NATIONAL DEPARTMENT OF TRANSPORT

NTR 1: Part 1

National Technical Requirement 1: Pedestrian Crossings

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Executive Summary

This research report is the first component of the process to inform the development of National Technical Requirements (NTRs). The first of this suite of National Technical Requirements is National Technical Requirement 1 (NTR 1) on Pedestrian Crossings.

The development of NTR 1 has been commissioned by the Public Transport Network Development Chief Directorate, Public Transport Branch. The primary objective of NTR 1 is a structured and standardized approach to address improved pedestrian safety, through a thorough understanding of the needs of all pedestrians, as a significant component of the public transport strategy.

NTR 1, *National Technical Requirements on the Design of Pedestrian Crossings,* recognizes the need to develop the NMT Facility Guidelines, published by the National Department of Transport in March 2015, into more specific technical requirements. This report is an overview of the background research to inform the rationale and functional requirements, recognizing the value of applying universal design principles to improve performance, functionality and safety of pedestrian crossings in South Africa.

The current status of pedestrian crossings, the relationship with other traffic standards (both national and SADC-related) and current road engineering practice has been reviewed. While this is not a comprehensive evaluation, it provides insight into the current culture of motor-vehicle-centric road design. Pedestrian and Non-Motorised Transport (NMT) infrastructure has, in many cases, been developed as a secondary consideration to primary road design. The geographical legacy of apartheid complicated this. It was a system based on separation in urban development and inequality of infrastructure provision, which provided the basis for developing even more hostile pedestrian environments. The dichotomy for pedestrians, who are exposed to the most sub-standard pedestrian infrastructure and are forced to walk long distances in the early mornings and evenings; is the reality faced by many South African's. A significant number of these pedestrians fall into the scope of the definition "targeted categories of passengers" (National Land Transport Amendment Bill, 2016:3), who are highly vulnerable, especially where pedestrian infrastructure creates conditions that make it difficult or dangerous to cross roadways and negotiate intersections.

The concept of appropriating and sharing the road space has been identified in a number of policy prerogatives since the strategic Moving South Africa Action Agenda (NDoT, 1997) which was implemented in 1999. Given the focus on the promotion of

public transport systems, a key component of these systems is appropriate and safe pedestrian access. This is an integral part of the functionality of public transport.

The paradigm shift to prioritizing pedestrians, and other forms of NMT, has been raised in a number of transport forums and there is general consensus that prioritizing pedestrians should be a fundamental prescript to the promotion of public transport.

The profile of road users includes a significant number of vulnerable NMT users which includes a large range of pedestrians who experience functional limitations (WHO ICF, 2001), which includes persons with a physical, sensory, neurological, learning or psychosocial disability. Disability may be permanent or temporary. In transport legislation other vulnerable pedestrians are identified; elderly people, pregnant women, children and those who are limited in their movements by children (i.e. travelling or moving accompanied by a child. There are also the following pedestrians/passengers who "have special categories of need" (NDoT, 2016), defined as life cycle passengers, signage passengers, female passengers, and load carrying passengers.

These are attempts at providing definitions of persons who may encounter a range of challenges when using pedestrian and public transport infrastructure, due to the fact that their needs have not been adequately accounted for in planning and execution of public transport systems. However, it is self-evident that pedestrian infrastructure should be designed to be universally accessible so that all pedestrians/passengers are able to operate through these systems as efficiently and independently as possible, while not exposing them to any danger.

In this regard, it is important to recognize that persons with cognitive and sensory impairments have traditionally been overlooked. These include persons who are partially sighted or blind, persons with hearing limitations, and persons who find it difficult to communicate. The last category, while not a consequence of impairment, also includes pedestrians/passengers who have linguistic challenges, due to illiteracy or foreign language.

The discussion on how we achieve universal access to meet all the needs of all pedestrians, including the vulnerable NMT users, in the road space has opened. Universal access is a product of applying the principals of Universal Design, (UN, UNCRPD, 2006). The fundamental premise is to design and develop pedestrian infrastructure to recognise the diversity and functional abilities or limitations experienced. The seven principles of universal design are (Universal Design Centre UNC, 1997):

- Equitable use

- Size and space for approach and use
- Perceptible information
- Flexibility in use
- Simple and intuitive use
- Tolerance for error
- Low physical effort.

When applied to pedestrian infrastructure, the principles provide us with an ability to analyse the key factors that should inform the design and development of functional, efficient and safe pedestrian crossings.

The significance to local users, the impact on access and usability of facilities, zoning and planning, as well as the role of road classification and speed limits, are critical factors to consider. The move away from motor vehicles as the primary users of the road space, with NMT users relegated to secondary status, has been established in the DoT NMT Guidelines and the DEA Sustainability Guidelines. The recognition of realistic walking speeds, and other factors that impact on a pedestrian's ability to negotiate and cross the road at a pedestrian crossing, are key to achieving a viable and safe pedestrian crossing layout.

The current inter-dependence between road classification and the associated design geometry, which dictates road width and bell mouth radii, as well as the application of regulated speed limits, create conditions which are unsafe for pedestrians. Intersections designed with the emphasis on optimizing the motor vehicle flows, encourage drivers to negotiate intersections with assumed priority at inappropriate speeds. Pedestrians are then required to negotiate these conditions, where inadequate or no safe areas of refuge exist, especially on median islands under multiple-cycle signalization of traffic lights.

The concept of 'Complete Streets' (City of Johannesburg, 2013), attempts to address a sustainable transport hierarchy by recognising the need for multi-modal transport systems that support safe, sustainable, and liveable communities. This approach identifies the significance of appropriate land use management and the development of associated infrastructure to reduce the overall length of journey necessary for public transport users and pedestrians.

This report investigates the existing design parameters that apply to pedestrian crossings, which are articulated in a range of guidelines, manuals, codes and standards. These include:

- CSIR's, Red Book: Guidelines for Human Settlement Planning and Design

- Tshwane's Bus Rapid Transit Engineering Designer Handbook
- City of Johannesburg's Complete Streets Manual
- National Department of Transport's NMT Facility Guidelines
- Johannesburg Road Agencies Roads and Storm-Water Manuals
- The Highway Capacity Manual
- South African Road Traffic Signs Manual
- South African Development Community Road Traffic Signs Manual
- SANRAL Routine Road Maintenance
- South African Bureau of Standards, SANS 10400
- International Standards Organisation, ISO 21542.

These documents were analysed and a number of significant parameters were identified. The principles of universal design were used as the determining factors for this research. This has resulted in the identification of design principles that are consistent with universal design and result in universally accessible pedestrian infrastructure.

In this research report, there are numerous references to requirements that are not seen in typical existing road design and designs proposed for upgrades. However, these have already, largely, been discussed and subsequently included in the thirteen municipalities developing Integrated Rapid Public Transport Networks (IPTN's). Thus, the design principles that inform NTR 1 draw heavily on the wisdom and experience of these project's management, design and construction teams.

It has been possible to identify some broad design principles, in the application of universal design to pedestrian crossings, which guided the formulation of the NTR 1. These broad design principles are:

- Completeness / Coherence
- Directness
- Less Conflict
- Speed Appropriateness
- Attractiveness
- Clear and Unobstructed Spaces
- Safety
- Accessibility.

These principles, drawn from significant documents such as the Complete Streets Guide published by the City of Johannesburg (2013), identify the need to provide safe, convenient mobility and accessibility for all pedestrians. The notion of 'Attractiveness' ensures the provision of safe and attractive conditions for walking and cycling to increase the physical activity levels of car-captured members of the travelling public.

Both the efficiency of public transport, and the wellness of the general public, are improved if people who are car-captured are able to leave their cars at home and use NMT facilities.

These factors suggest that the technical requirements for NTR 1 should recognize the extension of the universal design paradigm through the current goals of universal design, articulated by E. Steinfeld at UD2012 in Oslo. His eight goals are:

- Body Fit – Accommodating a wide range of body sizes and abilities
- Comfort – Keeping demands within desirable limits of body function
- Awareness – Ensuring that critical information for use is easily perceived
- Understanding – Making methods of operation and use intuitive, clear and unambiguous
- Wellness – Contributing to health promotion, avoidance of disease and prevention of injury
- Social Integration – Treating all groups with dignity and respect
- Personalization – Incorporating opportunities for choice and the expression of individual preferences
- Cultural Appropriateness – Respecting and reinforcing cultural values and the social and environmental context of any design project

NTR 1, however, must respond to the realities of traffic engineering which are covered in the '*Guidelines for Human Settlement Planning and Design (The Red Book)',* published by the CSIR in 2009, which include a range of significant components such as:

- Classification of the road and street system
- Traffic calming
- The road surface
- Design speed
- Stopping, decision and intersection sight distances
- Horizontal and vertical alignment
- Medians and outer separators
- Verges and sidewalks
- Location and form of intersections
- Intersection components
- The types of intersection control.

NTR 1 will also be informed by other significant design parameters related to construction systems, drainage and road markings.

Whilst the scope of this report is as wide and inclusive as possible, time and resource constraints have resulted in certain limitations, which ideally would have been addressed should the project have been afforded more resources and longer time frames. This research report (NTR 1: Part 1) is the background for the technical requirements (NTR 1: Part 2) to inform the design of universally accessible pedestrian crossings. The development process included stakeholder consultation which was incorporated in the final version of NTR 1 (Part 1 and Part 2). NTR 1, as a whole, will be published by the National Department of Transport and will lead to national regulations for pedestrian crossings under the National Land Transport Act 2009.

Acknowledgements

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Contents

List of Figures

List of Tables

1. Introduction

"The challenge is not one of cost; a good urban project does not cost more if it includes Universal Design concepts. The challenge is changing notions of what our urban environment should look like and whom it should accommodate" - IDB president, Enrique V. Iglesias (2001)

1.1 The Current Status Quo

The Draft Green Paper: Road Policy for South Africa (NDoT, 2016), states that road users are reliant on a safe and efficient road network. Road safety considerations for vulnerable road users have to be taken into account in the planning of new roads, human settlements, public facilities; generally all developments, as well as when improvements of existing roads are undertaken. Furthermore, it states that current road design guidelines should support Transit Orientated Developments (TOD), public transport needs, Universal Design requirements and NMT goals (Draft Green Paper on Roads Policy for South Africa, 2016: 26).

The current reality is different. The Public Transport Strategy and Action Plan (NDoT, 2007) indicates that South Africans are exposed to a hostile pedestrian environment. There is evidence of a direct correlation between this hostile public transport and lack of environment and social and economic development (Vanderschuren and Galaria, 2003; Behrens, 2004; Walters, 2008; Vanderschuren et al., 2015).

Many of the Reconstruction and Development Programme goals defined in the first years of democracy remain to be achieved (South African Cities Network, 2014: 2). These remain goals in the National Development Plan 2030.

Roads and streets can influence the urban quality of the surrounding areas and will be integrated with surrounding land use towards creating livable environments (NDoT, 2016) In reality, high levels of inequality have far reaching implications for all individuals, making self-empowerment difficult and, in some cases, impossible (Vanderschuren and Galaria, 2003; Behrens, 2004; South African Cities Network, 2014). The Gini coefficient[1] for South Africa was 63.4 in 2011, indicating that there is still significant inequity between different parts of the population. The experience of inequity for many South Africans is of a hostile, unaccommodating built environment.

[1] Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality (http://data.worldbank.org/indicator/SI.POV.GINI).

This includes:

- Poor mobility and accessibility to essential services and facilities;
- Expensive and time-consuming trips to places of employment and education;
- Dangerous transport facilities that do not take into consideration the local context or land use into account;
- High safety risks to all road users but especially to targeted individuals (National Land Transport Amendment Bill, 2016: 3).

Universal Design is fundamental in ensuring accessibility and integrating pedestrian movement within the South African transport systems. In South Africa, where the poor are forced to walk through circumstance and the more affluent do not walk because the road space is considered to be too dangerous, ensuring safe NMT facilities is an important aspect of encouraging more sustainable mode choices and cost-effective, efficient travel behaviour. Walking is a very efficient mode of transport that is often overlooked, due to the inadequate facilities or concerns over safety. The Green Paper (NDoT, 2016) demands that "in the design of roads and streets, the principles of Universal Design are followed, where appropriate and safe".

Accessible and integrated pedestrian movement is safe, convenient and comfortable. In South Africa, Some 33% of deaths that occur on South African roads are pedestrian fatalities (NDoT, 2016). Therefore, improving pedestrian safety is a critical component of enhancing the manner in which South Africans travel.

This research report examines the background research for the *National Technical Requirement 1: Pedestrian Crossings.* Safety aspects will be emphasised. The designs included in the *National Technical Requirement 1: Pedestrian Crossings* will incorporate Universal Design to better accommodate a wider range of individuals' abilities. Some of the central aspects that need to be considered include:

- Mobility of all pedestrians to public transport facilities and services, typically referred to in literature as the first / last km ("mile") challenge;
- Increased levels of accessibility to allow for all pedestrians (regardless of age, gender or ability) to access trip origins and destinations;
- Levels of pedestrian safety for all pedestrians, but especially vulnerable targeted groups;
- Encouraging links between private motorised vehicles to non-motorised transport facilities or to public transport facilities and services.

This report examines the research to support the planning requirements and technical designs included in the *National Technical Requirement 1: Pedestrian Crossings*. The conceptual framework for this, and further national technical requirements, is included in Figure 1.

