

An Innovative Design for Safe and Accessible Light Rail/Tram Stops Suitable for Mixed Traffic with Median Track Operations

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1 Introduction

Designing public transport infrastructure to enable safe access for all passengers including those persons with disabilities is a major priority for all public transport authorities. However there are significant challenges with tram and light rail systems when tracks run in the middle of the road (road median) in mixed traffic conditions. To access or egress trams, passengers must cross road traffic lanes. In many systems this includes interacting with road traffic using kerbside lanes. In addition, unless platforms are provided in the road median, passengers must climb onto vehicles without the assistance of road side kerbs to reduce the step height. Unless expensive lift based systems are used, access for people using wheelchairs is impossible in these circumstances.

This paper describes the design of an accessible tram/light rail stop suitable for median mixed traffic tram operations. The design was developed, tested and built in the City of Port Phillip, an inner urban local government area of Melbourne, Australia. This paper is structured as follows:

- An International Review of Tram Stops In Mixed Traffic — which reviews international experience of tram stop design and focuses on the issue of median mixed traffic tram operations
- Melbourne Conditions – which describes the Melbourne tram system
- The Innovative Design – which outlines the new design
- Impacts and Performance – which describes how the new design has performed
- Conclusions – which summarises the papers key findings and considers the implications of these for future transport system design.

2 An International Review of Tram Stops In Mixed Traffic

Physical accessibility has been identified as one of the most significant factors affecting the ease of use of light rail systems (Catling et al, 1995). As a result of national legislation, such as the Americans with Disabilities Act (US Department of Justice, 1990), achieving high quality access is now a mandatory requirement for new light rail systems. In Australia similar legislation in the form of the Disability Discrimination Act (Commonwealth of Australia, 1992) also requires that pre-existing infrastructure must also be made accessible through a retrofitting program over 30 years. This is a much more difficult task than designing and building new infrastructure (Catling et al, 1995).

Geissenheimer (1998) identified two main approaches for providing access for persons with disabilities on light rail stations; platforms or lifts. Platforms aim to create level entry between platforms and vehicle entrances. They can be either low or high depending on the height of the tram or light rail vehicle entrance. In Europe low floor platforms are considered to be 300-350mm above the level of the rail (Catling et al, 1995). The Department of Transport in Ireland (2002) defines platforms above 400mm from rail height as 'high' platforms.

Lifts can be either on-vehicle or on-platform. Either can be expensive to build and maintain. Lifts on vehicles can be a cause of delays to services during passenger loading and unloading. They also reduce vehicle seating and standing capacity. Overall platforms

appear a cheaper and more effective solution. However platforms are not always a feasible solution particularly when services operate in the road median in mixed traffic:

- Kerb side platforms are only feasible if the tram/light rail operates next to the kerb. With median operations this is only feasible if the road is one lane wide in both directions. Kerb extensions (or bulbs) are another option to generate a kerb side platform if the road is wider than a single lane in both directions. However these options are not always feasible with wide roads. Also in many locations road traffic capacity may be severely limited by reducing road width to a single lane. This is not always possible.
- For wide roads at high traffic volumes a platform could be designed either as a set of side platforms or an island platform within the centre lanes of the road. In this case road traffic surrounds the platforms and passengers must cross these traffic lanes to access/egress services. These options are not always feasible where road widths are confined. In addition they require that passengers must cross often busy traffic lanes.

Median tram/light rail vehicle operations in entirely mixed traffic conditions is not a common phenomenon in transit systems in the United States (see Table 1).

Table 1 : Type of Tram/Light Rail Right of Way – US Light Rail Transit Systems 2001

