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PROJECT REPORT

O14: Critical review of design and development practices that relate to access for people with disability (universal access): Part 3 Investigation of accessibility for people with disability and NDIS - Year 1 (2019/20)

ARRB Project No.: 014966

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SUMMARY

The accessibility needs of people with disability are the same as people without disability. They require barrier-free access in public places and should expect reasonable measures taken to lessen undue fatigue when transporting themselves. Without equal accessibility, people with disability are more likely to face exclusions to work and educational opportunities, social opportunities, and independence, which can negatively affect their wellbeing, dignity and quality of life. Therefore, built environments must be equally accessible by both people with disability and people without disability.

This report aimed to identify what provisions need to be put in place when topography results in undignified accessibility for people with disability and to investigate if electric assistance technology and the National Disability Insurance Scheme (NDIS) is changing design user capabilities (people with disability). The overall goal was to improve practices in the provision of universal access for all users, including people with disability or movement impairment, and the elderly.

The NDIS has provided aid to approximately 55 014 people in Queensland as of September 2019 and this number is expected to increase in years to come. It is providing people that face mobility and travel restrictions with the opportunity to receive mobility assistance and aids to better their quality of life. Due to the increase in people receiving assistance through the NDIS, it is critical to ensure transport options are accessible for people using wheeled devices (manual and powered wheelchairs and mobility scooters).

From the Australian Bureau of Statistics (2019b) data, the breakdown of people in Queensland using manual wheelchairs (MWC), powered wheelchairs (PWC) and mobility scooters are:

- Manual wheelchair – 24.3%
- Powered wheelchair – 4.6%
- Mobility scooter – 7.5%.

Manufacturer specifications for MWC, PWC and mobility scooters were reviewed against the Australian Standard (AS) 1428.1 and AS 1428.2 size specification of 800 mm x 1300 mm. From the review, it was found that approximately:

- 7% of available MWCs exceeded the 800 m width
- 2% of available PWCs exceeded the 1300 mm length
- 36% of available mobility scooters exceeded the 1300 mm length.

Most manufacturers do not list turning circle specifications and maximum safe slopes for support devices. This means that people are unable to determine if a device is suitable for their needs.

Topography can be a significant barrier to access not just for people with disability but also for the elderly, people with prams or luggage and people with injuries. Support through the use of assistive technology,

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personal carers, additional services and design standards can help people with disability to traverse difficult terrain.

People with wheeled devices run the risk of tipping their device if a slope is too steep for their device. When using an MWC, users may also experience undue fatigue on steeper slopes, whereas PWCs and mobility scooters should be less fatiguing. All types of wheelchairs and mobility scooters may become unstable on higher crossfalls.

The Queensland Department of Transport and Main Roads' (TMR's) Technical Note 38 states that footpaths may be built at the grade of the road which may result in footpaths exceeding AS 1428.1's limit for walkways of 1:14 (7%). Available services to navigate topographic barriers include:

- Implementation of lifts and ramps with landings
- Access to mobility aids
- Carers assistance
- Disability reserved parking spaces
- Transport funding
- Taxi Subsidy Scheme (TSS)
- Companion cards.

However, these services may not always be available or suitable for the area.

From the research, alternative practices that may provide benefit were found and summarised; however, it is noted that some practices had little research so benefits may only be theoretical. These alternatives include:

- Group consultations with users to better understand requirements
- Implementation of slope signage
- Strategic placement of bus stops
- Technological information tools
- Providing proof that intended users can successfully use standard compliant designs.

The following steps should be taken to improve accessibility for people with disability:

- Further, investigate the feasibility and benefits of alternative measures for topographic barriers (see Section 6.3).
- Investigate the elimination or reduction of topographic barriers as a result of greater or full subsidisation of transport in the transport scheme (e.g. public transport and TSS). This may improve user's freedom to utilise paid transport more frequently.
- Further investigate wheeled device's specifications and capabilities (dimensions, maximum safe uphill and downhill slope gradients, etc.), including modifications and accessories of wheeled devices. These should then be compared against standards and guidance to determine if the standards are satisfactory.
- Investigate environment attributes (longitudinal grades, crossfall, turning circles, etc.) that wheeled device and other assist device users feel comfortable operating to allow for the creation of desirable design limits for some design criteria.
- Defining reasonable accessible design should be explored from the intended user's perspective. This will determine when a route becomes unreasonable to use for people with disability.

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1 INTRODUCTION

1.1 BACKGROUND

The Department of Transport and Main Roads (TMR) has committed to improving the provision of accessible transport infrastructure to all users, with a significant focus being placed on access for people with disabilities. TMR has refocused its efforts by publishing the revised *Disability Service Plan 2017–2020* and *Disability Action Plan 2018–2022*, outlining actions to be taken to enhance accessibility.

The Australian Bureau of Statistics' (ABS 2019b) *Disability, Ageing and Carers* estimates there are currently 906 100 people with disability in Queensland, representing approximately 17.9% of the Queensland population (ABS 2019a)[1]. This means that around 1 in every 5 people in Queensland has a disability, which may affect their mobility.

Universal access is the provision of equal access to all users in a fair and dignified way. People with different levels of mobility or disability should be granted the same dignity, comfort, safety, speed and capacity when using road or public transport networks (Ajuria 2005).

The topography of Queensland regions may limit the dignified access for some user groups. Steep terrain specifically can become untraversable or undignified due to the increased effort requirements or physical impairments for some users.

The introduction of the National Disability Insurance Scheme in Queensland has been progressively providing support to people with disabilities. Part of the scheme is to help provide funding for mobility aids and services.

Wheeled devices are a commonly used aid for people with mobility impairments to improve their level of accessibility. However, people with wheeled devices run the risk of tipping if a slope or crossfall is too steep for their device and may experience undue fatigue particularly for people with manual wheelchairs (MWC). Between 2009 to 2018 there has been an increase of about 9200 MWC users; 3900 powered wheelchairs (PWC) users and 2900 mobility scooter users (ABS 2019b).

1.2 PROJECT AIM

This project aimed to review road industry practices and competencies with a view of achieving the TMR vision of creating a single integrated transport network capable of providing universal access for all users.

People with disability may experience risks and difficulties that other people without disability are unaware of or do not experience. This project is intended to investigate if and where systematic transport network access failures may be occurring for people with disability.

[1] Total QLD pop = 5 076 500 (ABS 2019a). Pop with disability = 906 100 (ABS 2019b).

This project was broken down into three key parts, with a separate report being produced for each part. The final stage of the project was to develop a summary report to summarise the contents of the three key parts. The aims for each part of this project are described below.

Part 1: Review of design and development practices that relate to access for people with a disability

This report aimed to identify access issues and recommend key areas of improvement in planning and design policies, training, and guidance. This is intended to adequately inform and lead designers, planners, engineers, and decision-makers to provide a transport network that to the greatest extent possible delivers safe and dignified universal access.

Part 2: Performance-based concepts and training requirements

The second report aimed to identify and review current performance-based concepts/strategies used in the design and planning of universal access and determine whether these may assist in ensuring dignified and defensible accessibility for all users. Training courses available to industry professionals and professional competency requirements were also reviewed, gaps were identified, and improvements were recommended.

Part 3: Investigation of accessibility for people with a disability and NDIS

The third report aimed to identify what provisions need to be put in place when topography results in undignified accessibility for people with disability and to investigate if electric assistance technology and NDIS is changing design user capabilities.

Part 4: Summary report of findings

The final summary report aimed to summarise the findings and recommendations of the entire project into one document.

This report focuses on part 3 of the project which aimed to define what accessibility is for people with disability in a road network and identify what provisions are needed where the topography is a barrier to access, and investigates if electric assistance technology and the National Disability Insurance Scheme (NDIS) is changing user design capabilities.

1.3 OBJECTIVE

The objective of this project was to identify ways to investigate existing practices and provide recommendations to improve practices in the provision of universal access for all users, including people with disability or movement impairment, and the elderly.

1.4 PROJECT SCOPE

The scope of this project included the following:

- review of existing policies and guidance published by TMR, Austroads and Australian Standards that impact the accessibility of people with a disability within the road network. Identification of gaps or barriers to access for people with a disability and recommend improvements
- identification of performance-based concepts (such as 8 to 80, human-centric design, or universal design) and how these may assist to ensure dignified and defensible accessibility
- review TMR's existing training courses available to industry professionals and professional competency requirements
- identification of what accessibility for people with disability means in the road network
- identification of barriers to access due to topography and provisions needed to ensure dignified and defensible accessibility

- identification of whether electrical assistance technology and the NDIS is changing the capabilities of people with disability.

2 ACCESSIBILITY FOR PEOPLE WITH DISABILITY

The general term for 'accessibility' means to easily be obtained, reached, or understood (Stevenson 2010). Accessibility in relation to people with disability in a road and footpath network means that they are easily and safely able to integrate onto the network, understand how to use these networks and manoeuvre through the network.

Furthermore, 'dignified access' for a person with disability means that a design or process allows for equitable and independent access to premises, goods and services without the assumption that assistance is required, and where people feel safe and connected (Australian Network on Disability 2016).

People with disability or naturally diminishing bodily function depend on the accessible transport systems in place in the same way as people without disability. Persons without disability have the choice to utilise most forms of transport independently, while people with mobility, sensory or intellectual disabilities often have barriers and restrictions for safety and physical reasons (McCausland et al. 2020; Queensland Government 2019b).

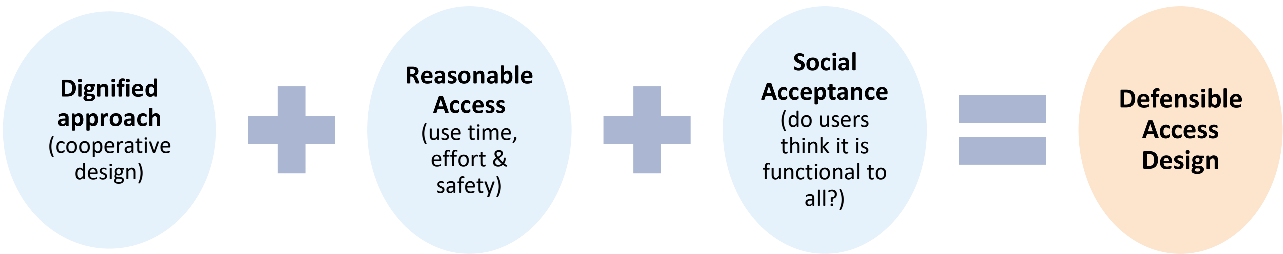
Transportation access issues are one of the topmost regarded inclusion issues for people with disabilities. People with disability depend on transport systems to access a range of services which include their home, shopping, education institutions, medical facilities, workplaces and recreational amenities (Kett, Cole & Turner 2020). Environmental barriers, such as steep topography, can result in complete denial of these services and general social and economic opportunities (Ayland et al. 2015). This creates inequality that disadvantages people with disabilities, which from a human rights perspective is undignified.

This existing inequality can lead to exclusion and is proven to lead to lower quality of life. Limitations in travel especially for driving means that an individual is more likely to experience social isolation and loneliness which can then be detrimental to their overall mental and physical health (Kett, Cole & Turner 2020). Instead, they are more likely to depend on others to drive them to their destination, walk (often unaided) or use public services such as public transport (Haning, Gazey & Woolmer 2012; ABS 2020) which often presents a greater number of barriers; is more time consuming, and requires greater levels of effort to achieve access. This can deter people who experience disability from travelling away from home which continues to add to the greater risk of social isolation and overall wellbeing (Kett, Cole & Turner 2020).

2.1 DEFENSIBLE ACCESSIBILITY

Appropriate accessibility is difficult to implement in areas where existing infrastructure is already established. Many of these existing establishments were built before current standards and guidelines were written, and in some cases before legislation regarding the rights for equality of people with disabilities was established. Social acceptance from people experiencing disability plays a large part in what is considered dignified and reasonable access for people with disability (Withers 2018). The relationship between a dignified approach, reasonable access, and social acceptance determines if a design is defensible (Ahman & Gulliksen 2014; Bevan 2009; Van Geenhuizen 2018), see Figure 2.1.

Figure 2.1 Developed framework example, showing relationship factors for defensible access



Under Queensland and Commonwealth legislation it is illegal to discriminate against people with disabilities based on the accessibility. With the resources available, developers should, to the best of their ability, create an environment (development) that is accessible for everyone within reason. Developers can be defined as being anyone involved in the building or modifying of publicly accessible places such as roads, this includes (but is not limited to) project managers, planners and engineers. 'Reasonable' in terms of accessibility is difficult to quantify as the needs of people with mobility, sensory, intellectual, and temporary disabilities and impairments are not homogenous (Kett, Cole & Turner 2020). A development or route that is not reasonable may still be accessible. Here non-reasonable would be apparent if the apparatus is too time-consuming for users to use or if the effort required to successfully enter is high for the majority of users with disability. It may also be unreasonable if users feel unsafe or are unsafe using the access facilities or even if the aesthetics are severely undermined compared to the other access facilities.

An example of non-reasonable design is an entrance to a facility that is accessed predominantly by people without disability through a flight of stairs and takes less than a minute to use; for a majority of people with mobility impairments, the same facility is accessible but only if they travel over 10 minutes to a (compliant) ramp with landings, leading to fatigue and other difficulties. For many this scenario may not be considered reasonable or dignified, and therefore, is socially unacceptable for use. In this scenario, it is more reasonable for a lift to be installed at the main entrance but, due to resources available, might not be an option within the foreseeable future; the existing arrangements may be the only feasible measures that can be currently taken.

Additionally, proving that attention and effort have been made to improving or creating the best reasonably accessible environment for everyone with the available resources can be considered defensible.

Cooperative design

Cooperative design, also known as 'participatory design' or 'co-design', is often used as part of design research or product development and is one example of a potentially dignified, user-centric design approach (Smith et al. 2017). Ahman and Gulliksen (2014) suggest that this strategy is particularly useful when it comes to users with special requirements as it entails full cooperation between development teams and the intended users throughout the development life. While standards specify the minimum defensible values of design components, cooperative design ensures the assembly of components results in a functional and dignified product.

In the interest of defending a design, during the development and progressive stages of the project, consultation with groups or bodies who have the best interest of the targeted audience in mind acting as an access and social acceptance consultant is beneficial. Their involvement can provide needed perspective on the suitability, reasonability, and social acceptability of a design. Their taken perspective and involvement mean that they can attest to witnessing efforts that were made in cooperation with developers to provide the best reasonable outcome.

A sample of organisations that may be able to act as access consultants or provide appropriate resources to improving universal access include:

- Vision Australia **–** a national provider of blindness and low vision services in Australia that works in partnership with the blind community
- Spinal Life Australia **–** support people with spinal cord damage to live an accessible, equitable and empowered life
- Endeavour Foundation **–** an independent, for-purpose organisation that supports people with an intellectual disability to live their best life.

