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Wayfinding in the Rail Environment: Technology and Behaviour Review

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Title: Wayfinding in the Rail Environment: Technology and Behaviour Review

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Synopsis:

Railway transport providers have a legal obligation to provide equal opportunity for all persons to utilise their services. This review was commissioned as a means to help meet obligations and improve passenger rail transport in Australia. The findings from this review identify: the challenges of wayfinding; the magnitude of the problem in Australia; the population groups which experience the greatest disadvantage; their wayfinding expectations and behaviours; and existing and over-the-horizon technologies that assist the wayfinding process. To reduce the problems identified, a list of suggested wayfinding technologies has been provided for both metropolitan and suburban/regional railway stations. The project limitations and future potential research directions are also discussed in the report. Key online resources, essential for handling disability access issues, are listed in the report as well.

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Executive Summary

To overcome a critical carriage-way access issue in Australia, this project was undertaken to identify feasible, robust, and cost effective solutions for people with wayfinding impairments. National legislation protects the right for all persons to have equal opportunity to community services, including public transport. For the disabled customer to utilise rail transport, the train station needs to be accessible: this includes having the physical infrastructure (e.g., ramps and hoists) as well as navigation tools (e.g., signs and information outlets). This report relates to the navigation and wayfinding aspects of accessibility.

Passengers with mobility, sensory and cognitive impairment experience additional difficulties when moving about the train station primarily due to a lack of suitable aids and technologies. Consequently, the rail transport system is underutilised by the disabled community.

To provide effective wayfinding solutions, a review of the current literature was conducted to identify: (1) the wayfinding process, including the requirements to perform successful wayfinding, (2) the wayfinding behaviours and strategies used by the different kinds of passengers, identifying expectations and preferences, (3) the barriers to accessible rail transport, and (4) possible solutions to overcome identified barriers. The findings of this project will provide avenues that the railway industry can utilise when developing and deploying practicable wayfinding solutions for improved access to platforms and carriages.

This report therefore outlines:

- legal obligations - the rail industry's responsibility to ensure they do not discriminate against people with a disability (PWD) or against new arrivals
- the wayfinding process and general wayfinding behaviours
- behaviours and strategies used by PWDs and therefore their expectations
- difficulties experienced by PWDs when negotiating carriageways and accessing platforms
- practical wayfinding solutions that exist across the world
- solutions that will enhance the wayfinding task.

The suggestions in this report should be considered in conjunction with good design practices which include:

- standardised selected aids and technologies for each station
- consistent placement to encourage predictability
- position new technologies and aids with situational awareness
- consider the issue of vandalism and misuse of new technologies and aids when installing
- maintain equipment and upgrade dynamic systems routinely
- implement aids systematically to ensure all stations are accessible to all people with disabilities
- ensure sufficient number of aids/technologies exist; audit each train station for needs
- provide good information that is up-to-date, accurate, and provided in various modalities.

Summary of suggestions:

Type	Metropolitan Stations	Suburban and Regional Stations
Trained staff	• At least one staff member who can communicate with customers at all operation times • Disability awareness – know their difficulties, needs and how to address these • Knowledge of transport system	'as for metropolitan stations'
Provide good information	• Up-to-date • Easy to read • Clear directions and instructions • Provided in a variety of modalities • Update information provisions regularly • Inform staff of changes, alterations, or deviations from normal activity	'as for metropolitan stations'
Passive solutions	• Update existing signage to conform to new building code standards and Australian standards for access • Colour code passage-ways • Appropriately install colour coded Tactile Guidance Surface Indicators • Install architectural and visual cues • Provide layout maps of the station showing all levels	• Update existing signage to conform to new building code standards and Australian standards for access • Colour code passage ways • Appropriately install colour coded Tactile Guidance Surface Indicators • Provide layout maps of the station, parking and facilities
Dynamic solutions	• Provide pen and paper to aid communication • Implement multimodal information stations • Install either Barcodes or Indoor Positioning System with application of smart phones and mobile devices	• Implement multimodal signage (pre-recorded voice information and Braille) • Install Barcode technology
Standardisation of aid technologies	All technologies and aids implemented need to become standard and positioned in similar locations for uniformity	'as for metropolitan stations'
Educate the public	Inform the disabled community and general public of changes, disruptions, and availability of particular technical aids.	'as for metropolitan stations'

Summary of technologies reviewed:

Type	Function	Applicability
Tactile ground surface indicators	Indicates the location of protruding and dangerous areas including edges/walls.	Both regional/suburban and metropolitan stations
Symbolic signage	Indicates facilities without using alphabetical language.	Both regional/suburban and metropolitan stations
Tactile maps /signs	Indicates station layout	Metropolitan stations
Order and numbering	Logical arrangement of facilities aids line of sight for wayfinding	Both regional/- suburban and metropolitan stations
Colour coding	Indicates section or area of the station to better orientate the customer	Both regional/suburban and metropolitan stations
Interactive information kiosks	Presents station information and facility information together	Metropolitan stations
Interactive tactile map	Presents survey/plan layout of the station	Metropolitan stations
Multimodal information station	Provides information in several ways including using sound, vision and touch	Metropolitan stations
Access to assistive information	Providing assistive information before the customer has reached the station, so up-to-date information on the condition of the station is available to all.	Both regional/suburban and metropolitan stations
Trained staff	Assist customers on an interpersonal level - the response can be tailored to the individual needs of the customers	Both regional/suburban and metropolitan stations
Interactive canes	Indicates position and location of objects in the station to blind and vision impaired customers	Both regional/suburban and metropolitan stations
Indoor positioning systems	Indicates the position of the customer within the layout of the station instantaneously	Metropolitan stations
Barcodes and smart phone locators	Indicates location of the customer by bringing up a map of their location when the barcode is scanned by a smart phone	Both regional/suburban and metropolitan stations
Pen and paper	Allows hearing impaired to communicate with the public without use of major technology	Both regional/suburban and metropolitan stations

Limitations and scope for further research:

Train station layout and wayfinding - little research has been conducted on the wayfinding behaviours exhibited by the various customers in train stations. Most of the research has been conducted in other types of complex structures. Although similarities exist amongst these structures, it has not been established that the same wayfinding behaviours exist within a train station environment.

Disabled usage of train stations - there is insufficient information available to identify accurately the number of disabled customers currently using the rail system, the type of disability they have, which station type they are using, and at what periods of the day or week they travel. The number of people who wish to utilise the rail system yet currently cannot is also unknown along with data regarding their preferences and current usage. Such information affects decisions on the number, type, time available, and location of assistive aids required for implementation.

Technology applicability – many technologies described in this report have not been tested or trialled for use by the disabled community. In order to ascertain suitability, further research trials must be conducted allowing the various disability groups to trial the potentially transferable technologies intended for implementation.

Safety and accessibility of stations – the focus of this report has been on the wayfinding and navigational aspects of using a train station. To ensure a successful train journey, issues regarding physical feasibility and safety when accessing stations need attention. This is beyond the scope of this project and would require further research.

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Abbreviations and Acronyms

ABI	Acquired Brain Injury
ADPP	Australian Disability Parking Permit
AS/NZS	Australian and New Zealand Standards
dB	Decibels
GPS	Global Positioning System
IEEE	Institute of Electrical and Electronics Engineers
IPS	Indoor Positioning System
IR	Infrared
IS	International Sign language
PDA	Personal Digital Assistant
PWD	Person with Disability
QR code	Quick Response Code
RF	Radio Frequency
RFID	Radio Frequency Identification
TGSI	Tactile Guidance Surface Indicators
TTY	Teletypewriter for telecommunications
TV	Television
VITP	Visually Impairment Travel Pass
UWV	Ultra-Wideband
WLAN	Wireless Local Area Network
WPAN	Wireless Personal Area Network
WPM	Words per Minute

Glossary

Abstraction: ability to interpret icons, maps or signage

Auslan: Australian sign language

Braille: a tactile method of reading for the blind. Each character, or cell, is made up of six dot positions arranged in a rectangle containing two columns of three dots each. A dot may be raised at any of the six positions to form sixty-four possible subsets.

Cognitive Impairment: a condition when a person experiences noticeable difficulty processing information, memory and decision making.

Communication: all languages, displays of text, Braille, tactile communication, large print, accessible multimedia, written, audio, plain-language, human-reader and augmentation and alternative modes, means, and formats of communication, including accessible information and communication technology (Article 2, United Nations (UN), 2006).

Customer/Patron/Passenger/Traveller/User: these refer to any person using the train station or its facilities, and are used interchangeably within this document.

Deafblindness: defined functionally rather than medically is described as a unique and isolating sensory disability resulting from the combination of both a hearing and vision loss or impairment which significantly affects communication, socialisation, mobility and daily living (Prain, 2005).

Disabilities Convention: the Convention on the rights of persons with disabilities

Discrimination on the basis of disability: any distinction, exclusion or restriction on the basis of disability which has the purpose or effect of impairing or nullifying the recognition, enjoyment or exercise, on an equal basis with others, of all human rights and fundamental freedoms in the political, economic, social, cultural, civil or any other field. It includes all forms of discrimination, including denial of reasonable accommodation (Article 2, UN, 2006).

Haptic device: is a tactile feedback technology that takes advantage of a user's sense of touch by applying forces, vibrations and /or motions to the user.

Haptic ability: ability to experience the environment through active exploration, typically with the hands. It involves the skin receptors and kinaesthetic capabilities.

Hearing impairment: when hearing normal speech becomes problematic, resulting from a loss from 36 to 70 dB.

Kinaesthetic sense: also known as proprioception relays information to the brain on the relative movement and positions of the body's limbs.

Language: spoken and signed languages and other forms of non spoken language (Article 2, UN, 2006).

Legally blind: in Australia, a person is considered legally blind when they have visual acuity measured on the Snellen Scale of 6/60 in both eyes, after correction by best possible lenses, or a constricted field of vision equal to or less than a 10 degree arc around central fixation in the better eye, irrespective of corrected visual acuity.

Persons with disabilities: include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others (Article 1, UN, 2006)

Reasonable accommodation: necessary and appropriate modification and adjustments not imposing a disproportionate or undue burden, where needed in a particular case, to ensure to persons with disabilities the enjoyment or exercise on an equal basis with others of all human rights and fundamental freedoms (Article 2, UN 2006).

Somesthesis: a general term for the touch sensitive systems: skin receptors, kinaesthetic sense and haptic ability.

Spatial cognition: refers to a range of abilities and skills which include tracking a moving object, localising and attending to an object or event in the spatial array, and understanding how the parts or features of an object combine to form and organised whole.

Speech impairment: a condition when a person is not able to verbally communicate coherently.

Universal design: the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. 'Universal design' shall not exclude assistive devices for particular groups of persons with disabilities where this is needed (Article 2, UN, 2006).

Wayfinding: is the process of using information from the environment to help us find our way around (Rail Safety and Standards Board, 2006).

Wayfinding systems: include such components as basic layout of buildings and site, interior and exterior landmarks, views to outside, signs, floor and room numbering, spoken directions, maps, directories, logical progression of spaces, and colour coding (Queensland Health, 1996a).

Introduction

Many Australians find it difficult, or impossible, to use public transport as it is today. In line with meeting a legal obligation to provide all Australians with equal opportunity to access community services, the Australian rail industry is looking for robust, yet cost effective solutions for resolving this problem. Groups who often rely on public transport services, such as the disabled community, are often greatly disadvantaged due to lack of appropriate accommodations.

This report has four aims. The first is to identify the wayfinding process that ensures a successfully completed journey; secondly, to identify the groups that experience difficulties with this process and why; and thirdly, to identify existing and over-the-horizon wayfinding support technologies, both personal and those of an infrastructural nature. The final aim of this report, and the outcome of this project, is to discuss the most effective technology aids to address this issue. These will be in the form of improvement suggestions and will be based on their compatibility, cost and ease of implementation and maintenance. In addition, these suggestions will be tailored to suit the larger metropolitan and smaller regional train stations in Australia.

The achievement of these aims will not only improve wayfinding and independence for disabled people, it will improve navigation for all Australians who choose to use the rail transport system. Modifying current infrastructure and including assistive technologies helps to create equal travel and mobility opportunities for every Australian. To meet these aims, a literature review was conducted on wayfinding behaviours and technology aids for disabled and able-bodied individuals. From this literature review, suggestions are made to enhance the capability of the Australian railway industry to effectively design and deploy platform and carriage-way access solutions.

The Disability Policy Group of the Australasian Railway Association, which comprises all passenger operators, is committed to the provision of integrated accessible rail services and has extended their interest and support in conducting the proposed research project.

Legal Obligations

Under National legislation, Australian Railways are obliged to provide all persons with equal opportunity to community services such as access to public transport services. Currently, many Australians cannot utilise rail transport because the environmental and navigational aids they require to help them complete their trips successfully are, in many cases, either non-existent or not appropriate to their particular needs. Minority groups, such as the disabled community, ageing citizens, Indigenous people, and new immigrants whose first language is not English, experience the greatest problems. There are provisions in place to advance equal rights for all. Following are the provisions that apply to railway service providers:

Provisions under the Anti-Discrimination Act 1991 (Qld)

- no person can discriminate directly or indirectly on the basis of an attribute or presumed attribute (Section 8)
- it is lawful to discriminate against a person if the supply of special services or facilities would impose unjustified hardship (Section 5)
- unjustified hardship takes into account (a) the nature of the special services or facilities; (b) the cost of supplying the special services or facilities and the number of people who would benefit or be disadvantaged; (c) the financial circumstances of the person; (d) the disruption that supplying the special services or facilities might cause; (e) the nature of any benefit or detriment to all people concerned (Section 5).

The provisions stated in the *Anti-Discrimination Act 1991 (Qld)*, stipulate that no individual is to be treated less favourably for being different from the main body of Australians. Therefore, to prevent discriminating against any person, railway providers must ensure the necessary services and facilities are available to aid wayfinding for all people. To be exempt from this provision, unjustified hardship, as defined above, must be proved to result from providing specialised services and facilities.

Provisions under the Disability Discrimination Act 1992

- *Disability Standards for Accessible Public Transport 2002* (subsection 31(1))
- in providing services related to transport, a person must make a reasonable adjustment to avoid discriminating against another person, unless making the adjustment imposes unjustifiable hardship on the person (section 4)
- direct disability discrimination involves (1) treating a disabled person less favourably than a person without a disability or (2) failing to make the reasonable adjustments, in circumstances that are not materially different (section 5).

The *Disability Standards for Accessible Public Transport 2002* have been endorsed as the minimum standards that must be applied by public transport providers to ensure reasonable adjustments are made to avoid discriminating against any person for having a disability. It is also stipulated that rail providers must afford all people, including those with disabilities, equal respect and treatment.

Provisions under the United Nations – Convention on the rights of persons with disabilities

- recognise that all persons are equal before and under the law
- prohibit all discrimination on the basis of disability
- take appropriate steps to ensure reasonable accommodation (Article 5)
- obstacles and barriers to accessibility: buildings, roads, transportation and indoor and outdoor facilities, including schools, housing, medical facilities and workplaces. Access to information, communications and other services, including electronic services and emergency services (Article 9)
- include persons with disabilities in decision-making processes about policies and programmes that directly concern them (Preamble) (United Nations, 2006).

The purpose of this provision is to promote, protect and ensure the full and equal enjoyment of all human rights and fundamental freedoms by all persons with disabilities, and to promote respect for their inherent dignity (Article 1).

Provisions under the *Diversity and Social Cohesion Program*

- opportunities for people to participate equitably in Australian society and to understand the rights and responsibilities that we share as part of that society.
- a sense of belonging for everyone by helping communities work towards a spirit of inclusiveness and a shared identity as Australians.

Cultural diversity objectives under the *Diversity and Social Cohesion Program* are designed to promote respect, fairness and a sense of belonging for all people (Department of Immigration and Citizenship, 2010a).

By meeting the obligations and cultural diversity objectives listed above, railway transport providers will improve access to their services for all Australians, not only minority groups who experience current difficulties. Additionally, assistive wayfinding environments and navigational aids stand to benefit the Australian economy through greater use of rail by tourists as they enjoy problem-free travelling between rail-linked Australian towns and cities.

1. What is wayfinding?

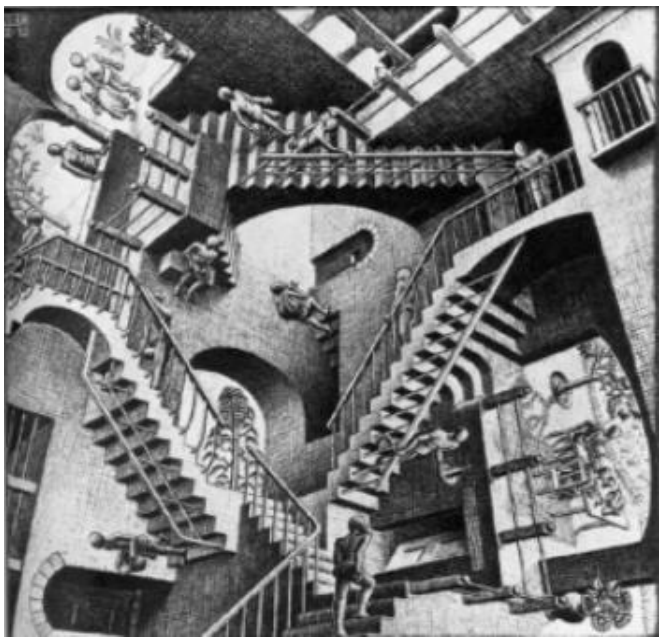

Figure 1: Optical illusion of a building painting by Escher
Source: http://paintingphotofy.com/picture/1108469/

Wayfinding is a term that describes the process people go through when they move from one place to another. Wayfinding therefore entails anything from orientating oneself, to reading a sign, using a GPS system, or any number of situations in which the individual is actively trying to find out the way to go. Wayfinding can be particularly confusing, especially in large multi-storey buildings. At times, to the disorientated individual, it seems like the building is from an Escher painting (see figure 1). However the science of wayfinding is not new. In the physiological and neurobiological fields, wayfinding is an important area of study. Wayfinding is scientifically defined as "…the process used to orient and navigate. The overall goal of wayfinding is to accurately relocate from one place to another in a large-scale space" (Gluck, 1990).

The ability to complete a journey successfully is largely a problem-solving process and is affected by five factors (Enterprise IG Information Design Unit, 2005):

1. people's perception of the environment
2. the available wayfinding information
3. the ability to orientate oneself spatially
4. the cognitive and decision-making capabilities of the traveller
5. the ability to perform the actual tasks required to move from one point to another to complete the journey successfully.

To ensure each of these steps are accomplished effectively and efficiently, wayfinding requires an individual to have survey knowledge, procedural knowledge and landmark knowledge (Bowles, 2009).

- *Survey knowledge* is defined as knowledge of the topological structure of the environment; so the individual not only knows the direct route to the desired destination but also where the adjacent and offshoot routes lead.
- *Procedural knowledge* is knowledge of the route from location A to location B; this is usually gained from prior experience of the same route or navigating the same area.
- *Landmark knowledge* is having knowledge of where specific points of interests are located; in a large building this may be in the form of a statue or painting that adorns a particular part of the building.

Consequently, for individuals to achieve successful wayfinding in a complex multi-level building with several alternative routes of navigation, they would need to apply all three types of knowledge.
Essential artefacts that assist passengers gather essential navigational knowledge within public transportation systems include: maps, schedules, landmarks, labels/signs and clocks - see Table 1 below (Carmien et al., 2005, p. 241).

Table 1: Essential navigation artefacts found in public transportation systems

Artefact	Purpose
Maps	show spatial relationships between one's current location and destination; identify routing options; provide an abstract means to assess overall trip progress
Schedules	provide temporal information about route availability at a given day and time
Landmarks	to confirm global progress and anticipate important events or tasks that will come next, such as preparing to get off, etc.
Labels and signs	to understand the local environment, including: current location, where to meet transportation vehicles; identify the "right" vehicle; where to get on and off; where to pay; etc.
Clocks	to synchronise schedules with physical events, including transportation vehicle arrivals and departures

Technologies and artefacts which help the individual in wayfinding aim to increase survey and landmark knowledge. Procedural knowledge is more dependent upon the individual's experiences rather than external factors. Traditional ways of providing wayfinding information by the railway industry, usually in the form of signage, have not always been suitable for passengers with disabilities. This has resulted in inequality of rail transport access. Wayfinding information in formats that are accessible to people with disabilities is discussed in this report.

Currently in the Australian railway industry there is little distinction between hazard warning technology and actual wayfinding technology for the disabled person. The focus has been on preventing accidents and warning of hazards. For example, Tactile Ground Surface Indicators (TGSI's) are installed in all train stations and are a part of the Australian Standards (AS/NZS 1428.4.1, 2009). Although TGSI's are effective in reducing the risk of a blind or vision impaired person from walking into a wall or into an incoming train, this technology does not give any information on how to reach a desired platform or indicate whether a person is travelling in the correct direction. In this instance, unless the blind or vision impaired person is familiar with the layout of the station, neither warning nor directional TGSI's would help them travel from the lobby to their train platform.

1.1 Wayfinding, a cognitive process

Wayfinding is a spatially cognitive process. Spatial cognition refers to a range of abilities and skills which include:

- tracking a moving object
- localising and attending to an object or event in the spatial array
- understanding how the parts or features of an object combine to form an organised whole (Stiles, 2001).

Acting within the spatial realm, information is received through the sensory organs, and processed by the brain to enable appropriate wayfinding decisions and actions to be performed (Wickens, Lee, Liu, & Gordon Becker, 2004). Similar strategies and processes are used by people to find their way around, regardless of their cognitive capability. However, those with cognitive impairment use and require additional strategies and aids to assist them find their way around successfully. Particularly useful environmental cues for people with cognitive impairment include spatial organisation, maps and directories, while helpful sensory cues include environmental noise, crowdedness, and smells/odours (Salmi, 2007).

People with cognitive impairment can easily become disorientated and may have abstraction difficulties (unable to interpret icons on maps or signage). For example, dementia patients may suffer from spatial disorientation at unfamiliar places or forget their intended destination. People with developmental disabilities may not be able to recall landmarks of the route they have often travelled previously (Chang et al., 2010).

People with or without impairments present different sets of criteria for technologies which would assist in wayfinding. Therefore wayfinding behaviours for people without cognitive impairment are examined along with those used by people with cognitive, sensory and mobility impairments.

1.2 General Wayfinding behaviours

There are many different wayfinding behaviours which people employ in different situations, depending on personal preference, experience, environmental factors, etc. Only the main behaviours and strategies are explained in this section with an emphasis on defining different wayfinding strategies that people generally exhibit.

1.2.1 Route planning in familiar environments

In familiar environments, where people have procedural knowledge of the area, there are various route planning strategies that are employed to reach a destination. These are dependent on various parameters such as the extent of survey knowledge, number of destinations or targets, and the size of the navigation area and others.

Least decision-loaded strategy: Human navigators plan their routes in order to minimise the complexity of the intended path. Researchers hypothesise that minimum complexity reduces the risk of getting lost on less complex routes (Wiener et al., 2004).

Cluster strategy: Human route planning takes into account the distribution of target locations within an environment (when multiple destinations or targets are present), resulting in a preference for paths that allow visiting as many target places as fast as possible (Wiener et al., 2004).

Fine to coarse strategy: For indoor environments this strategy can also be called floor strategy. This is where the floor of the building or the street is found first, and then, using the detailed plan, the person searches for the specific room or house. The route plan therefore is refined during navigation (Wiener et al., 2004).

Primary network strategy: Where familiar or often travelled networks are used in preference to a central point in navigation (Spiers & Maguire, 2008).

1.2.2 Path selection in unfamiliar environments

There are several strategies that lead to a person selecting a certain path over another. Most studies conducted on path choosing behaviour have been through computer simulations, as this gives the researchers more options in route choices for decisions by the participants. Several behaviours or strategies used when choosing amongst many unfamiliar routes have been observed and are described below.

Least angle strategy: People prefer to minimise the level of deviation from the direction of the goal position and at the same time, they avoid local direction deviations at junctions; thus they maintain a straight ahead strategy wherever possible (Hölscher et al., 2006).

Shortest path strategy: People initially prefer shorter segments over longer segments. This is hypothesised to be due to people trying to minimise their overall travel distance by minimising all segment distances - the best global optimum is a series of local optimal steps (Hochmair & Karlsson, 2005). Participants in the experiment also acknowledged that these shorter initial legs would provide them with the opportunity to explore further choice

options quickly at the next intersections, which in turn reduces the cost of back-tracking when compared to long initial segments (Hochmair & Karlsson, 2005).

Visibility strategy: People base their wayfinding strategy on what they can see; this is an answer to the environmental design (Troffa & Nenci, 2009). The navigator observes their initial locations, their destinations and the various landmarks along the route and decides which way to go depending on which pathways are more visible to the navigator (Omer & Goldblatt, 2007).

Central point strategy: People unfamiliar with a building also use well-known central points, such as the main hall, to navigate even though this may lead to significant detours (Hölscher, Meilinger et al., 2006).

1.2.3 Male and female preferences

The issue with differences in ability between the sexes is both a controversial and inconclusive topic of research in wayfinding. Most experimental trials which showed differences in male and female performances have included accuracy in measuring behavioural wayfinding ability. For example, in studies which involve participants in mentally following a route through a map of several city blocks then determining whether each turn is a right or left turn, found that males were reliably more accurate than females (Money et al., 1965). However, when researching sense of direction (Kozlowski & Bryant, 1977; Vandenberg et al., 1985) or latency (the amount of time to complete the task) there was no significant difference found between male and female performance. The different results could be due to the different wayfinding strategies favoured by males and females (Lawton, 1994).

In general, women rely more heavily on procedural or route knowledge than survey knowledge, whereas for men it is the opposite. Both types of knowledge allow successful wayfinding; however, reliance on one type of knowledge more than another is thought to be gender related (Bever, 1992). Bever reported that women were better at learning a figure-8 maze when travelling in the same direction than when required to start at opposite points on alternating trials. Men were better at learning the maze in both directions through the figure-8 maze. The one way direction was thought to correlate to route knowledge because each turning point is always associated with either a right or left turn. The two directional travel maze was associated with survey knowledge because turns at each point must be reversed on alternating trials. Therefore men performing better on the two way maze travel are thought to use and prefer survey knowledge in wayfinding.

Another aspect which influences wayfinding is spatial anxiety; that is, the navigator becomes emotionally anxious or nervous about the wayfinding task at hand. Spatial anxiety has a negative effect on wayfinding. From the literature it is unclear whether it is because: individuals who do not maintain a sense of direction are more likely to become confused and deviate from their intended route and then become anxious; or if anxiety about becoming lost reduces their ability to focus on the wayfinding cues necessary to maintain geographical orientation (Devlin & Bernstein, 1995; Lawton, 1994; Prestopnik & Roskos-Ewoldsen, 2000). Studies have found that stress in the form of noise and crowding reduces memory for spatial locations and that women have higher self-reported spatial anxiety (Lawton, 1994). Subsequently, women may need more directional and architectural cues within environments to orientate themselves.

There are no definitive differences in wayfinding ability between the genders, although men and women have different preferences in general. Essentially, they employ different strategies and prefer certain forms of wayfinding knowledge to navigate through the environment. However, the effect of familiarity with the environment and the complexity of the environment in the wayfinding task far outweigh any innate advantages.
Where different wayfinding preferences exist between the sexes, the implications from knowing this should affect the choice of assistance aids and technologies for addressing preferences. In addition, it has been noted that becoming familiar with the environment and reducing its complexity can assist everyone in finding their way around.

1.2.4 The senses used in wayfinding

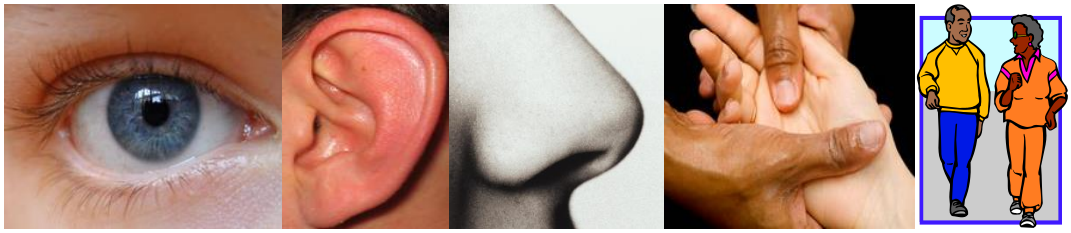

Figure 2: Wayfinding senses

To varying degrees, people use five senses to find their way around their environment: sight, sound, smell, touch, and kinaesthesia (see Figure 2). Often without even knowing it, our external sense organs (eyes, ears, nose, tongue, and skin) are taking in and sending information to the brain for processing, enabling us to see, hear, smell, taste and feel. Translated by the brain, the senses provide us with information about the environment around us. Some forms of stimuli draw more attention than others. From the various stimuli we orient ourselves and navigate by selecting desired information, making decisions and enacting wayfinding actions based on these decisions.

Sight: For people with good vision, sight is the most commonly relied upon sense for wayfinding because of its versatility. People with good vision can see things close up and at a distance. This is unlike sound which requires the person to be relatively close in order to hear it effectively. Generally however, people do not look about in a systematic way. Rather, people focus on what attracts their attention. In a wayfinding situation such points of focus may include:

- something that stands out, is prominent, or eye-catching
- something that looks interesting
- something that may help direct their way (signage, landmarks, lighting…)
- someone who might be able to assist them
- a map to locate a destination
- signage that indicates directions, facilities or locations.

When making wayfinding decisions, people with good vision, grasp information quickly at a glance. This heavy reliance on vision for wayfinding is often only noticed when someone loses their eye sight, forgets their glasses, or experiences reduced acuity (Enterprise IG Information Design Unit, 2005). Vision can be assisted with greater illumination, using colours that contrast, and enlarged text and signage.

Sound: For people with good eyesight, sound is often used for wayfinding subconsciously. For instance, although a lift may be hidden from view (round a corner), the bell indicating arrival of the lift can alert a person to its location. Spoken messages, such as those inside lifts saying the floor number, and spoken announcements at train platforms indicating the next train, are examples of audible wayfinding systems. As a general rule, rather than using signs and other wayfinding aids, most people prefer to ask an assistant for information, directions and travel reassurance (Enterprise IG Information Design Unit, 2005).

Train stations can be busy places and are therefore noisy. In order to hear what someone might be saying, unwanted sounds need to be screened out. Although possible, screening out irrelevant sounds is harder to do than unwanted sights, and this can become a significant problem for hearing-aid wearers. As a person's hearing diminishes, screening out unwanted sounds, hearing others speak, or hearing audio messages can pose significant problems. Thus clear and effective signage becomes ever more critical (Enterprise IG Information Design Unit, 2005).

Smell: Smell is another sense that can be used as a wayfinding strategy. Although not particularly useful for directional assistance, particular smells can help people remember or know where they are and therefore become useful landmarks. For instance, the smell of food or coffee can help a person know where they are, particularly if they are blind. Smells however can evoke emotions, in positive and negative ways and therefore need consideration (Enterprise IG Information Design Unit, 2005).

Touch: Although not greatly relied upon by people who have good eyesight, tactile indicators, such as changes in floor texture to delineate different areas, or warnings, can help all passengers. However, tactile indicators and the ability to explore one's environment typically through the hands, *haptic touch*, are extremely important for people who are blind or who have impaired vision.