Light Rail System	Direct Track Miles by Type of Right of Way ¹						% Mixed
	At Grade Exclusive ROW	At Grade With Cross Traffic	At Grade Mixed ROW	Elevated ROW	Tunnel ROW	Total	
San Diego	-	80.2	8.0	7.8	0.6	96.6	8.3%
Los Angeles	3.7	27.6	-	35.1	16.0	82.4	0.0%
San Francisco	4.5	6.0	47.9	-	14.9	73.3	65.3%
Philadelphia	-	23.6	41.3	-	4.4	69.3	59.6%
St. Louis	39.0	0.8	-	15.4	13.6	68.8	0.0%
Portland	6.1	41.7	0.2	1.0	15.9	64.9	0.3%
San Jose	12.2	36.5	-	8.6	1.1	58.4	0.0%
Baltimore	40.4	11.5	3.1	2.6	-	57.6	5.4%
Boston	19.2	19.1	1.3	2.4	9.0	51.0	2.5%
Dallas	1.5	30.4	2.5	5.0	7.7	47.1	5.3%
Sacramento	8.1	21.7	6.8	4.1	-	40.7	16.7%
Pittsburgh	24.3	-	4.4	1.9	4.2	34.8	12.6%
Salt Lake City	-	25.6	8.6	-	-	34.2	25.1%
Cleveland	10.3	14.5	-	2.9	3.1	30.8	0.0%
Denver	10.6	4.8	-	10.4	2.2	28.0	0.0%
Newark	7.6	7.1	1.9	-	-	16.6	11.4%
New Orleans	16.0	-	-	-	-	16.0	0.0%
Buffalo	-	2.8	-	-	9.6	12.4	0.0%
Newark	5.8	-	-	-	2.5	8.3	0.0%
Memphis	-	2.4	3.4	-	-	5.8	58.6%
Galveston	-	-	4.9	-	-	9.8	50.0% ²
Seattle	-	3.7	-	-	-	3.7	0.0%
Kenosha	-	0.5	1.4	-	-	1.9	73.7%
Detroit	-	-	1.3	-	-	1.3	100.0%
Total	209.3	360.5	137.0	97.2	104.8	913.7 ¹	15.0%
	23%	40%	15%	11%	12%		

Source: Analysis of the Florida Transit Information System database Florida International University (2001)

Note: ¹Direct track right of way measures adjacent tracks in the same right of way as a single measure of distance for right of way
²Galveston data from FTIS indicates 4.9 miles of mixed ROW but 9.8 miles of total direct track miles. No indication of the type of right of way for the remaining 4.9 miles is indicated although we suspect duplication by direction in the data. Percentages have been calculated assuming the total to be correct.

Some 15 % of total track mileage in the US is in mixed traffic almost all of which involve median tram operations. Some selected US systems have high proportions of mixed traffic operations including some of the largest systems. San Francisco and Philadelphia for example have over half their track operations in mixed traffic while several smaller and older systems are also characterised by mixed traffic operations. TCRP Report 17 (1996) recommended raised platforms to a minimum of kerb height to protect passengers from oncoming traffic in median alignment mixed traffic conditions. Sidewalk 'flare-outs' and restricted parking at stops were also recommended. The same source noted that 92% of LRT accidents occurred in shared or mixed rights of way at speeds below 35 mph despite the fact that these systems represented a very minor percentage of track mileage (31% of the systems surveyed). Pedestrian collisions represented 9% of all accident types for the systems surveyed however the accident data in TCRP 17 does not include pedestrian vehicle traffic accidents which are typically considered to be separate to those involving light rail vehicles. This is unfortunate since median operations necessarily generate greater traffic and pedestrian conflicts which require management. Some comments regarding safety issues associated with mixed traffic operation are noted in TCRP 17 (1996). Muni (San Francisco) notes passenger queuing in street traffic lanes as passengers disembark as a safety issue on the 'L Traval' line where there are no station platforms (TCRP, 1996 p 46). A later review of US light rail (TCRP 69, 2001) has less of a focus on non-exclusive rights of way in light rail systems. However it does emphasise the need for greater protection of pedestrians near light rail crossings.

Toronto is major North American system with mixed traffic operations on its light rail (or streetcar) system. A high proportion of the Toronto system involves median operations with kerbside stops and passenger loading onto and off the road itself. This is noted as one of the major difficulties being faced by the Toronto Transit Commission (2003) in addressing accessibility issues. Some platform stops are provided within the road median although many stops are kerbside (see Figure 1).



Figure 1 : Examples of Toronto Light Rail Stops in Median Mixed Traffic Operations

In Europe French light rail systems have almost no on-street running although UK systems have a similar proportion to as the US (at 14% see Table 2). Germany has 29% of all track length in mixed traffic. This is very high (over 50%) in Essen and Mulheim and Duisburg.

Of the UK systems Sheffield has by far the largest share of mixed traffic operations (at 60% of the network). The UK approach to light rail tram stop design in mixed traffic is almost entirely based on kerbside platforms such as those shown in Figure 2. In almost all cases UK light rail vehicles operating in mixed traffic run on roads of only a single lane width in both directions. Hence kerbside platforms enable easy and safe access. Traffic must wait behind

trams when passengers are boarding and alighting. 'Kerb extensions' (or 'flare-outs') are often employed to narrow roads to a single lane where trams or light rail vehicles run on wider roads. In wider roads pedestrian refuges are provided to stop overtaking of trams by traffic. Refuges also assist in safe pedestrian access across roads.

