A DESIGN LED STRATEGY TO ASSIST PEOPLE WITH REDUCED MOBILITY IN THE STATION ENVIRONMENT.

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ABSTRACT

This paper presents research supported under the Australian Government Cooperative Research Centre Programme for Rail Innovation. It forms part of a comprehensive review of station and infrastructure within Australia to establish guidelines for best practice in station design.

In Australia the Disability Standards for Accessible Public Transport 2002 (DSAPT) was shaped from the Disability Discrimination Act 1992 (DDA) to outline minimum accessibility compliances for operators of public transport. The paper aims to summarize research around universal access and passenger safety within stations from a design led perspective focusing on objects and infrastructure at the platform.

A literature review of existing material on the rail environment was undertaken to establish a common ground for establishing best practice guidelines specifically targeting People with Reduced Mobility (PRM).

The subsequent findings resulted in a set of criteria that can be used to inform further development opportunities for inclusive design and to improve and extend industry understanding and compliance under the DDA.
Although focused primarily in an Australian context this research holds relevance in progressing similar principles for inclusive accessibility in rail orientated transport outside of Australia.

Keywords: mobility, inclusive, PRM, station, retrofit, design, strategy.

1. INTRODUCTION

Mobility is an essential part of everyday activities and maintaining connections between individuals, groups and communities (Stanley et al. 2011). These activities will often require the use of various transportation modes, overcoming distance to arrive safely at a chosen destination. The ability to travel easily and safely becomes a significant factor for individuals and their choice of transportation mode (Collins 2005).
For those who have a reduction in mobility the concept of everyday travel presents greater physical challenges and planning. Public transportation is one mode that has traditionally presented barriers to accessible travel for those with disability.

There are a number of initiatives directed in response at removing barriers for individuals with mobility constraints. In public transport this is largely influenced by government policy (DDA 1992). In acknowledging individual rights to accessible travel, operators and providers of public transport are presented with the task of implementing measures to respond to new policy demands (Smart, Miller & Taylor 2009).

There are three key objectives for this paper.

- The first is examining expected milestones of the Disability Standards for Accessible Public Transport 2002 (DSAPT). A background on disability and user profiles will be given.

- The second objective is to put into context the impact of the DSAPT within a current operating rail environment. The locus of the discussion will be applied to the Australian State of Victoria in Melbourne's metropolitan rail network alongside a review of current worldwide literature with a focus on accessibility.

- A final objective is to propose a design strategy towards ameliorating issues in the rail station design, objects and infrastructure.

2. POLICY FOR DESIGN

This section of the paper is intended to provide context for accessibility focused discussion towards a design led strategy.

2.1 DISABILITY DISCRIMINATION ACT (1992)

The Australian Federal Government in 1992 introduced policy outlining a social obligation to eliminate discrimination on the basis of disability. The Disability Discrimination Act (1992) commonly referred to as the DDA constitutes an Australian response to a global initiative recognising the importance of human rights equality of all individuals. In the United Kingdom there is the Equality Act 2010 (previously the Disability Discrimination Act 1995) and in the United States of America with the Americans with Disabilities Act of 1990. The DDA (1992) encouraged reflective assessment of individual and social acceptance of disability. Importantly it provided basis for best practice guidelines in accessibility to public premises/facilities and transport services, in doing so it clarified what constitutes a disability.

2.1.1 Disability

The definition of disability is a complex issue. The World Health Organisation (WHO) through its own *International Classification of Functioning, Disability and Health* (ICF) discuss various medical and social models in doing so (WHO 2011). One significant perception from the WHO-ICF is the contribution or impact of environmental factors in creating disability.

This is alongside the more commonly understood human function attributes defined by the WHO-ICF shown here:

- **impairments** are problems in body function or alterations in body structure – for example, paralysis or blindness;
- **activity limitations** are difficulties in executing activities – for example, walking or eating;
- **participation restrictions** are problems with involvement in any area of life – for example, facing discrimination in employment or transportation.

Source: World Report on Disability 2011 (Chapter 1, pg. 5)

The DDA (1992) approach aligns with the WHO-ICF view on disability, focusing on the individual person and the indirect discrimination against that individual or group (DDA 1992) *Section 4, 5 & 6*. The extent of the individual's disability, their comprehension of the operating conditions and an enabling environment establishes practical design conditions.

2.1.2 Persons with Reduced Mobility

One causal effect of disability is a reduction of mobility which can be perpetuated through physical and environmental factors (WHO 2011). Individuals with visual or hearing impairments, wheelchair and mobility scooter users have motivated numerous mobility studies in the context of rail accessibility (de Kloe, de Boer & Daamen 2008; O'Neil & O'Mahony 2005).

Similarly, reduced mobility can result from lifecycle impairments, typically age related as in elderly or young and temporary challenges for expectant mothers and parents with an infant or baby stroller. Add to this group individuals with assistive aids, carers *(including animal assistants; DDA Section 9)* or persons laden with luggage (Rentzsch et al. 2008). The industry abbreviation for this group is PRM (Persons with Reduced Mobility) and will be used herein.

Fig. 1 Accessibility signage at ticketing barrier, Richmond Station, Melbourne (Moug 2012)

2.2 DISABILITY STANDARDS FOR ACCESSIBLE PUBLIC TRANSPORT (2002) MILESTONES

The Disability Standards for Accessible Public Transport 2002 (DSAPT) was drafted to commit the intentions of the DDA (1992) to public transport. One purpose is to obtain equivalent access for users across all modes of public transport in Australia. It applies to all conveyances including metropolitan trains, trams and buses, regional trains and buses, taxis and the adjoining infrastructure. Foremost it established standards for accessible station design.

Focused on measurable features such as ramp gradients, handrail positions, and appropriateness of material as examples, the DSAPT pursues minimum limits for an inclusive operating environment. In addition to tangible constraints the compliancy milestones were also set for public transport operators and providers towards 2022 and 2032 as shown below.

	2007	**2012**	**2017**	**2022**	**2032**
Infrastructure	25%	55%	90%	100%	
Conveyance	25%	-	80%	-	100%

Fig. 2 Information source: Disability Standards for Accessible Public Transport 2002.

2.2.1 Equivalent access

Upgrading existing infrastructure to comply with minimum requirements in the provision of equivalent access (DSAPT 2002) *Section 1.16* is a focused priority. A recent study undertaken in Melbourne by the Station User Panel (Seyers 2011) reaffirmed the importance of obtaining accessibility for all users. Seyers (2011) iterated the aspiration for the provision of a seamless connection. The simplicity of a seamless connection as a concept is admirable however it is the complexity in achieving this that is revealed throughout the research into accessibility.