Kinesthetic: People born with or who have developed profound or severe loss in both visual and hearing ability find it difficult to form a spatial image of a desired route of travel. Consequently, retrieving tactile information is not enough to aid a person to find their way around independently. Deafblind individuals learn best through experiencing and therefore rely on their kinesthetic sense to help them form a physical concept of the route to be travelled (James, 1997). Related subtly to touch, the kinesthetic sense, also known as *proprioception*, relays information to the brain on the relative movement and positions of the body's limbs. Specialised sensory receptors are located in muscles, tendons, joints, and on skin receptors in the hands. Many blind people use *haptic touch*, the ability to experience the environment through active exploration, typically with the hands, in which the skin receptors and kinesthetic capabilities play important roles (Robles-De-La-Torre, 2006).

Somesthesis: is the general term for the touch sensitive systems including the skin receptors, kinesthetic sense and haptic ability (Vocabulary.com, 2011). People who are somesthetically impaired can experience motor coordination and speed problems, including walking, hand dexterity and the ability to learn or relearn body language and gesturing skills (Robles-De-La-Torre, 2006). Being able to communicate and having the ability to move about independently can be made difficult for someone with somesthetic impairment, and these people stand to benefit from solutions that address these two issues.

Optimal level of arousal: Although sensory receptors can aid a person's ability to understand their environment, they can also overload the brain with too much information, resulting in negative effects**.** Many learning theories have explained a person's motivation and consequent performance levels through the concept of arousal. In this context, achieving appropriate levels of arousal are important because wayfinding is a cognitive process, and achieving the optimal level of arousal can facilitate effective wayfinding decisions.

The Implication is that tasks that require concentration, such as wayfinding, require low levels of mental arousal. Low levels of arousal can be induced by providing low sensory stimulation and environments of low complexity.

Stress has been proven to negatively affect an individual's cognitive processes such as attention, memory and problem-solving (Lupienet al., 2007). Under stress, people tend to channel their attention to the task they perceive as most important. Consequently, potentially useful peripheral information can go unnoticed (Staal, 2004). This has implications for moving about safely as well as finding the path from one point to another. It is therefore important not to provide too many sources of information that compete for attention or overstimulate by drawing a person's attention to too many objects in any particular area. Increasing complexity will only overload a person's mental ability to retrieve the required information, resulting in stress that reduces cognitive ability.

1.2.5 Importance of clear signage and good information

Signage should be legible and easy to follow. High contrast colours should be chosen, larger text should be used for high signage, all signs should be well illuminated, and not produce glare above 15%. Signage and information should also be in a variety of modalities to cater for different needs, including: Braille, embossed print, audio transmissions, print, and tactile maps. Directions and instructions should make use of pictograms (consistent with those used in signage), easy language, step by step instructions and be offered in a variety of languages.

Good information is vital and needs to be up-to-date, answers passenger questions, is delivered in a number of usable formats, and is easily accessed. Such usable formats include a variety of modalities, such as visual, auditory, and tactile. To ensure safety and comfort, people with disabilities may need additional information for their particular needs (Department for Transport & Transport Scotland, 2008). Accessibility information should cover the following areas: car parking facilities; local transport interchanges (bus stops, drop-off points; doors and sign-level entrances; main passenger routes through the station; floor surfaces, glass and wall markings, tactile information; toilets; station furniture (seating, waiting rooms); ticket offices and ticket vending machines; visual and spoken information; ramps, lifts and escalators; stairs, steps and handrails; boarding aids; commercial outlets, telephones, and vending machines (Department for Transport & Transport Scotland, 2008). Up-to-date information is required for hours of operation of facilities, train timetables, and any issues a disabled person may encounter. Information should be provided in a range of formats (large print, audio and Braille). Information should be accessible via a number of media (station operator's phone line, website, upon request at information and ticket offices). Station descriptions and layout designs should also be made available on the website to assist trip planners.

Four types of information enable people to complete various stages of travel (Enterprise IG Information Design Unit, 2005):

Pre-visit information: allows people to prepare their trip at a time and place best suited to them. Sources of pre-visit information include: telephone contact, website visit, paper pamphlets, timetables and maps.

En-route information: helps people arrive at the right station. Sources of information include: road signs, entrance signs and environmental landmarks.

On-site information: assists people find their way around the station. Sources of information include: staff assistance, directional signs, site maps and directories, landmarks, colour coding, audio messages, works of art and environmental information.

Locational information: helps orientate the traveller and provides feedback that they have arrived at the right location. Location labels/signage needs to be clear and easily understood. Signage needs to be consistent with pre-visit information and spoken directions. Landmarks and reassurance from an attendant are also sources of locational information.

2. Wayfinding with impairments

In the past very limited efforts were taken to adapt technologies to the needs of passengers (Jakubauskas, 2008). However, a significant number of Australians, and unfortunately those most reliant on public services, are either unable, or find it difficult to utilise Australia's rail transport system successfully. Therefore, to ensure passengers are given equal opportunity to travel independently and in safety, wayfinding solutions must be designed with an understanding of all possible passenger groups. By catering for people with disabilities, all Australians stand to benefit. To meet their expectations and to identify the most problematic obstacles for people with disabilities, an investigation was conducted to identify the groups that experience issues with wayfinding, to understand what is meant by their particular disability and their limitations, strengths and behaviours, and identify the current wayfinding strategies they use to assist this process.

2.1 What is meant by the term 'disability'?

Defined by the Australian Bureau of Statistics (2004a) disability is 'any limitation, restriction or impairment, which has lasted, or is likely to last, for at least six months and restricts everyday activities. Examples range from hearing loss which requires the use of a hearing aid, to difficulty dressing due to arthritis, to advanced dementia requiring constant help and supervision.'

Core everyday activities include self-care, and mobility and communication activities. The Australian Bureau of Statistics refers to and reports on disability as core activity limitation (Australian Bureau of Statistics, 2004b). It reports on these limitations in the follow groups of severity (Harper, 2010):

i. *Profound* – a person always needs help
ii. *Severe* – a person sometimes needs help
iii. *Moderate* – a person who has difficulties but does not need assistance
iv. *Mild* – a person who uses aids but does not have difficulty with any core activities. They may however have some level of difficulty performing certain tasks, such as walking 200m, negotiating stairs, bending to pick up objects or using public transport.

The Australian Institute of Health and Welfare categorises disabilities in the following categories: intellectual, psychiatric, sensory/speech, acquired brain injury (ABI) and physical/diverse disabilities. For the purposes of this report, disabilities will be divided into functional impairment categories (Australian Institute of Health and Welfare, 2009):

- *Cognitive* impairment (congenital, developmental, acquired brain injury (ABI) and psychiatric disorders)
- *Visual* impairment (partially, completely, and colour blindness)
- *Hearing and Speech* impairment (partial or complete deafness, mute, speech difficulties
- *Deafblind* impairment (partial or complete)
- *Mobility* impairment (agility, manual dexterity, paralysis, arthritis…)
- *Language barriers for those who speak English as a second language.*

2.2 The disabled population in Australia

According to the latest survey conducted in Australia, 19.8% of Australians reported having some form of disability with 15.2% experiencing a core-activity restriction (Australian Bureau of Statistics, 2004a). Of those who experience core-activity restriction, 6.3% accounted for those suffering profound or severe conditions (Australian Bureau of Statistics, 2004a). Harper (2010), a leading ABS statistician, noted that changes in prevalence of disability generally change slowly over time. Therefore, although nine years old, data reported in this document probably reflect the current situation fairly closely. Therefore calculating 15.2% of the currently estimated population of 22,537,404 (Australian Bureau of Statistics, 2010a), it can be noted that close to 3.4 million

Australians experience a core-activity disability and 6.3% (ca 1.4 million) experience a severe or profound condition.

Disabilities exist in varying combinations and degrees of severity. In Australia, half of those who reported having a disability have a combination of two or more disabilities and are additionally affected by an average of three to six long-term health conditions (Australian Institute of Health and Welfare, 2009). That is, 7.5% of the total Australian population (about 1.69 million people) have two or more disabilities (Australian Institute of Health and Welfare, 2009). People with long-term health conditions, such as dementia, autism, Parkinson's disease, schizophrenia, speech problems, and stroke commonly had multiple disabilities. The degree of severity and the need for assistance correlates closely with the number and type of disabilities of the individual (Statistics Canada, 2006). The majority (84%) of disabled people have a physical limitation (biomechanical, visual, hearing, speech), 5% have a cognitive and developmental disorder and 11% have mental and behavioural disorders (Human Rights and Equal Opportunity Commission, 2005). Comparing the states and territories, the three states with the highest disability rates are Queensland, South Australia and Tasmania, with the lowest rate reported in the Australian Capital Territory (Australian Bureau of Statistics, 2004ab). It has also been noted that as age increases, disabilities increase (Australian Bureau of Statistics, 2010c). The 2003 Survey of Disability, Ageing and Carers (SDAC) found that the prevalence rate of disabilities increased with age, at a steady rate from 4% for 0-4 year olds to 41% for 65-69 year olds to 81% for those aged 85 years and over and 92% for those aged 90 and over (Australian Bureau of Statistics, 2004a, 2004b).The estimates above are likely then to underestimate the full extent of the problem for wayfinding.

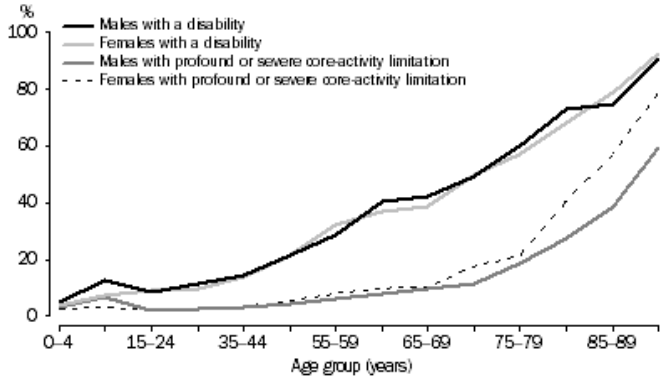

Figure 3: All persons, disability rates by age and sex, 2003
Source: (Australian Bureau of Statistics, 2004a)

Future trends

Considering disabilities increase with age, the prevalence of disability in Australia is likely to increase over the coming decades due to a trend towards an ageing population. Major drivers of this trend are negative fertility rates, increased life expectancy and shifts in the level and composition of international migration (Australian Bureau of Statistics, 2010d). The Australian Bureau of Statistics defines 'older people' as people aged 55 years and over (Australian Bureau of Statistics, 2010e). Australia's recent gains in life expectancy have been accompanied by an increase in years lived with disability. The recent increase in severe or profound limitations is largely attributed to the ageing population (Australian Institute of Health and Welfare, 2008).

Being overweight or obese is a major risk factor for a range of chronic diseases, including diabetes, cardiovascular diseases and cancer (World Health Organization, 2010). These diseases are likely to affect a person's mobility and therefore increase the prevalence of disabilities in Australia. In 2009, being overweight or obese was noted in 62.8% of the total male population and 47.6% of the total female population, aged 18 and over (Australian Bureau of Statistics, 2010b). Further, obesity has increased 18% over the past ten years (Australian Bureau of Statistics, 2008b). Therefore, due to the rising number of people in Australia who are becoming overweight, obesity is a current cause of concern that will continue into the future.

2.2.1 Cognitive impairment

It has been noted that for those with intellectual impairment, the necessary accommodations, models and guidelines are almost non-existent (Salmi, 2007). As a consequence, a considerable stigma currently exists and access to public transport is reported as a significant barrier to community inclusion and social participation for people with intellectual disabilities (Fager et al., 2005). Because of the stigma attached to the term 'intellectual' impairment, the term 'cognitive' will be used to include intellectual impairment due to congenital or developmental problems, and to also include types of dementia, severe and persistent mental illness and injuries to the brain that reduce a person's ability to process thoughts (Braddock et al., 2004).

How big is the problem?

Over half a million people (544,000) that is, about 16% of the disabled community, experience cognitive impairment due to congenital, developmental, ageing, mental or behavioural disorders (Human Rights and Equal Opportunity Commission, 2005). Of this group 80% (435,200) are diagnosed with mild disabilities, 14% (76,160) are considered to have moderate severity, with 6% (3,264) suffering profound impairment (Carmien et al., 2005). People with mental or behavioural conditions are more likely (46%) to have profound or severe limitations to their core activities than those with physical conditions (29%) (Human Rights and Equal Opportunity Commission, 2005).

Although only 16% report having an intellectual disability or mental illness, other statistics indicate that cognition may be interrupted by a significantly higher number of people. Of the 16 million Australians aged 16-85 years, almost half (45%) had at some point in their life experienced a mental disorder, while only 20% experienced the disorder for 12 months or longer. Of this 20%, 14.4% suffered anxiety disorders. Interestingly, 12-month mental disorders decline with age, with significant decreases after age 54. It was also found that, of the 20% who had experienced a 12-month mental disorder, 14.9% had at least one other (mental or physical) disabling condition, known as co-morbidity (Australian Bureau of Statistics, 2008a).

The growing number of new arrivals from non-English speaking countries is rising and 70% of new citizens come from countries whose dominant language is not English (Department of Immigration and Citizenship, 2010b). Approximately 170,000 people per year, (and this number is rising), become permanent residents in Australia and projections estimate that if immigration rates continue, Australia's total population will rise half as much again by 2050 (Bowen, 2010). Not all new arrivals, however, have communication problems. Prior to coming to Australia, many immigrants communicate well in English and those who do not adapt and learn the language over time - language barriers thus present only a temporary, yet persistent problem.

Including those experiencing comprehension and communication problems with the English language, and taking into account the under reporting due the stigma attached with 'mental illness' and 'intellectual disability', these figures are likely to be much higher.

What is cognitive impairment?

Cognitive impairment can reduce a person's ability to think, process information, make decisions, conceptualise, plan, sequence thoughts and actions, remember, interpret subtle social cues, and understand numbers and symbols. Cognitive impairment also reduces a person's ability to make judgments, to reason, or to cope with the stresses of living (Braddock et al., 2004). Essentially, people with conditions that cause difficulties with retrieving, processing and relaying information, memory, and decision making have cognitive impairment.

How do people become cognitively impaired?

Conditions associated with cognitive impairment in this document will refer to people who have had traumatic brain injury; stroke; birth defects such as Downs syndrome and cerebral palsy; developmental problems; age-related progressive diseases such as Alzheimer's and other dementias; Dyslexia; and psychiatric disorders. People with dyslexia also experience cognitive issues due to learning difficulties, difficulty reading and difficulty

understanding text. Many experience auditory processing, memory and sequencing difficulties (The Vanguard School, 2009). Although people with dyslexia usually have very strong non-verbal communication skills, some of the techniques used to improve wayfinding for other cognition impairing conditions can also benefit people with dyslexia.

Many people with psychiatric disorders experience difficulty thinking, remembering, perceiving a realistic level of danger and understanding symbols, signs and text messages. Some major mental illnesses include: depression, anxiety (panic disorder, agoraphobia, social phobia, general anxiety, and obsessive-compulsive and post-traumatic stress disorder), schizophrenia, bipolar mood disorder, personality disorders and eating disorders (Department of Health and Ageing, n.d.).

Other communication issues

Non-English speakers, if otherwise able bodied, do not have a disability outside their own communities. However, placed in an environment that caters predominantly for English speakers, their comprehension abilities may be quite diminished. Language barriers can exist for Australia's Indigenous people as many speak English as a second language (Australian Flexible Learning Framework, 2003). There are about 90 Indigenous Australian languages. Proud of its rich culture and diversity, the Australian Government also encourages immigration to help facilitate a growing economy and to meet critical labour needs (Bowen, 2010). Over the past ten years, the number of people settling in Australia has been steadily rising and has become a major contributor to Australia's rising population (ABHINAV Blog, 2010).

However, there are now over 200 different languages and dialects spoken in Australia. Aside from English, this figure includes Indigenous languages, with Italian, Greek, Cantonese, Arabic, Vietnamese and Mandarin being the most commonly spoken introduced languages in Australia (Department of Immigration and Citizenship, 2010c). In time, new arrivals learn to speak English; however, the steady influx of non-English speakers needs to be given consideration in wayfinding. Language barriers known to disrupt information exchange and therefore cause dysfunctional wayfinding need to be addressed.

Cognitive wayfinding strategies

To varying degrees, as with all disabilities, cognitively impaired people have a limited capacity to think, (comprehend, and process information), conceptualise, plan, sequence thoughts and actions, remember, interpret subtle social cues and understand numbers and symbols.

'Public transportation systems are among the most ubiquitous and complex large scale systems found in modern society (Carmien et al., 2005, p. 233). However, these systems are essential for people who cannot drive a car, to socialise, participate in community activities, and to travel independently. Cognitively impaired people may not appear to have a disability, however, due to reduced mental capability they may be more prone to misunderstanding, stress, anxiety, depression, paranoia, social withdrawal, confusion, panic, forgetfulness, wandering off and distraction, resulting in losing their way and not making it to their desired destination. Depending on the severity of their impairment, the majority of people with cognitive issues cannot drive a car and therefore rely on public transport to actively participate in society (Braddock et al., 2004). Various strategies are employed to improve their travel experiences.

Attention Improving Strategies

People with learning difficulties, mental disorders, or cognitive difficulties often use self-management skills to improve daily living. Preparation before a trip is a common strategy to help an individual go through the required sequence of travel steps in a place and time that best suits their own situation. Preparations may include consulting with a friend or carer, checking timetables with the aid of a computer and the internet, or by making a telephone enquiry.

Memory assistive strategies

External strategies such as: making lists, taking notes, following daily planners and diaries can all alleviate stress and aid a person's memory to reach their desired destination. Internal strategies that support memory include going through every detail of the trip (elaboration) and repeating the directions verbally (rehearsal) (McDougall, 2007).

Problem solving and decision-making strategies

If they are unsure where to go, or cannot decide where to go, most people will ask for assistance from a designated station officer. Asking questions and communicating with others can be daunting for people with cognitive impairment and so station staff should be on the lookout for people who seem stressed or require help to find their way. To assist a person effectively, station staff must be easily recognisable by wearing a uniform or high-visibility vest and wear a tag identifying their role. It is also important to properly train staff to ensure they are knowledgeable on all aspects involved with catching the correct train, how to communicate, and know the potential needs of people with different disabilities (James, 1997). People with cognitive impairment are not always easily identifiable. Therefore respect for passenger questions and calls for assistance should be granted.

Researchers have also found that effective strategies for use by cognitively impaired people include: thinking through the problem out loud, or discussing it with another person; developing a routine to stay organised; or anticipating problems and developing strategies to deal with them (McGurk & Mueser, 2006).

Stress reducing strategies

Other helpful strategies found by researchers include: travelling during the best time of day for the individual and times when train stations are less busy; developing a routine; verbally repeating or writing down multistep sequential directions; asking questions when receiving information to ensure understanding; breaking complex steps into smaller ones; and seeking assistance from station staff members when necessary (McGurk & Mueser, 2006).

Unfamiliar complex environments or audio messages can evoke feelings of stress and anxiety in anyone. However, people who experience panic attacks may develop an aversion to railway facilities due to a fear that they may trigger feelings of anxiety. Many people with anxiety disorders seek counselling from psychologists to receive cognitive and/or exposure therapy to help them cope with their feelings of anxiety in certain situations (Healthy Place, 2007). Others improve their wayfinding ability by seeking assistance from social workers and life or job coaches (Australian Bureau of Statistics, 2008a; Wilson, 2010). Essentially, crowds, complexity, sudden changes, unfamiliar surroundings, unfamiliar signs or fast flowing messages can all compound a person's ability to cope with wayfinding activities (Carmien et al., 2005).

Strategies used by non-English speaking people

Most Indigenous Australians prefer to learn through concrete, visual, oral and aural experiences. Information should therefore be provided in a number of modes with audio being their preferred medium. About 30% of all Australian Indigenous people live in major urban areas. When English is not their first language, many Indigenous Australians benefit from texts in larger print, simple language, and simple directional instructions (Australian Flexible Learning Framework, 2003).

Language translation software can translate foreign language documents of all types quickly and easily. Some offer free online services on the internet (e.g. Babylon, SYSTRANet), while others can be purchased at very reasonable prices (e.g. SYSTRAN, Legacy Software Migration by Semantic Designs, Commercial Translation Centre). Ensuring signs, symbols and pictograms are universally recognised will enhance standardisation and assist all passengers during their travels.

Assistive environments

To varying degrees, cognitively impaired people cope better with: simple and quiet environments; simple instructions and communication (not childlike); directions that are broken down into smaller steps; easy language; the use of symbols, pictures and pictograms; and information provided in alternate modalities. It has been found that therapeutic environments can improve outcomes for people with mental health disorders (Queensland Health, 1996a). Some of these principles may be carried across to public facilities such as train stations. Ways to create therapeutic environments include:

- creating a domestic ambience
- using clearly delineated transitions between spaces
- promoting a feeling of comfort
- promoting a feeling of security (Queensland Health, 1996b).

See Appendix B, Table 1 for a summary of the possible compensatory wayfinding behaviours of those with cognitive impairment, the barriers and obstacles they face, and the areas that need attention to ensure equal access is available to all people.

2.2.2 Visual impairment

How big is the problem?

Of the total Australian population, over half (52%) reported having problems with long and short sight. Coloured blindness affects 8% of the male population and 0.5% of the total female population (Australian Bureau of Statistics, 2004a). Approximately 444,400 Australians, that is 2% of the total population aged 55 or more are considered visually impaired (Australian Institute of Health and Welfare, 2005).

What is vision impairment?

A person considered to have normal sight is said to have a Snellen's score of 6/6 (meters) or in the original measurement 20/20 (feet). According to the chart established by Snellen in 1862, a normal sighted person will read the smallest row of letters on the chart at a distance of 20 feet (6 metres) or greater. A person's field of vision is the area of physical space seen by the eyes and measured in degrees, minutes and seconds. The visual sensation recorded on the eye's retina follows a visual pathway of optic nerves to the brain, where the image is interpreted and understood by the person (Anderson et al., 2002). Healthy vision provides a wealth of information in a single glimpse due to a field of vision, an arc measuring 180 degrees horizontal and 120 degrees vertical (Kaczmarek, 2000).

People with below normal visual acuity are considered 'vision impaired'. Using the Snellen Scale, a person with a vision acuity of 6/60 means that this person sees at 6 metres what a normally sighted person sees at 60 metres (Strouse Watt, 2003).

Various definitions exist in Australia for 'visual impairment', 'blindness' and 'low vision'. Statistics reported in this document refer to 'visual impairment' as visual acuity with the best possible correction of less than 6/12 (Australian Institute of Health and Welfare, 2005). Legal blindness is a concept that arose out of social security systems to provide a benchmark measurement to help the governments determine who is deemed eligible for various government concessions and disability support. Therefore, based on definitions of permanent blindness used in Commonwealth social security and veterans' affairs legislation, a person is considered 'legally' blind when visual acuity on the Snellen Scale is considered less than 6/60 in both eyes after correction by the best possible lenses, or a constricted field of vision equal to or less than a 10 degree arc around central fixation in the better eye, irrespective of corrected visual acuity (Department of Transport and Main Roads, 2009).

How do people become visually impaired?

If any part of the visual pathway (lens, retina, optic fibre, brain) is damaged, below normal vision can result. Additionally, both eyes see slightly different images and together they provide depth perception otherwise known as three-dimensional vision which provides an accurate means for locating objects in space. Vision with only one eye requires the person to judge an object's position from learned cues, such as bigger is closer (Marieb & Hoehn, 2007). Spatial resolution is very sensitive and operates at an estimated 0.5 to 2 minutes of arc, with visual acuity much finer at 2 seconds of arc. Therefore, visual acuity will be significantly reduced in low-contrast presentations (Kaczmarek, 2000).

Vision can therefore be impaired due to the following reasons (Department of Education and Training, 2006):

- present at birth
- caused by disease or accident
- part of a medical condition or syndrome.

The most common visual defects that affect a person's ability to focus are usually caused by refractive errors, such as myopia (near-sightedness), hyperopia (far-sightedness), presbyopia (inability to adjust focus and manifests as far-sightedness), and astigmatism (focus depth that varies with a radial orientation). Refractive errors rarely cause disability because they can be corrected with appropriate eyewear (Kaczmarek, 2000).
The major causes for visual impairment and blindness worldwide and in Australia are age-related with cataracts the main issue (Australian Institute of Health and Welfare, 2007). Ninety percent of conditions experienced by older Australians are progressive and include: cataracts, age-related macular degeneration, glaucoma, diabetic retinopathy, and uncorrected refraction error (URE) (Australian Institute of Health and Welfare, 2005).

Visual wayfinding strategies

In order to move about within society confidently, people with vision impairment compensate by using various strategies, including assistive devices that either augment or substitute for their vision. When augmentation to visual acuity is insufficient or not helpful, eyesight substitutes are used. Substitution may include strategies and devices that allow the person to gather information through the tactile and auditory senses.
Visual augmentation
Increasing illumination, larger text size, achieving greater contrast between colours, holding items closer, and judging an object's position from learned cues are all strategies used to augment visual acuity (Marieb & Hoehn, 2007). Lighting requirements differ from one individual to another. Comfortable reading is achieved with a luminance of 100 to 4,000 lux. However, depending on the eye disorder, some people will see better in higher, or lower-than-normal, levels of light (Kaczmarek, 2000). Moving safely in dark locations can be improved by increasing the intensity of light in a particular area, with devices such as torches, lights and lamps. Light from two directions can reduce unwanted shadows (Queensland Health, 1996a) especially in typically dark areas such as steps and pathways (McBrideet al., 2001).

Glare can be reduced by using textured or matt surfaces rather than glossy ones for flooring, walls, and glass/plastic panels (Currie & Allen, 2007). Ideal illumination is diffused and is directed at a 45-degree angle (Kaczmarek, 2000). When glare is removed, window indicators, bands and stickers should be placed on all clear glass walls, doors and panels to prevent serious injury from breakage due to accidental contact (McBride et al., 2001).

When vision defects do not respond to eyewear correction, the most useful form of image processing is magnification (Kaczmarek, 2000). Vision impaired people will often get closer to an object to see it. This is the simplest form of magnification, with halving the distance correlating to doubling the size of the object. At distances of up to 40 cm, hand-held or stand-alone magnifiers are often used to create a much larger image of an object (Kaczmarek, 2000).

Another strategy used by visually impaired people is to use products with larger text and high contrast colours, such as in their choice of reading material, watches and mobile phones. Other text enlargers used include: monocular hand held mini-scopes, large print software programs, ZoomCaps computer keyboards, Closed Circuit TV, screen-readers, and screen magnifiers. Closed Circuit TVs magnify text and images from regular printed material by placing the document under a camera lens. The magnified image is projected up to 60 times higher onto a TV screen for viewing (Kaczmarek, 2000). Adaptive computer software such as screen-readers and screen magnifiers used in combination with a computer can help users read electronic documents and the internet. Readability is enhanced by enlarging the text and adjusting the contrast and colours (DeafBlind Association (NSW), 2007). The DeafBlind Association website (http://www.dbansw.org.au/) has a more complete list of assistive technologies used by those who are deaf and/or blind.

Providing clean and clear signage, or signs with larger print that are well illuminated can assist people with low vision to gather information and to identify changes in direction, level, drop-offs and hazards.

Visual substitution

As visual acuity is further reduced, people become more reliant on substitution devices that place greater emphasis on the tactile and auditory senses. To aid confidence in moving about, people with low vision acuity may decide to travel with a 'symbolic' cane to alert others of their condition. The cane is also primarily used to acquire information through the tactile senses. Many visually impaired people can walk independently with the aid of a traditional long cane, by feeling the surface profile as it transmits to the hand. The internationally accepted cane, the 'Hoover' is white with a red tip. Other types are the folded long cane, and 'support' canes that can also provide stability support (Guide Dogs Queensland, 2010). People who use canes may also rely heavily on bright warning signage/markings and Tactile Ground Surface Indicators (TGSIs) that are placed appropriately to alert for hazards, and pathway directions. Protruding furnishings, and objects in pathways are often not seen, yet can be felt via a cane.

Visually impaired people can also learn to read via touch. Many learn to read raised (embossed) print and Braille. Braille readers can read at 30 to 40 words per minute (wpm) with individual letter substitution and up to 200 wpm with contracted Braille where symbols and affixes are used for common words (Kaczmarek, 2000). Many electronic devices exist such as screen-readers that can translate text into speech or Braille, while many voice output devices can be fitted to existing equipment such as telephones and mobiles. Other substitute technologies include: portable Braillers and micro readers; a tactile facsimile machine for reading ordinary print (e.g. Optacon by TeleSensory); speech calculators; personal computers with refreshable Braille display (e.g. VersaBraille); and reading machines that convert text to speech (e.g. OsCar). There are numerous technologies available to people with vision impairment (http://www2.edc.org/NCIP/library/vi/speech.htm#anchor1077897). Many technical aids, although very useful and heavily relied upon, are usually quite expensive, costly to maintain and many companies go out of business due to poor business profits, which is a common concern amongst users (Handel, 1997).

Many blind and 'legally' blind people travel with assistance dogs, guide dogs or seeing-eye dogs to help them move about safely. These dogs are recognised assistance animals and must be allowed to enter all premises to accompany their owner. People travelling with assistance dogs will require a greater area to move about in to accommodate the person and their dog. Assistance dogs can help people negotiate obstacles in their path, gaps, steps, stairs and assist with taking the most appropriate path of travel.

Government recognition

Legally blind passengers may travel with a Vision Impairment Travel Pass as illustrated below:

Figure 4: Vision impairment travel pass
Source: (Department of Transport and Main Roads, 2010b)

See Appendix B, Table 2 for a summary of the possible compensatory wayfinding behaviours of those with vision impairment, the barriers and obstacles they face, and the areas that need attention to ensure equal access is available to all people.

2.2.3 Hearing and speech impairment

How big is the problem?

Five to 10% of the total population in the United States have a hearing impairment (McCance & Huether, 2006). In Australia, 17% of those who are hearing-impaired are completely or severely deaf (Australian Bureau of Statistics, 2004a). The number of people with both speech and communication impairments has not been reported and therefore is not known.

What is hearing and speech impairment?

The lost ability to comprehend speech or be understood correlates to the lost ability to communicate with others. Those who experience communication difficulties include the deaf, partially deaf, the deafblind, people with speech difficulties (mute, trachea disorders) and non-English speaking people, including indigenous Australians, foreign nationals, tourists, and people on business from other countries. Being unable to communicate and comprehend speech bears the greatest effect on daily life and is the primary reason why people seek medical attention for hearing impairment (Kaczmarek, 2000). Solutions that assist the hearing impaired are likely to assist all people with communication difficulties. Deafblind people have unique and particular issues and will therefore be covered separately.

How do people become hearing and/or speech impaired?

Functional hearing impairment, that is difficulty understanding faint speech, begins with a loss in average sensitivity of 21 to 35 decibels (dB). Losses from 36 to 70 dB cause problems in hearing normal speech. Losses greater than 90 dB are considered as profound or extreme hearing loss, where no form of hearing augmentation, such as with a hearing aid, can be achieved. The normal dynamic range of speech is around 30 dB (Kaczmarek, 2000).

Causes of hearing loss include:

- conductive defects in the middle ear (tympanic membrane and ossicles)
- sensor neural defects in the inner ear (cochlear transduction mechanisms and auditory nerve).

