9-1-2011

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Recommended Citation

Macdonald, A., & Coxon, S. (2011). Towards a More Accessible Tram System in Melbourne –challenges for infrastructure design. Conference paper delivered at the 34th Australasian Transport Research Forum (ATRF) Proceedings held on 28 - 30 September 2011 in Adelaide, Australia.

Australasian Transport Research Forum 2011 Proceedings
28 – 30 September 2011, Adelaide, Australia
Publications website: http:/www.patrec.org/atrf.aspx

Towards a More Accessible Tram System in Melbourne – challenges for infrastructure design

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Abstract:

Melbourne has one of the largest tram systems in the world yet access is difficult for many passengers, generally excluding people using wheelchairs and scooters and those with prams, luggage and shopping. Overcrowding from sustained increases in patronage and traffic congestion aggravate the problem, leading to longer travel times. The Commonwealth Disability Discrimination Act (DDA) 1992 and Disability Standards for Accessible Public Transport (DSAPT) 2002 have recently imposed accessibility requirements on the design of conveyances and infrastructure. They are to be achieved within mandatory timeframes, adding legal pressure to develop a more accessible tram network.

The problem is common world-wide. The recent expansion of new light rail systems installed in Europe and elsewhere provides scope to analyse emerging trends in accessibility. Literature on infrastructure design is limited, so the research adopts a case study basis. It identifies key access issues then compares design solutions in several cities to identify common features and emerging trends.

This paper concludes that level access from a platform tram stop to a low floor tram remains the prevailing solution universally. It provides access for people with disabilities in accordance with the legislation, improves access for everyone, and delivers operational benefits. Integration of standard designs with the existing urban fabric also creates new directions for accessibility to public transport. The challenge of improving access to Melbourne's tram system may be assisted by applying design solutions and trends identified in the research.

1. Introduction

The Melbourne tram system

The tram is an icon of Melbourne, a city with a population of 4 million. Tourist images promote heritage trams and decorated art trams in tree -lined streets. The radial grid system has influenced Melbourne's built form by encouraging infill development, urban consolidation, and strip shopping centres. The tram system is one of the largest in the world, but has poor standards of accessibility, old infrastructure, and congested operation in mixed traffic.
Key data includes:

- 175.0m passenger trips per annum
- 28 Routes
- 500 trams
- 1800 stops

The system contributes significantly to moving people in inner Melbourne with 175.0m tram passenger trips per annum compared to 213.0m metro train passenger trips pa and 1.0m metro bus passenger trips pa. (www.transport.vic.gov.au DoT Origin and Destination Data) Substantial public transport patronage growth has been sustained over several years despite overcrowding, difficult access and unreliable services. This has been attributed to population growth, inner urban employment growth, effective urban consolidation policy and increased community preference. (www.transport.vic.gov.au DoT Patronage Data)

2. A Vision for Melbourne

2.1 Liveability and Urban Development

Melbourne's population is growing and urban policy advocates more sustainable, liveable and consolidated communities supported by improved more accessible public transport services. (DPCD 2002 Melbourne 2030, DoI 2006 MOTC, DoI 2006 VTP, DPCD 2009 melbourne@4million) Melbourne is projected to grow to around 7 million people by 2050. Programs advocate improving urban liveability by developing and improving public transport, promoting sustainable transport, enhancing social inclusion, improving access by walking and cycling, and promoting the design of pedestrian neighbourhoods.

