relationships with urban mobility and urban spaces.
The above theories are helpful as a foundation in understanding not

only inequalities facing women, but also as a lens to highlight issues facing social minority groups that include both men and women.

The gender lens in the methods used in the primary research aspect of this study is in Chapter 3 and Chapter 4. This gender-sensitive perspective and associated theoretical backgrounds in expanded on in the methods section of Chapter 3.

2.2.7 Safety & Fears in Urban Mobility

A sustainable urban mobility model requires the understanding of the importance in the social experiences of personal safety and security. Safety as a theme is not only important in promoting more individuals to use public transport as the dominant mode of urban mobility. It is also important in creating more positive experiences for current public transport users, of which many use and rely on public transport as the only option of transport due to affordability or socio-economic disadvantage. Safety and security are a deeply influential factor in an individual's choice regarding public transport and their freedom of movement. It is important to understand how influential issues of personal safety, vulnerability, fear and victimization are within urban mobility and public transport infrastructures. Therefore it can be argued that personal safety is a vital factor in our lifestyle options. This fear of personal safety affects and influences behaviour which cause people to avoid particular spaces, places and movement networks due to fear of safety. This in turn limits an individual's involvement in their urban environment and limits their personal radius (Blöbaum, 2005).
A criminological description of 'fear' in personal safety is an emotional response towards crime or symbols of crime that an individual associates with personal vulnerability or victimization. This links fear with perceptions of risk that are reproduced by the individual based on personal experiences, memories and relationships to the space (Loukaitou- Sideris, 2006).

According to Kruger & Landman (2007) issues of crime and personal safety are prominent in the context of South African public transport systems. The concepts around personal safety and public transport mobility are linked through personal fears of victimization and vulnerability. The Household Travel Survey (2003) indicated that although the crime rate in South Africa has shown a progressive decline; 58% of public transport users still fear victimization in their commute. This percentage was most visible in commuter's fears to 'walk alone in specific areas and neighbourhoods after dark' (112). These issues of safety and victimization highly limit individual's opportunity for choice and use of public transport.

Safety for women and children becomes a vital element in urban mobility and transport infrastructure. These issues of safety manifest as social fears of isolation, harassment, sexual harassment and gender violence. These fears of safety and security occur on public transport infrastructures, at transport stations or hubs, modal inter-changes and in the public spaces around these transport infrastructures (Kruger & Landman, 2007).

2.2.8 Gender Sensitive Planning

It is important for this research to view public transport infrastructures

as a system of public space within an urban environment. It must be considered a functional public space that is used by many different people as a network linkage that creates relationships between people, their activities and the city. Thus it must be understood that streets, stations, hubs, busses and trains are shared public space. How these public spaces are designed and used affects the social relationship with transport, urban mobility and urban living. Therefor within the topic of urban mobility and freedom of movement and accessibility it becomes important for factors of safety and security to be present within these public space/ public transport systems (Levy, 2013: 23-30; Meth, 2004; Sandercock & Forsyth, 1992).It can be argued that the above issues facing women in urban mobility is limiting the amount of female participation within greater transport networks. This is in turn limiting female participation in contributing to urban environments, economic opportunities, social connectivity and accessibility. The lack of female participation within these aspects of modern society and urban mobility is creating and perpetuating social inequalities. As argued in the UN Habitat Report (2013) the participation of women in urban transport networks is vital in creating spaces and platforms for gender sensitive systems and bridging gaps of social inequalities (118).

The concept of applying a gender-sensitive approach to planning and development will be expanded upon in the final recommendations to this study in Chapter 6. This will include current gender-sensitive planning theory and implementation tools that can be applied at a local scale now and into the future

2.3 Non-Motorized Transport in Urban Mobility

A dominant aspect in urban integrated public transport systems and accessibility to these infrastructures is based in Non-Motorized Transport elements. Non- Motorized Transport (NMT) systems include human-scale mobilities of walking and cycling. For the purpose of this study the predominant mode of NMT to be analysed is that of pedestrian walking or pedestrian mobility. NMT systems within the greater urban mobility structures play two significant roles. Firstly it must be noted that walking and pedestrian movement plays a vital mobility role in integrated transport systems. Walking is used by commuters as a way of moving between different modes of formal public transport infrastructures – from getting from the bus stop to the train station and then to a specific destination, and so on (Department of Public and Transport Works, 2009: 1-5).

Within developed and developing countries short distance trips are most often made through the mode of walking. Thus it is argued that walking is and must be considered a mode of transport that binds together other transport infrastructures and urban mobilities. Secondly, it must be highlighted that walking is also often a primary source of movement and mobility for minority groups and low-income groups within urban and rural environments. This is most evident in developing countries where poorer communities rely on walking based on affordability and lack of alternative accessibility options. Thus there are two types of NMT users including 'Choice' and 'Captive' users. Choice users use walking or cycling as their main mode of transport through choice, support, social and environmental standpoints and infrastructural availability. Captive user use this mode of transport due to necessity, affordability and spatial proximity – namely in poorer communities or marginalised settlement groups. Thus it becomes

important to note that NMT systems such as walking occupy various social elements and spaces (UN Habitat Report, 2013: 7-10; National Household Travel Survey Data Analysis, 2013).

However, NMT as a system of movement is and should be available for all members of society regardless of socio-economic and spatial identifiers. If we consider that NMT systems are present within integrated transport modes of transport, then it is clear that all commuters use NMT systems within their urban mobility. Thus there is a need for creating infrastructural transport systems that support this mode of transport and provide a more efficient, sustainable and safer environment to promote freedom of movement.

NMT systems require specific infrastructural structures that translate over all scales of development from a Metropolitan scale, to central urban city systems and neighbourhood scales. This requires road and sidewalk infrastructure, cycle lanes integrated into vehicular road networks. Including NMT systems into the integrated transport plan is vital in order to attempt to create a freedom of movement and choice for the population and the future of integrated mobility and sustainable urban environment (Da´vila (ed.), 2013).

2.3.1 Issues Facing NMT systems

NMT systems play an important role in the greater integrated public transport networks within cities. It is considered as a primary and secondary form of public transport, but also as a 'feeder system' within the greater public transport infrastructure. However, it is often found within developing countries that the provided transport infrastructures do not cater for NMT systems such as walking and cycling, to the same degree as that of motorized forms of mobility (Mohan & Tiwari, 1999).

As a result there is little planning and design dedicated to creating NMT infrastructures or movement corridors. NMT routes are often disjointed and lack continuity and movement flow. With this lack of NMT based design and planning there are subsequently issues around lack of safety for the pedestrian commuter. This is due to the lack of lighting and visibility along NMT movement routes, as well as the general absence of well-located and well-designed footpaths for pedestrian mobility. According to Liebenberg & Garrod (2005) 60% of pedestrian road accidents that were recorded in 2002 occurred due to unfavourable environments of low visibility and lack of street lighting infrastructures during evening hours and early morning hours (539).

As urban environments become more densified with activities and people so do the streets; which in turn contributes to some of the difficulties the NMT user experiences in sharing the functions of the streets and space with motor vehicles. Overcrowding of existing NMT corridors is also a contributing factor to the sense of safety and security experienced by commuters. This overcrowding is often due to the lack of NMT designated mobility infrastructures (Labuschagne & Ribbens, 2014).

A dominant aspect facing current NMT systems in developing countries is the issue of competing with the design, planning and social ideology that places motorized transport as the dominant mobility

option. It means that NMT commuters and infrastructures are vulnerable to the encroachment of motor vehicles. This can be a spatial issue- where transport infrastructure for vehicles takes preference of human-scale mobility. It is also the issue of safety for pedestrian commuters against high-speed zones and traffic zones that can result in collisions. This contributes to one element of safety and danger facing NMT users in competing with the motor vehicle. Thus this is a vital issue of motor vehicle involved collision fatalities of pedestrians and cyclists. Improving and designing safer NMT infrastructure could not only reduce the amount of pedestrian collision fatalities, but it could also improve better urban crime issues such as mugging, sexual assault and victimization within the urban environment as a whole (Mabunda, et al. 2008).

It can be argued that NMT systems are competing for space, funding and institutional support within urban environments and the integrated mobility model (Mohan & Tiwari, 1999; Gwala, 2007). The lack of planning and design support for NMT infrastructural systems needs to be reimagined and new forms of design intervention need to be implemented.

2.3.1.1 Issues of design and planning

According to Labuschagne & Ribbers (2014) there are significant issues facing NMT facilities and users due to the lack of government support and design. There is a deficiency in the provision for walking and cycling commuters within the urban environment, resulting in issues of safety and security for urban commuters. As argued by the authors – this urban mobility problem needs to be revised through innovative forms of intervention. This includes the need for incorporating new forms of design to provide for and strengthen NMT mobility within the integrated transport system. This deals with design elements such as 'Universal Design', 'Last Mile', 'Complete Streets' and 'Modal Hierarchy' as a form of intervention and implementation. As indicated in the UN Habitat Report (2013: 19 -24) urban design led initiatives have become popular and important in creating more dominant and pedestrian friendly streets and spaces to promote safety and sense of place. However, this aspect is still lacking in the design and implementation of NMT based transport within Cape Town. This is due to a need for a paradigm shift in the understanding of how people use public transport and how pedestrians and other human-scale mobility methods are an integral part in the sustainably of public transport mobility as the whole.

Labuschagne & Ribbers (2014) call for the need to change 'rhetorical' paradigm in planning, design and implementation of NMT based transport infrastructures. This deals with viewing and understanding NMT systems as a valid mode of transport. The argument is that through design, good practice and governmental support, NMT infrastructures and environments can be improved and enhanced. Here we will unpack design concepts such as 'Last Mile', 'Modal Hierarchies' and 'Complete Streets' systems within the NMT lens.

Firstly, the concept of 'context sensitive solutions' needs to be applied to the design and implementation of NMT infrastructures. This deals with understanding the specific urban environment and the nature of the context specific NMT user – their social and spatial requirements within their urban mobility experience. This concept of

'context sensitive solutions' needs to be applied to the design and planning of NMT infrastructures and urban mobility. For example, systems of traffic calming, pedestrianization of urban centres and activity corridors, public space linkages, green space linkages and expanded accessibility options (190 – 194).

The design concept of the 'Last Mile' deals with the difficulty of getting urban commuters from the transport hub or station to their final required destination. This concept is also present if the commuter struggles to get from their starting location to the transport infrastructure or network in order to start their commute. This is then considered the 'First Mile' or 'Last Mile' issue. Therefore this transport issue is often present in cities that are affected by land-use systems that promote sprawl, or in cities where the transport networks are inaccessible and segregated from large portions of the population. The issue of the First Mile – Last Mile struggle is most often the portion in the commuter's trip that requires walking or cycling in order to link destination with transport networks. This walking or cycling trip is considered the 'feeder trip' in the greater public transport model.

These NMT linking movement systems can be a struggle for commuters due to issues of safety, security and vulnerability, due to lack of NMT infrastructural support and design. This issue found in the 'Last Mile' dichotomy can be resolved through traditional forms of intervention such as feeder busses, cycle and pedestrian infrastructures and urban planning reform. There is a need for placing more focus on how MNT systems of mobility play an important role in feeder systems within urban mobility. This requires a deeper focus on designing and planning for these NMT routes within the realm of safety and efficiency (Labuschagne & Ribbers, 2014).

According to the Department of Transport (2003) there are existing planning standards in place with regards to NMT feeder systems to all public transport infrastructures. This is visible within South Africa through the standardized system of a 500 metre radius walking distance surrounding a public transport node. This planning standard is considered the 'half mile' feeder trip – which corresponds to an approximate 10 minute walk. This is seen as the provided standards for NMT feeder systems for walking to and from public transport facilities. However, this standardized system or 'catchment area' has been criticised and argued to not fit the general needs of public transport commuters. The issues with the 'half-mile' planning paradigm is that it does not consider that NMT mobility moves beyond the assigned catchment area. This means that NMT users move beyond the slandered 500 metre radius as often these trips are not linear movements. This is due to the nature of NMT mobility which is often more flexible due to facts of safety of the route, visibility of the route or the state of the pedestrainzed route. NMT commuters are also often using walking as a linking system in order to perform task and activities along the route – such a going to the shops, the pharmacy, to the library or to collect children from school. Thus the 500 metre radius that is designed for NMT feeder systems is lacking in the understanding of how NMT commuters actually move (UH Habitat, 2013).

As a result the planning for MNT movement networks becomes constricted due to the planning standards – the existing flow of NMT movement routes goes beyond current planning standards and understandings. The argument is that transport planning needs to better understand and provide for the context-specific commuter needs within a public transport network.

An extension of this argument is that if public transport station and nodes are upgraded so should the surrounding NMT feeder catchment routes and infrastructures. In order to create integrated transport infrastructures – there needs to be a focus in design and planning of NMT networks. Thus it is argued that no city within South Africa currently can claim to provide for a comprehensive integrated public transport system; due to the lack of understanding and planning for the NMT user's mobility and safety needs (Labuschagne & Ribbers, 2014: 199 -220)

NMT systems and human-scale mobilities are a primary focus for this research as it is a mode of transport that includes all commuters, across all social categories. It is a mobility systems that links different intersecting modes of public transportation. It is also an urban mobility system that links the public spaces within an urban environment with that of hard transport infrastructures. Finally, it is also a mobility system that deals with the often invisible NMT systems that facilitate the greater urban mobility puzzle. Human-scale mobilities are not only informed by the built environment, but by the social, economic and gender systems that are present within a context specific urban environment.

2.4 Safety through Urban Design

From the above arguments it is clear that issues of personal safety and vulnerability are paramount within public transport systems and NMT user's experiences of mobility. One aspect that can contribute to the alleviation of such issues of safety during transit reside in the need for urban design implementation that takes into account how safer commute can be designed for (UN Habitat, 2013; Labuschagne & Ribbers, 2014).
This requires safety design systems that culminate within the urban environment through the realms of public transport infrastructure, street design and open public spaces

2.4.1 Safety & Access

As explained by Lynch (1992) settlements and urban environments are importantly based on human acts, social acts and individual experiences. These social elements create connections and linkages between the built environment and human values. Thus it is argued that an urban environment becomes most functional when there is an understanding of how social elements and design are closely linked and interconnected. Lynch (1992) highlights some of the settlement qualities and performance dimensions that contribute in creating positive connections between people and their urban spaces. These theories can be applied to the context of urban mobility, equal accessibility and safety in public spaces and public transport systems.

These design qualities can be applied to the case study as a way of evaluating the form of the city and associated urban mobility infrastructures. Bentley, et al. (1985) furthers these qualities into an urban design lens that can influence how urban space should be designed to improve societal needs and required qualities. This will include the social qualities of fit, access, control, efficiency and justice. These will be further un-packed into design-based qualities of permeability, variety and legibility (Lynch, 1992; Bentley, et al. 1985).

'Fit' refers to the matching of capacity of space and channels with that of the residents' needs and wants. 'Access' deals with the need to link individuals to each other as well as the greater community through space, activities, resources and infrastructures. This is paired with the next quality of 'Control' which links the community to their degree of agency in the use and access to infrastructures, spaces and activities within the urban environment. This theory is paired with the concepts expressed by Newman (1996) in his book on 'Creating Defensible Space'. This highlights the importance of designing urban settlements and the surrounding public spaces, in such a way that the community can control, protect and enhance their living experiences and personal safety within their space (9 -27).

'Efficiency' deals with the cost and value of maintaining and expanding the urban environment and the structures within it; including the maintenance of public transport infrastructures based on a sustainable model that promotes longevity.

'Justice' deals with the distribution of environmental and structural elements within the urban environment and the equal distribution of these factors among all citizens. This deals with creating equality of access to public transport infrastructures and equal freedom of movement and safety. This settlement quality relies on and is the foundation for all other categories mentioned above. Creating social justice in design and planning can be considered a fundamental aspect in urban mobility and accessibility.

The settlement qualities as defined by Lynch (1992) create the theoretical foundation for the elements that contribute to creating urban environments that promote social activity, mobility, movement and connectivity. These qualities can be combined with the urban design qualities stipulated by Bentley, et al. (1985) of permeability, variety and legibility. 'Permeability' is defined as the designing of the overall layout of routes and development blocks. This is a tool used in order to create better accessibility and movement networks throughout an urban environment. Permeability as a design system should allow for better flow within urban spaces – linking public space with urban green corridors and transport routes. This requires the design foundation of 'variety' – creating a multiple of urban functions and uses that allow for citizens to execute their agency and choice regarding how they access and experience their urban surroundings. These two design qualities are influenced by the need for legibility of the urban spaces. 'Legibility' deals with the individual's ability to navigate through the urban environment at a human-scale. Within the realm of urban mobility this can be applied to the pedestrian scale within movement routes, public spaces and green spaces. Legibility deals with design in the sense of creating an urban layout that creates a natural linking network between different spaces and functions. This can be achieved by using building typologies to inform function and sense of place within a specific area. Design elements such as landmarks and widened streets can improve pedestrian legibility and promote a mixed-use activity corridor.

Legibility can also be drawn into the concept of safety and security for NMT movement corridors. This deals with infrastructures such as street lighting to promote visibility and safer navigation for commuters. Streets that are designed with wider sidewalks and cycle routes can promote a more legible commuter experience for NMT users.

This design not only creates a more visible human-scale movement corridor, but it also improves the visibility of NMT users themselves.

2.4.2 Safety in Public Spaces

It is important to follow through the understanding that public transport systems such as stations, hubs, pedestrian feeder catchments and NMT routes are elements of 'public space' and public realm. Therefore, the argument entails that it is important to apply design and planning standards to these spaces to ensure social needs of safety, sense of place and identity are applied. 'Public' spaces are categorized as areas available to the general public. This statement is transferred to systems of public transport and NMT networks. Amin (2008) argues that "...when public spaces are successful...they will increase opportunities to participate in communal activities... nurtures the growth of public life (5)" The argument deals with understanding NMT networks as public spaces within an urban environment, and thus they should require design principles that support making safe, accessible and desirable public space.

Kohlstedt (2016) explains an element within public space and human-scale mobility through the analysis of 'desire lines'. The author explains how 'desire lines' can lead better design interventions. 'Desire lines' are pathways and routes made and chosen by the public as they move through a specific urban environment such as a public space or movement corridor. The new pathway or desire line that is created by the citizens will deviate from the prescribed and designated pathways and/or road infrastructures implemented by the designer and planner. These desire lines inform us about various elements that are missing for the actual desire. These designed elements did not suite the users' movement needs, spatial needs or destination needs. Therefore a 'desire line' can indicate that citizens move through a specific space in a way that suites their human-scale needs. This could be creating a new desire line that makes the fastest route to a destination or a more accessible route. Or creating a new route that deviates from a specific area that is considered lost space, unsafe or secluded. Therefore the desire line is the users' experience, and the pathway structure is then an example where design has failed to capture the nature of the user.
This argument highlights the need to design for human-scale mobility and movement in urban public spaces in order to create a better connection between mobility and space. However, this argument also indicates how vital it is to consider and design for users within a context specific space – in order to meet the needs, desires and experiences of the urban commuter.

The above design systems and arguments highlight how important it is for design to focus on the movement of the user in order to create safer and more accessible urban environments, public space and mobility corridors. These design elements are visible in the case study of the transport networks in Medellin – how design that is centred on the users experiences has been used to create safer urban spaces.

2.4.3 Safety & Design, Medellin

The Medellin MetroCable transport system is a case study that demonstrates examples of 'social urbanism' and sustainable urban mobility through safety design, public participation and equal ac-

cessibility. The MetroCable is also innovative it its ability to create a foundation for un-packing and making visible the infrastructural, social and mobility issues facing women. As explained by Da´vila (ed.), (2013) there is a need in understanding gender related dynamics in transport infrastructure and accessibility. It is argued that the MetroCable attempted to combat some of these issues found in urban mobility within the Global South.

The Medellin MetroCable systems was created in 2004 with the intention of creating connectivity routes to link different socio-economic demographics with the area. It was intended to alleviate crime within the neighbourhoods of Medellin which had been considered one of the most violent urban environments in the early 1990's. The cableway was introduced to create an affordable form of public transport to connect areas and people that were previously isolated due to the geographical topology and spatial structure within Medellin. The MetroCable acts as a main transport framework that is used in conjunction with other modes of transport in the area including: bus and taxi systems, pedestrian movement and the MetroRail. The instalment of the MetroCable system created a more integrated transport system that allowed for different demographics in the area to access more mobility options and choices. This system created more choice for female commuters in terms of safety, over-crowding and efficiency.

The Medellin MetroCable model was also founded in the concept of 'social urbanism', and it has been considered the physical manifestation of social urbanism in practice and in design. This is visible through the public participation aspect that was vital in the planning, design and implementation of the cableway systems, and surrounding networks. The cableway also acts as a systems of urban integration and social connection. It creates links within the urban environment through access to mobility and through the design and integration of the infrastructures into the surrounding neighbourhoods and urban systems. This has in turn created social integration through the alleviation of crime within the area, and the improvement of safety and efficiency for local urban commuters, and tourists (50).

The design of the MetroCable included creating new public spaces surrounding these transport hubs to promote social integration and mobility. This is visible through the design of public squares, urban greenery and street art that surrounds the main MetroCable station. These public spaces were designed with a multi-functional approach to not only act as welcoming and safe mobility nodes, but also to perform functions to incorporate the public spaces and transport nodes into the city fabric. The design of park-libraries were also introduced into Medellin during this 'social urbanism' project. This allowed for public spaces to also function as communication and education hubs for local communities, through the access to internet facilities, books, training courses, community activities and recreational activities. Within the Metro stations there was the upgrading of social facilities such as the lending-libraries, security hubs and information centres. This created an identity for the MetroCables that integrated public transport and social amenities.

The issues of safety, especially for women and children was a fundamental aspect in the design, planning and vision for the cable-way system and the concept of 'social urbanism'. The research from Medellin indicated how women's perceptions of safety impact their choice of transport and mobility route. The project took into account

the issues facing women commuters within the realm of safety, sexual harassment, victimization and risk. These safety issues were met not only through design, but also through social education, monitoring and security control (27).

The creation of the Cultura Metro (Metro Culture) was enforced into the Medellin mass-transport systems as a form of monitoring and policing activity within the public transport network. This dealt with creating a balance between social control and monitoring in order to create a safer and more efficient mobility environment. Although the Cultura Metro is not explicitly gender aware or focussed on gender safety – it was considered to be a useful tool in managing activities within the transport networks.

These added design extensions within the Medellin MetroCable infrastructure were paramount in achieving better quality, safety and efficiency for public transport commuters (Brand & Davila, 201; Da´-vila (ed.), 2013).

The Medellin MetroCable is an example of how design can inform safer spaces for commuters through the interconnected function of public transport, social education and open space design. This in turn has creates a safer urban environment for public transport commuters and the surrounding residential community.

2.5 ICTS

An important aspect in understanding our urbanized cities and the complex mobility patterns and infrastructures within our urban environments, is founded in the infrastructure of technology that support information and communication technology (ICT) systems. Brand (2013); Caicedo (2013); UN Habitat (2013) and Green (2002) indicate the important of using technology as a tool to promote better urban mobility and public transport models. The argument is that urban landscapes and transport infrastructures need to be designed and informed by ICT tools and how they can provide for better quality of urban life. Technology has become a tool that transforms how cities, communities and infrastructures function.

The concept of the 'smart city' and 'smart citizen' is an integral aspect in the argument of how ICT can be used as a tool to help inform more equitable urban environments and urban mobility systems. The 'Smart City' urban development model is based in the integration of technology into informing, designing and maintaining urban environments and urban societies. This model is also founded in the understanding of 'bottom up' innovation, development and collaboration between the citizen and institutional spheres. This informs the notion of how the 'smart citizen' plays a collaborative and vital role in the development of their cities. This is done through the tool of technology in this current digital culture – were urban design and development is paired with ICT systems to inform change. These ICT tools include systems as open source data systems and software system that bridge the gap between the citizen and institutional spheres of governance. These tools allow for the citizens voice to be heard (Hill, 2013).

A further understanding as to how ICT systems can inform greater collaboration and integration between the citizen and their urban environment is required. Expanding arguments on how technology

infrastructures and the urban environment and interlinked to promote better quality of urban life should be included.

2.5.1 Technology & the City

A vital aspect that has influenced and continues to influence urban environments and urban societies is that of technology infrastructures. Technology has become an intrinsic part in how modern societies function, communicate, exchange and expand. It informs the relationship between humans and 'tech' as an important social infrastructure. Technology infrastructures have also been instrumental in the building and design of urban environments and spaces. It is one of the foundational aspects in the development processes that inform human and urban settlements. When considering technology it becomes important to note that it can be defined within this greater topic as a series of "…instrumental elements of a process aimed at pursuing a purpose."(Auriga & De Cindio, Eds., 2008: 291).

Technology infrastructures also shape the urban environment and contribute to urban functions within space. Technology takes on a physical domain within the built environment – digital flows transfer along grids and nets through the use of electricity to inform an output of various services to society. This informs aspects within the built environment such as where economic opportunities manifest and where individuals gather to communicate within cities. Technology infrastructures are reliant on energy infrastructures such as electricity in order to function, thus making technology an inflexible infrastructure within the greater system. It also becomes deeply embedded in the larger urban infrastructure systems and linkages – technology becomes the glue that maintains our tech-driven societies. It in turn influences how space and technology are highly interlinked – the virtual and the physical spaces are no longer separate systems. This is visible in the design and function of cities, which have become centred on technologies, digital communication and services. It is also visible in how society and their identification with urban space has become heightened and transformed through technology, the Internet and communication networks. Thus there is a circular relationship between society, space and technology (Sassen, 2015: 253-255).