Accessibility audits

Independent examinations of the level of universal accessibility and reasonability of a design could be conducted in the form of audits which may act as an additional measure to a dignified approach. The person/s conducting the audit should be possibly accredited or have a respectable amount of understanding of various vulnerable user needs. The suitability for a person to conduct audits should be further explored.

Audits would desirably be undertaken at multiple stages within the design process to ensure that accessibility is being consistently measured. The objective of the audits is not only to make sure that the level of accessibility is up to a reasonable standard but to also encourage designers to be more aware and aim to produce designs that are reasonably accessible.

3 NATIONAL DISABILITY INSURANCE SCHEME & PEOPLE WITH MOBILITY AIDS

The National Disability Insurance Scheme (NDIS) is a social policy program established under the National Disability Insurance Scheme Act 2013 (NDIS Act) to replace the National Disability Agreement (NDA). It also established the National Disability Insurance Agency (NDIA), the independent statutory agency responsible for administering the NDIS (Buckmaster 2017). NDIS has provided support to approved people with disability, their families and carers since its progressive introduction in Australia starting in July of 2016. The scheme is jointly funded and governed by the Federal Government and participating state Australian Governments (Buckmaster 2017). The intent behind the NDIS can be broken down simply as (NDIS 2020a):

- **National:** The NDIS is being introduced progressively across all states and territories.
- **Disability:** The NDIS provides support to eligible people with intellectual, physical, sensory, cognitive and psychosocial disabilities. Early intervention supports can also be provided for eligible people with disability or children with developmental delay.
- **Insurance:** The NDIS gives all Australians peace of mind if they, their child or loved one is born with or acquires a permanent and significant disability, they will get the support they need.
- **Scheme:** The NDIS is not a welfare system. The NDIS is designed to help people get the support they need so their skills and independence improves over time.

The main aim of the NDIS is to provide individualised support packages to eligible people with disability (Buckmaster 2017). The type of supports available for participants falls into three purpose categories (NDIS 2020b):

1. **CORE –** A support that enables a participant to complete activities of daily living and enables them to work towards their goals and meet their objectives.
2. **CAPITAL –** An investment, such as Assistive Technology (AT), equipment and home or vehicle modifications and funding for capital costs.
3. **CAPACITY BUILDING –** A support that enables a participant to build their independence and skills.

In Queensland, the NDIS first began its progressive rollout starting 1 July 2016 and continued until completion on 1 January 2019 (Queensland Health n.d). The NDIS at the time of writing this report has been fully operational for a little over a year since the completion of the rollout. The rollout occurred over a geographical basis, by Local Government Boundaries, see Table 3.1.

Table 3.1: Progressive regional rollout of the NDIS in Queensland

Start date of the rollout for LGA	Local Government Area (LGA)
1 July 2016	• Available for children and young people (0–17 years) in Townsville and Charters Towers
1 October 2016	• Townsville • Burke • Hinchinbrook • Charters Towers • Carpentaria • McKinlay • Palm Island • Cloncurry • Mornington • Boulia • Doomadgee • Mount Isa • Burdekin • Flinders • Richmond
1 November 2016	• Isaac • Mackay • Whitsunday
1 January 2017	• Balonne • Murweh • Toowoomba • Bulloo • Paroo • Western Downs • Goondiwindi • Quilpie • Maranoa • Southern Downs
1 July 2017	• Ipswich City • Scenic Rim • Lockyer Valley • Somerset
1 October 2017	• Bundaberg
1 January 2018	• Banana Shire • Central Highlands • Longreach • Barcaldine • Diamantina • Rockhampton • Barcoo • Gladstone • Winton • Blackall Tambo • Livingstone • Woorabinda

Start date of the rollout for LGA	Local Government Area (LGA)
1 July 2018	• Aurukun • Hope Vale • Pormpuraaw • Cairns • Kowanyama • Tablelands • Cassowary Coast • Lockhart River • Torres • Cook • Mapoon • Torres Strait Island • Croydon • Mareeba • Weipa • Douglas • Napranum • Wujal Wujal • Etheridge • Northern Peninsula Area • Yarrabah • Cherbourg • North Burnett • South Burnett • Fraser Coast Brisbane City • Logan City • Redland City • Gympie • Noosa • Sunshine Coast • Gold Coast
1 January 2019	• Moreton bay

Source: (Queensland Health n.d).

The NDIS also acts as an information and connections provider to services in the participants' state/territory and local community (NDIS 2020a), for:

- access to mainstream services, such as health, housing and education; and
- access to community services, such as sports clubs and libraries; and
- maintain informal supports, such as family and friends.

The NDIS procedures and regulations are legislative instruments rendered under the *National Disability Insurance Scheme Act 2013* (Buckmaster 2017). Objectives of the NDIS Act as stated, include:

- Support the independence and social and economic participation of people with disability.
- Provide reasonable and necessary supports, including early intervention supports for people with disability.
- Enable people with disability to exercise choice and control in the pursuit of their goals and the planning and delivery of their supports.
- Facilitate the development of a nationally consistent approach to the access to, and the planning and funding of, supports for people with disability.
- Promote the provision of high quality and innovative supports to people with disability.
- Protect and prevent people with disability from experiencing harm arising from poor quality or unsafe supports or service provided under the NDIS.
- Raise community awareness of the issues that affect the social and economic participation of people with disability and facilitate greater inclusion of people with disability.

The general eligibility criteria to participate in the scheme are as follows (NDIS 2020a):

- must be between the ages 7 and 65
- must be an Australian citizen or have a permanent or special category visa, who live in Australia
- use special equipment because of their permanent and significant disability
- usually need support from a person because of a permanent and significant disability
- need supports now to reduce future needs.

Children under the age of 7 may be eligible for the Early Childhood Early Intervention (ECEI) for disability or developmental delay support, which is a sub-scheme of the NDIS. Persons over the age of 65 may be eligible to participate in the Aged Care System which is supported by the *Aged Care Act 1997*.

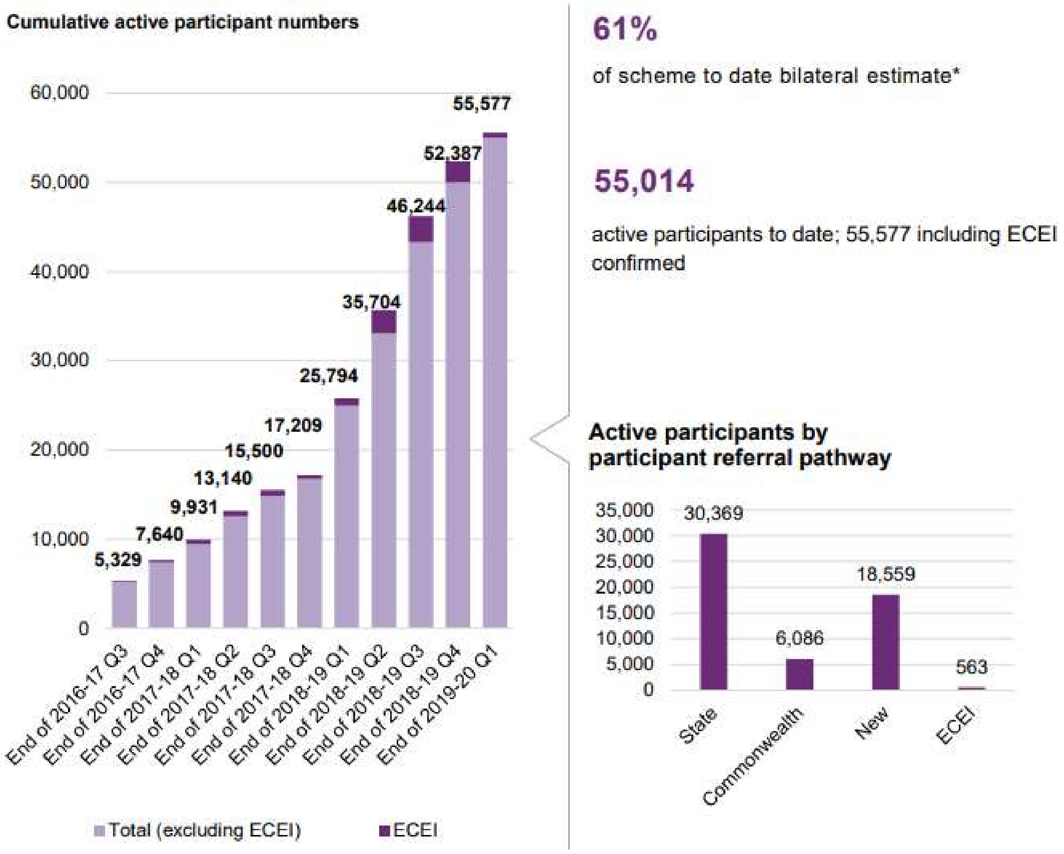
Approved NDIS participants may receive individualised support funding for (Buckmaster 2017):

- daily personal activities
- transport to enable participation in community, social, economic and daily life activities
- workplace help to allow a participant to successfully get or keep employment in the open or supported labour market
- therapeutic supports including behaviour support
- help with household tasks to allow the participant to maintain their home environment
- help by skilled personnel in arranging aids or equipment assessment, set up and training

- home modification design and construction
- mobility equipment
- vehicle modifications.

For many people, the NDIS supplies them with the disability support they need for the first time (NDIS 2020a). As of September 2019, there are over 55 014 participants supported by the NDIS in Queensland, with 5 247 additional active participants approved from 1 July 2019 to 30 September 2019 (Quarter 1 2019–20), which is an 11% increase from the previous quarter, see Figure 3.1. From the total number of participants, 18 559 (~33%) were receiving support for the first time (NDIS 2020b). Overall, NDIS participants only make up 6% of the total Queensland population of people living with disability.

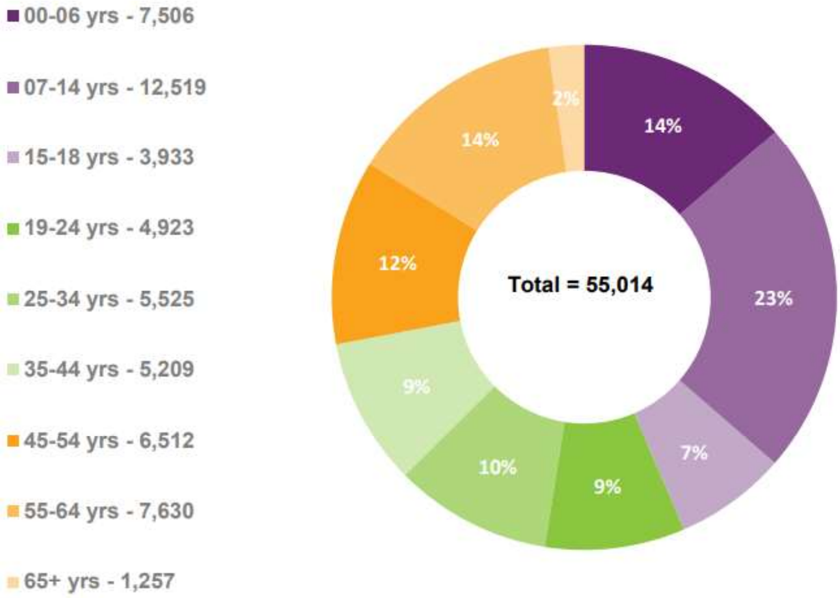
Figure 3.1 Cumulative position of NDIS participation as of September 2019



Source: NDIS (2019a).

Most participants entering the NDIS in the latest and previous quarters are under the age of 18 (see Figure 3.2). Most participants are evenly spread across each age bracket with the exceptions of 15–18 years and 65+ years which have less and 7–14 years which has double most other brackets.

Figure 3.2 Age profiles of active participants with an approved plan (no. of participants) as of September 2019



Source: NDIS (2019b).

In Figure 3.3 the primary disabilities of participants are listed; from this list, the following disabilities are linked to individuals potentially experiencing mobility and sensory difficulties:

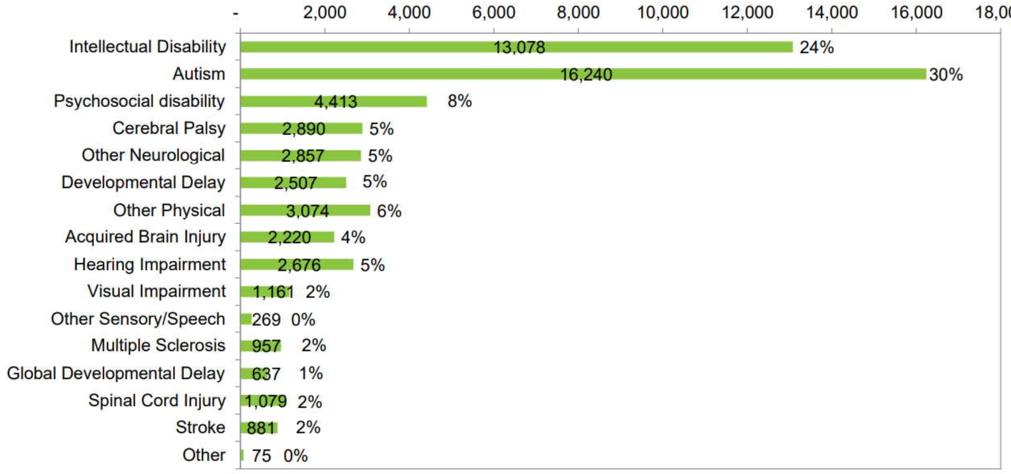
- **Cerebral palsy** is associated with movement and posture affecting minor to major motor skill problems or full physical dependency (Better Health Channel 2020a).
- **Other neurological** are a range of conditions such as Huntington's disease which can moderately to majorly affect movement and behaviour (Snowden 2017).
- **Developmental delay** is when a child is slower to reach developmental milestones in a single area such as speech, motor skills, self-help or problem-solving. The delay may be temporary or permanent (Sydney Children's Hospital n.d).
- **Other physical**
- **Acquired brain injury** (ABI) is any brain injury that occurs after birth. Two-thirds of all people with an ABI are restricted or limited in their activity (Better Health Channel 2020b).
- **Hearing impairments** can affect specific aspects regarding transport situations. Hearing is significantly important when walking and when using public transportation (Thorslund et al. 2012).
- **Visual impairment** is associated with reduced ability to move around and utilising all forms of transport. Walking in unfamiliar/complex environments is challenging (Gallagher 2011) and driving is a prohibition (Vision Australia 2013).
- **Multiple Sclerosis** is a chronic disease that affects the nervous system. A common symptom of Multiple Sclerosis is challenges controlling the body (e.g. weakness, loss of coordination) (Health Direct 2018).
- **Global developmental delay** is similar to developmental delay, but it is where a child is experiencing delays in milestones in some areas such as speech, motor, cognitive or social, emotional and behavioural delays (NYU Langone Health 2020).
- **Spinal cord injury** in most cases is irreversible and permanent. In 2012–13, 52% of spinal cord injuries resulted in quadriplegia in Queensland (Spinal Life Australia 2020).
- **Strokes** are neurological complications that affect motor control, can cause paralysis and can induce disability involving vision (Harris-Love et al. 2016; Langhorne et al. 2000).