2.2 Congestion and Tram priority

Melbourne like most large cities experiences traffic congestion particularly during morning and evening peak hours, with conflicting road space demands from a range of road users. Public transport vehicles (tram, bus, taxi) compete with heavy trucks, commercial and private vehicles and bicycles. Graphic representations of freeway lanes equivalents to the same number of car drivers in trams, buses or bicycles reinforce the benefits of improved public transport as a sustainable solution to accessibility.
Access to trams in Melbourne is currently inconvenient, potentially hazardous, difficult for many, and impossible for people using wheelchairs and scooters. Passengers wait in all weathers in the middle of the road and on crowded footpaths, mix with road traffic, and negotiate steps and narrow doors. At Kerb Access Stops passengers wait on the footpath, crossing the road when the tram arrives to board through narrow doors and steps, and all traffic stops. Dwell times are quite long and safety risks high. At Safety Zones in the centre of the road dwell times are slightly improved by allowing traffic to continue on independent of tram movements. Traffic signals control pedestrian access across two traffic lanes, and lack of synchronisation delays passengers who miss trams. A safety zone may be as narrow as 800mm wide with no shelter or time table information, so waiting is unpleasant.
Traffic congestion is aggravated by centre road boarding which delays everyone, increases dwell times for trams, and increases safety concerns. Queued cars block the boarding space for passengers. Cars are parked too close to the tram stop boarding area or street intersection, and overstay illegally at clearways. Further delays result from lack of synchronised traffic signals and real tram priority. Tram travel speeds have continued to fall, and are now 15 – 16 km's per hour average in peak hour (only slightly less than cars). Journey times are uncompetitive with a private car over distances greater then a couple of kilometres. (LUKE 2003) Most of the system operates in mixed traffic with less than 10% in a tramway right of way. A further 10% has separation kerbing or raised track. Elsewhere yellow lines define full of part time tramways with road rules allowing drivers to occupy tramways for up to 50m to enter or leave the road, make right hand turns in front of trams, or to avoid an obstruction. Accidents are frequent and impact significantly on efficient operation of the whole system. Statistics identify over 50 people are killed or injured per annum boarding and alighting from trams, and that there are an average of 5 crashes with cars every week (www.transport.vic.gov.au/tram data)

This highlights the need to reduce dwell times, improve travel times, and accommodate patronage growth. Further patronage growth could be achieved and traffic congestion reduced by improving frequency, services, and passenger amenity. DoT Passenger Satisfaction Surveys have identified quality of trip and service (in comparison to their car) as a key reason why they do not use public transport. (www.transport.vic.gov.au) VicRoads Tram and Bus Priority Programs (www.vicroads.vic.gov.au Tram and Bus Priority Programs) established to pursue real tram priority improvements have achieved some improvements. Dedicated tram lanes, priority lanes, traffic management and signalling improvements, stop rationalisation and the development of platform stops have cut a few seconds across a route journey segment. More is possible through measures such as tram initiated traffic signal changes and increased road space priority allocation to tramways and platform stops. Platform stops are contributing to reduced dwell times and improved journey travel times so are valued by operators for improved efficiency and profitability. (Currie 2008)

2.3 An Accessible Tram System - DDA DSAPT Legislation

An accessible tram system provides access for everyone. This includes people with disabilities, people using wheelchairs and scooters, walking frames, crutches and walking sticks, as well as older passengers, parents with prams and children, and those travelling with shopping, luggage and other equipment.

The need to develop a more accessible tram network in Melbourne has arisen partly from the need to improve tram passenger services but substantially from the legal obligations of the Commonwealth Disability Discrimination Act (DDA) 1992 and Disability Standards for Accessible Public Transport (DSAPT) 2002 and Guidelines (2004 amended). (Commonwealth Govt DDA DSAPT 2002) The DDA DSAPT legislation seeks to remove discrimination against people with disabilities in the provision of goods and services, in this case public transport services. It has imposed significant implications on the design of conveyances and infrastructure adding a pressing legal imperative to develop a more accessible tram network. The problem is common across the world as many countries seek to achieve accessible tram and light rail services in the context of disability legislation and mandatory timeframes.

The DSAPT and referenced Australian Standards (AS 1428.1 - .5) set out the requirements to be met in conveyances, premises, and infrastructure for train, tram, bus and taxi services, and establishes milestones for staged implementation and retrofitting over 20 and 30 years. The DDA DSAPT legislation requires 25% compliance by 2007, 55% compliance by 2012, 90% compliance by 2017 and full compliance for infrastructure by 2022 (2032 for trams and trains). When applied to tram services these requirements translate to level access from platform tram stops to low floor trams, and which effectively requires a complete re-engineering of the tram system. While many DSAPT requirements have already been met across the tram system, access for people with disabilities who use wheelchairs and scooters is particularly challenging.

2.4 Key access issues

Key DDA DSAPT issues for Melbourne's tram system are outlined below.

2.4.1 Circulation – space and support

Adequate circulation space is necessary to accommodate all passengers needs, particularly those using wheelchairs or scooters. Stops may become crowded where patronage is high, and may be aggravated by low service frequency.