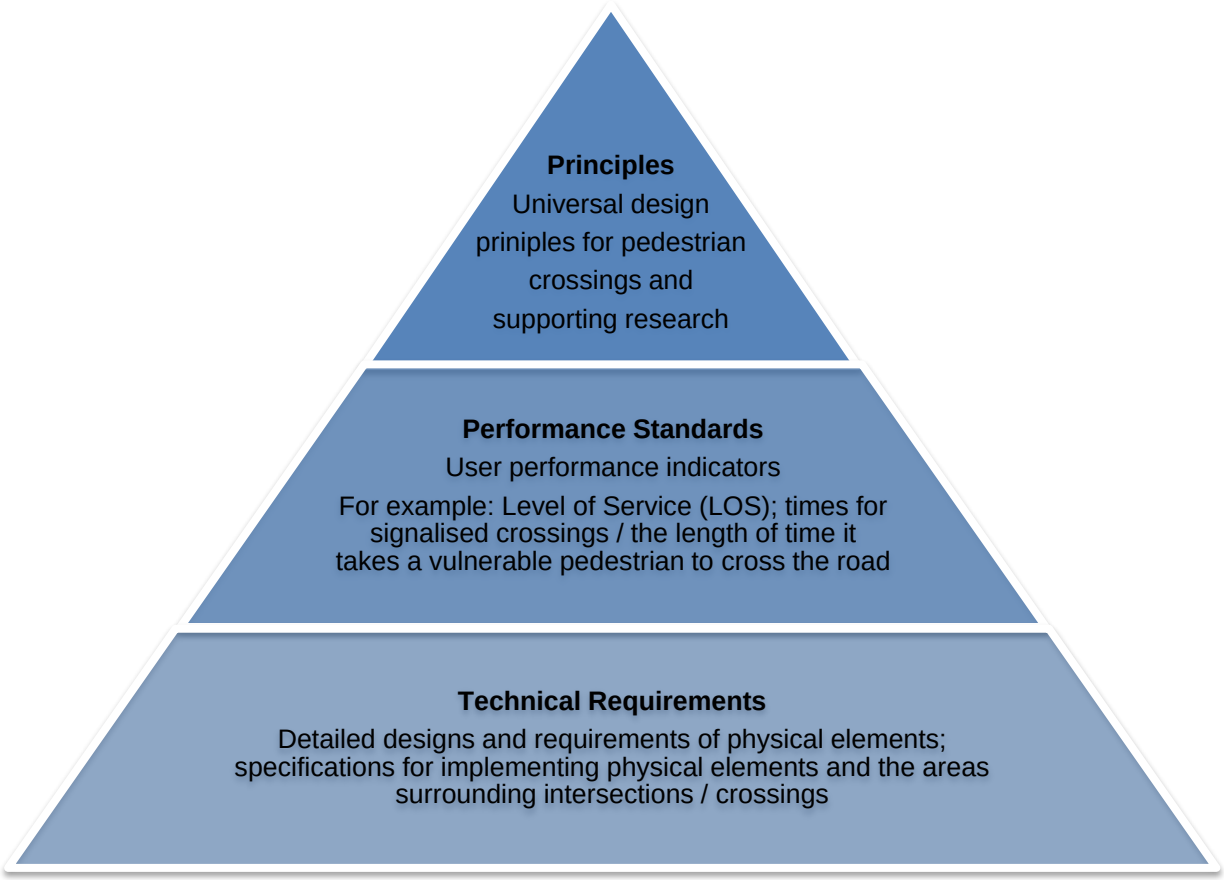

Figure 1: Relationship between Principles, Performance Standards, and Technical Requirements. Image created by UD Africa

1.2 Pedestrians and the Economy: The Walking Dichotomy

People in lower income socio-economic groups are more exposed to increases in public transport costs and experience an increased disconnection with public transport services (Vanderschuren and Galaria, 2003; Behrens, 2004; Van Wee, 2011).

This is, generally, because they tend to live further away from places of employment or education and health facilities, resulting in longer, more expensive and time-consuming trips (Vanderschuren and Galaria, 2003; Behrens, 2004).

They are also more likely to have lower levels of car-ownership, creating a dependency on public transport infrastructure and services. This is illustrated in Figure 1, where low-income groups rely on walking and public transport to fulfill their

transport demands, whereas higher-income groups use private motorised transport (either as driver or passenger).

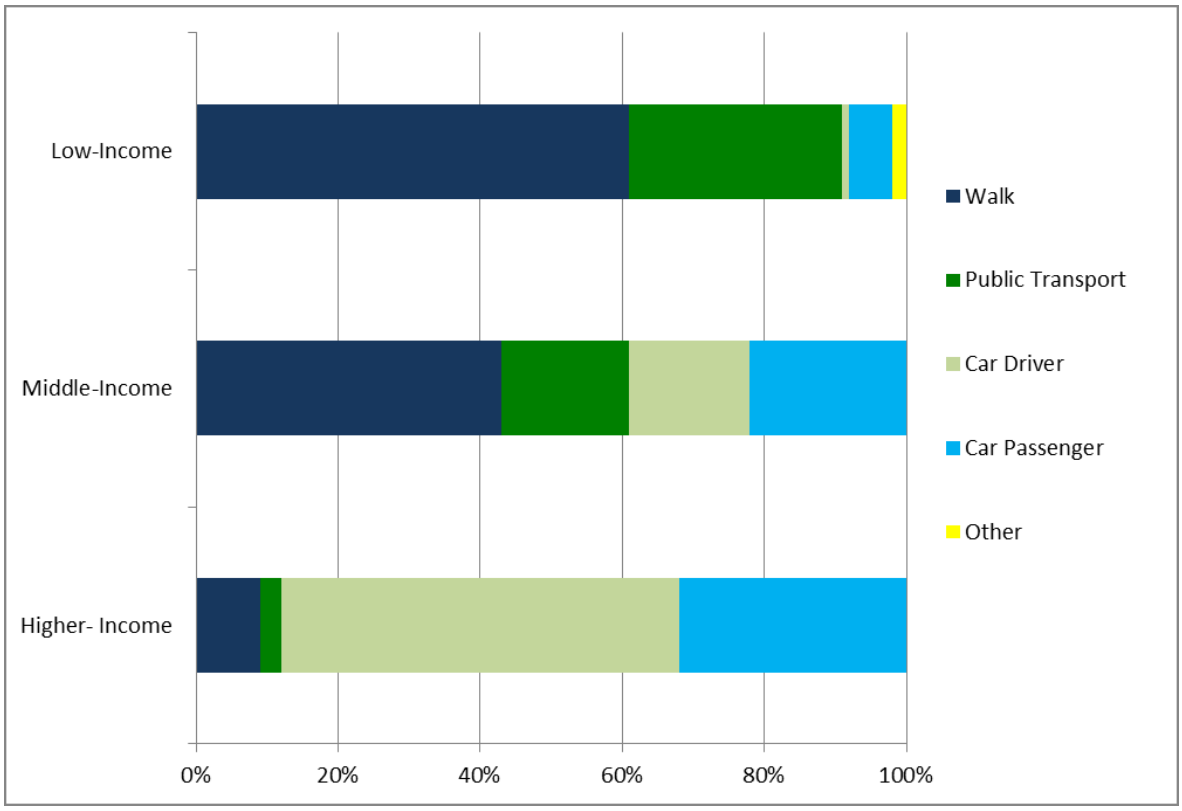

Figure 2: Percentage of the Main Mode use for all Trips by Household Income (n=204)

Source: Behrens, 2004

As transport costs increase and congestion causes increased travel time, lower income socio-economic groups experience higher levels of the travel burden than those who live closer to work (Vanderschuren and Galaria, 2003; Behrens, 2004).

Lower income socio-economic groups are more likely to walk early in the morning and late in the evening, reducing the amount of time available to spend with family, in order to access economic and other opportunities that are situated far from their places of residence (Vanderschuren and Galaria, 2003; NDoT, 2015).

Behrens (2004) shows that the urban poor, who move from rural to urban settlements, are at a higher risk of being involved in a road collision, following their move, than those that have been living in urban settlements for a longer period of time.

A road injury or fatality for an individual on a lower income has a measurably different level of impact in comparison to an individual on a higher income. The direct and indirect impacts are likely to have a larger financial burden on the livelihood of the involved family, as often there are many dependents on an individual's income (Behrens, 2004).

If public transport systems, infrastructure and services continue to fail vulnerable members of society, the negative externalities and unbalanced burden of poverty will continue (Van Wee, 2011; NDoT, 2015). This limits the possibilities for social and economic growth and stunts mobility between different income groups (Van Wee, 2011; South African Cities Network, 2014).

1.3 Scope and Limitations

This research report has been formulated to inform a broad understanding of the context and challenges experienced by pedestrians in South Africa and is not an exhaustive research exercise. While the report also recognises the diversity of urban and peri-urban development in South Africa, there are a wide range of different responses to addressing existing pedestrian infrastructure and it does not cover all variants. The research predominantly focuses on developed urban road infrastructure. It draws on general design principles from the most significant manuals, guidelines, design codes and standards. The timeframes and resources available for this commission have imposed limitations on the ability to interrogate all these codes and standards in detail. All significant components of these codes and standards have been evaluated, in the context of the design parameters related to pedestrian crossings, both at traffic intersection and midblock crossings. There has also been some emphasis on pedestrian crossings serving Bus Rapid Transport (BRT) trunk stations located on the median.

1.4 Structure of Report

The structure of this report draws on the elemental factors that impact on the status of the pedestrian as a user of the road space. To inform the understanding of this status the report first addresses the question of “Who Owns the Road Space” through an evaluation of road classification and which defines the functional classification of roads, access to the road network and the current hierarchy of users. It goes on to identify the profile of pedestrians and the issue of sharing the road space and prioritising pedestrians. The sector of road users that are regarded as vulnerable are explored, with a specific focus on NMT users and, specifically, pedestrians that have “special categories of need” (NDoT 2013) and their prevalence in a typical pedestrian profile. It then looks at the argument for making appropriate space for pedestrians and how Universal Design can address the argument. It goes further to look at local users and the impact on facilities, the impact of zoning and planning and the role of speed limits. The final chapter deals with design principles, analysing existing design, guidelines, manuals, codes and standards and articulates the principles that will

support the design of universally accessible pedestrian crossings based on the paradigm of Universal Design.

This report consists of six chapters, each with respective references, which are listed at the end of the report. The Introduction (Chapter 1) deals with the broader aspects of the status quo and introduces the relation between pedestrians and the economy, as well as giving basic layout and structural information about the report, which in its entirety is NTR 1: Part 1 Pedestrian Crossings. Knowing who is occupying the road space is dealt with in Chapter 2, where road classification is expanded on, as well as who pedestrians are and how the road space can be shared with them, which leads to transport user hierarchy - which concludes the chapter.

While the previous chapter deals with who pedestrians are, Chapter 3 investigates more detail around vulnerable NMT users and how spaces should be designed to incorporate all people, through universal design, at pedestrian crossings. After the implications of universal design for pedestrian crossings are concluded, Chapter 4 looks at specifics around universal design for pedestrian environments. This chapter considers local users and the impact on facilities, the impact of zoning and planning and closes with the role of speed limits. Based on the fundamentals of the NMT Facility Guidelines (NDoT, 2015) around designing for pedestrians, the final research chapter of this report highlights eight design parameters. Chapter 5 describes the design parameters that, together with the principles of universal design and findings from Municipal and National Codes, Standards, Guidelines and Practices, resulted in a basic methodology, which is summarised at the end of the research report, in Chapter 6: Conclusion.

2. Who Owns the Road Space?

"It's time.
Time to hear what people with disabilities are saying.
Time to confront prejudices regarding the value of all people.
Time to realise that the exclusion of one endangers us all." – Dave Hingsburger[2]

The implications for designing safe pedestrian areas range from broad concepts, such as the road classification, change in land usage due to urban development, design and allocation of the road space, to the priorities given to vulnerable road-users. At a detailed level, they include the placement of street furniture and determining acceptable gradient changes.

2.1 Classification of Roads

Accommodating pedestrians on higher classes of roads is difficult and dangerous. Some discussion of road classification is needed in order to understand the underlying frameworks that influence the quality of the facilities and infrastructure that are then made available for pedestrians or vehicles.

Traditional engineering documents, classifying roads, include:

- The *Technical Recommendations for Highways (TRH 26) - South African Road Classification and Access Management Manual* (COTO, 2012);
- This manual supersedes the *National Guidelines for Road Access Management in South Africa* (COTO, 2005) and *Manual for the Redefinition of the South African Road Network* (NDoT, 2008);
- The main purpose of *Technical Recommendations for Highways (TRH 26) - South African Road Classification and Access Management Manual* (COTO, 2012) is to provide guidance on determining the functional classification of a road, as well as managing the access to the road network (COTO, 2012).

Importantly, the *South African Road Classification and Access Management Manual* (*COTO,2012:6*) states that:

> *"Roads must be provided to suit land use and not the other way around."*

[2] http://www.inclusion.com/inclusion.html#change [accessed 03 November 2016]

Although this statement indicates that, if land use areas require prioritised pedestrian access a road should be reclassified, the manual still favours individuals with private motorised transport, as seen in the extract below (COTO, 2012:8):

"*Improved accessibility (of vehicles) leads to greater access to economic opportunities for both businesses and individuals:*

> *i) An increased market area from which customers can be drawn because of reduced travel times. If the average speed on roads in an area is 35 km/h, a business is within a 20-minute drive for customers living in a 12 km radius. For an average speed of 50 km/h, however, this distance increases to a 17 km radius, which is equivalent to an area twice as large. These advantages mainly would be obtained at regional shopping centres or office complexes that attract their clientele from a large area, but also apply to smaller developments.*"

Higher vehicle speeds drastically increase the severity of injuries to pedestrians who are involved in collisions with vehicles (NDoT, 2015). Thus, the above recommendation prioritises vehicular movement above the safety of pedestrians.