Often technology infrastructures are viewed as invisible systems within the built environment – that function below the surface of the city. This informs two elements, firstly that technology and its associated services are an assumed infrastructure that is so embedded in society and how we function. Secondly, that this infrastructure is so embedded in the functions and flows of modern society that they require a deeper understanding as to how technologies can be used in new and innovative ways to create better services for urban societies.

2.5.2 Transforming Data into Value-Added City Services

Within the argument of the smart citizen and the tool of ICT systems is the factor of open data sources and how they can be captured and reused by citizens to improve their urban environments and functions. This deals with a series of elements within the realms of open data and the various outputs that can be achieved from this resources. This is further unpacked as to how different forms of ICT and so-

cial digitization can be formulated to create a value-added service to citizens within a specific urban environment.

Understanding how open data and ICT systems are highly interlinking and interdependent is important. It relies on equal public accessibility to both systems in order to create services to the public or citizens. This would allow for the public to become more involved within the development and management process of their cities. Through the linking of open data sources and ICT systems the citizen in provided with an opportunity to strengthen their relationships with state provided infrastructures within the urban environment (Mainka, et al., 2015: 199- 214).

Firstly there is a focus on understanding various forms of open data within cities and associated governments. Open data and open government data is a concept that was recognised by the European Union in the 1980s as a way of creating more transparent and collaborative governments (Mainka, et al., 2015: 205). Thus this idea of open data systems is not a new concept – yet it has been transformed and developed due to rise of ICT systems and the digitization of data. This has also included a projection towards using data and technology to create value-added services within the urban environment. The concept is based in the desire for creating transparent, collaborative and participation process between the government and public sector. This concept currently deals with various constraints not only with the opening of large datasets, but with how valuable the use of these data systems are in creating a value-added service for citizens.

2.5.2.1 Understanding 'open data'

According to Mainka, et al (2015) the term data refers to "...qualitative values resulting from measurement and other sources" (201). Then within this broad understanding of data is that of Open data which is defined as freely available and accessible online data that has no technical, legal or financial obstructions in obtaining it. Open Government data deals with government produced or generated data that is made available and accessibly to the public. Open Urban Government Data is also that of government produced data at a municipal level within a specific urban environment or city.
Within open urban government data there are different forms of sources that contribute to the formulation of such data. This included official statistical data and sensor-based data. Official statistics include data based on population statistics, economics, employment, crime and health qualitative statistics. This can also consist of city-specific official data that is context specific. Sensor-based data deals with sensor networks embedded in the specific environments and structures which measure real-time data such as temperature, humidity, movement and speed. This system also includes the use of CCTV footage or the tracking and process along a bus or train route. Thus sensor-data can be considered 'big-data' as it can encapsulate the infrastructural workings, networks, flows and systems within a city (206).

An important aspect in these open urban government data systems is how these forms can be combined with user-generated content or crowd-sources data. This platform of data sharing is best achieved through ICT systems such as mobile phone Global Positioning

System (GPS) and location-based data. Individuals can use their personal mobile devices to pin locations and activities through GPS signals. Another form of this interaction can be achieved through micro-blogging services such as Twitter or Facebook which allow for individuals to produce real-time feedback to governments or institutions through online media channels (200 -201)

Another function the interlinking between open-data platforms and ICT systems can produce is the relationships that can occur between open governments, private developers, private companies and the public. Citizens themselves can act as developers for governmental services – and as a result contribute to generating more data and value-added services to their city – without being paid for it. This is considered a 21st century phenomenon – as open data and ICT systems have become interlinked in such a way that they move beyond the governmental authorities into the public realm. This phenomenon can be considered a form of public, social and economic value gain that can enhance quality of life for citizens within urban environments. Within this collaboration with state and public is the ideological concept of citizens acting as 'data bodyguards' – who help themselves and their communities through handling, understanding and reusing open data to be transformed into value-added services.

This system is most commonly manifested into the output of smartphone apps –however other such platforms exist such as websites and online forums – yet they are still mostly accessed and used through individual mobile devices. This is due to the nature of individual mobile devices and smartphones as hugely common-place system in modern societies. The Smartphone is highly used by citizens to facilitate instant communication and connectivity of our mobile and technological age. Individual mobile devices allow for instant and real-time data sharing and reusing within an individual's current space and movements. This becomes an important systems in how 'Smart Cities', 'Smart Citizens' and 'Smart Governments' work and collaborate (Foth , Brynskov, & Ojala, Eds., 2015).

2.5.3 Smart Apps & Smart Governments

The 'App and Smart Cities Manifesto' explain the 'Smart Government' model within the context of open data platforms and Smart Apps. This model indicates that Smart Governments will share resources and information through the incorporation with other governments, NGO's, citizens and businesses in a much more innovative and collaborative way in today's society with the help of ICT systems (Mainka, et al., 2015: 200-202).

The 'App and Smart Cities Manifesto' deals with the ideology behind the concept of smart and connected cities through technology. This includes a series of theories that cement the social impacts that smart city Apps should create within a city and its citizens. This is "To harness the true potential of Smart cities, the city must become a platform i.e. an enabler for developers, creativity and applications. In doing so, the city becomes like the Internet i.e. a connector and an enabler for citizens which aims to empower the citizen." ("Apps For Smart Cities…",n.d).

This manifesto deals with the understanding of collaboration between open urban government data and the reusing of this data by participating citizens within the urban space. This participation of the

public with an open government data systems can become a tool to inform spatial issues found within the urban environment and urban infrastructures. In turn this collaboration can contribute to a form of urban management that includes the intervention of the public and the state. An example can been seen in the production of such systems as urban m-apps. These m-apps can use open urban government data tools such as 'GoogleMaps' or 'OpenStreetsMaps' as the foundational data platforms for citizen users to contribute to fixing urban problems through generated 'citizen apps' (Mainka, et al., 2015: 202).

2.5.4 Precedents: SafetiPin, India.

The case study of the company Safetipin from India is an example of a project that incorporates ICTS, Smart Apps and user generated data to inform safer public transport within the urban environment. This project focuses on technology and communication through the format of the individual's smartphone. A platform to gain access to public transport information is used within the context specific urban environment in order to improve access, mobility and safety for commuters.

2.5.5 SafetiPin Mobile App, India.

SafetiPin is a mobile phone App tool which focusses on creating safer city environments and urban moblities for women and, thus for everyone. It is currently active in Bogata and Dehli NCR. The App and SafetiPin Company works with multiple partners including the local government, NGO's, city planners and citizens to generate, share and use safety data. This tool is based in using and collecting data through crowd-sourcing from users that live and move within these cities. The App uses a robust tracking system to allow for individual users to pin their locations and to pin other locations and activities within the spatial environment. The data that creates the foundation of the SafetiPin App is informed by the Safety Audit – a system that assesses different parameters based on the safety of streets and public spaces. This safety Audit rubric is used to collect qualitative data and experiences of citizens moving within a specific part of the city. These collected experiences have been integral in creating a Safety Audit rubric that creates an accurate proxy for assessing safety within the urban environment. The data has been collected with a vision that supports safety needs for women and children as a basis for improving safety for others of different social categories. The Safety Audit rubric and the SafetinPin App perform as tools to evaluate a specific spatial area and its safety measures. The organisation argues that by creating a qualification of an area there is more opportunity for management and to measure improvements (SafetinPin, n.d).

At the core of SafetinPin App is the Safety Audit. It is a set of 9 parameters that amount to an evaluation of perceptions of safety. Each audit generates in a pin which is placed on a specific location where the audit was performed and the safety of that area was evaluated. This audit pin also identifies time and date of the specific action. The 9 parameters include: Lighting in the Area, Openness of the Area, Visibility in the Area, People Density, Security, Walk Path, Transportation in the Area, Gender Diversity in the Area and Feeling. These categories are used as a system to evaluate the general safety of the spatial location based on the activities, built environment and infrastructure

through real-time experiences.
The colours of the audit pins are ranked – red, orange and green – as a safety measurement. This information is then turned into a Safety Score depending on the generated data. The user can also place a Safety Score or pin on a location to report an incident of harassment or even a sense of unsafety. Then a user can submit a comment to the App or link it with their various social media platforms in order to share information with others via this free crowd-sourcing system.
The user is also able to view generated information within their city, neighbourhood or street to help create safer mobility, and as a tool to help plan routes to walk or cycle. The App also indicates the closest ATMs and 24 hour Pharmacies within a specific user's area, and can direct the individual to these facilities. This created through the 'Locate' attribute within the App which uses location tracking and GIS data to formulate the safest routes, as well as displaying the safety of a specific facility and its surrounding environment. Users are also able to post information or pin a location of safety hazards or urban management issues such as pot-holes and broken lighting.

This system of user-generated data allows for collaborative and participatory involvement of the citizen in the act of alerting, planning for and maintaining safer urban environments (SafetinPin, n.d).
In 2014 a progress report was done by the SafetiPin organization through the 'Active Learning Solution' project for educating and helping women in low income groups in India. The argument of this report was to evaluate how SafetinPin can help women and girls in low income neighbourhoods through the planning and implementation of creating safety centres (chaupals) in partnership with local NGO's. This report deals with the understanding that smartphones and access to data or internet may be limited within these lower-income neighbourhoods. Therefore, limiting the residences' engagement with the App and limiting their ability to collect and project safety data in their specific neighbourhoods.
In order to allow the residence to gain from the SafetinPin project; the data that would have been collected through the SafetiPin App was translated and supplemented by community meetings and discussions. Therefore the safety data that was generated online was turned into a discussion panel system that allowed for all women to access the information, regardless of their lack of ICT access or technology education or abilities.

This is currently a pilot project by the SafetiPin group which is organising various chaupals within different communities. These meetings facilitate similar conversations that happen electronically within the App database. For example, women in the community are able to voice safety concerns and needs such as: limited street lighting and the need to maintain pathway infrastructures for traveling by foot. It is also a platform to have conversations around security and policing issues within these neighbourhoods (Knowledge Partnership Programme, 2014).

This pilot project creates an important aspect within the topic of safety and ICT systems, and within this research topic as a whole. It highlights that technologies such as mobile App, crowd-sourcing and open-source data are not limited to the realm of technology or limited to specific income-based individuals. It indicates that such safety and mobility-generated data that is acquired within a mobile App tool can be used and expanded beyond the bounds of

technology alone. As seen by the chaupal pilot projects; such data systems and safety evaluation tools can be used outside of the technology-based systems and move into the social realm.

Therefore it can be argued that the data generated through smart App tools can be used to inform other projects in which to create safer cities and environments for citizens. Data that is generated through the 'mobile App phenomenon' can be analysed and used as a tool to facilitate community discussions and participation, or to inform future planning and design intervention. Therefore it is argued that information that is generated through ICT systems can create improvements and new knowledges beyond the technology infrastructures itself. This can create a more inclusive system that does not limit individuals from access to information and opportunity (Foth, Brynskov, & Ojala, Eds., 2015).

2.6 Conclusion

This chapter has highlighted the current social, spatial and structural elements which encompass the multi-layered functions and experiences of urban infrastructures. The literature has highlighted the importance of understanding the socially constructed elements that contribute to experiences of urban mobility and public transport systems. This has expanded on the need and value of understanding how our gendered societies affect experiences of urban mobility in the realms of affordability, accessibility and personal safety. The information has created the foundation for exploring the potential for a mobile ICT system to enable safer transport use of all urban commuters. This is paired with the understanding of how the citizen can become an agent in the collaborative process of planning and designing for safer urban environments and urban mobility networks.

Chapter 3: Research Methods

3.1 Introduction

The desired output for this research topic was to create a prototype for a mobile phone App (Application Programme) that incorporates elements of safety integrated with public transport, pedestrian movement and other forms of urban mobility. This formulation of a mobile App relied on creating a proxy or set of standards that informs how safety is understood, experienced and spatialized. Thus it required a range of research methods and techniques in order to obtain such knowledge – on a technical, theoretical, experiential and social levels. Such research involved the use of secondary information to be paired with qualitative data in order to bring to the surface individual experiences and opinions. This App prototype is envisioned to evolve further as a tool in which to assist in urban management, planning and design intervention through user- generated data that can be analysed for benefits beyond the App itself.

The initial step was to view urban mobilities on an infrastructural and spatial level to see how mobility networks are linked and how urban travellers create the linkages. The next step was to consider the role of the pedestrian in the NMT mobility network and how safety and vulnerability play a vital aspect in urban mobility systems. Finally, the research required an understanding of individual experiences and opinions in order to create an understanding of how safety in mobility is socially and spatially contained. This was done in the vision of creating a tool that can alleviate these mobility pressures of safety and fears of vulnerability in the urban environment. It also includes method for creating a model for safer commuter experiences through technology and user-generated data systems.

This chapter expands the research methods used in order to gain qualitative social data and experiences of a portion of Cape Town public transport users within the CBD. Qualitative information was collected from research participants in order to highlight issues of safety and to determine ways in which an integrated safety and transport app could help in alleviating these issues.

Firstly, it was important to ground the proposed research methods in the researcher's theoretical positionality of applying a gender-sensitive lens for analysis. This was then paired with the understanding and definition of 'safety' and 'vulnerability' in mobility that is used throughout this research topic, and which is applied to the research methods and interviews.

3.2 Positionality

The research and the ethical and theoretical positionality of the researcher has been chosen to be grounded in a gender-sensitive lens. This is in an attempt to bring to light the topics of safety and vulnerability-based issues facing women commuting within urban spaces and within urban mobility networks. This theoretical stance is not exclusively based feminist positionality; in the sense of excluding the experiences and opinion of men from the study. It is rather an attempt to apply a gendered lens of intersectionality that places women's experiences at the centre of the study – as a guide to inform other experiences and understandings of other social experiences at large. Thus the researcher's positionality and the theoretical grounding

for the secondary data, primary data and associated methods, was influenced by a series of literature that highlights gender in society. It must be noted that the interpretation of the theories is highly personalized and reshaped to suit the needs and desires in the process of creating a mobile App, and a safety evaluation model to satisfy all forms of urban moblities. Therefore the designed questionnaires included a sample of both men and women within the data collection process. This was used as a method of viewing gendered difference and/or similarities with regards to feelings and perceptions of safety within urban mobility.

Crenshaw (1989) introduced the concept of intersectionality as a theoretical practice as an off-shoot of feminist ideology and theory. The theory of intersectionality requires the understanding that an individual's position within different societies and locations affects their personal experiences. An intersectional lens introduces the notion that race, class, gender, age, culture, socio-economic positioning and spatial location all intersect when discussing gender identity and gender-based inequalities.

Furthermore, Davis (2008; 70) explains how the emergence of intersectionality has been vital in the "...acknowledgement of difference among women" and not only the difference between men and women. The concepts of intersectionality are further translated into an analysis of power relations through the notion of the 'Matric of Domination'. This theory is approached by Hill Collins (1990) with the understanding that intersectionality is extended to the multi-layering of oppression and privilege found within societies. Hill Collins (1990) explains that by applying an intersectional approach it becomes clear that not one single mode of oppression or privilege (eg: race, gender, age, sexuality...) can be applied and highlighted at a single time. It becomes clear that different moments of individual power or oppression can manifest themselves within different space and social functions at different times. This notions becomes more deeply understood when considering the presence of gender discrepancies within our 'gendered society'.

This theory relies on placing the plight women at the centre of analysis when discussing gender issues within urban mobility. By focussing on marginalised groups within societies, we are able to gain greater and more in-depth knowledge as to how society views gender and gender roles. Through this theoretical grounding we are able to view urban mobility and that of pedestrian safety as a series of issues of privilege and of oppression that are founded on the premise of gender relations and the spatial and structural influence within an urban environment. This highlights the notion that urban mobility expands beyond the physical movement between spaces, but is also grounded in the social manifestations within different communities (Da´vila, et al.2013).

This argument of urban mobility, society and gender dynamics translate to deeper issues of safety, accessibility and inequality. It is argued that women's fears and vulnerability of personal safety limits their integration within the city and society on all aspects such as employment opportunities, social connectivity, communication networks and place making. By limiting women's ability to involve themselves safely within the urban space, city life and social interaction; we are allowing for the perpetuation of gender discrepancies and inequalities (Valentine, 1990). The limiting of women in urban spaces

and communities has further implications with regards to safety in the urban landscape. This is due to the expanding and visible lack of gender diversity within urban environments and urban mobility systems.
Furthermore, by placing a gendered-lens on urban mobility we are able to uncover the social aspects that affect and are present within transport infrastructures. The primary social element that requires emphasis is that of personal safety and vulnerability felt by urban commuters. This is argued to be a collection of social, spatial and structural elements. Deeper knowledge as to how individuals use, interact with and experience urban mobility and transport infrastructures can be created.

3.2.1 Defining & Measuring 'Safety'

In the creation of the qualitative research techniques it must be noted that a highly specific understanding of 'safety' is applied. In this context the concept of 'safety' applies to mobility in the form of pedestrian and NMT movement as well as including that of public transport mobility in the form of bus and or train systems. The understanding of safety within this mobility realm deals with the concept of safety and vulnerability experienced at a human-scale when moving within the urban environment on foot.

The focus of this research does not reside in the typical analysis of 'pedestrian safety' through road engineering and traffic engineering. These forms of analysis are often based in human or pedestrian safety from vehicular accidents, road collisions and pedestrian deaths. Although it is noted that pedestrian safety against vehicular collision is a contributing factor towards NMT safety; the focus of this study resides more on the topic of safety and vulnerability within the urban and public environment - beyond that of the streets and roads networks alone.

The understanding of 'safety' within the parameters of this research deals with more specific concepts of vulnerability, victimization and personal forms of fear within urban spaces and within urban modes of transport and transit. Loukaitou- Sideris (2006) provides a theoretical foundation for understanding this fear of safety within transit and within urban spaces. The author argues that fears of personal safety are related to a complex package of an individual's past experiences, social understanding and memories assigned to a physical, spatial environment. Thus personal concepts of safety and fear are often spatially manifested and rely on linkages between social elements and their relationship to space (222). This concept informs how socio-demographic factors influence perceptions of safety, vulnerability and fear within the urban environment.

Therefore the definition of safety for this research is based on the individual's personal fears of victimization, vulnerability, isolation and physical harm when commuting by foot within the urban environment and between public transport infrastructures.

The above definition of 'safety' influences the measurement of safety that is applied to this research model and associated research tools and techniques. The measurement of safety is thus identified through a set of evaluation systems used as an analysis tool of urban spaces with a socio-demographic lens of safety. The designing of this

safety analysis tool is influenced by the data collected from the qualitative research in Chapter 4, as well as the knowledge obtained through the literature reviewed in Chapter 2.

The measurement and definition of safety are unpacked within the primary qualitative research. Research participants were able to expand their personal understanding and experiences of safety within the urban environment and within transit. Participants were also then given a platform to express what kinds of safety systems they would require to improve their experiences of vulnerability and fear within urban mobility. Therefore this user-generated information will be used as a tool to inform the creation and criteria of a safety and mobility mobile App prototype.

3.3 Research Methods & Techniques

A range of research techniques were applied within this study; including a wealth of secondary data paired and supported by primary data. The primary data comprises of a series of structured and semi-structured questionnaires aimed at commuters within the Cape Town CBD study area.

The qualitative methods used for this research included that of a series of semi-structured interviews with a limited number of participants. The quantitative method used included a set of compact and limited structured-survey. All the methods used will be un-packed further in order to demonstrate the benefits and limitations of each system within the broader research.

The research techniques used were based on two influential aspects that need to be taken note of. Firstly it is important to highlight that the positionality as a researcher within qualitative research techniques. The researcher's positionality comprises of the application of applying a gendered-sensitive lens to the research as an ideological grounding. The second aspect that has informed the research techniques and influences the format of the qualitative interview structures is that of 'safety'. This deals with how safety and the measuring of safety has been defined for the purpose of this research. Both of the above mentioned aspects are important in creating a foundation for the research methods and associated tools and techniques.

3.4 Case Study Analysis of Cape Town, CBD.

A case study research method is based in focusing on a specific group of individuals or community. This case study method consists of a mixed method approach of qualitative and quantitative research techniques. Within this research topic the case study method is applied to a 'bounded system' that is spatialized. This stresses developmental factors and their relationship to a specific environment. The 'bounded system' deals with objects, processes and social systems within a spatial stencil. A case study method allows for acquiring in-depth knowledge at global and local levels. It allows for unpacking complex social elements and their manifestation and relationship to space. The method occupies the concept of a specific environment to be entrenched in social and political factors – both at global and local spheres. Within this case study model is that of actor- network theory. This element is visible within the research, through the under-

standing of radical relationality- that institutions, things, technologies and humans inform each other (Farías & Bender, 2010).

The Cape Town Central Business District (CBD) was analysed through the case study lens in order to gain an understanding as to the kinds of urban mobilities that take place within this specific urban environment. This method is beneficial to apply to the CBD and the associated mobility corridors found within the urban landscape. This case study analysis will unpack spatial, structural and infrastructural systems within the urban built fabric. However, it will also focus on how individuals and groups of individuals relate to and move within the space. This requires taking into consideration the social and institutional elements that also manifest within this urban environment and therefore the influence it has on the function of spatial elements. The case study method requires understanding that the information and research that is obtained cannot be generalized beyond the case study (Flyvbjerg, 2011: 304).

3.5 The Qualitative & Quantitative Research

A mixed-methods approach deals with balancing both quantitative and qualitative techniques within the research process. The quantitative based research was collected through a compact set of structured, self-completion surveys. The qualitative research was displayed through a smaller series of semi-structured questionnaires which highlight more in-depth experiences and individual opinions. This method is vital in gaining knowledge that informs social understandings and experiences on the topic of safety and urban mobility. It is also beneficial in creating a platform for user-generated data to be recognised as a strong tool for expanding knowledges on urban moblities and transport infrastructure.

The structured questionnaires are aimed at obtaining more quantitative data that can be coded and used to highlight, emphasize and add a foundation for the qualitative, experiential research. Each method will be explained and expanded upon in order to understand the opportunities and constraints they will provide.
Richie & Lewis (2003) describe qualitative research as an important factor in: “understanding of the nature and form of phenomena, to unpack meanings to develop explanations or to generate ideas, concepts and theories” (82). This concept is at the foundation of the qualitative research that is intended for this study.

Furthermore, the importance of qualitative sampling research is that it deals more with the opinion and expressions of the people being sampled. Punch (2005) and Richie & Lewis (2003) explain that the sample and sample settings (actors, settings, process, and events) should revert back to the overall questions and should enrich the study further. In the case of the intended study, the use of a qualitative method will ensure that personal experiences and opinions of the present and selected pedestrian commuters will be represented. The notion that the sample and the sample setting- or spatial and social location - are interlinked is a vital aspect when considering the gender theory of intersectionality. Thus it can be argued that using a qualitative method of collecting experiences of urban mobility and safety is the strongest method in highlighting the gendered issues submerged within the greater topic.

3.5.1 Semi-Structured Questionnaires

According to Bryman (2012) interviewing is the most widely employed method for obtaining knowledge and information. He argues that it is the flexibility and mobility of the 'interview' that makes this method so attractive to researchers. The semi-structured approach is often referred to as the 'qualitative interview' method and informs a different set of parameters to that of the structured interview (470). The semi-structured questionnaire method consists of a list of fairly structured and concise questions that perform as a prompt for further information within the specific topic. This allows for the research participant to have room to interpret and answer the questions with an element of agency and personalization. This element of the semi-structured interview is advantageous within the research process, as it allows for a deeper insight into the views and experiences of the research participant.

The semi-structured questionnaires were designed to allow for an option of self-completion by the research participants. This is due to the nature of the sampling for this questionnaire. The research participants were approached during transit or at a park or coffee shop within the case study area. Thus the research participants were approached and asked to answer the questionnaire within their current urban environment. This can allow for issues of noise levels or limited time, which can influence the questioning process. Therefore the questionnaire has been designed for the research participant to answer the questions themselves, with the option to ask the researcher for more input if needed.

The questionnaires, research method and sampling process have been designed with the intent to capture the individual's opinions and experiences within their spatial environment and transit environment. Due to the nature of these questionnaires and the sampling system, there is no traditional interviewing method applied or the audio recording of the information.
This system was designed with the intent of capturing the researcher participant's opinions and experiences within the moment, and within their current urban mobility and transit process. This allows for the research participant to express their current feelings of safety and mobility as they are acting out and experiencing their urban mobility procedures.

Annexure 2A demostrates the design of the semi-strucutred questionaires used within the research process.

3.5.2 Structured Surveys

The research tool used to acquire more quantitative data is through a set of structured surveys which are designed as self-completion questionnaires. The survey is designed with a series of 'closed questions' that require simple answers of either a 'yes' or a 'no', or the ranking of a scale. This system allows for the option for the absence of the researcher within the questionnaire process. This can allow for the participant to answer questions without outside influence or possible guidance from the researcher. The nature of this design is that it allows for a multitude of advantages, as well as presenting various limitations within the research process. The advantages include the accessibility and simplicity within the process – the surveys are easy

to use with a practical approach for participants to engage. This is visible in the design of the surveys in order to minimize confusion for the participant. The surveys are also designed to be shorter in length and information required so as to avoid 'respondent fatigue' within the process (Bryman, 2012).