- Access path – a continuous path of travel 1200mm min wide clear of all obstacles (bollards, bins, seats, shelters etc) and the safety setback line and tactiles along the edge of platforms.
- Manoeuvring - space for turning wheelchairs 90 degrees of 1540mm X 2020mm minimum (1740mm X 2270mm preferred)

- Passing –1800mm every 6m for two wheelchairs passing
- Resting points - seats every 60m between services
- Waiting areas - identified priority seats and space for wheelchair users
- Allocated space – for wheelchair and scooter users on vehicles
- Surfaces – non slip, shed water
- Handrails and grab rails.

2.4.2 Level changes

Continuous step free access at appropriate grades is required, with minimum gap between the platform stop and the vehicle floor.

- Ramps – 1 in 14 maximum grade, landings every 9m, handrails and kick plates
- Boarding – maximum gap between vehicles floor and platforms 40mm X12 mm or deploy a boarding device or ramp with maximum slope 1 in 4
- Stairs – profile dimensions, colour contrasted nosings.

2.4.3 Information

All information must be provided in multiple formats – visual, audible, tactile – to assist people with vision and hearing impairment.

- Symbols – 'wheelie' symbol identifies accessible services
- Signs – minimum letter sizes based on reading distance, minimum colour contrast, dark on light preferred
- Tactile ground surface indicators (tgsi's) – edges of platforms, top and bottom of stairs and ramps, changes of direction, obstacles, colour luminance contrast required minimum 30%
- Lighting – 150 lux minimum in interior spaces, waiting and ticket sale areas
- Payment of fares
- Hearing augmentation – hearing loops or equivalent visual information
- Information – all general transport information in multiple formats.

Users prefer real time information.

2.4.4 Waiting space and Shelters

Waiting amenity is important particularly where frequency is low and weather conditions variable. Shelter is not a DDA requirement but is preferred for rain, sun and wind protection whilst waiting. Shelters have always been provided at busy locations and several heritage 'Victorian' cast iron and corrugated iron structures from 1916-17 remain.
Street furniture (seats) are preferred and provided to various designs which meet DDA DSAPT requirements. 'Perch seats' are not preferred, armrests on seats are preferred, and priority must be identified for people with disabilities.
Passengers prefer high frequency service without waiting but it is a more pleasant comfortable experience in a well designed space so good design adds value.

2.4.5 Access to the stop and links to other transport modes - connectivity

Wider issues support an accessible tram system and access to the stop is significant as everyone arrives at the stop as a pedestrian eventually. Good pedestrian connections to other modes - cycling networks, bus services, connecting tram and train systems and car parking - are vital parts of an accessible tram system. Bikes are not allowed on trams so bike parking at or near stops and connecting bike paths are valuable. Considerable levels of park and ride may develop at tram stops where there is ample car parking. Amenity, convenience, proximity and information are all valued at modal interchange. These issues are subject to further research beyond the scope of this paper.

2.4.6 Other

Additional factors important in developing an accessible tram system, also not addressed here, include cost, materials, the implementation strategy, and the construction method.

3. 'On – tram' access solutions

The search for accessible solutions has been world wide - Europe, Scandinavia, USA, driven by accessibility rights legislation and pressing timeframes. On-tram access options have been investigated extensively and are not pursued in this research. Measures tested separately, and in combination with platform tram stops, and have included portable or fixed manual ramps deployed by the driver (Melbourne) or conductor (Adelaide) , automatic ramps (trialled in Gothenburg, Sweden), and automatic lifts (Munich). Access options to high floor trams have included high platform stops (nominally 800mm), a lift on the stop and a lift/hoist fitted on the tram. Ultra low floor trams in Vienna were developed with almost no step from the road pavement and a kneeling tram has been developed in Croatia.
Universally the preference has been towards level access from a platform stop to a low floor tram. (14) Low floor trams (nominally at 300mm above track) provide better access for everyone and now all new trams are designed on this basis. Level access platform stops are also commonly provided in all systems across the world. (LeSage 2005, WEISS 1995)

4. Current Melbourne level access solutions

Current policy to progress accessibility in Victoria is set out in the Action Plan 2006 – 2012 (DoI Action Plan 2006) and the Client Design requirements (CDR) Platform Tram Stop Standards (DoT CDR's 2010) which reflect DDA DSAPT minimum space requirements. There are many conflicts between accessibility objectives, technical requirements, safety and implementation.
Level access from a platform tram stop nominal 290mm high to a low floor tram (with a nominally matching floor height) and has been identified as the preferred access. This possibly requires building platforms at 1800 tram stop in Melbourne where 2/3 are kerb access and 1/3 are safety zones. Since DDA DSAPT was passed in 2002 there have been some 328 stops upgraded to platforms (18%) with more planned and to be built subject to funding. Progress is slow and difficult. Achieving the milestones of 25% compliance by 2007 is still progressing, making the next of 55% compliance by 31 December 2012 a challenge. (DoT Action Plan 2006)