Whilst benefits for private-motorised transport are fully outlined in *The Road Classification and Access Management Graphs (COTO, 2012)*, there is little or no mention of how improving different pedestrian aspects would benefit people using public transport modes or pedestrians walking all the way.

The definitions of mobility and access are narrowly defined and reserved for vehicle use alone. These definitions set the parameters from justifying safety and efficiency of the road network. The following graphs illustrate this (Figure 3).

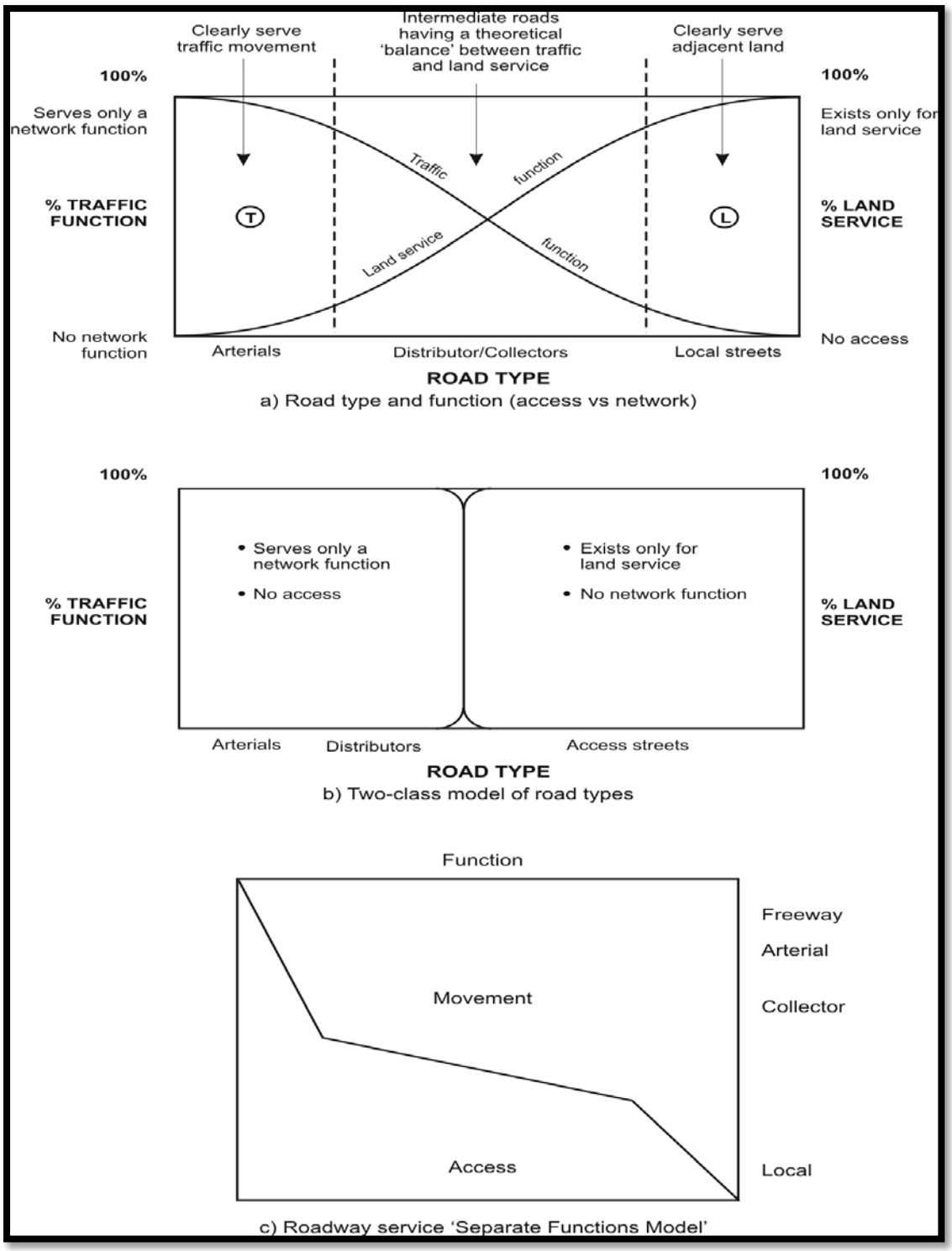

Figure 3: Road Classification and Access Management Graph (COTO, 2012:14)

Based on Figure 4, the mobility and access functions of a road are classified into five different classes. From the figure it is clear that the area allocated to the mobility function of the road is much larger than the access function. Furthermore, the COTO document (2012) does not accommodate the fact that, in the South African context, NMT fulfills part of the mobility function.

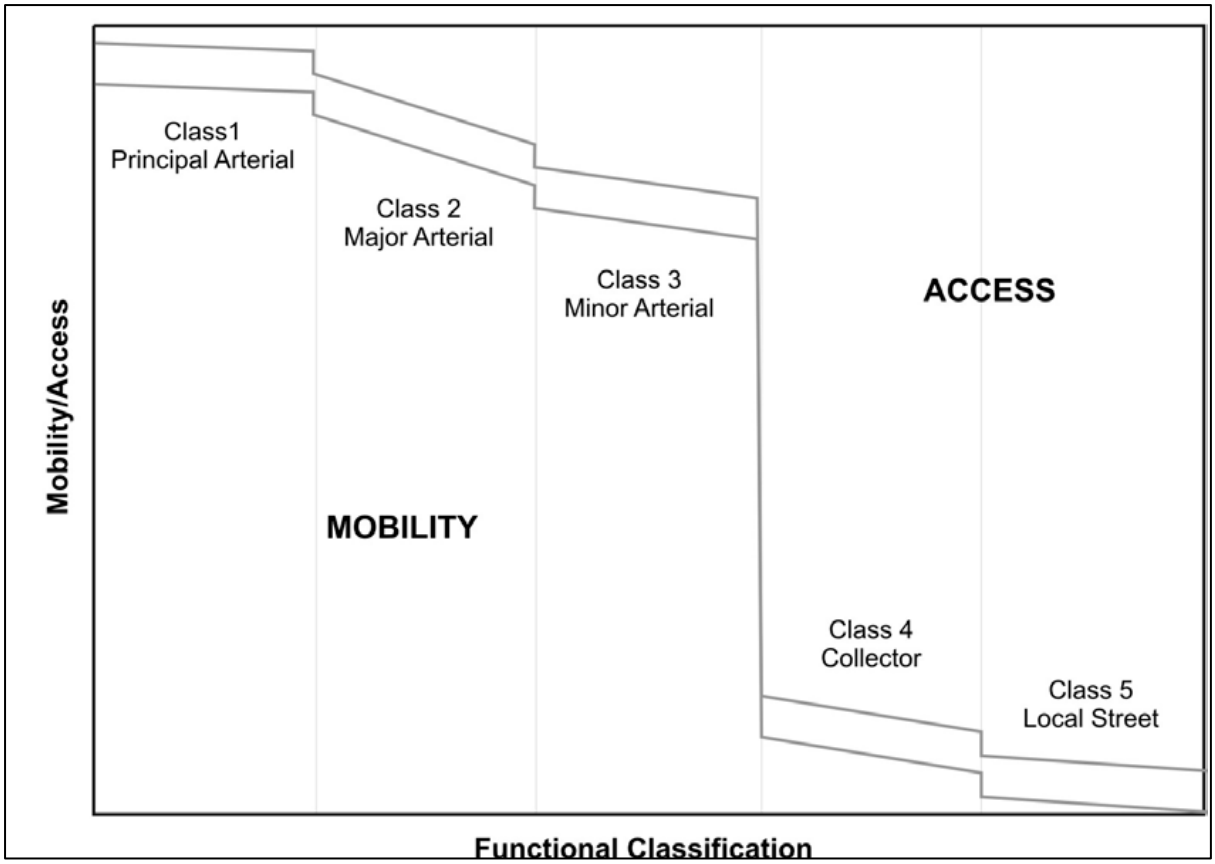

Figure 4: Road Functional Classification (COTO, 2012:16)

There is no dispute in this research report on pedestrian crossings with the Road Functional Classification approach. The number of road fatalities appears to indicate that there is a mismatch between the classification to roads and surrounding land use areas.

The reality is that along many of the roads classified as mobility routes (or express ways for vehicles), pedestrians and public transport users have to use these routes. Bus stops have been included. Minibus taxis are issued licenses. Nevertheless, their passenger's mobility and access needs have not been accommodated in the road space (NDoT, 2015).

The COTO Manual (2012:19) highlights the fact that public transport systems have their own classification systems, from Strategic Public Transport Routes (SPTR), Integrated Rapid Transit (IRT), Bus Rapid Transit (BRT) and High Occupancy Vehicle (HOV) priority lanes.

Given that the strategic goal of the Department of Transport (2015), is to increase the share of public transport and encourage NMT trips (NDoT, 2015), the classification of roads should be carefully considered and aligned with classifications for public transport usage.

Municipalities have begun to recognise that there is a lack of usable guidelines and introduce their own (Bauer *et al*., 2010; South African Cities Network, 2014; City of Johannesburg, 2013; City of Cape Town, 2014).

Complete Streets (City of Johannesburg, 2013), uses the road classification and promotes the accommodation of all road users (see Table 1):

Table 1: RIFSA Classification and Complete Streets Classifications (City of Johannesburg, 2013: 10-11)

RIFSA Classification	Complete Streets Considerations	New Typology	Pedestrians	Bicycles	Public Transport	Motor Vehicles	Goods Vehicles	Emergency Vehicles
Class 1	The primary function is high mobility, hence complete streets principles are applicable primarily in ensuring adequate provision of grade separated crossings for pedestrians and cyclists.	Motorway/ Primary Distributor						
Class 2	This class of road represents major arterials and have historically catered for need of motorised travel. In the context of Complete Streets, the following needs to be taken into account: • These route are the most direct linkages between home and work centres, hence cyclists are prone to use these routes. Consider providing Class II cycling facilities;. • Some of these roads have low income residential settlements adjacent to them, hence special attention needs to be provided to pedestrian crossing facilities and access to public transport stops; Where these roads form part of the Strategic Public Transport Network, public transport modes need to be given priority.	Arterial / Regional Distributor						
		BRT Trunk Route						
Class 3	Special care needs to be taken in separating motorised vehicles and pedestrians. Class III cycling facilities are appropriate.	District Distributor						

RIFSA Classification	Complete Streets Considerations	New Typology	Pedestrians	Bicycles	Public Transport	Motor Vehicles	Goods Vehicles	Emergency Vehicles
Class 4	Due to high number of pedestrians along these roads, Class III cycling facilities are more appropriate. In CBD areas: • On-street parking is important, hence special care needs to be taken when providing cylcing facilities adjacent to on-street parking. • Minimum sidewalk width is not appropriate due to high numbers of pedestrians and presence of other activities on the verge. In Industrial Areas Curb radii need to accommodate heavy vehicle turning movements, hence the presence of long crossing paths at intersections may not be avoidable.	CBD Road / Activity Street / Local Distributor/ Boulevard						
		Industrial Road						
Class 5	Speed reduction measures should be used to keep speeds within acceptable levels for the safe movement of pedestrians and cyclists	Residential Collector						
		Residential Street						
Class 6	Motorised vehicles are not permitted except for emergency vehicles in an emergency situation. Class I bicycle facilities to be provided.	NMT Route / Greenway/ Multi Use Pathway						

Not required, or poor performance is acceptable (low quality or no facilities, high travel delay)
Accommodated with variable standards (average quality facilities, average travel delay
Accommodated with high standards (high quality facilities, low travel delay)

The authors of this document have recognised that the classification system in the Complete Streets Manual (City of Johannesburg, 2013) has a major focus on motorised transport and cycling. This document adds emphasis on pedestrians.

In the Complete Streets Manual (City of Johannesburg, 2013), NMT users are not accommodated on Class 1 roads. As NMT users are legally not allowed to use Class 1 roads, this is not surprising. However, in practice, NMT users do use Class 1 roads, as there are, often, no other facilities available. Land-uses and road infrastructure are often not aligned, and they change over time. The NMT Facility Guidelines (NDoT, 2015), therefore, offers guidance on accommodating NMT alongside Class 1 corridors.

The Complete Streets Manual (City of Johannesburg, 2013) also suggests Class 2 cycling facilities. In the view of the authors of the NMT Facility Guidelines (NDoT, 2015) using integrated class numberings for NMT facilities and motorised transport facilities is confusing and counter-productive.

On-street parking is an important factor when developing NMT, hence, special care needs to be taken when providing pedestrian systems and cycling facilities adjacent to on-street parking.

Examples include:

- Parked cars can become a major risk to NMT users, when doors are opened without acknowledging the surrounding circumstances;
- When drivers/passengers disembark the vehicles or modes of transport and become pedestrians;
- Most importantly, the limited visibility a parked car can create for the pedestrian. Parking near a pedestrian crossing can impair sight lines, becoming a major hazard.