Disabilities listed that have low to no potential to affect personal mobility:

- **Intellectual disabilities** can limit personal mobility depending on the type of intellectual disability. People with down syndrome have physical differences such as ligamentous laxity and premature aging, which impacts mobility but is not severe (Cleaver, Hunter & Ouellette-Kuntz 2009).
- **Autism** can affect a person's behaviour by causing repetitive and dissimilar behaviours when moving their bodies in different ways (Better Health Channel 2020c).
- **Psychosocial disabilities** arise from mental health issues such as schizoid disorders, anxiety disorders or mood disorders; it is unrelated to mobility (Chess Connect 2020).
- **Other sensory/speech.**

Based on the data in Figure 3.3, about 37% of Queensland NDIS participants potentially experience or live with disability that inflicts a varying degree of mobility difficulties or issues.

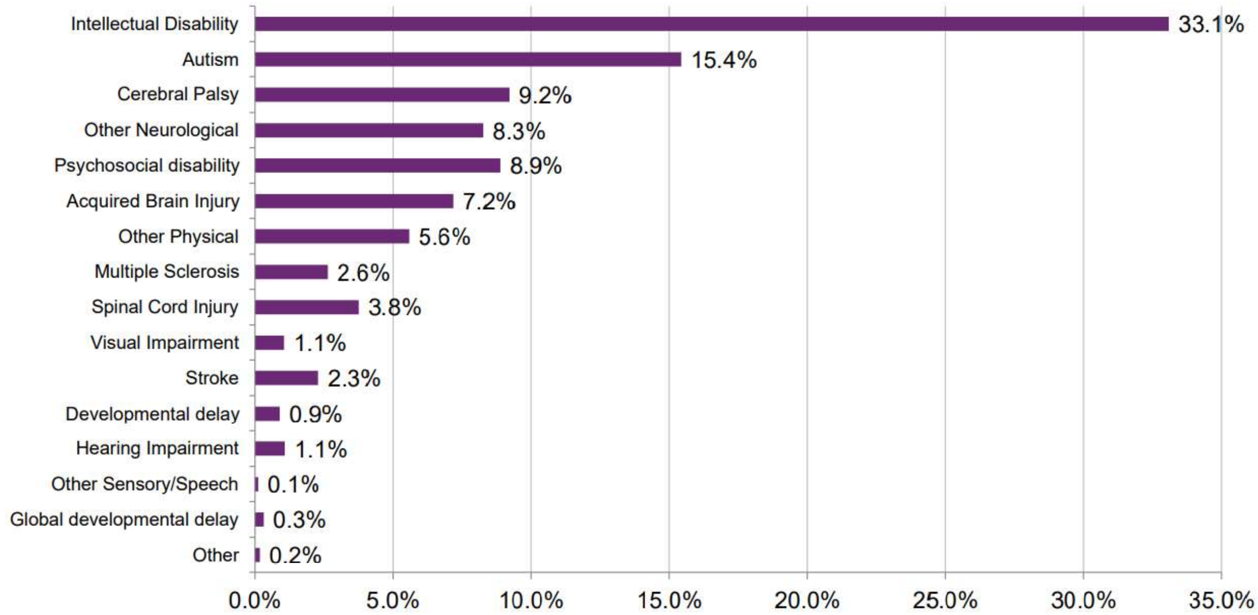
Figure 3.3 Primary disability of active participants with an approved plan in QLD



Source: NDIS (2019b).

Around 42.4% of Queensland-approved participants are receiving NDIS support for disabilities that potentially inflict a degree of mobility difficulty, see Figure 3.4. However, it unknown as to what type of funding is being provided.

Figure 3.4 Total annualised committed support for active participants with an approved plan by primary disability in Queensland



Source: NDIS (2019a).

4 PEOPLE WITH DISABILITY & ASSIST DEVICES

For some people with disability, topography can be a barrier or an extreme obstacle on their route, and they may require aid equipment to make their experience easier or eliminate the barrier.

The attainment of aids to people with disability (who require them) allows them to operate more independently from carers and take part in more activities, without which, they would not be able to participate. It also allows them to live life with greater ease and in a dignified way by allowing them to carry out everyday tasks independently. Accessible, affordable, safe and convenient transport is required to participate in education, healthcare, shopping, work and recreational activities.

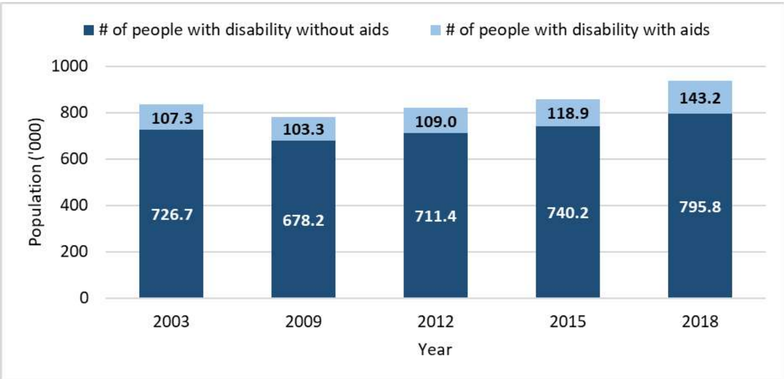
Built environments that are inaccessible or have limited accessibility for a person with disability limit their ability, disadvantages them and diminishes their quality of life. This disadvantage they experience puts them at a higher risk of social exclusion and negative health and well-being effects (Haning, Gazey & Woolmer 2012). Living with a severe mobility restriction in Australia means that you are less likely to pursue further education and participate in the labour force and therefore tend to have a lower income (Haning, Gazey & Woolmer 2012).

The NDIS uses a scale from 1 to 15 to classify the level of bodily function; 1 being the highest functional capacity and 15 being the lowest level of function. In the NDIS (NDIS 2020b):

- 23.8% of Qld participants have a high level of disability (level of function 1 to 5),
- 47.9% have a moderate level of disability (level of function 6 to 10), and
- 28.1% have a low level of disability (level of function 11 to 15).

From the number of approved plans of NDIS Queensland participants, 4.6% of participants are receiving support for Assistive Technology (AT) and 1.4% are receiving support for transport (NDIS 2020b). Since the progressive rollout of the NDIS in Queensland, the number of participants who use mobility assist aids has been on the increase as shown in Figure 4.1 (ABS 2020).

Figure 4.1 Population of people living with disability that require and do not require mobility assist aids in Queensland from 2003 to 2018

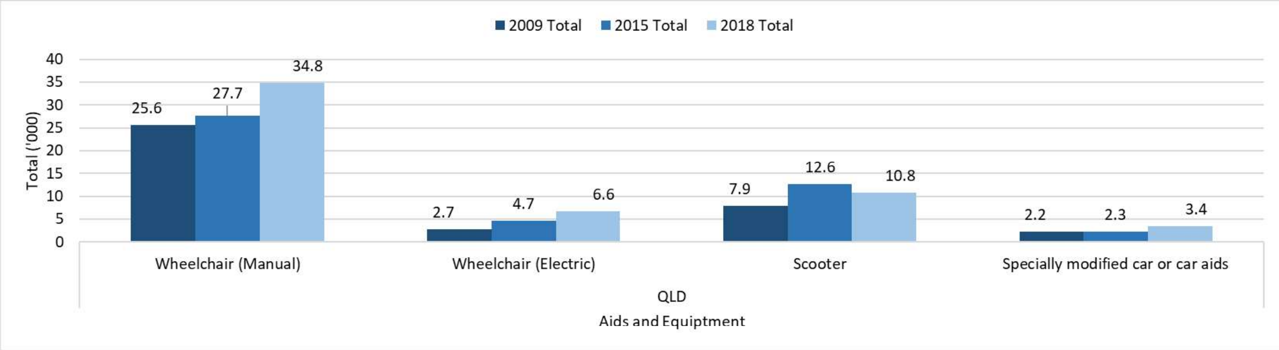


Year	% without mobility aids	% with mobility aids
2003	87.13%	12.87%
2009	86.78%	13.22%
2012	86.71%	13.29%
2015	86.16%	13.84%
2018	84.75%	15.25%

Source: ABS (2019b).

Data published by the Australian Bureau of Statistics (2020) shows a progressive rise in the number of powered (electric) and manual wheelchairs since 2009; for mobility scooters, there was a rise between 2009 to 2015 but has since declined which was when the NDIS rolled out (Figure 4.2). The decline in mobility scooters is speculated to be linked to the fact that they are more suitable for outdoor use, meaning they are less versatile; there have also been calls to better regulate mobility scooters as they have been involved in more crashes (Rural and Regional Affairs and Transport References Committee 2018). Other aids and equipment have for the most part been on the increase (Figure 4.3).

Figure 4.2 Portion of people with disability who use mobility aids reported by the Bureau of Statistics to use type of aids and equipment in Queensland by year



Source: ABS (2019b).

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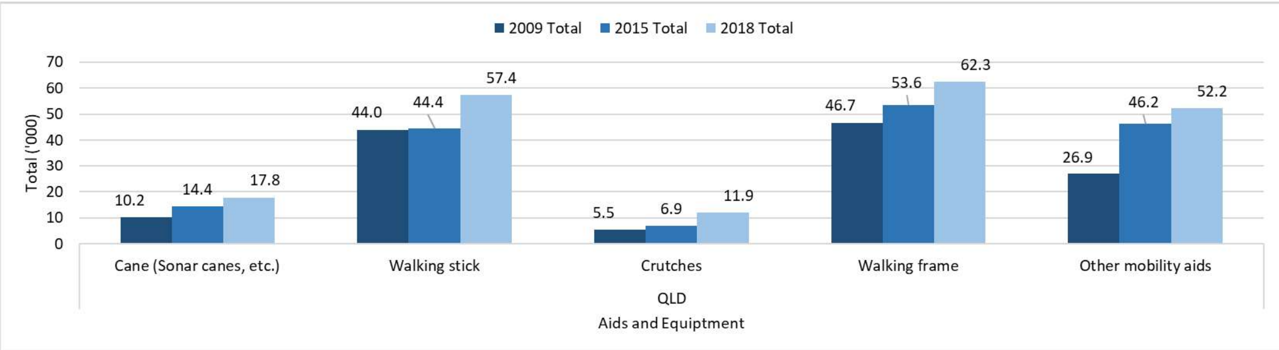
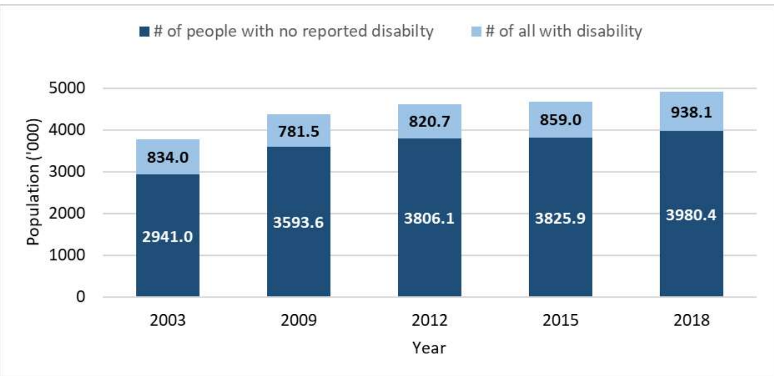


Source: ABS (2019b).

Seemingly, before the rollout of the NDIS, there was a general increase in electric assist technology as well as rises and relatively static growth in numbers of other assist aids and equipment (see Figure 4.2 and Figure 4.3). The overall general increase is suspected to be in some part related to the national and state population growth and, respectively, the number of people with disability (see Figure 4.4). Hence, there will likely be continuous growth in the number of people who require and use assistive aids, and thereby growth in the number of people who will experience transport disadvantages.

Figure 4.4 Population of people living with and without disability in Queensland from 2003 to 2018



Year	% without disability	% with disability
2003	77.46%	21.97%
2009	81.55%	17.73%
2012	83.47%	18.00%
2015	80.05%	17.97%
2018	79.41%	18.72%

Source: ABS (2019b).

According to the ABS (2019b) the number of people who require mobility and transport assistance exceeds the number of people with disability who use mobility aids (see Table 4.1) and the number of people who are receiving support under the NDIS.

Table 4.1: Number of people receiving and not receiving assistance for mobility and transport

	Mobility ('000)				Transport ('000)			
	2009	2012	2015	2018	2009	2012	2015	2018
Source of assistance (some may source from multiple)								
Informal	149.1	152.2	147.5	177.5	99.4	94.3	93	117.1
Private	14.8	22.7	22.1	14.9	12.2	11.4	15.6	15.6
Government	15.7	17.3	17.4	5.7	7.5	10.1	8.1	14
Number or people requiring (inc. not received) & Number not receiving assistance								
Not received	15.8	18.3	16.5	16.7	8.1	10.4	5.1	9.6
No. of people requiring assistance	175.2	176.5	172.3	203.9	114.6	117	107	136.9

Source: ABS (2019b).

Under the NDIS, mobility assistive items are classified as capital supports. When participant plans/applications are approved for capital supports, they are restricted to specific items under that participant's plan, which is assessed based on their circumstances. From the research performed it is uncertain as to how many NDIS approved participants have received financial capital supports to acquire specific mobility aids such as those listed in Figure 4.2 and Figure 4.3. Particular assistive items that were mentioned previously can be approved for participants as suggested by the NDIS Support Catalogue 2019–20, see Table 4.2.

Table 4.2: Availability of mobility assist items (from Figure 4.2 and Figure 4.3) under the NDIS

Assist item	Section	Item reference number	Description	Available under NDIS
Manual Wheelchairs	4.7.5 Wheelchairs and scooters	05_417_0105_1_2	Manual wheelchair designed for recreational and sports use.	Yes
		05_122203104_01 05_1_2	Wheelchair – manually propelled – average folding.	No – effective 30 June 2018
		05_122409171_01 05_1_2	Manual wheelchair with powered wheels that amplify pushing effort.	Yes
		05_122203121_01 05_1_2	Folding wheelchair made to individual measurements of the adult user (not including seating).	Yes
Powered Electric Wheelchairs	4.7.5 Wheelchairs and scooters	05_419_0105_1_2	Powered wheelchair for adult or child use, with factory seating.	Yes
Scooters	4.7.5 Wheelchairs and scooters	05_122303191_01 05_1_2	Powered 4-wheeled scooter for use by an individual of significant weight (> 150 kg) or in adverse settings.	Yes
		05_122303111_01 05_1_2	Powered occupant operated wheeled scooter.	Yes

Assist item	Section	Item reference number	Description	Available under NDIS
Canes & Walking Sticks	A.1 Low cost, low risk assistive technology	05_120303085_01 05_1_2	Devices that provide support when walking (single, 2 point, 3 point).	No – effective 30 June 2018
Crutches	A.1 Low cost, low-risk assistive technology	05_120306087_01 05_1_2	A device that provides support for the elbow when walking.	No – effective 30 June 2018
Walking Frames	4.7.2 Equipment related to walking	05_120606111_01 05_1_2	Walking devices to enable a person to maintain stability and balance while walking. Includes 4-wheeled walkers etc.	Yes

Source: NDIS (2019c).