4.1 Melbourne Stop Designs
(refer Figure 1 for images of each type of design)

4.1.1 Kerb access - No Platform
Kerb access stops as established in the 1880's comprise 2/3 network or nominally 1200 stops. Passengers wait on the footpath crossing the road to boarding when the tram stops. Traffic should stop behind the tram but cars may block the boarding space delayed by traffic signals. Typically there is one lane of traffic and possibly a bike lane to cross. Vehicles do not always stop and there are safety risks. The footpath width varies, generally about 3.0m and fully paved, but may cluttered with street furniture, parking signs and poles, rubbish bins etc. There may be a kerb ramp and associated traffic signals for pedestrian access.
Car parking is not allowed within 20m max of a tram stop unless pre dating the new Road Rules.

4.1.2. Safety zone
The rest of the stops are safety zones comprising1/3 network or nominally 400 stops. Waiting and boarding is in a separate fenced refuge in the centre of road adjoining the tram track. Widths vary and there may be a shelter and a timetable. Open railings have been replaced by fencing excluding informal access. Typically two lanes of traffic are crossed with

signalised access for pedestrians. Trams and traffic operate separately. Where space is narrow safety zone can be very overcrowded with safety risks for passengers with the moving tram.

Platforms
Potentially twelve different platform designs have been built in Melbourne, with varying benefits for tram passengers and other road users, and all with complex design issues.

4.1.3 Central city 'Superstops'
Central city 'superstop' platforms were the first level access solution developed. (Yarra Trams 2001) 'Up' and 'down' platforms were built in opposite or offset pairs, with traffic merging around them from two lanes to one. Arrival, departure and midblock variations have all been developed. Traffic signals generally control pedestrian access from one end. Informal pedestrian crossing at one or both ends has also been effective especially at mid block stops. All platforms are nominally 3.0m or more wide by 33.0m long with a 9.0m ramp at one end, sometimes both, or stairs at one end. Materials include bluestone edging, stainless steel structures and tiled paving.

4.1.4 'Suburban' Platforms
Suburban platforms are similar, some with reduced width. Materials are of lower quality - concrete, asphalt paving and galvanised steel handrails and fencing - and some do not have shelters or furniture.

4.1.5 Single Terminus
The current 'end of line' platform generally is the same as a single faced platform above but abutting a single track. Operational limitations have led to alternative designs with double track merging to single track and back to accommodate two services and hold a stored tram. An island with double track has been built and is the preferred terminus solution for optimum operational efficiency and passenger amenity. It also allows the line to be easily extended.

4.1.6 Light rail/median
A median stop in a central road median is similar to a single face platform stop but with reduced fencing and crash protection requirements so greater space and amenity, less traffic impact and reduced cost and easier construction.

4.1.7 Kerb Extension
The kerb extension provides the greatest passenger amenity with direct access from the footpath. Capacity is flexible and safe where crowds are present, and passengers do not have passing traffic close to them. Tram services are more efficient and cars merge from one lane to two where mid block locations are installed, with no net time reduction on their travel from traffic signal to traffic signal at adjoining signalised intersections. Traffic is delayed behind stopped trams.

4.1.8 Integrated
Integrated platforms are designed in pedestrianised streetscapes and malls where traffic is excluded, and uses other parts of the road network. Greater passenger and pedestrian amenity results.

4.1.9 Island
Island platforms are costly to build requiring all track and overhead electrical wiring to be rebuilt. Passenger access is signalised with ramp access at one or both ends. Platform width must be adequate to allow passenger loading both sides and accommodate all the structures and obstacles such as shelters, seats, poles, bins and timetable information totems. Fenced tram tracks are required for safety to prevent passengers from disembarking into moving

traffic. Traffic may have to merge from two lanes two one as shared traffic on the tracks is not efficient for tram operations.