Universal design is one such approach. It is perceived in design as an integral combination of principles engaged in the development of inclusive products and environments (Froyen 2008). As an approach it is concerned with accommodating users of all abilities. Equivalent access (DSAPT 2002) *Section 1.16* should be considered a proponent of a universal design. Arguably, Erlandson (2008) for example, distinguishes between universal and accessible design with the later satisfying legal requirements as opposed to suitable to all users. Still, the DSAPT (2002) a legal document, regards equivalent access as not segregated or in parallel but of equivalent standard, thus seemingly it prioritises inclusive design outputs akin to Froyen's (2008) view, a universal methodology. Further state government initiatives outlining social inclusion (Kanis 2010; Reynders 2011) has indicated a universal design approach for the DSAPT at a local legislative level.

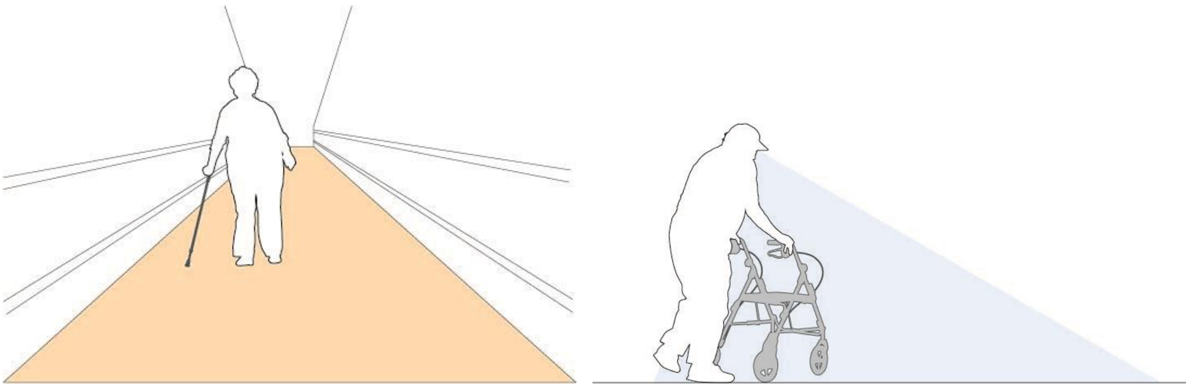

Fig. 3a & 3b (right) Persons with Reduced Mobility - PRM (Moug 2012)

2.2.2 PRM's on the rail network

Disability often results in a loss of independence and an individual's right to choice (Rock 1988). From a PRM's perspective independently navigating the station, the platform and the carriage and vice versa relies on a receptive, inclusive environment. A passenger's ability to board and alight the conveyance actively contributes to the 'dwell time' of the train at the platform. Dwell time is determined by the last person to either board the vehicle or disembark (Coxon, Burns & de Bono 2010). It is a critical factor of an efficiently functioning rail service and the running of a timetable (Wiggenraad, Lee & Daamen 2008). The situation for PRM's in rail networks are then twofold; degree of personal disability and the conditions of the environment to maintain independent mobility.

3. ISSUES IN A RAIL PASSAGE CONTEXT

To understand the significant design issues a review of the context is essential. Discussion draws from international research and thus can be recognised across most rail networks.

Australia's current rail environment is problematic as obstacles to the provision of safe, equitable access for passengers exist from both an operators and user's perspective.

3.1 Legacy Impacts

Fig. 4 Heritage listed Malvern Station, Melbourne (Moug 2012)

The lessening or eliminating of legacy issues to align with the DSAPT within an active network is challenging. Station design and infrastructure as public architecture are typically designed for a functional life of 100 years (VRIOGS 2011). Of 211 stations in operation across the Melbourne metropolitan rail network 39 are recognised by the Victorian Heritage Register as of particular significance to cultural heritage. Twenty nine of these stations are located in Melbourne's central ticketing designation.

One such example is Malvern Station (Fig. 4) along the Cranbourne line designed by architect W Hardy in 1912-1913. Heritage characteristics include red bricks, render banding, cantilevered verandahs with ripple iron valance, ornate parapets, tiled hip roof and arched entries which provide a stoic aesthetic to the station environment. The resulting caveats have a bearing on any future alteration or integration of significant visual impact.

In addition to visual aspects, increases in patronage and population growth (Morris, Wang & Berry 2002) has seen the rail industry confronted by its own legacy constraints. Stations with redundant facilities, historical platform dimensions (see Fig. 5) and functional limitations are often unsuited to the needs of the modern user (Griffin 2004) and operator.

Fig. 5 Legacy accessibility issue (adult with baby buggy) at Toorak Station, Melbourne (Moug 2012)

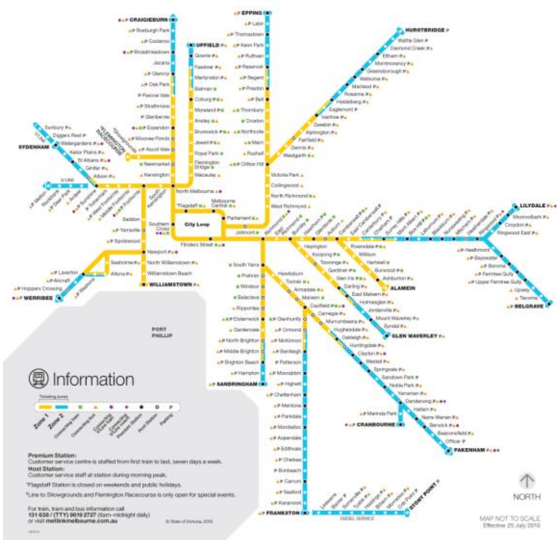

Fig. 6 Melbourne Metropolitan Rail Network Map (retrieved from: http://ptv.vic.gov.au/maps-stations-stops/metropolitan-maps/metropolitan-train-network-map/)

3.2 Interaction Zones

Froyen (2008) suggests five functional and accessible "social-spatial settings" within a "travel chain" as users negotiate passage through the station.
These are:

1. arrival
2. transfer to station and function of station
3. transfer to platform
4. boarding
5. disembarking and further connections

Similarly to Froyen's (2008) concept of social-spatial settings, this research delineates space into zones from a perspective where users are interfacing or encountering objects.