From consultation with a disability support worker, it was stated that some people with disability require aids to tackle areas where the topography is a barrier or challenge, and to some people using a wheeled device is their only option.

When participants do require assistance using wheeled-chair devices, the majority are still using manual wheelchairs, followed by mobility scooters then powered wheelchairs. Therefore, the majority of wheeled-chair users depend on their upper body physical strength to transport themselves or the ability of the person they are accompanied by. The prevalence of manual wheelchairs is likely contributed to the fact that they are generally less expensive to purchase and service, and most users can operate them. Other advantages and disadvantages of manual wheelchairs, powered wheelchairs and mobility scooters are listed in Table 4.3.

Table 4.3: Pros and cons to types of wheeled-chair devices

	Advantage	Disadvantage
Manual Wheelchair (MWC)	• Easier to transport • If necessary, while the user is in the chair, the user can be lifted up stairs • No reliance on charging batteries • Easy to self-navigate in tight spaces • Less expensive to purchase • Certain models are foldable • Appropriate for indoor and outdoor use • Easy to get in and out of • Health benefits due to physical movement/exercise	• Requires a minimum level of strength and balance • Potentially creates new bodily issues with long-term use (shoulder wear and tear) • Difficult to go longer distances or up slopes
Powered Wheelchair (PWC)	• Usually, no minimum strength required to use the joystick control • Can self-transport over long distances without reaching exhaustive states • Preference of drivetrains (rear, mid or front) positioning offers tailored preference for terrain • Some models include recline and tilt features for pressure relief and other • Appropriate for indoor and outdoor use • Easy to self-navigate in tight spaces • Easy to get in and out of	• The device tends to be heavy and challenging to transport (not foldable) and may require wheelchair lifts attached to cars • High incidence of maintenance and servicing • Requires regular battery charging • Generally, more expensive to purchase and service • Device programming controls can be sophisticated

	Advantage	Disadvantage
Mobility Scooters (MS)	• Choice between 3-wheels models and 4-wheel models • Best for outdoor or tougher terrain • Can self-transport over long distances without reaching exhaustive states • Have higher speed abilities compared to the other two options (up to 15 km/h) • Smaller scooters are collapsible and easier to transport	• Larger models are heavy and non-collapsible and therefore harder to transport • High incidence of maintenance and servicing compared to MWC, but lower than PWC • Requires regular battery charging • Generally, less expensive to purchase than PWC but more than MWC • Are steered with bicycle-like handlebars which are more difficult to control compared to PWC if the user has upper body mobility issues • Not designed for indoor use • Less physically supportive

Source: MobilityHQ (2020b); Power Mobility (2020a); Schwartz (2015).

After reviewing a sample of wheelchairs and accessories available in Australia, it became apparent that there has been some development in new electrical assistive technology. Some new accessories are attachable to traditional manual wheelchairs to enhance the user's capability. It was uncertain if these non-traditional or mainstream mobility attachments such as those depicted in Figure 4.5 can be acquired through NDIS financial supports. However, the NDIS assistive technology (AT) and Consumables Code Guide does have provisions for devices like the Freedom Trax – ft1, which are meant for rougher terrain (NDIS 2020b). It is unclear if provisions for devices such as the Triride – max or Smoove are covered under the catalogue item 'Manual Wheelchair Accessory – Power-Assist Drive Technology'. However, the guide does state under Section 1.4 that it is not a comprehensive list of all supports that may be reasonable and necessary for a participant (NDIS 2020b).

Figure 4.5 Power assistive technology that attaches to manual wheelchairs. (a) Triride – Mad Max (b) Smoove (c) Freedom Trax – FT1

(a) (b) (c)

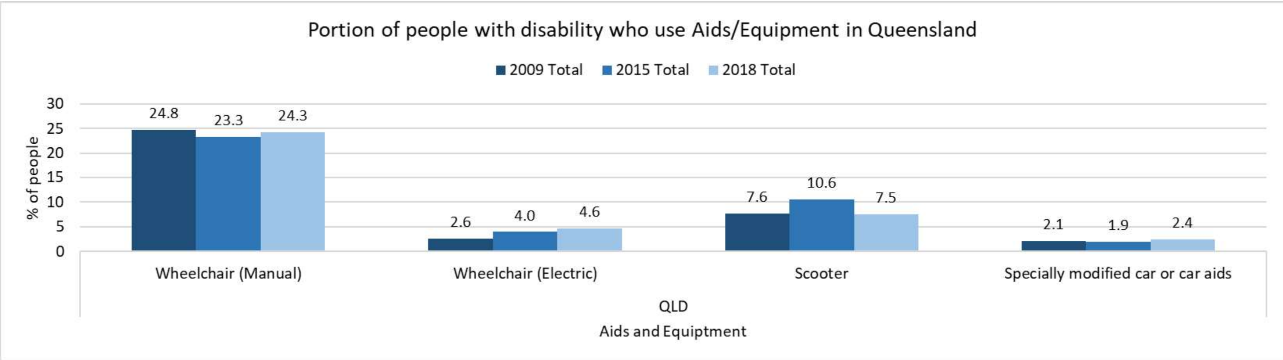
Source: Mobility Plus (2020a); Mobility Plus (2020b); and Mobility Plus (2020c)

New and improved technologies could extend the scope of participants' physical capabilities and their independence. In the future, these current non-traditional technologies may become more popular and quite possibly the 'norm'.

5 USER CAPABILITY WITH ASSIST DEVICES

Over the past decade, there has been an increase in the number of people who live with disability and who require assistance in both Queensland and nationally. A large portion of people with disability use one or more assistive aids. The portion of people with disability in Queensland who use the most common types of mobility aids is illustrated in Figure 5.1.

Figure 5.1 Percentage of people in Queensland with disability who use specific aids



Source: ABS (2019b).

Not only do these aids change the capability of people with disability, but they also change the required user space of the person which is dependent on the type of aid and the overall size of that aid. For instance, a person with a walking cane requires a small amount of extra area as the cane is held close to the body, whereas a person using a probing cane (for vision impairments) requires a greater amount of area surrounding their personal area because the cane is usually held out a few steps in front of the user. The same can be said for wheelchairs and mobility scooters, see Figure 5.2. Scooters generally tend to be the largest wheeled device in the area, followed by powered wheelchairs, then manual wheelchairs.

Figure 5.2 Wheeled-chair mobility devices. (a) Manual wheelchair: Ottobock Start M4 XXL (b) Powered wheelchair: Ottobock Juvo B6F Front Wheel Drive Power Chair (c) Scooter: Pride Sportrider

(a) (b) (c)

Source: Power Mobility (2020c); Power Mobility (2020b); and Pride Mobility (2020).

The Australian Standards AS 1428.1-2009 and AS 1428.2-1992 set the minimum requirements for accessible pathways. The scope of AS 1428.1 mentions that this standard gives particular attention to (a) continuous accessible paths of travel and circulation spaces for people who use wheelchairs; (b) access and facilities for people with ambulatory disabilities; and (c) access for people with sensory disabilities. It explicitly states that it does not include requirements for wheelchair sizes that exceed dimensions of 130 x 80 cm or for motorised mobility scooters. There is no minimum standard or guideline for the design of pathways for people with disabilities. AS 1428.1 also states that the allowable turning space provided should be at least 207 x 154 cm, the enhanced standard AS 1428.2 suggests a turning circle space of 225 x 225 cm.

AS 1428.1 states that the minimum desired width for pathways is 120 cm, which is enough space to allow for one average-sized wheelchair to fit on a path; the absolute minimum width is 100 cm. It is up to designers to increase width if desired. Designers who choose the bare minimum for the sake of compliance may produce designs that are inaccessible and undignified for travel.

A review of manufacturer size specifications was undertaken for three devices: MWCs, PWCs and mobility scooters. A sample of 50 size specifications was gathered for each of the three devices from a combination of available Australian manufacturer and retail websites. The desired characteristics: overall width, length, turning radius and the recommended maximum safe slope were recorded. The results for normal distribution of sizes are illustrated in Figure 5.3 to Figure 5.8, overall statistics are tabulated in Table 5.1 and Table 5.2.

Not all the desired characteristics were available from the manufacturer user manuals and brochures, and this was particularly frequent for turning radius and maximum safe slope. Therefore, the results in Table 5.2 have low reliability as only a small number of documents contained that information. This absence in information to users increases the risk of people buying devices that may not be suitable for their common place environments. This information is especially important for people to understand their own capability (in their device) when trying to ascend and descend steep inclines.

From what was collected, the MWCs had the greatest maximum and minimum safe slopes, suggesting that they have the greatest ability to ascend and descend inclines of the three devices. Although, scooters and PWCs still require less effort to ascend inclines making them more suitable for people with lower levels of function.

The majority of widths among all three devices were found to be similar, being between the 60 cm to 70 cm range for overall width. Approximately 7% of the MWC widths exceeded the Australian Standard of 80 cm, these devices were found to be bariatric wheelchairs, designed for people with obesity. Smaller devices were those designed for children.

The overall length of all the devices varied with the majority of MWC length being between 90 to 110 cm; PWCs majority was only slightly greater being 95 to 115 cm, and scooters had significantly the greatest variation in lengths with the majority being between 115 to 140 cm. None of the MWCs exceeded the 130 cm design standard; one of the PWC devices (equivalent to 2%) was over 130 cm in length; at least one-third of scooters were greater than 130 cm in length.

Due to the different wheel types used by scooters which do not have 360 degrees of rotation they require significantly more area of turning space compared to MWCs and PWCs. However, the greatest turning radius recorded for a scooter was still within the AS 1428.1 and AS 1428.2 suggested minimum turning space.

This investigation only looked at wheeled devices that were commercially available online. Further investigation into the size and capability (especially for size, turning radius, safe uphill and downhill slopes and base elevation) of wheeled devices that are in use by the wider public is required. Comparing the capability of publicly in-use wheeled devices against standards should then determine roughly what portion of wheeled chair devices is suitable for the standards. Based on these findings it can be determined if the current standards are sufficient or if changes and extra provisions (e.g. increase of dedicated space) need to be introduced.

Figure 5.3 Standard normal distribution for manual wheelchair widths

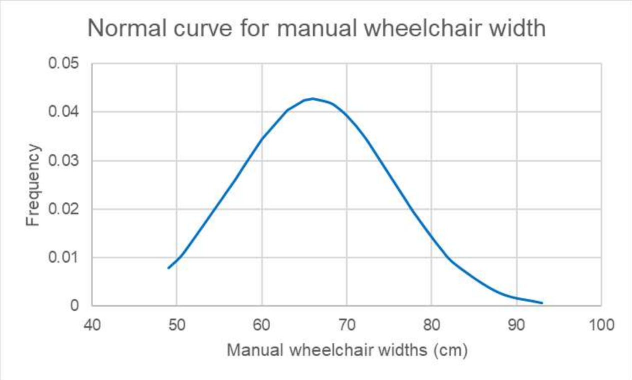


Figure 5.4 Standard normal distribution of manual wheelchair lengths

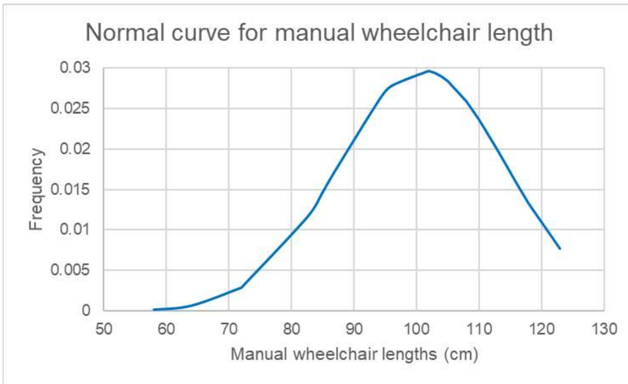


Figure 5.5 Standard normal distribution of powered wheelchair widths

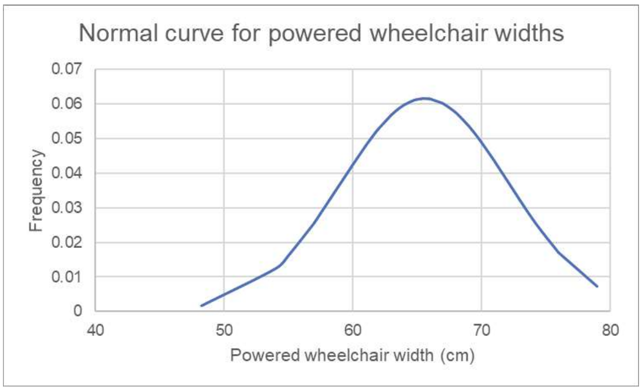


Figure 5.6 Standard normal distribution of powered wheelchair lengths

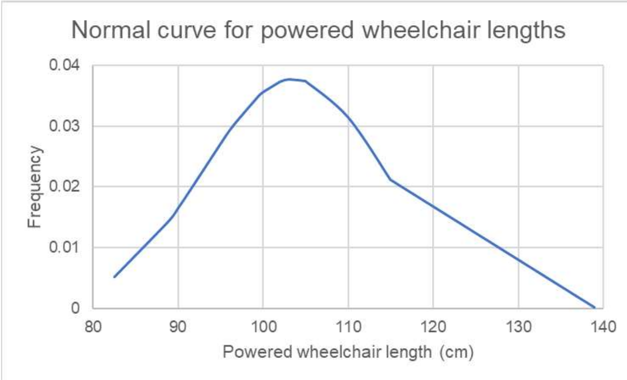


Figure 5.7 Standard normal distribution for scooter widths

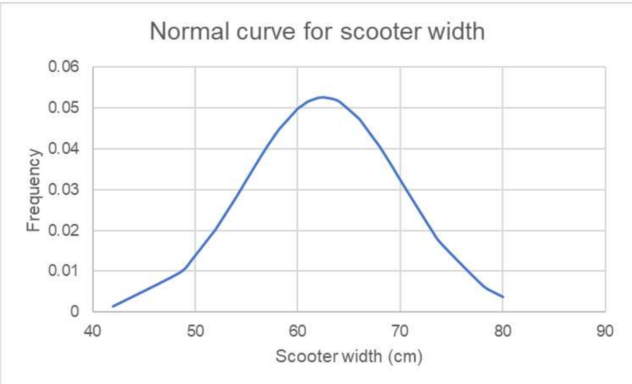


Figure 5.8 Standard normal distribution of scooter lengths

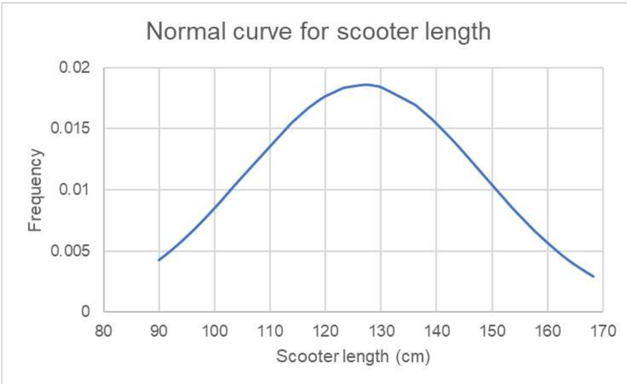


Table 5.1: Descriptive statistics of overall widths and lengths of MWCs, PWCs and scooters