The design of the survey is intended to limit the respondent opinions through very specific and 'closed questions'. This poses the opportunity for gaining specific knowledges, but also the option of losing deeper insight into participant's opinions or personal experiences. Annexure 2B is an example of the survey used in the research process.

3.5.3 Sampling

The structured surveys use the format of quantitative non-probability sampling which deals with a deliberately selected sample of inner city public transport commuters from a larger group sample. However, the selected sample is not used to represent the population as a whole, but rather to create insight into some of the minority social groups and their behaviour within the system. This minority group is defined through the data and experiences of women at the centre of analysis. However, the experiences of men who use public transport within the inner-city are also included and highlighted. This is intended as a way of creating a balance of opinions and to find possible similarities or discrepancies of perceptions of personal safety between the different genders.

According to Richie & Lewis (2003) it is important that the sample size is diverse in its cases within the boundaries of the greater population. This diversity will ensure a developed and in-depth analysis of the research question posed (83). The diversity within the overall selected sample is defined by a gender classification as well as an age group classification. This allows for obtaining both male and female experiences across a range of ages.

Within the scope of this qualitative sampling method the use of 'snowball sampling' was used in order to find more interested participants that fit the criteria (Punch, 2005). This 'snowballing' technique happens when one research participant offers to include their individual social circle to the research – friends, work colleagues or family. This is also considered a form of 'convenience sampling' as the desired research sample are easily accessible to the researcher. This convenience is possible because the researcher is part of the urban environment in the sense that the researcher takes public transport within the case study area. This is beneficial for the research study as the return rate from respondents is much more positive and often faster; as the researcher is immersed within the environment and mobility activities (Bryman, 2012: 201-220). It is also noted that this technique relies on the understanding of bias and the researchers influence on the process. This is unpacked further in the ethics and limitation section below.

3.6 Data Analysis and Interpretation

The semi-structured interviews and surveys gathered within the fieldwork will be analysed with the understanding of obtaining personal,

individual opinion and experienced based within the research topic. The data collected from the semi-structured interviews and surveys displays a small sample size- which does not represent the whole population or generalized opinions and experiences. Therefore the data will be interpreted as such and will not be applied to a larger spectrum, but rather as a small insight into some individual issues and understandings.

It must be noted that the analysis and interpretation of the data collected is anchored in the process of informing the mobile App prototype and associated 'Safety Evaluation System'. Thus the data collected will be used as a way of translating a small sample of qualitative and experienced information into a tool for the App design process.

3.6.1 Structured surveys

The structured survey questions will be coded and accumulated in order to view possible trends and systems. This will be used in order to find possible trends between gender, age and feelings of personal safety. The information gathered from the coding and analysis of this data will be paired with the more qualitative and in-depth experiences found within the semi-structured interviews (Bryman, 2012).

3.6.2 Field notes and observations

The semi-structured interviews are paired with field notes and observations made by the researcher during the process. These field notes and observations will be used in conjunction with the opinions expressed by the participants. The field notes are used to highlight elements that are not captured in the semi-structured interview questions. These elements include observation the researcher made based on some commonalities and differences that are exposed within the research process.

3.6.3 Personal Communication

Information regarding the App and database design that is expanded upon in Chapter 5 was obtained through personal communication with two ICT-based companies. Both companies are based in Cape Town and were approached for guidance and knowledge regarding; API systems, database interfaces, database layouts and user-generated systems. The personal communication with the companies is referenced throughout as 'personal communication' as the individuals are kept anonymous and the communication was done in a casual, conversational form.

3.7 Limitations

3.7.1 Ethical Considerations

Ethical consideration is an important aspect in qualitative research that is based in individual opinion and experiences. This has been highlighted through the ethical consent forms that research participants were asked to sign before embarking on the semi-structured interview. This ethical consent is used to protect the research participant through the promise of anonymity and consideration of the personal opinions and thoughts expressed.
The researcher requires to carry out these research technique with

the consideration of the ethics behind obtaining qualitative and personal information. This resides in the researchers understanding to do no harm to research participants and to be weary of the possibility that this research could bring about elements of distress to the research participant. The ethical consideration of the researcher is based on positionality of applying an intersectional lens of gendered experiences without applying personal judgement and bias (Hill Collins, 1994).

3.7.2 Constraints

It must be noted that one constraint within the research process is that of limited time. This includes the limited time in which the research process can occur, as well as the time in which to obtain all data and analyse the findings. Due to the limited timeframe of the research process it must be noted that the fieldwork and data collection is representative over a short time period. This further highlights the claim that the research and data collection is not representative of an entire population and is very time specific.

Furthermore it must be noted that the data was collected over a period of three week, over the winter months of July and August. This timeframe will influence the data collected on the topic of public transport user safety, based not only on the shortness of the research process, but also the weather during these months. This constraint is present within the topic of NMT and public transport users as weather conditions have a visible effect on commuters and their frequency in taking public transport, walking and their ability to respond to questionnaires.

3.7.3 The Researchers influence

It must be noted and made visible that of the researcher's gender and how this is effected and affects the fieldwork and research process. The researcher herself is submerged within the mobility routes found within the case study, and is an actor within the urban transit experience. Thus the researcher is herself influenced and affected by issues of personal safety and vulnerability within the commuter and fieldwork process due to her gender.

This element can affect the research process and output as the researcher has to approach different individuals within the urban mobility environment. This can affect the research participant's reactions and responses to the researcher and the research question. The process is also affected by the researchers own experiences of personal safety within the transit and research process – thus some cases, streets, times-of-day and public areas may have been avoided due to the researchers own decisions based on personal safety.

It can be argued that this poses a limitation on the research process through a lack of openness to represent without bias or personal opinion or agency. This much is true, however it can also be used as a tool to further highlight how present and visible gender-based issues are within the overall research topic of human-scale commuter safety and urban mobilities.

3.8 Conclusion

This chapter deals the research methods and techniques applied in obtaining qualitative information on perceptions of safety within urban mobility and urban spaces. It has relied on placing a gender-sensitive lens onto the topic of pedestrian safety and experiences of vulnerability within the urban environment. This theoretical foundation of a gendered lens has attempted to create a platform to gain deeper understandings on perceptions of safety by both male and female participants across a range of ages. The data has to be spatially and socially contained within the case study of the Cape Town Central Business District.

The research processes, tools and techniques highlighted in this chapter are devised with the objective of creating an ethical gathering of opinion-based information on the topic of commuter safety and urban mobility. The information gained is vital in the design process of creating a mobile phone App prototype and associates Safety Evaluation System which can be used to inform safer commuter experiences and future planning and urban management implementation.

The mobile App prototype is deigned on the premise of utilizing user-generated data as a tool for gaining deeper insight into social issues and functions. Thus it is vital to highlight how the qualitative data within this study is a form of user-generated data. The qualitative data shared by the participants becomes the foundation for creating the App. This is based on the need to highlight the importance and presence of the user or 'smart citizen' within the urban space and urban mobility networks.

Chapter 4: Findings

4.1 Introduction

The findings that are analysed in this chapter are from the two research techniques outlined in Chapter 3. This includes 20 quantitative structured surveys and 5 in-depth semi-structured questionnaires. These research techniques were paired with observations within the field. The research participants were found and engaged-with during their everyday commuter trips within the urban spaces of the Cape Town Central Business District (CBD) over a period of 3 weeks. This research method and the data that is collected and shared between the researcher and research participants is pursued with the desire to extend the narrative of safety and urban mobility that has been discussed in the previous chapters. This information is also vital in understanding how ICT systems can become a tool to assist citizens in safer pedestrian transit. Thus, this chapter deals with the views, needs and creative ideas of participants towards the creation and design of a transport and saety App.

The concepts of personal safety and pedestrain-based moblity were the main focus of the research process. This knowledge was gained through applying a gender-sensitive lens to the kinds of questions asked. It allowed for gaining deeper understandings as to how safety and NMT moblity are affected by gender dynamics and social structures.

The research collected from participants has been analysed through the system of highlighting reoccurring themes. These themes occupy both social and spatial elements that occur within the research and questioning process. The themes identified are also influenced by the literature in Chapter 2, which also influences the design of the research questions and survey structure. These themes are accompanied and expanded upon through observations that occurred during the research process and were not explicit within the written answers or responses from participants. This deals will bringing forth some stories and opinions that research participants shared with the researcher during conversations about safety and mobility.

The final aspect of this chapter is to unpack the opinions, desired and ideas put forward by the participants regarding the creation of a 'Safety and Transport' App prototype. This is a vital step in creating and determining the parameters for the App. This section highlights the participant's understandings and experience of what ICT system can provide and what they are lacking. The information gained in this chapter is vital in the creation and structural design the App prototype in Chapter 5. The knowledges and experiences shared by the participants are vital in the understanding of how user-generated data, user feedback and user input are paramount in the process of creating safer and more accessibility urban mobility and cities.

4.2. City of Cape Town Context

The City of Cape Town has a series of plans to facilitate the drive towards creating a more integrated public transport network within the city. The integrated public transport model includes various modes of transport as well as the inclusion of non-motorized transport (NMT) systems such as cycling and pedestrian-based mobility. Ho-

wever, these documents include a limited amount of information, data and planning implementation towards NMT based transport infrastructures.

The Cape Town Spatial Development Framework (2012), Cape Town Comprehensive Integrated Transport Plan (2013), Table Bay District Plan (2011) and the Transport Cape Town NMT Report (2005) are analysed in order gain an understanding of the current Cape Town context through the lens of public transport infrastructure and NMT systems.

4.2.1. Definition & Vision of 'Integrated Rapid Transport'

The Cape Town Integrated Transport Plan, CITP (2013) is based on a holistic approach to creating and managing a 5 year public transport plan for the City of Cape Town. This plan is bound to the terms stipulated by the National Land Transport Act (No.5 of 2009) and must be updated yearly. The Integrated Transport Plan (ITP) must be linked with and informed by the Cape Town Spatial Development Framework (CTSDF) guidelines and recommendations.

According to the CITP (2013) the definition of 'Integrated Rapid Transport' (IRT) systems is part of the national public transport orientated initiative that seeks to create safe, efficient and quality public transport in Cape Town. The Bus Rapid Transport (BRT) is a subset system that resides in the creation and facilitation of an integrated transport system.

The vision and overall objectives of the Integrated Transport Plan is to "...deliver an integrated, accessible, safe, reliable, affordable, sustainable and quality transport system and property infrastructure through socially just, developmental and empowering processes, to improve the quality of life for all."(CITP, 2013).

4.2.2. Spatial Development Framework & the Integrated Transport Plan

The Cape Town Spatial Development Framework, CTSDF (2012) and the Cape Town Comprehensive Integrated Transport Plan, CITP (2013) place a strong emphasis on an integrated transport model as a way of creating better employment opportunities through equality of access and improvement of opportunity for all. The current CTSDF places a strong focus on an integrated lens that links transport and accessibility with environmental sustainability, investment opportunity and economic growth. The integrated transport systems is also seen as a way of alleviating the past socio-spatial issues of segregation which are present within the Cape Town Metropolitan.

4.2.2.1 Intercept Survey data

The CITP (2013: 251-263) performed an intercept survey in 2012 to a selected group of 2438 individuals across 24 sub-councils in Cape Town. This survey was formulated to unpack priority needs and requirements for public transport users. The public transport-user survey sample was targeted at transport interchanges for the research data collection process.

The results indicate that 27, 5 % of participants indicated a greater need for safety and security within the public transport systems, with a further 27, 2% highlighting issues of overcrowding within these systems. Another issue that was highlighted was that of 'walking time' within the public transport systems with a 10, 7% dissatisfaction rate. Participants indicate that they endured a lengthy walk from their home to the nearest pubic transport system. This indicates that many public transport users within Cape Town are incorporating the transport mode of walking into their urban mobility and transit experience. It also indicates that participants are dissatisfied with the amount of walking-time that is required in order to access the public transport systems available within Cape Town.

The intercept survey also collected data for 'Stranded Users'. This 'Stranded User' demographic was targeted at community facilities and represents commuters that struggle to easily travel by car or by public transport on a daily basis. The highest demand (36, 7%) within this 'Strandard User' group was that of the need for safer and more secure public transport systems. It was indicated that the participants were concerned about their personal safety within their public transport experience.

The CITP report also highlights the categorization of 'safety' as; accident free systems in road safety. The definition of 'security' within this report was defined as 'protection from personal harm' when involved in public transport based commuting. This information is important in understanding what the City of Cape Town and the associated public transport officials and planners consider as 'commuter safety' and as public transport based 'security'.

The CITP (2013) definition of transport based 'safety' and 'security' is divided into two different factors. Their definition of 'safety' deals more with road accident avoidance than of explicit issues of personal safety from crimes or violent acts. 'Security' focusses on personal harm and the protection from social vulnerability.
It can be argued that the concept of NMT or human-scale mobility deals with a both issues of 'safety' and 'security' simultaneously. This is due to the vulnerability pedestrian-based commuters have of being involved in road and vehicular related accidents, as well as the vulnerability to becoming a victim to safety issues of violence, crime and personal harm.

According to the Transport Cape Town Road Safety Strategy (2013) in the year 2013, 58% of the total deaths due to road accidents involved pedestrians. With a further 2% of road accidents deaths involving cyclists. This data indicates that NMT users are at risk within the greater urban mobility networks and require intervention to improve safety and security.

4.2.3 NMT in Cape Town

The Cape Town Comprehensive Integrated Transport Plan (CITP) has a limited section dedicated to Non- motorized transport (NMT) systems; with the dominant provision of NMT planning focussed on the expansion of bicycle and cycle-lanes. Since 2010 the City has rolled-out the construction of 400 metres of pedestrian and cycle based lanes within the greater Cape Town area. The most dominant project being that of the Klipfontein NMT Corridor which has been initiated under the City-wide NMT programme. This programme has

also included that cycle lanes introduced along the R27 IRT route. However, these new projects are lacking in various elements and support. According to the Integrated Transport Plan (2013) there is currently a lack of evaluation data and inventory data of lighting and visibility infrastructures within the new project. These road-network upgrades fall outside of the case study of the CDB, yet they demonstrate the current institutional input to the NMT and public transport movement as a whole.

The City of Cape Town in association with Transport for Cape Town (TCT) created and added an NMT strategy system that guides planning and implementation for NMT infrastructures and mobility systems. This has been formulated in the NMT Strategy for the City of Cape Town as a tool for understanding and providing for NMT infrastructures into the future. The strategy attempts to unpack two objectives; firstly to create a policy that supports NMT systems and users. Secondly, to create a strategy plan that indicates where NMT routes and systems should take place within Cape Town Metropolitan. This strategy plan attempts to prioritise NMT systems within specific areas in order to maintain NMT culture and transport (Transport for Cape Town, 2005).

4.3 Current Public Transport Trends in Cape Town (and South Africa)

According to the 2013 National Household Travel Survey the statistical number of classified 'workers' (aged 15 and above) in South Africa that rely on public transport to get to work is 40%. Within in this survey it is demonstrated that walking contributes 21, 1% within their public transport movement systems. This indicates that at a National scale; public transport systems contribute to a fairly large portion of citizen's mobility systems. The data does not indicate if the 'walking' data percentage includes that of 'feeder' NMT mobility between taxi, bus or rail. This refers to the amount of walking that is done in between different modes of transport – the walking routes that link destinations to the mode of transport.

This data indicates the trends visible within South Africa and act as a foundational understating for the current public transport trends found in Cape Town and the CBD.

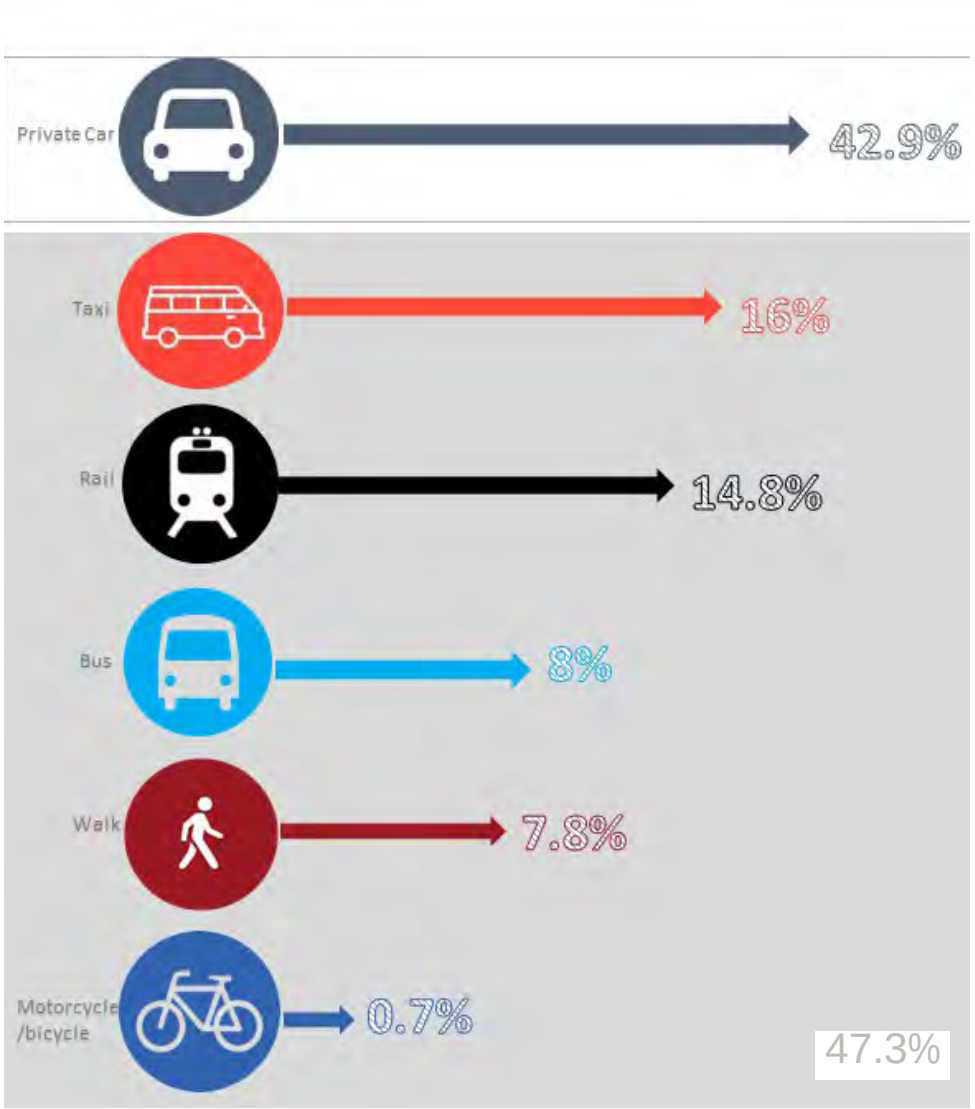
4.3.1 Transport Modes

The transport data for the City of Cape Town indicated the distribution of transport modes used within the city (Stats SA, 2012). This data indicates that private car transport is a singular dominant mode of transport at 42.9%. However, if we consider public transport as the combination of the modes - bus, taxi, rail, bicycle and walking – then it is visible that public transport is a highly used and highly needed function in urban mobility. The Figure 4.1 demonstrates the different modes of transport used within Cape Town.

The 2012 data demonstrates the amount on non-motorized transport (NMT) mobility through walking and cycling. The combination of these two NMT modes indicates a percentage that is similar to the percentage of commuter using bus systems for transport. This indicates that there is a considerable amount of NMT related transport being utilized within Cape Town and the public transport domain (See Figure 4.1).

It must be noted that the data taken from the Stats SA (2012) does not add up to 100. This indicates missing information that was not presented within the document. However, this was the most recent dataset found during the research process and has been used accordingly.

Figure 4.1 Different modes of transport used in Cape Town *(Stats SA 2012, City of Cape Town. Analysis: Authors Own 2016)*



4.3.2 A Gendered view

The Figure 4.2 is an infographic taken from the Low Carbon Policy Brief (Kane, 2016) through the Open Streets Cape Town organisation. This figure has analysed the 2013 City of Cape Town (Stats SA) data to interpret how men and women get to work, and which modes of transport they predominantly use.

The analysis indicates that within Cape Town, men are the dominant private car users for commuting to work. This is paired with the data that more women are using the private car transport mode as the 'car passenger'. This information perhaps demonstrates that more men own private vehicles or that more men are using private vehicles as the driver, and that women are more likely to be in the passenger position for commuting.

Figure 4.2 indicates that within the public transport realm there are more women using public transport systems as a whole than men. However, there are more men using Rail and pedestrian or 'walking' as their public transport mobility system. This trend could be due to the lack of personal safety within these two modes of public transport and the vulnerability NMT mobility is exposed to within the urban environment.

This information gives an insight into the current Cape Town trends of public transport modes and the user demographics within these modes. This facilitates an understanding of how people may be using and experienced public transport infrastructures within the urban landscape depending on their gender.

Figure 4.2 Gender Dynamics in transport use *(Data: City of Cape Town, 2013. Analysis Nel and Kane, 2016)*

4.3.3 Mobile Phone Trends in South Africa

The South African Mobile Report: A Survey of Desktop User's Attitudes and Uses of Mobile Phones (2014) indicates the most dominant mobile phone trends according to user demographics, data trends and data usage trends.

When the concept of a 'Smart Phone' is mentioned throughout this study, it is referring to a mobile phone that has more advanced computing and connecting capabilities than that of a feature mobile phone. Smart Phones are important tools of ICT systems as they are able to facilitate Apps through the use of internet capabilities, GPS capabilities and computing capabilities.

In order for the concept of promoting ICT systems as a tool for NMT safety – it must be considered as to who has access to such technologies.

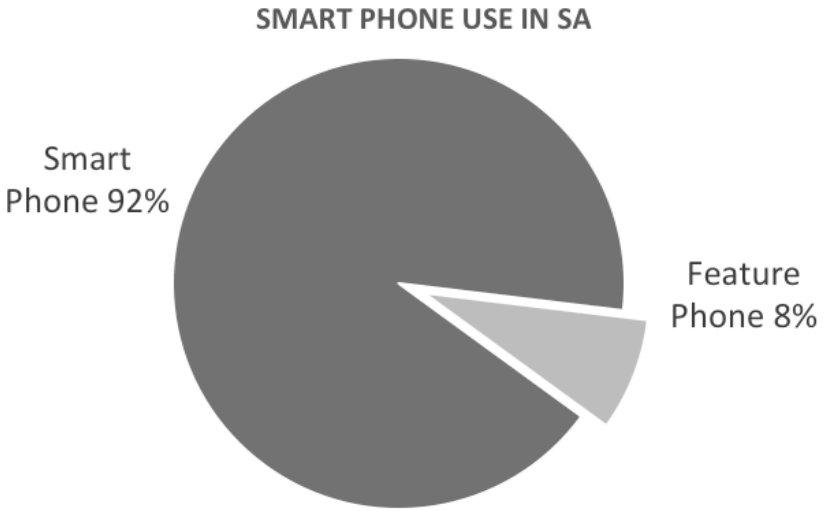


Figure 4.3 Smart Phone use in South Africa *(South Africa Mobile Report, 2014.)*

According to the South African Mobile Report (2014) the amount of Smart Phone users in South Africa was 92 %. Of these Smart phone users 80.2% use their mobile phone to access the internet or use internet capabilities (See Figure 4.3).

Of the 80.2% of mobile internet users there is a divide with regards to access to the internet source. 66% of mobile users subscribe to a data plan.

Within the data plan system a further 65% subscribe to a monthly mobile contract, and 35% use a pay-as-you-go or prepaid system.

This data indicates the distribution of Smartphone use and how these users are accessing ICT systems such as the internet in order to stay connected. This information is important in promoting the design of the mobile phone App as an ICT that can become a helpful tool for public transport users within the Cape Town context. The data demonstrates that a large number of South African have access to Smartphones and therefore have access to the functions and capabilities this system provides.

4.4 The Case Study Area: Cape Town Central Business District (CBD)

The concepts surrounding urban mobility become centred on the functions and systems present within the Cape Town Central Business District (CBD) area. This case study area is identified as an urban node that has an integration of social, technological, communication and economic functions within the spatial environment.

The Cape Town CBD is a dominant and competitive economic hub of the Cape Town Metropolitan area. The CBD functions as a meeting point for urban mobility as the environment supports an integration of different transport systems. This is the urban space where the Metrorail and BRT systems meet and are integrated with other forms of public transport systems such as taxi, mini-bus and non-motorized transport (NMT) systems such as cycling and pedestrian-based mobility (CTSDF, 2012).