4.1.10 Trafficable

Variations of the trafficable platform or raised road pavement stop have been developed due to road width constraints. Passengers interface with traffic and their paths cross for boarding trams. This type achieves level access and improved safety and amenity than the status quo with less cost than platforms where road width is very narrow. Traffic speed varies from 40kph and 50kph in local roads to 10 kph in shared roadway zones where pedestrians and motorists mix with equal rights. (Currie 2005, 2006)

Table 1 Summary of Numbers and Designs

A summary of what has been achieved to date (www.transport.vic.gov.au) includes:

	Design	No	%	Typical examples (refer Fig 1 Melbourne)
.1	**No Platform Kerb access**	**1100**	**60**	Whitehorse Rd at Bourke Rd
.2	**Safety zone**	**372**	**22**	typical safety zone stop
	Platforms			
.3	'Superstop'	48	3	Collins St at Spring St, CBD
.4	Suburban	71	4	Victoria St Richmond
.5	Terminus -	9	0.3	Doncaster Rd Balwyn
.6	Light Rail and Median platforms	156	9	Dandenong Rd Windsor
.7	Kerb extension	4	0.2	Whitehorse Rd at Inglesby, Box Hill
.8	Integrated	5	0.3	Bourke St Mall, Melbourne
.9	Island	7	0.4	Melbourne University
.10	Trafficable	5	0.3	Danks St at Harold St Albert Park
		2	0.1	Cleve Plaza
	Sub total	**328**	**18**	
	TOTAL nom	**1800**	**100**	

Figure 1 Melbourne

.1


.2


.3


.4


.5


.6


.7


.8


.9


.10


If the stop design type is selected based on the width of road space available, which varies along a route, the result is a wide variety of stop types along any route. This may cause operational, safety, passenger and traffic confusion for all road users. Key issues are the variability in the 'boarding' side of the tram, increased complexity for tram drivers, safety concerns, and passenger disruption within the tram for boarding and alighting. Others are motorist recognition of a tram stop and passenger confusion in identifying stops.

4.2 Further Stop Design Trials

4.2.1 Trafficable Easy Access Stops (TEAS)

This proposal to be tested is for a short trafficable platform in the roadway to provide level access to at least the middle accessible doors, preferably all doors. It is a more compact option, and broader application is sought. Ramps of 1 in 12, 20, and 24 have been tested, with lengths from 12m – 20m. Off road testing has been undertaken to be followed by an on - road trial/pilot/test.

A further proposal to be tested is for double trafficable lanes on 4 lane undivided arterial road. It would have a 60 kph speed limit, one lane of traffic follows the tram, and the other lane goes up and over the platform in a clearway alignment. Off road testing has been done and is to be followed by an on - road trial/pilot/test. This type has been proposed in several locations on the network but is yet to be built. Issues include loss of parking, side road access, cyclists, identifying a tram at the stop (multi routes) and where to get off.

4.2.2 Central Island Platform Stops (CIPS)

This proposal to be tested has end to end single face loading centre road platforms with widened track spacings and overhead. It was proposed for Boroondara and is currently in construction in Darebin locations. (www.vicroads.vic.gov.au)

4.3 Evaluation of the Design Types

Yarra Trams motto 'think like a passenger' prompts evaluation of the various designs from a tram passenger's viewpoint. Criteria are based on accessibility, functionality and amenity and include:

a. Access to the stop - direct (pedestrian crossing priority) vs delayed (signals), no time delay for signals or traffic causing missed services
b. Access to the tram - direct with modal segregation, no conflict with other modes eg cars, bicycles
c. DDA Compliance – level, no gaps, DSAPT compliance, 'accessible' for everyone
d. Road space for boarding – total area of platform, ramp and road space used
e. Passenger Amenity - quality of waiting and boarding experience
f. Passenger Safety
g. Dwell time
h. Cost

Ranking is based on relativity between each type of stop, with best (3) to worst (1) outcome assigned a score. The aim is for the highest points to achieve seamless access, level, direct, convenient and DDA compliant.

Table No 2 Evaluation of Stop Types

Type	**Criteria**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**		
	Type									**Total**	**Rank**
.1	**Kerb access**	1	0	0	1	1	1	1	3	8	**NA**
.2	**Safety zone**	0	1	0	3	2	2	3	3	14	**NA**
.3	**Platform**										**2**