Aid	Sample size	Width				Length			
		Min [cm]	Max [cm]	Average [cm]	No. that exceed 800 mm	Min [cm]	Max [cm]	Average [cm]	No. that exceed 1300 mm
MWC	56	49	93	66.2	4 (~7%)	58	123	101	0
PWC	52	48.3	79	65.6	0	82.55	139	103.6	1(~2%)
Scooter	52	48.5	80	62.5	0	92	168.3	126.9	19 (~36%)

Table 5.2: Descriptive statistics of safe slopes and turning radius of MWCs, PWCs and scooters

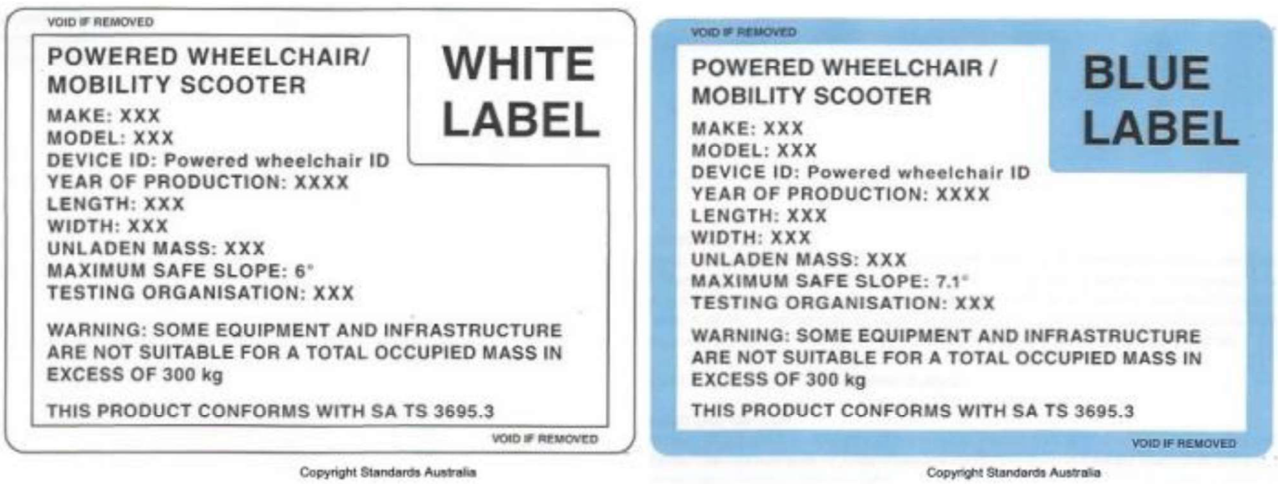
Aid	Maximum safe slope				Turning radius			
	Sample size	Min [degrees]	Max [degrees]	Average [degrees]	Sample size	Min [cm]	Max [cm]	Average [cm]
MWC	30	10	13	11	0	–	–	–
PWC	5	6	12	7.4	17	49	98	62.8
Scooter	11	9	12	9.7	45	78	275	138.4

Manual and powered wheelchair product requirements are provided in AS 3695-1992. The only regulatory requirements for a motorised wheeled device are that it must not exceed an unladen mass of 110 kg and must have a maximum forward speed of 10 km/h (Austroads 2019; National Transport Commission 2019). There are devices for sale in Australia that exceed these regulations and typically users are unaware of this before purchase.

Austroads has recently been involved in work that seeks to adopt Technical Specification (TS) 3695.3.2018. This TS details the construction and performance requirements for powered wheelchairs and mobility scooters for public transport and/or road-related area use (Austroads 2019). It was established in 2018 and is due for review in 2021. Responses to the discussion of adoption have received support in that it will provide clear identification of a device's compatibility with public transport due to lack of mandatory design standards to identify suitability for public transport (National Transport Commission 2019).

The TS also provides a labelling scheme that is intended to inform purchasers about the overall specification of devices for the intended use. The labelling scheme consists of two types of labels: white and blue (Figure 5.9).

Figure 5.9 White label and blue labels



Source: Austroads (2019).

Devices with white labels are suggested to be suitable for paths and public infrastructure. Devices with blue labels are indicated to be suitable for paths, public infrastructure, and public transportation conveyances (not including taxis). The TS provides the parameters for these two types of devices (see Table 5.3). Devices that are assessed but do not meet the parameters will not be provided with a white or blue label. Similarly, devices that are assessed and deemed too big or overdesigned in other aspects will not be provided with a label (Austroads 2019).

Research conducted by Central Queensland University reported that adopting this TS is not sufficient to determine that blue-awarded devices can be used on public infrastructure and asked for the label scheme to be recalled and further testing be undertaken to increase accuracy (National Transport Commission 2019).

Table 5.3: Comparison of Technical Specifications by label

Element	White label	Blue label
Overall width (max)	850 mm	740 mm
Overall length (max)	1500 mm	Determined by manoeuvrability performance
Overall height	No requirement	1500 mm maximum
Maximum unladen mass	170 kg – scooters only no requirement for powered wheelchairs	170 kg – scooters only no requirement for powered wheelchairs
Maximum laden mass	No mass specified – not a requirement within the Technical Specification. The warning provided that laden mass over 300 kg is not suitable for some equipment or infrastructure is provided	No mass specified – not a requirement within the Technical Specification. The warning provided that laden mass over 300 kg is not suitable for some equipment or infrastructure is provided
Maximum speed	10 km/h	10 km/h
Low speed switch	> 6 km/h	> 6 km/h
Stability on gradients	6° dynamic/9° static	7.1° dynamic/9° static
Ground unevenness	Drop on one side down a 50 mm step	

Source: Austroads (2019).

6 PROVISIONS FOR TOPOGRAPHY BARRIERS

When travelling away from home, many people with disability report having to plan routes for outings; alter planned routes; go more slowly than planned; or wait for a more suitable time to travel (Kircher, Gerber & Smith 2008). These actions are to avoid barriers such as steep longitudinal grades due to topography.

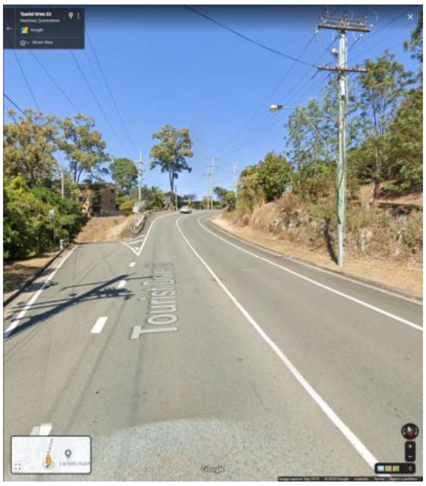
Unforeseen longitudinal grades on a planned route can often result in undignified levels of exhaustion for people with mobility impairments who still depend on their own physical or bodily strength abilities to traverse grades. For those who depend on the ability of their assistive device to traverse grades, it may be that their device is not equipped for inclines above a certain grade. Steep grades can increase the risk of people with wheeled devices tipping over and people walking losing balance and falling. Regardless of where the source of their mobility is, grades can ultimately prove dangerous which may lead to potential injuries or a complete denial of access. Device failure can disadvantage people using assistive devices and may pose greater safety and health risks if it occurs on steep grades.

People with other sensory disabilities may also experience difficulty ascending and descending longitudinal grades such as people with vision impairments as well as pedestrians pushing prams or carrying luggage.

Ideally, the topography of every greenfield and brownfield development would be relatively flat, but this is not always physically and financially feasible or justifiable. The scope of this section involves consideration of existing ways to achieve access on the footpath network.

Figure 6.1 to Figure 6.3 show examples where the topography is unlikely to be altered due to the existing infrastructure. These are the main three roads that connect to one of the major hospitals in the Sunshine Coast region. Hospital Road connects the hospital to the nearest major train station and town centre; the area surrounding the hospital is also close to elderly care facilities, day cares and suburbs, but the slope may be too steep for all users to access easily, even if it is easily traversable for a person without disability.

Figure 6.1 Netherton St (leads to hwy) – 300 m from Nambour Selangor Hospital (800 to General Hospital) – slope runs first 150 m



Source: Google Maps 2019, 'Tourist Drive 23, Nambour, Queensland', street view data, Google, California, USA, viewed 14 December 2020, https://goo.gl/maps/Vd5JgZ1dBt51xY379

Figure 6.2 Nambour-Mapleton Rd – 250 m from Nambour General Hospital – slope runs full 250 m

Source: Google Maps 2019, '42 Tourist Drive 23, Nambour, Queensland', street view data, Google, California, USA, viewed 14 December 2020, https://goo.gl/maps/qCc1zEsXBKs1juQ88

Figure 6.3 Hospital Rd – 500 m from Nambour General Hospital – slope runs full 500 m

Source: Google Maps 2019, 'Hospital Road, Nambour, Queensland', street view data, Google, California, USA, viewed 14 December 2020, https://goo.gl/maps/SV1ELMeoFcTktFWz8

Any unfamiliar destination may be unknowingly situated along a longitudinal grade; it may be at the top of the slope or even on the other side of a hill. Pedestrians who feel they or their device is incapable or know that they will experience greater difficulty attempting to ascend the longitudinal grade often look to find alternatives to reach their destination. If a person is travelling by private modes of transport (e.g. personal car) they may still experience the same difficulties. For example, if a destination does not provide on-site parking it could result in the need to park at the nearest parking facilities, which might be located at the bottom of a grade. In some cases, pedestrians may find that there are no suitable alternative routes for reasons such as pathways not being provided on alternative routes; alternative routes being unreasonably long, or that simply that there is only one available route.

The following situational factors are required for a person with disability to successfully use a footpath (Kockelman et al. 2000):

- the capability of their assist device
- length of continuous sidewalk route sections exceeding 2% cross slope
- the proportion of entire sidewalk route exceeding 2% cross slope
- adjacent automobile traffic volume and the separation distance from such traffic
- sidewalk pavement condition [type, texture, state of repair, surface (e.g. iced over or wet)]
- primary sidewalk slope (note: downgrade and upgrade effects differ)
- weather
- sidewalk width
- degree of accessibility of the entire route (including curb cuts, street crossings, and so forth).

The sidewalk environment can prove difficult to control for designers as they are built to follow the natural topography of the land.

6.1 GUIDANCE

Austroads' (2017) *Guide to Road Design Part 6A* (AGRD) provides guidance for the provision of pathway slopes which is based on Australian Standards 1428.1 and 1428.2. Guidance is also presented in TMR's (2010) *Technical Note 38: Longitudinal Grades for Footpaths, Walkways and Bikeways* (TN38).

AS 1428.1 describes the minimum technical specifications for accessible buildings to enable general use of buildings and facilities by people with disability while acting independently. However, this is aimed at access to premises, i.e. buildings, although it is frequently adopted for the outdoor settings, which Austroads caters for in their AGRD and TMR in their TN38.

AGRD Part 3 (Austroads 2016) provides the requirement for the maximum crossfall of the road which is 2.5%. For wheeled chair devices, crossfalls exceeding the maximum of 2.5% increases the force required to be applied by users to each wheel, which also increases the level of difficulty to keep a manual wheelchair heading in a straight direction (Australian Building Codes Board 2019). The maximum crossfall of 2.5% is appropriate (Vredenburgh et al. 2009).

AGRD Part 6A (Austroads 2017) provides the requirements for gradients and landings of footpaths. This guidance is based on AS 1428.2 and it states that where the standard cannot be applied due to topography issues, designers should refer to an Australian Rights Commission's Advisory Note. However, this Note does not provide any further guidance on topography issues. The lack of guidance surrounding topography can easily lead to paths that are undignified or inaccessible for people with disability.

Furthermore, TMRs TN38 states the maximum grades for footpaths are to be 'at grade of the road', there is no recommendation or guidance on changing the grade to be more suitable for people with disability. Equally maximum grades for walkways are said to not be required. This 'no limit' could easily lead to undignified access on longitudinal grades of footpaths.

Austroads (2017) advises that consultation should be carried out for feedback from disability groups, but this is only specifically mentioned/encouraged for kerb ramps. Consultation should be encouraged for all attributes and not limited to a select few.

Austroads (2017) and AS 1428.2 provide conflicting guidance regarding ramps and landings. The Austroads suggest that landings be provided at intervals of every 9 m for ramp grades of 1:14 and every 15 m for ramp grades of 1:20. While the AS 1428.2 states that landings be provided at intervals of every 6 m for ramp grades of 1:14 and every 14 m for ramp grades of 1:20. AS 1428.2 suggests shorter intervals, meaning that persons with disability travel less and exert less energy to reach rest areas.

Standards and guides provide basic information on road design attributes and regulations, but in some cases, the ability to redevelop a site according to these standards may not be possible without extreme courses of action that are not feasible or justifiable. Many areas that were built before the establishment of the latest recommendations and regulations do not meet these standards and this poses many issues and because of this, many areas are not accessible.

Table 6.1 contains a comparison of relevant guidance provided for attributes related to footpath infrastructure.

Table 6.1: General guidance for gradients for the following pedestrian access attributes

	AGRD Part 3	AGRD Part 6A	AS 1428.1	AS 1428.2	TN38
Crossfalls	Maximum of 1:40 (2.5%); anything over this is said to be potentially problematic for people using mobility devices.		–	–	–
Footpath	–	Required to be as flat as reasonably possible. Where AS 1428.2 cannot be applied due to topography or location, designers should refer to the Australian Rights Commission's Advisory Note on Streetscape, Public Outdoor Areas, Fixtures, Fittings and Furniture.	For gradients in general, if it is 1:33 or less, the slope does not require landings. 1:33 (~3%) requires landings of 1.2 m in length at no greater than 25 m intervals. Between 1:33 (~3%) and 1:20 (~5%), the interval for landings should be interpolated. 1:20 (~5%) the interval should not exceed 15 m. Greater than 1:20 (~5%) should be considered as ramps for design purposes.		The maximum longitudinal grade for footpaths is to be 'At the grade of the road'. Landings are said to not be required on footpaths. No provisions for maximum elevation.
Walkways	–	–	Grade not greater than 1:20.	–	Max grades are 1:20 and landings are not required.
Ramps	–	Landings are provided at intervals and changes in direction and intervals ranging every 9 m for grades of 1:14 (~7%) or every 15 m for grades of 1:20 (5%).	–	Continuous handrails at two levels are required for wheelchair users and other groups. For ramp gradients, 1:14 (~7%) landings should be every 6 m and for 1:19 (~5%) landings should be every 14 m.	–
Kerb ramps	–	A max gradient of 1:8 (~12.5%) should be used as an absolute value and only be used in extenuating circumstances.		–	–
		Advises that consultation be carried out for feedback from disability reference groups.	–		
Stairs	–	Advises incorporating shorter routes via staircases if possible.		Asserts that stairways are not to be the sole means of access and that ramps	–

	AGRD Part 3	AGRD Part 6A	AS 1428.1	AS 1428.2	TN38
				or lifts should be provided as alternatives.	