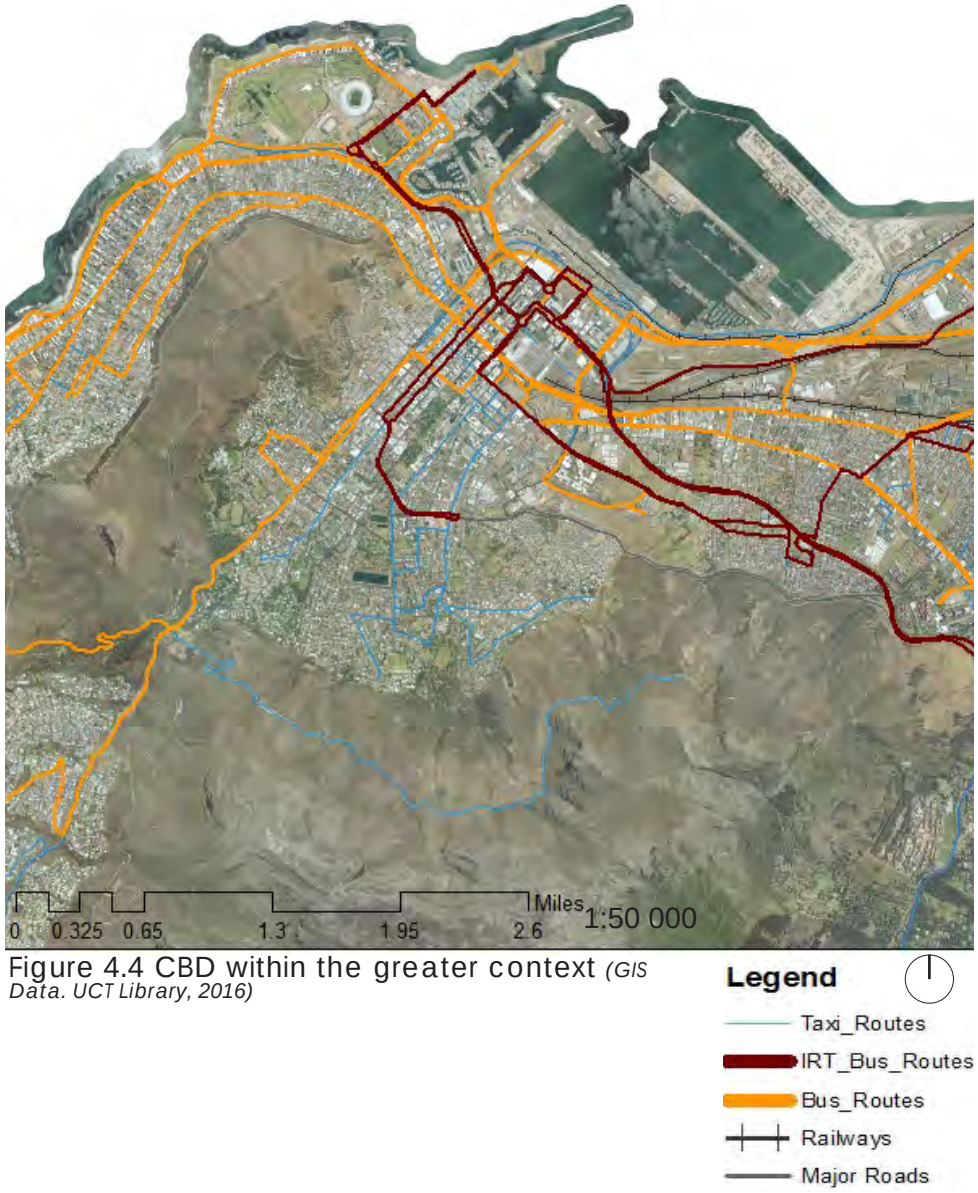


Figure 4.4 CBD within the greater context *(GIS Data. UCT Library, 2016)*

The Figure 4.4 and Figure 4.5 spatializes the Cape Town context and demonstrates the relationship between the CBD and the surrounding neighbourhoods. It identifies the major transport routes that create access into the CBD from the external road networks within of the city. These accessibility routes include public transport infrastructures and road networks that support the Metrorail, Integrated Rapid Transit (IRT), Bus Rapid Transit (BRT) and mini-bus and taxi systems.

According to the Cape Town Integrated Transport Plan (2013) the IRT facilities are classified as routes that integrate the BRT, minibus taxi integration and Metrorail into the greater transport systems. The IRT routes also facilitate space for feeder bus systems and improved facilities for pedestrian and bicycle mobility. Therefore the IRT routes facilitate road space and accessibility for these integrated forms of transport. The IRT routes also attempt to act as a linking network for other associated modes of public transport.

Figure 4.5 Surrounding neighbourhoods *(GIS Data. UCT Library, 2016)*

The BRT facilities are classified as a bus-based system that is cost-effective, fast and comfortable for public transport commuters. The BRT routes include right-of-way road infrastructures to facilitate the bus system within the urban environment and greater road network. The BRT systems also provide for a safer commuter experiences through the presence of security personal and CCTV infrastructure at BRT stations (Cape Town Integrated Transport Plan, 2013).

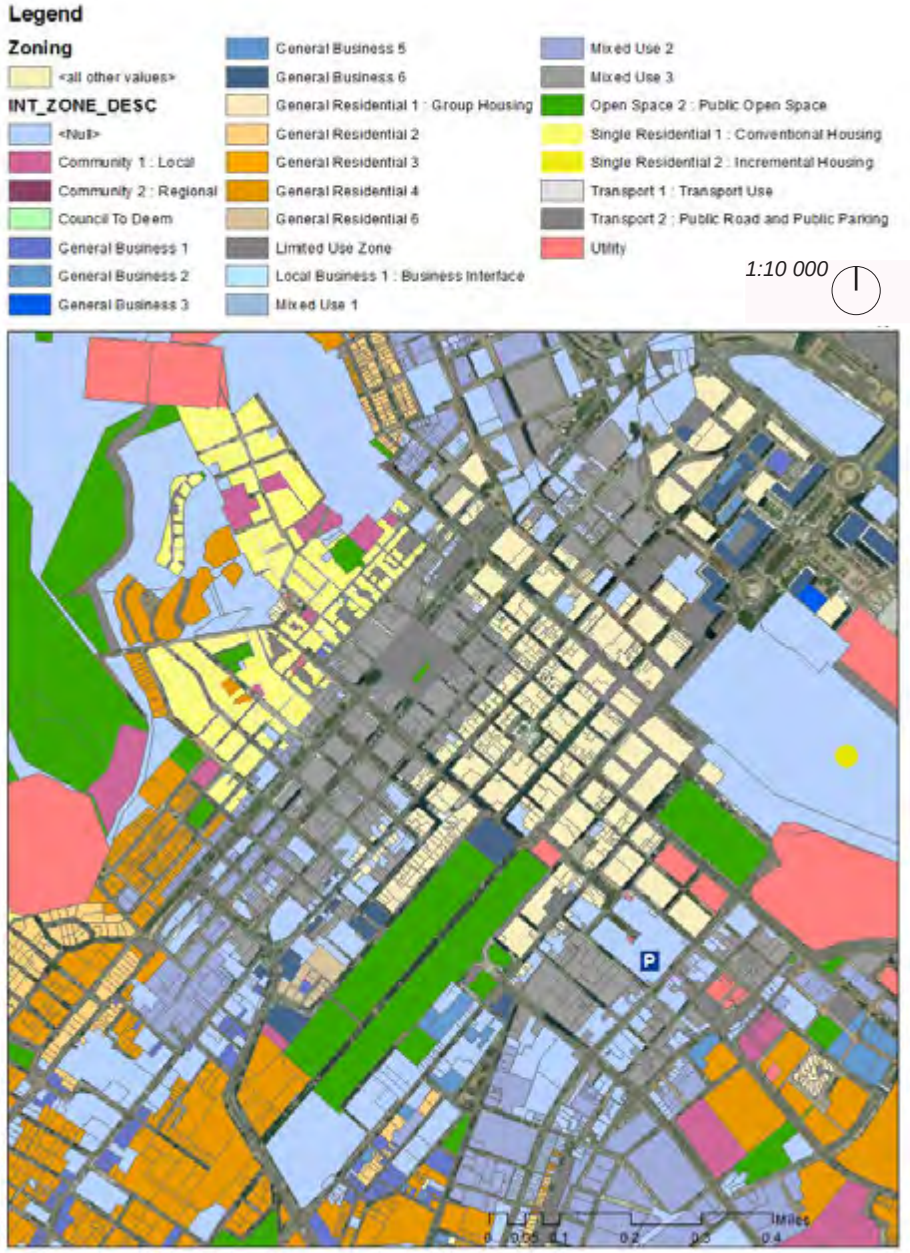
The focus area within the CDB case study is defined by the urban landscape between the foreshore and the edges of the suburban neighbourhoods on the slopes of Table Mountain. This designated study area includes the MetroRail Main Station, the Civic Centre My-CiTi Station and the associated BRT and IRT routes. The case study area also includes the Cape Town Central Police Station (See Figure 4.6).

4.6 CBD Public transport routes and stations *(GIS Data. UCT Library, 2016)*

This area in the CBD also has the presence of many public open-spaces, civic buildings and highly pedestrian-dominant movement corridors. The study area also holds a multitude of urban functions and land-uses that include commercial activity, residential, office, light industrial as well as social and community amenities. This indicates that the area has a mix of functions that include economic, community, civic and social elements. Therefore it can be argued that these urban functions and systems require the presence of public transport in order for citizens to access the functions present within the urban environment.

Figure 4.7 demonstrates the land-use found within the case study area. The zoning indicates a area that includes Residential use, Mixed Use, General business, Open Space and Transport 1 and 2 zones.

Figure 4.7 CBD Land-use *(GIS Data. UCT Library,2016)*



4.5 General findings

This part of the chapter begins by using the data collected from the structured surveys as a way of creating a foundational understanding of the issues within the research. The information gained from the surveys is used to visualize the current issues of safety, gender discrepancies and access to public transport within the case study area.

The first section reports on the survey results, the questionnaire with randomly selected respondents; the second section reports on semi-structured interviews. The survey information is then used as a tool to highlight and ground the experiences and options expressed within the more in-depth questionnaires and fieldwork observations.

4.5.1 Survey Results

The structured survey comprised of a sample size of 20 participants, of which 8 were self-identified males, and 12 self-identified female participants. These participants were found and engaged with at various locations within the Cape Town CBD. This included areas such as public spaces, coffee shops, walking from public transport systems and in public transport nodes and hubs. Participants were most often engaged with during morning and later afternoon times when commuting to or from work in the morning hours and evening hours between 7am and 8 pm.
The participants were asked a series of questions in order to gain a deeper understanding of the issues of gender and safety, urban mobility and the uses of technology in individual transit experiences.

4.5.2 Safety

Of the male participants 75% (6 out of 8) feel 'unsafe' using public transport system in Cape Town. However, when asked if they feel 'safe' walking to and from public transport system it was indicated that 62, 5% of male participants felt safe to walk. This poses interesting information regarding how a sample of men experience and use public transport. This indicates a recognition of feeling 'unsafe' within public transport systems, yet feeling more 'safe' when walking the streets to or from these public transport systems. The survey sample indicated that 75% of male participants plan their mobility routes based on their personal safety. In conjunction, all male participants indicated that personal safety is an important aspect for them within public transport systems.

The female sample of respondents was 12 of the overall sample of 20. Of these respondents 50% felt 'safe' using public transport systems. However, 60% of respondents indicated feeling 'unsafe' walking to and from different modes of public transport. The survey indicated that all female participants plan their transport routes based on their personal safety. The survey also indicated that all female participants consider 'safety' a highlight important aspect within public transport and mobility.

The survey demostrated interesting information regarding expereinces and feelings of safety in public trnasport systems and in pedestrain NMT mobility. The survey indicated that men felt more safe when walking as a mode of transport, whereas women felt unsafe when walking.

Both male and female particiapts indicated that their personal safety is an important factor in their public transport and urban moblity experience. This information is important as it supports the results found in the next section- where the survey shows that personal safety is one of the more important public transport factors in relation to affordability and convenience.

During the survey process it must be noted that many female participants engaged with the researcher on explaining some of their responses. Many of the female participants explained that if they indicated that they felt 'safe' within transit it was because of a number of external and situational influences. This included such factors as the ability to feel safe in public transport due to the personal opportunity to take the safest route or the safest time of day to commute. The ability to feel safe was also dependant on where a participant lived or worked and their proximity to a specific public transport system. This ability to choose and plan the safest transit route or system was indicated as a vital aspect in the ability to feel safe. Many female participants indicated through conversation with the researcher that if they were unable to make 'safer' transport decisions -then their personal safety would be highly compromised and they would experience public transport differently. (Structured Surveys, July – August 2016).

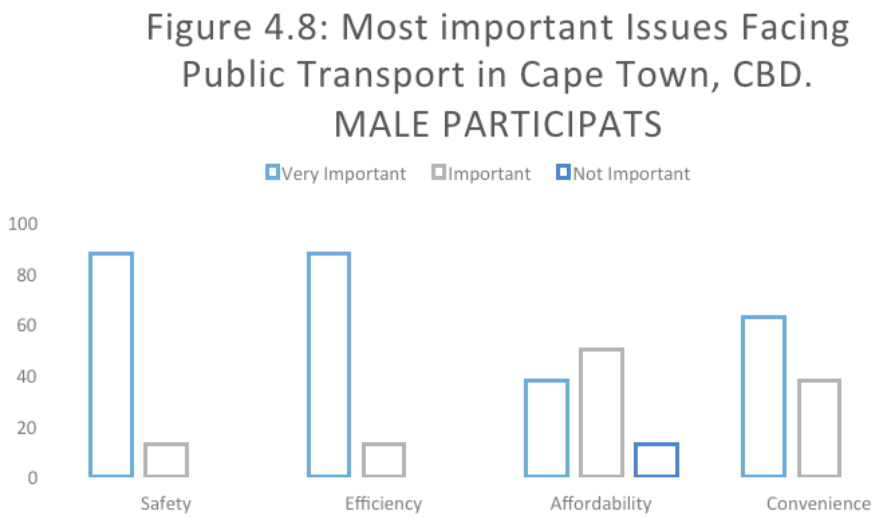
4.5.3 Safety, compared to Affordability, Efficiency & Convenience

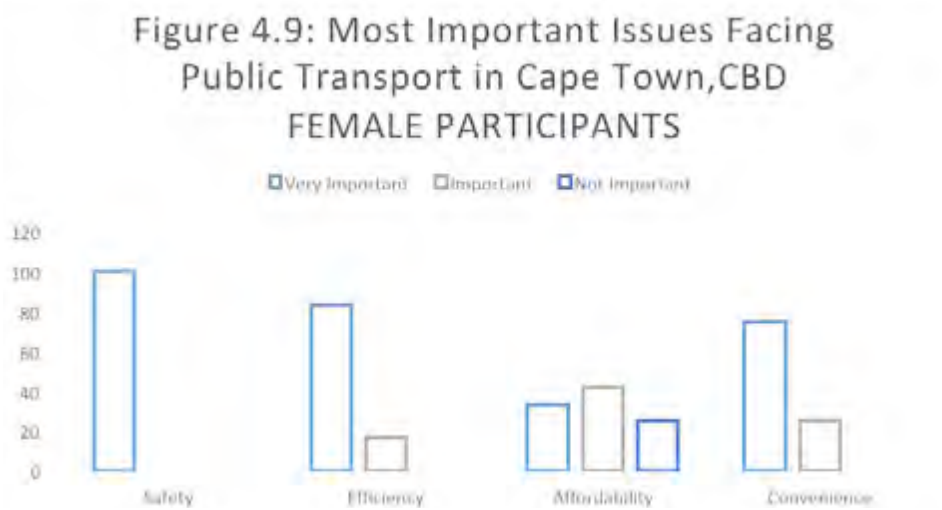
The survey asked the question regarding what are considered to be the most important issues facing public transport in Cape Town. This question was designed through the ranking of the topics of: safety, efficiency, affordability and convenience. The definition of safety for this question is that of personal safety from feelings of vulnerability or exposure to bodily harm or harassment. 'Efficiency' refers to how the public transport infrastructure is organised, how it functions and what systems if provides. This deals with practical elements such a timetables that are well designed and are used in order to have transport that is on time. 'Affordability' deals with the travel costs of public transport in the CBD and whether it hinders users from moving around the city. 'Convenience' deals with a spatial elements of proximity and accessibility to such public transport systems. It is defined as how easy and practical it is for the commuter to use, access and rely on the transport infrastructures.

All male and female participants indicated that safety is one of the most dominant issues facing public transport systems. Alongside with safety is the important for the need for efficiency in public transport systems. The Bar Charts (Figure 4.8 and 4.9) below indicate the break-down of information and the ranking of most prevalent issues based on the different genders.

A large proportion of both male and female participants indicated that affordability was not the more important issue facing the public transport system. Figure 4.9 indicates that 25% of female participants indicated that affordability was not an important issues facing public transport systems. This trend was similar for male participants as 12.5% indicated affordability was not the dominant concern.

Through observations with female respondents it was indicated by more than half the respondents that they would pay the public transport fees or even a higher transport fee if safety was improved. This gave an explanation to why affordability was not ranking high on the list of priorities for users. One participant expanded on this statement during a conversation in the research process. She explained that: "…my position…realisation recently is that affordability is over emphasised – safety and comfort are more highly valued."(Fieldwork Observation, 2nd August 2016).





Both Figure 4.8 and Figure 4.9 demonstrate similar opinions and outputs from both male and female survey participants. Safety and Efficiency are considered the most important issues and most needed elements in public transport and urban mobility.

4.5.4 Semi-structured Questions & Participants

The research participants used within the semi-structured questionnaire process comprise of 5 individuals. All participants were asked to sign a form of ethical clearance as well as the protection of their personal opinions and experiences through the promise of anonymity. This research process was also accompanied by observations taken by the researcher as stories and personal experiences were often shared between the participant and researcher within the process. This sharing of stories occurred in a 'conversational' manner if participants felt comfortable to share and express themselves further.

4.5.5 Research participants

For the purposed of un-packing the findings the research participants remain anonymous due to the nature of ethical protection. The only personal information attached to each participant is that of their self-classified gender and age. They will be assigned a number 1 through 5 as a means of identifying a participant and their personal views displayed within the findings. As stipulated throughout the research process thus far, the use of race or racial classification has not been applied to participants. Rather an age and gender spectrum has been applied in order to obtain a multitude of different experiences based on these social factors. The participants are identified as follows.

Participant 1: Female, age 15.
Participant 2: Female, age 55.
Participant 3: Female, age 27.
Participant 4: Male, age 26.
Participant 5: Male, age 30.

All of the above participants use public transport systems in and around the Cape Town CBD area. The participants have collectively expressed public transport modes to be that of: the bus, train, mini-cab, Uber and pedestrian mobility.

4.5.6 Questions asked

The questions asked within the semi-structured questionnaires dealt with a series of topics. This included asking the participants to express their day-to-day travel programme; the modes they use and their everyday mobility choices. Other questions include their personal opinions and feelings towards their own safety, and also their understanding of the safety of others. Participants were able to highlight the social elements that affect their feelings of safety – to expand on possible gender dynamics within the urban environment. This concept of safety was also paired with questions on safety and the spatial environment. Participants were able to give their account of the spatial and structural elements that promote feelings of safety or vulnerability. Participants were asked to identify places, streets and parks where they felt safe or unsafe and what contributed to that experience.

Finally participants were asked to delve into the concept of technology as a tool for promoting safer commuter experiences. They were asked about their use of personal mobile phone Apps within their commuter experience. This was concluded with an open ended question were participants would express what they would want from a safety and urban mobility mobile App. This allowed for participants to speak freely on their ideas around what they want, how it should be displayed and the possible benefits thereof.

It was found that throughout the process the research participants felt the desire to share stories and experiences with the researcher that were highlighted within the questionnaire. Thus observations were taken during this process as a means of expanding the shared knowledge that was expressed beyond the written responses.

4.6 Themes Identified from the interviews

From the collection of qualitative semi-structured questionnaires and fieldwork observations there are several themes identified that occur throughout the research and findings. The questionnaire and survey were designed to attempt to gain new knowledge on urban mobility with a focus on how much walking and pedestrian mobility contributes to and links the overall urban mobility system. The theme of personal safety and freedom of movement is at the foundation of the research. Thus the themes identified from the research findings include issues of social perceptions of safety, spatial contributors of perceptions and experiences of safety and then the socio-spatial manifestations of such experiences.

The themes that are identified underpin the variables that influence the design of the safety and mobility app. These themes will later be used as a tool to analyse mobility routes, streets and public spaces within the Cape Town CBD.

4.6.1 Social aspects of safety in mobility

The literature analysed in Chapter 2 has highlighted the understanding that concepts and perceptions of personal safety and urban mobility reside in the combination of social indicators, spatial elements and socio-spatial manifestations. Heinrichs & Bernet (2014), UN Habitat Report (2013) and Loukaitou- Sideris, (2006) have highlighted how urban mobility is greatly affected and influenced by societal aspects of inequality in the realms of accessibility, affordability, personal safety, vulnerability and fear. These aspects of inequality are grounded within the understanding of how the 'gendered society' perpetuates and guides such issues. Thus within the social aspects of urban mobility and experiences of safety is the paradigm of gender inequalities, power relations and discrepancies (McIntosh, P. 1995). According to Da´vila (ed.), (2013) this gender paradigm is argued to often make absent the needs and experiences of women out of the greater urban mobility model, infrastructural systems, structural design and urban environment.

This subsection highlighted the social influences and social experiences of personal safety, fear or vulnerability felt within the urban environment, and more dominantly within the topic of urban mobility. The social experiences are uncovered through the semi-structured questionnaires and fieldwork observations which serve as a form of primary research within this topic.

The experiences of safety that are expressed through the primary research are grounded in the framework of human-scale mobility. This deals with understanding how walking as a form of urban mobility is experienced within urban spaces.

4.6.2 Walking mobility

All of the research participants experienced and expressed walking as a part of their urban mobility. Walking was explained as a linking form of mobility to access and join the commuter to different forms of public transport. Often a large portion of time within moving from one destination to the next is spent on walking. This includes examples of walking from home to the bus, then walking again from

the bus to work. These linkage trips or feeder trips are predominantly achieved through walking.

The research participants unpacked their experiences of human-scale mobility and the multiple external spatial and social elements that affect the function of walking. It becomes clear through the unpacking of the research findings that pedestrian mobility is an important function within the greater concept of mobility. It can be considered an essential and immutable aspect in moving around the urban environment. However, through the gendered lens of analysis it becomes visible that different individuals experience the system of pedestrian mobility on a multi-layered platform under the topic of socio-spatial perceptions of safety.

4.6.3 Perceptions and feelings on safety in spaces: the gender lens

The research participants were asked a probing questions regarding social concepts of safety through a gendered lens. This dealt with asking questions on what affected their own personal sense of safety within pedestrian mobility. This was then overlaid with the direct and assertive question:

"Do you think it is safer for men to walk, than it is for women? And why do you think that?"

This question was specifically designed to generate possible uneasiness and perhaps confusion with some of the research participants. The question is designed under the premise that it is widely understood - both through discourse analysis and contemporary media – that it is most often less safe for women in urban environments. Perhaps more profoundly it is visible that women are more vulnerable and susceptible to sexual and verbal harassment, assault or violence within urban environments within societies (UN Habitat, 2013).
Therefore the probing question was designed to allow a platform for participants to express a personal opinion as to why and how such gendered issues transpire within urban spaces, urban mobility and concepts of safety.

4.6.3.1 Safety Issues highlighted by men

There were two male participants used in this research process – both work in Cape Town CBD and used various forms of public transport to get to work, including that of pedestrian mobility. They will be referred to by the titles 'Participant 4' and 'Participant 5' throughout. Participant 4 is 26 years of age, and Participant 5 is 30 years of age. Both participants were asked questions about their personal feelings and perceptions of safety. Then they were asked to apply their opinion regarding issues of gender and safety within society and the urban environment.

Both participants indicated that they generally felt safe when using public transport systems such as the Metrorail and the MyCiTi BRT. They both indicated that they felt safe walking to and from these mobility systems – they felt safe to navigate the urban environment and city streets on foot. Participant 5 indicted that he felt safe walking and taking public transport systems because of his gender. Both of the participants explained that they did consider it safer to walk around the city as a male – they considered it much less safe for

women. When asked to explain this; Participant 5 explained: "Men generally do not think about scenarios (lighting, surroundings, security) to and from destinations, but rather destination goods" (Semi-structured interview, 6 August 2016). Participant 4 explained this gendered discrepancy of safety through the notion that "…girls are easier targets I think – strength wise, handbags – easier to mug."(Semi-structured interview, 2 August 2016)

It must be noted that Participant 4 was hesitant to answer the probing question of gender safety and walking. He took time to think about his answer with a sense of caution. He explained that gender inequalities are visible, but he wondered if men and women are sometimes both equally vulnerable when walking in the city (Personal interview, 2 August 2016).

4.6.3.2 Safety Issues highlighted by women

Three female participants partook in the semi-structured questionnaires on safety, urban mobility and technology as a tool for creating safer urban mobility. The participants are identified as follows: Participant 1- age 15, Participant 2- age 55 and Participant 3, age 27. The participants were asked to express their views on how social concepts of gender affect personal feelings of safety and freedom of movement within the urban landscape. All female participants felt that it is safer for men to walk within the urban environment, than it is for women. The female participants gave various reasons for the gender discrepancies that manifest within urban mobility.
Participant 3 explained that women are seen as more vulnerable and thus become more of a target. She explained that this is due to 'gender roles' within society – mothers and women are often carrying more bags or groceries when conducting their daily mobility tasks. It was argued that this often makes women more vulnerable when walking on the street. The participant indicated that there is an ''… unevenness between men and women…" with regards to vulnerability and safety, as men can feel safe from being publicly sexualized or objectified sexually (Semi-structured interview, 9 August 2016).