Conductive defects can be corrected medically or surgically or hearing can be augmented with the help of hearing aids. Sensor neural defects however, cannot be helped by amplification or filtering and therefore this group of people require hearing substitution technologies (Kaczmarek, 2000).

Causes of incomprehensible speech:

- a person born with hearing loss may never learn to use their voice for communication (mute)
- laryngectomy – oesophageal speech is used due to removal of the larynx (Anderson et al., 2002)
- speech difficulties: stuttering, slurred speech, speech disorders, speech abnormalities, aphasia and incoherent speech (WrongDiagnosis.com, 2010b)
- problem speech symptoms: inability to hear, anxiety, stress, mental retardation, stroke, damage to the vocal cords, and various brain disorders (WrongDiagnosis.com, 2010a).
- speaking an unfamiliar language to the listener.

Hearing and speech wayfinding strategies

Not being able to communicate with other people bears the greatest negative impact on daily life (Kaczmarek, 2000). Verbal communication is a very immediate form of receiving and transmitting messages. However this is not easy or even possible for many individuals. People who have a hearing impairment will alter their behaviour to augment their hearing ability. People with profound and severely impaired hearing, and those who are deaf, will substitute their auditory sense typically with visual and/or tactile substitutes.

Apart from difficulty retrieving information, some people have difficulty relaying information to others. The inability to speak, to speak English, or to speak in a comprehensible manner presents significant problems for staff at railway stations who are trying to attend to questions and queries.

Auditory augmentation

People with a hearing impairment will often stand closer to the person speaking, so that they can better hear what is said. With gradual hearing loss, the high tones are the first to disappear, and amplification devices can assist, such as hearing aids. Many hearing impaired people amplify sound by turning up the volume on their personal devices such as mobile phones, sound systems, televisions, and computers, etc. Hearing aid users, those with a 'T' setting, may wear an induction neck loop to reduce digital interference picked up by their hearing aids, thus giving them a clearer signal (Schindler, 2003). A drawback however, is that hearing aids amplify all sounds, including background noise. This can be very annoying and distracting for the wearer. Discomfort caused to hearing aid wearers may lead to an intolerance of crowded areas and result in an aversion to places frequented by large numbers of people (Anderson et al., 2002).

Auditory substitution

Some hearing impaired people travel with hearing or assistance dogs when accessing supermarkets, restaurants and public transport (Hearing Dogs for Deaf People, n.d.).

Visual auditory augmentation

Many hearing impaired people learn to lip-read and watch for facial expressions and body language to gain a fuller intent of the conversation (Bauman, 2008). When visual cues are relied upon, good lighting and the ability to see the other person's face is critical (James, 1997). This has implications for railway staff, particularly those who are information and ticket officers.

In most large buildings, visual displays of information are common. Reliance on good visual signage is even more important for those people who find it difficult to communicate with others. In many train stations, changes to timetables, or train schedules are often announced in an audible fashion over an overhead loud speaker. For hearing impaired people, however, this transmission is not always received and therefore they rely heavily on accurate and regularly updated travel information that can be received in a visual form at a readable height (James, 1997).

Visual auditory substitution

People who cannot hear sounds in another room, behind them, or around a corner, will use visual cues, such as reflections, wall/door transparency, and openness to gather spatial awareness (Bauman, 2008). People who are deaf feel more comfortable and safer in open spaces and places that they can see through, such as lifts, as they feel more in control of where they are. The use of strategic glass panels, doors and open corners improve spatial awareness for the deaf, alerting them to people walking up behind them, allowing them to see what is happening in the next room/ area and the approach of a motorised wheelchair, etc (Bauman, 2008).

As for many people, those who are deaf enjoy sending and receiving text messages on their mobile phones. Apart from breaking through geographic and linguistic barriers for the deaf community, the mobile phone is enjoyed because it does not draw attention to their disability and, best of all, it is competitively priced (Schindler, 2003). The use of flashing lights at designated places can effectively warn deaf people of the presence of a hazardous area. Deaf people will become more alert, cautious and look about their surroundings if they see flashing lights. Illuminated signage is an effective way to get the attention of all passengers who rely on visual cues when looking for facilities, entry or exit points (Currie & Allen, 2007).

Tactile auditory substitution

For individuals who are profoundly or severely deaf, the visual and tactile sensors become more receptive. The use of vibration to signal attention is also often used. In fact, many people with no impairment use vibration signals to alert them for various reasons, such as the common setting on mobile phones to allow for discrete notification/alarm that they have received a phone call, message, or that it is a certain time of day. The deaf community also uses alerts in this way. A hand on a shoulder can alert a deaf person that you wish to communicate with them (Department for Transport & Transport Scotland, 2008). Staff training on disability awareness can improve the services on offer for those who are deaf.

Profoundly or severely deaf people may learn to communicate with sign language. There are 271 sign languages worldwide; Australians use Auslan, while travellers often use International Sign language (IS) (European Union of the Deaf, 2009). People who sign tend to cluster in circles and arcs and semicircular setting arrangements can allow for more informal conversation. People who sign also like to sign as they walk, just as people like to talk as they walk. Doors that are not automatic or narrow staircases interrupt their natural flow of conversation (Bauman, 2008). Kerbs, steps, and stairs all pose as a trip hazard to distracted signers in conversation (Bauman, 2008).

Bright, harsh, and glaring lights can fatigue the eyes of the already taxed signer. Light colours and glossy flooring can make lighting conditions worse for all people, not only the deaf person who is trying to walk and sign at the same time. The new terminal at the Dubai airport illustrates the effect shiny walls and flooring can have on the level of glare in an area. Figure 5 illustrates the effect of glare intensified by light reflecting on shiny walls and highly polished floors

Figure 5: A glary walkway in Dubai airport, terminal 3
Source: Author's photo Dubai airport

People who are deaf and those who sign often find it difficult to ask questions to non-signers. Many will carry a pen and paper with them for this purpose.

Government recognition

Many deaf and speech impaired people utilise telephone services offered by the National Relay Service, a government service which offers Australia-wide telephone access at the cost of a local call. For instance, if a person cannot hear and doesn't use their voice, there is a 'type and read' telephone service. There is a 'speak and read' service for those who can't hear but can speak, a 'type and listen' service for those who can't speak but can hear, and a 'speak and listen' service for those who are hard to understand on the phone (National Relay Service, 2008). To take advantage of these services, the National Relay Service provides free training materials, free information sessions, website wording and print material recommendations, and advice on how to transition from a dedicated TTY line to the National Relay Service (National Relay Service, 2010).

Appendix B, Table 3 provides a summary of possible compensatory wayfinding behaviours of those who have a hearing impairment, the barriers and obstacles they face, and the areas that need attention to ensure equal access is available to all people.

2.2.4 Deafblind impairment

How big is the problem?

Deafblindness affects 288,000 Australians (1.3%) and is expected to rise to 1.1 million by 2050. Although there are some exceptional support services to assist the deafblind in various places around Australia, in general terms, limited services exist, particularly in regional areas. Many feel that deafblindness is a forgotten disability and the deafblind feel that very few people are aware of their plight and particular needs (Able Australia, 2010b). Encouragingly, it has been estimated that around 80% of all deafblind people have some residual vision or hearing which assists them to perform daily tasks (James, 1997). However, in order to manage daily life, many of those with deteriorating conditions must undertake rehabilitation activities continually, otherwise skills acquired prior to deaf impairment or blindness can be lost. Some individuals can retain speech and may be able to speak for themselves (James, 1997).

What is deafblind Impairment?

Deafblindness is described as 'a unique and isolating sensory disability resulting from the combination of both a hearing and vision loss which significantly affects communication, socialisation, mobility and daily living' (Steer, 2006, p. 1). Varying degrees of severity exist and pose significant difficulties for those who are neither profoundly deaf nor legally blind because sight and sound are the two key senses used when wayfinding (Enterprise IG Information Design Unit, 2005). Essentially, one sensory disability compounds the effects from the second.

How do people become deafblind impaired?

There are four causes of deafblindness:

- hearing and sight impaired from birth or early childhood
- blind from birth or early childhood and acquire a hearing loss
- profoundly deaf from birth or early childhood and acquire vision loss
- age related - acquire hearing and vision loss later in life.

The degree of impact severity on an individual varies according to learning opportunities. Australians born with deafblind will have limited understanding of the world and little or no formal language, as they have never been able to watch or listen to others and things around them. Australians who have acquired their deafblindness have the advantage of remembering what they saw or heard and are more likely to have had access to learning and language. Unfortunately, in Australia major gaps exist in service provision for the deafblind, especially in Queensland (Steer, 2006).

Deafblind wayfinding strategies

Critical issues for the deafblind that have been identified include: poor transport access; inadequate transport assistance; lack of information in a format of individual choice; and lack of appropriately trained staff (Steer, 2006).

When both the visual and hearing senses fail, greater reliance is placed on gathering information through touch and kinaesthetic activity. People born profoundly deafblind can only learn through touch, smell, taste and their kinaesthetic relationship in space. For these people, life is to be experienced rather than observed or heard (James, 1997). Consequently, for a profoundly deafblind individual to find their way around a train station independently, they would require assisted orientation and wayfinding practice of a particular route to help establish their own mental spatial mapping. Some deafblind people are able to live relatively independent lives in a share house under the guidance of a 'team leader' who monitors and assists where necessary (Able Australia, 2010a). This enables them to learn how to travel to regular places, for example. It has been noted, however, that individuals who are profoundly deafblind will find it nearly impossible to travel about unassisted, particularly in unfamiliar environments (James, 1997). The deafblind thus rely heavily on well-trained staff that understand their needs and can assist effectively. The deafblind consider that their needs are different from those of people with single sensory impairments and feel that greater awareness of their particular needs would better equip station staff when offering assistance (James, 1997). To help station staff, most deafblind individuals will keep a communication book or have and show various signs to indicate that they are deafblind and what are their specific needs (James, 1997).

When navigating a system, deafblind people tend to develop their own strategies to best suit their particular needs. Some can communicate with speech, however many will rely on specialised communication techniques (Australian DeafBlind Council, 2010). More than 13 different techniques exist in varying forms and these include: tactile sign, hand over hand sign, deafblind fingerspelling, various forms of communication used to augment residual sensory capabilities, raised print, enlarged print and Braille (Able Australia, 2010b). Because strategies vary considerably, deafblind people are likely to explain how to communicate with them (Department for Transport & Transport Scotland, 2008). Those with residual sight or hearing will benefit from augmentation techniques used for people with a single sensory impairment. Some individuals use non verbal communication such as miming and gesturing to find out directions, times, and platform numbers (James, 1997).
Information gathering is often obtained in similar ways for travellers with a single sensory impairment - for example, many will travel with a cane to alert people of their presence or to obtain tactile feedback (Department for Transport & Transport Scotland, 2008). Some can use computers and have access to the various assistive technologies similar to deaf or blind individuals, such as TeleBraille for telecommunications (TTY), telephones, mobile phones, hearing aids, Braille, Moon, and software packages that enlarge print or convert text to speech or Braille. It has been noted that those who communicate with sign find it difficult to learn English (James, 1997) and therefore will not comprehend English text translated into different media. The profoundly deafblind may have access to a Special Support Provider (SSP) who is able to interpret visual information to the impaired individual or to interpret a query to a station staff member.

Although some deafblind people have received 'assertiveness' training (Able Australia, 2010c) to improve confidence and self-esteem and enable them to travel about, gathering and communicating information for the deafblind is a significant hurdle for the deafblind.

Government recognition

Mobility access is a complex issue. Difficulties that create additional barriers to access community services have been noted by the deafblind community. The deafblind have identified that the lack of a 'one stop shop' for the deafblind means that they have to access services from different organisations who do not fully understand deafblindness. Mobility is further complicated by limited access to aids, equipment, case managers and Special Support Personnel due to their significant cost or lack of services (Australian DeafBlind Council, 2010). The deafblind community has expressed a need for trained carers at more convenient times, workers who can communicate in Auslan, a need for qualified interpreters and note takers, and a greater sense of community from all (Zammit & Gaile, n.d.). The load on case managers and carers can be reduced however, with effective use-focused wayfinding solutions.

Deafblind people classified as legally blind are also eligible for the Vision Impaired Travel Pass and are therefore eligible for various concessions provided by the Australian government.

Appendix B, Table 4 provides a summary of the possible compensatory wayfinding behaviours of those with vision impairment, the barriers and obstacles they face, and the areas that need attention to ensure equal access is available to all people.

2.2.5 Mobility impairment

How big is the problem?

Impaired mobility affects 15.2% of the total Australian population, that is 3.4 million people and 1.4 million people experience profound or severe mobility disability (Australian Bureau of Statistics, 2004a).

What is mobility impairment?

In the context of this document, mobility impairment is associated with a person's ability to move around and manipulate their environment. Impaired mobility will reduce the distance, speed and/or endurance the affected person can move. The Australian Institute of Health and Welfare defines mobility as a person's ability to get into or out of a bed or chair, move around at home and go to, or get around a place away from home (2008). Typical mobility activities include: walking, sitting, bending, manoeuvring, stretching, grasping, holding, pushing, pulling, manipulating and lifting.

How do people become mobility impaired?

Mobility impairment can result from a variety of conditions, such as: reduced muscle mass; reduced strength, power and endurance; pain; and fatigue. Typical conditions that cause these issues are: paralysis, injury, amputation, and muscular diseases (Anderson et al., 2002). Reduced mobility can result in reduced size, agility/flexibility, manual dexterity, co-ordination, balance and reduced body temperature (Currie & Allen, 2007). In addition to muscular, joint and limb problems other conditions that reduce mobility include heart disease, obesity, pregnancy, and travelling with children or luggage (see Figure 6).

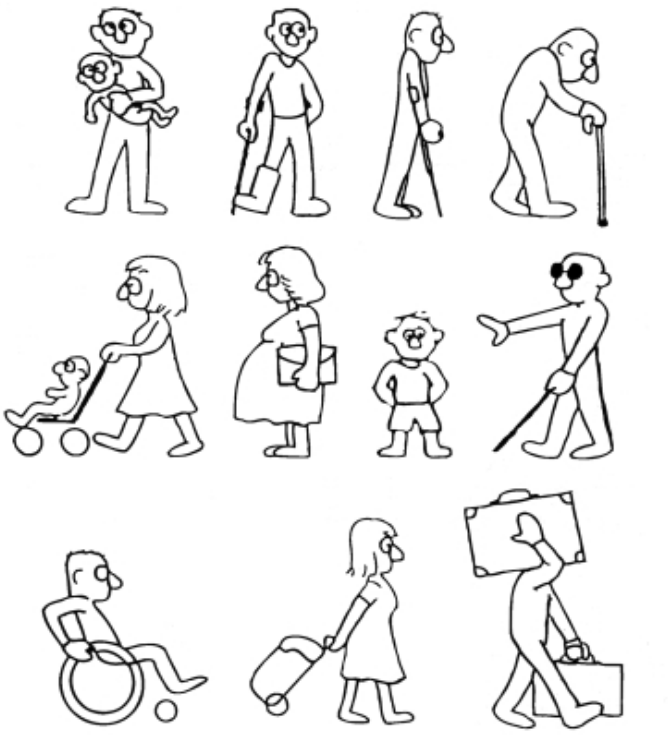

Figure 6: People with reduced mobility
Source: (European Commission Directorate-General for Research, 2004, p. 18)

Mobility Augmentation

In order to move about *within society, people with re*duced mobility compensate by assisting their mobility in a variety of ways. Reduction in strength, endurance, agility, and balance may cause an individual to be fatigued more quickly and therefore take more frequent rest stops and breaks. Lengthy distances and the lack of suitable rest areas create barriers for the mobility impaired, posing a problem to reach certain desired locations. People requiring greater stability and support while climbing steps or stairs look for hand rails to grasp and places to lean against. As reduced muscle tone and joint weakness progress, walking rhythm is affected as well as coordination and reaction time, resulting in a far more cautious and less confident approach to walking about. As a result, smaller steps are taken, walking rhythm is interrupted, and a shuffling movement of the feet may develop. With limited mobility, uneven, bumpy or broken surfaces present additional problems. Surfaces that are slippery or soft also lack the necessary support to aid stability and co-ordination. As joints become weakened or painful, or when a person's centre of gravity changes due to increased weight, pregnancy, or from carrying heavy loads, various abnormal gaits can develop increasing the additional need for support and the area required for moving about. Moving crowds increase the risk of falling due to flow interruptions and bumping. When confidence in walking unassisted is further reduced, various assistive devices are used such as walking frames, walking sticks and crutches.

Mobility substitution

When walking is no longer possible, mobile aids are used such as wheelchairs and mobility scooters. For these devices to assist effectively, different demands are placed on the environment and new barriers to access become apparent. A person travelling in a mobility device changes the amount of space they require around them to allow for free movement. For those using wheelchairs and scooters, the person's height will be reduced making it more difficult to read signs or use service facilities at normal heights. A person's width is enlarged by these devices, making it impossible to pass through regular ticket turnstiles, or certain doorways. To reduce this barrier, automated, widened, bi-directional doorways are an ideal solution. Turning around in a mobility vehicle will demand a larger area and can be difficult if passageways are too narrow. Issues arise when a person has to go to a different platform level if assistive equipment such as lifts or ramps are not present.

Reduced manual dexterity

Reduced manual dexterity from joint damage and reduced strength can impair a person's ability to manipulate, grasp and hold onto objects, further reducing their confidence and ability to move about successfully. The ability to manipulate certain switches, knobs or handles often relies on appropriate shape, size and ease of movement. The ability to grasp hand rails can also be limited if these are not of an appropriate size or shape, or positioned at an appropriate height. Designs that incorporate the guidelines for handle position, shape, width and grip span in the *Manual Tasks Code of Practice 2010* (Qld) can benefit all users. People suffering profound and severe manual dexterity problems will seek pathways that are highly automated.

Government recognition

The particular needs of people with reduced mobility have been recognised by the government for some time and in an effort to make access to public facilities easier, designated parking spaces, close to entrances, have become a requirement. People classified as suffering from severe mobility issues are eligible for an Australian Disability Parking Permit (ADPP), as illustrated in Figure 7 below:

Figure 7: Australian Disability Parking Permit
Source: (Department of Transport and Main Roads, 2010a)

Appendix B, Table 5 provides a summary of the possible compensatory wayfinding behaviours of those with reduced mobility, the barriers and obstacles created because of those compensatory actions and the areas that need attention to ensure equal access is available to all people. People with reduced mobility due to pregnancy, travelling with children in strollers and prams, and people travelling with luggage or heavy items will all benefit when the needs of those in wheelchairs and scooters are met.

2.2.5 Summary

Of the total population in Australia (ca. 22,537,400), 19.8% have reported experiencing one or more disabilities that restrict involvement in core-activities. Most people with a disability experience moderate severity as illustrated in Figure 8. Many more Australians experience disabilities. However with aids (e.g. reading glasses, etc) these do not restrict their ability to perform daily activities.

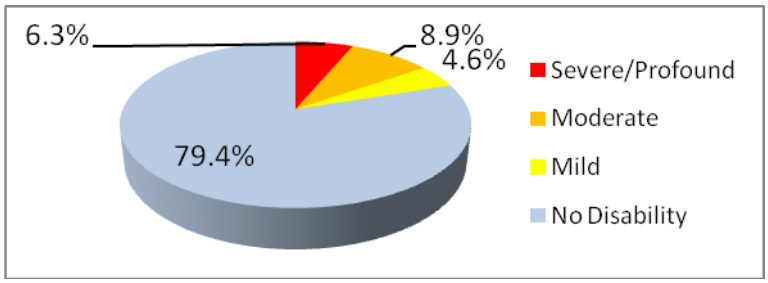

Figure 8: Percentage of Australians per Disability Severity

Determining percentages per disability type is more difficult due to insufficient reporting in the literature. Conservative estimates are illustrated in Figure 9. However, the number of those who experience a disability is likely to be significantly higher for the following reasons:

- stigma associated with mental illnesses and intellectual disabilities results in underreporting
- the number of people who experience speech problems has not been reported in the literature
- disabilities are on the rise due to the ageing population
- the level of communication difficulties experienced by new arrivals to Australia is unknown.

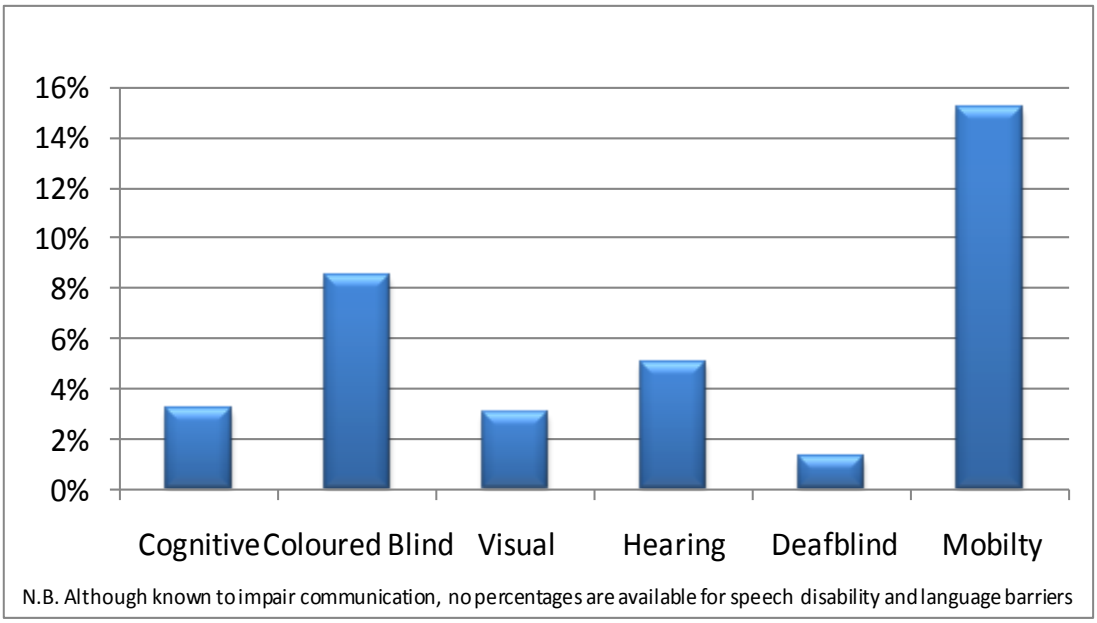

Figure 9: Percentage of Australians per Disability Type

More Australians report that they have a mobility disability rather than any other type of disability. However, cognition interruptions cause the greatest problems during the wayfinding process. This is highlighted below in Table 2.

Table 2: Factors that pose problems in wayfinding for each disability group

Wayfinding with Impairments					
Impairment	Perception of environment	Information gathering	Orientation	Cognition	Task performance
Cognitive	•	•	•	•	
Sensory	•	•	•		
Mobility	•				•

As the table illustrates, people who are planning a train trip are affected by their perception of the train station environment. For this reason it is extremely important to ensure stations are as safe and as user-friendly as possible, to encourage use by all members of the public. People with disabilities face difficulties in obtaining the information, facilities and assistance necessary for them to physically reach their desired destination. Those with sensory impairment are able to make wayfinding decisions provided they can retrieve the necessary information and provisions to properly orientate themselves. Those with cognitive impairment face the greatest difficulty making navigational decisions. However, by providing an environment conducive to concentration, and wayfinding strategies that are understood, these problems can be diminished.

2.3 Structures which conflict/aid wayfinding behaviour

The main structures of a public building can be of particular importance to wayfinding. Regardless of the signage or other wayfinding aids, the architectural elements of the building can often assist or hinder wayfinding. Several architectural elements are discussed regarding this issue.

2.3.1 Entrance Hall

In public buildings the entrance hall is the most important aspect of the building as it symbolises the gateway to the rest of the building. The function of the entrance hall needs to be readily accessible to the user and display the cogitative structure and route network of the building. For unfamiliar visitors, who tend to rely on central point strategy, the entrance hall is critical to their navigation strategy. For users entering the entrance hall, the relevant navigation choices need to be visible simultaneously - if this is not the case, the entrance hall can hinder all subsequent wayfinding tasks (Hölscher et al., 2006a).

2.3.2 Survey Places

Survey places are areas where there are visual connections between spaces and areas, where staircases and other passageways of moving in between levels can be seen. A lack of survey places can result in users taking longer and hesitating in wayfinding tasks (Hölscher et al., 2006a).

2.3.3 Floor Plans

Floors or levels in a building with very different layouts are hindrances to wayfinding. For a person standing in the building, they naturally assume that the layout of the floors is the same on all levels. However, the hallways could be considerably different. This assumption about the route network confuses the user and gives false expectations about the connectivity or integration possibilities of their surroundings, which is counterproductive to wayfinding (Hölscher et al., 2006a).

2.3.4 Dead Ends

These structures are counterproductive to wayfinding. Dead ends block the person's exploration activity and are extremely difficult to reconcile within the mental representation of the building. People tend to feel 'lost' within dead ends (Hölscher et al., 2006b).

2.3.5 Interior Building structures

These can be both productive and counterproductive to wayfinding. Dissimilarity of geometric shapes and architectural forms would appear to be helpful for the user when trying to orientate themself. However, when actually navigating in the building, the different subsections are no long readily recognisable for the user which could be due to a lack of visual differentiation and lack of survey places (Hölscher et al., 2006a).

2.3.6 Public and Private Space

Private places are staff only places within a public building - there are usually whole corridors and stairways which are only for staff. While this increases efficiency for staff to move around the building, it may interfere with the circulation networks of buildings for public access and may have negative consequences for building navigability (Hölscher et al., 2006a).

2.3.7 Stairways, Escalators and Elevators

In general, stairways should help with integrating vertical information while exploring multilevel buildings and they should help in experiencing the spatial layout of the building as a whole. However, this can become a hindrance with multiple stairways and elevators that do not reach all floors and can be both frustrating and disorientating (Hölscher et al., 2006a).

3. Wayfinding technologies

Wayfinding technologies (see Figure 10) in this report are defined as technologies which aid navigation, mainly within an indoor environment. In particular, the focus is on technologies that aid people with disabilities. Technologies are separated into two broad categories, passive technology which does not interact with the user, and dynamic technologies, which interact with the user. Another more literal distinction between passive and dynamic technologies is that passive technology provides feedback to users without using power sources whereas dynamic technologies generally require some power source for operation. Dynamic technology is then separated into infrastructural and personal technologies, where infrastructural technologies require technology to be installed into the building / fabric of the station. Personal technology is defined as technology that is portable and does not require modifications within the train station.

Figure 10: Successful wayfinding diagram
Source: (Rail Safety & Standards Board, 2006, p. 1)

3.1 Train access wayfinding flowchart

The tasks that individuals may perform in a train station are shown in Figure 11 where the ultimate goal of wayfinding is to gain lividuals may wish to access other facilities

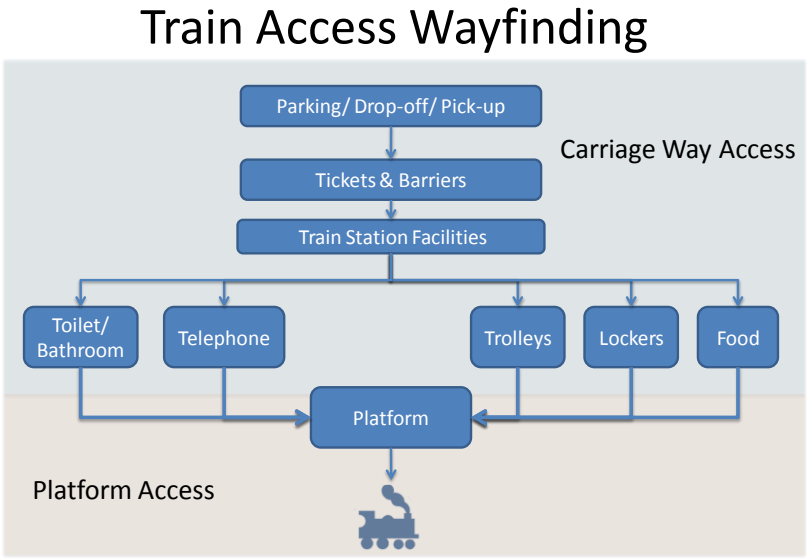

Figure 11: Train access wayfinding flow chart

3.2 Passive wayfinding technologies and aids

Passive wayfinding technologies refer to technologies or devices that do not interact or provide feedback to the user. They do not usually require a power source and the information that is displayed is fixed. Most passive wayfinding technologies have being incorporated into the Australian Building standards due to their relatively low cost of implementation and maintenance.

3.2.1 Tactile ground surface indicators (TGSIs)

3.2.1.1 Warning TGSIs

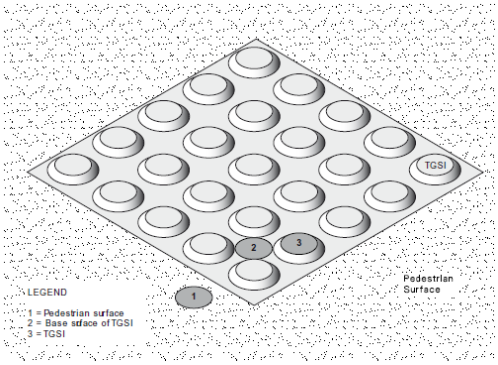

Figure 12: Warning tactile ground surface indicators
Source: (AS/NZS, 2009)

Description:

Warning tactile ground surface indicators (TGSIs) (see Figure 12) are a part of the Australian building code and defined in Australian Standards (AS/NZS, 2009). Warning TGSIs are installed in*"…potentially hazardous situations such as stairs, ramps, kerb ramps and level transitions between pedestrian access ways and vehicle carriage ways…"* to ensure*"…safe and dignified mobility of people who are blind or vision impaired."*

Compatibility with existing technology:

Warning TGSIs are a part of the existing technology. (For further explanation of warning TGSIs see Appendix A.)

Standards:

AS/NZS 1428.4.1 Design for access and mobility Part 4.1: Means to assist the orientation of people with vision impairment - tactile ground surface indicators.

Area for further consideration:

Warning TGSIs should not be overly used as TGSIs may affect the balance of people with mobility impairment or interfere with their mobility aids. TGSIs should be minimised on areas where people in wheelchairs are likely to need to make fine adjustments in manoeuvring and turning their wheelchairs (AS/NZS 1428.4.1, 2009).

3.2.1.2 Directional TGSIs

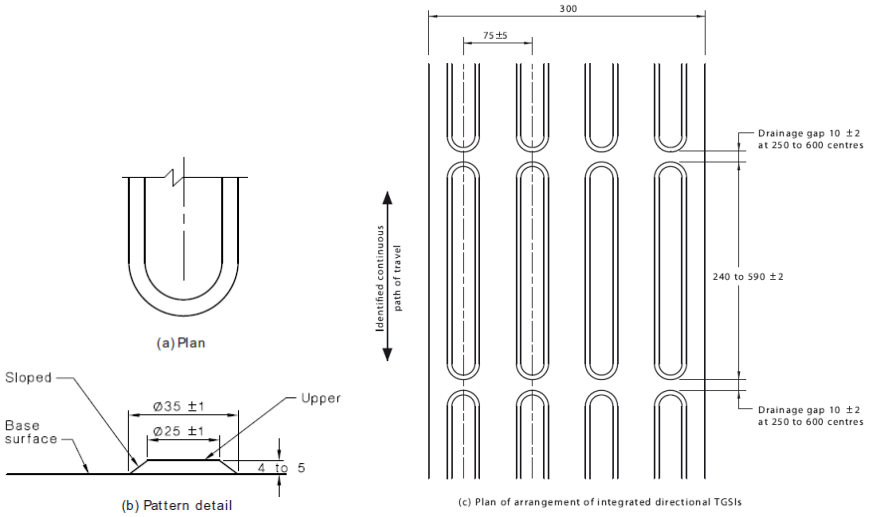

Figure 13: Directional tactile ground surface indicators
Source: (AS/NS, 2009)

Description:

Directional Tactile Ground Surface Indicators (TGSIs) (see Figure 13) are a part of the Australian Building Code and defined in Australian Standards (AS/NZS, 2009). Directional TGSIs are used *"… to give directional orientation in open spaces where there are insufficient tactile directional cues…"* in order to ensure*"…safe and dignified mobility of people who are blind or vision impaired."*

Compatibility with existing technology:

Warning TGSIs are a part of the existing technology (For further explanations on warning TGSIs see Appendix A.)