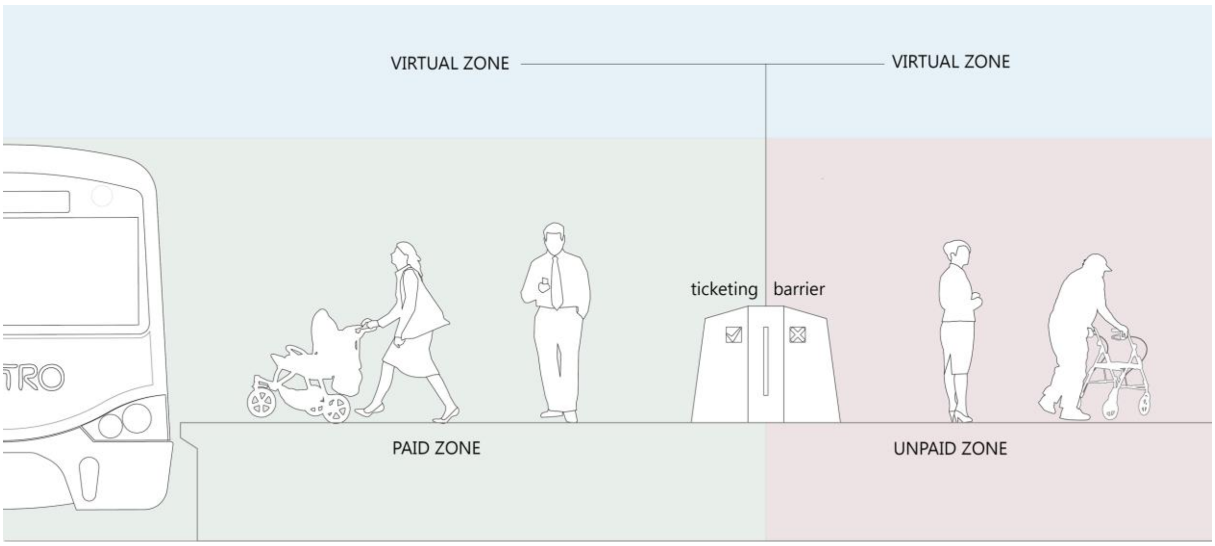

Fig. 7 Interaction Zones (Moug 2012)

Observations of interactions for PRM's in the station environment reveals both physical functionalities and introduces information functionalities, these occur from virtual assisted interactions.

Physical interaction points are readily apparent as passengers navigate from the station entrance towards the boarding destination and onto the conveyance. Foremost areas where physical interactions occur take place in two distinct zones; one being the unpaid zone, the second being the paid zone, as illustrated in Fig. 7.

In addition to the immediate physical environment it is widely accepted of the increasing popularity and adaption of digital technology from smartphones. Engaging and functional this technology offers opportunities to influence and inform the actions and interactions of passengers including PRM's (Baudoin, Venard & Pretorius 2010). For consistency and clarity this is termed the virtual zone and is discussed further on.

3.3 UNPAID ZONE

The unpaid zone is the space between the public station entrance and the point where a payment facilitates entrance to a paid zone. A common interaction within this space is a patron locating and purchasing a fare for valid travel.

3.3.1 Payment of fares

The purchasing of a valid ticket fare requires the use of a fare payment system. Melbourne uses a Myki branded smartcard system which superseded the prior integrated fare payment system known as Metcard at the end of 2012.

As a consequence a majority of Myki fare payment vending machines were installed in direct replacement and proximity of the Metcard vending machines. The DSAPT Section 25.4 outlines the requirements for a front of machine circulation space of 180° turn for a wheelchair. This currently necessitates a perpendicular orientation of the machine to the adjacent wall.
The implication of this is evident in Fig. 8, at peak time this becomes increasingly problematic. The inclination for patrons is to form a continual line *front-on* to the fare vending machine, behind the engaged user. This inadvertently creates a congestion point within the station passageway and subsequently reduces the ease of circulation of arriving or departing passengers.
The author has indicated how well-known solutions could be applied to this context; one is a bollard arrangement (Fig. 9); the second (Fig. 10) is a standing demarcation graphic similar to the one previously shown in Fig. 1.

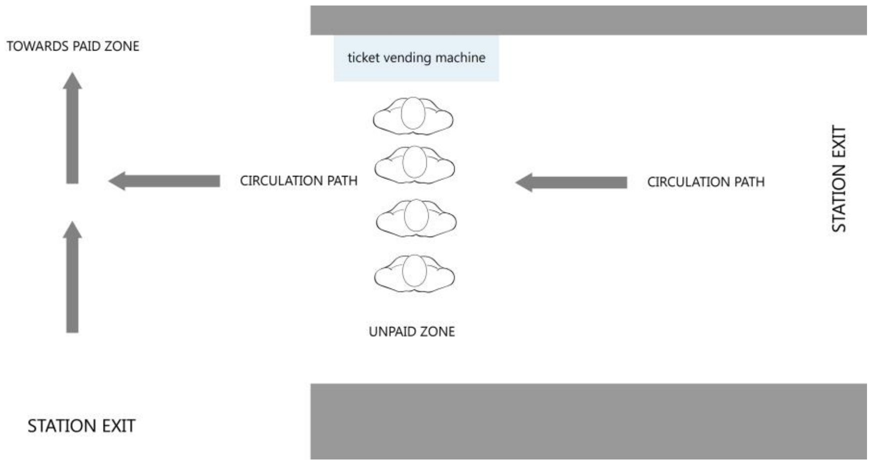

Fig. 8 Unpaid Zone fare payment (Moug 2012)

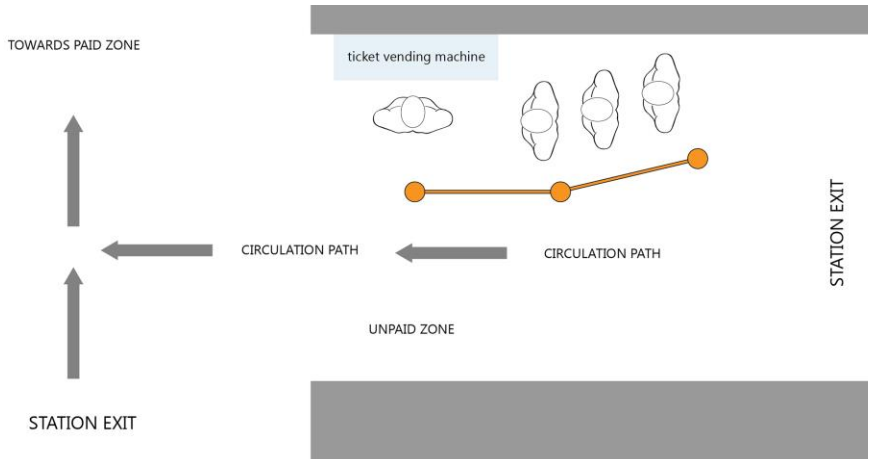

Fig. 9 Unpaid Zone fare payment – bollard arrangement (Moug 2012)

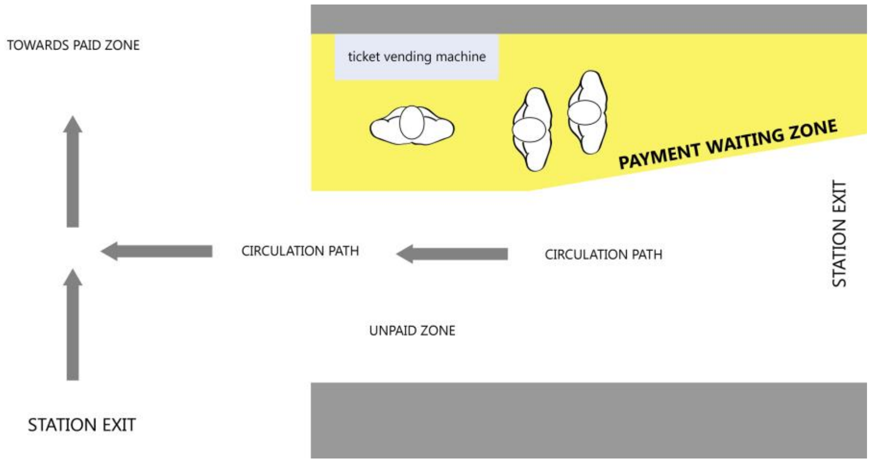

Fig. 10 Unpaid Zone fare payment – surface demarcation (Moug 2012)

3.4 PAID ZONE

Within the immediate research the paid zone spans the point of payment usually a ticketing barrier to the interaction where a successful occupancy of the rail carriage has occurred. The author acknowledges the duration of on-train travel and eventual departure point also forms part of this zone. The focus here is on the platform and close proximity.