Table 2 : Type of Tram Rail Right of Way – French German & UK Systems

Light Rail System	Track Kms by Type of Right of Way				
	Segregated ROW	Dedicated ROW	Mixed Traffic	Total	% Mixed Traffic
France					
Grenoble	-	20.8	-	20.8	0.0%
IDF	11.4	8.7	0.3	20.4	1.5%
Lyon	-	19.5	-	19.5	0.0%
Montoellier	-	15.2	-	15.2	0.0%
Nantes	-	36.0	0.5	36.5	1.4%
Orleans	-	17.7	-	17.7	0.0%
Rouen	2.2	13.4	-	15.6	0.0%
Strasbourg	1.2	23.9	-	25.1	0.0%
Sub-Total France	14.8	155.2	0.8	170.8	0.5%
	9%	91%	0.5%		
Germany					
Bielefeld	5.0	12.7	9.2	27.0	34.1%
Bochum	32.3	21.5	48.6	102.4	47.5%
Bonn SSB	-	22.8	0.5	23.2	2.2%
Bonn SWB	-	23.0	9.4	32.3	29.1%
Dortmund	20.2	31.7	24.4	76.3	32.0%
Duisburg	14.7	13.1	30.9	58.7	52.6%
Dusseldorf	44.7	35.0	66.0	145.7	45.3%
Essen	6.5	18.3	44.1	68.9	64.0%
Frankfurt/Main	49.2	43.4	24.7	117.3	21.1%
Hanover	71.8	18.6	18.0	108.4	16.6%
Karlsruhe (VBK)	31.0 (34.1)	19.7 (318.8)	12.6 (12.6)	63.3 (365.5)	19.9% (3.4%)
Cologne	32.0	131.0	23.0	186.0	12.4%
Mannheim	45.1	-	14.1	59.2	23.8%
Mulheim	3.4	12.1	23.7	39.2	60.5%
Saarbruchen	5.8	-	-	5.8	0.0%
Stuttgart	62.8	39.2	11.8	113.8	10.4%
Sub-Total Germany	424.5	442.1	361.0	1,227.5	29.4%
	34.6%	36.0%	29.4%		
United Kingdom					
West Midlands	19.0	0.7	0.7	20.4	3.4%
Croydon	24.0	-	4.0	28.0	14.3%
Sheffield	11.6	-	17.4	29.0	60.0%
Manchester	33.0	-	4.0	37.0	10.8%
Tyne and Wear	77.0	-	-	77.0	0.0%
Nottingham	10.6	1.0	2.7	14.3	18.9%
Sub-Total UK	175.2	1.7	28.8	205.7	14.0%
	85%	1%	14%		

Source: South Yorkshire Passenger Transport Executive, 2004 and Association of German Transport Undertakings, 2000