Standards:

AS/NZS 1428.4.1 Design for access and mobility Part 4.1: Means to assist the orientation of people with vision impairment - tactile ground surface indicators.

Area for further consideration:

Directional TGSIs should not be overly used as TGSIs may affect the balance of people with mobility impairment or interfere with their mobility aids. TGSIs should be minimised on areas where people in wheelchairs are likely to need to make fine adjustments in manoeuvring and turning their wheelchairs (AS/NZS 1428.4.1, 2009).

3.2.2 Symbolic signage

Figure 14:a) International disability symbols b) Symbols used in a public building
Source: a) (AS/NZS 1428.1, 2009), b) (Salmi, 2007)

Description:

Symbolic signage gives the sighted user a shorthand symbol for a particular service. That is, symbols can indicate and draw attention to services that cater for the needs of those with disabilities by using the disabled sign and the deaf symbol as shown Figure 14a) and Figure 14b) respectively. This also allows people with cognitive impairment or foreign language speakers to access wayfinding information in a universally recognised language.

Compatibility with existing technology:

Symbolic signage is part of the existing wayfinding technology. (For further explanation see Appendix A.)

Standards:

AS/NZS 1428.1 Design for access and mobility Part 1: General requirements for access - New building wor

Area for further consideration:

Symbolic signage is an effective and efficient way of indicating a specific service. However, only a few main symbols are utilised for wayfinding for disabled services. This is underutilised and signage used in conjunction with writing and other wayfinding aids can be a simple way to make the train station an easier environment in which to navigate.

3.2.3 Tactile maps/ signs

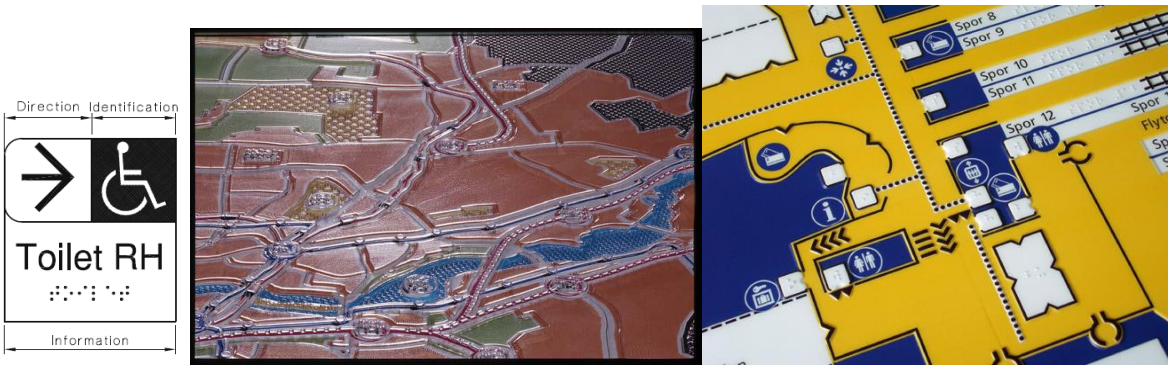

Figure 15: a) Disabled tactile sign, b) Tactile map, c) Tactile map with Braille
Source: a)(AS/NZS 1428.1, 2009), b) ((ECMT), 2006), c) ("Tactile Maps," 2008)

Description:

Tactile maps and signage (see Figure 15) are stationary items that allow the blind and vision impaired customers to feel symbols and writing. This allows them to obtain information on signs and maps that is already available to sighted people. Maps are often problematic for people with cognitive disabilities, and for people who simply have trouble translating the two-dimensional information to a three-dimensional space (Salmi, 2007).

Compatibility with existing technology:

Tactical signage is part of the Australian standards. However tactile maps have not been included in the Building Codes. In fact, no standards exist on how many and what types of maps should be included in new public building works.

Standards:

AS/NZS 1428.1 Design for access and mobility Part 1: General requirements for access - New building work

Area for further consideration:

Tactile maps are already implemented in many public buildings throughout Australia to cater for disability access. This could be included in train stations at relatively low cost.

3.2.4 Order and numbering

Figure 16: Hospital sign with numbers
Source: http://www.hospitalsignage.com/

Description:

Human wayfinding behaviour is such that logical order and numbering (see Figure 16) are important, because illogical arrangement and inconsistent numbering of areas can cause confusion and disorientation and hinder wayfinding performance within a multi-level public building.

Building environments have been described as a dynamic process of movement caused by the human's experience in the spatial layout of a building as we travel through the building (Hölscher et al., 2006b). It was found that disruption to circulation of the buildings in the form of dead ends and fragmented visual access to major passageways led some people to becoming disorientated,, which, on the whole, added stress to the wayfinding task.

Compatibility with existing technology:

For new buildings or extensions it would not be too difficult to include a design audit by an architect with universal design training. However, for existing buildings, better signage at the problem areas could be considered. Increasing the use of numbering and order in public buildings may counter the illogical arrangement of circulating areas.

Standards:

There are no current standards in numbering and ordering public spaces.

Areas for further consideration:

New public building works and renovations to existing buildings are expensive. It would be beneficial for an architect who is conscious of human behaviour and universal design to audit any new design works to ensure they address numbering and ordering issues. When renovations are carried out, the original flow and circulation pattern of the station maybe affected.

3.2.5 Colour coding

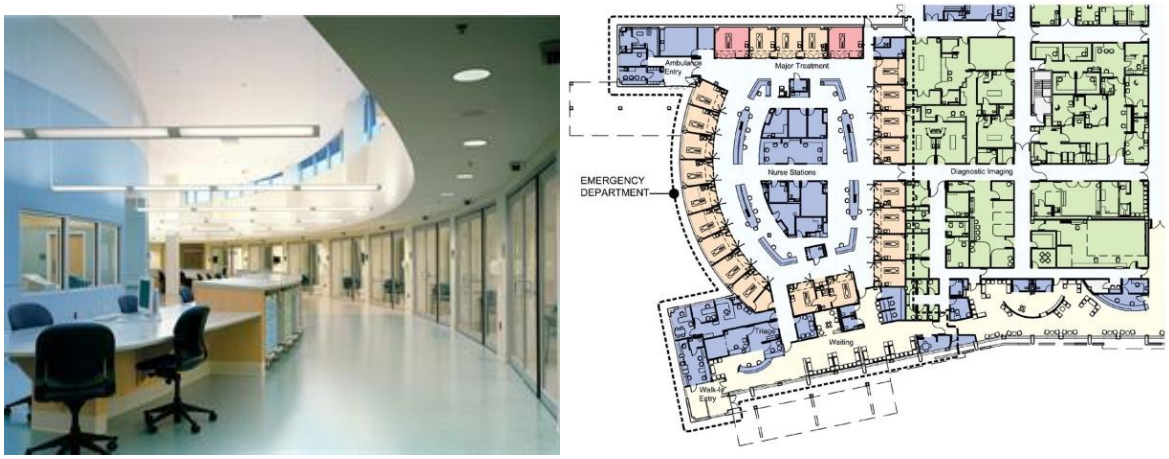

Figure 17: a) Colour coded hospital corridor, b) Colour coded layout map
Source: a) &b) (Evitts, 2007)

Description:

Many public buildings such as hospitals use colour coding (see Figure 17) to ensure that equipment and furniture from one department stays in that department. In wayfinding behaviour studies (Evans et al. 1980; Jansen-Osmann & Wiedenbauer, 2004) it was found that in wayfinding tasks participants (adults and children) found their way through unfamiliar surroundings and needed fewer learning trials to find the shortest route to a goal when the ground was colour coded. Furthermore, participants were also able to re-orientate themselves in the task.

Compatibility with existing technology:

Colour coding corridors and passageways are compatible with existing infrastructure.

Standards:

There are no current standards in colour coding public spaces.

Areas for further consideration:

Colour coding could be used in conjunction with other technology to aid of wayfinding. However, there is a proportion of the population that is colour-blind and colour coding alone to aid wayfinding is not sufficient. Nevertheless, subtle colour coded strips in corridors and entrances to station platforms which are uniform across stations, could be very beneficial for people orientating themselves in the station environment.

3.2.6 Architectural/visual cues

Figure 18: a) Lobby architectural cue, b) Artwork statue visual cue
Source: a) http://www.ljhooker.com.au/chinatown , b) http://www.huntington.org/huntingtonlibrary.aspx?id=362

Description:

Architectural or visual cues (see Figure 18) are objects, or distinctive decorative features, that distinguish one space, or area, from another. Generally, any objects that distinguish one space from another, in the form of a piece of art work or difference in architecture, helps with recognition and therefore become landmarks. In office buildings where corridors and levels can look identical, it is usually differentiated by art work or architectural details.

Compatibility with existing technology:

Including artworks and other design features is compatible with the existing infrastructure.

Standards:

There are no existing standards on the placement of architectural or visual cues.

Areas for further consideration:

For train stations which have many different platforms and many similarly decorated entrances, including some art work or other architectural features like clocks displays would aid in helping the customer distinguish between the various entrances. This would aid in subsequent re-orientation of the customer if they become disorientated within the station and help the customer to distinguish between various entrances and spaces. This would be most appropriate for large train stations that have several similar areas which are hard to distinguish from each other.

3.3 Dynamic or active wayfinding technologies

Active wayfinding technologies interact with the user, so the information that the user receives is tailored to their needs. In this report, active wayfinding technologies are separated into personal devices where these are devices that are purchased by the individuals and infrastructure technologies which are a part of the infrastructure of the station. Technology that needs both infrastructure modifications and personal purchases has been listed under section 5.3.2. Personal Technologies - this is because although infrastructure modifications have to be made, the customer ultimately has to purchase the device and the proliferation of use is ultimately dependent on the customer.

3.3.1 Infrastructure technologies

Infrastructure technologies refer to technologies or aids inside the railway station or provided by the railway station. These must be designed in consultation with and to the expectations of disabled passengers. The ideal station layout should allow for quick access to the right information for all customers. The configuration, designation and decision-making cues provided in station infrastructure are critical to enable an effective wayfinding solution. The technologies which foster these principles are explained in the following sections.

3.3.1.1 Interactive information kiosks/maps

Figure 19: Information kiosk, Brisbane International Airport

Description:

Information kiosks with map displays (see Figure 19) are common within large shopping centres and airports in Australia. Most information kiosks are touch-screen based. There are no physical buttons to navigate through the information, rather, the button icons appear on screen and when the screen is touched at the particular location the specific information appears on screen. Depending on the software that is run on the kiosk, users can input search terms which the software finds and displays for them.

Compatibility with existing technology:

Interactive information kiosks are compatible with existing technology. They have already been utilised in other public buildings such as large shopping centres and universities. It would be reasonable to assume that they could be implemented in train stations in Australia if they are not already present.

Standards:

No existing standards relate to placement of information kiosks. However, this standard should be consulted: AS EN 12182-2002 Technical Aids for disabled person – General requirements and test methods

Areas for further consideration:

Information kiosks would be helpful to the general public as well as the disabled customer. However, they do not cater for blind and severely vision-impaired customers who cannot see the buttons on the touch screen. This technology could be very useful if it was modified so that a blind customer or severely vision impaired customer could use it.

3.3.1.2 Interactive tactile maps

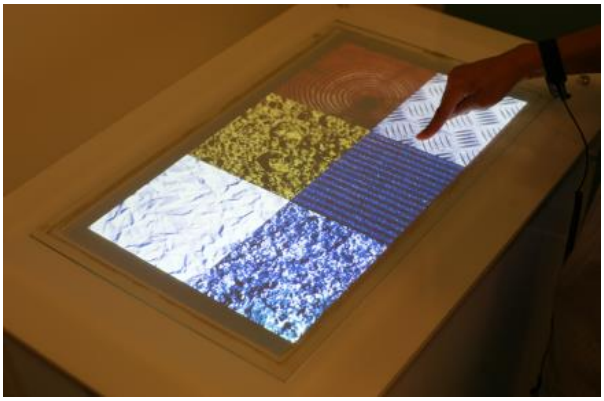

Figure 20: Demonstration of haptic technology
Source: http://www.inventinginteractive.com/2010/10/18/new-haptic-possibilities/

Description:

Interactive tactile maps (see Figure 20) are a form of haptic technology which is *"…where the application of touch sensation and control is used in the interaction with computer applications…"* (Thurfjellet al., 2002). Haptic devices produce an outward force when there is an input displacement by the user. The user experiences the mass and friction of the specific object being displayed. Therefore, several different maps with different routes can be read in a tactile manner to the blind or vision impaired user with haptic technology. No haptic maps are currently commercially available; however products like Samsung SCH-W420/W4200a (smart phone with haptic technology) was launched over a year ago.

URL:http://www.newlaunches.com/archives/samsung_anycall_haptic_a_premium_touchscreen_phone.php.
The technology will be developed within the foreseeable future.

Compatibility with existing technology:

Interactive tactile maps can be readily installed where conventional maps are located. The sighted can readily use these maps as well as those who are blind or vision impaired.

Standards:

No standards currently exist for haptic technology.

Areas for further consideration:

In a study conducted in the U.S. (Arditi et al., 1999), with blind and vision impaired participants who had never before used an interactive tactile map, Researchers found the interactive touch map system reduced wayfinding errors by half compared to verbal directions given by sighted bystanders. The technology needs further development and testing but initial results indicate that the interactive tactile map is an effective tool for the blind or vision impaired customer's wayfinding needs.

3.3.1.3 Multimodal information stations

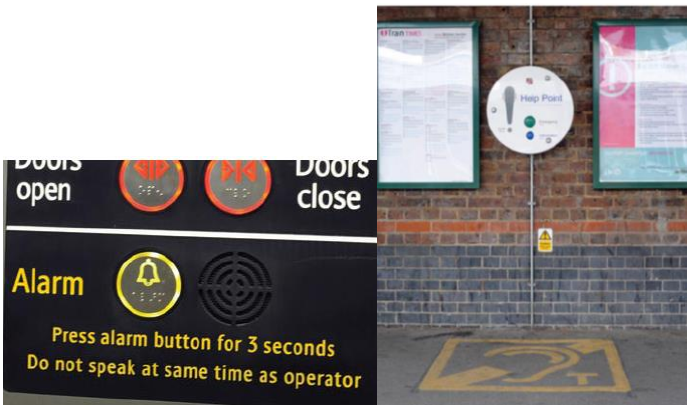

Figure 21: Multimodal information point
Source: (Department for Transport & Transport Scotland, 2008)

Description:

Multimodal information stations (see Figure 21) are information points where the same information is presented in more than one format so that it can be accessed by customers with various disabilities. At one point, the signage has tactile Braille markers, symbols and recorded voice descriptions, so that the disabled customer has several options to understand the wayfinding elements.

Compatibility with existing technology:

Multimodal stations are compatible with existing technology. Apart from the power outlet, most multimodal options can be installed easily.

Standards:

No Australian Standards exist for multimodal information stations.

Areas for further consideration:

Multimodal stations should be implemented in train station environments for access to wayfinding information that everyone can read. It may be cheaper in price than some other technologies. The disabled customer has to know where to find the multimodal station and this requires education and clear signage.

3.3.1.4 Access to assistive information

Figure 22: Tim (with Duchene's disease) uses rail website
Source: Personal friend of author

Description:

The first point of contact for individuals who are unfamiliar with a transport system is not at the train station. Long before reaching the station individuals would have researched their travel route. The initial contact between the rail company and the individual is on the company's website or external information (see figure 22) that each rail company provides. This information needs to be accessible and user-friendly for the disabled individual. Such service provisions should include options for: larger print, verbal cueing, audio response, video information services, and multi-lingual options.

After the disabled customer has entered the station, similar and consistent information should also be available, so that if the person becomes disorientated they can plan an alternate route or use other options.

Available information before entering the station should include:

- station facilities: such as disabled toilets, ramp access, public phone access etc.
- route descriptions: how to travel from the entrance to the various platforms that allow for disability access
- local transport interchanges: what other transport, such as buses and trams, is also available at the station
- timetable information: when the trains are scheduled and if the train caters for disability access
- ticketing information: where to purchase the tickets, and the price of the ticket.

Products:

1. an accessible website must be compatible with the web accessibility initiative standards (W3C, 2005), so that the disabled person will be able to access the above mentioned information in the comfort of their own home
2. pamphlets and other paper based information displays should also be available, as not every disabled customer has access to the internet. Pamphlets should be made available to disability organisations, schools, tourist information centres and other community organisations
3. applications for mobile phones, avi store, apple iStore, android apps, should be introduced for train stations so that the information can be available when people are on the move
4. rail organisations should have dedicated phone information services free of charge on landlines.

Compatibility with existing technology:

These products are already commercially available and easily compatible with technology in people's homes.

Standards:

There are no Australian standards for website accessibility, however a Web Accessibility Initiative (WAI) does exist http://www.w3.org/WAI/ , which governs webpage accessibility.

Areas for further consideration:

Railway websites already exist for all major capital cities in Australia. Unfortunately, these websites are not linked nor standardised. A customer who lives in Sydney but wants to travel to Brisbane needs to search different websites to find out about 'disability access'. Also, the application for mobile phone users is different from the web based layout. A suggestion would be to research these websites and standardise the information access points and the type of information that is given. These websites should also be compatible with web readers and other technologies for accessibility access.

3.3.1.5 Trained staff

Figure 23: a) Staff member with customer, b) Volunteer assistant at Brisbane Airport
Source: a)(Department for Transport & Transport Scotland, 2008), b) personal photo

Description:

Training staff to understand how to communicate with a disabled customer (see Figure 23) would also be effective in assisting disabled people with wayfinding. Providing properly trained staff can make rail services more attractive to people with disabilities. Staff can cater to the exact needs of the customer and direct them efficiently to their desired location.

Compatibility with existing technology:

Training staff is compatible with existing practices in rail. However, more staff may be required for this expanded role.

Standards:

There are Customer Service standards and training programs available in which staff could be trained.

Areas for further consideration:

Retaining and hiring more staff at large metropolitan stations is desirable, as staff members are mobile wayfinding aids to all customers. The ratio of trained staff to customers' needs to be carefully considered. It should take into account the peak flow number of customers that will use the station throughout the day and the

needs of the customers using each station. As labour is expensive in Australia, smart scheduling of staff, and using staff in conjunction with other technologies, is preferred. Awareness training can be sourced by contacting the various disability associations.

3.3.2 Personal technologies

Personal technologies, or aids, are items which customers own or carry. These are not usually provided by the railway station and come at a monetary cost to the customer. The ideal product should allow for quick access to relevant information within all station locations and can be independent from or dependent on railway station technologies.

3.3.2.1 Interactive canes

Figure 24: a) I Cane, b)Batcane, c)BAT 'K' sonar cane, d)PRIMPO Korean iSONIC cane
Source: a) (I Cane Intelligence in a cane, 2009), b) (Griffiths, 2003), c) (Bay Advanced Technologies, 2006), d) (Jeff (BrailleWorks Blog Admin), 2010)

Description:

Interactive walking canes (see Figure 24) use various positioning technologies such as ultrasonic, or sonic, to detect surrounding objects and feed the location of the object back to the user either in the form of pressure on the hand holding the device or as voice feedback. Various devices exist commercially and some canes also include GPS navigation so that the user can be positioned within the larger context of the city layout. Depending on the device coverage, area and functions can vary.

Various devices include those corresponding to the picture above: stitching I-cane (I Cane Intelligence in a cane, 2009), Batcane (Griffiths, 2003), BAT 'K' sonar cane (Bay Advanced Technologies, 2006), **and** PRIMPO's Korean iSONIC cane**,** (Jeff (BrailleWorks Blog Admin), 2010).

Compatibility with existing technology:

Canes are compatible with existing technology within a train station.

Standards:

There are no existing Australian standards for interactive canes. However as a technology aid for the disabled it does need to conform to AS EN 12182-2001 Technical aids for disabled persons – General requirements and test methods.

Areas for further consideration:

Interactive canes could be highly beneficial for customers who are blind, vision impaired, or deafblind, as these canes give a tactile indication of the object surrounding the person. This is a personal device, so the cost of the device is a consideration, and negotiation with the government for rebates may be possible. As this technology is easy to use, it could be integrated with an indoor positioning system, with interactive maps or other technologies.

3.3.2.2 Indoor positioning systems

Description:

Positioning systems such as the global positioning system (GPS), which is widely used in outdoor navigation, is satellite-based and cannot be used for indoor navigation because line of sight transmission between receivers and satellites needed for GPS operation is not possible. Finding a position system for indoor environments is more complicated as there are more obstacles such as walls, equipment, and human beings, which influence the propagation of electromagnetic waves in the environment. Electromagnetic waves lead to multi-path effects which interrupt the positioning system. Indoor positioning systems (IPSs) are defined as systems that continuously determine the position of something or someone in an indoor physical space (Gu, Lo, & Niemegeers, 2009). IPS should work all the time unless the user turns off the system. IPSs have already been used in hospitals where expensive equipment needs to be tracked inside a complex hospital environment.

Various types of IPS exist. They consist of:

1. Hardware: including transmitters and receivers which use technology such as infrared, and ultra-sound. This performs measurements of the location of the receiver.
2. Software: which converts the data reported from the location sensing system into a user friendly presentation.

Various Types of Indoor Positioning Systems:

Infrared positioning system

Infrared (IR) positioning systems are the most widely available positioning systems. IR technology is currently used in TV remote controls printers, mobile phones, PDAs etc. IR positioning systems need line of sight between the transmitters and receivers. Strong light sources can interfere with the IR technology so this limits the range within a room (Casas & Cuartielles, 2007).

Products using IR in positioning systems include:

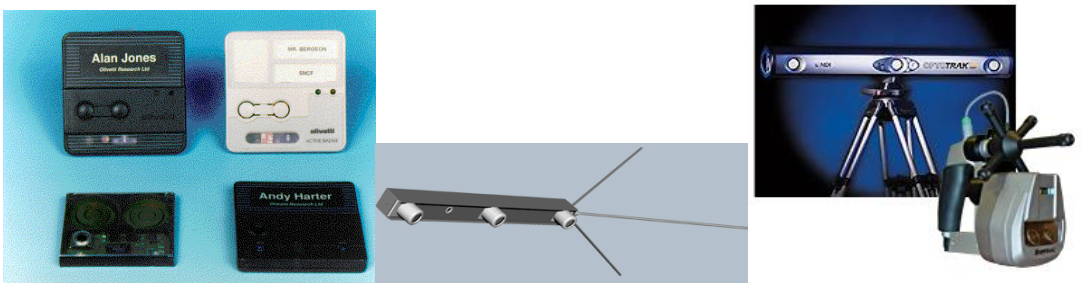

Figure 25: a) Acitve badges, b) Firefly, c) OPTOTRACK PRO
Sources : a) http://www.cl.cam.ac.uk/research/dtg/attarchive/thebadge.html,
b) http://www.gesturecentral.com/firefly/FireflyUserGuide.pdf, c) http://www.ndigital.com/industrial/optotrakproseries-family.php

Products using the IR positioning system include (see Figure 25):

1. *Active Badge*: provides location information of each active badge, such as the room where the active badge is located. Sensors are mounted in the room to detect the location of the Active Badge and so the accuracy of the Active Badge is restricted to room size. No commercial product of the active badge system is available.

2. *Firefly*: an IR-based motion capture system where multiple interconnected tags emit IR and are captured by the IR cameras so that a 3-D image of the person or object's movement can be seen. Firefly has an accuracy of 3.0mm, however the system is not practical for everyday wear due to the interconnected tags and the number of cameras needed to cater for a public building.

3. *OPTOTRAK PRO* series: similar to the Firefly, as it is also a motion capture IR system, consists of three cameras as a linear array to track the 3-D position of numerous marks on an object. This covers a volume of 20 m^3 where the markers emit IR light. The IR light is detected by the camera and used to estimate the person's location. Similar disadvantages to the Firefly device exist.

4. *Infrared Indoor Scout Local Positioning System (IRIS_LPS)*: similar to the Firefly and OPTOTRACK PRO it is an optical IR local positioning system. Stationary mounted stereo-cameras receive IR signals from IR emitting tags. Accuracy of the IRIS_LPS is about 16 cm covering an area of 100m^2 which is a larger coverage area than both Firefly and OPTOTRACK.

Ultra-sound positioning system

An ultrasound signal provides a positioning measurement. It can be combined with Radio Frequency signals to increase its coverage area. However, ultrasound based positioning systems have lower measurement accuracy than IR systems and also suffer from reflected ultrasound signals and other noise sources, and interference such as from metal objects, etc.

Products using Ultrasound in positioning systems include (see Figure 26):

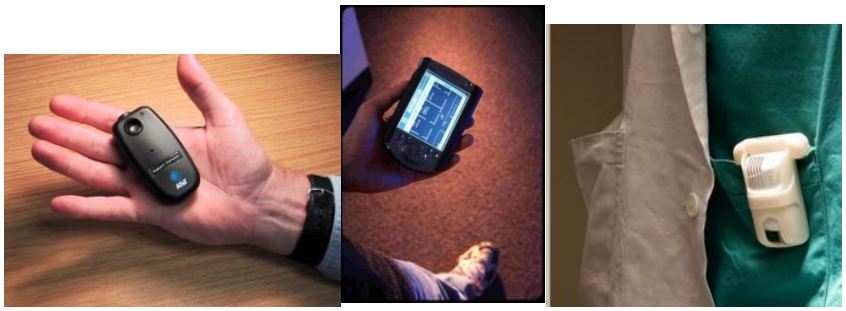

Figure 26: a) Active Bat, b) Cricket, c) Sonitor
Sources: a) http://www.cl.cam.ac.uk/research/dtg/attarchive/bat/, b) http://cricket.csail.mit.edu/
c) http://www.sonitor.com/technology/tags/e-tag

1. *Active Bat*: is an ultrasonic technology and triangulation location technique used to measure the location of a tag carried by a person. A tag periodically broadcasts a short pulse of ultrasound which is received by a matrix of ceiling mounted receivers at known positions. At least 3 receivers sensing the broadcast are needed to calculate the 3-D position of the tag. 720 receivers are fixed on the ceiling to cover an area of 1000 m^2, where 75 tags can be tracked with an accuracy of about 3cm. The number of receivers needed for the system to function effectively is not cost effective for large public buildings.

2. *Cricket*: is an ultrasonic technology that uses time of arrival triangulation to locate a target. In contrast to the Active Bat, ultrasonic emitters are attached to the infrastructure on walls or ceilings. The receiver is carried on the person or object. This provides privacy for the user by performing all the position triangulations on the object, so that the person owns their location information. Cricket emitters can also

transmit radio frequency messages for synchronisation of the ultrasonic triangulation measurements and forwarding their location information, so that if there are not enough emitters for the location calculation, the receiver can use the information forwarded by the radio link to calculate the proximity location.

3. *Sonitor*: similar to the Active Bat the emitter is located on the person or object, and the receiver is embedded in the infrastructure. It also uses existing wired or wireless technology to synchronise and forward triangulation methods. Sonitor has similar disadvantages to the Active Bat as it needs multiple receivers for accurate triangulation to exist.

Radio Frequency Positioning System

Radio Frequency (RF) positioning systems use radio waves to form a position measurement. Radio waves can travel through walls and human bodies easier than IR, so RF positioning systems have a larger coverage area and require less hardware compared with other systems. Several different types of systems exist, which are differentiated by their coverage range. See Figure 27 below and IEEE standards for operation and design purposes. All the various RF technologies can be used in conjunction with other technologies as a personal indoor positioning system.

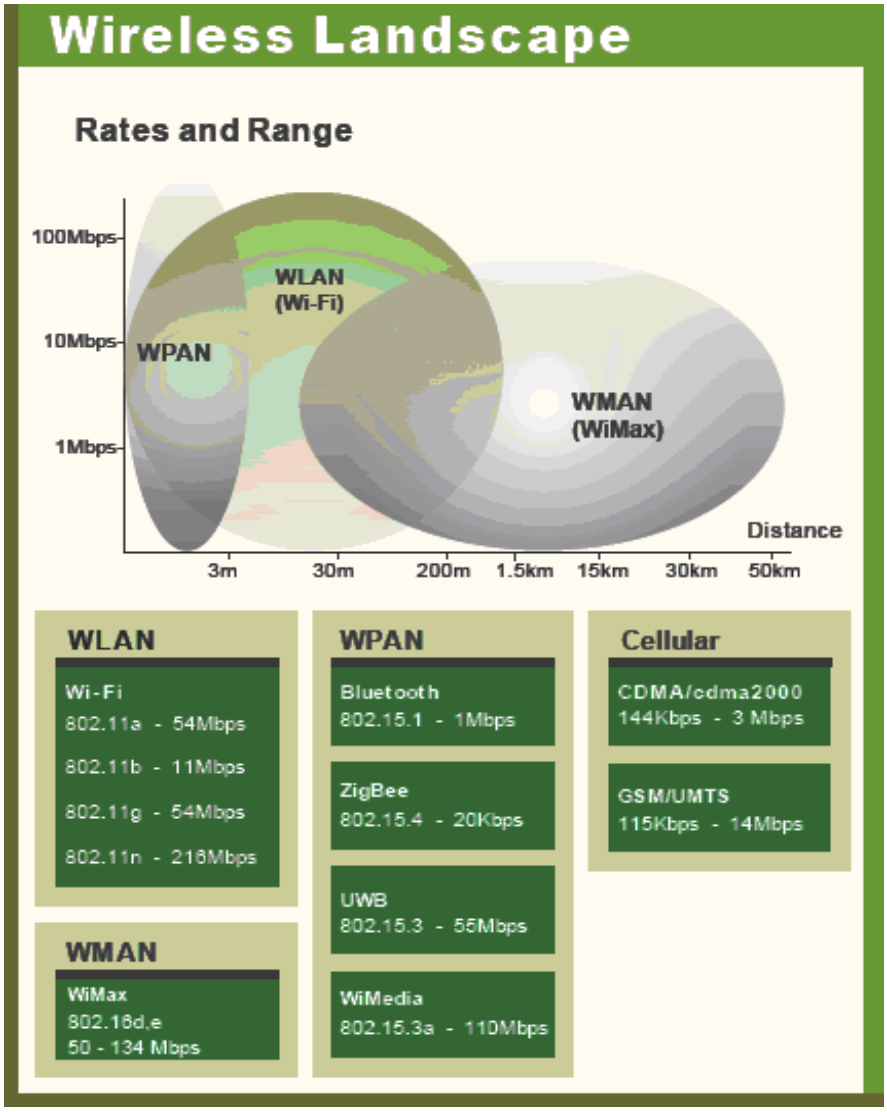

Figure 27: Coverage range of various RF bands

Source: http://www.networkdictionary.com/Wireless/Comparison-of-WLAN.php

Products using RF in positioning systems include (see Figures 28, 29, 30 and 31):

1. *Radio Frequency Identification (RFID):* comes in two types, passive and active. Passive RFID has the tracked tag as the receiver, active RFID has the tags as the transceivers. Passive RFID's are smaller and less expensive, however coverage range is shorter. Active RFIDs have larger coverage but are larger and more expensive. Currently passive RFIDs are used as an alternative to barcodes in tracking various pieces of equipment and livestock. Various types of RFID technology are used in different industry areas with different frequencies which are described in Table 3 below.