3.4.1 The platform

A functional space, the platform performs an important part in the organisation and distribution of passengers in transit. It is arguably the space within the station where commuters spend the greatest percentage of waiting time (Iseki & Taylor 2010).
Melbourne's network comprises a range of station layout designations; aerial, at-grade and underground, generally accepted as the three most common (Griffin 2004). The platform footprints are either an island platform or a single faced platform. Distinguishing between the two is characterised by the location relative to the track section. Single faced having one platform edge and one edge adjacent to a wall or fence and the island platform positioned between to track sections (VRIOGS 2011). Melbourne stations are High Level Platforms (HLP) which intends to provide level boarding access to the train, however as previously demonstrated (Fig. 5) legacy issues prevent level boarding.

This functional space is also configured by platform objects such as seating, vending machines, lighting and structures for shelter. Passenger loading constraints are also used to determine this arrangement of functional space (VRIOGS 2011) towards establishing minimum and maximum capacity on the platform. Fruin's Level of Service is a commonly used approach to evaluate such urban spatial requirements. Involving an ellipse typically 600mmm in breadth and 500mm in depth it defines a person's vertical footprint (VRIOGS 2011). Compared to the user of a wheelchair or mobility aid this increases to 800mm x 1300mm in depth (AS 1428.1-2009) which has greater implications in prioritising space. Safe operable space is further designated by a warning strip 600mm from the vertical face of the platform edge. However this area is used frequently to negotiate the platform by passengers, this brings increased risk to personal safety from operational trains.

3.4.2 Staff at the platform

Station platforms across the Melbourne Metropolitan network falls into three categories.

- Premium - 77 in total and staffed during all operational hours
- Host - 22 in total and staffed at morning peak of the working week
- Unattended – remaining stations totalling 112 have no staff present

The availability of staff will have a direct impact on design solutions in terms of operability and remedial intervention in either maintenance or assistive capacities.

3.4.3 Indications at the platform

Most modern stations use a combination of visual indicators to communicate to passengers scheduling information, location of appropriate boarding platforms and designated waiting areas. Increasingly Passenger Information Display Systems (PIDS) relay either scheduled or real-time information in addition to conventional graphic based signage. Melbourne utilises both PIDS and printed timetables.

An additional visual element in use for PRM's is the installation of tactile ground surface indicators. TGSI's as shown in Figs. 11a & 11b are used to delineate the platform. TGSI's are a prerequisite for all new platform surfaces (DSAPT 2002)(*Section 18*). It is also a requirement of the DSAPT for existing railway stations.
Two variants are in use; dot type warning indicators and bar type directional indicators and a combination of integrated (multiple TGSI arrangements) and discrete (individual installation) placements. Colour resonance and materiality specified in AS/NZS 1428.4.1:2009 control the visual appearance and common tactile properties. As a retrofitted product TGSI's can present a misnomer when affected by conditional elements as demonstrated in Fig. 11b and present trip hazards and on-going maintenance requirements.


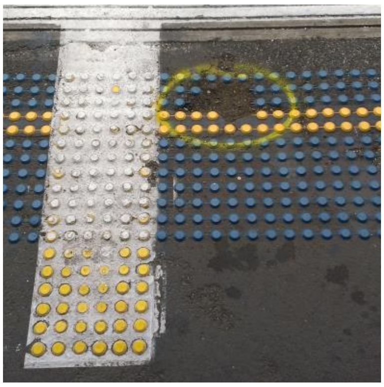

Fig. 11a and 11b (right) TGSI documented at Richmond Station, Melbourne (Moug 2012)

3.4.4 Boarding door position at the platform

Efficient rail networks allow for the quick passage of patrons between the platform and carriage. Increases in the dwell time is often directly a result of boarding and alighting (Wiggenraad, Lee & Daamen 2008).
The default length of Melbourne's platforms including a supplementary 10 metres for added operational purposes is 160m (VRIOGS 2011). Referring to Fig. 12a & 12b the entrance to platforms is either towards each end or in the middle as indicated by designations A, B and C.
The International Symbol of Access indicated by a blue square with a white stylized person in a wheelchair is placed near the front carriage and indicates the assisted boarding position for a PRM. This is necessary as in Melbourne the train driver is often responsible for planting and stowing a manual ramp (see Fig. 14).

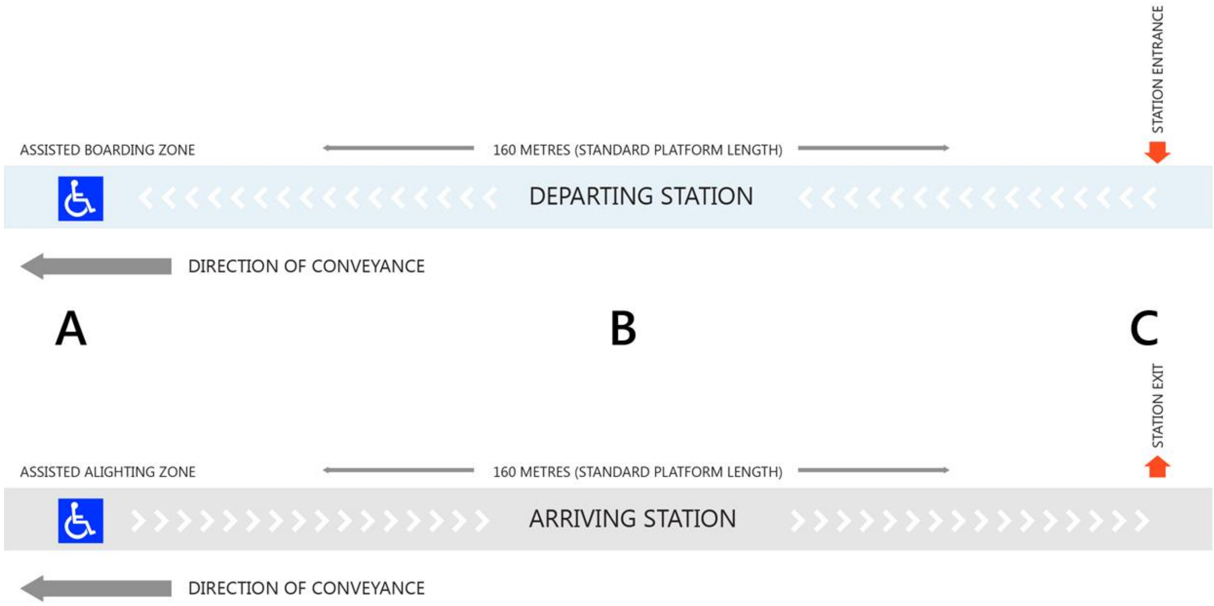

Fig. 12a & 12b (bottom) Boarding and alighting designations (Moug 2012)