A common thread in many government documents is the misalignment between the colloquial land use, zoned land use, surrounding land use, road classification and public transport usage of an area (CSIR, 2003; NDoT, 2015; City of Johannesburg, 2013)

Beukes *et al*. (2011) demonstrates the importance of taking the current contextual use of the road into the design. This is especially important in developing countries where land use patterns are not as stable as those in developing countries; the initial road design may no longer be appropriate for the established road context.

If the road classification and land use is ignored, the needs of vulnerable users (pedestrians) and un-zoned public transport requirements are likely to remain unfulfilled, resulting in poor levels of safety which will result in fatalities and injuries, especially when crossing the road.

Non-pedestrian road users will experience increased levels of stress and danger, as the pedestrians attempt to utilize the inappropriately designed infrastructure (Behrens, 2004; NDoT, 2015). Therefore, many roads may need to be reclassified, and associated land use modified, as the land use and needs of the roads change (Beukes *et al*., 2011). By reclassifying roads to a more appropriate class, the needs of pedestrians (including those who are most vulnerable) are more likely to be recognised and accommodated.

At national level, the conventional approach of designing roads, based on the vehicle characteristics and not the needs of pedestrians or public transport users, is apparent in all the main design manuals, apart from the NMT Facility Guidelines (NDoT, 2015), and there is no cross-reference to this document. It acts in isolation of the others, which is of concern. These documents include Guidelines for Human Settlements Planning and Design (Volume 1 and Volume 2) also known as the Red Book (CSIR,

2000); South African Development Community Road Traffic Signs Manual (NDoT, 1998); South African Road Traffic Signs Manual (NDoT, 2012b) and Routine Road Maintenance (SANRAL, 2009). Furthermore, the South African Bureau of Standards has developed and adopted codes that guide specific aspects, such as access to facilities for people with disabilities (SANS 10400:S (2011) and ISO 21542 (2011)).

Elements common in all these documents include:

- An emphasis on improving safety and security;
- Facilities and services to increase access and mobility for all road users;
- Colloquial land use to create spaces with a sense of place;
- More sustainable and healthier travel modes;
- Recognising the presence of pedestrians and public transport users and a focus on integration of everyone's needs and objectives; and
- More cost-effective infrastructure and services.

An area that is largely omitted from documents, regarding road design or pedestrian infrastructure, is lighting. The NMT Facility Guidelines (2014) make mention of "sufficient lighting", "good lighting" and "well-lit walkways" but there are no specific guidelines as to what that would imply within the design and construction of NMT facilities. The lighting specialist, Philip Hammond, from Blair Hammond & Associates (Pty) Ltd, similarly indicated that lighting at painted pedestrian crossings should be increased but he recommends that "LED lighting technology in colour 4000k to 4200k" be installed, specifically at pedestrian crossings, to enhance pedestrian visibility for drivers, as well as increasing the colour contrast levels at crossings to assist driver visibility through the crossing (2015; 11). But while many standards and codes do not make direct reference of the Universal Design Principles, they are likely to have aspects of positive effects and implications for the urban environment; as long as the Universal Design paradigm is recognised and incorporated.

2.2 Introducing Pedestrians: Who Are They?

The typical approach to pedestrians as public transport users, by urban and transport planners, is to consider them as people going to work, or children going to school. Although the National Household Travel Survey (NHTS) also emphasizes work and school travel, however, it also recognises trips to medical facilities, municipal services, the post office or police station. When all purposes are included in the analysis, 50% of trips or trip segments (access and egress trips to public transport) are pedestrians (NHTS database, 2011).

However, the pedestrians identified are mostly captive users. To attract choice users to public transport, and to encourage walking, requires the consideration of the needs of other sociological groups.

These groups of people, whose transport needs could be met by public transport and should, therefore, be target groups in any study of potential public transport users that walk for their access and egress trip segments, require a safe, comfortable and convenient pedestrian environment:

- Students in tertiary education, from all over the country;
- Scholars (of all ages, dropping off and picking up at 2pm when parents are at work);
- Scholars on bicycles, or other cyclists who cycle to work;
- People trying to get to the neighbourhood shops;
- Parents with small children;
- Elderly people and single women travelling alone;
- People with sight impairments trying to access neighbourhood facilities;
- People who are deaf and unable to hear passing traffic;
- Workers on their lunch break;
- Workers disembarking a long commute on train; bus; BRT; taxi;
- Any passenger changing between one mode and another;
- People on low income, on grants or no income;
- Tourists, visitors; this may include medical tourists who are in South Africa for specialised treatment/s.

Some of these groups are covered in public transport legislation, both the NLTA (special categories of passengers) and the NLTA Amendment Act (targeted categories of passengers).

2.3 Sharing Road Space with Pedestrians

South African transport users demonstrate significant inequalities between different income groups. Equality striking disparities can be found between transport users with different disabilities and different road user categories.

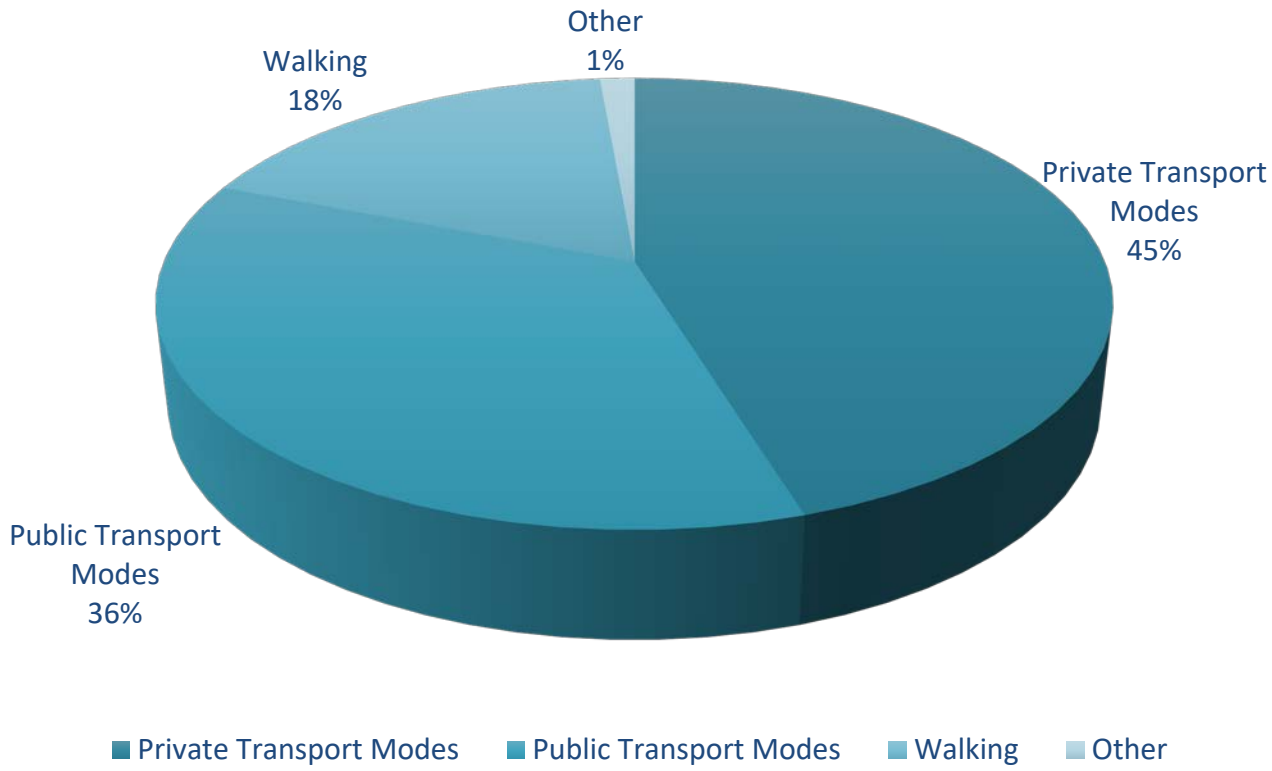

Figure 5: Different Transport Modes Used by Work Commuters in the Western Cape.

Source: Statistics obtained from NDoT, (2015)

Non-Motorised Transport (NMT) users are the most vulnerable road users. NMT users are users that fulfill their travel demand through movement that is not powered by an engine. All pedestrians, cyclists, individuals using wheelchairs, trolleys or prams, skate-boards or push-scooters are included in this category. Pedestrians are by far the dominant type of NMT users and the most vulnerable. The *NMT Facility Guidelines* (NDoT, 2014), described three approaches to improving equality of access to public transport, firstly, being people focused, then offering alternatives for car-orientated lifestyles and, lastly, is the incorporation of universal access.

2.4 Transport User Hierarchy

The first approach is using the transport user hierarchy for planning and designing public transport facilities and services, prioritising pedestrians (people) rather than private vehicles. As more sustainable approaches to urban development are adopted, so the prioritisation of different road users has changed.

This is shown in Figure 6, where the needs of pedestrians is considered to be the most important, while the needs of the private motorised traffic are considered least

important. This is considered to be the reverse of the current conventional traffic engineering approach.

The change in approach focuses on improving the liveability[3] and sustainability of public transport (South African Cities Network, 2014). It has been widely adopted in many countries, as public transport networks struggle to cope with high levels of congestion, pollution and the associated negative externalities of high levels of private motorised transportation (Vanderschuren and Galaria, 2003; South African Cities Network, 2014; NDoT, 2015).

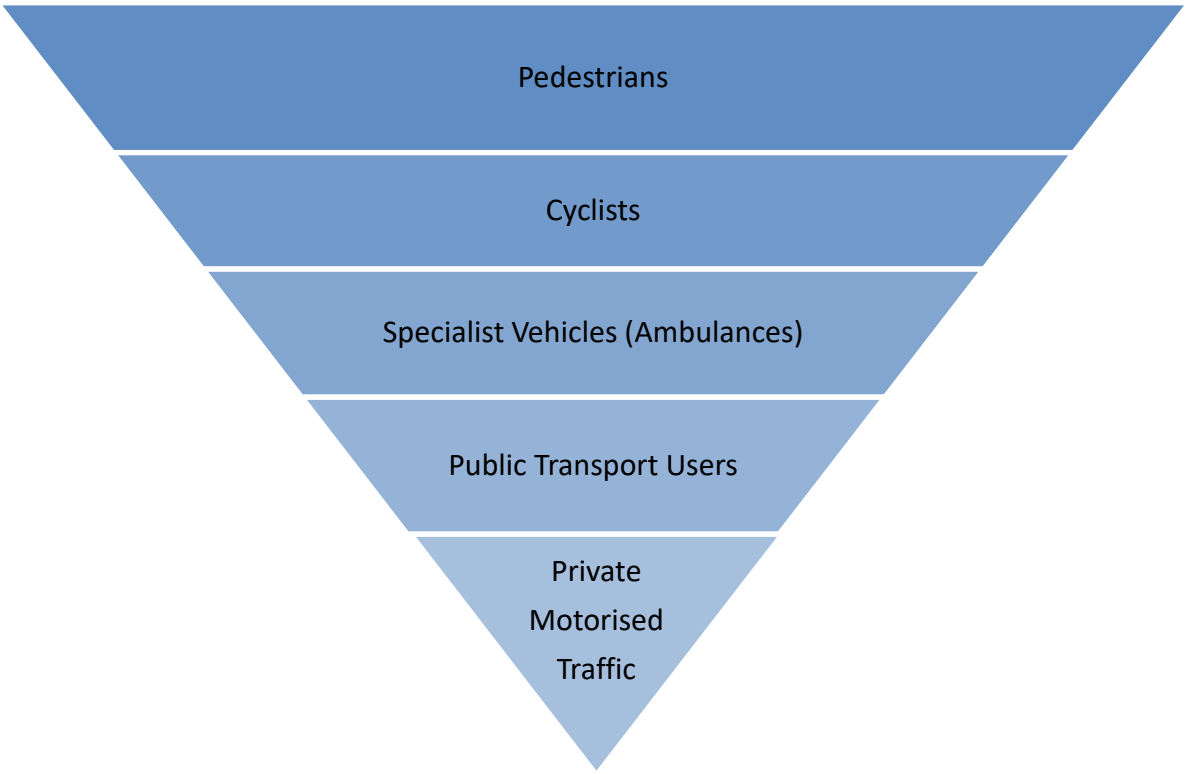

Figure 6: Sustainable, People Focused, Transport Hierarchy (Adapted from The Bicycle Innovation Lab, Source: http://www.bicycleinnovationlab.dk/?show=jpn)

In this hierarchy, the most vulnerable road user types are considered before the less vulnerable types of road users. In explicit terms, the needs of the most vulnerable NMT user (example: small child walking to school or an elderly adult with a disability going to get a pension) is prioritised above the needs of the least vulnerable transport user (example: a single occupancy vehicle, as well as large freight vehicles). This type of transport user hierarchy is aligned with sustainable public transport goals, as NMT and Public Transport (PT) users are considered before those in private vehicles. This helps

[3] **Liveability** is the sum of the factors that add up to a community's quality of life—including the built and natural environments, economic prosperity, social stability and equity, educational opportunity, and cultural, entertainment and recreation possibilities.

to support more sustainable modes of transport, as well as creating a 'people focused' transport system that prioritises the needs of the human individual over the demands of the vehicles and their associated occupants which, in turn, influences planning decisions and the subsequent designs to accommodate different categories of road user.

While these more sustainable approaches have been adopted, in theory, in reality critical documents, requirements and design manuals have generally not been updated sufficiently to incorporate this reversal of prioritisation of mode types.

