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Evaluating accessibility provisions for existing rail station platforms in Melbourne, Australia

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Abstract

This paper documents current measures to understand and address station platform accessibility compliance for Melbourne's metropolitan rail network. Compliance is set by the Australian Disability Standards for Accessible Public Transport (DSAPT, 2002). In particular, this paper focuses on the maximum allowable provision under the standards of a platform to door gap of 40 mm horizontal length x 12 mm vertical step height. Beyond these dimensions, driver assistance is required.

A boarding simulation rig replicating the platform and train door threshold was constructed and mobility impaired users from the local community invited to participate in testing a range of gap variables. Data collected improved Melbourne's rail operator Metro Trains Melbourne (MTM) and Victoria's statutory authority Public Transport Victoria (PTV) understanding of a current design. Alongside the DSAPT legislation and the limitations in capability and confidence of mobility impaired passengers. Multiple simulations confirmed that the present platform design is a significant improvement in both accessibility and disability compliance but factors such as modern mobility scooters and wheelchair design and their operation still presented challenges.

This research has been undertaken in a design practice based PhD which seeks to address some of the operational obstacles revealed through the trials. Invited by the trial organisers, the author's observations and response to the trials through design interventions are briefly discussed.

1. Introduction

An acknowledged problem for mobility impaired passengers and accessibility advocates within rail networks is the gap between the train and the platform. Public transport (PT) attempts to offer an inclusive mode of transportation, an alternative to or in place of the private motor vehicle. PT origins are in a government enterprise, in Australia PT is usually provided by the government itself, private operators or in partnership. The operator/s required to adhere to any governing legislation often in response to changing societal demands and attitudes (Reynders, 2011). One key challenge facing Melbourne's public rail operator MTM and rail authority PTV is addressing DSAPT requirements around the accessible platform to train boarding and alighting, often referred to as 'the gap'.

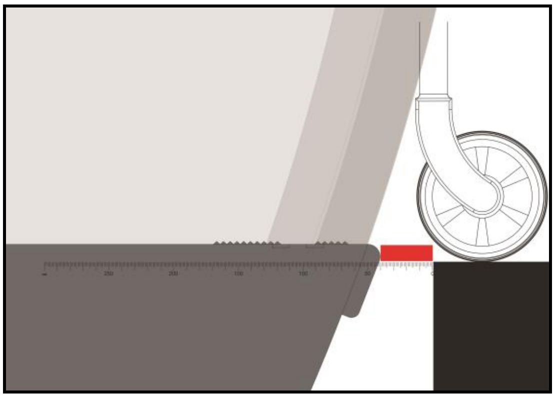
Currently, a maximum crossing gap dimension, the space between the platform and train of 40 mm horizontal by 12 mm vertical step is specified (Fig 1). Under DSAPT legislation an equitable method of boarding must be provided by the operator when this gap dimension is exceeded, or when required by a passenger. Currently, this comprises in most instances of a ramp manually deployed by the driver. Manually deploying a ramp is both time consuming and can only reasonably be offered at the nearest door to the driver in order to maintain network service punctuality. It is therefore not the ideal solution. Further, still, a manual-based solution will not meet DSAPT legislation regarding equitable boarding at each door along the length of the platform by the compliance date of 2022 and 2032 -for infrastructure and vehicles respectively.

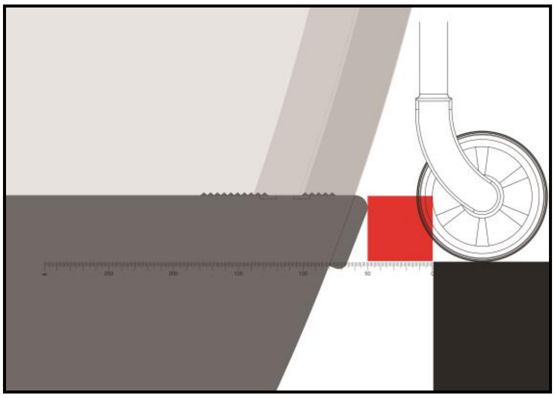
Attaining this maximum gap dimension within the entire network is considered improbable by industry experts without significant redevelopment of the network. As Melbourne’s network comprises infrastructure built across three centuries. The periodical development has produced platform designs with differing height specifications and longitudinal profiles both straight and curved. Coupled with multiple carriage designs; differing door positions; shared freight, regional passenger and metropolitan passenger services further compound the problem. Understandably these assets are also subject to wear and tear; consequently, the gap dimension is constantly changing through track subsidence, wheel wear and everyday use.

The aim of the research is to firstly evaluate the existing raised boarding ramp design across a number of reduced mobility users. All users are operating self-selected powered and manual wheeled devices. Secondly, the incorporation of a moulded rubber gap filler at the coping edge of the raised area is evaluated for functional performance. From the study, a clearer understanding of both the performance of the gap filler and insights from the user group will assist in determining further development of this and future iterations regarding accessible platform design.

Fig 1: Image of DSAPT gap geometry of 40 mm horizontal x 12 mm vertical (below left)

Fig 2: Image of European accepted gap geometry of 50 mm horizontal x 50 mm vertical (below right)





2. Background

A number of studies have been conducted into the mitigation of gaps between the platform and train; mobility approach strategies and user perception (de Kloe, 2008; Harris, 2014; Hashizume, 2009). Providing accessible boarding is inevitably been defined by the capability of mobility impaired users to independently negotiate a gap geometry of particular size. This is not isolated to the Australian rail industry. The UK, New Zealand, American and European rail operators are concurrently facing similar challenges within respective ageing rail networks. For example, a European acceptable gap dimension of 50 mm x 50 mm (Fig 2) has been proven to be too greater an obstacle for most reduced mobility users (de Kloe, 2008), New Zealand rail operators have also subscribed to this generally accepted European standard.

Melbourne's own network operator MTM has, since 2011, begun to install raised areas of platforms in order to overcome some of its own network's physical and operational encumbrances. MTM and PTV have undertaken this trial to further inform and evaluate a current design strategy, the installation of rubber gap filler and to ascertain an understanding of the boarding and alighting limits of mobility impaired passengers in mitigating this problem regarding the level of comfort and capability.