Depending on the arrival point (Fig. 12a) and travel direction of the conveyance a PRM (i.e. manual wheelchair user) needing assisted boarding is expected to exert the most effort to board the train. At the arrival destination as indicated in Fig. 12b this is also a concerning factor. At the very least accessible boarding positions should be provided at opposing platform ends A & C and ideally in a central location as indicated by B.

3.4.5 PEDS - Platform edge doors at the platform

Indicators assume a number of physical arrangements, one example of this are the use of a vertical barrier system. Three variations are recognised; Platform Screen Doors (PSD), Platform Edge Doors (PED) and Platform Gates (PG). Differentiating the configurations is the vertical height of the barrier or functional application (Nicholson 2010). These systems provide two useful benefits to users; an indication as to the location of the boarding point and the provision of a safety barrier between themselves and the train. One situational difficulty is the alignment of carriage doors in relation to the pre-fixed platform door position. Nicholson (2010) suggests Automated Train Operation (ATO) is desirable to eliminate inaccuracies of human drivers. The use of market barrier systems is currently unworkable in Melbourne due to inconsistent door locations across operating rolling stock (see Fig. 17).

3.4.6 Mind the GAP at the platform – train/ platform interface

One persistent issue of accessibility is the problem associated with the train carriage and the platform edge commonly referred to as 'the gap'. Considerable research has been conducted in this area to determine the limits of acceptable unaided access for disabled patrons (Daniel & Rotter 2009; DeJeammes 2000; Hashizume et al. 2009).

In Europe the accepted gap of 50mm x 50mm has proven too large an obstacle for PRM's including wheelchair users for which it was recommended (de Kloe, de Boer & Daamen 2008). With its own limitations the DSAPT *(Section 8.2)* requires that assistive devices must be available when a vertical rise or gap exceeds 15mm or a horizontal gap of 40mm.
This specification is currently unattainable in Melbourne thus requiring operators to employ a manually placed ramp by the train driver or a station attendant. Minimum DSAPT *(Section 8.2)* requirements state that operators and providers may assume that passengers will board at a point that has a firm and level surface to which a boarding device can be deployed. The design of a fixed platform surface with the DSAPT provision for acceptable incline will extend beyond the 600mm warning line when the vertical rise (to the vestibule landing) exceeds 75mm; this occurs when a ratio of 1:8 for unassisted access is given.

Current specifications for design consideration from the DSAPT are summarised:

- 1:12 for unassisted (external ramp)
- 1:8 for unassisted where ramp length is less than 1520mm
- 1:4 for assisted access (external ramp)
- Maximum load up to 200kg
- Cross fall and Camber of platform to permit efficient drainage.
- Cant (axis deviation) of train in relation to vertical platform edge

3.4.7 BAD - Boarding aid devices at the platform

Boarding aid devices (BADS) provide varying solutions in obtaining equivalent access in negotiating the problematic distance/height issue of 'the gap' when boarding carriages. On-board or on-platform solutions form the majority with some requiring manual operation by trained staff. A suggested scope of 12 design combinations has been proposed between ramps, lifts, gaps, manual or automated function and platform or vehicle based systems (Rueger 2011).

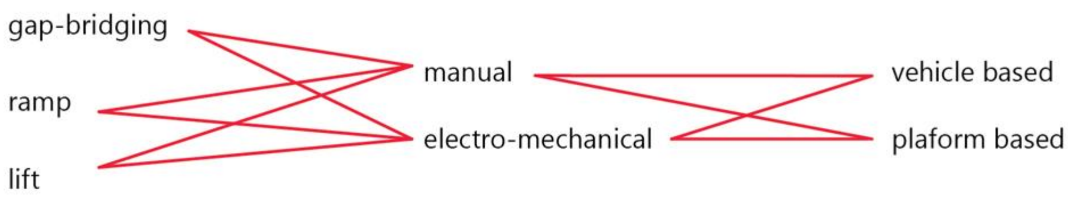

Fig. 13 Model borrowed from B. Rueger 2011 - Platform-based devices for accessible railway boarding

Rueger's (2011) evaluation concluded that such devices remain unfavourable in comparison to a personalised staffed assisted solution. A staff assisted solution provides choice but not importantly the independence of PRM's. The European study into BADS - *COST Action 335* (DeJeammes 2000) highlighted the value of independent mobility and 'step free access' as instrumental to any long term strategy.

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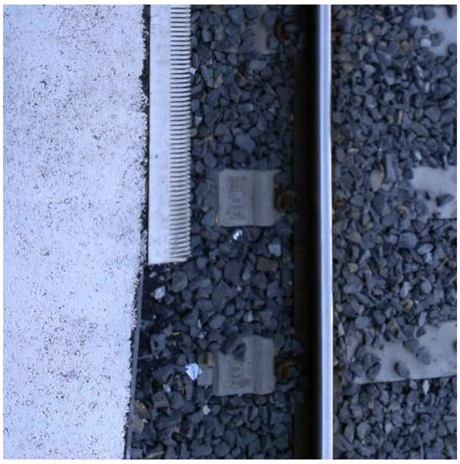
15a

15b



15c

Fig. 14 Boarding ramp in use at Showground Station (retrieved from http://tdu.to/31944.att)
Fig. 15a, 15b & 15c All weather raised ramp at Flinders Street Station, Melbourne (Moug 2012)

Currently 'step free access' developments towards inclusive platforms and to overcome legacy issues are under trial in Melbourne. As of July 2011 all-weather raised ramps have been progressively installed at three metro stations; Flinders, Newport and Box Hill. The Flinders ramp is shown above (Figs. 15a, b, c). It comprises a fixed solid surface tapering towards the rail gauge with a modular gap filler, it is currently limited to railway lines operating two specific train carriage designs, the Comeng and the Xtrapolis (see Fig. 17).

Inventive solutions also exist in patents detailing a number of mechanical, automated and material solutions. These present some innovative approaches to remedial and integrated design solutions (Devadoss, Ahmad & Dhamodharan 2012). Patent US 5,854,580 (Fig. 16) as an example uses a resiliently deflecting apparatus similar to the raised platform edge shown in Fig. 15a. The continued pursuit in this subject area vindicates further design development.