Table 3: Characteristics and applications of various RF bands

Frequency Band	Characteristics	Typical Applications
Low 100-500 kHz	Short to medium read range Inexpensive low reading speed	Access control Animal identification Inventory control Car immobiliser
Intermediate 10-15 MHz	Short to medium read range potentially inexpensive medium reading speed	Access control Smart cards
High 850-950 MHz 2.4-5.8 GHz	Long read range High reading speed Line of sight required Expensive	Railroad car monitoring Toll collection systems

Source: http://www.adilam.com.au/RFID/RFIDPrimer.pdf

Figure 28: WhereNet RFID IPS

Source: http://www.cisco.com/en/US/docs/solutions/Enterprise/Mobility/wifich6.html

WhereNet is a commercially available RFID indoor positioning system product offered by Zebra Technologies (http://zes.zebra.com/solutions/index.jsp).

2. *Wireless Local Area Network (WLAN*): WLAN infrastructure is already prevalent within Australian capital cities. Therefore implementation of WLAN IPS would not be as difficult as other IPSs which need more infrastructure investment. The accuracy of WLAN location estimations is dependent on the signal strength of WLAN which can be affected by orientation of the human body, other physical objects and the number of access points. The accuracy of WLAN IPS can be improved if signal strength is mapped within the specific locations so uneven coverage is pre-calculated. This improves the location accuracy as signal strength is used to calculate location (further away areas have a weaker signal). Pre-calculation accounts for areas with weaker signals because of obstructions rather than distance.

Figure 29: Ekahau WLAN IPS
Source: http://ekahau.wordpress.com/

RADAR, Ekahau, and COMPASS are examples of commercially available WLAN IPS. Ekahau and COMPAS use Wi-Fi (Wireless Fidelity trademark) as the WLAN technology.

3. *Wireless Personal Area Network (WPAN):* WPAN coverage is less than WLAN. The most famous and prevalent form of WPAN technology is Bluetooth, which is used in laptop computers, mobile phones and various other personal aids. Probability of the customer already owning technology that uses WPAN technology is more than the other technologies. If WPAN can be combined with IR technology the accuracy and utilisation would provide greater capacity.

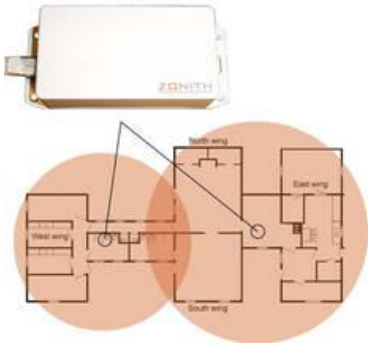

Figure 30: Zonith WPAN IPS
Source: http://www.zonith.com/products/zonith-indoor-positioning-module/

Zonith is a commercially available WPAN positioning system.

4. *Ultra-wideband (UWV):* this RF technology uses pluses of short duration (typically less than 1 nanosecond per pulse), which makes it possible to filter out reflected signals (distortion of radio signals due to reflection by the walls or other objects) from the original signal. This offers greater accuracy than the other RF technologies. UWV also has the advantages of not needing line of sight and has better wall penetration ability. However there is a greater investment in this technology as UWV transmitters are already set up in the public domain and personal technologies do not include UWV receivers.

Figure 31: Ubisense UWV IPS
Source: http://www.ubisense.net/en/about-us/media.html

Ubisense is a commercially available UWV product.

Sensor Networks

For other devices that use physical or environmental phenomena to locate the object (see Figures 31, and 32), the working element could be pressure, sound, temperature or light, etc. Like IR technology, sensors can be active or passive. Where active, sensors can interact with the environment and passive sensors only receive information

from the outside world. The sensor based positioning system also consists of a large number of sensors fixed in predefined locations like the IR and RF positioning systems.

1. *Magnetic positioning system*: uses pulse magnetic fields to simultaneously locate sensors. Magnetic IPS has one main advantage over the RF IPS, as the magnetic positioning signal can travel through walls and other obstacles. However, the disadvantage is that the coverage range of the magnetic position system is limited to a couple of meters.
   - The MotionStar Wireless system is an example of a commercially available magnetic IPS.

Figure 32: MotionSTAR magnetic IPS
Source: http://www.ascension-tech.com/realtime/MotionSTARWirelessLITE.php

2. *Vision based positions system*: video imaging and camera based equipment are used as an IPS. The main advantage of using vision based IPS is that unlike all the other positioning systems it does not need a receiver or tag to locate the object. The main disadvantage of a vision based IPS is the computational processing time which is needed to track each person, and the position of the person is dependent on the device processing each frame of the image. The more time taken to process the image the more inaccurate is the position of the person, as the person may have moved in the time that it took for the image to be processed and therefore their actual position can be quite different from the position that the system has calculated. Another disadvantage is that the quality of the positioning system is dependent on the lighting conditions and when the person becomes less visible they become harder to track.

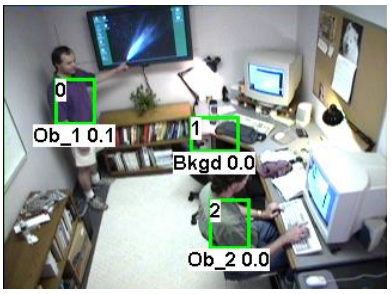

Figure 33: Vision based IPS
Source: http://research.microsoft.com/en-us/um/people/marycz/el.doc

Microsoft Easy living is an in progress vision based IPS

3. *Audible sound position system*: uses audible sound to track the position of the person. This utilises mobile phones which have become prevalent in current Australian society. The positioning system can track a particular sound that is available on these devices for indoor positioning. In this way the advantage is that wearable tracked tags are also not needed, and the computation time of triangulation is greatly reduced compared to a visual based positioning system. The main disadvantages of audible sound are that it can get interference from other sounds within the environment and it does not have penetration ability, so sensors need to be placed in every room. Currently there are no commercially available products but 'Beep', an audible sound IPS, is being developed, source link provided below:
   http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=1405195&tag=1

Table 4: IPS product comparisons on security and privacy, cost performance and robustness

System Name	Security and Privacy	Cost	Performance	Robustness
Active Badge	No	Reasonable price with cheap tags and sensors	Room level accuracy	Line of sight requirements and influence from light source
Firefly	No	A tag controller and 32 tags cost $27,500	Error range below 3.0mm; high positioning frequency; short delay	Influence from light source
OPTOTRAK	No	Expensive	An accuracy of 0.1mm to 0.5mm with 95% probability	Line of sight requirement
IRIS_LPS	No	Less than Firefly and OPTOTRAK	Error range is 16 cm; IRIS_LPS is more accurate than Firefly and OPTOTRAK	IRIS_LPS can only locate a static object with acceptable accuracy. For moving objects, the system needs to be improved
Active Bat	No	Expensive	Accuracy is about 3cm with 95% probability	Influenced by reflection for and obstacles between a tag and receiver
Cricket	Yes	Cheap	An accuracy of 10cm and an orientation accuracy of 3^{o}	Good
Sonitor	No	Inexpensive	Room level accuracy	Hidden targets can be tracked
WhereNet	No	Not cheap	Error range of 2m to 3m; position estimation frequency is very 5seconds to 1hour	Instead of using RFID technology in positioning magnetic signals are used to give the location zone of a tracked target.
RADAR	No	Research-oriented solution - no products	Accuracy is about 4m with 50% probability	As the accuracy is low, the position measurement are not reliable
Ekahau	No	Inexpensive	Accuracy is up 1m and the system can simultaneously track thousands of devices	Only if there are enough APs (more than3) , the system can locate a target with an accuracy of up to 1m
COMPASS	No	Inexpensive	Accuracy is about 1.65m	The system considers the human body blocking effect and use digital compasses to improve the performance
Topaz	No	Expensive	Error range is about 3m to 3m, room level accuracy	Using Bluetooth and IR technologies at the same time to achieve higher robustness
OPT	No	Cheap	Error range is about 1.5m to 3.8m	The system needs at least three sensor

				measurements to locate target
Ubisense	No	An active research package containing 5 tags and 4 sensors cost $18,354	Accuracy is about 15cm with short location estimation delay	Good
MotionStar	No	Expensive magnetic trackers	Accuracy is about 1cm, both the position and orientation are estimated	Influenced by metal elements
Easy living	No	Inexpensive stereo cameras are used	System accuracy cannot be guaranteed due to various interference sources	System is not reliable in a dynamic changing environment
Beep	Yes	Inexpensive sensors	Accuracy is up to 0.4cm with 90% probability	Influenced by sound sources in the same place

Source: (Gu et al., 2009)

Table 5: IPS product comparisons on complexity, user preference, availability and limitations

System Name	Complexity	User Preference	Availability	Limitations
Active Badge	Low	Active badges are lightweight and have acceptable sizes; the battery life is about half to one year	Not available	Absolute location information is not available
Firefly	Low	Tag controller and tags are not comfortable to be worn, because they are wired	Commercially available	Scope of the system is limited to within 7m
OPTOTRAK	Low	No battery; the emitters are small and wired connected to the power supply	Commercially available	Limited coverage area
IRIS_LPS	Low	No battery; emitters are small	Not available	A trade-off between accuracy and coverage
Active Bat	Lots of receivers need to be mounted on the ceiling	Battery life is about 15 month	Not available	Deploying large numbers of sensors on the ceiling for each room is a time-consuming task
Cricket	Low	The object receiver consumes more power, because the position calculation is done by itself	Not available	Movie device's power consumption
Sonitor	Numerous detectors fixed in each place of tracking area	Tags are small and lightweight; the battery life can last up to 5 years	Commercially available	System cannot give absolute position measurements
WhereNet	Complex	Tags are small, lightweight and long battery life of up to 7 years	Commercially available	Accuracy of the system is not good

RADAR	System uses PCs and APs and does not address issues with installation and maintenance	System uses laptops as tracked targets and does not consider the user preference	Not available	The system does not take advantage of the existing WLAN infrastructure in indoor environments
Ekahau	System reuses the WLAN infrastructure; the system needs several hours on site install	Any WiFi device can be used as a tracked target; the tags are small, lightweight; the battery life is up to 5 years	Commercially available	System needs site calibration time in the installation phase
COMPASS	System reuses the WLAN infrastructure	A device located at the end-user should contain a digital compass	Not available	System does not give real-time tracking services
Topaz	There are many IR APs and servers needed to be installed	The tracked tags need to be recharged every week	Commercially available	Delay of calculating the position of a tag is long (around10s-30s)
OPT	Low	The tracked T-motes are small and lightweight, but its battery life is not long	Not available	Location measurement is not reliable
Ubisense	Low, only sensors are used as infrastructure and four sensors can cover an area of 400 m^2	Tracked tags are small and lightweight with battery life around 1 year	Commercially available	The UWB technology is new and the price of the system is high
MotionStar	Small coverage area with 3m in length; it is not scalable	Tracked sensors are connected via wire to RF transmitters; RF transmitters are heavy (about 1kg) to wear; the battery life is around 1-2 hours	Commercially available	The system is designed for short range mobility tracking
Easy living	Low, for example, two stereo cameras can cover a single room	The users do not need to carry any positioning device	Commercially available	Image processing is complex and needs substantial processing power
Beep	Not complex	Users can use their own devices such as PDA, mobile phone, etc, as positioning devices	Not available	The audible sound technology is influenced by sound noise in indoor environments

Source: (Gu et al., 2009)

Compatibility with existing technology:

Systems that use radio waves like those that are Wi-Fi compatible can be easily implemented as they use existing WLAN networks. See Tables 4 and 5 for product comparisons.

Standards:

Standards that govern the technical aspects of wireless technology are published by the Institute of Electrical and Electronics Engineers and are listed below.

Table 6: Standards of Wireless technology

IEEE standard	Technology	Brief Description
802	Overview	Basics of physical and logical networking concepts.
802.1	Bridging	LAN/MAN bridging and management. Covers management and the lower sub-layers of OSI Layer 2, including MAC-based bridging (Media Access Control), virtual LANs and port-based access control.
802.2	Logical Link	Commonly referred to as the LLC or Logical Link Control specification. The LLC is the top sub-layer in the data-link layer, OSI Layer 2. Interfaces with the network Layer 3.
802.3	Ethernet	"Grandaddy" of the 802 specifications. Provides asynchronous networking using "carrier sense, multiple access with collision detect" (CSMA/CD) over coax, twisted-pair copper, and fiber media. Current speeds range from 10 Mbps to 10 Gbps.
802.4	Token Bus	Disbanded
802.5	Token Ring	The original token-passing standard for twisted-pair, shielded copper cables. Supports copper and fiber cabling from 4 Mbps to 100 Mbps. Often called "IBM Token-Ring."
802.6	Distributed queue dual bus (DQDB)	"Superseded **Revision of 802.1D-1990 edition (ISO/IEC 10038). 802.1D incorporates P802.1p and P802.12e. It also incorporates and supersedes published standards 802.1j and 802.6k. Superseded by 802.1D-2004."
802.7	Broadband LAN Practices	Withdrawn Standard. Withdrawn Date: Feb 07, 2003. No longer endorsed by the IEEE.
802.8	Fiber Optic Practices	Withdrawn PAR. Standards project no longer endorsed by the IEEE.
802.9	Integrated Services LAN	Withdrawn PAR. Standards project no longer endorsed by the IEEE.
802.10	Interoperable LAN security	Superseded **Contains: IEEE Std 802.10b-1992.
802.11	Wi-Fi	Wireless LAN Media Access Control and Physical Layer specification. 802.11a,b,g,etc. are amendments to the original 802.11 standard. Products that implement 802.11 standards must pass tests and are referred to as "Wi-Fi certified."
802.11a		• Specifies a PHY that operates in the 5 GHz U-NII band in the US - initially 5.15-5.35 AND 5.725-5.85 - since expanded to additional frequencies • Uses Orthogonal Frequency-Division Multiplexing • Enhanced data speed to 54 Mbps • Ratified after 802.11b
802.11b		• Enhancement to 802.11 that added higher data rate modes to the DSSS (Direct Sequence Spread Spectrum) already defined in the original 802.11 standard • Boosted data speed to 11 Mbps • 22 MHz Bandwidth yields 3 non-overlapping channels in the frequency range of 2.400 GHz to 2.4835 GHz • Beacons at 1 Mbps, falls back to 5.5, 2, or 1 Mbps from 11 Mbps max.
802.11d		• Enhancement to 802.11a and 802.11b that allows for global roaming • Particulars can be set at Media Access Control (MAC) layer
802.11e		• Enhancement to 802.11 that includes quality of service (QoS) features • Facilitates prioritization of data, voice, and video transmissions
802.11g		• Extends the maximum data rate of WLAN devices that operate in the 2.4 GHz band, in a fashion that permits interoperation with 802.11b devices • Uses OFDM Modulation (Orthogonal FDM) • Operates at up to 54 megabits per second (Mbps), with fall-back speeds that include the "b" speeds
802.11h		• Enhancement to 802.11a that rsolves interference issues • Dynamic frequency selection (DFS) • Transmit power control (TPC)
802.11i		• Enhancement to 802.11 that offers additional security for WLAN applications

		• Defines more robust encryption, authentication, and key exchange, as well as options for key caching and pre-authentication
802.11j		• Japanese regulatory extensions to 802.11a specification • Frequency range 4.9 GHz to 5.0 GHz
802.11k		• Radio resource measurements for networks using 802.11 family specifications
802.11m		• Maintenance of 802.11 family specifications • Corrections and amendments to existing documentation
802.11n		1. Higher-speed standards -- under development 2. Several competing and non-compatible technologies; often called "pre-n" 3. Top speeds claimed of 108, 240, and 350+ MHz 4. Competing proposals come from the groups, EWC, TGn Sync, and WWiSE and are all variations based on MIMO (multiple input, multiple output)
802.11x		• Misused "generic" term for 802.11 family specifications
802.12	Demand Priority	Increases Ethernet data rate to 100 Mbps by controlling media utilization.
802.13	Not used	Not used
802.14	Cable modems	Withdrawn PAR. Standards project no longer endorsed by the IEEE.
802.15	Wireless Personal Area Networks	Communications specification that was approved in early 2002 by the IEEE for wireless personal area networks (WPANs).
802.15.1	Bluetooth	Short range (10m) wireless technology for cordless mouse, keyboard, and hands-free headset at 2.4 GHz.
802.15.3a	UWB	Short range, high-bandwidth "ultra wideband" link
802.15.4	ZigBee	Short range wireless sensor networks
802.15.5	Mesh Network	• Extension of network coverage without increasing the transmit power or the receiver sensitivity • Enhanced reliability via route redundancy • Easier network configuration - Better device battery life
802.16	Wireless Metropolitan Area Networks	This family of standards covers Fixed and Mobile Broadband Wireless Access methods used to create Wireless Metropolitan Area Networks (WMANs.) Connects Base Stations to the Internet using OFDM in unlicensed (900 MHz, 2.4, 5.8 GHz) or licensed (700 MHz, 2.5 – 3.6 GHz) frequency bands. Products that implement 802.16 standards can undergo WiMAX certification testing.
802.17	Resilient Packet Ring	IEEE working group description
802.18	Radio Regulatory TAG	IEEE 802.18 standards committee
802.19	Coexistence	IEEE 802.19 Coexistence Technical Advisory Group
802.20	Mobile Broadband Wireless Access	IEEE 802.20 mission and project scope
802.21	Media Independent Handoff	IEEE 802.21 mission and project scope
802.22	Wireless Regional Area Network	IEEE 802.22 mission and project scope

Source: http://searchmobilecomputing.techtarget.com/definition/IEEE-802-Wireless-Standards-Fast-Reference

Areas for further consideration:

The technology is twofold: not only does the railway company have to install the infrastructure of signal generators or receivers but the customer also needs to purchase or have access to the tracking device that corresponds to the infrastructure investment. There needs to be a consensus on which system would best suit the railway industry, as installing more than one system would be overly expensive. Disability advocates and the disabled community should be consulted before any widespread system is accepted.

A comparison of all the technologies described (Gu et al., 2009) is listed above. For a train station environment, audible sound and visual based IPS would not be desirable, as the environment includes a lot of dynamic elements that would disrupt its operation. The other IPS such as IR and RF could be considered as a viable optioning of indoor positioning within large train stations, however, again the implementation is dependent on the users and the railway company.

4.3.2.3 Barcodes and smart phones

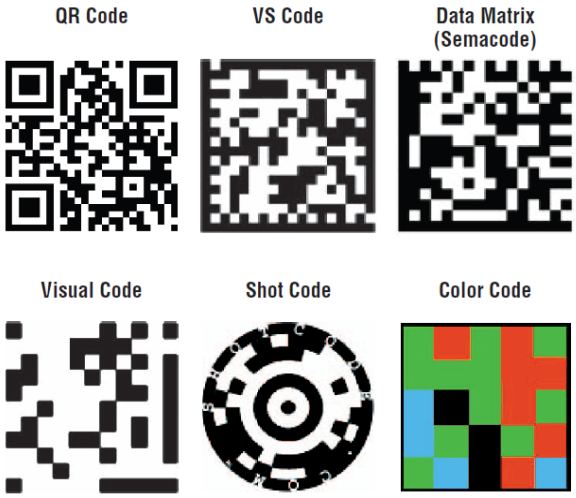

Figure 34: a) QR code, b) VS code, c) Data Matrix, d) Visual code, e) Shot code, f) Colour code
Source: (Kato & Tan, 2007)

Description:

There is widespread use of barcodes (see Figure 34) in supermarkets and various other stores. These barcodes are made up of intervals of black lines and white spaces, and are usually read by a special scanner which accesses a database producing the information about the product for the register. In order to read the information on these supermarket (1 dimensional) barcodes, specific imaging scanners are required. If used by an incompatible scanner, distortion of the image can result. 2-dimensional (2D) (see Figure 34) barcodes are more robust and can be used in conjunction with camera phones as the scanner. This technology has been developed over the past 2 decades. There are 2 types of 2D barcodes: a portable database and the index to a database (Kato & Tan, 2005). Some smartphones have the technology to decode the barcode, whereas other codes can be processed by the phone. Some need to be sent over the internet as a picture message and a replying text message will ensue. There are approximately 60 different 2D barcodes which are in circulation - 6 representative examples of 2D barcodes are shown in the image above**.**

Compatibility with existing technology:

2D barcodes would be compatible with existing technology as they are already being used in promoting campaigns and a QR code reader is available through Telstra http://www.qrious.com.au/. Various other internet sites let the user design their own 2D barcodes for free. Therefore, implementing this technology would not be difficult.

Standards:

There are no Australian standards on this product. However QR codes are subject to ISO/IEC18004.

Areas for further consideration:

The main issue with implementing a 2D barcode system is positioning the codes in easily accessible locations. The image of the code needs to be taken at quite a close distance so as to minimise distortion and uneven lighting effects. Some codes like the short code have a maximum picture distance of 10cm for the 2.5cm^2 code. This could be problematic at train stations where the passengers travel quite a distance from the walls. Similar problems are likely to be faced by blind or vision impaired customers who would have difficulty trying to locate the barcode. Used in conjunction with traditional wayfinding technologies this could be an inexpensive alternative to more signage.

4.3.2.4 Pen and paper

Figure 35: Pen and writing pad
Source: http://blog.talent-shout.com/?p=74

Description
Pen and paper (see Figure 35), if used correctly, can be a wayfinding aid in communicating with the station staff or other customers. A deaf person can write down their questions and a staff member who does not understand sign language or what someone is saying can communicate with them by writing down the question or requested directions. A vision impaired person may place the written message close to their eyes so as to read the writing more clearly.

Compatibility with existing technology:

This is compatible with existing technology.

Standards:

There are no standards for this technology.

Areas for further consideration:

Pen and paper can be placed near ticket counters and at positions where station staff are located. It is a cost effective communication tool for people who are deaf or hearing impaired, and for people with vision impairment.

4. Discussion on Implementation

Usually, the most cost-effective wayfinding system is one that enables people with disabilities to find their way around an environment, by using the same routes as everyone else, as easily as people without disabilities. Environments developed with the needs of physical, sensory and cognitive impairments in mind will also result in much easier environments for all users (Enterprise IG Information Design Unit, 2005).

4.1 Standardised placement and solution choice

As identified in this report, people generally follow similar wayfinding strategies while the disabled passenger makes various adjustments depending on their impairments. Therefore, when deciding on implementing solutions it is extremely important to make the wayfinding environment as familiar and predictable as possible. Customers who know what to expect can travel with greater ease and with greater efficiency than in environments that change unexpectedly, or have inconsistent layouts and services. Easy to use and access systems that have consistent facilities, services, signs and layouts can also improve the railway transport image and public perception. Therefore solutions need to be standardised and systematically implemented for each train station.

Preferred layouts have clear, well defined pathways that are well illuminated and acoustically quiet. They contain open spaces, generous corners, automated doors, and strategically placed glass walls and doors. Landmarks and the use of colour coding certain areas can help to orientate passengers. Exits and access points need clear identification and warnings need to be in a variety of modalities. Visual (strobe) and audible (alarm) indicators are a must and, where possible, there should also be tactile indicators (vibration). Exit points need warnings in case of oncoming vehicles or traffic.

The placement and location of information stations, ticket offices, directions, maps, clocks, etc. once chosen should be of a standard type and should be positioned in predetermined standard locations. Information stations are good ways to cater for everyone without too much information.

4.2 Implementation with situational awareness

Figure 36: Information kiosk with glare
Source: Personal photo, Brisbane international airport

During the implementation process, selected technologies or solution aids need to be positioned with awareness of local activities, traffic flow, and other facilities. Position selection can be just as important as

selection of the solution itself. Facilities that provide audio messages, or require speaking and listening to an attendant or on a telephone, need to be positioned away from busy and noisy areas. Ticket vending machines and ATMs need to be facing away from busy pathways. Someone trying to access a vending machine could easily be bumped or pushed over if the machine causes the person to stand in the space of a moving crowd.

Interactive information stations adjacent to facilities with bright lights might be subject to glare and therefore become difficult to use, as illustrated in Figure 36 of the information kiosk at the Brisbane International Airport. The lights used to draw attention to the two stores adjacent to the kiosk produced considerable glare - finding information was close to impossible, particularly for those with reduced visual acuity.

4.3 Unforeseen factors effecting implementation

4.3.1 Vandalism

Unfortunately, many assistive devices and technologies are subject to vandalism. Barcodes, for instance can be beneficial for commuters but they can be easily vandalised and destroyed. Train stations can attract people who behave in anti-social ways, giving the perception that rail travel is unsafe, therefore negatively affecting patronage. People's perceptions of train stations can either encourage or discourage use of the facilities. Public confidence is influenced by perceptions of safety, crime, violence and anti-social behaviour at train stations and their surroundings (Village Well, 2006). In Australia, vandalism costs millions each year to rectify (Beckinsale, 2009). Well-designed public spaces can discourage inappropriate behaviour and loitering, making train stations safer places for all customers. Well-designed public spaces can also encourage positive mental health (Village Well, 2006) which can improve concentration and wayfinding for those with mental health disorders and cognitive impairment.
By beautifying a train station with community art projects (see Figure 38), it not only enhances a station's appearance, it can replace and discourage graffiti and vandalism, support social programs that encourage freedom of discrimination and cultural exchanges, foster custodianship, increase safety and deter crime, increase positive social interaction, and importantly increase patronage (Village Well, 2006).

Figure 37: a) Platform art Algate East, London, b) Platform art St Kilda, Melbourne
Source: a) & b) (Village Well, 2006)

Aside from art, various other activities can actively discourage vandalism. It has been found that sandblasting vandalized glass beautifies bus stops and deters further vandalism (Village Well, 2006). Good lighting and regularly maintaining facilities also discourage further vandalism.

Figure 38: Classical music played at Brixton Station entrance
Source: (Brixton Tube, 2007)

It has been found that playing 'uncool' classical music at station entrances can deter anti-social behaviour and loitering of undesirable people (see Figure 38). In 2005, classical music trials were run at four East London stations resulting in a 33% drop in abuse against staff. Researchers concluded that the drop in mainly young teenagers hanging about at stations was because the music was unfamiliar to them and it was considered 'uncool' (Brixton Tube, 2007).

One of the main reasons why vandals are able to destroy train stations is because some of them are unmanned. It has been noted that since Melbourne shifted to an operating system of unmanned train stations, the stations have suffered at the hands of vandals, drunks and idle minded people (Beckinsale, 2009). When stations are not staffed the likelihood of vandalism is higher.

4.3.2 Misuse

Systems that are new, different and unfamiliar to people may accidentally be misused, resulting in unwanted outcomes, or breakage of the item (Burnham, 2009). Well designed objects are intuitive and instructions should not be needed (Norman, 1998). However, to guard against misuse, when implementing a new technology, it is important to ensure all staff are fully trained in the use and operation of the new device (e.g. information station, ticket machine, etc) and that direct, easily understood instructions are located on the device if required. When a device is first installed, trained staff should be present to help facilitate and monitor proper use of the device. Over time, as people do not require as much help to use the device, less monitoring is necessary.

4.4 Maintenance and upgrades

With passive technologies, like colour coding and art works, these need virtually no upgrades and less maintenance than the dynamic technologies. Mosaics and art works would not need any more maintenance than the general cleaning and maintenance for all wall spaces in a station. However, as mentioned in the previous section on vandalism, maintenance may become more frequent if vandalism takes place.

Dynamic technologies that rely on telecommunication advance at a rapid rate, and so conducting an audit of new technology every few years is desirable. However, most telecommunication technologies can be used for 10 to 20 years. For example, the mobile phone has changed greatly in appearance and has had many additional features added; however, the functionality of talking to another person on another phone has not changed. The 2G network in which mobile phones operate is still in use today. Maintenance of dynamic technology would depend largely on which technologies were chosen to be implemented. Indoor position systems would need relatively more maintenance than barcodes. Even so, this would be on a par with maintaining several computer systems at a public library.

4.5 Number of facilities

Relatively inexpensive passive aids should be implemented at each station in turn. Over time, colour and maps should also be made available at each station. This standardises the station facilities and lets the disabled passengers access every station.

For dynamic technological aids and facilities, a station to station audit should be conducted. The number of dynamic aids required at each station is dependent on the population who use the station and the size and complexity of the station. A detailed audit of the existing station and the peak flow capacity of each station needs to be undertaken before implementation.

5. Discussion

The project comprised a literature review of wayfinding to improve the use of the rail transport system for the disabled customer. Reviews were conducted on disability types and their needs in regards to wayfinding in Australia, and a review was conducted on the assistive technologies to aid their wayfinding, including infrastructural and personal technologies. Both passive and active technologies were examined. There are several limitations noted that are beyond the scope of this report. These limitations are mainly due to the lack of available information, or because no research has been conducted for this purpose in Australia. The following section sets out the limitations of the project, and outlines opportunities for further research that can be used to lay the foundation for a more accurate understanding of the needs of the disabled community in regards to using rail transport.

5.1 Limitations of the project and scope for further research

5.1.1 Train station layout and wayfinding

Although various wayfinding behaviours and strategies are outlined in Chapter 1 and Chapter 2, most of the existing research on wayfinding has been conducted in large university complexes, hospitals, hotels, or in virtual reality. No significant research on wayfinding in train stations has been conducted in Australia or overseas. While similarities exist between the various structures, it has not been established that the various behaviours identified also exist within the train station environment.

5.1.2 Disabled usage of train stations

Disabled customers are entitled to use the rail system as much as the general public. However, insufficient information is available on:

- the number of disabled customers
- the disabilities they experience
- the types of stations they use
- the periods of the day or week they prefer to travel.

This information is important because the locations with high concentrations of disabled customers may need more assistive aids than areas that experience no disabled customers. This is also important when scheduling trained rail personnel to be present at times at which more disabled customers use the station. Additionally, when making effective implementation decisions, consideration needs to be given to which personal aids disabled customers prefer to use and carry with them. Knowing what personal aids are used and to what extent affects the types and quantity of assistive technologies selected. Currently, information is also not available on how many more people wish to utilise the rail system. This information is useful when projecting future use and growth. Therefore, customer requirements needs further research to ensure that the availability of appropriate aids meets community needs.

5.1.3 Technology applicability

Many of the assistive technologies described in this report are either in the initial stages of development and not currently commercially available, or are designed for use by the general public. Although technologies have the potential to be transferable for use by a disabled customer, not all technologies have been tested for this purpose, or trialled by the disabled community. Further research trials need to be conducted, therefore, with the disabled community utilising some of the technologies intended for implementation.

5.1.4 Safety and accessibility of stations

The focus of this report has been on the wayfinding and navigational aspects of using the train station. To complete a successful journey, two other important requirements for a disabled customer are accessibility and safety. Examples of issues include: the train station may not contain passageways large enough to allow access for the disabled customer travelling in a large automated wheelchair, or it may not be physically safe for the customer to access the train station. Accessibility and safety of train stations therefore, needs to be discussed in further research as it was beyond the scope of this report.