	'Superstop'	0	1	1	2	3	3	3	2	15	
.4	**Suburban**	0	1	1	2	3	3	3	2	15	**2**
.5	**Terminus**	0	1	1	2	3	3	3	2	15	**2**
.6	**Median**	0	1	1	2	3	3	3	2	15	**2**
.7	**Kerb extension**	1	1	1	2	3	3	3	2	16	**1**
.8	**Integrated**	1	1	1	2	3	3	3	1	15	**2**
.9	**Island**	0	1	1	3	3	3	3	0	14	**3**
.10	**Trafficable a Danks**	1	0	1	1	2	2	2	2	11	**4**
	Shared b Cleve	0	1	1	3	3	2	3	2	15	**2**

This evaluation identifies that tram passengers are better served where separated from cars and other modes but with direct, unconstrained access to tram services. Passengers and cars are the least compatible modal mix, and where they are forced to mix passenger amenity reduces to the lowest. The kerb access stop and safety zone are neither 'accessible' nor DDA compliant.
The kerb extension design scores the highest passenger amenity but requires traffic to merge two lanes into one and to stop behind the tram. The platform stops (super, suburban, terminus and integrated) score the second highest. Integrated stops rely on a plaza/pedestrian street context where there is no traffic throughway.

5. Other design solutions

The recent expansion of new light rail systems installed in cities in Europe – Spain, France, Italy, UK, and elsewhere - Scandinavia, America, Canada, and Turkey, provides great scope to analyse emerging trends. (UIPT 2010, Walker 1992, Wansbeek 2003) The focus of the research is on the design standards for tram passenger access to trams by platform tram stops. Published Standards tend to be generic as referenced or are internal project design reports Literature on the design and implementation of platform tram stops, particularly the passenger accessibility and urban design outcomes, is limited, so the research adopts a case study basis. Full documentation of 'case studies' (the term may be misleading) and analysed examples is beyond scope of this paper. All systems were inspected, photographed, analysed and categorised, with key data for each system complied (not included). The paper identifies key access issues then compares solutions at various locations to identify common outcomes and emerging design trends. The impact of this type of stop on traffic capacity is not addressed in this paper as the focus is on accessibility for tram passengers. (The basis for comparison should be the number of person trips plus goods/services trips, not numbers of vehicles travelling. Further the time impact of a platform stop where traffic merges two lanes to one and passes the boarding tram should be compared with a kerb access stop where all traffic stops to wait while tram passengers board and alight across the road.
The networks reviewed in this research are outlined below.

5.1 France

French case studies were selected due to their 'leading reputation', being the first to introduce many new accessibility features, to demonstrate the 'ideal' service levels achievable with total priority, and delivering good urban integration. (Haydock 2006) Tram operations are in streets rather than disused heavy rail reserves. They are also known for quality design of tram stops or 'stations' involving architecture and landscape architecture design professionals. There are direct links between Melbourne's Yarra Trams and French

Companies KDR, Keolis, Veola, and tram manufacturers, providing opportunities for information exchange and potential improvements to Melbourne's system.

Grenoble	first fully accessible tram system with a 'wheelchair city' reputation
Marseilles	regenerating a large older diminished system
Montpelier	introducing a new system replacing buses to achieve social inclusion, accessibility, and urban renewal objectives (M le Tourneur 2010, Mills 2001)
Lyon	expanding a network in France's second city, with direct links to Melbourne through Yarra Trams (KDR) (Wansbeek 2003)
Strasbourg	Demonstrating innovative urban design
Paris	Old and new linking systems demonstrating complex urban integration, renewal, and high quality passenger design features
Bordeaux	introducing a new tramway system into heritage city fabric, and implementing innovative environmental and urban design outcomes.

5.2 Spain

Spanish case studies were identified due to their 'leading the light rail revolution'. (Pinto 2010, UITP 2010) The UITP chose Spain for the 10th Light Rail Study Tour and Conference in October 2010. New, upgraded and extended tramway systems have recently been implemented in 8 – 10 Spanish cities, with more planned. High standards of innovative passenger facilities and urban design integration have been demonstrated.

Bilbao	expanding systems introduced with city revitalisation associated with the new Guggenheim Museum of Modern Art (Alegre 2010)
Vittorio	introducing a new system in the old city pedestrianised streets (ditto)
Zaragosa	integrating major urban renewal streetscapes (ditto)
Barcelona	systems as part of a world renown urban renewal strategy
Valencia	extending the Calatrava tradition of innovative design (Advertorial 2010)
Madrid	enhancing parts of a whole city public transport modernisation with a social inclusion basis
Seville	responding to heritage and urban integration challenges

5.3 Other

Gothenburg	mixing tram and bus modes, with innovative tram ramps
North Croydon (UK)	integrating complex traffic conditions - one way systems, grade separation and a pedestrian mall
Toronto	blending a mixed traffic legacy with a new segregated system. (Giambrone A 2010)
Sydney	mostly operating on a former heavy rail line
Adelaide	tram in right of way extended into city streets.