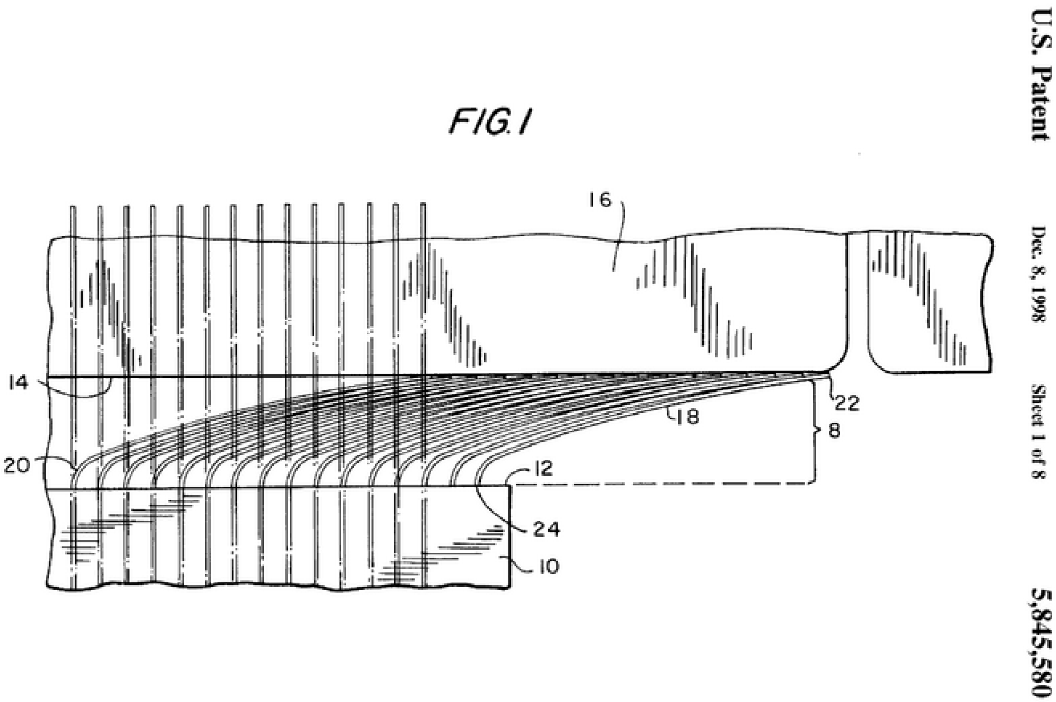

Fig. 16 US Patent 5845580 Railway platform gap filler (retrieved from http://www.google.com/patents/US5845580)

3.4.8 Rolling stock at the platform

The conveyance has a critical role in providing equivalent access in its relationship to the boarding edge of the platform. DSAPT does not directly address the physical specification of the conveyance in ameliorating this issue. Melbourne's rail network is further complicated with four different models of rolling stock. In addition, a regional passenger service operating from Southern Cross Station, Melbourne's major transport hub into regional Victoria also operates on the same network.

Comparing the five operating models, variability exists in not only the door height but the position along carriage. This is demonstrated with reference to the front vestibule in Fig. 17b with all five different train front carriages stopped at one specific point. Deviation is shown in the vertical height (Y) is between 25mm and 118mm without factoring the height from the platform surface.

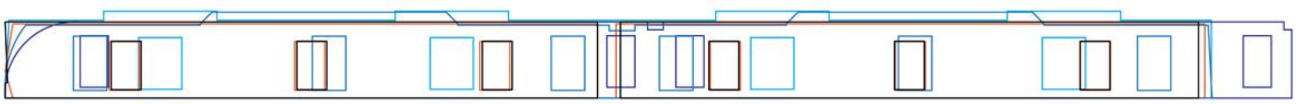

Fig. 17a Height and linear variation of Melbourne's rolling stock (Moug 2012)

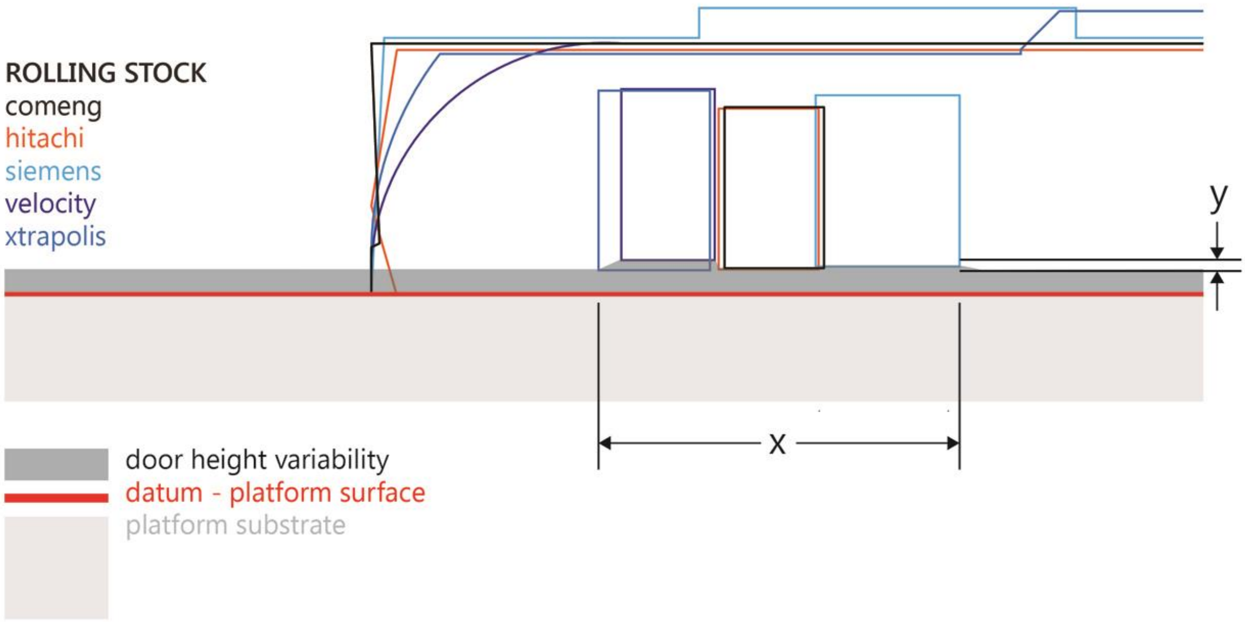

Fig. 17b Detail of height and linear variation of Melbourne's rolling stock (Moug 2012)

Variation in the linear location across the trains' carriages can be observed in Fig. 17b. The vertical edge to edge distance of 4560mm (X) shows the stationary dwell position of the front vestibules of the five train carriages in this one particular arrangement. Further observations from Fig.17a demonstrate the increased misalignment of door vestibules along two carriages.