6. Suggestions and solution implantation

To improve access to public railway transport this report has examined general wayfinding strategies used in Australia, barriers and obstacles people face and the possible solutions for reducing these barriers. From the findings, various suggestions are made based on good practice principles and the various needs of the customers. However, before committing to the implementation of a wayfinding solution for any particular station, it is desirable that a project plan be established. The following flowchart, Figure 39 illustrates the stages involved:

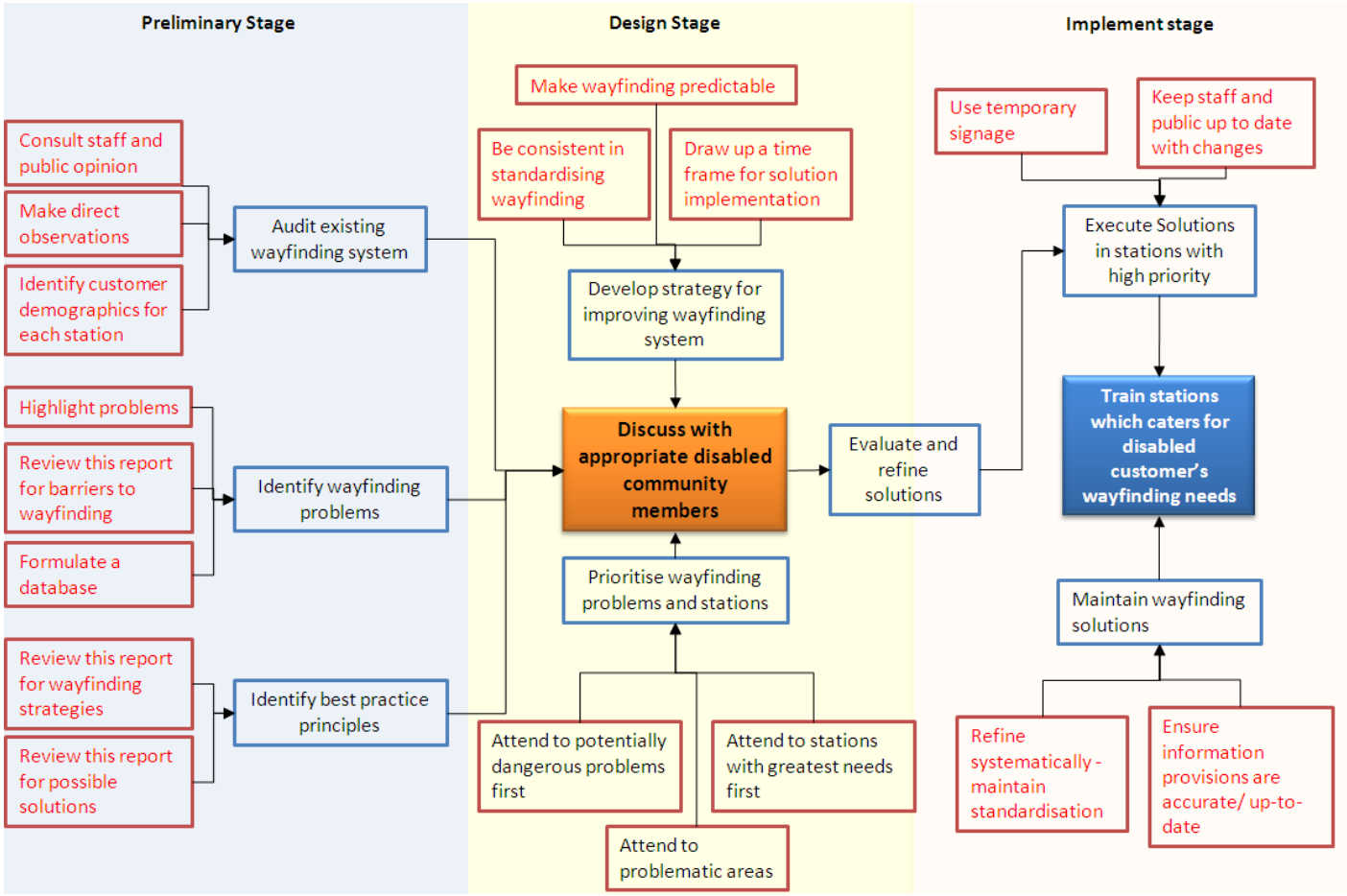

Figure 39: Design and implementation process flow chart

6.1 Technical aids for metropolitan stations

6.1.1 Background

Large metropolitan stations in Australian capital cities usually consist of several centrally located hub stations with different network lines emanating to various suburbs and regional areas. This has made metropolitan stations large and highly sectioned to accommodate the different train lines, tourist services and connecting bus services. Often these stations are located underground and integrated directly into a large shopping centre complex like that of Melbourne Central Station; or the station can take up several city blocks and have various exits to the different surrounding streets. These environments are as complex if not more so than any hospital or airport, however, unlike both airports and hospitals, train stations have far fewer staff and the corridors and pathways can be much narrower and harder to navigate; train stations are usually located in densely populated areas where space is a high commodity.

6.1.2 Solutions

Large metropolitan stations already have some signage which aids in wayfinding for the general public. While this is encouraging, more wayfinding features and technology can be included as detailed below:

Priorities for large metropolitan stations:

1. Trained staff: existing personnel should be made aware of the needs of people with various disabilities so that at all operational times the station has at least one staff member who can communicate with customers with disabilities and who understands their needs. (See Appendix C for tips on how to communicate with people with impairments.) Well-trained staff also need to know how to find information, know what and when facilities are available, and how to access these facilities. In general, it is desirable that more staff be made available in different areas of the stations especially at the different entrances.

2. Provide good information: all information sources need to be up-to-date and provide easy to read information, clear directions or instructions, and be provided in a variety of modalities to cater for individual preferences. Information should be available in the form of paper-based pamphlets, Braille pamphlets, electronic applications for mobile phones and personal technologies, and websites. If permanent changes in information on a particular station occur, these information sources should be updated. If the changes to the station are temporary, then real time updates via an electronic medium which is easily manipulated can be implemented. Staff need to be notified and brought up to date on any changes, alterations, or deviations from normal activity.

3. Passive solutions: are cost effective and easily implemented. Those which should be considered are:
   - update existing signage so it conforms to the new building code standards and the Australian standards for access
   - colour code passageways, either using strips of colour or colour indicators corresponding to the train platform
   - install Tactile Ground Surface Indicators as they are an effective way of indicating direction of travel and these could be colour-coded for use by non-blind customers. These indicators need to be placed appropriately and lead to relevant facilities or places
   - install architectural / visual cues, such as artwork on the walls, landmarks, or small defined sections of the station. These additions assist to distinguish the different sections of the station
   - provide layout maps of the station, showing levels and how to move between the levels. Information and directions to each platform should also be included

4. Dynamic solutions: although these may be more expensive than the passive solutions, when implemented successfully they can have a greater impact in aiding wayfinding for the disabled customer.

- having simple communication tools like a pen and paper for disabled customers to communicate with the staff member is an easy and often sufficient solution when other means are not possible
- implement multimodal information stations, providing information via voice, text, signage or tactile surfaces. These should be placed strategically about the station. Considerations would need to include the distribution of these stations and their density within the station complex as in the discussion in section 4.1 above
- install either Barcodes or an indoor positioning system with an application that can be accessed by smart phones and mobile devices. Both software applications for the various devices need to be developed in conjunction with the disabled community for use in large metropolitan stations. For installing an IPS, consideration would need to be given to locating enough transceivers over the station so that the receivers are within range. For barcodes, the issue would be ensuring the integrity of the image, as they may be easily vandalised and destroyed.

5. Standardisation of aid technologies: all technologies and aids, if implemented in one station, need to be standardised and implemented in similar locations in each station. If one technology is chosen over another, they need to be uniformly implemented.

6. Educate the public: The disabled community and the general public need to hear about the availability of particular technical aids, and at which locations and stations they exist. Media awareness campaigns are excellent ways to broadcast information quickly to the general public. In addition, the various disability associations and service providers should be notified about the improved service provisions and on how to locate railway services so that pertinent information is readily known and made available to assist their clients with enquiries. If documentation is provided to disability associations and service providers, these documents need to be maintained and reflect up to date information.

6.2 Technical aids for suburban and regional stations

6.2.1 Background

Suburban and regional train stations usually consist of a few platforms and cater at most for a few network lines in comparison with all the network lines of metropolitan stations. The suburban and regional train stations are above ground and usually have no more than two exits. Smaller suburban stations in Australia do not have permanent staff; pre-recorded train arrival information is broadcast over the PA system; public access to the bathroom facilities is non-existent out-of-hours and the timetable information is often vandalised. This in itself presents a whole different set of problems for the disabled customer trying to access relevant information.

The environments of metropolitan and suburban train stations are vastly different, and in regards to installing technology for disabled customers using these stations, consideration needs to be given to the challenges that the disabled customer would face in each situation. This section is therefore separated into technical aids for metropolitan stations and technical aids for suburban and regional stations. Of course any implementation of changes would need consultation with the disabled community and it is strongly advised that these suggestions be discussed with both the disabled community and the community at large before any investment or works begin.

6.2.2 Solutions

Suburban and regional stations have less complicated layouts compared to metropolitan stations. However smaller stations rarely have wayfinding signage as there are usually only one or two platforms, and there is usually only one main entrance to the station. The main concern is aiding the disabled customer in understanding which platform is the one they want and which disabled facilities are available at the particular station.
Priorities for suburban and regional stations:

1. Trained staff: small suburban stations rarely have permanent staff. This is problematic when signage is also inaccessible to the disabled customer making the station inaccessible for independent travel. A solution would be to station at least one staff member at each suburban station at all times, or at particular times of greatest demand. Staff need disability awareness training and need to be up-to-date on all services and facilities available at that station. (See Appendix C for tips on how to communicate with people with impairments.) If a station is not manned at all times, the times that a staff member is present needs to be made clear to customers on information provisions. Alternatively, multimodal signage could be introduced and improved at regional and suburban stations.

2. Provide good information: all information sources need to be up-to-date and provide easy to read information, clear directions or instructions, and provided in a variety of forms to cater for individual preferences. Information should be available in the form of paper based pamphlets, Braille pamphlets, electronic applications for mobile phones and personal technologies as well as websites should be available. If permanent changes in information on a particular station occur, these information sources should be updated. If the changes to the station are temporary, then real time updates via electronic media which is easily manipulated can be implemented. Station staff need to be notified and brought up to date on any changes, alterations, or deviations from normal activity.

3. Passive solutions: are cost effective and easily implemented. Those which should be considered are:
   - update existing signage so that it conforms to the new building codes standards and the Australian standards for access. Have large tactile signage of the platform numbers at the platform entrances.
   - colour code the platform so that one strip indicates heading towards the city centre and the other colour indicates the other direction, etc.
   - install Tactile Ground Surface Indicators as they are an effective way of indicating direction of travel and these could be colour coded for use by non blind customers.
   - provide layout maps of the station, showing the designated disabled parking spaces and other facilities

4. Dynamic solutions: although may be more expensive than the passive solutions, if implemented successfully they can have a greater impact in aiding wayfinding for the disabled customer.
   - implement multimodal signage in the form of pre-recorded voice information and Braille. As suburban and regional stations have lower noise levels in the station than metropolitan complexes, the regular volume of the pre-recorded information and announcements should suffice. However, to cater for the deaf community, announcements should also be made available in large text form. These could be placed preferably at ATM height to cater for people who are also shorter or who have reduced visual acuity
   - install Barcode technology in suburban and regional stations. These stations are smaller and their layouts are more straightforward. One station would require only a few barcodes to display information, including timetables and location of the platform.

5. Standardisation of aid technologies: all technology and aids, if implemented in one station, need to be standardised and implemented in similar locations in each station.

6. Educate the public: The disabled community and the general public need to hear about the availability of particular technical aids, and at which locations and stations they exist. Media awareness campaigns are excellent ways to broadcast information quickly to the general public. In addition, the various disability associations and service providers should be notified about the improved service provisions and how to locate railway services so that pertinent information is readily known and made available to assist their clients with enquiries. If documentation is provided to disability associations and service providers, these documents need to be maintained and reflect up-to-date information.

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8.1 Appendix A - Disability Related A/NZ Standards

Table A1: New building disability Australian Standards for outside the station

Objective	Importance	Existing standards AS	Measurements
Outside the station			
Number of parking	*Mobility: Medium* • The importance of disabled parking is not the number but that a designated parking for the disabled exists. Rating 7/10 *Hearing impaired: Low* • Individuals with only hearing impairments have full mobility and are able to walk towards the station entrance when clear signage is provided. Rating 2/10 *Vision Impaired: Medium* • Individuals with vision impairment only, have full mobility and are able to walk towards the station entrance when there are sufficient indicators and guides to the entrance. Rating 7/10 Communication Impairment: Medium • Individuals with communication impairment have full mobility and are able to walk towards the station entrance when there are sufficient indicators and guides to the entrance. Rating 6/10	Parking facilities – off-street parking for people with disabilities AS/NZS 2890.6:2009 Appendix B pp18	*Applies to NZS only* • total number of car spaces 1 - 20 accessible car space > 1 • Total number of car spaces 21-50 accessible car spaces > 2 • Every additional 50 car spaces additional > 1 accessible car space.
Dimensions of parking space	*Mobility: High* • This is important as often people with limited mobility are in a wheelchair	Parking facilities – off-street parking for people with disabilities	*Angle parking* • 2400 mm wide by 5400 mm long • Shared areas on one side of dedicated space 2400

Objective	Importance	Existing standards AS	Measurements
	which indicates a larger vehicle to carry them. This vehicle may be hard to manoeuvre into standard sized parking spaces. Rating 10/10 *Hearing Impaired : Low* • Individuals with only hearing impairments have full mobility and do not need extra manoeuvrable space. Rating 2/10 Vision Impaired: Low • Individuals with vision impairments only have full mobility and do not need extra manoeuvrable space. • Individuals with vision impairments cannot legally operate a vehicle, so some assistance by the driver can be provided to the individual. Rating 3/10 Communication Impairment: Low • Individuals with communication impairment have full mobility and do not need extra manoeuvrable space. Rating 2/10	AS/NZS 2890.6:2009 pp5-11	mm wide by 5400 mm long • Shared area on one end of space : 2400 mm long by 2400 mm wide • Angle-parking should be between 45^{o} and 90^{o} *Parallel parking* • 3200 mm wide by 7800 mm long • Shared area adjacent to non traffic side • >1600 mm wide by 7800 mm • Shared area may be at a higher level than the dedicated space separator by a kerb not more than 190 mm high.
Location of parking	*Mobility: High* • The disabled parking needs to be located close to the entrance of the station. It is not such a problem if the person is in a wheelchair or other moving device, but for the elderly and people in crutches	Parking facilities – off-street parking for people with disabilities AS/NZS 2890.6:2009 pp17	• If route to parking space for people with disabilities is not readily apparent from the vehicular entrance to the car park, direction signs comprising the international symbol of access and an arrow should be use at the entrance and at each change of direction to direct traffic to the space.

Objective	Importance	Existing standards AS	Measurements
	being located far away and have to walk un-reasonable distances are a discouragement for using trains. Rating 10/10 *Hearing Impaired : Low* • Individuals with hearing impairment only have full mobility clear signage and signage placement needs to be considered if parking is far away from the entrance. Rating 3/10 *Vision Impaired: Medium* • Individuals with vision impairment only have full mobility, sufficient indicators and guides to the entrance is needed and clear indication between road and pedestrian walkway need to be indicated for the vision impaired individual. Rating 7/10 Communication Impairment: Medium • Individuals with communication impairment only have full mobility, sufficient indicators and guides to the entrance are needed. Rating 6/10	Design for access and mobility Part 4.1: Means to assist the orientation of people with vision impairment – Tactile ground surface indicators. pp37	*Path leading to the entrance* • Warning indicators (Tactile Ground Surface Indicators TGSIs – shape : truncated cone defined pp11 of AS/NZS 1428.4.1 2009) shall be placed : ○ For the full width of the path of travel ○ Perpendicular to the direction of travel when approaching the hazard ○ Set back 300 +/- 10 mm from the edge of hazard except at railway platforms and wharves. ○ Where integrated warning TGSIs are used, they shall be arranged according to figure 2.1 c pp13 ○ Where integrated warning TGSI's need to be detected by a person approaching at an angle to the continuous accessible path of travel, the TGSIs shall be arranged as shown in Figure 2.1 over a min distance of 600 mm to 800 mm in depth from the direction of approach. ○ Where discrete warning TGSIs are used over a depth of 300 mm to 400 mm, the arrangement shall be as shown in figure 2.1 with min of 6 discrete truncated cones in the direction of travel. ○ Where discrete warning TGSI's need to be detected by a person approaching at an angle to the continuous accessible path of travel, the TGSIs shall be arranged as shown in figure 2.1 with min of 12 discrete truncated cones in the direction of travel.
Designated set-down and pickup areas	*Mobility :High* • If individuals cannot be easily picked up	Unavailable	Unavailable

Objective	Importance	Existing standards AS	Measurements
	or set down near the entrance of the station then they are less likely to use trains • If these designate areas are taken up by other non-disable users this defeats the purpose of having this designation. Rating 8/10 *Hearing Impaired :Low* • Individuals with hearing impairments only could walk to the station without assistance if there is clear signage. Rating 2/10 *Vision Impaired: Medium* • Individuals with vision impairments only, could walk to the station with assistance. However a designated area would reduce the risk of inadvertently walking into oncoming traffic. Rating 7/10 *Communication Impairment: Medium* • Individuals with communication impairment only, could walk to the station with assistance. However a designate area would reduce the risk of an individual becoming disorientated and not finding the entrance. Rating 5/10		

Table A2: New building disability Australian Standards for entrances

Objective	Importance	Existing standards AS	Measurements
Entrance			

Doors	*Mobility: High*
	• Individuals in wheel chairs have a limited pushing capacity.
	• Individuals without wheelchairs may become unstable after using force to push open a door
	• However other customers or station staff can help out and integrating automation into the door design is standard.
	Rating 8/10
	
	Hearing Impaired: Low
	• Individuals with hearing impairments need clear signage to the door and the location
	Rating 2/10
	
	Vision Impaired: High
	• Individuals with vision impairment are more likely to walk into clear glass doors.
	• A blind individual may have trouble locating the door
	Rating 9/10
	
	Communication Impairment: Medium
	• Individuals with communication impairment may have trouble locating the door.
		Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp 56-62	*Door handles*
			• Clearance between the handle and back plate or door face at the centre grip section of the handle shall be 35 mm > gap > 45 mm
			• 'D' type handles shall be provided on sliding doors.
			• Snib handles are installed they shall have a lever handle of a minimum length of 45 mm from the centre of the spindle.
			
			Force required to operate door
			• To initially open door < 20N
			• To swing or slide door < 20N
			• To hold the door open between 60^{o}and 90^{o} < 20N
			
			Luminance contrast
			• Doorways shall have a minimum luminance contrast of 30% provided between :
			  ○ Door leaf and door jamb
			  ○ Door leaf and adjacent wall
			  ○ Architrave and wall
			  ○ Door leaf and architrave
			  ○ Door jamb an adjacent wall
			• Minimum width of the area of luminance contrast shall be 50 mm
			
			Power operated doors
			• Push buttons controls shall have a minimum dimensions of 25 mm diameter and be proud of the surface and shall activate the door before the button becomes level with the surrounding surfaces

Objective	Importance	Existing standards AS	Measurements

	Rating 5/10		*Bathroom doors*
			• WC doors may be either hinged or sliding. WC doors shall comply with the following:
			  ○ Outward-opening doors shall have a mechanism that holds the door in a closed position without the use of a latch.
			  ○ Doors shall be provided with an in-use indicator and a bolt or catch. Where a snib catch is used, the snib handle shall have minimum length of 45 mm from the centre of the spindle. In an emergency, the latch mechanism shall be able to be opened from the outside.
			  ○ The force required to operate the door shall be in accordance with Clause 13.5.2(e).
			  ○ Door handles and hardware shall be in accordance with Clause 13.5.
			  ○ Outward-opening doors shall have a hinge mechanism that holds the door in a closed position without the use of a latch.
			  ○ Inward opening doors shall be fitted with a retractable stop or similar device to allow in an emergency the latch to be released and the door to swing outward or the door to be removed.

Doorway dimensions	*Mobility: High* • Individuals with limited mobility need to be able to enter the station. Rating :10/10 *Hearing Impaired: Low* • Individuals with hearing impairments only do not need extra space for	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp 56-62	• Clear opening of doorway on a continuous accessible path of trave shall be > 850 mm when measured from face of opened door to the doorstop • Double doors should have the > 850 mm clearance between the active leaf. • Surface mounted doors • The door face, where the sliding door is surface

Objective	Importance	Existing standards AS	Measurements
	manoeuvrability. Rating :2/10 *Vision Impaired: Medium* • Individuals with vision impairments only do not need extra space for manoeuvrability. • However clear indication needs to be on the doorway as indication dimension of doorway. Rating 5/10 Communication Impairment: Low • Individuals with communication impairments only do not need extra space for manoeuvrability. Rating 2/10		mounted, should be < 300 mm • Distance between doorways in vestibules, air locks and other similarly enclosed spaces shall > 1450 mm on top of the door leaf. *Power operated doors* • Push buttons controls shall have a minimum dimensions of 25 mm diameter and be proud of the surface and shall activate the door before the button becomes level with the surrounding surfaces
Ticketing booth	*Mobility: High* • If an individual with limited mobility cannot reach an automated ticket booth this can discourage transport usage. • If a personnel operated ticket booth is present the dimensions of the opening can make purchasing a ticket difficult if the person is travelling alone. Rating 9/10 *Hearing Impaired : Medium* • If individual with hearing impairments are interacting with ticketing personnel hearing the ticketing operator maybe difficult due to the background noise in a train station. • Light needs to be standard for lip	Automatic teller machines – User access AS 3769 -1990 pp7-8 Design for access and mobility Part 5: Communication for people who are deaf or hearing impaired AS 1428.5 – 2010 pp 17 Design for access and mobility Part 5: Communication for people who are deaf or hearing impaired AS 1428.5 – 2010 pp 55-56 Design for access and mobility Part 4.1: Means to assist the	• Clear circulation space in front of the ATM > 1900mm width and > 1400mm long, with crossfall > 1 in 40 slope • User interface of the ATM should be located within a zone which is > 685mm to < 1370mm from the finished floor and not more than 500 mm from an internal corner • Lighting of the task area maintenance illuminance of at least 160 1x should be provided for all opaque message areas • Dot matrix technology is used the dot matrix for characters should be at least 7 x 9 and preferably 9 x 14 • Screen should be legible • ALS's (Assistive Listening Systems). • ALS's shall be provided at any place where a service provider deals with a client , including all classes of

Objective	Importance	Existing standards AS	Measurements
	reading and for reading text on automated ticketing machine. Rating 7/10 *Vision Impaired: High* • If individuals with vision impairment are interacting with ticketing personnel hearing the staff member with loud background noise maybe difficult. • When using an automated ticketing machine, voice interaction and Braille for the blind need to be included. Rating 9/10 *Communication Impairment: High* • If individuals with communications impairment are interacting with ticketing personnel understanding staff member with loud background noise and unfamiliar vocabulary maybe difficult. • When using an automated ticketing machine, symbolic representations may be needed for effective communication. Rating 8/10	orientation of people with vision impairment – Tactile ground surface indicators pp32	counters and where multiple counters in one location provide the same service. And where the user has a choice of which counter to use ALS's shall be provided at a minimum proportion of 20% of each class of counters at each location. • Individuals who are blind or have vision impairment are able to make use of personal assistants, guide dogs, orientation training plus specialised items such as proximity devices, audible signs and Braille signs. • See lighting category for lighting standards
Entrance to paid areas	*Mobility: High* • Between the entrance and the paid waiting area, large metropolitan stations have an automated entrance which prevents fare evasion but this makes it difficult for the mobile disabled person. • Rural stations have less sophisticated access points but may still be a barrier to the disabled individual. Rating : 10/10	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp 56-62 Design for access and mobility Part 5: Communication for people who are deaf or hearing impaired AS 1428.5 – 2010 pp 55-56	• Clear opening of doorway on a continuous accessible path of travel shall be > 850 mm when measured from face of opened door to the doorstop • See lighting category for lighting standards

Objective	Importance	Existing standards AS	Measurements
	Hearing Impaired: Medium • Entrance needs to be sufficiently lit for lip-reading and sign language communications. Rating : 6/10 *Vision Impaired: Medium* • Individuals with vision impairments only do not need extra space for manoeuvrability. • However clear indication needs to be on the entrance areas. Rating 7/10 *Communication Impairment: Medium* • Individuals with communication impairments only do not need extra space for manoeuvrability. • However clear indication of entering the entrance areas needs to be clearly defined. Rating 5/10		

Table A3: New building disability Australian Standards for passageways

Objective	Importance	Existing standards AS	Measurements
Passageways			
Elevators	*Mobility: High* • It is important that one step access from the main foyer of the train station and platform is provided. • Changing elevators and looking for disability access routes to navigating the station is a deterrent disabled individuals • This may be linked to signage specifications • Elevators and escalators needs to accommodate individuals who may not be stable on their feet and need a larger space for individuals in wheel chairs. • The controls or buttons need to be at a height that can be accessible for a person sitting in a wheel chair Rating 9/10 *Hearing Impaired: Medium* • Elevators need to be sufficiently lit for lip reading and sign language communications • There needs to be enough space for a group of hearing impaired individuals to stand facing each other for communications. Rating 7/10 *Vision Impaired: High* • Individuals with vision impairment need to be able to access the controls and	Lifts, escalators and moving walks Part 12: Facilities for persons with disabilities AS 1735.12-1999 Design for access and mobility Part 5: Communication for people who are deaf or hearing impaired AS 1428.5 – 2010 pp 55-56 Design for access and mobility Part 5: Communication for people who are deaf or hearing impaired AS 1428.5 – 2010 pp pp17	• Doors remain fully open for > 6s *Door opening comply with AS 1428.1 -2009 pp 56-62* • Front face of control buttons, are centred > 900 mm above the car floor, be vertical or face upwards with an inclination < 15^{o} and > 30^{o} • Floor indicator > 1800 mm above floor of the lift car, size of numbers and letters > 25 mm high • All elevators provide functioning systems to enable all persons to communicate with others not in the elevator and to receive all information being communicated to passengers , emergency communication system in enclosed elevators shall comply with clause 4.3 and AS1735.12 *Buttons/control panel to call the elevator* • Each landing served shall provide with one or more control buttons to call a lift. • Where up and down buttons are provided on a landing and are not located vertically within 200 mm of each other a tactile symbol and Braille equivalent shall be provided and shall be located either above or to the left on the face of the respective button. • Centre of buttons shall > 900 mm and < 1200 mm above the landing floor *Buttons / control panel inside the elevator* • Where either the width of depth of the car is < 1400 mm not less than 2 control panels shall be

Objective	Importance	Existing standards AS	Measurements
	understand what the controls do. Rating 9/10 *Communication Impairment: Medium* • Individuals with communication impairment have full mobility, but understanding the controls may be difficult. Rating 5/10		provided in positions that are accessible one to the left and one to the right of a person entering the lift car. • In other situations, not less than one control panel shall be provided in a position that is accessible either to the left or the right of the person entering the lift car. • Button centre and any security operating device shall be located at a height > 700 mm or < 1250 mm above the car floor • Smallest dimension of button > 19 mm • Separation between moving parts of adjacent control buttons > 10 mm • Moving par of control button or its surround shall project > 1 mm beyond the face of the control panel excluding any tactile elements. • Button shall contrast with their surrounding surface by one of the following: o Continuous illumination from within the button o A coloured border on or around the button. Shall be > 3 mm wide around button, o Button shall be in contract to the surround area with a luminance factor > 0.3 in contract to that of the background. • If button > 900 mm above lift floor, inclination upwards < 15^{o} • Button < 900 mm above lift floor, inclination upwards of > 15^{o} and < 30^{o} *Buttons* • Communication button shall be located at right-hand end of the lowest row of control buttons as viewed when facing the control panel.

Objective	Importance	Existing standards AS	Measurements
			• Communication button shall be identified by a visible symbol located on the button face (figure 8.4.2 c pp18 AS 1735.12-1999) • Emergency stop button or switch need not be position on the above control panels • Where a second control panel is required, a second stop button is not required • A tactile symbol and Braille equivalent located above or to the left or on the face of the respective buttons shall be provided. • Control buttons shall require a movement of > 5 mm and < 3 mm cause operation of the contact. • Force required > 2N and < 5N • Seeing lighting category for lighting standards
Dimensions of walk ways	*Mobility: High* • If an individual in a wheel chair cannot access the walk way then reaching the train platforms would be impossible Rating 10/10 *Hearing Impaired: Medium* • Corridors and walk ways need to be sufficiently lit for lip reading and sign language communications • There needs to be enough space for a group of hearing impaired individuals to walk stand facing each other for communications. Rating 6/10 *Vision Impaired: Medium* • Individuals with vision impairments only	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp10-13 Design for access and mobility Part 2: Enhanced and additional requirements –buildings and facilities AS 1428.2 -1992 pp 7 Design for access and mobility Part 3: Requirements for children and adolescents with physical disabilities. AS 148.3-1992 pp AS 1428.1 -2009 pp 23-24	• Unobstructed height of continuous accessible path of travel 2000 mm • Width of continuous accessible path of travel 1000 mm not including fixtures. *Furniture in walkways* • In areas of high use by people with ambulatory disability, such as areas frequented by elderly people seats should be provided no more than 60 m apart alongside path of travel. • Seeing lighting category for lighting standards

Objective	Importance	Existing standards AS	Measurements
	do not need extra space for manoeuvrability. • However clear indication of where the individual is in relation to their surrounds needs to be clearly indicated. Rating 6/10 *Communication Impairment: Low* • Individuals with communication impairments only do not need extra space for manoeuvrability. • However clear indication of where the individual is in relation to their surrounds needs to be clearly indicated. Rating 3/10		
Steps and stairs	*Mobility: High* • Individuals with limited mobility need guardrails and other stabilising handles. • The dimensions of each step need to be considered for individuals with limited mobility. • If no elevators are provided, wheelchair access up stairs s critical. Rating 10/10 *Hearing Impaired: Medium* • Steps and stairways need to be sufficiently lit for lip reading and sign language communications • The stairways need to be inclined at an angle that a hearing impaired individual can see who is approaching them. Rating 7/10	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp 46-53 Fixed platforms, walkways, stairways and ladders – Design, construction and installation AS 1657-1992 pp12-13	• Intersection is at a property boundary the stair is set back > 900 mm so that handrail and TGSI do not protrude into the transverse path of travel. • Intersection is at internal corner set back 600 - 800 mm • Stair nosing each tread have a strip of > 50 mm to < 75 mm deep across full width of the path of travel, strip have > 30% luminance contrast • Rise and goings in the same flight of stairs shall be uniform dimensions • Rise > 150 mm and < 215 mm • Going (horizontal surface of stairs) shall not be > 215 mm and < 305 mm • Tread width shall not be less than the going and a minimum overlap of 10 mm • Handrails every stairway shall be provided with at least one handrail which shall have a smooth continuous top surface throughout the length of each stairway flight.