5.4 Key findings

The key findings for each access issue are summarised in the table below. Typical examples of each city solution are also illustrated in **Figure 2 France**, **Figure 3 Spain** and **Figure 4 Details** with access issues annotated by correlating number (author's photographs). The images are limited in conveying the quality, amenity and accessibility of the tram systems. Their urban integration and contribution to the social inclusion and liveability of the cities they serve is remarkable, and best experienced in real time and space.

Table 3 Key Findings

	Access Issue	Findings – all systems
1	**Circulation space** Access path Manoeuvring areas Passing areas	Generally access paths are wider than 3.0m, a standard minimum throughout the route, and supplemented with connecting footpaths, plazas and bike paths
2	**Level changes** Ramps	Generally provided for full platform width and at both ends
3	Boarding gaps	Level boarding with minimal horizontal gap, wheelchair accessible
4	Stairs	rarely used as supplementary access only
5	**Structures** Waiting areas - space priority and shelter	Coverage 30 – 60 % area or more Taller, integrated design, character unique to the city, custom design, high quality
6	Surfaces	High quality materials, robust, low maintenance, slip and vandal resistance
7	Handrails and grab rails	Minimal, at centre of ramp, fencing at car lanes
8	Street furniture (seats)	High quality custom design, variations
9	**Other** Crash protection	Traffic Crash barriers not provided Traffic calmed, single lanes, low speed limits
10	**Information** Symbols Signs	Clear, large letters for route and stop ID Sign link to other public transport modes
11	Tactiles (tgsi's)	Ceramic tiles, not always colour contrasted
	Lighting	Provided as integrated design solution
12	Payment of fares	Fares equipment incorporated in 'standard' structure design, one per pair platforms
	Hearing augmentation	Visual information provided
13	Information	- Real time 'next service' and clock - Route maps - Information on connecting public transport - Local area maps - Service disruption notices

Figure 2 France

Lyon
1
2
5
6

Lyon

1
5

Lyon

1
3
5

Montpellier

1
5
8

Paris

1
5
6

Paris

1
5

Marseilles

1
2

Figure 3 Spain

Barcelona

1
5
8
12
13

Madrid

5
8
12
13

Vittorio

1
5
12
13

Valencia

1
5

Parla (near Madrid)

1
5
12
13

Parla

1
5
8

Seville

1
5
8

Zaragosa

1
5

Figure 4 Details

Lyon

2
6

Lyon

6
8

Madrid

9

Madrid

8

Zaragosa

6 **8**

Barcelona

3

Barcelona

6
10

Madrid

12

Strasbourg

13
14

Bilbao

12
13

Further work will address tram stop connectivity to other modes, and urban integration of the stops with the street context in which the tram system operates.

6. Emerging trends

Key trends identified are:

6.1 Full accessibility

Full accessibility is achieved with platforms built at all stops along a route, to provide level access to a low floor tram, with a minimal gap of less than 50mm horizontally and imperceptible vertical level difference. Ramp access and a continuous path of travel provide easy access for everyone.

6.2 High quality stop design

Well resolved stop design is achieved including a large canopy (nominally 60% coverage of the stop) to provide shelter from sun, wind and rain. The platform itself is of simple robust masonry design with quality low maintenance long lasting finishes. Adequate generous circulation space and clear paths allow easy passenger access and dispersal for all users. Passenger facilities are well integrated into the design of the structures. There is no clutter, few obstacles, and no traffic conflict at stops. Fencing is minimal as is the provision of handrails, often only one side of a ramp or not at all. Traffic protection crash barriers are rarely provided.

6.3 Standardized stops designs – side or island

Stop design is standardised for the full length of any route and rolled out as a single installation project. There are only two types of design, a pair of side platforms and occasionally island platforms.

6.4 Information

Real Time next tram services information (passenger information displays/PIDs) is provided on every stop. Clock time is also provided. Tram Route maps, connecting public transport services and local geographic maps are also provided. Ticketing machines are provided on at least one platform (up or down).