Another indirectly measurable outcome for these trials is to understand the gap compliance measures of the DSAPT, and whether a rail industry specification for accessibility is needed. This could support a recent Commonwealth Report review of the DSAPT (Australia, 2015). Within this document the Australian Government supports updating the Transport Standards, recognising after a decade in existence the DSAPT is not translating seamlessly into existing network constraints as expected, or supporting existing and future needs of mobility impaired users (Commonwealth Government of Australia, 2015, p. 2).

These trials provide a valuable opportunity to evaluate the impact of MTM's gap filler on across gap boarding and alighting of Melbourne passengers. It also sees the first assessment of mid-wheel drive motorised wheelchairs in these types of experiments. Similar studies have focused on the achieved outcomes of gap negotiation where this trial allows a more recent evaluation of both design interventions and the changing shape of mobility devices.

2.1 Modern mobility devices

The use of motorised or assistive devices to aid independent travel is a common occurrence in metropolitan rail networks. With these types of devices mobility impaired users have a greater capacity to travel distances and for active societal engagement (Stanley, 2011). Variants such as motorised mobility scooters (MMS) are also an increasing travel choice for older Australians (Johnson, 2013). As a result, passenger use of mobility devices is an increasing challenge for rail operators in both accessibility compliance and on-carriage spatial requirements.

International studies (de Kloe, 2008) focusing on accessibility compliance have explored this problem of cross gap access within public transport, investigating a range of mobility devices including motorised wheelchairs, scooters, manual wheelchairs, and rollators as examples. One distinction within this specific user group is the increasing prevalence of motorised wheelchairs with the mid-wheel drive. 50% of participants were using a mid-wheel devices sourced from five unique manufacturers. The remainder of mobility devices can be categorised alongside this particular device specification into the following groups:

Mobility devices operated in Victoria and across Australia, aside from Queensland, are afforded the same compliance restriction in regards to road rules as that of a pedestrian. Queensland differs in that these devices must be registered as a motor vehicle; this is also expected in other Australian states and territories if a maximum travel speed of 10 kmph is achievable. Product specification for these devices remains at the discretion of manufacturer's who are only voluntary obligated to comply with Australian Standards (VicRoads, 2011).

Mobility device selection remains an individual choice, and as such, there is not one specific model suited for either travel within a rail network or a minimum standard for DSAPT compliance. This variability is demonstrated in the types of device models trialled. These are as variable as the functional capabilities of the users themselves, and it is expected the capability in the trials to correlate between the device and the user's functional limitations.

Table 1: Distribution of mobility devices within user group

DEVICE TYPE	**NO. OF PARTICIPANTS**
Wheelchair (motorised mid wheel)	11
Wheelchair (motorised)	2
Wheelchair (manual)	3
Scooter (motorised)	5
Other (wheelchair with power handcycle attachment)	1
TOTAL	**22**

3. Trials

Participants volunteered to take part in a 6-hour trial involving two setups; one was a test rig which involved the use of MTM’s modified platform gap filler, the second involved a train adjacent to a platform on a temporarily suspended line. Results and discussions were recorded alongside the use of videography and photography to document. The user group included mixed motorised devices and manually operated mobility devices (refer Table 1).

3.1 Mobility device, user capability and the environment

Three direct observations were made of the trial user group through the conducting of this study.

- Firstly, an evaluation of the device itself can be made by documenting the physical performance in meeting the requirements of the test towards either enabling or inhibiting users.
- Secondly, the user’s negotiation of the gap could be observed, whether through individual control of the device, approach methodology or user inclination to engage in the trials.
- Thirdly, immediate environmental factors were observed and recorded if it had a physical bearing on the outcomes of trials

3.2 Device design guidelines

The specification parameters of particular interest of the mobility devices within this user group are shown in Fig 3. Each device was measured during the trial period and measurements were confirmed by a retrospective review of manufacturer sourced parameters (see Table 2). Interestingly the kerb climbing capabilities of the devices were significantly larger than expected and suggested a correlation between the ground clearance of the device rather than the smallest wheel diameter which was initially expected.