Both South Africa and the SADC regions previously devised transport infrastructure and operated practices heavily biased towards motorised traffic; especially private motorised transport users, with limited consideration towards other road users (City of Cape Town, 2005). This was not only an unsustainable and outdated view of transport but is also a major misalignment with the reality of South Africa. Most individuals (in South Africa and the SADC regions), rely on public transport and NMT trips to fulfill their transport demands (South African Cities Network, 2014; NDoT, 2015).

By continuing the practice of (personal) car-orientated transport environments, South Africa is failing to not only meet the transport demands of the majority of the population but also failing to address the inequalities that are supported and reinforced by what was previously considered to be the convenient transport engineering approach.

Recognising and prioritising the functional design needs of most vulnerable road users in South Africa will meet the needs of the majority, and along with other measures, start to tackle the crippling number of pedestrian fatalities.

3. Vulnerable Road Users

"Create inclusion - with simple mindfulness that others might have a different reality from your own." – Patti Digh (2008)

3.1 Definition of Vulnerable NMT Users

Active transport or non-motorised transport (NMT) is a term typically used in South Africa. It refers to all forms of movement that does not rely on an engine or motor for mobility (NDoT, 2016). Walking and cycling are more common forms of NMT. However, NMT also includes other transport options, such as pedi-cabs, roller-skates or in-line skates, skateboards, wheelbarrows, push carts and non-powered scooters. Animal-drawn or animal-powered vehicles, as well as targeted categories of passengers, are also included in this NMT definition (NDoT, 2008). According to the National Land Transport Amendment Act, targeted categories of passengers include the following (NDoT, 2016):

- People with disabilities - defined in the National Land Transport Act as people with a physical, sensory or mental disability, which may be permanent or temporary;
- The elderly - people over the age of 55 usually fall in this category;
- Pregnant women - usually taken as women in their last three months of pregnancy;
- Those who are limited in their movements by children - men and women with small children also have access needs that public transport systems need to cater for.

Whilst not formally contemplated in any current departmental legislation, it is important to note that the following people are also considered to be people with functional limitations, under the auspices of universal access:

- Life cycle passengers - these are customers who have additional transport needs by virtue of the fact that they happen to be in a particular stage of the human life cycle;
- Signage passengers - people who are unable to read or who are unable to understand the language used on the signage, including tourists;
- Female passengers - whilst safety and security affects all passenger groups and both genders, it should be noted that female passengers (together with people with disabilities) are particularly at risk of crime and abuse;
- Load carrying passengers - people carrying bags, luggage, or goods of a size that means that they benefit from accessibility features. This is important to

people on low incomes in South Africa. People travelling with bicycles are generally also included in this category.

Lack of familiarity with an area or difficulties navigating a strange environment leads to, or can be caused by, a range of responses. Planners of public transport networks often fail to consider cognitive and sensory effects, responses and requirements (Suen, *et al*., 2007). By making public transport (and public space) more accommodating, the accessibility and mobility of people, often not considered in the traditional stakeholder groups acknowledged by planners, will change (Audirac, 2008).

The Department of Transport, together with Statistics South Africa, demonstrated that between 60-65% of the population can be categorised as beneficiaries of universal design (NDoT, Position Paper on Statistical Information on Passengers with special categories of need, with reference to the National Land Transport Act 2009, 2012: 1). This establishes latent need, as many people who need universally accessible public transport and public space are, similarly, not able to travel and are, therefore, mostly excluded from the conventional household travel survey data.

3.2 Volume of Vulnerable NMT Users

Using the National Household Travel Survey Data that is available on the travelling public, Vanderschuren et al., (2015) demonstrates that in metropolitan populations 45.6% would directly benefit from Universal Design and that in urban areas 50% of the population would experience a direct benefit. The majority are children under 12 years old, which is approximately 25% of the South African population (Census 2011 data). Of those that are able to travel, the most vulnerable and frequent users are children under the age of 12, followed by individuals who self-reported that they had difficulties influencing their ability to travel. This is shown in Figure 7.

As the urban environment is the interface between individuals and society, the individual's movement needs to be met, so that they can actively engage in society. Therefore, it is of critical importance that the public transport infrastructure and services cater for all individuals, to allow for improved access and mobility, which supports achieving higher levels of equality. Failing to do so, will not only result in increased levels of inequalities, but also a higher burden for friends and family of individuals who are unable to utilise the public transport network. Additionally, increased levels of poverty are likely, especially if individuals do not have adequate support systems, as access and mobility needed for opportunities for employment or activities are partially, or completely, inaccessible to vulnerable individuals.

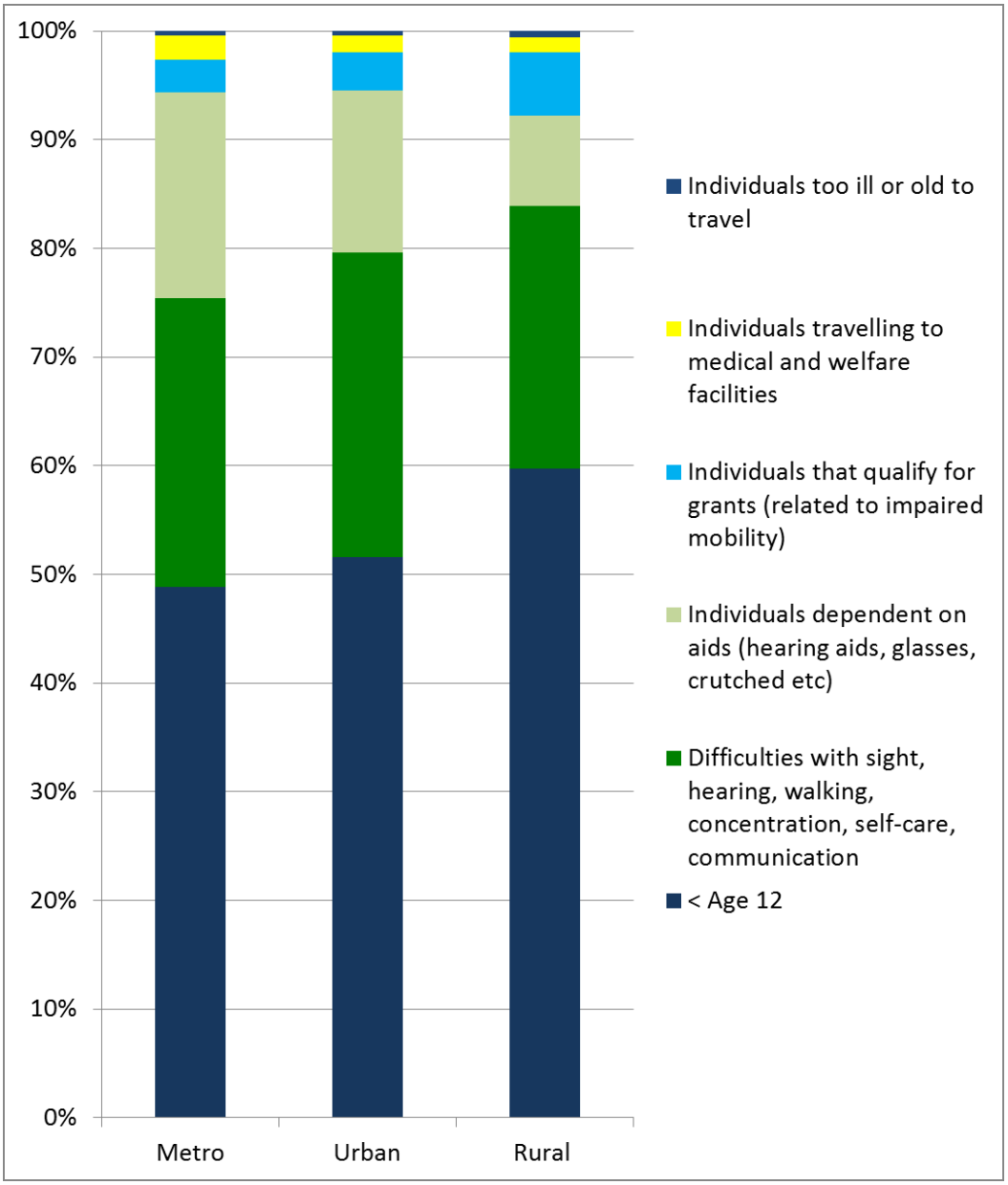

Figure 7: Vulnerable Individuals who are able to Travel in Urban Settlements in South Africa

Source: Vanderschuren *et al*., 2015

3.3 Making Space for Pedestrians

The NMT Facility Guidelines (NDoT, 2015: 42-45), provide space and assumed dimensions of vulnerable road users. The design implications of designing for the public, as a whole, are:

- Assigning more space to pedestrian, public transport users and other NMT users;

- Recognising that there is no standard ‘one-size-fits-all’ mobility aid. Someone with twins will have a far bigger pushchair than someone with a single baby, for example;
- Prioritising the movement of pedestrians and other vulnerable road-users above those in motorised transport, especially those in private vehicles;
- Ensuring that gradient changes for pedestrians are minimised to create a kinder, more accommodating pedestrian environment;
- Ensure that surfaces provided for pedestrians are of sufficient quality. Moving away from creating the worst surface for pedestrians and the best for vehicle users;
- Walking surfaces are the most important Universal Design feature, because they affect everyone;
- Good quality walking surfaces does not necessarily mean that they are expensive. The key factors are gradient, water drainage, horizontal and vertical gaps or changes in level, and specification of surface type (smooth, flat, straight edged);
- Establishing sufficient physical separation between vulnerable road-users and motorised traffic;
- Ensuring that facilities and infrastructure are properly maintained and improved, to increase the quality of the urban environment for people outside vehicles;
- Providing sufficient amenities, shade (from the sun by trees), shelter (from rain and wind) and street furniture to ensure individuals’ journeys are comfortable and convenient;
- Introducing traffic calming measures, to control and reduce the speeds that motorised traffic moves at;
- Pedestrian amenities include: benches; water fountains; shelters/retail (including informal traders) and cafes accessed by foot; information and way-finding.

3.4 Universal Design Implications for Pedestrian Crossings

The design implications of designing public spaces for the general public are reflected in manuals that embrace the complete streets notion, as well as those that aim to improve the equality of the public transport network. However, for pedestrian crossings to provide universal access, attention to detail is required:

- The correct class of road for the activities in the environments situated along each side of the road;
- The relationship of the crossing to the direction of travel for pedestrians. For example, pedestrian bridges over motorways are often not used because they do not serve the needs of the pedestrians for which they were intended;

- The relationship of the crossing to interchanges of different modes of transport: stations, stops, park and ride facilities;
- Interchanges of different transport modes: stations, stops, park and ride facilities;
- The design of bell mouths to align the crossing design in a logical manner for pedestrians which, in turn, reduces the speed of vehicles and has implications for service vehicles (such as refuse, ambulances, mover vehicles);
- Reconciliation of the needs of pedestrians, cyclists and motorists, their approaching speed and expected behaviour within the crossing environment;
- The accommodation of cyclists, whether children or adults, by the provision of bike boxes and cycling lanes in and around the crossing;
- The size of roads in relationship to the sidewalk;
- The relationship of the crossing to the pedestrian desire line and the location;
- Pedestrian islands: their design and the criteria for their placement, related to the number of lanes a pedestrian is expected to cross and the speed of general traffic;
- The expected walking distance from one side of the road to the other to reach not only the other side of the road, but also a destination;
- Signalised pedestrian crossings; who has the power to push? Whether or not pedestrians are given the control to stop the traffic or not with a pedestrian signal linked to their personal crossing phase;
- The position of the crossing button in the most useful location for the pedestrian, which requires reconciliation with the placement of the traffic light pole in the most useful location for the general traffic flow;
- Providing guidance and alignment for the most vulnerable pedestrians crossing the road without full sight, with reduced confidence, or with unpredictable behaviour; such as children crossing without adult supervision;
- The removal of obstacles in the pedestrian zone; repositioning of signage, other street furniture and amenities;
- Ensuring that changes in different road and paving materials are flush to reduce tripping hazards or barriers.

4. Universal Design for Pedestrian Environments

"The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore, all progress depends on the unreasonable man." – George Bernard Shaw (1903)

Research and data used to demonstrate the need for Universal Design is not merely a philosophical one but a concept that has significant practical implications in the physical environment and the quality of life of individuals (Babinard *et al*., 2012).

One of the main effects of Universal Design will be improved mobility and accessibility for a large percentage of South Africans. This has significant implications for improving equality of public transport infrastructure and services, and access to all the other services provided by both the public and private sectors.

The fundamental principles that describe Universal Design are explained before the technical implications of Universal Design are examined. These principles have already been outlined in the *NMT Facility Guidelines* (NDoT, 2015: 41). The technical standards develop the NMT Facility Guidelines to provide clear direction to transport planners and engineers.

Pedestrian crossings play an important role in ensuring that individuals are able to access all forms of public transport as well as origins and destinations. Trips may consist entirely of walking, interchanging between different forms of public transport, moving between modes and final destinations, transferring from private car to public transport, or from private car to final destination (in a car park). If people are able to walk rather than use public transport or a private car, they save money, they become healthier, and they reduce the amount of congestion on the roads and contributions to air-borne pollution.