Objective	Importance	Existing standards AS	Measurements
	Vision Impaired: High • Individuals with vision impairment need clear indication of where the stairs/ ends and when a landing is reached. • Vision impaired individuals need more stabilizing elements when climbing up or downstairs. Rating 9/10 *Communication Impairment: Low* • Individuals with communication impairment only, have full mobility and provided there is clear signage stairs and steps are not a large consideration. Rating 2/10		• Width of stairway exceeds 1000 mm 2 handrails shall be provided. *Landings* • For walkway gradients of 1:33 at intervals no greater than 25 m. • For walk ways gradients of 1:20, at intervals no greater than 15 m. • For walkways between 1:20 to 1:33, at intervals that shall be obtained by liner interpolation. • For walkways shallower than 1: 33, no landings are required. • Interval specified • Seeing lighting category for lighting standards

Unobstructed straight passageway	*Mobility: Medium*
	• Manoeuvring wheelchairs in tight spaces with large number of pedestrians is difficult, so having a large passage and unobstructed passage way is important.
	• However it is not impossible for 2 wheelchairs to pass each other if a recess is included in the design
	Rating 7/10
	
	Hearing Impaired: Medium
	• Provisions need to be made for bends in the passageways so that the hearing impaired individuals are not surprised by other approaching customers.
	Rating 5/10
	
	Vision Impaired: High
	• Individuals with vision impairments only
		Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp 10-13
		
		Design for access and mobility Part 2: Enhanced and additional requirements – buildings and facilities AS 1428.2 -1992 pp 7
		
		Design for access and mobility Part 4.1 : Means to assist the orientation of people with vision impairment – tactile ground surface indicators AS/NZS 1428.4.1:2009 pp21-24
			• Passing space for 2 persons using wheelchairs shall be a minimum width of 1800 mm for a minimum length of 2000 mm
			• Circulation space for 60º- 90º wheelchair turn gradient < 1:40, width > 1500 mm wide and > 1500 mm long in the direction of travel
			• Circulation space for 30º- 60º a splay of at least 500 mm x 500 mm
			• Circulation space for > 90º- 180º a splay of at least 2070 mm x 1540 mm
			• Continuous accessible path of travel shall be provided as follows :
			  ○ Accessible paths of travel within the boundary of the site shall be provided from transportation stops, accessible parking and accessible passenger loading zones, and public streets or walkways to the accessible building entrance they serve.
			  ○ Accessible paths of travel shall connect

Objective	Importance	Existing standards AS	Measurements
	do not need extra space for manoeuvrability. • However provisions need to be made for bends and over hangs Rating 9/10 Communication Impairment: Low • Individuals with communication impairment have full mobility and are able to navigate around obstacles Rating 2/10		accessible buildings, facilities and spaces that are on the same site. ○ Accessible paths of travel shall connect accessible building entrances with all accessible spaces and facilities within a building. ○ Accessible paths of trave shall connect accessible entrances of each accessible building with those exterior and interior spaces and facilities that serve it. ○ Accessible elements of buildings and facilities shall be arranged so as to minimize distances to be travelled between them. *Hazards within the circulation space* • Where there are impediments or hazards with less than 2000 mm clearance in an accessible open public space with no clearly defined continuous accessible path of travel, contract with over head hazard shall be prevented by a suitable barrier such as : ○ Enclosing the area ○ Providing handrails with kerbs or kerb rails ○ In the absence of a suitable barrier, TGSI's shall be installed show in Figure 2.6 (B) pp24 AS/NZS 1428.4.1:2009

Table A4: New building disability Australian Standards for toilets and bathrooms

Objective	Importance	Existing standards AS	• Measurements
Toilet and Bathroom			

Disabled sink /wash basin	*Mobility: High*
	• Individuals with limited mobility may be wheelchair bound so the height of basins need to be adjusted for their use.
	• Individuals not in wheel chairs may have stability impairment near the sink, so supporting structures such as hand rails may be needed
	Rating 10/10
	
	Hearing Impaired : Low
	• Individuals with hearing impairment only have full mobility.
	Rating 2/10
	
	Vision Impaired: Medium
	• Individuals with hearing impairment only have full mobility.
	• However location of the sink needs to be clearly indicated.
	Rating 5/10
	
	Communication Impairment: low
	• Individuals with communication impairment have full mobility.
	Rating 2/10
		Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp 75-80
		
		Design for access and mobility Part 2: Enhanced and additional requirements – buildings and facilities pp 23
		
		Design for access and mobility Part 3: Requirements for children and adolescents with physical disabilities. AS 148.3-1992 pp7
			• Basin height 800 mm to 840 mm height
			• Basin dimensions tap to side > 225 mm overall width > 550 mm
			• Basin protrusion > 440 mm
			• > 425 mm from wall
			• Knee/toe clearance > 200 mm
			• Circulation space for basin > 850 mm width and > 700 mm long
			
			Sole occupancy units
			• The projection of the washbasin from the wall and the position of taps, bowl and drain outlet shall be determined in accordance with Figure 45.
			• Water supply pipes and waste outlet pipes shall not encroach on the required clear space under the washbasin, as shown in Figure 45 pp79 AS 1428.1 - 2009.
			• Each washbasin fixture, the unobstructed circulation space shall be in accordance with Figure 46. The washbasin fixture and its fittings are the only fixtures permitted in this space.
			• Shelf space shall be provided adjacent to the washbasin in one of the following ways:
			  ○ As a vanity top— height > 800 mm and < 830 mm above the floor;
			  ○ width of < 120 mm beside the basin;
			  ○ depth of > 300 mm from the front to the rear wall
			  ○ No encroachment into any knee and toe clearance space for width of > 850 mm centred on the basin.

Objective	Importance	Existing standards AS	• Measurements
			• As a separate fixture ○ within any circulation space at a height of 900 mm to 1000 mm with ○ a minimum underside clearance of 850 mm for a width of 120 mm ○ depth 150 mm and length of 300 mm to 400 mm; and ○ External to all circulation spaces at a height of 800 mm to 1000 mm ○ Width > 120 mm and length > 400 mm. *Frontal approach and angled approach* • Water controls and outlet within the reach of a single hand figure 18 b
Taps and faucets	*Mobility: High* • Small circular taps located on the other side basin can cause difficulties if the individual needs to lean over the sink to access the taps. Small round circular tabs are also hard to turn. • Height and location of the faucet may result in individuals in wheelchairs needing to lean over to access them and may cause an imbalance. Rating 9/10 *Hearing Impaired : Low* • Individuals with hearing impairment only have full mobility. Rating 2/10 Vision Impaired: High • Individuals with hearing impairment only have full mobility.	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp 80-81 Design for access and mobility Part 2: Enhanced and additional requirements – Buildings and facilities AS 1428.2 -1992 pp 43 Design for access and mobility Part 3: Requirements for children and adolescents with physical disabilities. AS 148.3-1992 pp7-11	• Taps shall have lever handles , sensor plates or similar • Lever < 50 mm clearance from an adjacent surface • Separate taps , hot water on the left cold on the right • Hot water is provided, shall be delivered through a mixing spout. • For people with vision impairment, the cold water tap should be identified by having a two-pronged handle, with the hot water tap remaining a handle with four prongs. • Wherever practicable, tap washers operating on the principle of a ball valve in synthetic rubber washers, or ceramic or hydraseal types should be used because of the ease of turning on and off and their maintenance-free life and ease of replacement. • For people with limited hand movement, lever action fittings should be used •

Objective	Importance	Existing standards AS	• Measurements
	• However if hot water is provided, which tap supplies the hot water needs to be indicated. Rating 8/10 *Communication Impairment: Medium* • Individuals with hearing impairment only have full mobility. • However if hot water is provided, which tap supplies the hot water needs to be indicated. Rating 6/10		
Hand dryers/paper towels	*Mobility: Medium* • Push button hand dryers and paper towels may be located at a height out of read to a person sitting in a wheel chair. • Motion activated hand dryers may need a person's hands to be at a certain distance away from the dryer to activate which may not be at a good height for an individual in a wheel chair. • However having wet hands is not as critical as access the toilet facilities Rating 5/10 *Hearing Impaired : Low* • Individuals with hearing impairment only have full mobility do not need extra consideration for hand towels. • However clear visual indication of how to operate the hand dryer/paper towels need to be displayed. Rating 2/10	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 Design for access and mobility Part 2: Enhanced and additional requirements – Buildings and facilities AS 1428.2 -1992 pp 30-32 Design for access and mobility Part 3: Requirements for children and adolescents with physical disabilities. AS 148.3-1992 pp7	• Height operative component > 900 mm and < 1100 mm from floor / plane of the finished floor • > 500 mm from an internal corner • Sensor operated air hand dyers shall be provided

Objective	Importance	Existing standards AS	• Measurements
	Vision Impaired: Medium • Individuals with vision impairment have full mobility. • However clear indication of how to operate the hand dryer/paper towel need to be displayed. • Hand drying is not critical to the WC experience. Rating 5/10 *Communication Impairment: Low* • Individuals with communication impairment have full mobility. • However clear indication of how to operate the hand dryer/paper towel need to be displayed. • Hand drying is not critical to the WC experience. Rating 2/10		
Toilet	*Mobility: High* • Individuals with limited mobility have difficult lifting themselves into the sitting position of the standard toilets. The height and size may be hard to manoeuvre. Handrails, height and size considerations are important. • If individuals with limited mobility need to lift themselves out of a wheelchair onto the toilet seat, toilet seats will generally place greater than average shear forces on seats and fittings. Rating 10/10	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp67-88 Design for access and mobility Part2: Enhanced and additional requirements-buildings and facilities as1428.2-1992 pp14-25	• At least one emergency call button which complies with AS 2999 shall be installed in accordance with clause 23 in each sanitary facility or combined facility. • Separate call buttons should be placed near the WC pan, shower recess and bath. • Seat be of full round type • Load-rate to 150 kg • Backrest withstand forces in any direction of 1100N • Lower edge of back rest to top of WC pan of 120 to 150 mm • Top of seat > 460 mm and < 480 mm

Objective	Importance	Existing standards AS	• Measurements
	Hearing Impaired : Low • Individuals with hearing impairment only, have full mobility. Rating 2/10 *Vision Impaired: High* • Individuals with vision impairment have full mobility. • However they will need a clear indication of where the facilities are inside and outside of the cubicle. Rating 8/10 *Communication Impairment: Low* • Individuals with communication impairment have full mobility. • However they will need a clear indication of where the facilities are inside and outside of the cubicle. Rating 4/10		• Top of pan > 430 mm to < 440 mm *Seat* • A toilet seat shall be provided on accessible toilets. The toilet seat shall: ○ Be of the full-round type, (i.e., not open fronted) and with minimal contours to the top surface ○ be securely fixed in position when in use ○ have seat fixings that create lateral stability for the seat when in use to be load-rated to 150 kg ○ Have a minimum luminance contrast of 30% with the background (e.g., pan, wall or floor against which it is viewed). ○ Seas of moulded plastics must comply with AS 1371. The design of the seat shall provide lateral stability. *Backrest* • A backrest shall be provided on accessible toilets. The backrest shall: ○ be capable of withstanding a force in any direction of 1100 N; ○ have a height, at the lower edge of backrest to the top of the WC pan, of 120 mm to 150 mm, as shown in Figure 39(a) ○ have a vertical height of 150 – 200 mm and a width of 350 – 400 mm, as shown in Figure 39(a) ○ Front edge of the centre of the backrest must be positioned to achieve an angle of between 95° to 100° back from the seat hinge (Figure 39(b)).

Objective	Importance	Existing standards AS	• Measurements
			Flushing control • Flushing controls shall be user activated, either hand operated or automatic. Where hand-operated flushing controls are used, they shall be located within the zone shown in Figure 40, or centred on the centre-line of the toilet, wholly within the vertical limits of that zone. • The position of the flushing control within this zone shall not be within the area required for any grab rails. • The flushing control shall be proud of the surface and shall activate the flush before the button becomes level with the surrounding surface *Grab rail* • Where a concealed or high level cistern is used, a continuous grab rail as specified in Clause 10.2 shall be provided across the rear wall and side wall nearest the WC plan. • Where low-level cistern is used the garb rail may be terminate at each side of the cistern. *Toilet paper dispenser* • The outlet for the toilet paper dispenser shall be located within the zone specified in Figure 41. • The toilet paper dispenser shall not encroach upon the clearance space required around the grab rail specified in Clause 15.2.7.
Cubical dimensions	*Mobility: High* • If individuals are in wheelchairs, then the dimension of the cubical must be large enough for the wheelchair to turn in the space. Rating 10/10	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp86-91 Design for access and mobility	• Unobstructed circulation space from finished floor to floor > 2000 mm • Wall cabinets must not protrude more than 150 mm into circulation space • Cabinets shall be at least 900 mm above floor level and top shelf < 1250 mm above floor

Objective	Importance	Existing standards AS	• Measurements
	Hearing Impaired : Low • Individuals with hearing impairment only do not have mobility issues and will be able to access the facility without much difficulty. Rating 2/10 Vision Impaired: Medium • Individuals with vision impairment only can manoeuvre through the space. • However clear indication of the protruding objects needs to be given, and a clear path from the door to the toilet seat needs to be provided. Rating 6/10 Communication Impairment: Low • Individuals with communication impairment only can manoeuvre through the space. Rating 2/10	Part 2: Enhanced and additional requirements – Buildings and facilities AS 1428.2-1992 pp14-18	*General* • For each WC, the unobstructed circulation space from the finished floor to a height of not less than 2000 mm shall be as shown in Figure 43, except for the following, which are allowed to intrude into the circulation space: • Wall cabinets, where provided, which shall not protrude more than 150 mm into the circulation space. • The mounting of wall cabinets shall be at least 900 mm above floor level and the top shelf shall be a maximum of 1250 mm above floor level. • Clothes hanging devices (see Clause 15.4.4). • Portable sanitary disposal unit as shown in Figure 43. • Other wall mounted fixtures, such as dispensing units and sharps disposal • The overlapping of circulation spaces shall be in accordance with Clause 15.6.
Light switches	High • The height of the light switch location is important, if light switches are not automatic in the public bathroom, than they have to be located at an appropriate height for an individual to use when in a wheelchair Rating 10/10 *Hearing Impaired : Medium* • Individuals with hearing impairment only are able to reach and see light switches. • However in pitch black situations there	Design for access and mobility Part 2: Enhanced and additional requirements – buildings and facilities AS 1428.1 -2009 pp32 Design for access and mobility Part 3: Requirements for children and adolescents with physical disabilities. AS 148.3-1992 pp18-20	• Common zone of reach for adults : > 700 mm and < 1200 mm • Common zone of reach for children and adolescents • Age 10-14 : < 970 mm • Age 14-18 :< 1000 mm • Where provided near the washbasin, switches and general purpose outlets shall be located in accordance with Clause 14 and as close to the shelf or worktop as practicable. All switches and controls on an accessible path of travel, other than general purpose outlets, shall be located not less than 900 mm or more than 1100 mm above the plane of the finished floor and not less than 500 mm from

Objective	Importance	Existing standards AS	• Measurements
	should be a clear indication of where the light switches are. Rating 6/10 Vision Impaired: High • Individuals with vision impairment only are able to reach light switches Communication Impairment: Low		internal corners except where on the architrave on the latch side. • Rocker action and toggle switches shall be provided and have a minimum dimension of 30 mm × 30 mm. Push-pad switches shall have a minimum dimension of 25 mm in diameter. • General purpose outlets shall be located not less than 600 mm or more than 1100 mm above the plane of the finished floor and not less than 500 mm from internal corners.

Table A5: New building disability Australian Standards for signage

Objective	Importance	Existing standards AS	• Measurements
Signage			
Signage	*Mobility : Medium* • Information should be displayed within easy viewing of someone in a wheelchair • Interactive displays with buttons should be at a height that can be accessible by someone in a wheel chair • Information can also be obtained by asking a staff member or other member of the general public. Rating 6/10 *Hearing Impaired : Medium* • Individuals with hearing impairment only have full mobility so can adjust their position to read signage. • However knowing where the signage is located and looking in that direction maybe difficult Rating 7/10 *Vision Impaired: High* • Individuals with vision impairment may have trouble seeing signs especially if they are far away. • Contrast and lighting need to be considered. Rating 9/10 *Communication Impairment: Medium*	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp17-24 Design for access and mobility Part2: Enhanced and additional requirements - buildings and facilities AS 1428.2-1992 pp26-27	*Placement* • Signs shall be arranged horizontally or vertically except when words are used when they shall be displayed horizontally • Signs should be placed within a zone at a height not less than 1400 mm and not more than 1600 mm above the plan of the finished floor • Where a sign can be temporarily obscured, the sign should be placed at a height of not less than 2000 mm above the plane of the finished floor *Braille* • The BCA contains requirements for Braille and tactile signage in specification D 3.6. • Where required, raised tactile and or Braille signage shall be provided • Unisex accessible sanitary facilities shall be identified with the international symbol of access and male and female symbols. • Signage for unisex accessible facilities shall be provided with the letters • LH or RH to indicate a left-hand or right-hand side transfer onto the WC pan. The minimum font size shall be 20 mm san serif. *Bathrooms* • Facilities signs shall be English words between 1200 mm and 1600 mm above finished floor levels • Entry doors to airlocks serving areas containing sanitary facilities shall be identified with a symbol identifying each sanitary facility within.

Objective	Importance	Existing standards AS	• **Measurements**

			• One symbol for each facility need only be used.
			• Where the facilities for male and female are separate, a dividing line should be placed between each symbol.
			• Elements of a sign shall be set out singularly, or in a modular form.
			• Elements of a sign shall be arranged horizontally or vertically, except where words are used. Words shall be displayed horizontally.
			• Facilities shall be identified by the use of English words between 1200 mm and 1600 mm above finished floor levels.
			• Sanitary compartment for people with ambulant disabilities shall be identified in accordance with Figure 9(f). pp 19 AS 1428.1 -2009
			 
			• The International Symbol of Access and the international Symbol for Deafness (see Clause 8.2.2) may be used without explanatory text such as 'accessible', 'hearing loop installed'.
			
			Access symbols
			• International symbol of access
			• The form of the international symbol of access shall be as follows:
			  ○ The symbol of access shall consist of two elements: a stylized figure in a wheelchair pointing to the right on a plain square background.
			  ○ The proportional layout of the symbol of

<table>
<tr><th>Objective</th><th>Importance</th><th>Existing standards AS</th><th>• Measurements</th></tr>
<tr><td></td><td></td><td></td><td>access shall be in accordance with Figure 10.
○ The colour of the Figure shall be white on a blue background in accordance with Figure 11. The blue shall be B21, ultramarine, of AS 2700, or similar.
○ For signs indicating the direction to a facility, an arrow shall be used in combination with the international symbol of access.
○ Signs identifying a facility may be used either with or without directional arrows.

International symbol for deafness
• The symbol for deafness shall consist of two elements: a stylized ear and diagonal slash on a plain square background.
• The proportional layout of the symbol for deafness shall be in accordance with Figure 12.
• The colour of the symbol shall be white on a blue background. The blue shall be B21, ultramarine, of AS 2700, or similar.</td></tr>
<tr><td>Size of lettering</td><td>Mobility: High
• Size of the lettering should be visible for a person sitting in a wheelchair.
Rating 8/10

Hearing Impaired : High
Vision Impaired: Low

Communication Impairment: Low</td><td>Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp17-24

Design for access and mobility Part 2: Enhanced and additional requirements - buildings and facilities AS 1428.2-1992 pp26-27</td><td>Height of letters for varying viewing distances
<table>
<tr><th>Required viewing distance (m)</th><th>Minimum height of letters (mm)</th></tr>
<tr><td>2</td><td>6</td></tr>
<tr><td>4</td><td>12</td></tr>
<tr><td>6</td><td>20</td></tr>
<tr><td>8</td><td>25</td></tr>
<tr><td>12</td><td>40</td></tr>
<tr><td>15</td><td>50</td></tr>
<tr><td>25</td><td>80</td></tr>
<tr><td>35</td><td>100</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Objective</th><th>Importance</th><th>Existing standards AS</th><th>• Measurements</th></tr>
<tr><td></td><td></td><td></td><td><table>
<tr><td>40</td><td>130</td></tr>
<tr><td>50</td><td>150</td></tr>
</table></td></tr>
<tr><td>Lighting</td><td>Mobility : High
• Individual sitting in the wheelchair may be subjected to glare as the angle at which they are viewing the signs are different to the standing customer, this can cause confusion and difficulty in wayfinding.
Rating 8/10

Hearing Impaired: High
• Sufficient lighting needs to be provided for lip reading and sign language communications in all areas of the station.
Rating 10/10

Vision Impaired : High
• Sufficient light needs to be provided so individuals with vision impairment can have the best chance of seeing the signage that is present.
Rating 9/10

Communication Impairment: Low
• Individuals with communication impairment only, do not have vision impairment so will be able to see signs.
Rating 2/10</td><td>Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 Appendix B Measurement of luminance contrast between building elements pp98-103

Design for access and mobility Part2: Enhanced and additional requirements - buildings and facilities AS 1428.2-1992 pp28

Design for access and mobility Part 5: Communication for people who are deaf or hearing impaired AS 1428.5-2010 pp55-56</td><td><table>
<tr><td colspan="2">Minimum levels of lighting</td></tr>
<tr><td>Entrances</td><td>S150 lx</td></tr>
<tr><td>Passage ways and walkways</td><td>150 lx</td></tr>
<tr><td>Stairs</td><td>150 lx</td></tr>
<tr><td>Ramps</td><td>150 lx</td></tr>
<tr><td>Lifts</td><td>AS 1735.12</td></tr>
<tr><td>Toilet and locker rooms</td><td>200 lx</td></tr>
<tr><td>Counter tops</td><td>250 lx</td></tr>
<tr><td>General displays</td><td>200-300 lx</td></tr>
<tr><td>Telephones</td><td>200 lx</td></tr>
</table>
• Lighting of face and body required to in the following settings for lip reading and sign language communication:
  ○ At places where information is exchanged
  ○ In position where a sign interpreter is to be located
  ○ In areas where spontaneous general conversation may occur, i.e. foyers, public spaces, outdoor public transport terminals and similar venues
• Lighting systems shall be provided to facilitate communication in a safe and comfortable visual environment
  ○ Even lighting levels to avoid luminance variations and shadows
  ○ Minimization of glare and unwanted reflections.
• Signage shall be illuminated to minimum illumination of 240lx
• Minimum illumination shall comply with AS/NZS</td></tr>
</table>

Objective	Importance	Existing standards AS	• **Measurements**
			1680.1 and AS/NZS 3827.2 • Minimum illumination of 160lx shall be provided where no higher illumination has been specified by AS/NZS 1680.1 and AS/NZS 1158. • Light systems shall have : o Produce an even overall illumination of the speaker's lips and face, without shadows o Use directional lightning where the angle of the lighting shall be in the range of 15^{o} to 45^{o} from the horizontal to illuminate the speaker. • Lighting system to assist sign language interpretation o Produce an overall illumination of face and hands of the sign language interpreter with minimal shadow o Illuminate an area 1 m wide by 2 m high to cater for width of movement and various interpreters' height sand sitting/standing positions. • Glare shall be prevented as specified in AS/NZS 1680.1 o Techniques such as fitting curtains or blinds, tinted low transmission glazing or adjustable opaque louvers at windows Techniques such as appropriate choice of luminaries, use of light diffusers, positioning luminaries away from the line of sight of the viewer and use of low reflectance surfaces.

Table A6: New building disability Australian Standards for floors

Objective	Importance	Existing standards AS	Measurements
Floors			

Surfaces	*Mobility High*
	• Join between 2 floor surfaces should not be at a height that is difficult for wheelchair access
	• Grates should be a certain size so that wheelchair wheels cannot be trapped into the opening space.
	Rating 10/10
	
	Hearing Impaired : Low
	
	Rating
	Vision Impaired: High
	
	Communication Impairment: Low
		Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp14-17
		
		Design for access and mobility Part 2: Enhanced and additional requirements – buildings and facilities AS 1428.2-1992 pp8
		
		Design for access and mobility Part 4.1 : Means to assist the orientation of people with vision impairment – tactile ground surface indicators AS/NZS 1428.4.1:2009 pp21-24
			• Abutment of surfaces shall have a smooth transition
			• vertical transition of < +/- 3 mm
			• vertical transition of < +/-5 mm if edge is bevelled or rounded to reduce likelihood of tripping
			• carpet pile < 6 mm and base height < 4 mm
			• exposed edges covering shall be fastened to floor surface with trim along entire length of any exposed edge
			
			• matting recessed within a continuous accessible path of trave
			  ○ where of metal and bristle type construction or similar, its surface shall be no more than 3mm if vertical or 5mm if rounded or bevelled, above or below the surrounding surface
			  ○ where of mat or carpet type material, shall have the fully compressed surface level with or above the surrounding surface with a level difference no greater than 3 mm if vertical or 5 mm if rounded or bevelled.
			
			• Paving bricks will bevelled edges or chamfered arises and heavily textured and figured surfaces such as raked joint pavers shall not be used.
			Carpet
			• Shall be securely attached
			• Any pad, backing or cushioning shall provide a firm surface
			• Shall have a level loop, a textured loop, a level cut pile or a level cut or uncut pile texture.

Objective	Importance	Existing standards AS	Measurements
			• Pile height > 6 mm • Exposed edges shall be fastened to the floor surface and shall have a trim along the entire length of any exposed edge. • carpet edge trim shall create no ridge on the floor surface > 3 mm • If gratings are located in a walking surface, they shall have spaces < 13 mm wide and < 15 mm long. • If gratings have elongated openings, they shall be placed so that the long dimension is transverse to the dominant direction of travel. *Warning TGSI's* • Shape truncated cone • Elevation 4 to 5 mm • Spacing 50 +/-1 mm from centre Directional TGSIs • Shape rectangles with semi-circle ends. • Direction of travel length = 240 mm to 600 mm • Diameter ends of 35 +/- 1 mm See unobstructed path for placement of TGIs
Ramps	*Mobility: High* • Elevations in height should be accounted for by ramps. The gradient should be stable for all wheelchairs. Rating 10/10 *Hearing Impaired : Low* • Individuals with hearing impairment only have full mobility and are able to navigate stairs. • However the rise of the stairs must be considered so that individuals have a visual on the person coming in the	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1-2009 pp24-35 Hoists and ramps for people with disabilities – Vehicle-mounted Part 1: Product requirements AS/NZS 3856.1:1998 Hoists and ramps for people with disabilities – Vehicle-	*Ramps:* • Overall width > 760 mm • Public transport use overall width > 800 mm • Surface should be slip-resistant accordance with AS3696.13 • Use of ramp vertical height > 400 mm need edge barriers • Grad of ramp < 1:4 ratio • If assistance is provided grad< 1:6 *Step ramps* • Max rise 190 mm

Objective	Importance	Existing standards AS	Measurements
	opposite direction. Rating 3/10 *Vision Impaired: Medium* • Individuals with vision impairment only have full mobility and would be able to navigate stairs. • However ramps may can contain the TGSI's so that vision impaired individuals can avoid other dangers. Rating 5/10 Communication Impairment: Low • Individuals with communication impairment have full mobility. Rating 2/10	mounted Part 2: Installation requirements AS/NZS 3856.2:1998	• Length < 1900 mm • Grad < 1:10 *Threshold ramps* • Max rise 35 mm • Max length 280 mm • Max grad 1:8 • Located 20 mm of the door of leaf which it serves

Table A7: New building disability Australian Standards for miscellaneous facilities

Objective	Importance	Existing standards AS	Measurements
Miscellaneous			

Public phones	*Mobility: Medium*
	• Dimension and height of the phone should be accessible for a person sitting in a wheelchair.
	• However, with new mobile phone technology being wide spread and prevalent, public phones are no longer as important as before
	Rating 8/10
	
	Hearing Impaired : High
	• The audible level for hearing impaired individuals is different to other individuals.
	• However with new mobile phone technology being wide spread and prevalent public phones no longer as important as before.
	Rating 9/10
	
	Vision Impaired: High
	• Operating the controls maybe difficult for individuals with vision impairment.
	• However with new mobile phone technology being wide spread and prevalent public phones are no longer as important as before.
	Rating 8 /10
	
	Communication Impairment: Medium
	• Operating the controls maybe confusing
		Design for access and mobility Part2: Enhanced and additional requirements - buildings and facilities AS 1428.2-1992 pp41
		
		Design for access and mobility Part 5: Communication for people who are deaf or hearing impaired pp17-18
			• At least one accessible payphone shall be at an accessible floor level.
			• Clear floor space A clear floor space in front of the payphone of not less than 800 mm by 1300 mm that allows a forward approach by a person using a wheelchair shall be provided.
			• The required clear space shall not be restricted by bases, enclosures and fixed seats.
			• The highest operable parts that are essential to the basic operation of the telephone shall be as shown in Figure 35(a) pp41 AS 1428.2-1992.
			• Controls, handset, touch pads and the like shall be within Zone 1 (see Figure 35(b)), and notices and information within Zone 2.
			• Protruding objects Telephones, enclosures and related equipment shall comply with Clause 6.7.
			• Equipment for hearing-impaired people shall
			  ○ Equipped with a volume control and a built-in coupler.
			  ○ The location of such payphones shall be indicated by symbols in accordance with Clause 16.
			• Dial Accessible payphones shall have push-button controls.
			• All payphones shall have an adjustable volume control that results in the level of sound from the earpiece of the payphone being a minimum of 20 dB above that specified for the earpiece of a standard handset connected to the standard telephone service. On hang-up, the volume shall revert to normal.