Participant 2 was an older women and felt generally rather safe when walking within the CBD area. She found the streets and the public transport stations to be relatively safe due to the busyness and amount of people using the space. However, she did recall a recent uncomfortable experience she had endured when walking home from work alone in the dark through Church Square and being verbally abused by a number of men. Her previous personal experience can be seen as being interpreted within her argument for why it is safer for men to walk in the city. She explained that "…women tend to avoid certain routes and tend to walk in groups, so they take greater care and are more fearful and protect themselves more" (Semi-Structured interview, 3rd August 2016).

Participant 1 also indicated that women tend to feel more vulnerable on the streets and within different forms of public transport because of the dominant presence of men. She explained that "…men are 'stronger' on the streets. They run the public transport. It feels as though there are more men" (Semi-Structured interview, 3rd August 2016).

The opinions and personal experiences shared with the female research participants brings to light the trends identified within the survey sample. These personal experiences highlight examples of why and how women feel vulnerable and unsafe within the mobility systems. These experiences are vital in bringing forth a deeper understanding as to what the problems are at large within urban mobilities and urban public transit spaces.

4.6.2 Observations

It must be noted that during this final stage of the semi-structured questionnaire process, the researcher was required to do a substantial amount of probing and guiding the participants through the App brainstorming question. When asking what a participant would want from a safety App, the question was often met with slight hesitation. Many participants struggled to produce any ideas around what the technology could provide them with or help them with. This meant that the researcher had to get involved at the beginning of the process in order to get the ideas flowing. It required a slight push towards thinking about how technology can create some practical tools and how they can be contained within a mobile phone App model. Once conversations with the research participants began, it seemed to become easier for the participants to bring forwards their ideas and needs.

A common occurrence that was observed was that many participants thought the App ideas they put forward would be difficult or impossible to create. For example the concept that you could track a family member and their walking or transport route in order to see their personal safety. This ideas was expressed by two different participants, who finished the questionnaire by asking if such a concept was even possible to create. One participant gave no suggestions for the safety and transport App, but indicated that for such an App concept to work it would require 'real-time' safety data and updates. The participant then asked if such a system could even be made.

The response to the participants in doubt was to explain that such system often already exist. For example the location GSP system is fitted into most current 'smart phones' which allows for a tracking option. This location GPS tool also allows for pinning locations and places with 'real-time' data.

These observations are important to highlight as they demonstrate two possible notions. Firstly, that participants are unaware of the positive benefits and abilities that a mobile phone App could produce. This perception could be because such an App has not been created to support such needs, and therefore it is hard to image its possibilities. The other notion is that perhaps the concepts of the personal mobile Apps is an over-saturated system and tool that has not been as useful for the user.

This observation is highlighted by the information unpacked above in Section 4.3.5. This section gave data from the survey conducted regarding how many participants use their mobile phone to access transport information. The data indicated that 50% of all participants used their mobile phones as an information tool. However, in the semi-structured questionnaires it was indicated that all of the partici-

pants used their mobile phone to access transport information on the internet tool – but none used a transport based mobile App.
The final observation made was that once the participants felt comfortable to conceptualize ideas for the safety and transport App – they produced insightful and practical designs. It became clear that participants were happy and inspired to share their ideas and design suggestions, yet reluctant to the possibility of such an App system really working. The survey result also demonstrated that more than half of the participants would use a 'Safety and Transport' App if it was available.

4.7. Spatial aspects in Safety in mobility

The analysis of the experiences of urban mobility and experiences of personal safety not only reside in social and sociodemographic perceptions; but also in the spatial manifestation of such experiences. This deals with understanding how elements of the built environment affect experiences of mobility and experiences of safety in mobility.

The elements of the built environment that are being referred to include aspects such as design, structural elements and infrastructural systems. These system manifest themselves in the design and layout of streets, public spaces, parks, public transport nodes and transport stations. Furthermore the design of such systems inform the way in which citizen's experience and function within the environment.
Trancik (1986), Lynch (1992) and Bentley, et al. (1985) explain urban design concepts that inform how urban environments, public spaces and streets should be designed in order to create positive urban experiences for all citizens. This informs how vital well designed environments play a role in creating such experiences as safer communities, neighbourhoods and 'street life'. This emphasis on urban design forms also has implications in the realm of public transport infrastructures, urban mobility and pedestrian movement systems. This calls for the argument that well designed streets and urban spaces can enhance the public transport commuter and NMT commuter's experiences of safety and freedom of movement (Labuschagne & Ribbens, 2014).

These aspects are highlighted within the primary research done with research participants. The semi-structured questionnaires are used as a tool for participants to express how the design of the urban environment affects their personal experiences of safety and urban mobility. From this research, vital information was formulated regarding some of the spatial elements that visibly affect feelings of safety, vulnerability and accessibility.

4.7.1 Lighting & Visibility

The research participants were asked what spatial or design based elements within the urban environment affect their experiences of safety – especially safety in pedestrian mobility. The most dominant issues that occurred within the research process was the issue of lighting and visibility. Within this topic the concept of lighting defined by participants deals with street lighting, public space lighting and lighting from commercial activity along a corridor and the concept of visibility.

The participants argued that lighting in the form of street lights and the brightness of commercial activity along a street are important elements for creating a more 'visible' and 'clear' walking route. It was explained that a badly lit area or street becomes a less savoury environment to move through – most dominantly during the evening or as the day light fades within the city. The concept of lighting deals with not only illuminating and making visible the movement route, but also the commuter felt more visible and safer.

Through observation it was understood that street lighting and urban lighting tends to create a symbolic notion of safety. If a street or area is well lit and visible it creates more positive ideas of safety as the street feels more 'official', well managed and user-friendly (Fieldwork Observations, July-August 2016).

Another element within the context is the visibility and presence of official signage. The research participants indicated that often there is a lack of signs in and on public transport modes such as the train or bus. This lack of signage on the transport systems often creates an uneasiness and confusion as to what the current location is, and where the desired location is. This lack of signage and navigation can contribute to difficulties in moving around the city freely and efficiently, without the fear of getting lost or confused. The lack of information signs create a feeling of mobility without the option of guidance. Therefore the implications of having little or no adequate signs, maps or navigation tools, can contribute to a commuter's experience of feeling unsafe and vulnerable.

The concept of visibility becomes important when referring to safety as it allows for the commuter to feel less vulnerable and susceptible to be made into a 'target'. The need for clear visibility when walking through the urban environment informs which routes and streets the research participants take within their urban mobility patterns.

4.7.2 Security & Surveillance

Within the topic of lighting and visibility was that of surveillance and security. Many of the research participants indicated feeling safer or more 'comfortable' to move within areas of visible or dormant surveillance. The topic of surveillance was categories by the research participants as technological surveillance and human surveillance. The technological surveillance included that of visible CCTV cameras within an urban space. This was mainly mentioned by participants when refereeing to larger transport stations, or along large commercial activity corridors. The notion of visible and passive surveillance, paired with visible lighting allowed for some participants to feel safer when waiting for the bus or waiting for a friend outside a shop on a busy street (Semi-structured interview, July – August 2016).

The other aspect of surveillance is that of human surveillance or as it is referred to within this chapter: 'security'. Many of the research participants highlighted the importance in having visible security members, guards, police officers, train or bus officials and Cape Town Central City Improvement District (CCID) security persons within the urban environment.

All of the female research participants indicated feeling safer walking through the streets when the CCID staff were visible and frequently circulating routes. The presence of the CCID security staff create a safer environment because they performs acts of visible surveillance within the physical space, whilst they also contribute to the activity and 'feel' of a street or public space.

One of the male participants indicated that he felt unsafe or 'uncomfortable' when using the Metro Rail if there are no 'official' staff on the train or at the platforms. He explained these official staff to be referred to as a train monitor or security officer. It was then highlighted that he felt safer within the presence of official staff – even if it was just to be able to see a uniformed official person. He indicated that just the visibility of a uniform could change the mood and feeling on the train or at the platform (Semi-Structured Questionnaire, 2rd August 2016).

4.7.3 Human-scale density and activity

All of the research participant indicated that safety on the streets or at a public transport station is highly affected by the number of people within the area and the activities taking place at that time. Participants explain that a busy street with a lot of commercial activity promotes a safer walking experience when commuting. The density and busy activity of a street is often an informer for when participants plan or chose their routes.

It was also indicated that the types of activities occurring on a busy street informs how safe and welcoming it feels for an NMT commuter. Participant indicated that streets with a good 'street life' felt safer to walk down. This included factors such as coffee shops, food markets, bars, public and commercial pavement seating. These activities along a street create a more vibrant and welcoming feeling to the street that promotes human-scale activity and the opportunity for a safer NMT commute.

4.7.4 Time of Day

A common theme throughout the qualitative research process is that of the relationship between feelings of safety and the time of day. This issues of time of day in fact encapsulates many of the pervious themes explained above. The safety experienced during a specific time of the day is highly influenced by the variables of lighting, visibility, human density, activity and navigation.
All of the research participants indicated that specific times during the day affect their personal feelings of safety during the public transport system. It was identified that early morning and late afternoons or evenings were generally the most vulnerable time to use public transport and to walk to such systems. The research participants indicated that they felt safer during peak-times, and that they would plan their routes in order to avoid off-peak times such as late evening.

These specific off-peak times feel unsafe due to the issue of lack of daylight and thus limited sense of visibility. It was indicated that the lack of both a natural light source and an artificial light source contribute to feelings of unsafety, fear and vulnerability to physical harm. The participants also argued that the issues of visibility and daylight

during commuting times is also affected by the weather or season. It was highlighted that during winter days and 'bad' weather conditions some participants felt more reluctant when taking public transport or walking. This is because they felt more vulnerable as the weather and season often reduced the daylight and visibility. It was also stipulated by Participant 3 that when walking to public transport in the rain she felt more vulnerable and susceptible to harassment because her umbrella or heavy rainfall would be blocking her line of sight when walking (Semi-structured questionnaire, 9th of August 2016).

It was explained further by participants that during these 'off-peak' times public transport systems and the associated NMT feeder routes are often unoccupied by other commuters. This lack of density and activity during the early and late hours of the day contribute to feelings of vulnerability and exposure. One participant identified this issues as a sense of 'loneliness' within the urban environment which created a discomfort when commuting (Semi-structured questionnaire, 3rd August 2016).

An important element that becomes visible in the argument of 'time of day 'and commuting is in the topic of accessibility. Many of the participants argued that they felt safe because they could chose to a degree; the time of day they would commute, and on which public transport systems they rely on. This option of agency and accessibility allowed these participants to take safer routes and therefore to have safer NMT and public transport experiences. The participant indicated that if they could not afford a specific transport option, or if they lived further away from public transport they would have to leave earlier for work, and arrive home later in the day. It was said that the 'time of day' highly affected their experience of safety and freedom of movement (Semi-structured questionnaire, July and August 2016).

4.8 Street Analysis

During the research process the participants were asked to identify which streets in the CBD felt safe, and what spatial and socio-spatial elements make them feel safe. The participant identified the following streets based on how often they use NMT and public transportation systems along these routes. However, there is a greater focus on walking and the personal perceptions of safety on these streets and surrounding urban environment.
The photographs displayed throughout this section are used in a conceptual manner to highlight some of the expereinces and opinions expressed by the participants. Each photograph was taken in order to capture the information the participant provided. The images act as a conceptual and visual guide through the streets.

4.8.1 Wale Street

Wale Street was mentioned by two participants as a very safe street to walk on. This was due to the wide street design paired with relatively wide pavement area for walking. This street design make it easy to navigate and creates a good sense of visibility and location. The presence of the CCID security huts also contribute greatly to the sense and perception of safety along this corridor (See Figure 4.10).

Figure 4.10 Wale Street, Late Afternoon *(Authors own, 2016)*

4.8.2 Long Street

Participant 3 identified Long Street as one of the safer street to walk along as a women. She explained that due to the on-going activity from the bars and cafes paired with the general flow of people, she feels happy to walk there as she is less likely to be attacked or harassed. The participant indicated that if something happened to her, she could call for help and there would be enough people around to respond. She also indicated that due to the on-going busy activity of Long Street it is often well lit and visible to navigate (Semi-structured interview, 9th August 2016).

Figure 4.11 is a photograph that visualises the information expressed by Perticipant 3. The photograph is taken in the late afternoon and demonstrates the kinds of activities and denisty that commonly occurs along this route.

Figure 4.12 on the following page is a photograph displaying Long Street in the early hours of a weekday morning. This image displays a contrast between the activities found on this street depending on the time of day. There is less human activity along this route during the morning hours - which can possibly effect NMT safest and moblity due to the isolation or an NMT commuter.

Figure 4.11 Long Street, Late Afternoon *(Authors own, 2016)*

Figure 4.12 Long Street, Early Morning *(Authors own, 2016)*

4.8.3 Government Avenue

Government Avenue is a unique street in that it defines a NMT corridor that links users from the Metro Rail main station and MyCiTi main station to the more suburban areas of Gardens and Vredehoek. The avenue also links NMT commuters to the commercial activities of Kloof Street and Orange Street. This makes the avenue an important NMT route that links pedestrians to residential and commercial activity.

The avenue is safe during daylight for NMT commuters as it is predominantly a pedestrian-only route. The avenue is wide in design and is framed by street lighting. The avenue is surrounding by public space and open-green space. This creates an opportunity for pedestrians to feel safe whilst walking through a scenic route that is busy with activity (See Figure 4.13 on the following page).

Government Avenue is also highly policed and secured by a CCID hub and information desk at the entrance onto Wale Street. The avenue and surrounding public space is also patrolled by security staff. This allows for NMT commuters to feel safe when using this route within the greater urban mobility system (Semi-structured interview and observation, August 2016).

Figure 4.13 Government Avenue, Afternoon *(Authors own, 2016)*

4.8.4 St Georges Mall

This is a predominantly pedestrian-only street which acts as a linking route from the foreshore to Wale Street. The street links various modes of public transport and is therefore highly used as a pedestrian route. St Georges Mall links up with Government Avenue as a pedestrian mobility route through the Cape Town CDB. The street is considered safe due to the commercial activity along the route. Therefore it also has high visibility due to street lighting and the presence of CCID security staff and hubs (See Figure 4.14).

Figure 4.14 St Georges Mall, Afternoon *(Authors own, 2016)*

4.8.5 Darling Street

Two Participants indicated that Darling Street felt safe to walk on due to the wide pavements and wide street design. The street is considered safe because of its constant human activity, informal trading and pedestrian activity. It is an important street as it is highly used by NMT commuters using the train or MyCiTi public transport systems (See Figure 4.15).

Figure 4.15 Darling Street, Afternoon *(Authors own, 2016)*

4.8.6 Bree Street

Participant 4 defined Bree Street as a safe zone for pedestrian activity due to the wideness and openness of the street design, the street lighting and visibility (Semi-structured interview, 2th August 2016). (See Figure 4.16).

Figure 4.16 Bree Street, Afternoon *(Authors Own, 2016)*

4.8.7 Adderley Street

Adderley Street is a highly used NMT route as it facilitates entry to a dominat MyCiTi BRT stop and the Cape Town Central Train station. The transport node that surrounds the BRT stop and the train station is paired with pedestrainized linkages and crossings to facilitate NMT mobility from the public transport systems (See Figure 4.17).

Figure 4.17 Adderley, Afternoon *(Authors own, 2016)*

4.8.8 Orange Street

Participant 5 specified that Orange Street felt safe when he was walking to the MyCiTi bus stop due to the presence of "mixed use activity, lighting and noise" along the street (Semi-structured interview, 6nd August 2016).
The figure below creates a visualization of the functions, deisgn and feel of this route (See Figure 4.18).

Figure 4.18 St Orange Street, Afternoon *(Authors own, 2016)*

4.9 ICT systems: the mobile phone

Both the survey and semi-structured questionnaires expanded on data regarding the use of information and communication technology (ICT) to access transport information and guidance. This section highlights how many research participants use their personal mobile phone as a tool to navigate their public transport systems. This includes using their mobile phone as a tool to access information about their public transport departure/arrival times or locations. Participants were asked if they used their personal mobile phone to access such information – using either the internet function or a mobile phone App.

4.9.1 Current ICT tools used by Participants

Of the male and female participant sample that took part in the survey, it was indicated that 50% of all participants currently use their mobile phone to access information about their public transport mode of choice (Structured Survey, July – August 2016).

This information was expanded on through the semi-structured questionnaires which provided information as to which kinds ICT systems are used by the participant sample.

Two of the participants indicated that they did not use any Cape Town based transport mobile Apps to assist with their urban mobility. However, both participants indicated that the only transport based App they currently use is Uber (Participant 2 & 5 Semi-structured Questionnaires, 3rd August 2016).

Participants 3 and 4 use the train system frequently in their commute and therefore they access their train schedule through the CT Train website. They indicated that they access the website via their mobile phone in order to plan their trips. However, both participants indicated that they do not use an App to assist them in this process – they go straight to the internet website via their mobile phone (Fieldwork Observations, 3rd August 2016).

The other three participants indicated that the only ICT systems they used for transport navigation and assistance was Google Maps. This was the most common tool used by all participants to navigate the city. It is used as a tool to help participants when they are lost or venturing into a new or unknown area.

The above information acquired from the survey had indicated that 50% of the sample participants used their mobile phone to access transport information. However, through the semi-structured questionnaires it can be argued that most participants use their mobile phones to access the internet facilities– not to use transport based mobile Apps. This information explains that mobile phones (including smart phones) are highly used tools for public transport planning and urban navigation through access to the internet. However, it can be argued that other associated ICT systems such as mobile Apps are not as commonly used.

The semi-structured questionnaires and survey also facilitated with uncovering information as to the number of participants that would use the proposed concept of a mobile App. This app question was

presented to the participants so that it included ideas of safety and public transport in an interlinked format to improve urban mobility experiences. When participants were asked if they would use a 'transport and safety' App to assist them in their transit experience the responses indicated that all female participants would use such a tool, and a further 75% of all male participants informed their interest and support towards such an App (Structured Survey, July- August 2016).

4.10 Parameters for a Safety & Transport App

The information gained from the structured surveys indicated that all research participants would use a safety and transport mobile phone App. This statement is then extended further through the information shared in the semi-structured questionnaires and fieldwork observations. The final aspect of the semi-structured questionnaires was for participants to answer the question of what they would want and expect from a safety and transport App.

"Would you use a mobile App that showed you the safest walking routes to your bus or train?"

"What would you expect for such an App?"

This allowed for participants to consider what technical elements and access to information would improve their experience of safety and mobility within the urban environment. These opinions and suggestions are an important aspect in the creation of the App prototype – the qualitative information will be used in the design process of the App. It allows for gaining an understanding of what people feel they need, what affects them, how they could relate to such a tool and the benefits it could provide.

4.10.1 Participant's Safety App concepts

From the semi-structured interviews a number of useful and practical suggestions were put forward by research participants. The participants were asked to think about how they use public transport and NMT systems, how important their personal safety is in this process and what elements affect their safety. These personal feelings, opinions and past experiences were used as a foundation for thinking about how a safety and transport App would function. Participant's unpacked issues of what they need and want from the technology as well as how it should be designed and used.

The research has been unpacked into a series of dominant themes that were highlighted and shared by the participants. These themes or concepts will be unpacked further in the sections below. A conceptual diagram is used to illustrate the concepts and their connections within the App. This can be considered the App mind-map – it is used to visualize the ideas and concepts expressed by the research participants.

- **Real-time data and updates**

Many participants indicated that any information that the App would provide would need to be 'real-time' data. This means that any information that is generate and displayed digitally would need to be based on the most recent data and information. This argument for the need for 'real-time' and frequently updated information is

vital when considering issues of safety within the urban space. This is due to the nature of how quickly scenarios, functions and systems change within urban environments and urban mobilities. Thus the best way to create an option for finding the safety routes is to have data that is constantly flowing, being updated and transformed.

- **Activity**

The concept of human activity was a prominent aspect in identifying safe streets, as well as creating a perimeter for the App concepts. The participants indicated that a street that is abundant with human activity and commercial activity is more prone to creating feelings of safety. Therefore, many participants argued that it would be beneficial to have an App that highlighted such streets. These streets could be identified as activity corridors which highlight the kinds of commercial activity and functions available.

One Participants indicated that the App should show the nearest 'Shop' or 'Kiosk' so that the user could know where to buy more mobile data if it was needed. Another Participant indicated it would be helpful to know where formal and informal traders were positioned along their NMT route.

- **Tracking**

The concept of 'tracking' was visible within the research process. Many participants showed an interest in creating an App that could track the user's movements and routes. This also included tracking of the movements of other users. Participants argued that it would be beneficial to be able to track their loved ones who may be walking home from work.

- **Safety Emergency Button**

Many participants indicated that they would like the option of an emergency button attached to the App. This button would be linked to the nearest security facility or police station in their area. The participants argued that the button could be used if the user was being harmed, or if a user is reporting on an incident along their route.

4.10.2 App Mind-Map

Figure 4.19 is a mind-map that demostrates all the App concepts expressed by the research participants.

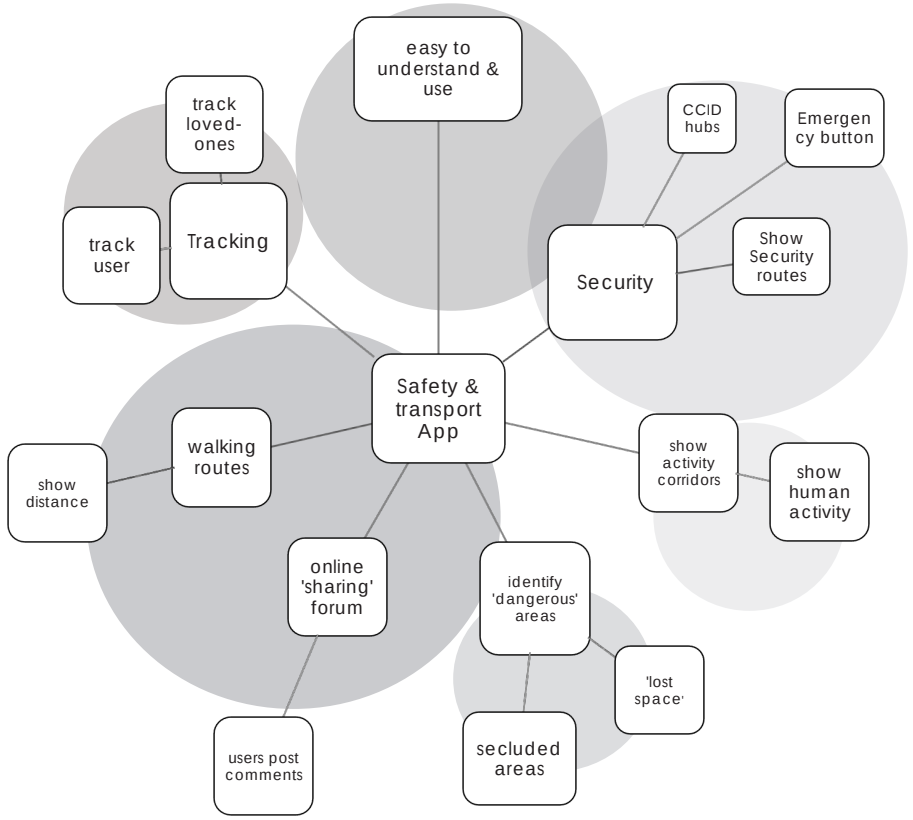


Figure 4.19 App Mind-Map *(Authors Own, 2016)*

4.11 Conclusion

The aim of this chapter was to unpack the research findings in order to support the main and subsidiary research questions within the topic of walking mobility, personal safety and the possibilities technology can provide in creating better urban mobilities and environments. The information gained within this chapter expands the argument that public transport infrastructure and urban spaces move beyond the physical and structural. This is visible within the social experiences and relationships between the spaces and the functions they provide.

This chapter is vital in understanding the importance and value of qualitative research and the benefits it can provide in creating new knowledges. The qualitative research provided for a platform in understanding how beneficial the 'smart citizen' can be in creating and envisioning safer urban environments. The information gained from the survey and questionnaire tools have also been a demonstration of how crowd-sources and/ or user generated data can be used to create new understandings of issues and the possible ways of intervention inorder to create safer spaces.

The information and knowledge discovered within this chapter is used within Chapter 5 when designing the Safety and Transport mobile App prototype. The design process is informed by the experiences and opinions shared within the research process.

Chapter 5: Design

5.1 Introduction

The purpose of this chapter is to expand and explain the design process, tools and information that are involved in creating the App prototype. The knowledge obtained through the literature and research findings have been encased in order to create the functions, systems and design of the prototype.

This chapter includes the explanation and design of the database systems associated with the App prototype. This will demonstrate the functions available to the App prototype through the use of user-generated data. This will indicate how valuable and useful the users input and experiences are within the entire process. The user-generated data becomes a useful tool in future urban management and planning intervention. This statement is made clear through the design and structured of the App's database.

The user-generated data is also highly visible in the design process of creating the Safety 'Evaluation System'. This systems has been designed based on the data collected within the qualitative research and fieldwork findings section from chapter 4. The information gained from the research participants will be translated into the safety evaluation tool that is used to analyse the safety of the urban environment and NMT movement routes.