Fig 3: Symbographic of mobility device

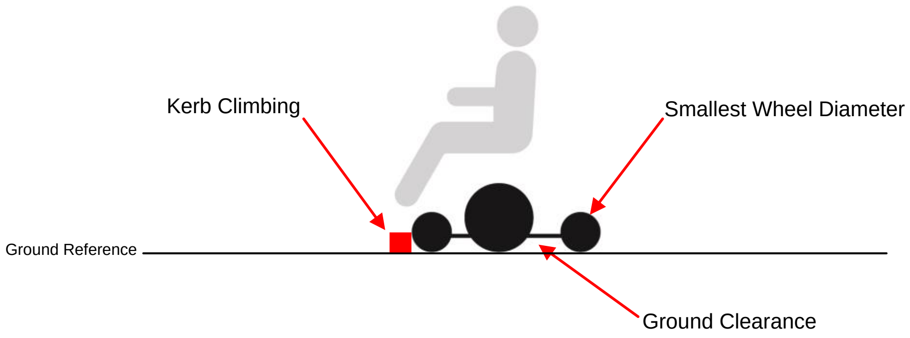
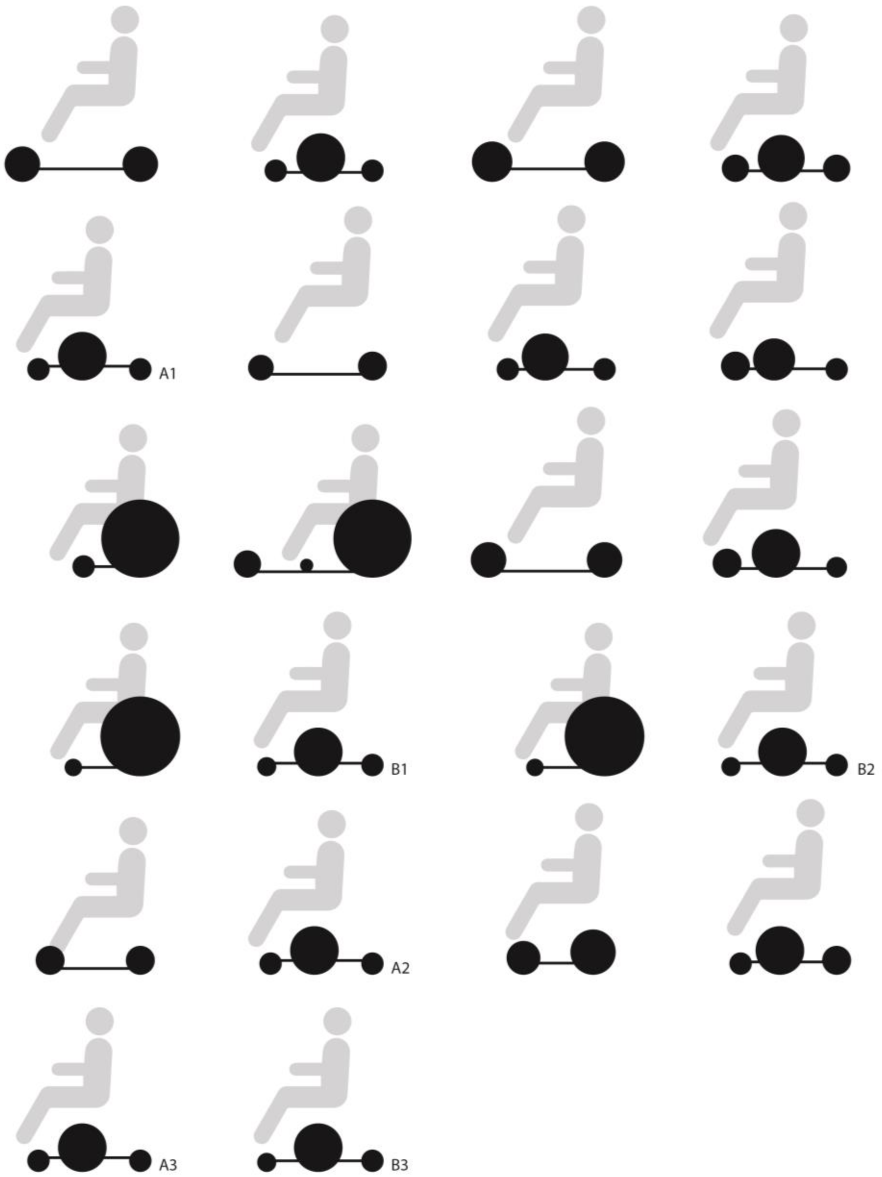


Table 2: Manufacturer specification of key design parameters of mobility devices

MODEL	CATEGORY	SMALLEST WHEEL DIA. " / mm	GROUND CLEARANCE	MAX. INCLINE LIMIT °	KERB CLIMBING
Pride Celebrity X	Scooter (motorised)	10 / 254	90	8	50
Pride Quantum Edge	Wheelchair (motorised MID)	6 / 152.4	63.5	6	50
Invacare Pegasus,	Scooter (motorised)	11.5 / 292.1	90	8	80
Permobil M300	Wheelchair (motorised MID)	7.5 / 190.5	75	9	76
Magic Mobility Frontier V6	Wheelchair (motorised MID)	6 / 152.4	100	4	100
GoGo LX with CTS suspension	Scooter (motorised)	7 / 177.8	38	6	50
Invacare TDX SP	Wheelchair (motorised MID)	6 / 152.4	76	9	63.5
Centro APT Suspension Glide products	Wheelchair (motorised MID)	8 / 203.2	80	15	80
Manual	Wheelchair (manual)	5 / 127	-	-	-
Manual Electric Drive (modified)	Other	7.5 / 190.5	35	-	35
CTM Evolutions 4	Scooter (motorised)	10 / 254	40	12	76
Levo Combi	Wheelchair (motorised)	8 / 203.2	60	10	80
Elite	Wheelchair (manual)	4.5 / 114.3	-	-	-
Pride Quantum 6000	Wheelchair (motorised MID)	5 / 127	90	5	50
Mobility Plus (Manual)	Wheelchair (manual)	4.5 / 114.3	-	-	-
Pride Quantum 6000	Wheelchair (motorised MID)	5 / 127	90	5	50
Pride Shoprider	Scooter (motorised)	8 / 203.2	38	8.5	38
Magic Mobility Frontier V6	Wheelchair (motorised MID)	6 / 152.4	100	4	100
Pride Quantum 4000 (Red)	Wheelchair (motorised)	9.5 / 241.3	80	5	50
Pride Jazzy 1121	Wheelchair (motorised MID)	6 / 152.4	89	5	50
Magic Mobility Frontier V6	Wheelchair (motorised MID)	6 / 152.4	100	4	100
Pride Quantum 600	Wheelchair (motorised MID)	5 / 127	76	5	50

Fig 4: Symbographic of mobility devices composition within user group



Of significant difference within this particular user group is the inclusion of mid-wheel drive, motorised wheelchairs. A visual representation of these mobility device types (alongside others) is presented in Fig 4 capturing the wheel distribution and relative position of the user. The frequency of mid-wheel devices appears to reflect an emerging user preference choice in mobility devices. The performance of these devices can be assessed against studies completed to date where these devices are not represented to see if any added performance is offered. Of peripheral interest and not documented directly in this paper is whether the composition of mid-wheels and subsequent weight distribution has any impact on actual performance. Given these mid-wheel devices are typically marketed with offering greater mobility opportunities than the traditionally viewed motorised wheelchairs and scooters the kerb climbing capabilities were of particular interest throughout the trials.

3.3. User control and approach

The operation of these devices varies with the motorised mobility scooters employing what's known as a tiller with wig-wag control. Tiller arrangement levers at the top of a steering column, the tillers handlebar configuration moves synchronously with the wheels in a preferred direction. This steering method is directly transferred in a mobility scooter with one front wheel. Wig-wag controls employ a mechanism where a lever is positioned both sides of the steering column and controls the forward and reverse progression of MMS. In contrast motorised wheelchairs all employ a joystick arrangement where the directional controls and acceleration are controlled electronically in the direction of the joystick movements.