3.5 VIRTUAL ZONE

As suggested earlier, the physical zones are increasingly connected and informed by an intangible zone. The impact of digital technologies presents considerably design opportunity for PRM's and able bodied users also. Such examples are advanced organizational information through RFID real time information (Lee & Tsang 2008) and the application of localised platform based navigation systems (Baudoin, Venard & Pretorius 2010).

4. DESIGN CRITERIA

Research into accessibility issues for PRM's in the rail context reveals the inherent difficulty of achieving a universal design solution. Edge of platform legacy issues present one major obstacle to overcome. As do operational issues; multiple rolling stock, staff availability and future policy compliance. With the DSAPT (2002) milestone of 2022 approaching these functional and environmental issues confront current industry measures towards equivalent accessibility.

Reflecting on the operating environment in Melbourne the following explorative design criteria are segmented into the three previously identified zones.

VIRTUAL ZONE – Advanced communication	UNPAID ZONE – Advanced navigation	PAID ZONE – Advanced organization
Information of station DSAPT compliancy	Unobstructed navigation	Unassisted boarding/alighting (human factors)
Localised digital map of station	Unassisted navigation	Retrofitted products to complement legacy constraints i.e. heritage and redundant station space
Indicators - arriving door position	-	Predetermined boarding/alighting areas
Indicators - arriving carriage capacity	-	Next generation products
-	-	Safety at platform edge

5. DESIGN STRATEGY

From a design perspective the presented research and current solutions have offered varying level of improvements in physical accessibility for PRM's and have identified persistent issues in station design. Manual ramp deployment between train and platform in Melbourne is one solution for its HLP platforms but it is considered unsustainable in the long-term (Reynders 2011). The raised platform progresses DSAPT standards but is restricted in its current application due to limited locations and operating conditions.

With the aim to unifying the experience of 'independent accessibility' within station design and infrastructure from a user's perspective the following diagram is provided, building on the diagram of Reuger's (2011).

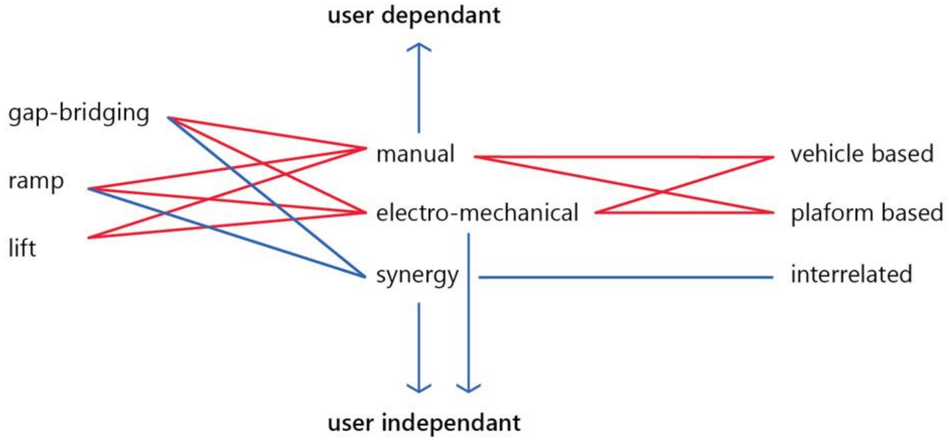

Fig. 18 Focus for further design led research

(Original model borrowed from B. Rueger 2011 - diagram by Moug 2012)

Emphasis in the design approach is given to the importance of user independence of PRM's and this will direct future studio design practice. Of note the following areas will form part of the future research.

- A further evaluation of the physical synergy between the train and platform. Platform based devices which mutually interrelate with the train carriage.

- Advancing knowledge and interactions of users and devices at the approaching platform through applied digital information to indicate boarding and carriage capacity.

- A practical design outcome considerate of the legacy constraints imposed on Melbourne's many rail stations suggests a retro fitted solution that can be integrated into the current operating environment.

From a design led strategy towards providing mobility improvements for PRM's the following statements are considered reasonable.

- Train patron - a priority is the difficulty of the train platform interface. An independent assistive system to mitigate the gap and improve safety at the platform edge is a critical obstacle to overcome.

- Train operator - maintenance, evaluation and punctuality are prioritised. An analytical and communication product could be developed to inform operators of current DSAPT compliancy, maintenance improvements at the platform edge.

- Train Operator/Patron - a social communication product at the platform edge can establish a dialogue between the interested groups.

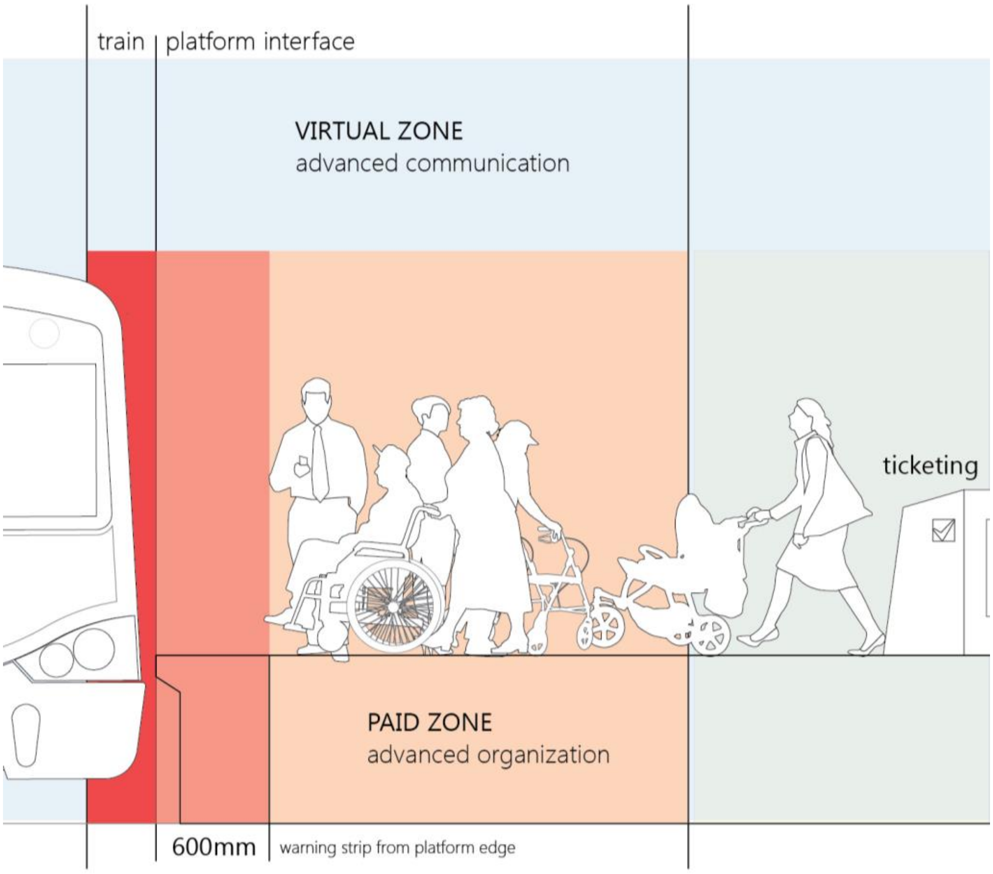

Fig. 19 Focus for further design led research (Moug 2012)

6. CONCLUSION

The Australian DDA (1992) and DSAPT (2002) in pursuing improvements to disability compliance have established a new point of reference for inclusive design practice.
Research within the literature review revealed a number of persistent issues amongst which 'the gap' remains a significant area still in need of resolution. The milestones of the DSAPT bring a further sense of urgency and priority to this issue.