6.2 AVAILABLE SERVICES

People who encounter longitudinal grades on footpaths that are not independently traversable (without the help of a carer) will seek alternative methods of transport or alternative routes of transport. In a telephone consultation on 18 March 2020, a support worker for persons with disability stated that in instances where persons with mobility impairments cannot self-propel themselves on ‘steep’ slopes, they may use the following services or infrastructure:

- lifts and ramps with landings
- mobility aids
- carers
- disability reserved parking spaces
- transport funding
- Taxi Subsidy Scheme (TSS)
- Companion Cards.

6.2.1 IMPLEMENTATION OF LIFTS, ESCALATORS AND RAMPS WITH LANDINGS

Where elevation changes have been an issue, a common solution has been to install stairs, lifts, escalators or ramps with landings. This is common in entrances and exits to underground train stations and shopping centres.

Ramps and lifts are generally suitable where stairs are the only other means of access. Ramps are more commonly used for a relatively small change in elevation over short lengths of travel and are required to have rails for added support. Additionally, landings are also required at intervals for specific slope gradients and lengths of ramps, and these are beneficial as it allows for a pedestrian to take breaks at intervals. Escalators in general are only viable for use in indoor, enclosed spaces.

However, where the topography is the issue, these options may not always be an acceptable solution. Topography is generally an issue that extends over long lengths, while lifts and ramps are used for changes in elevation within the immediate vicinity.

Figure 6.4 shows an example where stairs, lifts or ramps may not provide any benefits to the pathway to allow for suitable accessibility to all users.

Figure 6.4 Example of where lift or ramp is not a solution where topography creates accessibility issues

6.2.2 ACCESS TO MOBILITY AIDS

Mobility devices such as, but not limited to, scooters and powered wheelchairs allow for people with mobility impairments to traverse longitudinal grades with less physical exertion. The use of mobility aids also allows for some users to have a greater sense of balance or stability when traversing up or down slopes. Access to aids can provide the necessary support for independent travel (MobilityHQ 2020a; Power Mobillty 2020a).

Previously mentioned in Section 3 was the NDIS through which approved participants may acquire mobility aids such as electric wheeled devices (NDIS 2020b). In a telephone conversation on 18 March 2020, with a support worker for persons with disability, it was stated that if participants can prove that the attainment of a motorised mobility aid can significantly improve independence or quality of life, then it may be sufficient enough reason for approval.

The same support worker also noted that cases have been seen where special consideration is given to mobility-impaired applicants who live in areas where accessibility to footpaths and road networks is substantially more easily achievable with electric assist technology, including where it is required for them to travel on significantly sloped sidewalks from home and can be enough reason to approve electric assist technology. However, this has not been verified through NDIS.

6.2.3 CARERS

Through phone consultation on 18 March 2020 with a support worker for persons with disability, it was stated that persons with mobility impairments who cannot self-propel up or down 'steep' slopes can organise assistance through formal or informal providers to assist them on their journey. Formal providers are service providers for support workers or carers, and informal providers would be family or friends.

Carer or support workers provide people, especially those with mobility impairments, assistance by propelling and or manoeuvring bodies and assistance devices, such as wheelchairs. In instances where slopes cause an increased risk of people falling and are potentially dangerous, carers can act as added support for increased stability.

Some people with disability require care at all hours of the day meaning they have assistance whenever they are required to traverse unforeseen longitudinal grades. Those who do not need all-day assistance of carers usually arrange their care through the service provider in advance of the journey. This absence of ready availability cannot combat unforeseen barriers of longitudinal grades that arise along a lone journey in progress.

Acquiring carers and support workers can be done through privately funded means. They can also be funded through government funding schemes such as the NDIS and disability support pensions.

6.2.4 DISABILITY RESERVED PARKING SPACES

Persons who are using private methods of transport benefit from having disability reserved parking spaces, close to community gathering spaces such as seen in Figure 6.5. This is so they do not need to travel as far to reach their destination and is generally safer and may reduce the travel required on up and down slopes. Parking spaces are usually located where it is considered most convenient. Taxi bays, like disability reserved parking, are usually located near accessible entrances to premises.

On-street parking is more dangerous for people with disability; is not as frequently available compared to off-road car parking and is quite difficult to implement when there is little space to accommodate applicable standards.

Figure 6.5 Oxford park train station (Scanlan Rd)

Source: Google Maps 2017, 'Scanlan Road, Mitchelton, Queensland', street view data, Google, California, USA, viewed 14 December 2020, https://goo.gl/maps/DJLdUcDCDWxP2ktg9

Parking in spaces such as these requires a disability parking permit acquired through the Department of Transport. To be eligible for a permit, applicants must have a functional impairment that severely limits their ability to walk permanently or temporarily. If the applicant has mobility restrictions that limit their ability to carry out basic activities, they are also eligible (Queensland Government 2020).

A bill currently before Queensland Parliament, if passed, will allow people with vision impairments who are legally blind to be included in the eligibility criteria (Queensland Government 2020).

6.2.5 TRANSPORT FUNDING

The NDIS funds 'reasonable' and 'necessary' support for transport to assist participants with the additional transport costs for services such as taxis (NDIS 2018). These services can be used to travel to locations that may otherwise be inaccessible due to unsuitable infrastructure or environment, such as topographic issues causing steep pathways. Participants are paid fortnightly and can receive a maximum of $3456 a year (Endeavour Foundation 2019; NDIS 2019d).

Mobility allowances can be given through Centrelink to help with travel costs for work, study or looking for work for people with disability, illness or injury. Approved persons are eligible to receive up to $2587 per year (Services Australia 2019).

6.2.6 TAXI SUBSIDY SCHEME (TSS)

Taxi services are used by people with disability if they require it to avoid travelling where the topography is a barrier. Before the NDIS implementation, TSS issued a card to approved members to use and would subsidise half of a taxi fare of up to $50 per trip (subsidy $25). The Queensland Government announced that it will continue to provide the TSS for NDIS participants until 30 June 2020 (Endeavour Foundation 2019). From 1 March 2020, NDIS participants will be able to flexibly use their plan's core support funding to claim service provider costs associated with transporting participants to and from NDIS funded community-based activities.

Non-NDIS eligible applicants must meet at least one of the following criteria (Queensland Government 2019a):

1. Physical disability requiring dependence on a wheelchair for all mobility outside the home.
2. Severe ambulatory problem that cannot functionally be improved and restricts walking to an extremely limited distance.
3. Total loss of vision or severe visual impairment (both eyes).
4. Severe and uncontrollable epilepsy with seizures involving loss of consciousness.
5. Intellectual impairment or dementia resulting in the need to be accompanied by another person at all times for travel on public transport.
6. Severe emotional and/or behaviour disorders with a level of disorganisation resulting in the need to be accompanied by another person at all times for travel on public transport.

Wheelchair accessible taxis are available, and the operator of these vehicles must give preference to the carriage of people restricted to a wheelchair. At any other time, the vehicle can be used to provide a taxi service for the carriage of any public passenger (Queensland Government 2019a).

This option is limiting to some people with disabilities, as it is said to be heavily orientated around providing support for certain user groups of disability (people using wheelchairs). Limitations in subsidies for such schemes possibly limit the user's independence as to how many times they can travel based on affordability.

6.2.7 COMPANION CARDS

Each state and territory's Companion Card Program operates under the National Companion Card Scheme and is aimed at removing the financial barrier for people requiring carers when participating in events, activities and venues (Australian Government 2019).

Figure 6.6 Example of companion card

Source: Queensland Government (2016).

The Companion Card (Figure 6.6) enables a person with disability that has specific support needs to involve a companion (usually carer or support worker), who is given free access to services and events including public transport. The program provides increased accessibility for individuals with specific and permanent mobility and transport support needs (Queensland Government 2016). This allows for people with disability to participate in the program to achieve greater accessibility, economic benefits and social benefits.

6.3 ALTERNATIVES

People with mobility impairments who use electric wheeled devices are less likely to experience difficulties ascending and descending longitudinal grades compared to those without them. Some people choose not to use or have an electric assist device as they are more difficult to transport and more expensive to maintain (Power Mobility 2020a). Ideally, everyone who uses a wheeled assist device would be able to access funding for an electric assistive aid and means to conveniently transport themselves through the NDIS. However, it simply is not feasible, because government-supported funding may not be enough and without funding, people with disability are less likely to be employed and have lower incomes.

From the research conducted, outside of the current guidance of standards and guidelines, there is very little literature as to how topography on immense scales can be mitigated to ensure accessibility for all users.

Where topography may be limiting or denying access to pedestrians, it will require a solution that is unique to the locality of the dilemma. The use of ramps and landings may be seen as an applicable solution but retrofitting landings may steepen existing grades if provided in line with the road. Equally, handrails (if not a spearing hazard) as assist devices can be seen as a possible solution but it is only applicable and effective on a case-by-case basis. It is unlikely that trying to fix the physical built environment issue of sites one-by-one is feasible. The resources available may not be sufficient to fix the issue of topography on a project, but improving awareness surrounding the issue and providing good quality information to pedestrians as a strategy to help inform them about the suitability of the route to their own personal ability may improve overall accessibility.

6.3.1 GROUP CONSULTATIONS

People who experience mobility impairments will have an unmatched understanding and perspective of how topography can restrict access and what measures are highly effective to counter this. Cooperative design and development through group consultations with people experiencing mobility impairments should be highly regarded to automatically address accessibility issues (Ahman & Gulliksen 2014). This approach is meant for developers and intended users to share knowledge and experiences, ultimately providing developers with new insights into the development process (Ahman & Gulliksen 2014; Steen et al. 2011).

6.3.2 MOVING WALKWAYS

Moving walkways are similar to escalators; they are slow-moving conveyor ramps that transport people over horizontal or inclined planes. There has been some development in moving walkway technologies, which are not widely used but are being introduced into some communities in other countries.

In Vitoria-Gasteiz, Spain sequential moving walkways were introduced, spanning mostly over areas where longitudinal gradients were accessed by stairs or long steep slopes; landings were also provided along the walkway as access points for users (Metcalfe 2012). Similarly, on a German golf course, a 150 m outdoor walkway was introduced to aid golfers in ascending one particular hill (Allen 2011). Both have been particularly beneficial to elderly persons as they reduced the amount of fatigue experienced (Allen 2011; Metcalfe 2012). This would potentially be beneficial to users of wheeled devices, assuming the slope and conveyer conditions (surface, width etc.) were appropriate for the capability of wheeled devices without assistance.

This technology is still rather new and there are few cases where these have been installed. This technology is likely more costly to build and maintain at one site alone and would have to be strategically placed where it would get a lot of use by people with mobility difficulties and the general public. However, this only eliminates the barrier of topography on a site-by-site basis. This should be further investigated to find what cases this would be applicable and to conduct a cost to benefit analysis. Consultation with persons with reduced mobility groups should be carried out to determine the effectiveness of this strategy to said groups.

6.3.3 IMPLEMENTATION OF SLOPE SIGNAGE

Pedestrians with impairments may use Google Maps and Google Streetview as a resource to visually plan routes ahead of the trip (Akasaka 2018). However, these images can be misleading as some images are out of date by years and the ability to understand the true nature of the slope through images can be problematic.

Signage or indicators such as displayed in Figure 6.7 could be installed where a slope is considered potentially inaccessible to some users. This has been implemented at some independent facilities such as shopping centres (Beyond the Creek 2012). However, there was no literature found to support the potential benefits and effectiveness of implementing slope signage. Therefore, any benefits mentioned here are theoretical. Consultation with mobility impaired groups should be carried out to determine the effectiveness of this strategy to said groups.

Figure 6.7 Example of signage indicator for inaccessibility for wheelchairs

Source: Beyond the Creek (2012).

Concerns that call for the use of signs should be where:

- a slope is steep enough that users of wheelchairs or similar devices risk tipping forward, backwards or sideways
- slope travel of the sidewalk starts and ends
- the grade and length of the slope is likely to become straining for users with moderate and severe mobility difficulty
  - consider if only part of the slope is inaccessible, an indicator should be given in advance
  - consider if the presence or frequency of landings changes the perceived level of accessibility
- the end of a slope is not obvious (example in Figure 6.8)
- the area is deemed appropriate (near hospitals, parks, aged care facilities etc.)
- condition of the sidewalk.

These informational signs will hopefully prepare the pedestrian with enough information about the longitudinal grade so that they can determine if their capabilities at that moment are sufficient enough to complete the travel. Information that could or should be included are:

- maximum slope grade
- length of slope/s
- presence of hazardous cross slopes greater than 2% (based on Australian Standards for ramps)
  - Vredenburgh et al. (2009) states that crossfalls greater than 4% are problematic for ramps.

Figure 6.8 South-east from 81 Carter Rd, Nambour – visual representation of where the end of the slope is located is not apparent

Source: Google Maps 2018, 'Carter Road, Nambour, Queensland', street view data, Google, California, USA, viewed 14 December 2020, <https://bit.ly/37n61kf>

6.3.4 STRATEGIC PLACEMENT OF BUS STOPS

In the scope of this project, it was suggested by TMR that parking facilities available on the top of elevations are a potential solution to alleviate some barriers associated with topography. Suggesting that parking facilities are placed at the top rather than at the bottom of elevations would allow for the pedestrian to descend from their vehicle to their destination that may be on a longitudinal grade, but pedestrians would then have to ascend that grade to return to their vehicle, which still generates topographic issues.

Nevertheless, this generated the idea that public transport stations and similar facilities (e.g. taxi and ride 'n share bays) could be strategically positioned in locations where stops can help overcome topography issues for people with disability, for example, stops or stations located at the top and bottom of hills allows for downhill travel in-between. A practical approach is to strategically place stations at locations where there are significant changes in elevation or long changes in elevation without resting areas or landings. This type of guidance is not published in the AGRD or the AS 1428.1 and AS 1428.2.