Manual wheelchair users use a method that cognisant of differential braking systems where one large wheel is slowed or throttled and the other wheel moves nominally or increased speed to direct the chair. Front castors are swivelled in accordance with the motioned direction of the wheelchair.

A recommended approach strategy from manufacturers of mobility devices is a direct front-on approach, perpendicular to the platform. It is known that users at times have engaged an angular approach strategy. Within the trials this has been observed as a secondary requirement, insufficient data was collected to record any benefit from this approach.

4. Evaluation Methods

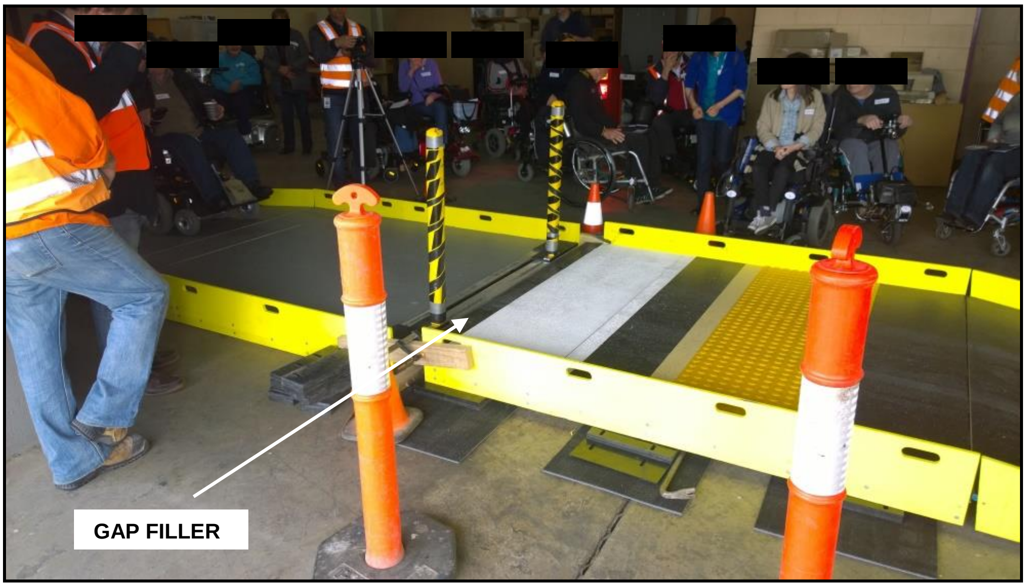
The recording of participants was undertaken through various methods. Volunteers recorded feedback through a questionnaire, recording participant's completion, non-completion or non-attempt of each trialled arrangement. Also recorded were individual's comments and responses to each trial as well as any additional comments. A five-point Likert scaling method was used to record respondent's responses. Qualitative feedback was gathered such as the level of confidence as gauged by their undertaking of each task. Physical parameters such as manufacturer's model of device, wheel size, positions and quantity were also recorded alongside the wheelbase length, the distance between wheel centres. Videography and photography were used to document the trials and provide further insight retrospective of the conducted trials.

4.1. Test rig set up

A test rig was established in the proximity of Box Hill train station along Melbourne's eastern rail corridor. The Box Hill location provided the trial both a sheltered location for the prototype setup and afforded the use of an enclosed station within the network for a carriage to platform setup. A Metro X'trapolis train occupied the track adjacent Platform 1 whilst the line was temporarily suspended for the trial.

The test rig comprises a fixed platform and an adjustable platform which was manually adjusted both laterally and vertically, in relation to the fixed platform. The fixed and adjustable platforms were affixed with industry standard surface finishes and materials to accurately represent operating conditions. One significant difference between this and other gap trials is the installation of a rubber gap filler affixed to the edge of the platform coping edge (Fig 5). The rubber comb arrangement has been installed along platform copings at various stations across Melbourne's network and lessens the horizontal gap between train and platform.

Fig 5: Test rig set up at Box Hill Station



4.2. Boarding and alighting trials

The trial set out to evaluate a range of horizontal and vertical gap geometry, seven specified gap geometries were trialled. Trials 1, 3-7 involved the test rig (Fig 5) whilst Test 2 involved the platform to train interface at Platform 1 (Fig 6) Participants were then invited to proceed with boarding and alighting between the platform and train (Fig 6). The trials did not investigate peripheral demand that users may encounter in everyday travel such as door operation, crowd navigation and variable carriage door positions. The trials were conducted under supervision in dry conditions.

Fig 6: Image of participants' trialling train adjacent to platform

5. Trial Results

The following graphs present the results of the trials. The horizontal axis describes the tested gap geometry, for example, 40 H is the horizontal distance in millimetres, i.e. 40 mm and -20 V is a vertical distance of minus 20 mm. The vertical axis presents the completion rate in percentage.

Participants were invited to attempt all seven trials. Non-attempts, as recorded, indicate where participants were advised to either not attempt due to the possible aggravation of personal injuries or participants self-nominating to withdraw from specific trials. A significant proportion of non-attempts were recorded against participants as a result of personal comfort levels in completing the prior test.