4.1 Local Users and the Impact on Facilities

Gist and Mitchell (1992) demonstrated that people interpret their environment based on a variety of personal factors, including their experience, their physical and psychological state. Therefore, designing facilities and environments so that there is a predictable and safe response from all types of users is a key element in creating a safe and accessible environment. While many human characteristics and needs are universal, cultural and local influences can and do influence people (Trompenaars and Hampden-Turner, 2011). Examination of these factors influences the way in which new design standards for pedestrian crossings should be implemented.

International design guidelines for pedestrian types include (UK Department of Transport, 2004):

- Commuter – prefers a fast direct route between home and work or when accessing public transport, regardless of quality of environment;
- Shopper/leisure walker – looks for ease of access, attractive retail environments, and attractive routes;
- Disabled person (person with a disability) – requires level, clearly defined easy access and careful attention in the design and placement of street furniture, including resting points. Satisfying these requirements will also satisfy the needs of all other users, especially older people, people with heavy shopping/young children, and people with temporary impairments or low levels of fitness; and
- Child – requires a high level of segregation from motorised traffic and/or other measures to reduce the dominance of motor vehicles, such as speed reduction, together with good passive surveillance from other users. These are important factors where children and young people make independent journeys, especially journeys to school.

A study of pedestrians in Cape Town demonstrated that people walking to public transport in the morning, walk significantly slower than the speeds assumed for adults internationally (Hitge and Vanderschuren, 2015). Walking speeds of pedestrians in Cape Town are closer to the walking speeds used internationally to design for older persons in other parts of the country (see Figure 8). This has important implications for the design and timing of pedestrian crossings.

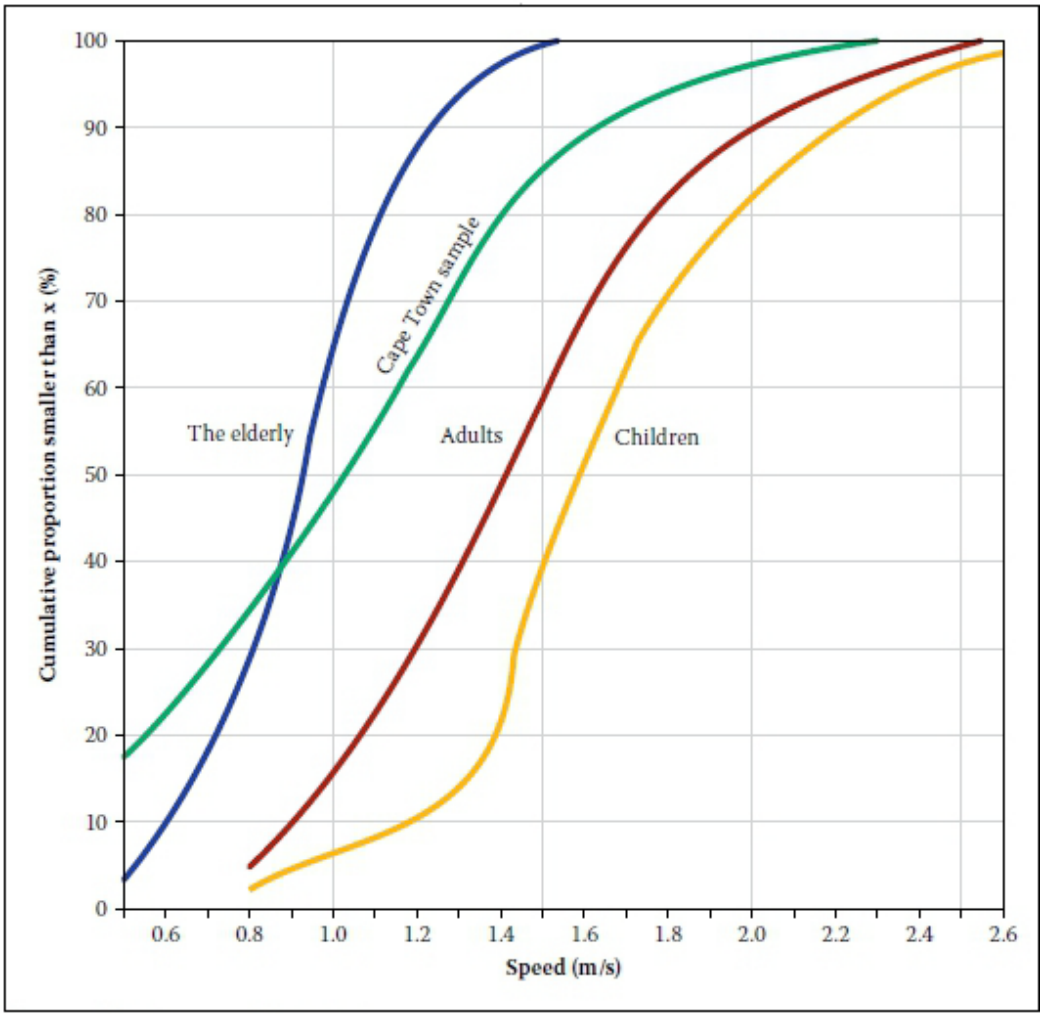

Figure 8: Cape Town Walking Speed Distribution alongside Assumed Walking Distribution of Adults, Children (<18 years) and Older Persons (>65 years) in The Netherlands (Cape Town sample: n = 304) Source: Hitge and Vanderschuren, 2015

Further research in other areas of South Africa is needed in order to determine if the slower walking speed of pedestrians in Cape Town holds in other areas of the country. However, considering that there are no significant cultural factors between individuals in Cape Town and individuals in other areas of South Africa, it could be assumed that these, slower, walking speeds are more appropriate than the walking speeds currently used in South Africa.

4.2 The Impact of Zoning and Planning

High speed mobility routes, arterials and freeways often divide communities for a variety of reasons. Land use creates barriers to mobility and accessibility for the surrounding communities (Vanderschuren and Galaria, 2003; Behrens, 2004). These, in turn, create a significant safety challenge for individuals in these communities.

Pedestrians are exposed to several dangers when they attempt to access surrounding areas or public transport services (often directly off the mobility route).

As development and urbanisation has increased in South Africa, dead space next to mobility routes has been developed. Developed empty space is often allocated land uses that require and generate higher levels of accessibility and mobility for pedestrians and cyclists than the initial design classification of the road. While mobility routes are important for transporting people and goods, they often create barriers and unsafe conditions for other road users, especially for vulnerable road users (Behrens, 2002; Vanderschuren, 2006).

Many unsafe and inequitable land use scenarios cannot be addressed because of the road classification. Road classifications are an engineering concept based on the speed, volume of motorised traffic and whether the environment is rural or urban (NDoT, 2015). For example, mobility spines (class 2 and class 3) have a speed limit of 80 km/h in urban areas, while in rural areas the speed can be set at 100 km/h – 120 km/h. Roads that are classified to be collectors (class 4) have speeds of 50 km/h or 60 km/h in urban areas, while in rural areas the speeds are 80 km/h or 100 km/h (NDoT, 2015). Historic neighbourhoods have a maximum speed limit of 40 km/ph. It is evident that after 1994 other areas that should have been classified as neighbourhoods were not classified as such.

4.3 The Role of Speed Limits

Speed limits are a critical aspect of the road design. Speed limits determine the flows of motorised traffic but, more importantly, have safety consequences for vulnerable road users (NDoT, 2015). Speeds of motorised traffic influences how safe public transport users and non-motorised users perceive themselves to be, as well as how safe they actually are (NDoT, 2015).

Furthermore, there is a well-established relationship between speed and the severity of injuries in collisions between motorised vehicles and individuals (outside a vehicle). At lower speeds (less than 50 km/h), the severity of such a collision is reduced (NDoT, 2015). The pedestrian, or person, outside the vehicle involved in the collision has a reduced risk of sustaining fatal injuries if the speed of the vehicle is low.

When the motorist is travelling at higher speeds, the individual involved in a collision has a much lower chance of surviving the collision (NDoT, 2015). Therefore, limiting the speeds as far as possible is an important part of ensuring that the road environment is safe for individuals outside of vehicles. Proposed amendments to the Road Traffic Act (Act No.93 of 1996) reflect the importance of lowering speed limits. It is proposed that speed limits be reduced from 60 km/h to 40 km/h in urban areas; from

100 km/h to 80 km/h in rural areas and from 120 km/h to 100 km/h on freeways running through a residential area (Arrive Alive, 2015). Universally designed pedestrian crossings can assist in the effort to lower speed limits where pedestrians are likely to be found, because with the introduction of a crossing (linked to a bus stop of a destination), the section of the road for a prescribed distance either side of the crossing, effectively becomes a neighbourhood area. The crossing in itself cannot perform as a safe area for pedestrians and NMT users if not designed in conjunction with a more holistic approach to reduce vehicles speeds when approaching crossings (New Zealand Transport Authority, 2009; FHA, 2005).

Additional design elements can also help reduce speed of approaching drivers and the subsequent risk of collision between individuals and vehicles. These include separated (fully or partial) facilities, bollards, reducing widths of motorised roads (increase ease of crossing for pedestrians) or the installation of pedestrian refuge islands (City of Johannesburg, 2013; NDoT, 2015).

By designing these components using Universal Design principles, the levels of safety and usability will increase as the facilities and infrastructure becomes more user-friendly to a larger percentage of the South African population (example, elderly person getting to the shops or a child walking to school).

Road classification is an important tool in designing efficient transport networks. However, the short-comings apparent to the walking public need to be addressed if the equality and safety of South African roads are to improve. When the surrounding context of the road no longer matches the initial design, Beukes, *et al.*, (2011) show that the same road may need several classifications along the length of the corridor. A variety of designs on different portions of the road may be necessary in order to accommodate the requirements of the road-users, land uses and activities that occur in each particular section of the road.

Developed and developing countries are moving away from designing roads based on the functioning and criteria of motorised vehicles and towards designing roads based on individuals' abilities and needs. This concept is commonly referred to as 'Complete Streets' (City of Johannesburg, 2013). While this concept relates to the sustainable transport hierarchy (Section 1.1), it focuses on creating a multi-modal transport system that supports safe, sustainable, and liveable communities (City of Johannesburg, 2013).

5. Design Parameters

"Universal Design is Essential for 10%, Supportive to 40%, and Comfortable to 100% of the Population"– PSCDR, 2010[4]

5.1 Designing for Pedestrians

In South Africa, pedestrian crossings are normally designed or upgraded within a larger construction project, for example, upgrading a commercial centre or redesigning a portion of the road network to accommodate new lanes or infrastructure. Therefore, the design approach that could be used depends on the motivation behind the project and whether the needs of the pedestrians are well considered or not.

However, in recent years, the importance of accommodating pedestrians and other vulnerable road users has increased, and so has the importance of how pedestrians are accommodated in the built environment. This can be seen in several local and international documents, including the following:

- NMT Facility Guidelines (NDoT, 2015)
- Complete Streets (City of Johannesburg, 2013)
- Tshwane Rapid Bus Transit System (City of Tshwane, 2012)
- Roads and Storm-water Manual, Volume 2, Part 2 (Johannesburg Roads Agency SOC Limited (JRA), 2015)
- Traffic Engineering Manual, Volume 1, Chapter 4 (VicRoads' Traffic Engineering Manual)
- Pedestrian Crossing Treatment Guidelines (City of Longmont, 2009)
- Measuring Pedestrian Activity (Transport for London, 2007)
- Pedestrian Environment Assessment Tool (PEAT) (University of Pretoria, 2010).

The 'Complete Streets' approach has several principles. The relevant principles for Universal Design are summarised below: (City of Johannesburg, 2013):

- Providing safe, convenient mobility and accessibility for all users, focusing on addressing the needs of pedestrians, other non-motorised transport users, public transport users and people of all ages and abilities;
- Focus on providing attractive public spaces that have the necessary amenities including landscaping, lighting, public transport facilities and street furniture to ensure that the space is welcoming and comfortable for social integration;

[4] http://www.kscdr.org.sa/en/research/Documents/uap-tourism-en.pdf

- Neighbourhood that can be revitalised by investing in public infrastructural improvements that attract private investments and non-motorised transport activity;
- Ensure and provide safe and attractive conditions for walking and cycling to increase the physical activity levels of individuals, thereby improving the health of individuals and lowering medical costs;
- Improve air quality by reducing car use and, therefore, emissions and by including vegetation into the streetscape;
- Promote public transport by improving the efficiency and the infrastructure to create safe and attractive urban environments.

Whilst in contrast to the above mentioned documents, the previous generation of documentation, which are also largely still being applied, have little to no design consideration for NMT or pedestrian safety. A number of the major metropolitan areas have their own guidelines and standards. There are cases where these guidelines, codes and standards conflict with other codes and it is not always clear as to which guideline or standard takes precedence. This is further compounded by the fragmentation of these documents. The following, "previous generation", primary codes and standards are currently being used universally in traffic and road engineering:

- Guidelines for the Provision of Engineering Services in Residential Townships [Blue Book] (CSIR, 1994)
- Urban Transport Guidelines (UTG) (specifically for use by Local Authorities)
- Technical Methods for Highways (SANRAL) (specifically for use by Provinces and National Government)
- Technical Recommendations for Highways- South African Road Classification and Access Management Manuals (COTO) (specifically for use by Provinces and National Government)
- SANS 0120-3 Guidelines for Design [green pages] (SANS: 1986).