The primary guidance for the placement of bus stops in Queensland comes from TMR's (2019) *Public Transport Infrastructure Manual* (PTIM). This document provides the following key considerations for the placement of bus stops (TMR 2019):

- accessibility and equitable access
- proximity to surrounding services and facilities
- frequency of services
- routing and future services expectations and network growth.

Unfortunately, the document does not go on to further explain these key considerations or how to put them into practice.

Figure 6.9 South-east from 83 Carter Rd, Nambour – visual representation of where the end of the slope is not apparent

An example of how the placement of bus stops could be used to improve accessibility for people with disability is bypassing topographic barriers.

Generally descending a grade requires less physical effort from the pedestrian than having to travel uphill. The idea here is that users may use the bus service to reach their destination by getting off at a station located at a higher elevation and then make their way down to their destination, once leaving their destination the pedestrian then continues down to another bus stop. This eliminates the need to travel uphill when arriving and leaving their destination (see Figure 6.9).

If regarded as an effective strategy, suitable locations would have to be identified for implementation; bus stops may even have to be relocated. It would likely require ongoing monitoring and feedback from users and the undertaking of trials may be fitting. Participants in trials should be from a range of levels of mobility and different types of mobility limitations.

A set of criteria should be set as to how this would be implemented and what characteristics of the site and elevation of the sidewalk, make it suitable. Basic characteristics recommended for consideration when defining criteria for the placement of bus stops included in Table 6.2

Table 6.2: Considerations for strategic placement of bus stops

Consideration	Notes
accessibility and equitable access	
proximity to surrounding services and facilities	• Type of facilities, e.g. medical centres, retirement villages, parks, airports • Number of facilities • Availability and placement of other transport facilities, e.g. parking facilities, light rail stations, train stations, ferries and taxi parking bays
frequency of types of the bus service	
routing and future services expectations and network growth	
quantity of people that visit the area	• number of people who use the sidewalk • number of people who use the roads • number of people who use the parking facilities available
number of people who potentially experience some level of difficulty using the sidewalk (e.g. people with mobility impairment, elderly, pedestrians with strollers and people with luggage)	• Severity of impairments to cater for
slope	• gradients and lengths of gradients • maximum safe uphill gradients • maximum safe downhill gradients • number of landings or potential rest areas • macro-scale topography of urbanised and rural areas of Queensland.

This effort would require the attainment of locality data that potentially does not already exist. Before trials or implementation begins, a set of performance indicators need to be set. After any trials, evaluation of the strategy should take place to quantify the level of success and satisfaction among participants. If proven to be an effective method, it may apply to other forms of public transport including taxi parking bays.

It is noted that research conducted unearthed no literature to support the potential benefits and effectiveness of this strategy. Therefore, any benefits mentioned here are theoretical. Consultation with people with reduced mobility or groups should be carried out to address any concerns and issues they may have with this strategy in different scenarios to try and address as many potential issues and to reduce the risk of non-dignified and non-defensible access.

6.3.5 TECHNOLOGICAL INFORMATIVE TOOLS (GOOGLE MAPS AND BRIOMETRIX)

Making more detailed streetscape topographical and accessibility information available (open data) may assist in more accurate trip routing according to user preferences/limitations. Better data collection of pedestrian routes, especially for people with disability, could allow early identification of the barriers in transport networks.

One Australian company taking a technological approach is Briometrix. They are developing technology targeting the population of those who use wheelchairs (Briometrix n.d.). Briometrix co-founder Natalie Verdon claimed that their research found four out of five wheelchair users had not been anywhere new in the last year due to the unreliability of accessibility information and that many wheelchair users had experiences of travelling along accessible routes to a destination venue that was not suitable for them (Withers 2018). Natalie claimed that when asking participants who they trusted to provide accessibility information many replied, ‘someone with the same condition as me’ (Withers 2018).

The organisation has been developing a GIS mapping system, similar to the Google Maps layout but with overlay information about the longitudinal grade, and training and employing people who use wheelchairs to survey footpath networks to maintain currency of data (Briometrix n.d). This is done through fitting footpath assessment technology to the wheelchairs of participants. Participants then become a part of an integrated smart city transport system, reporting and monitoring the health and integrity of footpaths (Briometrix n.d.). Data collected offers insight into determining mobility solutions for people using wheelchairs and inclusive of people using scooters, strollers, shopping carts and wheeled luggage carriers. The geolocated data collected includes (Briometrix n.d.):

- the terrain, gradient, and the effort required
- the surface type and condition with geolocated record and images of hazards
- the access to the buildings and properties adjoining the footpath
- the access to the road network via kerb ramps and crossings
- the location of facilities and services such as toilets and changerooms
- the transport nodes serving the precinct – bus, train, ferry, car parks
- the wormholes – unofficial routes used by wheelchair pilots
- the data is the basis for an accessible routing service including public transport connections.

The idea is that a path suitable for ‘wheelability’ is also suitable for walkability. The consolidation of this information into an interactive map application will provide an alternative solution to wheelchair users allowing them to better determine their capability (Briometrix n.d.). It is also insightful to any visitors to the region (Spinal Life 2019).

The Briometrix tool is designed for the needs of people who use wheelchairs, by considering the following (Briometrix n.d.):

- People who use wheelchairs have an active role in the project, not just after work.
- The map includes features to improve the enjoyment factor, showing accessibility features at cafes, hotels, venues, nature and city cultural trails, not just about accessible toilets and parking spaces.
- Universal language and style are used, providing a colour-coded map and ratings that can be universally applied and understood.

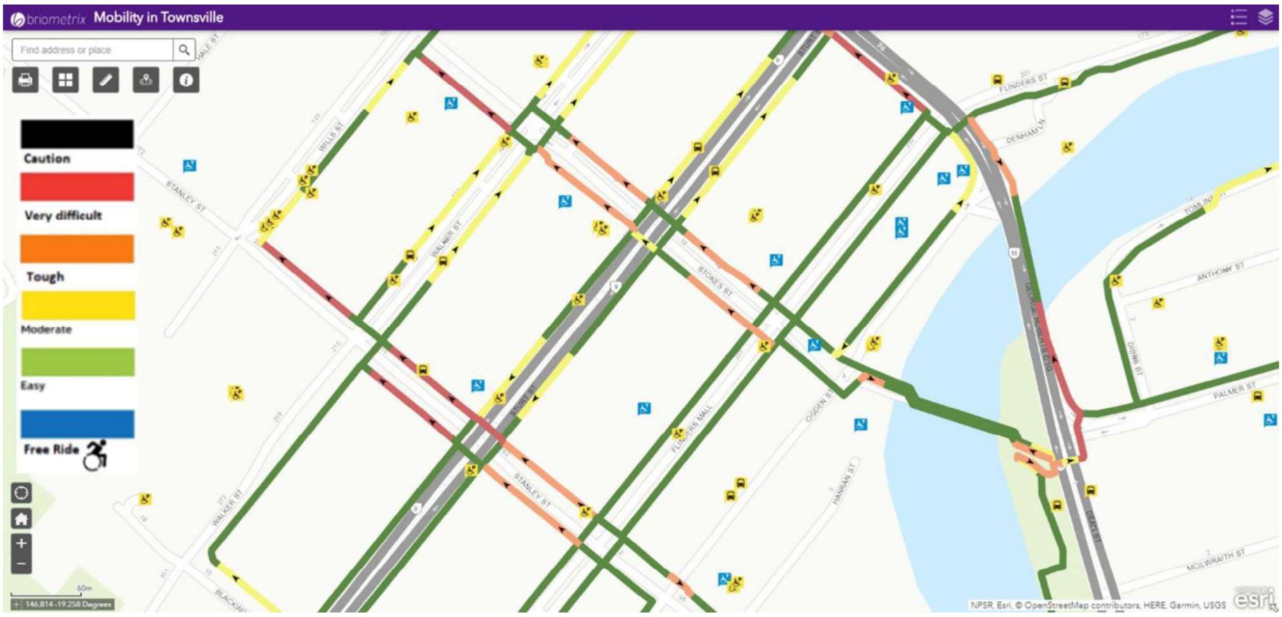
The tool is also designed to be usable for (but not limited to) local governments by providing the following services/tools (Briometrix n.d.):

- Australian standards compliant datasets.

- Interoperable with council GIS systems – files in required formats, maps can be displayed on local council websites and tourism websites.
- Visual tool – maps make communication with stakeholders easy to understand yet more comprehensive.
- Forecasting model – the focus is not about data and graphs but providing a forecasting tool that compiles data into meaningful analysis to drive action.
- Scalability – simply selecting more miles to map. Maps/mileage can be the entire city or specific area.

The City of Townsville has partnered with Briometrix to launch their accessibility map of the Townsville CBD, available on the City of Townsville website (Spinal Life 2019). The map has a similar interface to Google Maps, although it highlights paths in different colours based on the level of grade accessibility, and contains arrows advising the uphill direction of the slope. Some icons denote accessible parking, toilets and public transport stations. The response from the City of Townsville has been a positive one and the map has been a great resource to those with a physical disability (Spinal Life 2019).

Figure 6.10 Briometrix mobility mapping of Townsville



Source: City of Townsville (2020).

Through personal communications with Briometrix director, Natalie Verdon via email, it was mentioned that the organisation has recently completed mapping contracts with 'Townsville City Council, TMR (Brisbane, Rockhampton and Yeppoon)'. Currently, there are no case study reports on any of these projects as they are ongoing.

Another technology already available aimed at people who use wheeled devices is the Google Maps 'wheelchair accessible' setting on its journey planning tool. In 2018, Google introduced this feature intending to assist people who use wheelchairs in finding tailored public transport options in metropolitan areas (Deahl 2018).To enable this feature, Google Maps allows for users to choose only one of the following four route options (Dehal 2018):

1. Best route
2. Fewer transfers
3. Less walking
4. Wheelchair accessible.

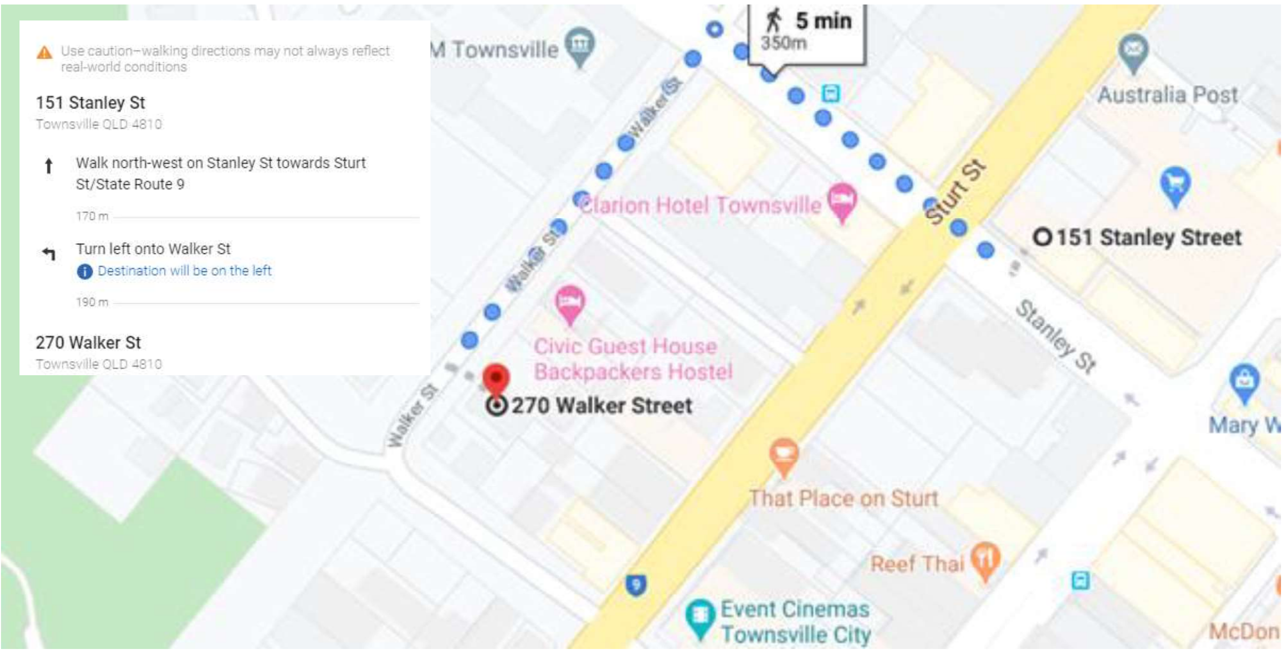
While this may be useful to some, the tool does not provide as much comprehensive information as the Briometrix mapping system, but it does suggest route options with estimated time to reach the destination. When enabled, the wheelchair-accessible route option simply provides users with the 'best' route options;

there is no information to say whether a path is preferred over another due to topographical reasons (i.e. slope and direction of uphill) or path conditions.

An example of such is demonstrated in Figure 6.11 in Townsville, Qld where the starting location has been input as 151 Stanley Street and the destination as 270 Walker Street. Google Maps highlights their supposed wheelchair accessible route with a travel distance of approximately 350 m, along with their estimated time to reach the destination of 5 minutes, which curiously is the same as the walking mode option (without wheelchair accessible feature enabled).

The setting is said to be tailored to finding public transport options, suggesting that the tool is not tailored to personal (walking) means of transport, which may be why the travel time by wheelchair and walking is the same even though a section of the route is a very difficult uphill slope (see Figure 6.12).

Figure 6.11 Google Maps route suggestion from 151 Stanley St, Townsville, Qld to 270 Walker St, Townsville, Qld



Source: Google Maps 2020, '151 Stanley St – 270 Walker St, Townsville, Queensland', map view data, Google, California, USA, viewed 14 December 2020, <https://bit.ly/3mlIDZW>

The same route has been highlighted onto a Briometrix map of the same location in Figure 6.12 as dark blue. An alternative route is highlighted in light blue.

Figure 6.12 Briometrix Mobility in Townsville map of 151 Stanley St, Townsville, Qld to 270 Walker St, Townsville, Qld – dark blue dotted path (350 m) and red location markers have been edited to reflect the path suggested in Google Maps of Figure 6.11 – light blue dotted path (420 m) is an alternative path

Source: Adapted from City of Townsville (2020).

Overall, both routes have the same amount of uphill travel, except the overall average difficulty of the uphill travel is different (see Table 6.3). The Google Maps route has a very difficult uphill (red) segment that spans approximately 120 m which is 34.3% of the journey; 57.1% is considered easy. The alternative route does not contain any 'very difficult' portions of the journey, the highest level of difficulty is the tough portion that is the same 30 m length as the Google Maps journey. In the alternative journey, 92.6% of the route is considered to be moderate to easy.

Pedestrians can proceed with the journey route they feel is best, based on the information provided by the Briometrix map. The 'very difficult' segment of the Google Map route, may cause the pedestrian to take breaks and slow down from exhaustion adding to the overall travel time, then potentially reaching the destination in the same amount of time as the alternative route. In such a case, the pedestrian may identify that the alternative route allows for a more dignified journey.