Fig 7: Results for all gaps and all mobility devices of participants

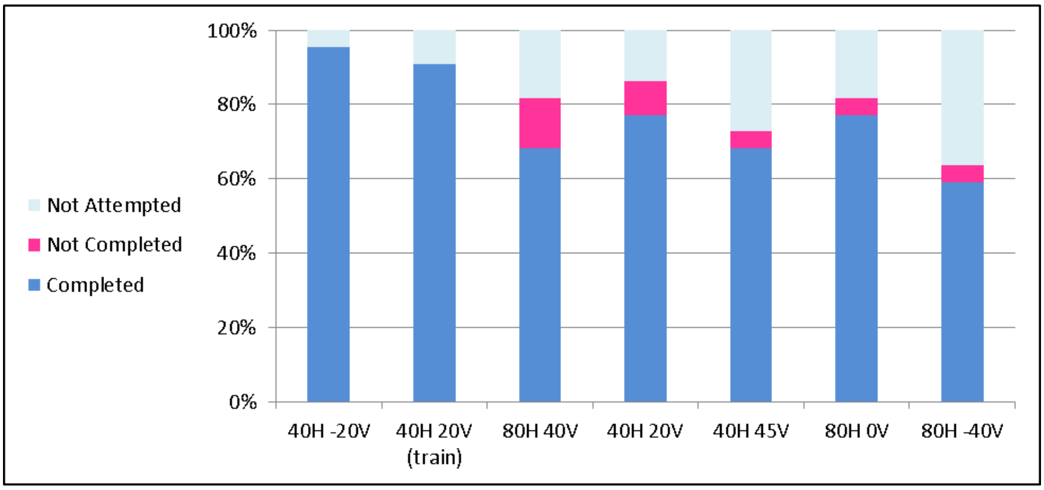


Fig 8: Results for all gaps for participants using manual wheelchair

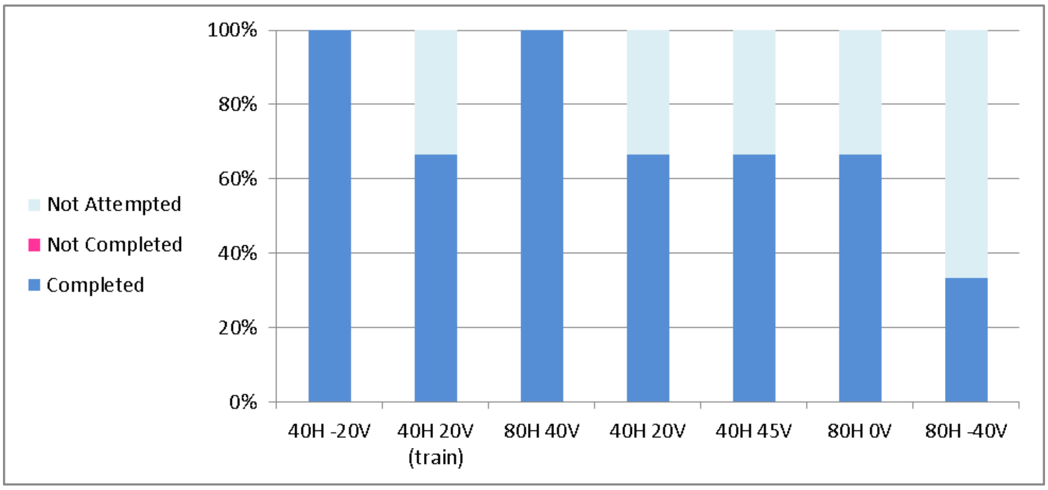


Fig 9: Results for all gaps for participants using motorised wheelchair (mid wheel drive)

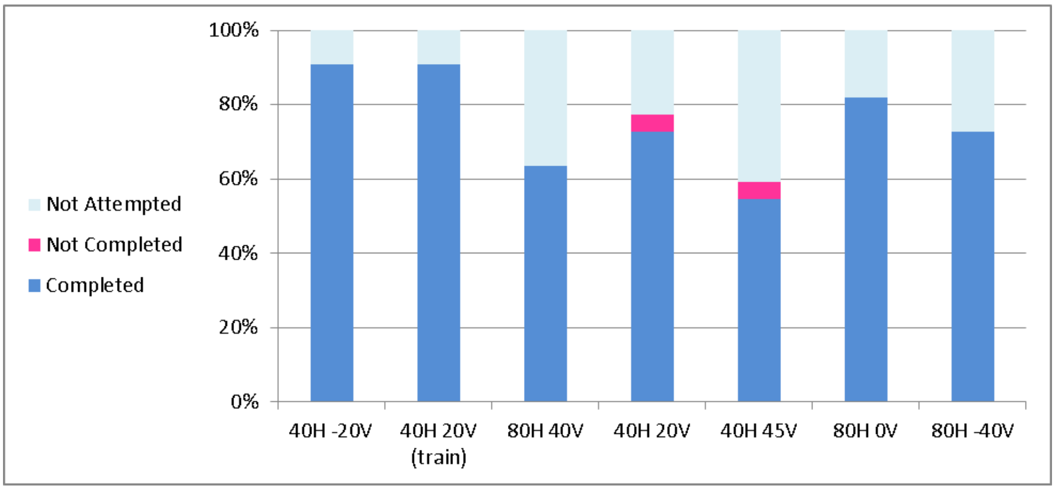


Fig 10: Results for all gaps for participants using motorised mobility scooter (rear wheel drive)

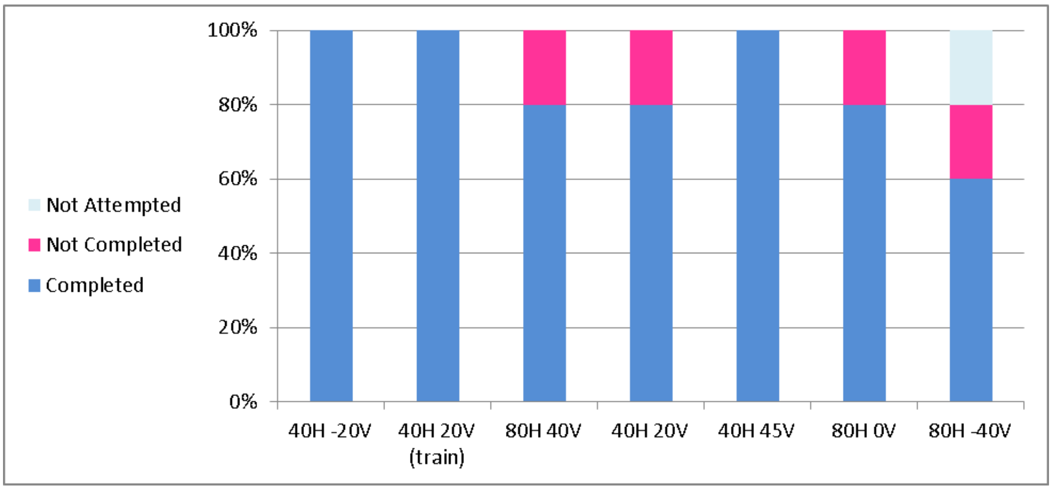


Fig 11: Results for all gaps for participants using manual with electric drive wheel (modified)