The final step within the process of creating the App prototype is in the visual design and display of the system within a mobile phone interface. This design section will demonstrate how the prototype will look, how it can be used and the benefits it can provide.

5.2 Design Process

The design process is informed by the research uncovered within the literature review in Chapter 2, as well as the qualitative research obtained through the semi-structured questionnaires and structured surveys found in Chapter 4. The design process is also informed by knowledge and guidance gained through interviews and conversations with an individual from 'Where Is My Transport '(WIMT) and an individual from 'ENS Software Limited Pty' (2016).

The ENS Software Limited Pty company develops a wide range of database solutions for customers through their knowledge of the latest developments in IT. The company is based in Cape Town and focusses their work on database design and software solutions (personal communication, August 2016).

Where is My Transport (WIMT) is a Cape Town based company that specializes in creating API systems with predominantly local transport-based data. The company also produced a functioning App prototype that demonstrates how their API can be used to create an integrated transport mobile App device (personal communication, 26th April 2016).

The prototype will consist of a series of urban design based systems of analysis for the built environment. This will be used to evaluate the design and structures of the streets and public spaces within the

Cape Town CBD area. This design analysis will then be supported by the qualitative data obtained through the questionnaires and surveys from Chapter 4. This information will highlight more experienced and social forms of safety and pedestrian mobility within the urban space.

5.2.1 The Knowledge Process

The information and knowledge gained through the literature in Chapter 2 is used within the design process to inform the theoretical background for the App prototype design.

The qualitative data collected in Chapter 4 is used as a tool to inform the design of the 'Safety Evaluation System' which is then visualized within the App design. This system is informed by the suggestions and needs expressed by the research participants. The research participants represent an example of the 'user' or focus group that this App prototype would attempt to provide for. The Safety Evaluation Systems' comprises of 6 factors or variables that encapsulate elements that affect commuter safety. The Safety Evaluation System also comprises of a Ranking System – this allows users to rate their route based on how safe it felt.

The next step within the design process is to create a proxy or evaluating system to quantify and rate feelings and experiences of safety – both social and spatial. The creation of this safety proxy will then be translated into the App prototype.

5.2.2 The Technical Process

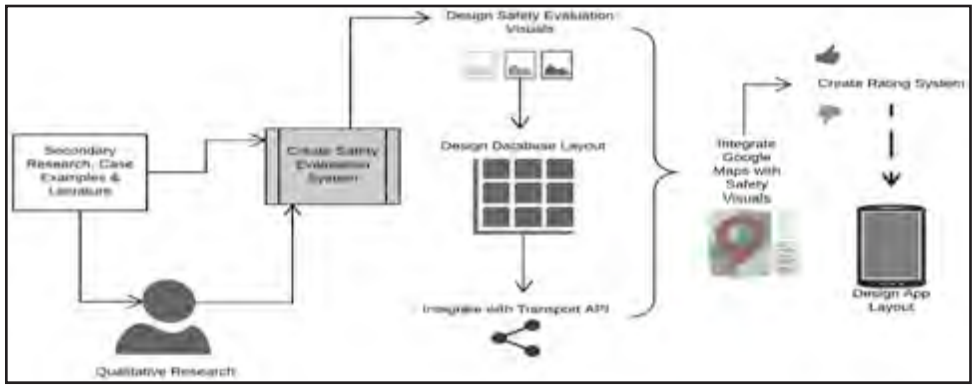
Once the qualitative information has been translated into the design of the 'Safety Evaluation Systems', the next step is to explain and design the technical tools that will read, collect, order and analyse the data that is fed into the App.

This relies on unpacking the function and requirement of a public transport-based API system that allows for locating different modes of transport on a spatial mapping platform.

The next step is to create and design the systems and functions of the App's database. The database is designed to take the user-generated data obtained through the App and to organize it into a system that allows for it to become an urban management tool.
The database is designed based on the 6 variables devised within the 'Safety Evaluation System'. These variables are represented in the database. This allows for the database to collect and sort the submissions that the user will input into the App based on the 6 safety factors.

The Figure 5.1 below demostrates the design process towards creating the App prototype. It indicates the roll of the qualtiative research of Chapter 4 and the secodary research of Chapter 2 in informing the design and creating of the Safety Evaluation System and the associated Route Rating System. These systems are designed to function within the App prototype and are used as a tool to analyse the urban environment based on the users' experieinces of NMT safety in moblity.

Figure 5.1 Technical Process Diagram *(Authors Own, 2016)*



5.3 Safety Evaluation System

The 'safety evaluation system' is designed based on knowledge obtained in the qualitative research process, as well as information gained from the case study examples of 'SafetiPin' and 'Where is My Transport' (WIMT) found in Chapter 2.

5.3.1 Spatial, Social & Socio-spatial

The 'Safety Evaluation Systems' is designed as a tool in which to analyse a NMT mobility route based on issues and experiences of safety felt by the user. This system is designed in order to evaluate spatial, social and socio-spatial element within the mobility route and surrounding urban environment.

The spatial aspects under analysis include elements of the built environment, both structural and infrastructural. This can include the presence of street lighting, the design of the pavement, the visibility of the street, the function of the street and the state of the foot path or pavement.

The social elements are harder to quantify – as they will be influenced by the individuals personal experiences, understandings and needs. This will allow for the option of evaluating more qualitative elements of safety through the evaluation of 'sense' or 'feeling' of a route. This allows for a more personal approach and opinion to the evaluation of a route or space based on the individual user's experience.
The socio-spatial elements include a safety evaluation systems that refers to human-based activity and function within the urban space. This includes the evaluation of the presence of human activity, human density and commercial activity along a route. The socio-spatial elements include that of the presence of security – security staff, securing hubs, police stations and/or patrol vehicles.

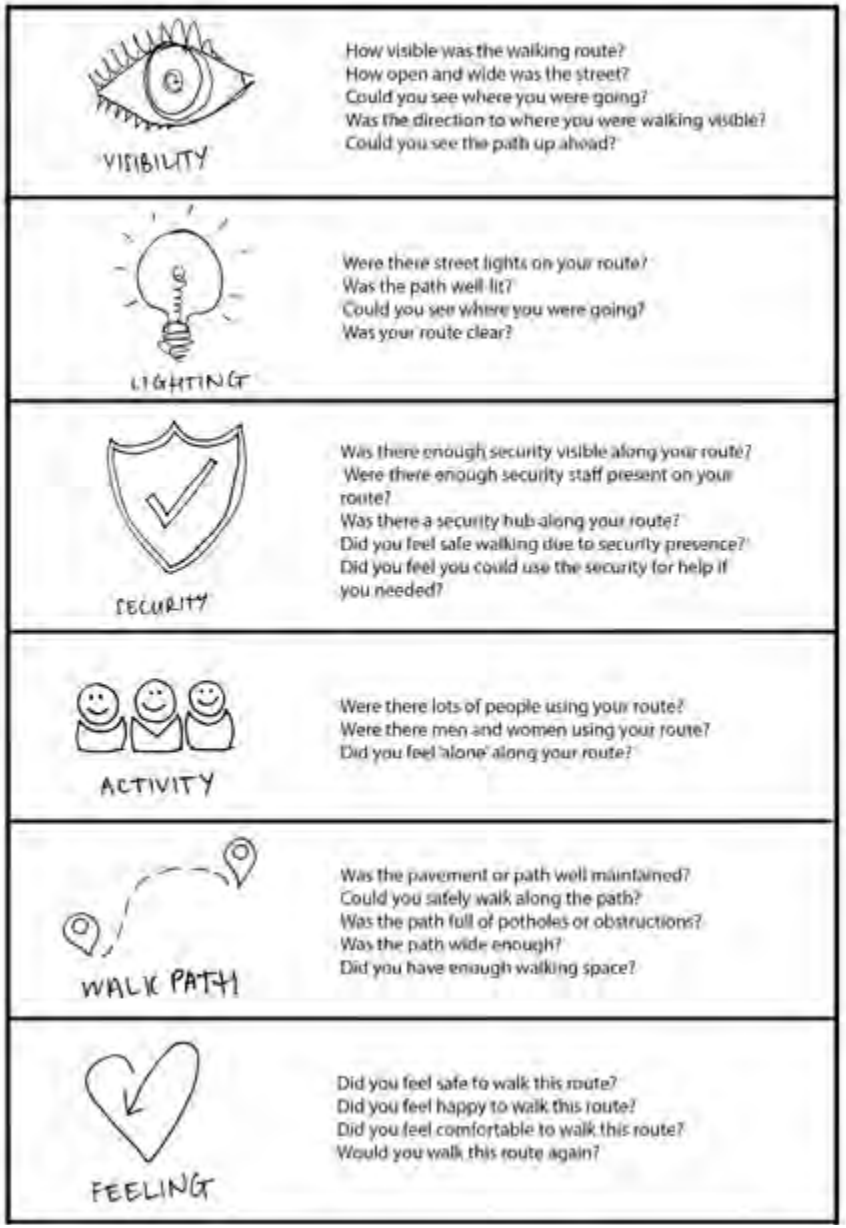
5.3.2 The 'Safety Evaluation System' – the 6 variables

From the knowledge gained through the literature and the qualitative research process a 'Safety Evaluation System' of 6 variable has been designed. These variables are informed by the most common issues highlighted by research participants. They have also been influenced by the theoretical understandings explained in urban design methods of creating and designing for positive urban mobility systems and city form.

1. Visibility
2. Lighting
3. Security
4. Activity
5. Walk Path
6. Feeling

The Figure 5.2 demonstrates the 6 'Safety Evaluation System' variables as the visual icon that will appear in the App prototype. The user will rate their route on the App and submit which variables were missing or lacking during their walking route. The App will ask the user a series of questions to support each variable in order to guide the user as to what elements were missing. The variables are designed with easy to understanding icons so that the user is able to navigate the information without confusion. The information that the user submits through the App will then be accumulated within the associate App database, which can later be collected and analysed for future urban management and planning guidance.

Figure 5.2 Safety Evaluation System App Icons (*Authors Own, 2016)*



5.3.2.1 The Ranking System

The Safety Evaluation System also comprises of a rating or ranking aspect. This is a ranking system used by the user to 'rate' the general safety experiences of the specific route they walked. The ranting system is based on a simple proxy of 3 layers: 'Green = Safe', 'Orange = Less Safe' and 'Red = Unsafe'.

This ranking systems allows for specific routes to be tracked using GPS and then to be assigned a rating colour based on the users experience of safety. This allows for other users to view the previous routes taken and their safety ranking. This system visually highlights a walking route with a colour which will become a layer over a map of the city streets.

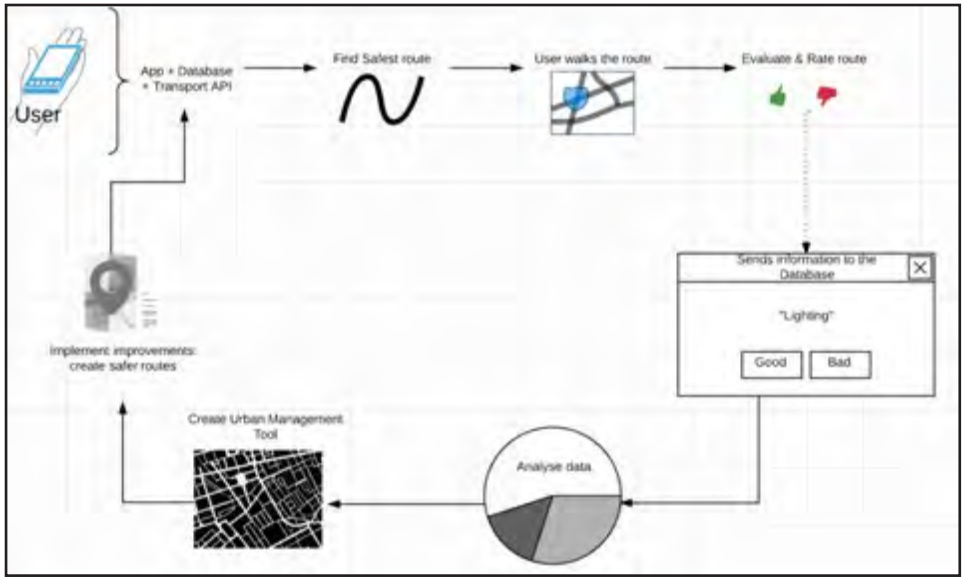
5.3.3 Function

The function of this 'Safety Evaluation System' has two outcomes. Firstly, this evaluation system is placed within the App as a tool to evaluate the routes walked by the user. At the end of the user's trip they will be able to evaluate the experience of the route based on the key safety evaluation themes. The first step in the process within the App is to rank the route that was walked by the user through the 'Green', 'Orange' and 'Red' levels. The next step would be to evaluate the route walked by the user through the use of the 6 variables from the Safety Evaluation system.

The App would ask the user: "What was missing on your route?". Then the App would display the 6 Safety Evaluation System variables as icons button. The user would then press the icon displaying the missing element within their route, eg: 'Lighting.'

The Figure 5.3 below demonstrates the relationship between all the contributing factors and elements in the design, function and output of the App prototype. This figure demonstrates the cyclical relationship between the user, the App, the API systems, the App Database and the data capturing platform which can be used as an urban management tool for implementing urban mobility improvements.

Figure 5.3 App Cyclical Process *(Authors Own, 2016)*



5.4 APIs

The proposal for this App prototype design resides in the notion of allowing an integration with a current Cape Town based public transport Application Programming Interface (API) and a spatial map API system. An API is a system of features that allow for the creation of an application system that could access the features or data of the

operation system (Where is My Transport, personal communication, 26th April 2016).

For the purpose of this App prototype and its designed functions it provides; the App would rely on a combination of API systems. The App prototype would benefit from using the Where is My Transport (WIMT) API for public transport data as the company is founded on producing and projecting data for Cape Town and the CBD. This would be beneficial for the App prototype as it is based on the case study of the CBD and the users that reside within this space.

5.4.1 Where is My Transport API, Cape Town

Where is My Transport (WIMT) provides an API system for integrated public transport systems in emerging cities in South Africa, with a local lens focussed on the City of Cape Town. The company generates and connects existing transport data to one centralized platform; the API. This includes elements of tracking different modes of transport such as Cape Town based BRT networks and the University of Cape Town Jammie Shuttle Services. This transport data is updated constantly at real-time data in order to track changes and trends in the movement networks. The data that is collected is also then analysed overtime in order to learn new information from the data to inform cities of ways in which to optimize and improve their public transport networks (Where is My Transport, personal communication, 26th April 2016).

The company has produced an integrated public transport App called 'Find My Way' which uses their integrated transport API system to allow for users to navigate their city using the different modes of transport. The App is based in creating a navigation tool for public transport systems only. It does not include information regarding NMT routes and the safest options for commuters. Thus, the App prototype that is promoted in this study could possibly be integrated with the current functions of the 'Find My Way' App in the future.

5.4.2 Google Maps API

The Google Maps API provides for location data and experiences of users of this API system. Google Maps API allows app or website developers to embed Google Maps into their web page or mobile phone App interface. It also allows for developers to retrieve data from Google Maps and use the data to perform the tasks the developer requires.

The Google Maps API and the available functions would be used within the App prototype in order to allow for the transport-based system to work. This would include the use of GPS location to be geolocation on spatial lens, tracking movements and routes of the user, locating different modes of public transport within a specific area. It would also include the function of visualizing and spatializing the distance and duration of movement routes and commuter trips (Google Maps API, n.d.).

The App prototype would rely on a combination of API system made available by Google Maps. This would include: Directions API, Distance Matrix API, Geolocation API, Roads API and Time Zone API.

5.5 Database Design

In order for the concept of user-generated data to be turned into a useful tool for data collection, data analysis and interpretation within the App format – it requires a database that is designed to facilitate such functions. The figure below is an excerpt from an excel spread sheet which indicates the layout of the database and how it would function as a tool for analysis and future intervention. (ENS Software Solutions (Pty) Ltd, personal communication, August 2016).

Figure 5.4 Database Excel design *(Authors Own, 2016)*

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	DBKey	userid	StartLocationLong	StartLocationLat	DestinationLocationLong	DestinationLocationLat	DateTime	RouteRating	Lighting	Security	Visibility	Activity	Feeling	WalkPath
2	1	451258	-33,9383545	18,8543913	-42,8454768	19, 6756931	2016-09-11	1=Red 3= Orange 5=green	0	1	1	0	1	0
3														
4														
5														

5.5.1 Database Systems: Figure 5.4

Each user is assigned a 'user identification' number which feeds the individual data into the database. This was the database is able to identify which user generated specific data outputs.

The database inputs the user's current location when using the App. This is demonstrated through the 'Start Location' system which includes the longitude and latitude codes to geo-locate the user's position within a space.

The 'Destination location' is also collected within the database. This shows the end location that the user walked to, in relation to their start location. The 'Destination location' also comprises of two aspects: the longitude and latitude figures.

These location inputs are a vital aspect within the database and function of the App. This system is required in order to create a tracking of the route that the user walked, and to be able to then location it spatially on a map within the App.

The database also logs the date and time of a submission made by the App user. This allows for the collected data to analysed or grouped by time of day and by week or month.

The Route Rating system is also logged within the database. The database assigns a numerical value to the Route Rating System of "Red = unsafe", "Orange = Less safe" and "Green = Safe". The database creates a number system that assigns the number 1 to the rating of "Red", 3 to the rating of "Orange" and 5 to the rating of "Green."

This allows for the database to accumulate a Route Rating over a period of time and to then use an algorithm to calculate the average safety of a specific area, street or route.

The final step within the database system is the logging of the "Safety Evaluation System" assigned to a route. The user is asked to rate their route in the relation to which elements were missing during their

commute. These elements are the 6 icons identified within the Safety Evaluation System design: lighting, visibility, security, walk-path, activity and feeling.

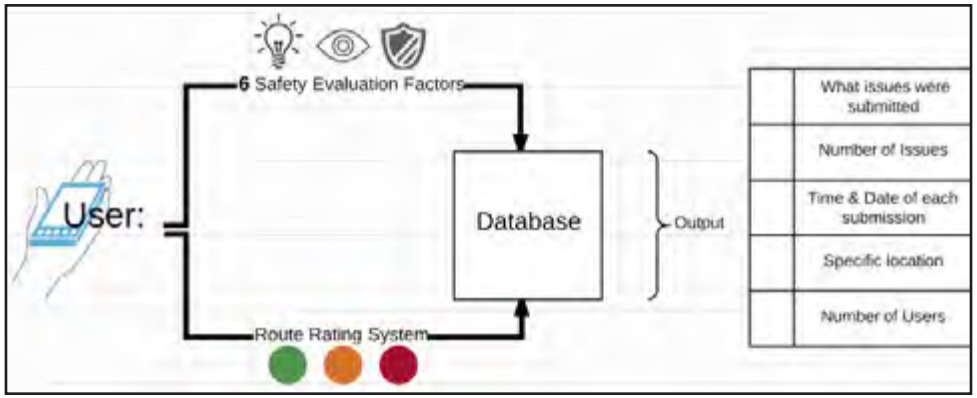
The database formats the information submitted by the app user as follows: if a user indicated that a specific elements was missing in the route then the database assigns a numerical value of 1. If a user did not highlight a specific elements as missing then the database assigns it the number 0. Therefore if the user felt that lighting and visibility were lacking in the route then those elements will be assigned the value of 1. The other elements will be noted as 0.

This systems allows for the database to then accumulate how many times a specific safety element was noted to be missing on a specific location and route. Therefore the database could calculate that at the end of a specific month, along a specific urban corridor or route there were a certain amount of complaints regarding missing safety infrastructures elements (ENS Software Solutions (Pty) Ltd, personal communication, August 2016).

5.5.2 Database Process

The Figure 5.5 below is a flowchart that demonstrates the relationship between the App and the associated database. Once the user has reached their desired destination they input the Route Rating System, then they rate the route based on the 6 Safety Evaluation System variables. The submissions that the user inputs using the App are sent to the Database. The final output of this process is then the collected information that is compiled, accumulated and analysed within the database spreadsheet. This includes factors such as: Accumulative route data, Accumulative Safety evaluation, Data and time related data, Location/ route related data and the number of users.

Figure 5.5 Database Diagram *(Authors Own, 2016)*



5.6 CBD Network-Analysis

The case study area of the Cape Town CBD was analysed through a series of lenses in order to gain more knowledge on the spatial elements that support NMT commuter safety.

This analysis is built through using data from GIS information to create a foundational understanding for what is present within the CBD built environment. This information indicates where the public transport routes and stations are within the CBD. The spatial information has been paired with the qualitative data collected within Chapter 4. The maps below are the visualization of the information shared by the research participants with regards to which streets are the safest and what spatial and social elements contribute to this experience of safety.

The 6 Safety Evaluation System variables are applied to the built environment in order to spatialize and visualized the current elements that promote or impeach pedestrian safety.

The scope of the analysis of the CBD is defined by the information expressed by the research participants in Chapter 4. Therefore the analysis is defined by a specific boundary as identified in the Figure 5.6. The street names and transport facilities highlighted within this figure are the dominant NMT routes and urban spaces examined within this chapter.