Features of Google Maps and Briometrix used together, would enhance users' planning to move around with greater ease. To utilise public transport, Google Maps has the tools to provide information to the user to then make an informed decision based on the geographical location but is limited in the personal (walking or equivalent) means of transport. While the Briometrix mapping system does not have a journey planning feature similar to Google, it provides enough information to the user about the longitudinal grades, for the user to then make an informed decision about their ability and preference to take a suggested route, to find an alternative route or to find more adequate modes of transport. TMR may consider developing a tool that incorporates the benefits of both tools in one.

Table 6.3: Length quantities of routes in relation to difficulty (based on colour and effort code used in Briometrix).

Colour	Level of difficulty	Google Maps suggested route		Alternative route	
		Total length of route (m)	Percentage of total length of route (%)	Total length of route (m)	Percentage of total length of route (%)
Black	Caution	0	0.0	0	0.0
Red	Very difficult	120	34.3	0	0.0
Orange	Tough	30	8.6	30	7.1
Yellow	Moderate	0	0.0	115	27.4
Green	Easy	200	57.1	275	65.5
Blue	Free ride	0	0.0	0	0.0

This technology is beneficial to users by allowing them to choose more appropriate routes based on their own judgement, but this detouring factor also means that users may have to take longer trips. If the scenario meant that the alternative route was less difficult (no fatigue) but would require 30 minutes more than the shortest suggested route, it would still pose issues of discrimination and undignified access. Therefore, this alone is not a measure that will eliminate barriers where topography limits access.

6.3.6 PROVING USER ABILITY COMPLIANT DESIGN

Designing for universal access should not rely solely on compliance with guides and standards. Designers need to consider the ability of all people, with particular attention to people who have mobility limitations and restrictions. It is difficult to understand how much consideration is given to the implications of longitudinal grades by designers or developers. Demonstrating some level of attention to the users of wheel devices in a rational way may be of benefit.

The research conducted in this project uncovered no literature to support the potential benefits and effectiveness of this strategy in a transport context. Therefore, any benefits mentioned here are presumptions.

The Australian Building Codes Board (Australian Building Codes Board) (2019) provides designers with a method (through the 'Access Verification Methods' Handbook) to 'demonstrate the compliance' of ramps so that people using manual wheelchairs can move safely and equitably to and within a building. There is the possibility of a similar approach being adopted for footpaths and other transport infrastructure; however, the research uncovered no literature to support the potential benefits and effectiveness of this strategy. Therefore, the use of this method is only theoretical, and any benefits may not transition. This process allows designers to develop new techniques and design outside common guides and standards so long as they can demonstrate compliance by having (Australian Building Codes Board 2019):

- walking surfaces (AS 4586-2013) with safe gradients; and
- doors installed to avoid the risk of occupants having their way out impeded or being trapped in the building; and
- stairways and ramps with:
  - slip-resistant walking surfaces on-ramps and stairway treads near the edge of the nosing; and
  - suitable handrails where necessary to assist and provide stability to people using the stairway or ramp; and
  - suitable landings to avoid undue fatigue; and
  - landings where a door opens from or onto the stairway or ramp so that the door does not create an obstruction; and
  - in the case of a stairway, suitable safe passage in relation to the nature, volume and frequency of likely usage.

The 'Access Verification Methods' Handbook is used to guide solutions that relate to the situation in built environments, improve the flexibility of designers and reduce reliance on regulation (Australian Building Codes Board 2019). Part of this focuses on the stability of a wheelchair when ascending and descending ramps as the risk of tipping is present.

There are four requirements of the Access Verification Method (Australian Building Codes Board 2019). The handbook notes that these physical parameters may be varied to better suit particular building, devices and characteristics of the building occupants at the discretion of the designer or appropriate authority (Australian Building Codes Board 2019). The method specifically assesses:

1. **Pushing force required during ascent**, which must be in accordance with Equation 1:

$$F_p > m \cdot g \cdot \sin(\alpha) + C_{\pi 1}N_1 + C_{\pi 2}N_2 \qquad \mathbf{1}$$

where

F_p	=	the maximum pushing force during ascent, equal to 40 N for ramps required to be usable by the general public
m	=	the design mass of the wheelchair and person using the wheelchair, equal to 127 kg for ramps required to be usable by the general public
g	=	the gravitational constant, equal to 9.8 m/s^2
sin(α)	=	the angle of incline of the ramp
$C_{\pi 1}$, $C_{\pi 2}$	=	coefficient of rolling resistance between the wheelchair wheel and ramp surface, or the rear wheels and front wheels, respectively
N_1, N_2	=	the normal force between the wheelchair wheels and ramp surface, for the rear wheels and front wheels, respectively

The applied force by the person using the wheelchair for successful transverse of the ramp needs to be sufficient. Equation 1 assumes the Fp being exerted is even on each rear wheel (Australian Building Codes Board 2019).

2. **Braking force required during descent**, which must be in accordance with Equation 2

$$F_b = m \cdot g \cdot \sin(\alpha) - C_{\pi 1}N_1 - C_{\pi 2}N_2 \qquad \textbf{2}$$

where

F_b	=	The braking force during descent (must be less than 9 N)

The braking system used for a manual wheelchair is via the user's hands to the wheels, and the amount of force that can be applied is unique to the capability characteristics of the user. The proposed braking force limit for the user is 9 N (based on ISO 7176 test) but can be varied where the user/s expectant characteristics vary and are accepted by the relevant authority. The risk of destabilisation is highest when users are in descent (Australian Building Codes Board 2019).

3. **Time taken for an ascend ramp** (must be less than 17 s and reasonable for the capabilities of the user). Must be calculated in accordance with Equation 3:

$$T = (L \cdot m) / (t \cdot (F_p - m \cdot g \cdot \sin(\alpha) - C_{\pi 1}N_1 - C_{\pi 2}N_2)) \qquad \textbf{3}$$

where

T	=	time taken to ascend the ramp in seconds
L	=	the length of the ramp in meters
t	=	time taken for the wheelchair to achieve maximum velocity, equal to 0.8 s

If the resulted time (T) exceeds 17 s, then the ramp gradient and length is suggested to be lessened. Velocity is also recommended to be checked, although there are no suggested criteria for safe velocities nominated in this document (Australian Building Codes Board 2019).

4. **Crossfall, surface profile and slip resistance in conjunction with the gradient**. Verified when:
   - the overarching gradient must not be greater than 1:8
   - pushing force during ascent is less than or equal to 40 N (for ramps)
   - braking force during descent is less than 9 N
   - projected ascent time must be less than 17 s

– crossfall must be no steeper than, surface profile must be no rougher than, and the slip resistance must be no less than, the values indicated in Table 6.4.

Table 6.4: Ramp crossfall, surface profile and slip resistance

Gradient	Crossfall	Surface profile (mm)	Slip resistance
1:14	1:40	2	P4/R11
1:12	1:50	2	P5/R12
1:10	1:100	1	P5/R12
1:8	1:100	0.5	P5/R12

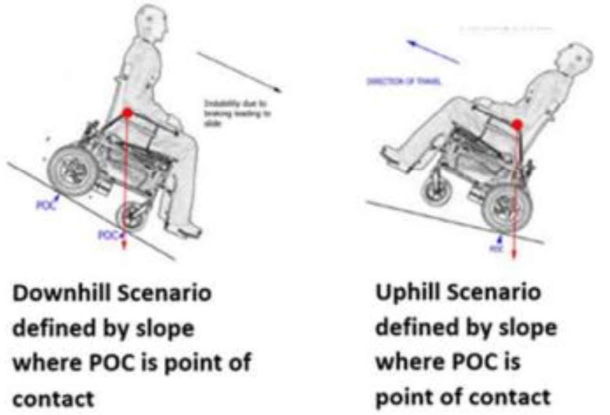
Source: Australian Building Codes Board (2019).

Care should be taken when setting out these characteristics as they all have the potential to affect the stability of the users and or wheelchair. Crossfall increases result in higher forces demanded by the user to continue moving the wheelchair in a uniform direction (Australian Building Codes Board 2019). Surface profiles are specific for each gradient and therefore require appropriate test/measurements performed for on-site checking to minimise surface resonance, especially for electric wheelchairs. Electric wheelchairs can stall and slide on hard and very smooth surfaces if they have a low slip resistance classification; gradients steeper than 1:14 are required to have a P5 slip resistance rating (Australian Building Codes Board 2019).

5. **Tipping checks** (optional)

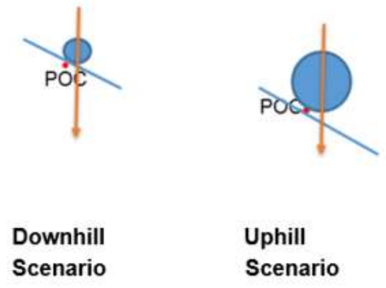
   Tipping checks are suggested when checking the design for people using electric wheelchairs. It is done by creating a graphical illustration (Figure 6.13), drawing in a vertical component to represent the local force of the mass distribution of the user.

Figure 6.13 Example for graphical checking diagram for electric wheelchair – centre of gravity represented by red node



Source: Australian Building Codes Board (2019).

Figure 6.14 Downhill and uphill scenarios.



Source: Australian Building Codes Board (2019).

The downhill scenario requires the local force to pass through the front wheel. While the uphill scenario requires the local force to pass through the rear wheel (Figure 6.14). Tipping is suggested to occur if the centre of gravity is outside of the point of contact and therefore the ramp is not suitable (Australian Building Codes Board 2019).

7 SUMMARY OF FINDINGS

The accessibility needs of people with disability are the same as people without disability. They require barrier-free access in public places and should expect reasonable measures taken to lessen undue fatigue when manoeuvring themselves. Without equal accessibility, people with disability are more likely to face exclusions to work and educational opportunities, social opportunities and independence, which can negatively affect their wellbeing and quality of life. Therefore, built environments must be equally accessible by both people with disability and people without disability.

There is no doubt that the NDIS is providing aid to an abundance of people in Queensland with 55 014 people in the scheme as of September 2019. It is providing people that face mobility and travel restrictions with the opportunity to receive mobility assistance and aids to better their quality of life. Of the 55 014 participants in the NDIS, 18 559 (~33%) are receiving assistance for the first time. The portion of people with disability using aids has been higher than ever before with a rise in the number of wheeled devices being used. However, it cannot be conclusively attributed to the introduction of the NDIS, as the NDIS rollout was only completed one year ago (1 January 2019). The overall effects of the NDIS in the people with disability community is too early to determine.

With the increase in people receiving assistance through the NDIS, it is critical to ensure transport options are accessible for people using wheeled devices. From a review of manufacturer specifications for manual wheelchairs (MWC), powered wheelchairs (PWC) and scooters it was found that some exceed the dimensions of the standard wheelchair size (800 mm width and 1300 mm length) from Australian Standards AS 1428.1 and AS 1428.2 (see Table 5.1). The results show that approximately 7% of MWCs exceed 800 mm width and approximately 2% of PWCs and 36% of scooters exceed 1300 mm length.

From the Australian Bureau of Statistics (2019b) data, the distribution of people with disability in Queensland that used wheeled devices was:

- Manual wheelchair – 24.3%
- Powered wheelchair – 4.6%
- Scooter – 7.5%.

When combining this with the number of wheeled devices that exceed the standard, it becomes concerning whether a large portion of the community can effectively access the network. Designing using the standards based on a standard wheelchair size (800 mm width and 1300 mm length) from AS 1428.1 and AS 1428.2 is no longer suitable.

Topography can be a significant barrier to access not just for people with disability but also for the elderly, people with prams or luggage and people with injuries. Many existing places were built to follow the natural formation of the land, typically resulting in steep topography. Even today preferably flat environments are extremely difficult and costly to produce.

Support through the use of assistive technology, personal carers, additional services and design standards have helped people with disability to traverse difficult terrain. These methods provide them with better access to environments and create social and economic opportunities, without which they may have been restricted by barriers to access from steep longitudinal grades. However, even with these supports, grades still pose an immediate concern for users of the transport network.

People with wheeled devices run the risk of tipping their device if a slope is too steep, they may also experience undue fatigue. Where a slope is not steep enough to tip the device, people with mobility scooters and powered wheelchairs will experience little fatigue; people with manual wheelchairs can add electric setups to their device to act as a powered wheelchair. Overall, though, the manual wheelchair is the most used option of the three and is most susceptible to the issues that topography can impose.

Some solutions in this report look at trying to offer current services more conveniently; others look at designers seeing compliance and design from a more user involved perspective. Lastly, one other solution includes offering informational services to better equip people with information about their planned route to better determine if the destination is accessible using their device or bodily ability.

There is unlikely to be a one-size-fits-all solution. Solutions should be tailored to the situational circumstances of a project and area. Topography remains a relevant issue to people with disability even when looking at the advances from NDIS. Additional guidance and services should be considered when designing access to new developments that incorporate steep grades. Alternatives that should be investigated in more depth and potentially trialled include:

- group consultations
- moving walkways
- slope signage
- strategic placement of bus stops
- technological information tools
- providing proof that intended users can successfully use standard compliant designs.

7.1 RECOMMENDATIONS

From the investigations of the NDIS, wheeled device capabilities, and existing and potential provisions for topographical barriers, the following steps should be taken:

- Further investigate the feasibility and benefits of alternative measures for topographic barriers (see Section 6.3) in conjunction with development teams (including engineers, project manager, planners) and disability reference groups.
- An investigation should be undertaken to determine what topographic barriers would be eliminated or reduced (by bypassing them) in urban and regional areas if greater or full subsidised funding into the transport scheme (e.g. public transport and TSS) were introduced. Further funding would theoretically decrease costs to scheme participants allowing them more freedom to utilise paid transport services more frequently, as well as improve independence (less dependence on others such as family to drive them).
- Further investigate wheeled devices’ specifications and capabilities (dimensions, maximum safe uphill and downhill slope gradients, etc.). This should also consider modifications to and accessories added to wheeled devices. This would focus on the attributes and capabilities of devices in public use, not commercially available devices. These should then be compared against standards and guidance to determine if the standards are satisfactory.
- Investigate environment attributes (longitudinal grades, crossfall, turning circles, etc.) that wheeled device and other assist device users feel comfortable operating at in comparison to existing standards. Users may not feel comfortable operating assist devices at maximum capacity (e.g. wheeled devices operating at maximum slope capacity) and these preferences should be investigated. This would allow for the creation of desirable design limits for some design criteria.
- Defining reasonable accessible design should be explored from the intended user’s perspective. People with disability sometimes must use alternative (to mainstream) routes, e.g. provided ramps as an alternative to stairs. However, it is not known at what point the accessible design becomes an unreasonable route to use (e.g. route with accessible ramps adds 10 minutes to the original route). User experience plays a major factor in what users consider reasonable. A good experience is based on the time taken to use, the added length of travel, the effort needed, the feeling of safety and the aesthetics.

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