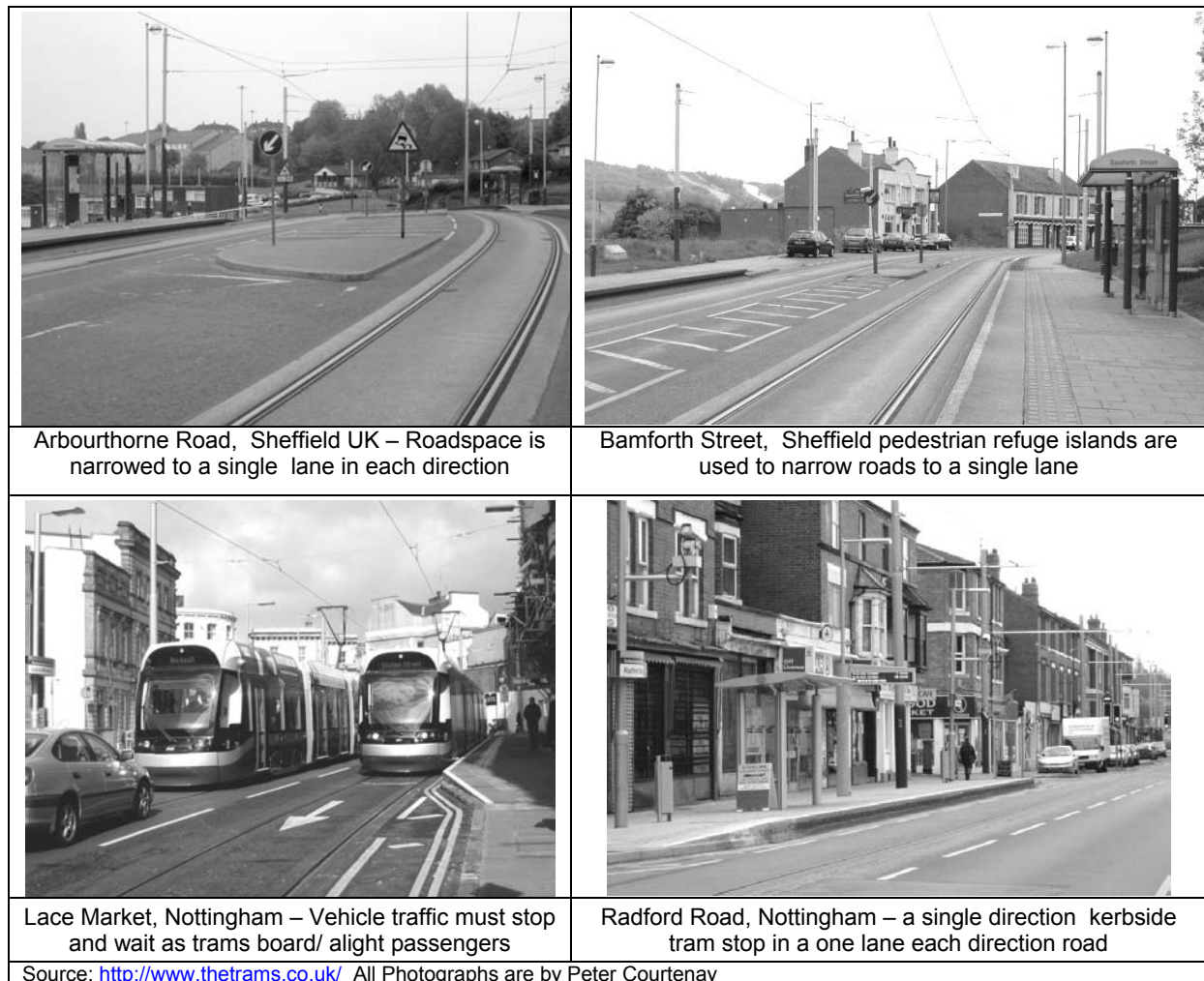


Figure 2 : Examples of UK Tram Stops in Median Mixed Traffic Operations

Safety of passengers accessing stops is a major concern for German light rail systems:

“Experience has shown that passengers who cross roads at or near a stop are exposed to a considerable degree of risk....For this reason safe level crossings, and, more rarely, bridges and underpasses are built for passengers crossing roads and/or rail tracks”

Association of German Transport Undertakings, 2000

While segregated platform arrangements are recommended in German light rail planning it is recognised that this is not always feasible due to space limitations. Kerb extensions (termed ‘cape stops’ in Germany) is recommended by the Association of German Transport Undertakings (2000) who also identify ‘Dynamic Stops’. These are signalised stops where passengers wait at the kerb side. When trams arrive in the median, traffic is halted at the edge of the passenger boarding area by signals. This clears the road for passengers beside the tram. This arrangement is also termed the ‘time island’.

The Association of German Transport Undertakings (2000) also identify an alternative approach where the kerbside traffic lane is raised 15-25 cm above the tram tracks. Passengers wait on the kerb side and cross the raised traffic lane and have level/low boarding height onto the tram. Termed ‘driver over’ stops or “false” stops this arrangement is used in Erfurt, Dresden, Dusseldorf, Halle, Rostock and Vienna (Association of German Transport Undertakings, 2000).

3 Melbourne Conditions

The Melbourne tram and light rail system is one of the largest in the western world. In total there are 31 major routes operated by 474 tram and light rail vehicles (Yarra Trams, 2005). Some 75 of these vehicles are new low floor designs. None have lifts. Some 68% (167kms) of its 245kms (152 miles) route length is operated in mixed traffic conditions all of which is run in the road median (Guyot, 2004). The scale of the mixed traffic median tracks operation in Melbourne is very large by world standards. Melbourne is equivalent to around 6 times larger than in all the cities of the UK combined, 76% of all the operations in all cities in the United States and 46% of all the operations in all cities in Germany.

There are 1,770 tram stops out of which some 1,200 (68%) are 'kerbside stops'. Here passengers wait at the kerb and cross traffic lanes without signal protection for access to and from light rail vehicles in the middle of the road (Guyot, 2004, Booz Allen Hamilton 2003). Figure 3 shows some pictures of this type of arrangement.