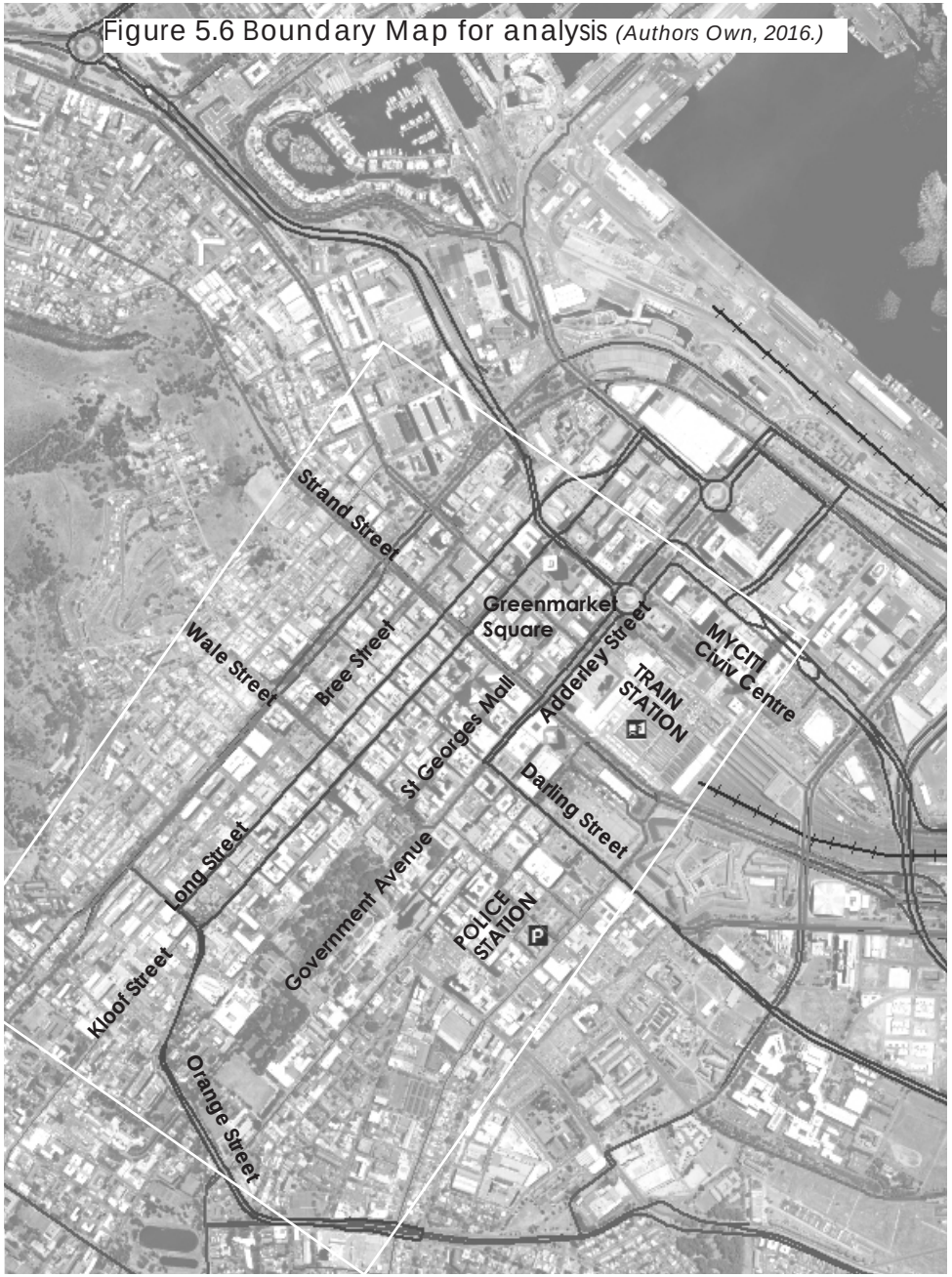


Figure 5.6 Boundary Map for analysis *(Authors Own, 2016.)*

5.6.1 Pedestrian- Friendly Routes & Public Spaces

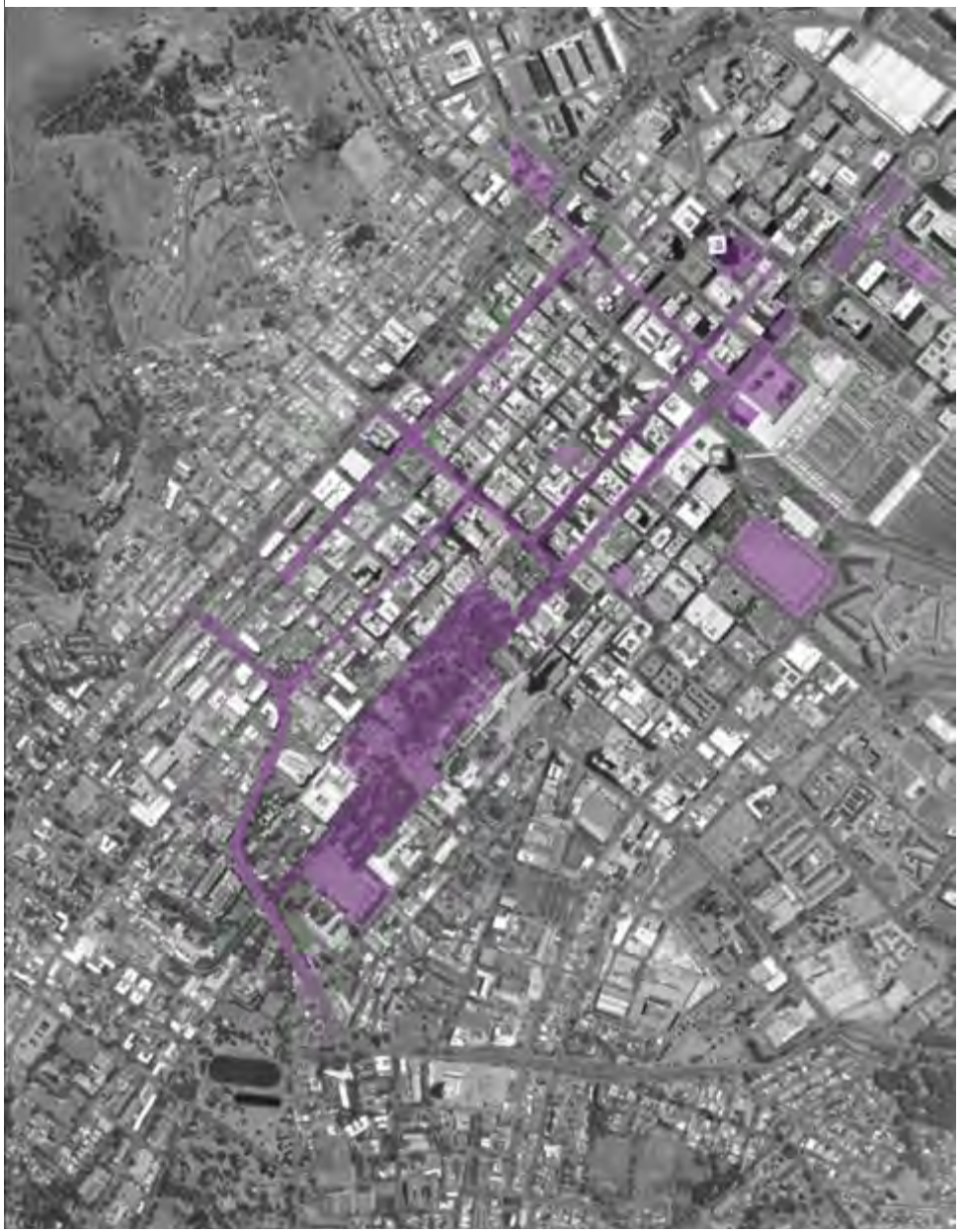
Figure 5.7 demonstrates the pedestrian-friendly routes and public spaces that create a web within the CBD area. The 'Pedestrian-friendly Routes' concept is defined by literature unpacked throughout the study, as well as the opinions expressed by the participants in the qualitative research process. Therefore this categorization is defined by design elements of wide pedestrian routes, clear accessibility, visible and physical legibility (Labuschagne & Ribbers (2014), Bentley, et al. (1985), Lynch (1992), Semi-Structured Questionnaires (July to August 2016).

The public spaces are defined as parks, squares and pedestrain pavements. The public spaces act as meeting points in the built environment for citizens to connect within a shared environment. They also act as movement corridors that create linkages in the greater NMT mobility systems.

This layer highlights these elements as a combination of these public elements. It indicates the West to East linkages that are visible within the street grid. It indicates a link moving from the Foreshore up to the suburbs of Gardens, Vredehoek and Tamboerskloof.

There is a linkages system from the main public transport stations of the MetroRail, MyCiTi Civic Centre and informal taxi rank that are linked through pedestrian routes and the public spaces present.

Figure 5.7 Pedestrian- Friendly Routes & Public Spaces *(Authors Own, 2016)*

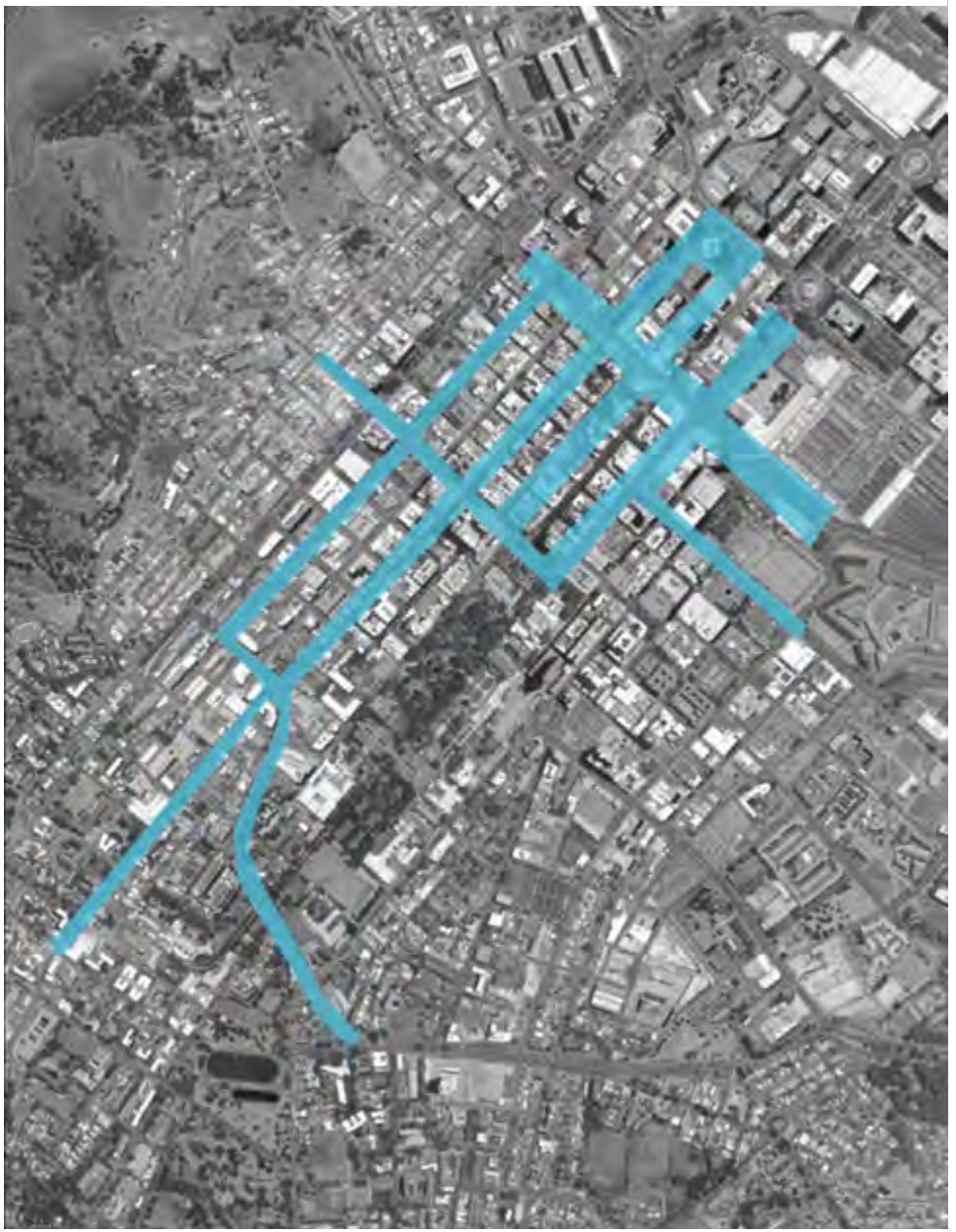


5.6.2 Activity & Transport Corridors

Figure 5.8 highlights the commercial and human activity areas that run along some of the major transport corridors. These activity corridors are defined by the commercial based functions that appear along these streets. These land-use and activity functions include examples such as light-commercial systems of retail and services. Other functions include more social activities of cafes, bars and clubs. These are social activity systems that are present at a human-scale level, and they frame the streets and movement corridors.

Figure 5.9 is overlaid with the public transport routes and associated bus stops and stations (See page 96).

Figure 5.8 Activity & Transport Corridors *(Authors Own, 2016)*



The research participants indicated that this human-scale activity or commercial-based activity routes create a safer environment for pedestrian mobility. This is due to the human activity and density that comes with the presence of commercial and social-based street activity.

The dominant activity and transport corridors have a West to East direction and linkage. This includes highly dense activity streets such as Adderley Street, Long Street and Kloof Street.

Figure 5.9 indicates a link between where the public transport routes and associated stations are placed in relation to the most dominant commercial and social-activity routes. This informs better opportunity for accessiblity between public transport, NMT and urban land-use activities.

Figure 5.9 Transport Overlay *(Authors Own, 2016)*

5.6.3 Lighting & Visibility: Day

Figure 5.10 demonstrates lighting and visibility aspects of the urban environment and associated routes during the day.
The aspect of lighting refers to structural and physical elements such as street lighting and lighting from commercial activities along the streets.
The concept of 'day' or time-of-day deals with the commuting hours when the natural day light is present and contributes to the visibility of the commute.

During the 'day' many of the dominant commecial and public transport routes are highly visible. This is due to the lighting infrastructure along these routes - for example Long Street, Governemnt Avenue and Wale Street.

Figure 5.10 Lighting & Visibility: Day *(Authors Own, 2016)*

5.6.4 Lighting & Visibility with Pedestrian Routes

The Figure 5.11 layer indicates the most visible and well-lit routes in relation to the previously identified pedestrian-friendly routes and public space linkages. This layer indicates that positive and safe elements of lighting and visibility during the day correspond with the most pedestrian-friendly routes and public spaces. This shows that these routes during the day have a high level of safety for a pedestrian or NMT citizen within the CBD.

Figure 5.11 Lighting & Visibility with Pedestrian Routes *(Authors Own, 2016)*

5.6.5 Lighting & Visibility Night

Figure 5.12 demonstrated the most visible and well-lit routes during the night. These routes were defined by research participants as the safest streets to walk during the night due to the presence of lighting. This definition of 'lighting' includes infrastructures such as street lights, but also lighting created by the commercial and social activities found along these routes.

The most safe routes efined within this category were Bree Street and Long street.

Figure 5.12 Lighting & Visibility Night *(Authors Own, 2016)*

5.6.6 Lighting & Visibility with Pedestrian routes

Figure 5.13 is a synthesis layer that comprises of the lighting and visibility during the night paired with that of the pedestrian-friendly and public spaces web. This map indicates that the public spaces and pedestrian linkages within the CBD are considered un-safe during the evening or night due to lack of lighting infrastructures and pedestrian visibility. This demonstrates a disjuncture between the defined public spaces and NMT mobility routes with that of lighting safety and human activity during the evening hours. The lack of lighting infrastructure along some routes renders those spatial zones unsafe for NMT mobility. This includes the public spaces and pedestrain routes of the Government Avenue and areas surrounding the Train Station.

Figure 5.13 Lighting & Visibility with Pedestrian routes *(Authors Own, 2016)*

5.6.7 CCID Zones & Safety Kiosks

Figure 5.14 indicates some of the security facilities available within the Cape Town CBD. This deals with highlighting the presence of the Cape Town Central City Improvement District (CCID), which has a public-private partnership with the City of Cape Town. The CCID is a non-profit organisation that attempts to maintain and facilitate a "...safe, clean and caring urban environment." (Cape Town Central City Improvement District [CCID]. n.d.).

The dark-green overlay demonstrates the 1.6km squared boundary where the CCID perform their security protection and urban management tasks. These zones include most of the site and routes used and specified by the research participants. These zones are where CCID staff patrol the urban environment as passive security members (Cape Town Central City Improvement District [CCID]. n.d).

The light-green dots indicate the location of the CCID safety and security kiosks. These Kiosks are movable structures that are placed throughout the CBD within the CCID boundary zones. The Kiosks provide the function of a security hub where citizens can gain information about the city, report an incident or ask for safety and protection (CCID, personal communication, 5 September 2016).

Figure 5.14 CCID Zones & Safety Kiosks *(Authors Own, 2016)*

5.6.8 CCID Zones & Public-Pedestrian Routes

The Figure 5.15 layer indicates the CCID Zones and safety kiosks in relation to the public spaces and pedestrian-friendly routes. This demonstrates that some of the pedestrian-friendly routes identified and used by the research participants fall outside of the CCID boundary. However there is a positive relationship between CCID designated areas and many of the pedestrian routes. It is also visible that many of the public open spaces within the CBD are facilitated by the CCID security and safety kiosks. This is visible on the Grand Parade, Green Market Square and at the entrance to the Company Gardens.

Figure 5.15 CCID Zones & Public-Pedestrian Routes *(Authors Own, 2016)*

5.6.9 Synthesis

Figure 5.16 is the synthesis layer of all the above CBD analysis maps. All the maps are overlaid to indicate the combination of all routes, public spaces and nodes with their functions and spatial manifestations. It indicates all the linkages and systems that occur within the built environment of the CBD.

From the synthesis map we can identify certain streets or routes that incorporate many of the functions un-packed above. These streets include elements of day-time and night-time lighting and visibility, commercial activity, public transport hubs and include the presence of public security from the CCID nodes and zones. The streets that include all these elements include Wale Street, Bree Street, Kloof Street, Upper Long Street and Orange Street.

This map is used as the foundation or ground-map for the next step in the app design process. By looking at routes and areas that demonstrate the most over-lapping of layers and their functions we can begin to analyse the case study to find the safest pedestrian routes during the day and during the night. We can then apply the Safety Evaluation System to these routes in order to create a conceptual analysis of the possible 'Green', 'Orange' and 'Red' routes within the CBD.

Figure 5.16 Synthesis *(Authors Own, 2016)*

5.7 Applying the Safety Ranking System

The route ranking system has been applied to the synthesis of the analysis maps un-packed above. The method includes taking routes which have the most positive functions and to rate the routes based on the ranking system of: "Green = Safe", "Orange = Less Safe" and "Red = Unsafe". These routes are then assigned a colour in order to be visualized within the built environment. The figures below demonstrate how this system could be visualised and displayed within the App prototype. This system is applied to a day-time and night-time layer in order to demonstrate how elements of safety are influenced by many different environmental and social factors.

5.7.1 Green, Orange & Red Routes: DAY

Figure 5.17 demonstrates the safest and least safest walking routes within the case study area during the day. The concept of day-time is defined by the presence of day light; which is a contributing factor to safety due to visibility within the environment. The Green routes highlight the most walkable streets based on their encapsulation of all the analysis elements. The Orange routes display the less safe-streets for NMT users. These streets have less human-scale activity and visibility along the routes and thus contribute to feelings of diminishing safety. The Red routes are the least safe during the day-time. This is due to the isolated nature of these routes – the lack of lighting, visibility, human activity and security.

This map indicates that there are many safe West to East linkages within the CBD that promote pedestrian mobility and safety. These safer routes link the integrated transport systems (Civic Centre MyCiti Station and MetroRail Station) with the rest of the urban environment. Therefore it can be argued that NMT mobility is integrated with the greater public transport infrastructures through the design and functions within the urban environment.

This map also indicates that levels of personal safety for NMT commuters is improved due to the social functions and infrastructural systems present during the day. Elements such as lighting, security and density improve systems of safety for pedestrian commuters.

Figure 5.17 Green, Orange & Red Routes: DAY *(Authors Own, 2016)*

5.7.2 Green, Orange & Red Routes: NIGHT

Figure 5.18 takes the streets and applies the experiences of safety and functionality during the night-time. For the purpose of this study the concept of night-time is defined by the lack of natural sun light. The functions and activities within the city also change during the night – certain streets become dormant of social activity, whereas other become alive with human activity and 'night-life'. These social elements affect experiences of safety for pedestrian-scale mobility systems (See page 107).

The Green routes highlight the safest streets during the evening hours. This includes streets that are well-lit, visible and have human-scale activities and functions. This includes functions such as bars, art galleries and eateries. Due to the activity of these street they are more likely to have higher densities and economic activity due to people and social interactions. These Green streets are situated some distance from the main public transport nodes (Rail and BRT) which indicates not only a lack of safety around the transport node at night, but also the lack of commercial activity and land-use surrounding public transport systems.

The Orange routes are defined as the linkages between the safety routes and the unsafe routes. These streets are routes that are less occupied by social activity and commercial function – yet their proximity to safer streets is closer than that of the unsafe or 'Red' routes. The analysis of the Orange routes highlights the concept that each street has a different 'feel', function and purpose within the urban environment. Within the example of the case study, Bree Street and Upper Long Street are identified as safe routes due to lighting and density. However, Loop Street is considered less safe for NMT commuters. Loop Street lies inbetween the other safe routes, yet it has a very different feel and function to the neighbouring safer routes.

The Red routes are the most unsafe streets within the CBD during the night for NMT commuters. These streets are unsafe because they become dormant and isolated during the evening and are excluded from most or the urban activity and night-life. These streets lack positive elements of lighting and therefore lack visibility and can contribute to pedestrian experiences of vulnerability and isolation.

The Red routes that have been identified surround the major public transport modes of BRT and MetroRail. This indicates that the environment around these major transit nodes is unsafe for pedestrian and NMT commuters during the evening hours. The functions surrounding these public transport hubs do not support examples of public space and night-life that can facilitate human-scale activity and social interaction in a safe space.

Figure 5.19 is the map showing the safety routes during the day. It is placed parallel to Figure 5.18 in order to highlight the differences and similarities of NMT safety depending on the time of day or night.

Figure 5.18 Green, Orange & Red Routes: NIGHT *(Authors Own, 2016)*

Figure 5.19 Green, Orange & Red Routes: DAY *(Authors Own, 2016)*

5.7.3 Applied to the App

The 'Day' and 'Night' layers explained above could be used as the foundation information layer for the App prototype. These routes could be displayed for the users to identify which existing routes are already ranked due to their presence of safety. The user could then add to this existing system by rating existing routes and new routes within the App.

The App and associated database is able to identify the categories of 'day' and 'night', and to sort the data within a specific category. This is achieved by the first step in the App process: when the user logs into the App they will log their current 'time' and 'date' information into the App automatically. This information will go straight to the database and will be logged accordingly as a 'time stamp'.

The database programing system can assign a set of parameters to define when it is 'day' and when it is 'night'. This can also be programmed in relation to the different seasons and changes in daylight times. Therefore as an example, the database programme can define 'day' in the summer to be from 6am to 8pm. This timeframe can then be changed during winter.

Therefore, whatever data is logged by the user into the App and database - it can be sorted and organised to be defined by 'day' or 'night'. This also allows for the function of extracting all 'night' or 'day' time data and to then organise it accordingly for analysis.

5.8 App Layout & Function

The following section below demonstrates the step by step functions and visualizations of the App prototype and the interface layout.

5.8.1 Step One

Once the App has been downloaded and then opened on the user's smart phone the first step will be for the user to log into the App with a user name and a password system. This is to ensure the user and the data he/she generates is logged into the App and database.

Figure 5.20 Step One of the App Interface *(Authors Own, 2016)*

5.8.2 Step Two

The second step in the App is for the user to activate and verify their current location. This requires the user to turn on their GPS location system on their mobile device. This function will allow the App to access information from Google Maps and the associated API in order to locate elements on the map of the urban environment.

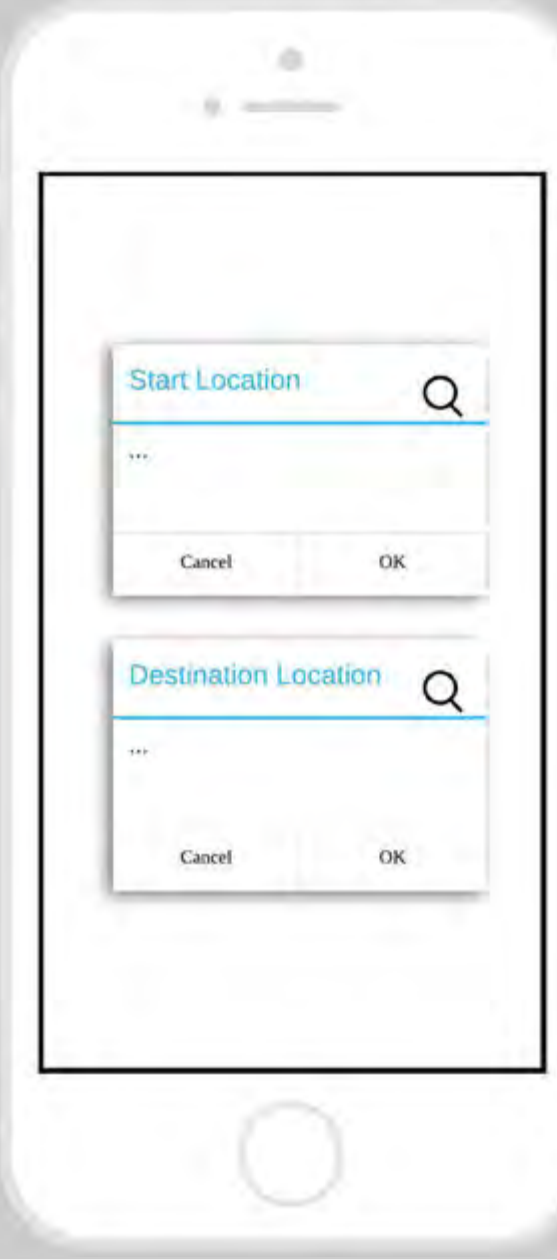
Figure 5.21 Step Two of the App Interface *(Authors Own, 2016)*

5.8.3 Step Three

The user is then required to input their current location using the search bar. The user can use the search bar to manually type in an address, or to use Google Maps to pin the exact location.

for the next step the user must use the same process to input the 'destination location'. This will be the location the user want to get to. This could either be a bus stop, train station or a specific place.

Figure 5.22 Step Three of the App Interface *(Authors Own, 2016)*



5.8.4 Step Four

Once the user has identified their current location and their desired destination location the App is able to generate this request onto a Google Maps image. This interface layer will have a series of useful elements for the user to interact with and use. Firstly the user will be able to see all the public transport system available in their location area. For example the BRT stops and BRT routes will be displayed as an overlay on the Google Maps base.

This layer will also display the rated routes defined by the Safety Evaluation System; the green, orange and red routes. These routes will be generated and plotted by previous users and will appear on this layer within the specific located area.

The example used in this layout demonstrates a user located within the CBD. The users start location is in the Bo-Kaap on Rose Street. The users desired destination location in the Cape Town MetroRail Station. The interface layer indicates all the visible BRT stops and routes within close proximity. The layer then also shows the user the safest walking routes within the area. Within this example Strand Street has been identified as a 'Green' route and therefore the safest walking route to the destination location. The user can either walk directly to the Cape Town MetroRail Station via the safest walking route, or the user could walk to the nearest BRT stop along the safest walking route and take the bus to the desired destination.
Whichever route the user wishes to take the App will track their movement and log the path. This system will allow for the user to complete the next steps within the App.

Figure 5.23 Step Four of the App Interface *(Authors Own, 2016)*

5.8.5 Step Five

Once the user has walked their route and reached their destination, the next steps within the App are to rate and evaluate the route taken. Step Five comprises of an interface that asks the user to rate their route based on the ranking system of “Green”, “Orange” or “Red”. The user is required to choose a category and submit their rating in order for the next interface layer to pop-up.

This ranking data that the user submits is then accumulated within the App Database and is added to the API. This information can then be reintroduced into the App to display newly rated routes within the located urban environment.