The need to harmonise and standardise these guidelines is a well understood reality. The introduction of more detailed design guidelines, criteria and standards, specifically related to the NMT infrastructure, has been identified as one of the material impediments to achieving pedestrian safety in the road space. The introduction of tactile guidance and warning surface indicators is currently an area of confusion and while the SANS 784 voluntary standard was introduced having been adopted from the Australian and New Zealand standards, the functionality of the standards has been called into question based on local application of these standards in IPTN's.

The next chapter explains the Universal Design principles that need to be adopted in neighbourhood plans and designs in order for the urban environment to effectively

change and include the levels of accessibility, mobility, safety and comfort that are a requirement for the human condition.

5.2 Parameters that Support Universal Design in South Africa

As part of ongoing road improvement projects, principles of Universal Design shall also be incorporated, where appropriate and safe (NDoT, 2016). Furthermore, the regulations adopted by the South African Bureau of Standards, based on international guidance in the ISO 21542 (2011) where required, as well as the application of the National Building Regulations (SANS10400), shall apply.

The Department of Transport NMT Facility Guidelines (NDoT, 2015), describe the principles of Universal Design and describe pedestrian-focused principles that support the Universal Design principles. Both sets of principles are combined and supported. Through this examination the technical requirements for pedestrian crossing infrastructure can be justified. The application of NTR 1 will initially affect public transport systems, largely within municipalities, to start off with. However, the designs must be robust enough to be implemented throughout the country over time. Therefore, the UD principles should be adopted in a comprehensive manner to ensure implementations that add practical value for all individuals and improve the entire public transport system as a whole.

5.2.1 Completeness / Coherence

This principle focuses on establishing a consistent network from origins and destinations (NDoT, 2015). It also focuses on establishing a network that is comprehensive and inclusive. In terms of providing pedestrian crossings, key crossings along the desire lines of individuals should be identified and used to increase the level of coherence of the pedestrian network.

Additionally, taking the needs of individuals into account, as they change from one type of transport to another, is an important aspect of creating a complete and coherent pedestrian network. This enables individuals to effectively use the available transportation infrastructure and services to meet their travel demands. Therefore, ensuring that the facilities and amenities, that allow individuals to change between modes, meet the needs of all individuals of varying physical and cognitive abilities, is a key aspect of improving accessibility and mobility of all individuals.

5.2.2 Directness

Straight lines and direct routes are prioritised over detours and routes that do not follow direct paths (NDoT, 2015). For pedestrians, cyclists and public transport users, taking into account the desire lines of movement patterns is important to effectively provide for these more vulnerable road users. Taking into account that these users' trips, generally, take more time than those in private-motorised transportation, it is important

to ensure that the movement needs of these users are prioritised higher. This can be done in several ways. An example of a broad conceptual level could be prioritising road space and the routes of NMT users and PT users over those of motorised transport routes. Dedicated bus lanes are one practical facility that embodies this or, similarly, ensuring that adequate road space is provided to pedestrians and cyclists is another manner.

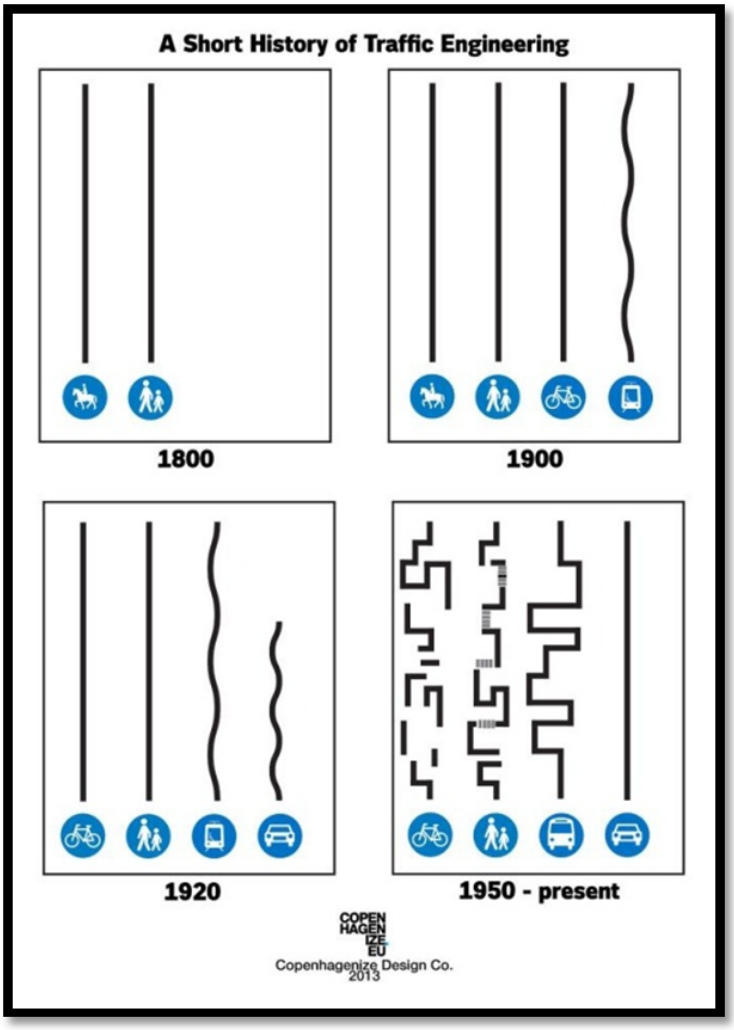

Figure 9: A Short History of Traffic Engineering, NDoT: NMT Facility Guidelines (2015: 40)

5.2.3 Less Conflict

This may be one of the most important aspects for South Africa, where road fatalities and injuries are one of the highest in the world. By reducing conflict points along NMT routes and at pedestrian crossings, the level of safety for pedestrians is likely to improve (NDoT, 2015). An important aspect of this is to take into consideration the reality that South Africa is a developing country and consequently has several problems that result in situations that are unsafe and dangerous. The most common of these are urban poor living in settlements situated near to or along highways.

Figure 10: Example of a Separate NMT Bridge Structure next to the Roadway, NMT Guidelines (2015: 71)

5.2.4 Speed Appropriateness

In South Africa, where there is a high rate of speeding (NDoT, 2015), it is important to consider the speed appropriateness of the urban environment. In areas where there is mixed traffic, embarking or disembarking of public transport modes, sensitive and vulnerable road users, extra care should be taken when setting the speed limits (Beukes *et al*., 2012).

More specifically, for areas close to pedestrian crossing facilities, the use of raised speed tables, road diets, chicanes, place-making landscaping and paving, as well as signalised crossing facilities, should all be considered based on the context of the specific area and the users.

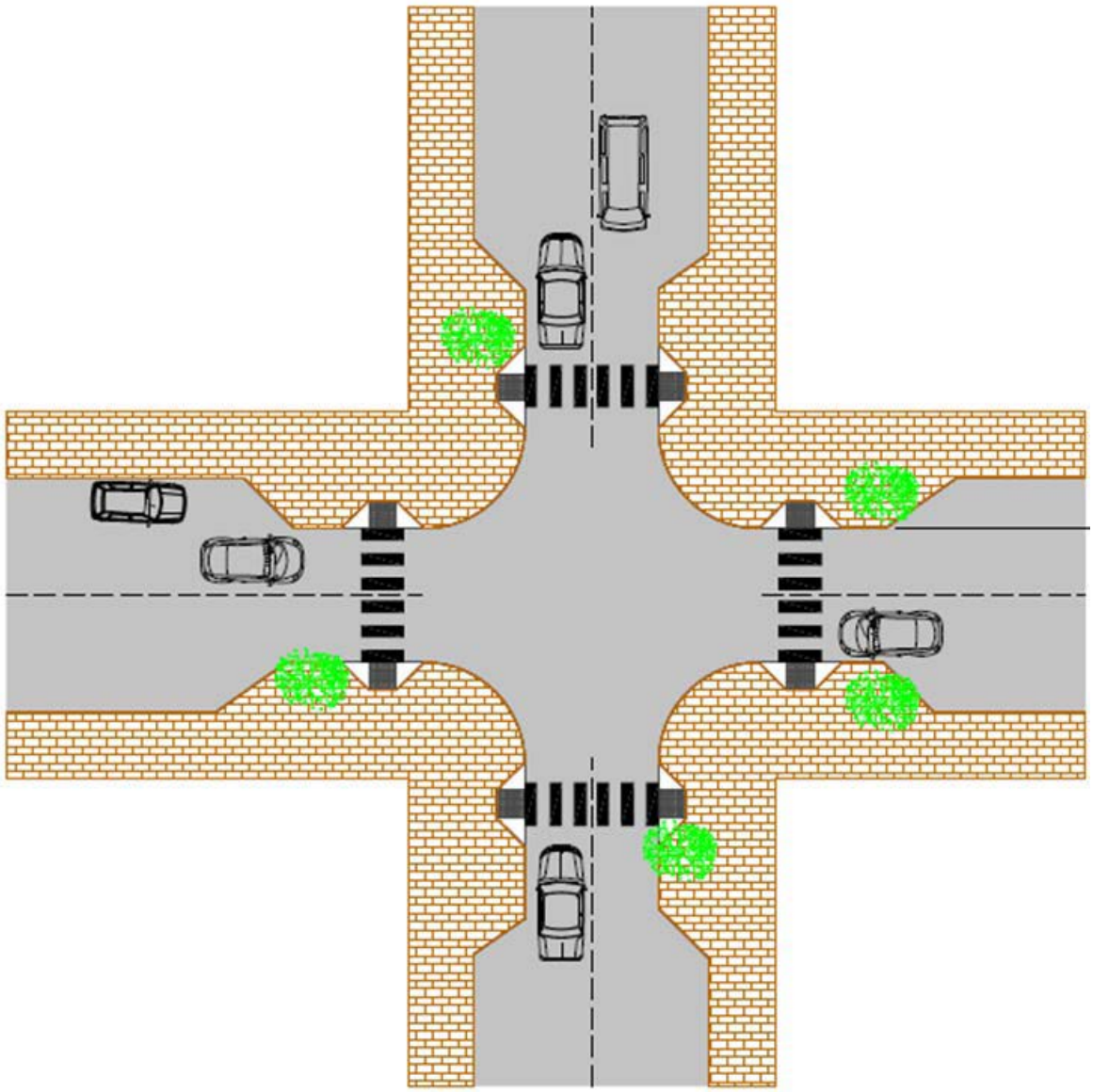

Figure 11: Example of Neck Downs, NMT Guidelines (2015: 105)

5.2.5 Attractiveness

This is an important aspect addressing the unequal investments in public facilities and spaces in South African settlements. Improving the attractiveness of NMT facilities encourages walking and cycling trips, and helps to establish a positive relationship between the members of the communities and their environment (Saelens *et al*., 2003). There is also evidence that suggests that ensuring that the environment is well maintained and minor deviant behaviour is reduced, levels of safety and security improve (Hinkle and Weisburd, 2008).

Individuals who are sensitive to the level of attractiveness are likely to be vulnerable road users. Therefore, by addressing the attractiveness of an environment, the services and facilities then become accessible and user-friendly to these individuals.

Figure 12: NMT Facilities along Kerbed Arterials (80km/hr and above), NDoT: NMT Facility Guidelines (2015: 58)

5.2.6 Clear and Unobstructed Spaces

Reducing the number of physical obstructions is an important aspect of improving the convenience, efficiency and attractiveness of making trips (NDoT, 2015). This can be critical for NMT and PT trips, most of which have a walking trip. Therefore, when designing and implementing the infrastructure and services, care should be taken to reduce the various types of barriers as far as possible.

Areas that have difficult terrain, such as steep slopes, long distances or ground conditions that become difficult in poor weather conditions, should be carefully considered to reduce the impact of these characteristics on the convenience and comfort level of making these trips. This includes facilities and amenities that can help mitigate these challenges. For example, providing sheltered rest areas/benches or water fountains and other similar amenities at convenient locations along the routes can assist individuals along their trip, hence, making the trip more manageable. For more vulnerable road users, these amenities may enable them in making the trip; where without these amenities the trip may be too challenging or uncomfortable for them to manage it.

There is a balance between providing amenities and ensuring that these amenities do not create barriers to pedestrians and other NMT users. Managing conflict between informal trading activities, providing amenities and facilities that serve the mobility and access needs of individuals and ensuring that there is no encroachment onto private property is an important aspect of ensuring that the road space remains optimally functional.

Another type of obstruction that should be considered are routes that have sudden and frequent changes in direction. These routes should be altered, so that movement

along these routes are efficient and more comfortable. A further aspect of improving movement along routes is ensuring that there is sufficient way-finding information available.

Finally, ensuring that vulnerable users are not exposed to obstructions that present potential hazards to their safety is an important aspect of ensuring mobility and accessibility. In South Africa, the most common hazardous barriers are high mobility routes (freeways and arterials) that divide communities and have urban poor communities situated adjacent to them (Vanderschuren and Galaria, 2003; Behrens, 2004). Ensuring that the safety needs of individuals living in settlements are met, is another way that the equality of individuals in South Africa can be significantly improved.

Figure 14: Intermediate Bus Stop, NDoT, NMT Facility Guidelines (2015:120).