However resolving DSAPT compliance across the Victorian network will be challenged by both legacy and operational constraints. A design approach towards a modular, retro-fit product able to integrate into the legacy environment is therefore encouraged. Potentially merging advanced information offered by digital applications with tangible products focused on accessibility at the platform edge.

The research in this paper reveals that to meet DSAPT and DDA compliance in the context of the Melbourne network and its legacy stations an innovative approach to integrating components and systems will be needed. To improve the station experience especially for disabled patrons and PRM's towards independent mobility in public transport. This points the way to future studio based research.

7. REFERENCES

Baudoin, G, Venard, O & Pretorius, S 2010, 'Real time information, Communication and localization Environment for improving the Mobility of travelers with sensory Disabilities (visual or auditory) in Public transports – the Infomoville project', paper presented to The 12th International Conference on Mobility and Transport for Elderly and Disabled Persons (TRANSED), Hong Kong, 2-4 June.

Collins, CM 2005, 'Psychological and Situational Influences on Commuter-Transport-Mode Choice', *Environment and Behavior*, vol. 37, no. 5, pp. 640-61.

Coxon, S, Burns, K & de Bono, A 2010, 'Design strategies for mitigating passenger door holding behavior on suburban trains in Paris', paper presented to 33rd Australasian Transport Research Forum Canberra.

Daniel, JR & Rotter, NG 2009, *Customer Behaviour Relative to Gap Between Platform and Train*, New Jersey Institute of Technology.

A-Gs Department 1992, *Disability Discrimination Act 1992 (DDA)*, by DDA, Australian Government.

DDA - *see* Disability Discrimination Act 1992

de Kloe, R, de Boer, E & Daamen, W 2008, 'Assessing the Gap Between Public Transport Vehicles and Platforms as a Barrier for the Disabled: Use of Laboratory Experiments', *Transportation Research Record: Journal of the Transportation Research Board*, vol. 2072, no. -1, pp. 131-8.

DeJeammes, M 2000, 'Boarding Aid Devices for Disabled Passengers on Heavy Rail Evaluation of Accessibility', *Transportation Research Record*, vol. 1713, pp. 48-55.

Devadoss, R, Ahmad, S & Dhamodharan, DR 2012, ''Station Platform -Train Interface for Rail passengers - A Technology review '', CRC for Rail Innovation.

A-Gs Department 2002, *Disability Standards for Accessible Public Transport 2002 (DSAPT)*, by DSAPT, Australian Government.

DSAPT - *see* Disability Standards for Accessible Public Transport 2002

Froyen, H (ed.) 2008, *Universal Design Patterns and Their Use in Designing Inclusive Environments*, Designing Inclusive Futures, Springer London.

Griffin, KW 2004, *Building type basics for transit facilities*, Transit facilities, New York ; Chichester : Wiley, New York ; Chichester.

Hashizume, T, Yoneda, I, Kitagawa, H, Fujisawa, S & Sueda, O 2009, 'Accessibilities of Wheelchair Users to Cross the Gaps and Steps between Platforms and Trains', *Journal of Control, Measurement, and System Integration*, vol. 02, no. 04, pp. 199 - 205.

Iseki, H & Taylor, BD 2010, 'Style versus Service? An Analysis of user Perceptions of Transit Stops and Stations', *Journal of Public Transportation*, vol. 13, no. No. 3, pp. 23-48.

2010, *Our Melbourne : Disability Action Plan 2010 - 2013*, by Kanis, JC.

Lee, LT & Tsang, K 2008, 'An Active RFID System for Railway Vehicle Identification and Positioning', paper presented to Railway Engineering - Challenges for Railway Transportation in Information Age, 25-28 March.

Morris, J, Wang, F & Berry, M 2002, 'Planning for public transport in the future: challenges of a changing metropolitan Melbourne', paper presented to 25th Australasian Transport Research Forum Incorporating the BTRE Transport Policy Colloquim, Canberra.

Nicholson, TJ 2010, 'Total Automation : Impacts & Systems', in *Railway Signalling and Control Systems (RSCS 2010)*, pp. 271 - 80

O'Neil, Y & O'Mahony, M 2005, 'Travel Behaviour and Transportation Needs of People with Disabilities : Case study of Some Categories of Disability in Dublin, Ireland', *Journal of the Transportation Research Board*, no. 1924.

Rentzsch, M, Seliger, D, Meissner, T & Wessner, C 2008, 'Barrier Free Accessibility to Trains for All', *International Journey of Railway*, vol. 01, no. 04, pp. 143-8.

Reynders, L 2011, *Creating Accessible Journeys*, Victorian Council of Social Service, Melbourne.

Rock, PJ 1988, 'Independence: What It Means to Six Disabled People Living in the Community', *Disability, Handicap & Society*, vol. 3, no. 1, pp. 27-35.

Rueger, DB 2011, 'Platform-based devices for accesible railway boarding', paper presented to Railway Terminal World - Design and Technology Conference 2011, Bella Center, Copenhagen, Denmark.

Seyers, L 2011, *Railway Station Useability Principles : Prepared by the Station User Panel*.

Smart, M, Miller, MA & Taylor, BD 2009, 'Transit Stops and Stations: Transit Managers' Perspectives on Evaluating Performance', *Journal of Public Transportation*, vol. 12, no. 1, pp. 59-77.

Stanley, J, Hensher, DA, Stanley, J, Currie, G, Greene, WH & Vella-Brodrick, D 2011, 'Social Exclusion and the value of mobility', *Journal of Transport Economics and Policy*, vol. 45, no. 2, pp. 197–222.

Do Transport & VRIOG Standards 2011, *VRIOGS 002.1*
Railway Station Design Standard and Guidelines, by VRIOGS, vol. Revision A, State Government of Victoria.

WHO 2011, *World report on disability 2011*, World Health Organization (WHO),Geneva, Geneva.

WHO - *see* World Health Organization

Wiggenraad, P, Lee, Y-c & Daamen, W 2008, 'Boarding and Alighting Experiments: Overview of Setup and Performance and Some Preliminary Results', *Transportation Research Record: Journal of the Transportation Research Board*, vol. 2042, no. -1, pp. 71-81.