Figure 5.24 Step Five of the App Interface *(Authors Own, 2016)*

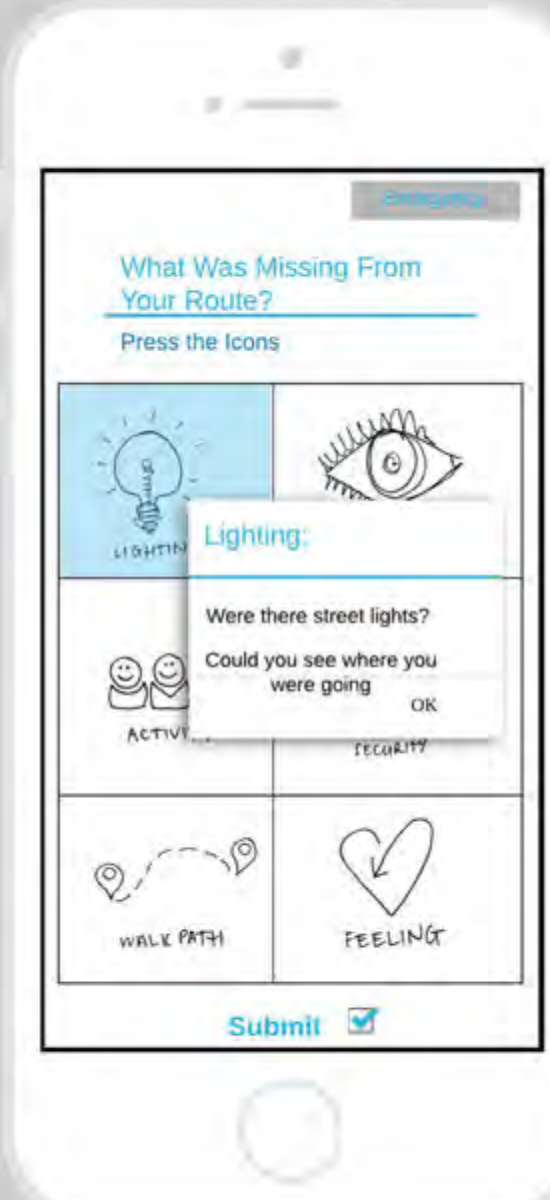
5.8.6 Step Six

The final step in the App process is to evaluate the route based on the 6 Safety Evaluation System variables. The user will be asked what aspects were missing in their route. This layer will display the 6 variables and their associated icons – each icon represents each of the 6 variables. The user is required to highlight which variables were missing, lacking or require improvement within their route. When the user presses a specific icon a tab will open-up that will explain what the specific variable entails. For example the icon for 'Lighting' will have a text box that askes a few quick questions:

"Was there street lights on your route?", "Could you see where you were going?"

This system allows for the user to easily understand and submit their evaluation of the route. The user will simply press a series of icons or 'issues' that were missing for the route, and then the user submits their evaluation at the bottom of the interface layer. This information goes directly to the associated Database to be analysed and used as an 'information pool' of new spatial knowledge.

Figure 5.25 Step Six of the App Interface *(Authors Own, 2016)*



5.8.7 Emergency Button

Many of the research participates interviewed in Chapter 4 highlighted the desire for an 'emergency button' to be present within the App functions. The interface layers for Step Four, Five and Six all have access to the 'Emergency Button". These layers have the "Emergency Button" function as a header for each interface screen that can carry on to the next panel or layer. This button appears on the top right-hand header of each panel. The Emergency Button is linked to the contact for the South African Police Services (SAPS) in Cape Town Central. This allows for the user to have quick access to the contact number to report an issue or to gain help if their personal safety has been affected.

5.9 Conclusion

This chapter has demonstrated how ICT systems, paired with user-generated data can create a tool in which to improve urban mobility experiences for commuters. It becomes clear that personal safety and vulnerability is an important factor that influences NMT and human-scale mobility within the urban environment. The app prototype demonstrates that issues of personal safety and individual experiences can be seen as a valid contributor to understanding the greater urban mobility systems and transport infrastructures.

The app prototype demonstrates how the experiences, knowledges and inputs of the user can be important tools in highlighting issues facing the urban environment. This places a recognition that the citizen or 'user' has a powerful role in generating new knowledge about NMT safety, and the ability to create safer commuter experiences through individual and group input. Therefore the App prototype has been designed in a simple structure that promotes a system that is easy for the user to navigate and to find the safest routes.

Chapter 6: Recommendations and Conclusion

6.1 Introduction

This study was a small window of insight into a much larger picture regarding urban mobility, urban environments and the individual experiences of personal safety and social vulnerability within these spaces. Concepts around urban mobility and public transport have been expanded apon to move beyond that of purely structural and infrastructural elements – but to be engaged with through the understanding of the social influences in mobility.

6.2 Reflection

The research was a comprehensive study on the topic of safety and public transport through an intensive case study which has uncovered issues regarding safety and public transport within a specific spatial context. This was done using a gendered perspective in order to evaluate and better understand experiences of safety and mobility within the specific urban environment of the Cape Town, CBD.
The research was able to gain a deeper understanding into some issues facing public transport systems and the users within the CBD. The study was focussed on the influence and prevalence of non-motorized transport (NMT) system within the greater public transport network. The focus on NMT systems was vital in understanding how much the Cape Town integrated public transport system relies on the NMT movement in order for users to gain access to the greater transport infrastructures and networks.

The research on NMT mobility and safety was expanded on through the primary research that focussed on the experiences of public transport users situated within the case study area. The participants expanded on issues facing pedestrian and human-scale experiences of safety within the public transport network and surrounding urban environment. The participants also expanded on knowledge regarding how gender and gender dynamics affect accessibility, mobility and personal safety within the built environment.

The main research question dealt with the issue of how ICT systems can assist in providing safer and more efficient commuter experiences for all. This was made visible within the design of the App prototype and associated ICT systems that inform the function thereof. The prototype was used as a tool to analyse the urban environment based on pedestrian NMT safety within the streets and within the public spaces.

The design of the Safety and Evaluation Systems was able created as a tool for the user to identify what made a street feel safe or unsafe based on a series of principals. This then allowed the urban environment to then be analysed through a set of spatial and social parameters. This could then be visualised within the App and associated mapping techniques. Finally this information was turned into a system of data management that could then be analysed in order to gain knowledge on trends and occurrences within the spatial environment.

The subsidiary research questions dealt with issues around commuter safety at a human-scale through NMT and pedestrian mobility. In or-

der to gain an insight into issues facing public transport users and their personal safety within the urban mobility networks; a gender-sensitive lens was applied to collecting primary data on the topic.

The primary qualitative research in Chapter 4 uncovered some of the dominant issues facing public transport users within the case study of the Cape Town CBD. The research indicated that personal safety was an important aspect for the research sample and that current public transport systems are lacking in a deeper understanding of the nuances of commuter- safety, accessibility and freedom of mobility.

A gender-sensitive lens was applied to the collection of qualitative research in order to identify some of the social and spatial elements that inform pedestrian commuter experiences of safety within the urban environment. A gender-sensitive lens was important to apply to the study as it was used as a tool that allowed for considering how vulnerable minority groups experiences safety and NMT mobility within the CBD. This allowed for gaining knowledge into how men and women use public transport and experience mobility in the urban environment. It also allowed for understanding how gender dynamics play a role in negotiate safety and mobility. This allowed for the unpacking of gender-based power-relations within the realms of accessibility, affordability and commuter safety.

i. How can ICT assist in providing a safer and more efficient commuter experience for all?

ii. How do public transport systems and NMT systems function within the Cape Town CBD, through the lens of gender-sensitive commuter safety experiences?

iii. How can user-generated data and ICT system be used as urban management and planning tools to provide for safer urban mobility structures within the urban environment?

6.3 Looking Towards the Future

The research has demonstrated how ICT systems can be used as a tool to improve the mobility experiences of public transport users within the CBD. This was done through the platform of a mobile phone App that can help users find the safest NMT or pedestrian mobility routes to link to public transport systems within the city.

Furthermore, the App also allows for the user to update information regarding the state of the urban environment in relation to their personal experiences within the space. This can result in a collection of real-time data on the nature of the urban space that the users are interacting with. This can result in creating updates regarding issues of commuter safety within the urban environment, but also for creating updates regarding the state of the urban environment at a structural, design and spatial level.

The user-generated aspect of the App becomes vital in the future user as a tool to inform planning and urban management. This system of user-generated data collection and sharing informs the importance of acknowledging the functions and contributions the user or 'smart citizen' has in creating safer and more informed urban en-

vironments and mobility networks. It informs the notion of cyclical planning and production at all levels; from the user to the planner , government and beyond.

6.3.1 Planning and Coproduction

The user-generated data aspect of the App is vital in creating new information and updated knowledge about the urban environment through the lens of public transport and NMT commuter safety. Such user-generated data is an ever-changing and fluid system that is constantly transformed and influenced by the structural factors and social factors within the specific environment. This study has argued that this data that is generated by the App through the input of the user, can be used as a planning and urban management tool. It would require a new understanding of planning and planning practice that is centred in a form of coproduction and user-generated data and sharing. This relies on understanding how ICT systems can be used as tools of management and sharing by both citizens and planners.

This concept informs the current need for planning and planning practice that applies a more coproduction perspective with the user, community and/or citizen. The system of user-generated data as a tool to inform future planning, is a system that focuses on a form of 'bottom-up' practice in planning. This creates a partnership of sharing between the citizen or community and the planner.

Albrechts (2013) argues for a change in the approach and perception of planners and professionals both in the private and public sector that applies a more coproduction lens within a strategic planning model. It calls for new form of strategic planning that is rooted in creating individual change through the coproduction of citizens and grassroots organizations. This will result in more effective management of issues and development projects in a dynamic system that supports transformation in ever changing contexts (44-50). The argument for coproduction lies in empowering the citizen and individual to become part of the planning and development process. It moves away from the notion of citizens being passive bodies to that of become empowered citizens through individual and community agency. This involves a coproduction lens of involvement and sharing between the citizen, stakeholder and the government (55).

This theoretical argument can be applied to this study and to the concept of user-generated data and the 'smart citizen' (Hemment & Townsen, 2013). The app was designed in order to not only provide a services for the user or citizen, but also for the user to contribute to knowledge production within their society and urban environment. Thus the concept of user-generated data acts as another form of public participation. This function through an App tool can become a fast, efficient and an up-to-date system that relies on ICT as a tool for sharing. It is a simple system that allows for the user to gain control and agency to create improvements for their everyday urban livelihoods and experiences.

6.3.2 Gender, Mobility & Planning

The study has also highlighted the importance of recognising gender dynamics within societies and therefore within urban environment

and within the topic of urban mobility. This study applied a gender-sensitive lens to concepts around urban mobility, public transport infrastructures and NMT mobility. The concepts surrounding accessibility and freedom of movement were expanded on in order to demonstrate that these system move beyond that of structural and spatial elements. It became clear that these topics are also highly influenced by social factors and the intersections of such factors of: gender, socio-economic status, spatial proximity and personal experiences of safety and vulnerability.

Through the gender-sensitive lens this study was able to bring to light some of the more 'invisible' elements that contribute to urban mobility, public transport and equal accessibility. This was made visible through the qualitative research on personal experiences of safety and vulnerability within the Cape Town CDB through human-scale mobility and public transport mobility. The qualitative research divulged personal experiences of safety and what spatial and social elements contribute to these experiences.

It was also made clear how these elements limit individual's ability to use, access and rely on public transport system within Cape Town. The research also highlighted how vital NMT mobility is within the greater public transport environment, and how providing for NMT users and their safety if fundamental in improving the integrated transport model that Cape Town is working towards.

This information influences the need for applying a more gender-sensitive agenda to planning in Cape Town and South Africa. Returning to Collins (1990); it becomes important for planners to consider when the experiences of different women based on class, race and spatial location can be understood and represented correspondingly (Sandercock & Forsyth, 1992). On the topic of urban mobility and personal safety within the urban environment and within transit - it needs to be considered how the experiences of women are highly important.

The lack of personal safety and fear of vulnerability have contributed to limited accessibility and freedom of movement for women within urban spaces. This results in the limiting and depletion of women as a part of the urban fabric of cities, their communities, their economic contribution and social functions. By creating safer urban spaces and mobility networks, other social issues can be improved.

6.3.3 Safer Streets for NMT mobility

The research that was collected within Chapter 4 and the design of the App prototype in Chapter 5 can be used as a system to inform what makes a street, urban corridor or public open space feel safe for pedestrian-scale commuters. The research identified a series of elements of social and spatial factors that influence experiences of commuter safety within the urban environment.

The argument throughout the research is that urban environments, mobility routes and streets that are designed at a human-scale create a deeper 'sense of place', 'place making' and 'street life' (Lynch, 1982; Cullen, 1968; Jiven & Larkham, 2003). These factors then inform urban environments that promote more human-scale mobility structure that is safe and welcoming for all commuters. The research

participants in Chapter 4 identified that streets that promote human activity, density and space for social networks are viewed and experiences as safer environments for human-scale commuters. Therefore urban spaces, mobility nodes and public spaces need to be designed in order to facilitate these social functions and systems.

The spatial elements that contribute to safer commuter experiences are based in the design and functions of the street. These design elements were identified in the literature analysed in Chapter 2, as well as the primary research unpacked in Chapter 4 and Chapter 5.

This included the need for a street to have specific design aspects in order to create a safer human-scale commuter environment. This includes urban design elements of visibility, legibility, social activity, security and mobility at the human-scale.

Elements of visibility include design aspects of: good street lighting, wide pavements, public transport infastructures and wide, busy, active streets. These aspects were identified by the research participants in Chapter 4 as contributing design factors in creating safe street environments for NMT mobility. The aspect of commuter legibility was identified as an important element in creating commuter safety. This deals with design elements such as: urban landmarks, well- defined walking routes and pathways. These elements need to be present at a human-scale in order to create a more functional and comfortable mobility route for the NMT user (Lynch, 1992; Labuschagne & Ribbens, 2014; Bentley, et al. 1985).

The presence of security was defined as a fundamental aspect in creating safer urban environments, mobility routes and public spaces. The concepts around security that were unpacked in Chapter 4 and Chapter 5 can be introduced into the spatial environment by providing urban safety zones with security centres, security personnel and information hubs.

6.3.3.1 Street Section

The above mentioned design elements are applied to the spatial environment through two section sketches shown below (See Figure 6.1 and 6.2).

This section demonstrates the design elements and layout of a street that promotes NMT commuter safety through the presence of human-scale urban design influences. These sections indicate how different forms of public transport infrastructures can be incorporated into the built environment in order to create an integration of urban mobility. This is visible through the street design that support cycle lanes, wide pedestrianized sidewalks and BRT designated road lanes.

Figure 6.1 demonstrates the street layout in relation to the land-use activities and social activities present along the route. This indicates a street design that is wide to include multiple functions including; public transport, commercial activity, open public space and social activity (See Figue on page 121).
The public transport function should include design for the presence of a BRT system with a designated bus lane and associated bus stops along the movement route. The street should also provide for NMT

mobility through the provision for pedestrian mobility through wide sidewalk design. Bicycle mobility should be provided for through designated cycle lanes incorporated within the street design.

This street model should be designed to include land-uses such as commercial activity and social amenities that are situated in close proximity to public transport systems. This enables better accessibility for the public transport user to access the functions present within the urban environment. The presence of commercial activity along a mobility corridor also contributes to a more integrated urban environment that supports human-scale mobility and activities. This allows for a greater human-scale presence at a street level which provides for the promotion of pedestrian movement. This in turn also creates safer urban spaces for NMT movement which is incorporated into the urban fabric through the corridor design.

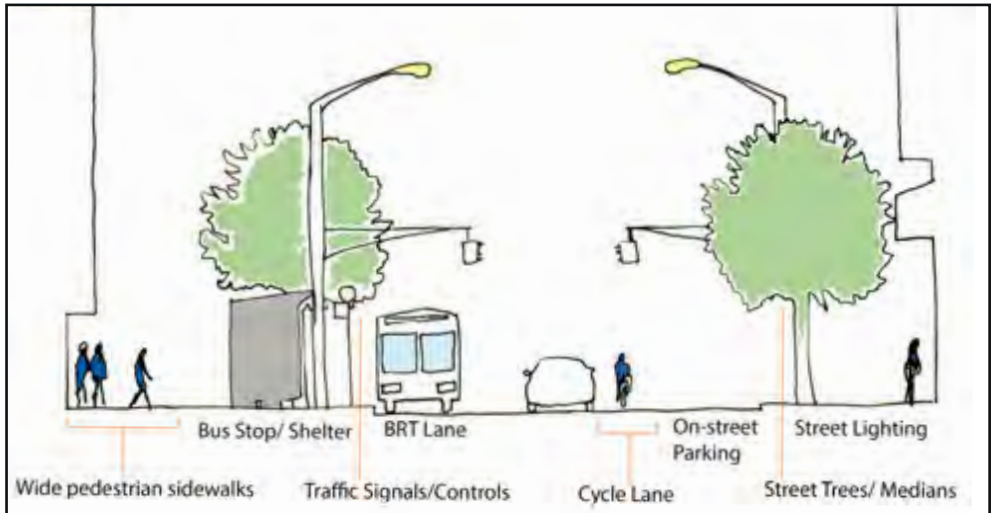


Figure 6.1 Street Section: Design to Promote Integrated Public Transport *(Authors Own, 2016)*

The structural design of the street model shown in Figure 6.1 also demonstrates how safety is improved by street lighting and urban greenery. This improves visibility and legibility at a human-scale level and provides for better navigation within the urban environment.

Figure 6.2 is a section to demonstrate the pavement design within the greater urban corridor layout and function. The pavement design provides space for a pedestrian mobility zone, and spill-out zones for commercial activity, informal trade, and public space zones and security zones. The design also indicates the presence of street lighting and urban greenery to contribute to the sense of place and to improve safety through visibility. These elements could be used as indicators to inform the design and maintenance of creating safer urban environments and commuter routes.

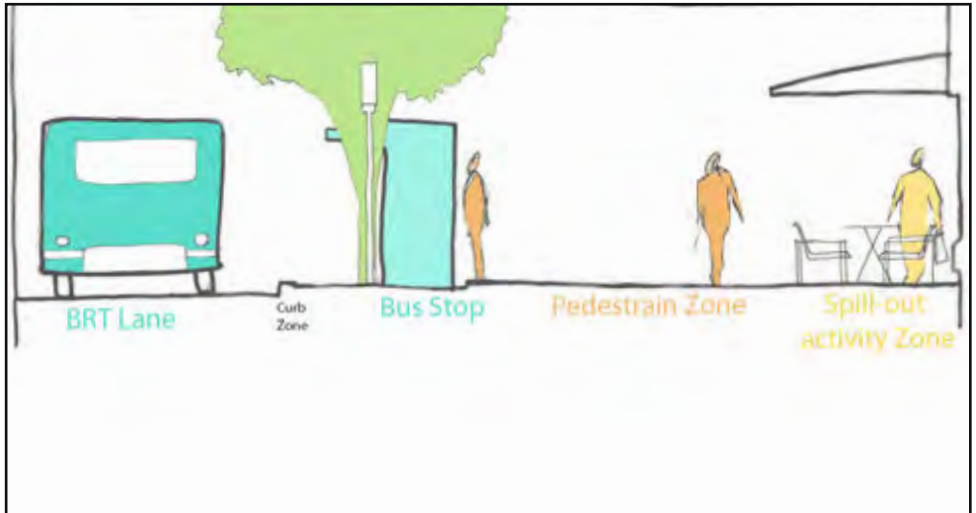


Figure 6.2 Street Section: Pavement design to promote safer NMT *(Authors Own, 2016)*

6.3.4 Future of the App

The design of the App prototype within this study only presents the initial phase and functions that the App could provide. The App could expand its functions and systems as it becomes more popular with commuters and planners or urban developers.

Firstly the App could expand to new spatial locations and urban environments. This relies purely on the user and where they expand their mobility routes and where they generate their safety evaluations using the App. This expansion could create more expansive knowledge and data about public transport, safety and the urban environment within specific locations. This could expand the safest NMT routes throughout the Cape Town Metropolitan and therefore create more efficient and safer public transport networks and linkages throughout the urban landscape.

The App prototype also creates room for the expansion of new urban data and mapping data. This can be achieved through the updating of API systems that can produce new spatial and mapping data for the App. This can be used to create more in-depth mapping tools, tracking systems, location options and public transport selection for the App user.

The App and user-generated data system would rely on a continuous flow of input and management from users and from the planners and App producers. In order for the App database to continue to collect and analyse the user-generated data, the database would require constant maintenance and monitoring.

The more the user of the App creates new route and safety data, and the more the planner or urban manager uses this information to create, plan and develop safer urban moblity networks, the greater the App database will become. This cyclical process of sharing is at the foundation of the App and its success as a tool for both the citizen and the planner.

6.4 Conclusion

Through this study it has become clear that concepts around urban mobility and public transport infrastructures are highly influenced and informed by the user's experience and the user's relationship with the specific urban environment and social networks found within the space. This statement puts forward the need for creating new urban public tansport and moblity systems that design and plan for the user and the human-scale at the centre of analysis.

The concept around user-generated data sharing and coproduction in planning have been highlighted through the medium of using ICTS systems as tool for change and development. It engages with the concept that a form of cyclical planning and production between the citizen and the 'institution' can create safer and mor equitable urban spaces. Allowing for the user to gain agency within their everyday urban activities can promote a more equitable relationship between the citizen and the urban environement. Through technology and the sharing of experiences and knowledges on a social and spatial level, there is the possibility for creating a better understanding of space, design and infrastrucures and the social experiences which manifest within these urban networks.

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Annexure 1

SCHOOL OF ARCHITECTURE, PLANNING AND GEOMATICS
University of Cape Town
Private Bag x3, Rondebosch 7701
Centlivres Building
Email: Janine.Meyer@uct.ac.za Tel: 27 21 6502359

UNIVERSITY OF CAPE TOWN

STATEMENT TO BE READ OUT TO AN INTERVIEWEE BY A STUDENT ABOUT TO UNDERTAKE AN INTERVIEW FOR THE PURPOSES OF A MASTERS DISSERTATION

MY NAME IS **CLAIRE ENSLIN** AND I AM STUDYING CITY AND REGIONAL PLANNING AT THE UNIVERSITY OF CAPE TOWN.

I AM DOING RESEARCH ON **SAFETY & PUBLIC TRANSPORT** AS PART OF MY MASTERS DISSERTATION AND I WOULD LIKE TO ASK YOU SOME QUESTIONS TO HELP ME WITH MY RESEARCH.

I CAN PROMISE THAT I WILL NOT RECORD YOUR NAME OR ADDRESS, AND YOUR PERSONAL DETAILS WILL NOT IN ANY WAY BE REVEALED IN MY DISSERTATION OR ANY PUBLICATION I PRODUCE.

THE QUESTIONS I ASK ARE ONLY FOR RESEARCH AND THEY CANNOT DIRECTLY BENEFIT YOU OR YOUR COMMUNITY.

IF YOU WANT TO END THE INTERVIEW AT ANY POINT YOU ARE FREE TO DO SO.

MY SUPERVISOR IS **NANCY ODENDAAL** AND HER CONTACT DETAILS ARE: **nancy.odendaal@uct.ac.za**

Signed

Signed
04.09.16.

This form is to be completed with your details filled in, and submitted with your ethics form

SCHOOL OF ARCHITECTURE, PLANNING AND GEOMATICS
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MY SUPERVISOR IS NANCY ODENDAAL AND HER CONTACT DETAILS ARE: nancy.odendaal@uct.ac.za

Signed

Signed

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MY SUPERVISOR IS **NANCY ODENDAAL** AND HER CONTACT DETAILS ARE: **nancy.odendaal@uct.ac.za**

Signed 06/08/16

Signed

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Signed 3/08/16

Signed

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Signed

Signed

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Annexure 2A

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UNIVERSITY OF CAPE TOWN

PLEASE FILL OUT THE QUESTIONS BELLOW:

1. Do you take public transport in the Cape Town, CBD?
2. Which transport systems do you use? What time of day?
3. Do you also rely a lot on **walking** to get to these transport systems? Approximately how much time do you spend walking? How many times do you change transport modes?
4. Can you describe to me your average **route to work/schoo**l in the morning?
5. Do you feel **safe** when you are in different public transport stations or on the bus/train? In which mode (if you use more than one) do you feel safer?
6. What makes you feel this way? Are there particular places where you feel unsafe? Time of the day?
7. Do you feel safe **walking** to or from the bus or train?
8. Do you think it is safer for men to walk, then it is for women?
9. Why do you think that?
10. Do you **plan your walking** routes before to leave home?
11. What informs your plans?
12. Which **streets feel safe to walk**, and what makes them feel safe?
13. Do you use your mobile phone to access information about public transport – such as departure times, locations and tracking?
14. Do you use any Cape Town transport mobile apps? Or any others? (Google Maps for example)
15. **Would you use a mobile app that showed you the safest walking routes to your bus/train station? What would you expect from such an App?**

Annexure 2B

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UNIVERSITY OF CAPE TOWN

PLEASE TICK THE FOLLOWING BOXES PROVIDED BELLOW:

Female ☐

Male ☐

Age: 15 -25, 26 – 36, 37 – 47, 48 – 58, 59 – 68, older

1. **Do you feel safe using public transport systems in Cape Town?**

   Yes ☐

   No ☐

2. **Do you feel safe walking to public transport systems in Cape Town?**

   Yes ☐

   No ☐

3. **Is safety an important aspect for you when you are taking public transport?**

   Very Important ☐

   Important ☐

   Not Important ☐

4. **Do you plan which transport routes you take based on your personal safety?**

   Yes ☐

   No ☐

5. **What are the biggest issue facing public transport in Cape Town? Tick a box.**

Safety	Yes, very	Maybe	No
Efficiency	Yes, very	Maybe	No
Affordability	Yes, very	Maybe	No
Convenience	Yes, very	Maybe	No

6. **Do you use your personal mobile phone to access information about your bus or train?**

   Yes ☐

   No ☐

7. **Would you use a mobile phone App to help you with safety and your transport?**

   Yes ☐

   No ☐

8. **Would you use a mobile phone App if you knew and understood how to use it?**

   Yes ☐

   No ☐