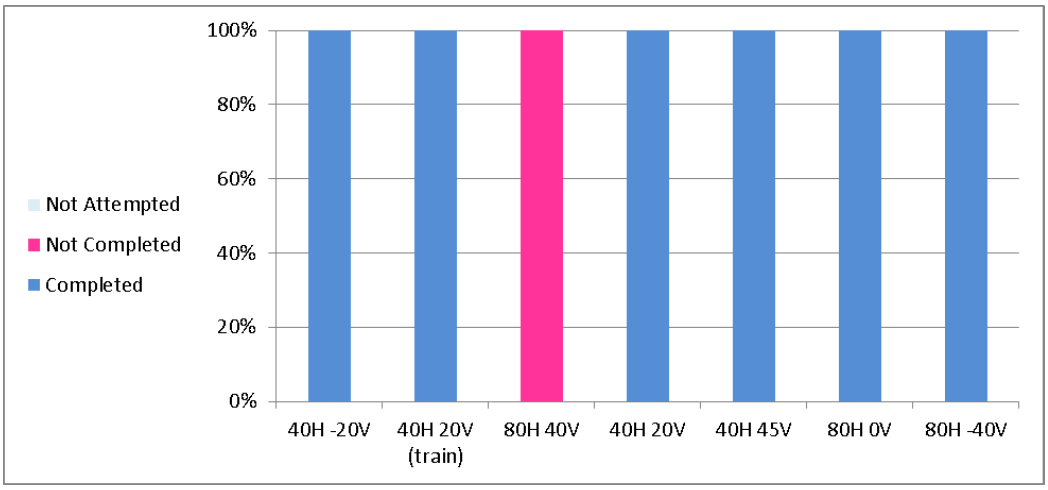
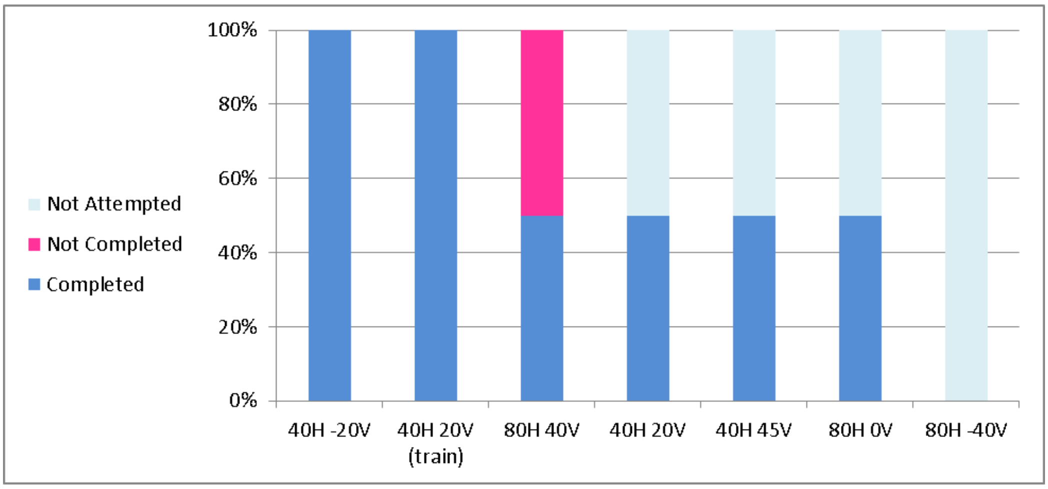
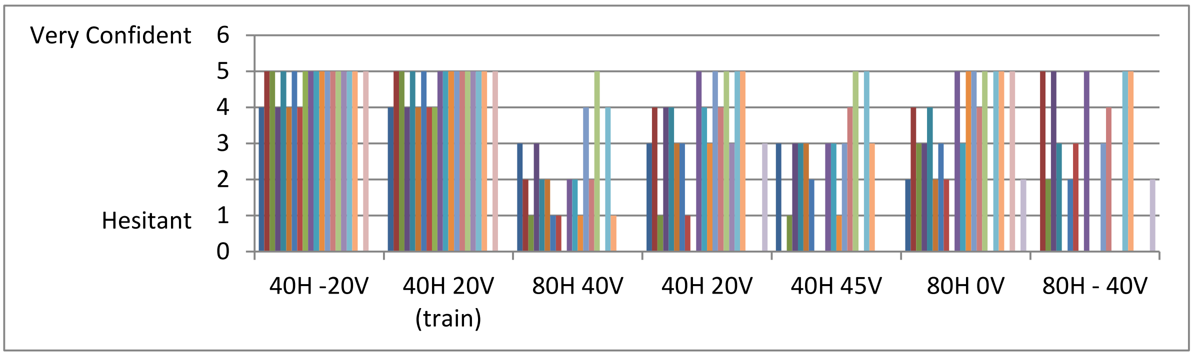


Fig 12: Results for all gaps for participants using motorised wheelchair (rear wheel drive)



The following graph (Fig 13) records participants' self-acknowledged level of confidence in the perception of the gap. One unexpected observation is shown between the two 40H 20V gap trials (train and test rig) with the actual train simulated arrangement recording participants as more confident than when undertaking the setup of the test rig.

Fig 13: Results for all gaps for participants' confidence relative to perception of gap



The following two graphs (Fig 14 & 15) record and compare the confidence level of participants of each trial relating to the direction of travel, either boarding or alighting the train.