6.5 Provide direct access to the stop and improved modal interchange

Direct pedestrian access to a stop is provided from other modes. This includes from pedestrian spaces and places, cycle paths, bus stops, metro train stations, taxi ranks and car parking areas, including multi story car park buildings. Bicycle racks and storage cages may be provided on adjoining space. Direct connections are made with space allocated as necessary to link seamlessly. Connectivity and priority access are important components of an accessible tram system. Modal interchange design issues are expanded elsewhere as this paper is part of a broader study.

6.6 Minimize traffic conflict

There is very little traffic conflict with tram passengers at the stops. Traffic is calmed and conflict with the tram system removed at high level in the traffic management system. Heavy traffic roads are provided elsewhere in streets which do not accommodate tram systems. At the stop level therefore local traffic calming measures can be minimal.

Low speed limits calm any surrounding traffic, lane numbers are minimal or non – existent adjoining tram stops, and traffic signals give total priority to tram movements and pedestrians accessing trams. Trams only stop to change passengers. Signals, boom barriers, merging lanes and closed roads allow efficient operation of the public transport investment.
Road space is allocated for the requirements of the tram stop and tram passengers without compromise across the whole route. Necessary connections to the other modes are made directly and road space for private vehicles is adjusted accordingly. Some 'informal' private vehicle access arrangements are established to provide for local private or commercial access to properties (houses, apartments, shops or businesses) and car parking.
In some cases new urban places are developed from space left over after tram planning. Eg public squares or parks are created at stops at merging routes.

6.7 High urban integration

The design of the stops achieves a high degree of urban integration. They physically blend into their urban setting whilst remaining readily identifiable as a tram stop. Local design features are incorporated such as shade trees or pergolas in very hot cities, bright colour and curvilinear lines. Stops may be integrated into squares, plazas, parks and shopping streets. They contribute significantly to the population of public open space bringing life and economic prosperity to civic life. Standard details may be varied or simplified where they adjoin significant heritage buildings. The stops installation may include major or minor landscape upgrades to the streetscape. They may precipitate major urban regeneration around them and may stimulate further urban development in precincts beyond the terminus.

6.8 Additional service and operational benefits

The uncompromising approach to designing the stops provides other passenger benefits in tram operations and level of service delivered. Platform stops provide reduced dwell times so improve the journey times and efficiency and return on state investment in the tram system. The improved amenity and safety attracts more passengers so contributes to further patronage growth. Combined with other operational measures such as total priority the cumulative impact for tram services is extraordinary. The consequential benefits to urban liveability are also immediately apparent at many levels, and are expanded separately in related research.

7. Conclusions

The challenge to improve accessibility to the Melbourne tram system for all passengers to accommodate demand and in response to the requirements of the DDA DSAPT (2002) raises significant issues for the design of tram stop infrastructure. Several designs have been implemented but overall progress has been slow and standards variable and compromised for tram passengers. Examples elsewhere have made better progress, achieving full accessibility, and demonstrate that good consistent stop design across the whole route is fundamental.
The paper concludes that level access from a platform tram stop to a low floor tram remains the prevailing and preferred solution universally. It provides access for people with disabilities in accordance with the legislation, and better access for everyone. Good stop design with adequate circulation space for passengers and consistent application of a standard stop design along on the whole route is the general design strategy adopted elsewhere. Space requirements for tram passengers and service operations are defined and allocated along tram routes. Space requirements for other transport modes and associated traffic planning are modified accordingly. Direct connections from tram services to other transport modes are made to ensure good access to the stop. Traffic calming and high levels of urban integration

demonstrate that further improvements in accessibility can be achieved. Platform tram stops are also providing faster safer boarding for all passengers, and leading to reduced dwell times, improved travel times and better service quality. They are also generating increased patronage to the system.

The current 'accessible' components of the Melbourne system adopt many of these features to some degree, but not consistently, extensively or comprehensively. As one of the largest systems in the world, tram passenger requirements are often highly compromised and standards may be inadequate. Upgrading stops to platforms is undertaken in a piecemeal way and lacks commitment to the adoption of a robust design strategy for the planning, design and delivery of an accessible tram system. The challenge of achieving improved accessibility through retrofitting Melbourne's tram system may be assisted by application of the design solutions and emerging trends identified in the research.

Acknowledgements

The authors would like to thank the Victorian Department of Transport for their support in undertaking this research. The research is an independent view from the authors and does not necessarily represent the views of other parties. We would also like to thank the paper reviewers who added much value to the work. Any omission or errors are the responsibility of the authors.

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