5.2.7 Safety

In South Africa, safety and security are major concerns. The urban environment can play an important role in improving the levels of personal safety and security by implementing well designed NMT facilities, including pedestrian crossings. In the *NMT Facility Guidelines* (NDoT, 2015), the following recommendations are given to improve the security of urban spaces:

- Dead zones or areas that are concealed should be avoided in designs and remedied if established in existing urban areas. This can be done by ensuring clear lines of sight through areas and around corners; splayed building and boundary corners; vibrant street events that encourage people to travel through these areas;
- Alternative routes and connections that people can use if they wish to avoid insecure areas;

- Sufficient lighting that is maintained;
- Reduced areas and barriers that could hide criminals. This is especially important for maintaining vegetation, which may be attractive during the day but potentially unsettling at night. Therefore, no vegetation between 0.4 and 1.5 m unless area has sufficient security measures to deter crime;
- NMT facilities should be protected from being used by motorised transport, especially against the use of parking, which cause pedestrians and other NMT users to spill onto motorised transport facilities.

The local security context of each area should be taken into account when considering the design' implementation and/or retrofitting of pedestrian crossings, so that the most appropriate designs are selected.

A further type of safety risk that is critical in South Africa for pedestrians is reducing the risk of a collision with other modes of transport, most notably those of motorised transport modes. However, collisions between cyclists and pedestrians can also result in serious injuries to both the pedestrian and the cyclist. In these collisions, it is often the cyclist that has more serious injuries as they travel at higher speeds than the pedestrians. Therefore, careful consideration of designs where there is an interface between different modes is important in improving the safety of all road users.

While managing how different road users share the road space is one aspect of safety, the second aspect of safety is to ensure that speeds are appropriate to the crossing facilities that are implemented. An increase in speeds has been documented to result in significantly more fatalities and injuries in pedestrians, while a decrease in speeds can greatly improve the levels of safety for pedestrians (NDoT, 2014).

There is a balance between providing amenities and ensuring that these amenities do not create barriers to pedestrians and other NMT users. Managing conflict between informal trading activities, providing amenities and facilities that serve the mobility and access needs of individuals, and ensuring that there is no encroachment onto private property are important aspects of ensuring that the road space remains optimally functional.

Increased volumes of pedestrians or cyclists can also provide better security as a form of 'passive policing' (NDoT, 2016, Page 67). The presence of informal traders may have the same effect, i.e. provide additional security.

Routes with sudden and frequent changes in direction (both vertical and horizontal direction) cause an obstruction to the overall flow of traffic. Orientation and way-finding are sciences on their own and sufficient, effective way-finding is an important aspect of ensuring that all areas are accessible to individuals.

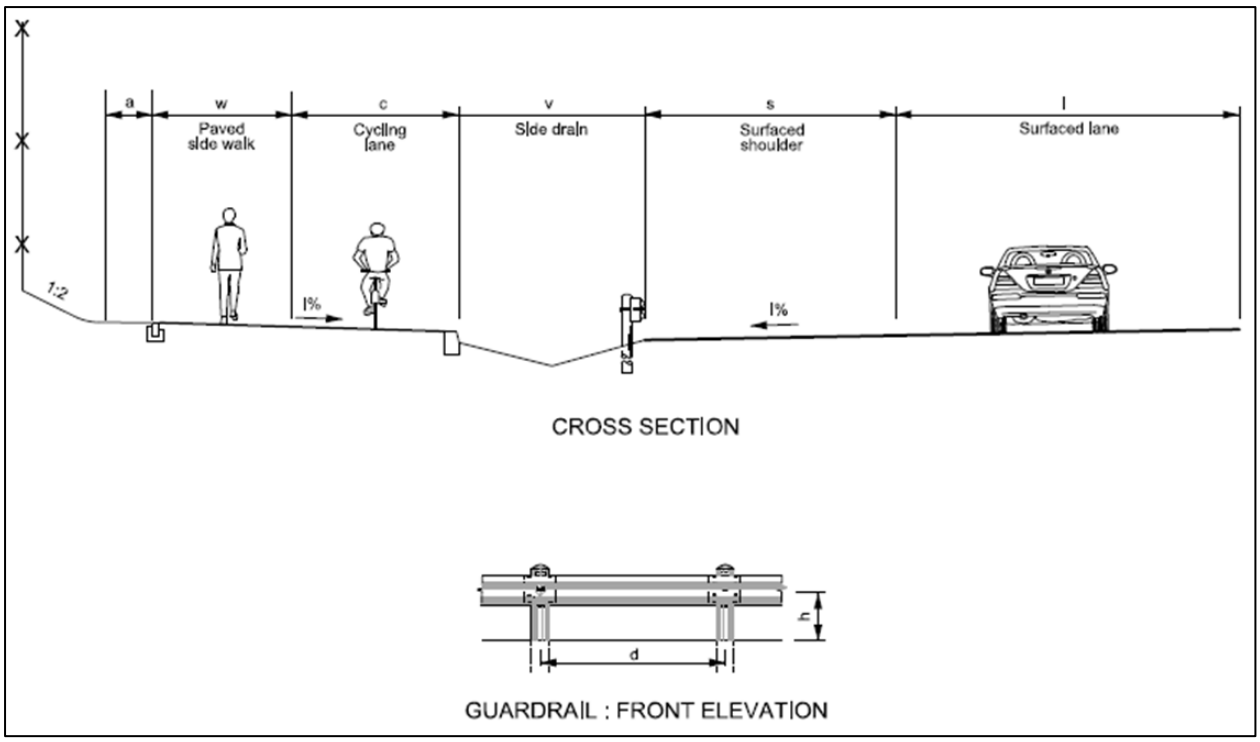

Figure 16: High Speed Highways, Sourced from COTO (2012), NMT Guidelines (2015:56)

5.2.8 Accessibility

The catchment area of public transport stops are considered to be 50 meters. However, Hitge and Vanderschuren (2015) established that the average walking distance to BRT stops is 1.3 kilometers. In other words, user friendly NMT facilities translate into BRT catchment areas with a radius of 1.3 kilometers. Appropriate public transport precinct design should include coherent, direct and safe routes, with a minimum amount of conflicts at intersections. Furthermore, facilities should not be obstructed by road furniture or any other elements.

6. Conclusion

"It always seems impossible until it's done." – Nelson Mandela (1903)

Including Universal Design principles with other principles in the planning and design of pedestrian crossings is a first step in addressing the urban infrastructure inequality, to ensure that the road space becomes more accessible and safer to all pedestrians. Monitoring and designing pedestrian facilities to meet appropriately identified performance standards is one way to ensure that the pedestrian crossings are safe and convenient to use.

Whilst there are several pilot projects aiming to test an urban environment that is more inclusive, the reality is that the majority of urban areas are inadequately designed for pedestrians and dangerous for those depending on this infrastructure. Current transport networks have high levels of inequality, usually at the cost of vulnerable road users. This needs to be addressed in a more comprehensive manner, from the way in which roads are classified to the detailed design of pedestrian facilities and their implementation.

This requires municipalities to have carried out an overall assessment of public space in line with their Built Environment Performance Plan (BEPP), their Integrated Development Plan (IDP) and their Integrated Transport Plan (ITP). On the basis of these public space audits, it will be possible to know which areas of a city will then become a priority for upgrading. In this way, new design projects can be targeted at priority areas and partial upgrading for unrelated work can include Universal Design improvements.

It is clear that in order to make progress, a clear set of planning policy guidelines on Universal Design are required for pedestrian spaces, in general, as well as the detailed specifications for specific facilities (such as pedestrian crossings). This will provide the change to public space that vulnerable pedestrians so desperately need. Along with policy, no implementation is successful without awareness raising and advocacy for change.

Through the research and discussions with engineers, the rationale for the proposed design methodology was largely appreciated and understood. This indicates that the larger field of practicing engineers, and other related practices, are not reluctant to change, they require rationale and support for Universal Design thinking and understanding of the input from stakeholders.

The proposed design methodology is the product of this research report (NTR 1: Part 1). It creates the basis for a procedural design process, based on the findings from the previous chapters of this report. This design methodology is expanded on in more detail, along with technical drawings in the second and final part of the NTR 1, titled NTR 1: Part 2 Pedestrian Crossings. The basic design methodology should be undertaken in three design processes, which are as follows:

1. Design Process One: Site Specific Research
   Focuses on the larger precinct at the intersection or midblock, where the pedestrian crossing might be required to be installed, retrofitted or maintained. Research areas to assist with this include:

   - Road Classification
   - NMT and Vehicular Counts (including modes)
   - Primary Geometric Design
   - Priority Areas for Pedestrian and NMT Users

2. Design Process Two: Primary Design
   Undertakes a more in-depth investigation into the planning and primary design, utilising the information gathered in Design Process One. Design Process Two focuses on the, principal design decisions that need to be made on the following:

   - Minimum Number of Lanes
   - Median Island Treatment
   - Bell mouth Radii
   - Cycle Lanes
   - Location of Pedestrian Crossing
   - Pedestrian Crossing Width
   - Width of Sidewalks

3. Design Process Three: Detailed Design
   The final and most detailed design process requires final decision on details and specific solutions related to:

   - Pedestrian Crossing Markings
   - Location of Traffic Signals
   - Stop Lines and Sight Lines
   - Traffic Signal Design
   - Sidewalk Gradient Treatment
   - Pedestrian Only Areas
   - Tactile Assistance and Orientation
   - Walk Through Island Configuration

- Median Island Configuration
- Additional Public Transport Recommendations.

It is essential that this report, and the technical document that follows, which contains detailed descriptions of design issues and recommended solutions, which have been captured in the schematic drawings for the NTR 1, form the basis for new approach to pedestrian crossing designs and implementation. It should provide the basis to enlighten practitioners in all related fields, through workshops and training, as well as providing the basis to inform other stakeholders of the progress made by the National Department of Transport, and focus on the safety of all pedestrians, particularly at pedestrian crossings related to public transport systems.

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Annexure One: Terms and Definitions

Accessibility – Enabling persons with different types of disabilities to live independently and to participate fully in all aspects of life, and the dismantling of barriers that hinder the effective enjoyment of all rights by persons with disabilities. (Republic of South Africa, 2016: 40)

Block crossings or painted crossing – An area that is designated for pedestrians to use when crossing a roadway, painted in a configuration that is the width of the road and in section parallel to the vehicular road traffic which is 600 mm wide with a 600 mm gap

Bollard – A post used to protect pedestrians at block crossings by preventing vehicle intrusions

BRT – Bus Rapid Transit

Disability – A difficulty experienced doing activities of daily living in any domain of life due to a health or physical problem (WHO ICF)

Functional Limitations – Restrictions in performing fundamental physical and mental actions used in daily life such as mobility (physical) or memory (mental) (WHO ICF)

Impairments – Dysfunctions in specific body systems (WHO ICF)

Interchange – An intersection that is designed to move traffic from one freeway to another via a network of ramps and connectors (*Designing Complex Interchanges* by Mark Doctor, George Merritt and Steve Moler. US Department of Transport. November/December 2009)

Intersection (ie pedestrian crossing at an intersection) – Occur wherever the pedestrian network intersects the roadway network, or when two or more roadways intersect

Signalised and Un-signalised Intersections – Intersections where there are either traffic lights to indicate vehicular traffic flows and movement or where there are no traffic lights. Traffic lights can also be installed at midblock crossings to assist in the safe road crossing of pedestrians

Kerb side bus stop - A bus stop designed for convenience of access for passengers, with the kerbs and the entrance level of the bus, offering level boarding (with a maximum gradient of 1:50)

Kerbside – The area next to a kerb or behind the traffic facing side of the kerb

Kerbside to median – A pedestrian crossing designed for the purpose of connecting a kerb side to a median island

LOS – Level of Service

Midblock – Between two vehicular traffic intersections which is then either from kerb to kerb or kerb to median island.

Mobility – the ability of movement of people or goods, including NMT users

Neighbourhood – A local community

NMT – Non-Motorised Transport, transportation that does not rely on energy generated from an engine (NDoT, 2015)

NMT users – Any individual that fulfills their travel demand through movement that is not powered by an engine

Park and Ride - A facility where private car owners park their vehicles before boarding a bus to a particular place

Pedestrian crossing – facilities that accommodate the movement of pedestrians and or NMT users, across vehicular traffic

Performance Standards – Standards that help to ensure the implementations fulfill the users' needs

Precinct – A region directly around a specific location

Principles – Over-arching principles that help to guide practitioners thinking and design process

Public Transport – All modes of transport that serve the transportation needs of the general public

Rail – A platform/surface used by trains for movement

Raised crossings – Pedestrian crossings that are level with the height of the adjacent pedestrian pavement/kerbside/sidewalk

Roadside – The area next to a roadway

Shared space – Space that is used by more than one party for a particular purpose

Sidewalks – Facilities that accommodate NMT as the most basic mode of transportation of people (City of Johannesburg, 2010)

Signage – graphic designs, as symbols, emblems, or words, used especially for identification or as a means of giving directions or warning (http://www.dictionary.com/browse/signage)

Signalling – the control of a crossing using traffic lights, pedestrian signalling and/ or audible signals and other similar technologies

Stop lines – Lines indicating that drivers of a vehicle must stop and give way to other road users

Stopping Sight Distance (SSD) – The distance that allows for a driver to bring a vehicle safely to stop taking into account the distance travelled during the driver's reaction period and the distance required to decelerate to 0 km/h (CSIR, 2000)

Targeted categories of passengers – "Persons with disabilities; and the elderly, pregnant women scholars, young children and those who are limited in their movements by children" (National Land Transport Amendment Bill, 2016: 3)

Technical Requirements – A list of technical aspects that pedestrian crossings shall adhere to.

Universal Design – "The design of products and environments to be useable by all people, to the greatest extent possible without the need for

adaption or specialised design.” (http://ddadesign.com.au/accessible-design/)