Fig 14: Results for all gaps for participants' confidence in task – platform to train

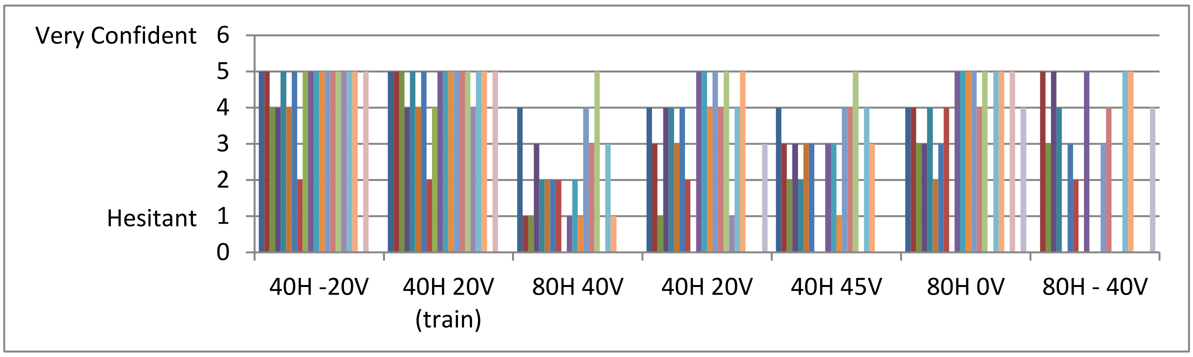
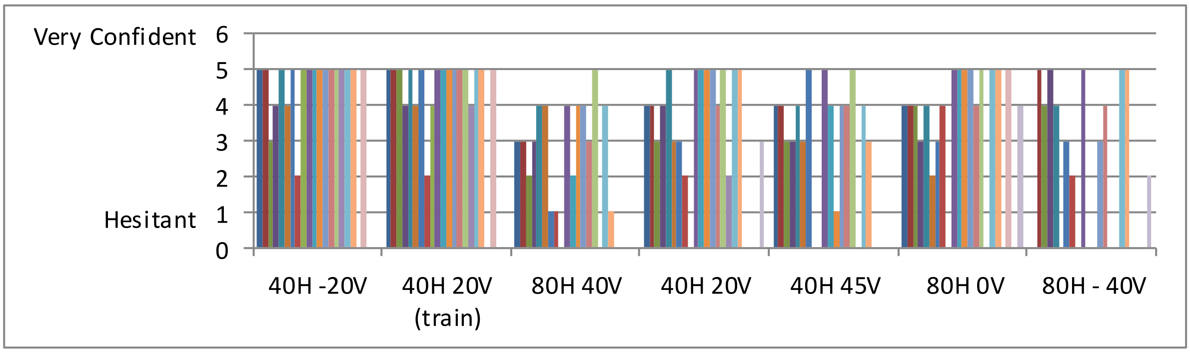


Fig 15: Results for all gaps for participants' confidence in task – train to platform



6. Analysis of the Trials

The boarding and alighting experiments confirmed some mobility impaired users were able to negotiate a variety of gap geometries exceeding that of the DSAPT recommended 40H x 12V. The nearest trialled gap parameter to the DSAPT, 40H x 20V, could be successfully completed by all participants under the tested conditions (refer Fig 7). Non-attempts were countered by those participants completing either Test 2 or Test 4 and in a single case a participant completing Test 3 instead. All of which equalled or exceeded the fore mentioned gap parameter of 40H 20V. Successful completions with an increase in gap and height were varied across the trials and types of mobility devices.

Notably, the mobility device, Manual with Electric Drive Wheel (modified), appears the most competent however this represented use by a single user. Manual wheelchair users were also positively represented in successful completions which reflected the experience and athleticism of the user, unencumbered by the mobility device. Mid-wheel drive wheelchair users were well represented in the user group and appear to perform slightly better than their Rear-wheel drive counterparts however not as well as motorised mobility scooters. When compared to international research (de Kloe, 2008) observed similar findings where the trials showed an increase in horizontal gaps proved less of an obstacle than a vertical step increase.

The trials were inconclusive in preferring one type of mobility device over others. Participants operating the same device recorded conflicting outcomes and the group size for some devices led to positive bias when compared to others. Individual approach strategies, the experience of the user may also have influenced the results.

> *'My wheelchair went up fine when I changed the drive setting to 'ramp_curb' which is more of a 4 wheel drive setting. I wouldn't attempt that gap getting onto a real train though because I wasn't confident at all that I would make it'*

> *'An angle would increase the chance of getting my wheelchair caster wheels stuck. I needed to do a wheelie to get the front wheels up. Easy for me, others would struggle'*

A number of participants recorded in the Trial 3 and 5 where the step height was increased to 40 mm and 45 mm respectively would not translate into real life scenarios. A number of variables were raised to communicate this.

'Touch and go as whether I would attempt by myself. Definitely not when wet, lots of people in area would make it hard'

'Need to increase speed to cross which is not possible if passengers are obstructing. If wet, wheels would be spinning - Would be scarier'

'Going down was easy and I was very confident but I wouldn't feel confident going up the step if it were a real train. It was also rather bumpy / uncomfortable'

'Boarding was not possible without assistance. Front wheels went up okay; main wheels spun, rear wheels got caught'

6.1 Test rig limitations

It is unclear if the test rig arrangement predisposed users to approach the gap from a front on direction which reduced the opportunity for variability in user's approach. A front on approach is in line with manufacturer recommendations, however, evaluating the angle approach proved troublesome and as such the result were excluded.

It was also observed that some users were inclined to approach the test with a considerable amount of acceleration in attempts to navigate the gap, a scenario observed in comparative trials (de Kloe, 2008). Participants exhibited exuberance in trialling the different gap geometry whilst acknowledging more precautionary behaviour would be observed in ever day situations. Understandably, the results are likely to be more positively biased as a result.

'Need to increase speed to cross which is not possible if passengers are obstructing. If wet, wheels would be spinning - Would be scarier'

One significant improvement for future trials would be the inclusion of a terminating wall on the carriage module as participants began to freely use a descending ramp once the gap was negotiated. In everyday travel, users would be confronted with the opposing carriage door (closed) in situ. The tendency in descending both ends of the ramp with no speed restrictions to the awaiting platform space may have adversely affected the accuracy of the outcomes, to what extent is unknown.