Objective	Importance	Existing standards AS	Measurements
	for individuals with communication difficulties. • However, with new mobile phone technology being wide spread and prevalent, public phones are no longer as important as before Rating 4/10		• All payphones with adjustable volume controls shall reduce side tone ratio when the volume control is increased. NOTE: Increasing the volume control also increases the background noise received by the payphone mouthpiece. • All payphones shall emit a magnetic field strength from the handset receiver greater than −23 dB relative to 1 A/m at 1 kHz for at least one setting of the volume control. • All payphones shall have adequate background noise attenuation ability. • For public telephones to be accessible by all members of the public (including wheelchair users with hearing loss), in every bank of telephones, a minimum of one telephone shall: o have Telephone typewriter (TTY) capabilities, o be wheelchair accessible o be equipped for both coin and card operation. • The location of TTY- equipped payphones shall be indicated by the international access symbol for deafness. • All TTY- equipped payphones shall be identified by the international access symbol for telephone typewriters, as illustrated in AS/NZS 4277. • All TTY- equipped payphones shall be capable of communicating with all other TTYs sold in Australia and with the National Relay Service. Clear and concise instructions for using such payphones shall be clearly displayed at their locations. • Where TTY- equipped payphones are provided in shopping areas or any location with an information stand, such information stand (or directory boards

Objective	Importance	Existing standards AS	Measurements
			with maps) shall indicate where the TTY- equipped payphones are located.
Waiting rooms and shelters	*Mobility: High* • Dimensions of waiting rooms should be large enough to accommodate a wheelchair and wheelchair changing direction. • There should be wheelchair seating spaces so that a carer can sit next to the individual in the chair Rating 9/10 *Hearing Impaired : Low* • Individuals with hearing impairment have full mobility. Rating 3/10 Vision Impaired: Low Communication Impairment: Low	Design for access and mobility Part 1: General requirement for access – New building work AS 1428.1 -2009 pp 92-95 Design for access and mobility Part 3: Requirements for children and adolescents with physical disabilities. AS 148.3-1992 pp12 Design for access and mobility Part 2: Enhanced and additional requirements – buildings and facilities AS 1428.2 -1992 pp 38	• Wheelchair specific space 1700 mm width for 2 wheelchairs and 800 mm width for 1 wheelchair • Whole space allocated for any wheelchair shall not impinge on the dimensions required for aisles by more than 250 mm or crossovers by more than 300 mm • Located to allow lines of sight comparable to those for general viewing areas and shall not be obstructed by opaque handrails or balustrades • Age 10-14 : height of chairs > 360 mm and <460 mm • Age 14-18 : > 485 mm and < 510 mm • Seating should generally be 450 mm high but where a high proportion of elderly users are anticipated, heights up to 520 mm are preferred. Children and small people may prefer seats as low as 350 mm high. Where possible a range of seat heights should be provided. • Front of the seat shall have a clear space between any legs at ground level to within 150 mm of the front edge of the seat, and to within 100 mm of the seat height to allow or rearward adjustment of feet when rising. • Where armrests are provided, the top surface of the armrest shall be at a height of 260 +/- 40 mm above the seat. • Armrests should be provided for all seats • Armrest should be within the centre of gravity of the seat • Front edge of the seat shall have a minimum radius of 30 mm • No edge or projection shall have a radius of less

Objective	Importance	Existing standards AS	Measurements
			than 5 mm unless protected from contact with the user. • Seat shall drain free of water.
PA systems	*Mobility: Low* • Individuals with mobility impairment only do not need extra assistance hearing. Rating 2/ 10 *Hearing Impaired: High* • Individuals with hearing impairment need louder and less distorted messages. Rating 9/10 *Vision Impaired: Low* • Individuals with vision impairment only, can hear. • However instructions need to be given clearly as the individuals may not be able to ready navigate the surrounding other. Rating 3/10 *Communication Impairment: Medium* • Individuals with communication impairment only have no hearing difficulties. • However clear and simple instructions need to be given to avoid confusion. Rating 6/10	Design for access and mobility Part5: Communication for people who are deaf or hearing impaired AS1428.5-2010	Assistive Listening Systems (ALS) • Audio frequency induction loop systems • Modulate radio system • Infra-red systems ALS requirements : • Distortion of all input < 2% • Distortion form electrical input to electrical output < 3% • Distortion shall be measured with a pure tone at frequencies of 500Hz, 1kHz and 2KHz Signal to noise ratio • Minimum signal to noise ratio (s/N) at the output of the ALS shall be greater than or equal to 15 dB, where the A-weighted value of noise is compared with the long-time linear speech level Audio Frequency induction loop systems (AFILS) • Unmodulated wireless transmission system • AFILS defined as all points inside, outside over, or under the loop that meets the AFILS specifications at the heights specified above the finished floor level. Modulated Radio systems • Different radio systems can operate over a wide range of carrier frequencies from 100 kHz to 1 GHz, • Transmitter and receiver of modulated radio system shall be capable of achieving clear communication • Modulated radio system shall not drift in frequency

Objective	Importance	Existing standards AS	Measurements
			• Each receiver shall be marked with frequency or the channel(s) on which it operates, with sufficient detail for consumers to identify that the unit is the correct unit or the intended area of operation. • Receiver shall have a volume control that is either continuously variable or can be adjusted in steps of no more than 2 dB increments • Receiver shall have a volume rant of 30 dB • User shall have a choice of either a neck loop or headphones/stetoclips/ earbudes/earpieces • Venue's responsibility to provide both choice of items • Peek level of speech emitted by the neck loop or induction plates shall >+ -11 dB re 1 A/m when measured at the ear. • Headphones etc shall be stereo or binaural Infra-red system • The transmitter and receiver of an infra-red system shall be compatible, to achieve clear communication. This may involve multiple transmitters. • The system shall provide sufficient coverage of the intended area of operation. • It shall include adequate capability to allow for normal movement of the head and upper body when being worn, without loss or degradation of signal. • The receiver shall have a volume control that is either continuously variable, or can be adjusted in steps of no more than 2 dB increments. • The receiver shall have a volume range of 30 dB. • The user shall have a choice of either— a neck loop

8.2 Appendix B - Summary Behaviours, Obstacles and Needs According to Impairment

TableB1: Wayfinding with Cognitive Impairment

Cognitive Impairment: *Brain disorders* – Traumatic brain injury, stroke, congenital (Down Syndrome, Cerebral Palsy), developmental, age related (Alzheimer's disease and other dementias, Dyslexia.		
Possible wayfinding behaviours	**Barriers and obstacles**	**Wayfinding Needs**
Information gathering • Can read with a limited capacity (Braddock et al., 2004) *Path finding* • Reliance on public transport (Carmien et al., 2005) • Can with limited ability: comprehend, process information, conceptualise, plan, sequence thoughts and actions, remember and understand numbers/symbols. (Braddock et al., 2004) • Some are easily distracted (Liu et al., 2007) • Some wander (National Down Syndrome Society, 2010) • Many use assistive technologies (low and high-tech) to augment daily living and control of their environment *Attention improving strategies* • Prepare before a trip (to go through the sequence of travel steps in a place and time that best suits their concentration • Consult with a friend, carer, timetables, website (computer, internet, telephone) (McDougall, 2007) *Memory improving strategies* • Make lists, take notes, follow daily planners & diaries • Go through every detail of the trip • Repeat directions verbally (McDougall, 2007) *Problem solving strategies*	*Information gathering* • Illiteracy • Complexity is confusing and stressful • Unfamiliar text messages • Interaction with outlets • Reading and understanding directions • Understanding operator announcements (Yalon-Chamovitz, 2009) *Path finding* • Busy station (Department for Transport & Transport Scotland, 2008) • High pace & temporal demands (Need more time to mentally process, and have slow reaction times) • Unfamiliar surroundings • Sudden changes • Fast moving crowds • Lack of landmarks • Understanding navigational artefacts e.g. clocks, maps, schedules, timetables, labels and signage (because of their generality, and therefore complex) (Carmien et al., 2005)	*Information gathering* • A way to receive information that is meaningful (simplified, specific, and ask one question at a time (Family Caregiver Alliance, n.d.) • A meaningful way to receive announcements and warnings • Provide information in a variety of modalities (auditory, visual, text) (Yalon-Chamovitz, 2009) *Staff training* • Do not treat like a child • Use simple directions • Explain one step at a time • Use easy language • Do not speak too fast • Be respectful *Path finding* • Clear and well-defined pathways • Simple physical environmental design ○ Symbols, pictures, signs & pictograms (internationally recognised) (Yalon-Chamovitz, 2009)

• Ask for assistance • Think through the problem out loud • Discuss the problem with another person • Develop a routine to stay organised • Anticipate problems and develop strategies to deal with them (before making a journey) (McDougall, 2007) *To alleviate stress* • Travel at non-peak station times • Travel at best time of day for the individual • Develop a routine • Break down complex steps into smaller ones (McDougall, 2007) • Some may take unperceived risks • May exhibit poor judgement (Family Caregiver Alliance, n.d.)		
Cognitive Impairment: *Psychiatric disorders (severe and persistent)*- Depression, Anxiety, Obsessive Compulsive, Bipolar, Schizophrenia, Multiple personalities		
Possible wayfinding behaviours	**Barriers and obstacles**	**Wayfinding Needs**
Information gathering • May ask questions from station staff • Rely on clear signage, and simply maps • Rely on clear, well-defined pathways • May seek pre-visit information (computer and internet, friend, counsellor, use of telephone) (McGurk & Mueser, 2006) *Path finding* • May be assisted by a job coach • May take unperceived risks • May have a life-coach to help transition from health care provision to independent living (Wilson, 2010) • To aid memory use external strategies: take notes, make lists, use diaries • To aid memory use internal strategies: elaboration or	*Information gathering* • Complexity • Unfamiliar signals, signs or messages *Path finding* • Crowds in general • Noisy environments • Cluttered environments • Sterile environments • Complexity • Sudden changes • Unfamiliar surroundings (Queensland Health, 1996b)	*Information gathering* • Rely on clear, simple signage, maps and directories • Rely on pre-visit information to be clear, and well written directions • Rely on information to be accurate and up-to-date *Staff training* • Direct instruction and communication • Awareness of the various conditions, and needs they may have • Treat with respect • Do not treat like a child • Direct one step at a time *Path finding* • Create therapeutic environments to reduce stress: ○ domestic ambience – indoor plants, artworks, soft colours, fittings. Avoid fluorescent lights

rehearsal (McDougall, 2007) • May obtain help from a general practitioner or psychologist to improve being with people • May use self-management strategies (use the internet, or attend a self-help group) • Attend counselling to improve life-skills • Access skills training from life coaches (Australian Bureau of Statistics, 2008a) • Travel at a time that best suits the individual's concentration • Avoid travelling at peak traffic times • Develop a routine to stay organised • Verbally repeat or write down multistep sequential directions • Break complex steps into smaller ones (McGurk & Mueser, 2006)		○ clearly delineate transition progressing from large to smaller spaces (colour, texture) ○ promote a feeling of comfort - soft furnishings, textures (avoid glossy flooring and glaring light) ○ promote security and self-esteem – diffused light, inaccessibility to restricted areas and places (symbolic/visual cue is better than a physical barrier), simple floor plans and directional signage (Queensland Health, 1996b) • Provide safe and purposeful access to alleviate confusion • Comfortable lighting (daylight strategy, not glary, not dull, light from two directions softens features of people, furniture and the space, indirect lighting • Feedback and reassurance of location – artefacts, colour, texture to calm • Simple floor plans, clearly delineated (employ a graphic system that is consistent throughout the complex to reduce stress • Utilise natural ventilation to aid concentration • Acoustically quiet: use soft furnishings, break up harsh flat surfaces to aid cognition. • Use artwork that generates favourable psychological responses and to aid cognition (Queensland Health, 1996a)

Table B2: Wayfinding with Visual Impairment

Visual Impairment: partially blind, legally blind, completely blind, coloured blind, age related (Degenerative conditions: cataracts, myopia, macular degeneration		
Possible wayfinding behaviours	**Barriers and obstacles**	**Wayfinding Needs**
Information gathering • May access information with assistive technology: Closed Circuit TV, Micro recorders, Monocular hand held mini-scopes, large print software programs,	*Information gathering* • May forget to wear reading glasses • Size, colour, contrast and illumination of signs • Deciphering messages that use certain colour	*Information gathering* • Interaction with outlets and ticket machines in different modalities (Braille, raised print, audio) • Tactile, graphic and audio communication services

ZoomCaps computer keyboards, a portable Brailler, or Screen readers. • May rely on retrieving information in the following way: Braille, tactile surfaces, raised lettering, vibration and audio transmissions (TAFE Disability Program Unit, n.a.) • May wear glasses or contact lenses for short or long distances to see information better (Anderson et al., 2002) • Rely on clean and clear signage, and large print *Path finding* • Travel with assistance, guide, or seeing eye dogs • May use a cane ('Hoover' cane white with red tip, folded long cane,' symbolic' cane to alert others, and 'support' canes for added stability) (TAFE Disability Program Unit, n.a.) • Rely on hazard markers and tactile guidance paths (Blind Citizens Australia, n.d.) • Use mobile phones and other personal devices (Anderson et al., 2002) • Use tactile interfaces that relay audio messages (ATMs) (McCance & Huether, 2006) • May be a holder of a Vision Impairment (VIP) Travel Pass (entitled to various concessions) (Department of Transport and Main Roads, 2010b)	mixes: Red & Green (colour blind), and blue & green (yellowing of the lenses due to age) (McCance & Huether, 2006) *Path finding* • Identifying changes in direction, level, drop offs and hazards • Distinguishing between road and pedestrian areas • Objects in path of travel • Insufficient lighting (steps and pathways in particular) • Knowing specific location (e.g. if lift has arrived at the right floor) • Negotiating steps • Avoiding obstacles • Seeing glass walls, doors and panels (Currie & Allen, 2007) • Moving crowds increase risk	• Signage for the partially blind (embossed print, Braille, size, placement, high contrast, illuminated) • Signage for the colour blind: avoid placing adjacent: red & green and green & blue. *Staff training* • Staff training to improve awareness, sensitivity, communication and sighted-guide skills (Blind Citizens Australia, 2010) *Path finding* • Assisted navigation through the train station -TGSI • Aware to all potential hazards • Be able to exit safely in an emergency • Audible signals at escalators and lifts • Indicators of hazards and changes in direction. • Reinforcement that they are travelling in the right direction (talking lifts, talking signs) (Hogan, Crawford, Smit, & Smith, 2007) • All stairs fitted with Tactile Ground Surface Indicators (TGSIs) indicating top and bottom. • Clear path of travel • Identification of location (e.g. what floor/platform a lift has arrived at, audible messages, signals) • Be able to see glass walls, doors and panels (McBride et al., 2001)

Table B3: Wayfinding with Hearing and Speech Impairment

Hearing Impairment: Partially and complete deafness, deaf and mute, age related – Presbycusis		
Possible wayfinding behaviours	**Barriers and obstacles**	**Wayfinding Needs**
Information gathering • Sign as they walk • Signers tend to form circles and arcs when communicating • Heightened awareness of sights and smells • Need to see the eyes and facial expressions of the one speaking	*Information gathering* • Lack of visual information • Asking questions • Making telephone enquiries (J. Evans & White, 1998) *Path finding*	*Information gathering* (visual, tactile) • Pre-visit information includes maps, directions, timetables • Clear signs, maps and directories • Clear, well-defined pathways • Clear written directions

(Bauman, 2008)
- Communicate with sign language (international or country specific- 271 sign languages, Australians use Auslan, while travellers often use International sign language IS)

(European Union of the Deaf, 2009)
- May lip read (need to see the face and gestures of the one speaking
- Some wear hearing aids
- Reliance on accurate, regularly updated travel information (visual)
- Some wear induction neck loops

(Department for Transport & Transport Scotland, 2008)

Path finding
- Travel assisted with a hearing dog
- Rely on spatial awareness - transparency and reflection

(Bauman, 2008)
- Reliance on visual and vibration communication/cues.
- Reliance on well-trained staff

(Department for Transport & Transport Scotland, 2008)
- May have received life-skill training

(Our Community Pty Ltd, n.d.)

- Inability to detect approaching vehicles (wheelchairs), especially when vision is obscured

(J. Evans & White, 1998)
- Background noise and crowds (Hearing aid wearers may be intolerant of loud noises as aids amplify background noise)

(Anderson et al., 2002)
- Stairs and curbs pose trip hazards to distracted signers in conversation
- Blind corners
- Doors that require the hands to open and close (thus pauses conversation)
- Too much enclosure reduces 'pro-social behaviour'
- Bright, harsh, contrasting and glaring light can fatigue eyes
- Lightly coloured or glossy flooring also strains the eyes while walking and signing
- Insufficient visual alarm strobes

(Bauman, 2008)

- Visual announcements
- Optimal lighting levels at all times, in all places, particularly at information desks, and onto faces to facilitate lip-reading

(Enterprise IG Information Design Unit, 2005)

Staff training
- Speak clearly, facing the person
- Able to use sign language (particularly Auslan)
- Be aware that some words can sound like others (terms, departments or landmarks)

(Enterprise IG Information Design Unit, 2005)

Path finding
- Maps and written directions available at information desks
- Induction loops at information desks to help people with hearing aids to hear spoken direction (consider magnetic interference)
- A system that effectively amplified specific sounds
- Reduce to need for people to ask questions (provide a clear wayfinding system)
- Visual announcements in lifts (which floor, if the lift breaks down, indicate assistance is on its way)
- Visual fire alarms
- Escorts that can take people to their destination

(Enterprise IG Information Design Unit, 2005)
- Ability to receive announcements and warnings (strobes of sufficient number, vibration)
- Flooring that does not strain the eye while walking and signing. Avoid light coloured, polished and shiny flooring.
- Acoustically quiet spaces Reduce: echoes, reverberation; consider: floor coverings and sound proofing

		• Place artefacts/ landmarks at strategic positions to assist location identification. • Assist location identification: vary colour, texture, design motif, numbering system – a coded system • Glass walls, lift panels, doors, etc provide situational awareness and safety (transparency and reflection) • Provide some curved seating to allow informal conversation while waiting for trains • Automated doors allow continuous conversation (Bauman, 2008)
Speech Impairment*:* Mute, difficulty speaking, use a trachea vibrator (oesophageal speech, damaged vocal cords, chronic laryngitis, slurring, stuttering, deaf, incoherent		
Possible wayfinding behaviours	**Barriers and obstacles**	**Wayfinding Needs**
Information gathering • Rely on visual cues and signs • To ask for directions, may speak slowly or write down the question • May avoid using telephones • Text using mobile phones • Reliance on visual or tactile provision of information	*Information gathering* • Asking for help - Inability to be understood (WrongDiagnosis.com, 2010b) *Path finding* • Communicating in noisy environments Crowds increase risk	*Information gathering* • Pen and paper at information and ticket desks • Quiet area to communicate *Staff training* • Ask the person to speak slowly, or provide pen and paper • Repeat what you think the person is asking
Non-English Speaking: Indigenous Australian, foreign national, tourist, people travelling on business		
Possible wayfinding behaviours	**Barriers and obstacles**	**Wayfinding Needs**
Information gathering • Likely to speak one of the top ten languages spoken in the world: English, French, Spanish, Russian, Arabic, Chinese, German, Japanese, Portuguese and Hindi/Urdu (Weber, 2008) • May speak one of 90 indigenous languages (Australian Flexible Learning Framework, 2003) • Reliance on internationally recognised signs, symbols and pictograms	*Information gathering* • Text too difficult to understand (too long, difficult language) • Insufficient international signs, symbols, and pictograms • Unfamiliar text messages *Path finding* • Unfamiliar surroundings	*Information gathering* • Use internationally recognised signs, symbols and pictograms • Information provided in a choice of languages *Staff training* • Awareness of the diversity of Indigenous Australians • Use simple language

Path finding • Reliance on clear and well-defined pathways Simple and clear signage, maps and directors (Enterprise IG Information Design Unit, 2005)	• Unfamiliar text messages (James, 1997)	• Explain directions one step at a time *Path finding* • Clear and well-defined pathways • Simple and clear signage, maps and directories (Enterprise IG Information Design Unit, 2005)

Table B4: Wayfinding with Deafblind Impairment

Deafblind: dual sensory loss - complete loss, partial hearing & sight loss, complete hearing & partial sight loss, complete sight & partial hearing loss, age related		
Possible wayfinding behaviours	**Barriers and obstacles**	**Wayfinding Needs**
Information gathering • Use specialised communication techniques (speech, oral/aural, tactile, raised print, Braille, sign language) (Australian DeafBlind Council, 2010) • Various sign languages used- tactile sign, or hand over hand, deafblind fingerspelling • Those sign, find it difficult to learn English (spoken and written) (Able Australia, 2010b) • Likely to explain how to communicate with them (Department for Transport & Transport Scotland, 2008) • Some obtain information from the website, email, TeleBraille for telecommunications (TTY), phone or contacting train stations directly for assistance • Some use non verbal communication (e.g. miming the time and asking how many stops) • Learn -touch, smell, taste, kinaesthetic link in space • May have a Special Support Provider SSP (provides interpreting and visual information about the environment, description of people and mood of a meeting, etc. (James,1997) *Path finding* • Some use canes/ carriers of Vision Impaired Travel Pass • Carry a communication book or signs indicating they are deafblind and their needs • Develop their own strategies to navigate the system • Life is to be experienced rather than observed/heard • May do 'assertiveness' training (Able Australia, 2010c) • May have a 'team leader' - monitors and assists (Able Australia, 2010a)	*Information gathering* • Communication • Learning • Access to interpreters • Access information on train platforms (preferred at an ATM height and with larger text) • Insufficient case managers, support workers and carers who communicate in Auslan at anytime *Path finding* • All issues that the deaf and blind people face only compounded. (Australian DeafBlind Council, 2010) • Orientation and mobility • Confidence and self-esteem • Access to aids and equipment due to cost (Deaf Blind Association (NSW), 2010) PLUS • Accessing suitably qualified and trained staff aware of the needs of the deafblind Other issues that impact public transport access indirectly • Shortage of qualified interpreters and note takers (Zammit & Gaile, n.d.) • Inability to access gates when no staff are present.	*Information gathering* • Sufficient information in accessible formats (pagers, alarm clocks, computers, large visual display TTYs, Braille caption devices, internet facilities) (James 1997) • A means of communication (access to their specialised techniques, visual, auditory, tactile) • Announcements need to be in large font preferably at an ATM height • A way to receive announcements and warning (visual, tactile and audio) • Good lighting on platforms, to ensure signs are readable *Staff training* • Access to trained staff assistance • Identifiable staff (e.g. wearing a coloured vest) • Assistant to touch deafblind person on shoulder or on the side to let their presence known. • Staff are requested to communicate in verbal and non verbal ways (nodding, smiles, thumbs up, etc) *Path finding* • Location feedback to know if in the right spot • Proactive staff that offer to help • Cross modal assistance (e.g. Federation square - superstop to the Flinders street station) (James, 1997 • Orientation and mobility training

Table B5: Wayfinding with Mobility Impairment

Mobility Impairment: paralysis, injury, amputation, arthritis, limited agility, age related, somatosensory impairment, heart disease, obesity, pregnancy, Travelling with children, luggage, or large objects		
Possible wayfinding behaviours	**Barriers and obstacles**	**Wayfinding Needs**
Information gathering • Use lower facilities to obtain information *Path finding* • Use wheelchairs and scooters • Use walking aids to provide stability: sticks, frames and crutches (due to: injury, reduced muscle mass, strength, power and endurance, or joint pain, fatigue easily • Walk with an abnormal gait (due to: changed centre of balance) • Use blankets for warmth (due to: lower core temp) (Anderson et al., 2002) • Use hand rails, take frequent rests, take small steps, and avoid steps (due to: reduced balance, reduced walking speed, reduced step length, reduced walking rhythm, reduced motor coordination &reaction time) • Use services that are easy to reach (due to: reduced height, reduced flexibility) (McCance & Huether, 2006) • May hold a 'disability parking permit' (In Qld, holder is eligible to use designated parking bays)	*Information gathering* • Access to facilities at regular height (toilet, bathroom, telephone, ticket/ banking interfaces • Signs placed too high *Path finding* • Level changes and no ramps • Cluttered station layouts • Lack of space to move or sit, protruding fittings and furniture • Uneven, bumpy, soft, broken surfaces • Negotiating kerbs, steps and stairs • Insufficient or badly designed parking spaces • A moving crowd increases risk (Carmien et al., 2005) • Travelling long distances • Moving in narrow spaces • Pushing or pulling heavy doors • Drafts and poorly vented areas (J. Evans & White, 1998) Moving through regular ticket turn stalls or barriers	*Information gathering* • Access to all facilities (height and space) *Staff training* • Use of mobility equipment *Path finding* • Access to all facilities and different levels (staff assistance, ramps, lifts & aids) • Close access • Space to move about (Department for Transport & Transport Scotland, 2008) • Appropriate exit and entry points (automated wide bi-directional door) • Designated and close wheelchair and scooter access, drop-off points, parking facilities (McBride et al., 2001) • Consideration of distances & need for rest areas • Smooth but not slippery floor surfaces • Hand rails (height and shape)
Manual dexterity: Sensory impairment, arthritis, muscular diseases, amputation		
Possible wayfinding behaviours	**Barriers and obstacles**	**Wayfinding Needs**
Information gathering *Path finding*	*Information gathering* • Inability to operate handles, switches ticket machines *Path finding* • The placement and shape of handrails (Currie & Allen, 2007)	*Information gathering* • Easy to press buttons /switches (size and shape) *Path finding* • Facilities that are easy to operate • Handles that are easy to use (size and shape, automated)

8.3 Appendix C – Tips on Communicating with People with Impairments

Blind (Association for the Blind of WA, 2010):

- Introduce yourself. Don't expect a person who is blind to guess your name
- Upon approaching the person, say something to signal your presence (e.g. "Hello, it's Jim")
- When leaving the person, inform them quietly
- Don't leave a person standing alone in the middle of a room, make sure they have contact with a table or lounge, and knowledge of their position
- Speak directly to the person and look at them as this directs your voice towards them
- Don't be afraid to use words like 'see', or 'look' as these words have meaning for everyone
- Don't shout – don't assume blind people are also deaf
- Ask the person if they need assistance, don't assume. Don't be offended if they decline
- Make sure the person knows where they are going and that they have a clear travel path.

Deaf (adapted from Cryer, n.d.)

- Don't shout - speak a bit louder. Shouting comes across as aggressive
- Stand closer to deaf people when speaking
- Separate words and pronounce beginnings and endings of words for clarity (speaking slower doesn't have the same effect)
- Wait for a quiet environment before trying to converse
- Make sure the deaf person knows the topic of the discussion
- Make sure the deaf person is attending to you before trying to talk (people with unbalanced hearing tend to get used to ignoring the odd sounds around them)
- Don't begin with a question, allow the person to get used to the rhythm/intonation of your voice
- Where appropriate, alert others to the needs of a deaf person, negotiate that is okay first
- If you know a sudden loud noise is about to occur, alert the person.

Deafblind (adapted from James, 1997)

- Be proactive, offer help rather than being asked to help
- Indicate your presence by touching the person on their shoulder or on their side
- Look for communication signs or books as many carry these to indicate their needs
- If necessary, escort the person to their required destination, platform
- Communicate using verbal and non verbal ways (e.g. nodding, smiles, thumbs up, etc)
- If there is residual sight or hearing, stand closer to and face the person when speaking
- Profoundly deafblind will predominantly speak through an interpreter (Auslan)
- Fingerspell numbers or words, many Deafblind people sign or fingerspell as deaf people do.

Cognitive Impaired (adapted from Yalon-Chamovitz, 2009)

- If a person looks confused or stressed, ask if they require assistance
- When approaching an anxious person, tell the person who you are and how you can help
- Speak calmly and clearly, separating your words, this assists comprehension for those who process information slowly
- Try to converse in a quiet area
- Use easy language and do not treat them as a child
- Provide the simplest and most direct routes, point out landmarks
- Provide directions, one step at a time
- Ensure the person understands the directions, ask them to repeat back the steps
- Give a map or clear directions on paper for the person to keep, to assist the person's memory

- If necessary, escort the person to their desired destination, platform
- Do not leave a person alone who is confused and anxious.

Speech Impaired (adapted by Department for Transport & Transport Scotland, 2008)

- Look for a quiet place to converse
- Repeat what the person has said to ensure you understand
- Ask the person to write their enquiry down.

Non-English speaker

- Offer assistance if someone is looking confused or stressed
- Use non-verbal communication to find out the cause of confusion or enquiry (mime or point to possible needs, e.g. watch, schedules, facilities)
- Use pictograms of facilities and ask the person to indicate their area of need
- Provide timetables, maps and directions in a variety of languages
- Provide maps and directions using symbols and images.

8.4 Appendix D – Helpful Websites on Disability Issues

Ageing

http://www.health.gov.au/
http://www.population.org.au/index.php/resources/fact-sheets/312-australias-ageing-qproblemq

Deafblind

http://www.ableaustralia.org.au/training-dates.asp
http://deafblind.org.au/
http://www.dbansw.org.au/

General Disability

http://hcdg.org/definition.htm
http://www.nds.org.au/

Hearing Impairment

http://www.deafau.org.au/
http://www.deafcando.org.au/
http://deafness.about.com/od/deafhohorganizations/Deaf_and_Hard_of_Hearing_Organizations.htm
http://www.deafservicesqld.org.au/
http://www.deafsocietynsw.org.au/information/links_deaf_services.html
http://www.deafsocietynsw.org.au/?gclid=CPDk2ueug6ICFYYvpAod0HGPCg
http://www.deaftalk.co.uk/helping-interaction.htm
http://www.dhhs.ca/
http://www.hearingdogs.org.uk/aware_assistance_dogs.php
http://www.gadhoh.com/
http://www.ridbc.org.au/resources/hi_online_hi.asp
http://www.righthealth.com/topic/Deaf_And_Hard_Of_Hearing?p=l&as=goog&ac=519&kgl=35461336
http://www.tasdeaf.org.au/
http://www.vicdeaf.com.au/
http://www.wadeaf.org.au/
http://www.wadeaf.org.au/index.php?id=46
http://www.widhh.com/

Cognitive Impairment

http://www.as.wvu.edu/~scidis/intel.html
http://catalogue.nla.gov.au/Record/32360
http://home.vicnet.net.au/~dealcc/TcpCnet.htm
http://kttutors.tripod.com/id5.html
http://www.vanguardschool.org/Default.aspx?tabid=671&gclid=CJq90I-pxaUCFQvbbgod7Q2p_g
http://www.wrongdiagnosis.com/symptoms/speech_symptoms/causes.htm
http://www.yfs.org.au/Intellectually-impaired-people-pg9149.html

Mobility Issues

http://www.electricscooter.com.au/
http://www.oamobility.com.au/?gclid=CO2ox42ug6ICFcgvpAodiX84IQ
http://www.paraquad.org.au/ (New South Wales)
http://www.paraquad.org.au/ (South Australia)
http://www.paraquadtas.org.au/ (Tasmania)
http://www.paraquadwa.asn.au/ (Western Australia)

Statistics

http://www.abs.gov.au/ausstats/abs@.nsf/mf/4326.0 (Mental Health)
http://www.abs.gov.au/ausstats/abs@.nsf/mf/4430.0 (Disability, Ageing and Carers, Australia 2009)
http://www.abs.gov.au/websitedbs/C311215.nsf/web/disability+and+carers (Disability and Carers Australia)
http://www.abs.gov.au/ausstats/abs@.nsf/mf/4704.0.55.001 (Aboriginal and Torres Strait Islander Health)
http://www.abs.gov.au/ausstats/abs@.nsf/mf/4704.0 (Aboriginal and Torres Strait Islander Health)
http://www.who.int/topics/disabilities/en/ (Disabilities)
http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/4326.0Main%20Features32007?opendocument&tabname=Summary&prodno=4326.0&issue=2007&num=&view (Mental Health)
http://www.abs.gov.au/AUSSTATS/abs@.nsf/ProductsbyTopic/768EE722E31F6315CA256E8B007F3055?OpenDocument (Disability)
http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4430.0Main+Features12003?OpenDocument (Disability and Ageing)
http://www.abs.gov.au/websitedbs/c311215.nsf/20564c23f3183fdaca25672100813ef1/29ac3ed8564fe715ca256943002c4e3c!opendocument (Disability and Ageing)
http://www.abs.gov.au/websitedbs/c311215.nsf/20564c23f3183fdaca25672100813ef1/d5802bafcaf33e01ca257126000abe28! (Ageing)
http://www.who.int/blindness/table/en/ (vision impaired)
http://www.who.int/mediacentre/factsheets/fs282/en/ (Visual impairment and blindness)

Transport accessibility and Australian Human Rights

http://www.hreoc.gov.au/di_rights/transport/transport.html
http://www.immi.gov.au/

Vision Impairment

http://www.bca.org.au/
http://www.blindwelfare.org.au/ (South Australia)
http://www.dbansw.org.au/
http://www.guidedogs.org.au/our-services/guide-dog-services/autism-assistance-dogs
http://www.guidedogswa.com.au/about-vision-loss/community-education/blindness-and-disability-awareness/
http://www.royalblindsociety.org
http://rsb.org.au/
http://www.visionaustralia.org/info.aspx