7. Design Opportunities to Improve Boarding and Alighting

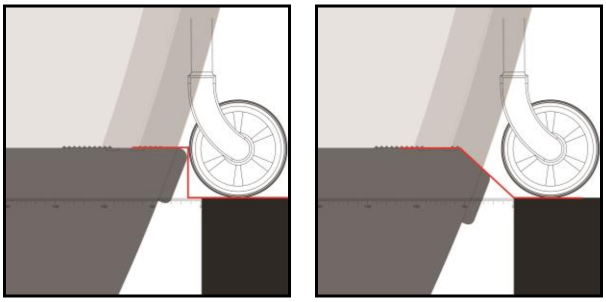
The trials offered valuable insight into potential functional design opportunities aside of evaluating the current gap provisions of the DSAPT. The following opportunities were identified through nuances revealed in the boarding and alighting experiments, via direct observation and in consultation with participants.

Firstly, the transition from platform to train and vice versa requires that the mobility device, enacted through the wheel, to climb the leading vertical edge of the train (Fig 16). Manual wheelchair operators in this trial were sufficiently able, both physically and skilfully, to perform a wheelie, whereby the front castor wheels were floated clear of this leading edge. However, motorised devices were subject to colliding with this front edge to force the wheel up the leading edge. For most users this experience was confronting and where the performance specifications of their chosen device were most evident in restricting successful completion of the task.

The critical component here is the diameter of the leading wheel, within this user group the smallest measured at 114.3 mm (4 ½“). Enabling smaller diameter wheels and preventing wheel abutment against the tread step (Fig 17a) the employing of an angled entrance way (Fig 17b) or the use of an impact absorbing material/design or even an inclined platform surface is proposed. Opening the angle could lessen both the initial jolt experienced by users and better accommodate the circumference of the wheel, to provide a smoother transition between platform and train.

Fig 16: Image of wheel on gap filler abutting train tread step (below left)

Fig 17a & 17b: Images of current condition and proposed design intervention (below right)



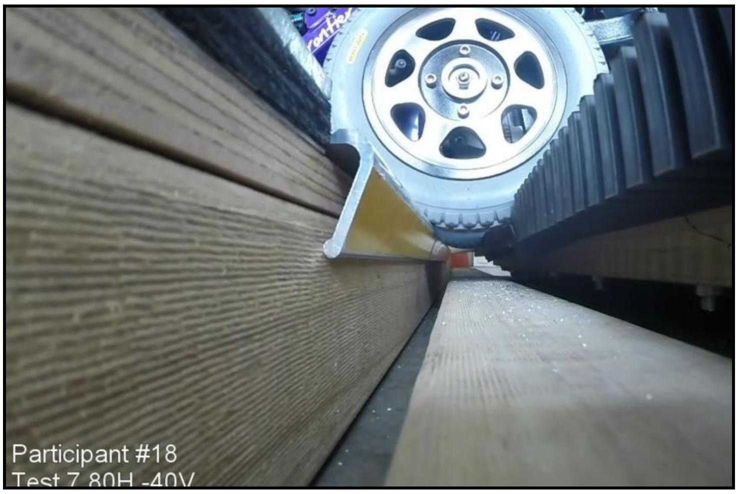
Secondly, the rubber comb arrangement as used by MTM throughout parts of its network was directly integrated into these trials. Within Trials 1 and 7 it was indirectly evaluated with the train vestibule in a lower vertical position than the platform surface. Current industry understanding recognises the effectiveness of the rubber comb arrangement in extending the lateral coping edge of platform surface. In these trial setups deflection occurring at the distal end of the rubber comb could be observed (Fig 19) particularly under load from heavier devices. It was communicated by a number of participants that the vertical rubber edges felt less abrupt than current aluminium tread plates, as experienced in accompanying trials. Further design arrangements to understand the impact, if any, of similar materials and flexible profiles to reduce impact and increase traction is proposed.

Lastly, with 50% of participants using a mid-wheel drive motorised chair MTM had a unique opportunity to evaluate this mobility device composition. Data shows these devices responding as well to gap variability as traditional motorised devices however on occasion unexpected wheel spinning occurred. As observed in Fig 18 the evidence of spinning occurred post ascending the gap and aluminium tread plate, whilst clearing the two rear trailing wheels.

Further research would establish whether a combination of the weight distribution, centre of gravity (with user operating), or chassis clearance is a factor. It could also suggest that the entrance surface of the carriage be investigated to improve the coefficient of friction through material specification or surface design, extending further beyond the initial doorstep.

Fig 18: Image of evidence of abrasive wheel spinning (below left)

Fig 19: Image of gap filler deflecting under load (below right)



8. Conclusion

This paper documents the findings of MTM and PTV boarding and alighting experiments. These trials were successful in evaluating a range of gap geometry and ascertaining comfort limits of mobility impaired users to further inform research into delivering accessibility into Melbourne's rail network. Some key conclusions that could be drawn from the research are presented here.

- Participants could safely negotiate a gap exceeding that of the DSAPT, 40 mm horizontal x 12 mm vertical. The research suggests 40 mm horizontal x 20 mm vertical is comfortable for participants.
- Some participants were capable of negotiating gap geometry up to 80 mm horizontal and up to 45 mm vertical. Trials concluded that the horizontal gap did not present as greater an obstacle as the vertical step height.
- Manufacturer's specification for Kerb Climbing is not reflected in user's operation of a mobility device or successful completion of trials where the vertical step height set to 45 mm vertical.
- Rubber gap filler was successful in extending the platform coping edge and impact on wheel entrapment minimal.
- Further design consideration could be extended to the internal floor surface of the train to prevent wheel spin, particularly in regards to increasingly popular mid wheel drive devices.
- Further design consideration could be given to the material or arrangement of the leading edge of the tread step or in proximity to. Material specification and composition could lessen the initial impact of mobility devices, in particular when boarding without the aid of a ramp.
- Consistent with international studies the European accepted maximum gap size of 50mm x 50mm would not be achievable by most users and range of mobility devices.

In summary, this research indicates minimum standards for rail operators regarding gap geometry of the DSAPT could be revisited. By understanding the limitations of modern mobility devices and their users implementing a platform/train design intervention provides an opportunity to improve the boarding and alighting experience of mobility impaired users. Further research into the design of a bridging apparatus', re-composition of the platform-to-train interface and material specification is to be presented through further research.

DISCLAIMER: The conclusions drawn from this research data are independent of Metro Trains Melbourne and Public Transport Victoria and as such do not represent the views of either of these organisations.

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