Figure 3 : Typical Kerbside Tram and Light Rail Stops in Melbourne, Australia

'Kerbside stops' are an acknowledge problem in the Melbourne tram system. They are a barrier to access for persons with disabilities (Currie et al, 2003) because no platforms are provided. Even with low floor light rail vehicles (see Table 3), the height from the kerb of low floor vehicles is a minimum of 300mm.

Table 3 : Accessibility to Melbourne Tram and Light Rail Vehicles

Tram/ Light Rail Vehicle Type	Number	Step Height from Road (mm)	Additional Steps in Vehicle Entrance
Newer Low Floor Accessible Trams			
C Class - Citadis	36	330	0
D Class - Combino	39	300	0
Older Tram and Light Rail Vehicles			
A Class	70	338	2
B Class	132	338	2
W Class	53	347	2
Z Class	124	334	2

Source: Liaison with Yarra Trams (2005).

'Kerbside stops' have been identified as a major passenger safety concern. They generate pedestrian-road traffic accidents at a rate of 25 p.a. and are thought to result in a far greater number of 'near misses' (Booz Allen Hamilton, 2003). Surveys of passengers perceptions of

safety found that some 20% of passengers consider 'kerbside stops' the most significant safety issue on the Melbourne public transport system (Booz Allen Hamilton, 2003).

Another perspective is the impact which kerbside stops have on the efficient use of the roadspace. During each boarding and alighting all road traffic behind the tram must stop. Traffic simulation has shown this to reduce average tram and traffic speeds by as much as 8-12% compared to roads without kerbside stops (Currie et al, 2004). The same modelling has shown that kerbside stops cause trams to run unreliably. This is because trams running further back in the traffic stream are slowed by the 'delay wave' impacts caused by tail backs of traffic queuing behind trams stopping at kerbside stops (Currie et al, 2004).

Addressing the concerns about kerbside stops is a major priority for Melbourne's tram system. Given the number of stops involved (1,200) and the fact that they cover most of Melbourne's inner urban street network, the scale of the issue is also significant one for urban planning in general. A number of more conventional solutions have been adopted to replace kerbside stops (see Figure 4):

- **'Safety Zone' Stops** - These have been the historically most common solution to median tram stops in mixed traffic in Melbourne. Some 571 stops in the network have this design (Booz Allen Hamilton, 2003). A safety zone is a boarding area located in the road median with railings to protect waiting passengers from the traffic flow. No platforms are provided. Usually at least some signalised pedestrian access is provided.
- **'Super Stops'** - These are high quality station style designs located in the road median including platforms, shelters and real time passenger information. The road is narrowed to a single lane in each direction and pedestrian access is limited to few protected crossing points. Some 15 of these designs have been constructed (Yarra Trams, 2005) most within the CBD. Although the quality of these stops is excellent they are expensive; each costs around \$Aust \$800,000. This design would not be a practical solution for the 1,200 remaining kerbside stops due to high cost. Smaller scale platform stops are also a possible option however this would not solve the safety problem caused by having to cross trafficked roads. Also in many situations it is not possible to fit platforms of a reasonable width into the available roadspace without impacting road capacity and safety.
- **'Kerb Access Stops'** - These are sidewalk 'flareouts' or kerb extensions where the road is thinned to a single lane in each direction. A platform is constructed to aid tram access. Although a cheaper solution compared to Super Stops this design still significantly impacts roadspace and road capacity. Its application is therefore limited.

**Table 4 : Assessment of Alternatives to Kerbside Stops in Mixed Traffic Median
Tram and Light Rail Operations – Melbourne, Australia**

Alternative Design to Kerbside Stops	Cost (\$Aust , 1,000)	Addresses Problems Associated with Kerbside Stops		
		Access for Persons with Disabilities	Passenger Conflicts with Road Traffic	Delays to Trams and Road Traffic
Conventional Approaches				
Safety Zone	NA ¹	No	Some Reduction	Some reduction
Kerb Access Stop	250 - 300	Yes	Yes	No - significantly reduces road capacity where kerb lane used for traffic
Super Stop	800	Yes	Some signed/ controlled access	Some reduction But reduces road capacity
Proposed Design				
Easy Access Stop	135	Yes	Some Reduction	Improves loading / alighting efficiencies Yes but does slow traffic down

Note: ¹New safety zone stops will not be permitted in future because passengers with disabilities cannot use these stops. Hence identifying a cost is not appropriate.

Table 4 shows an assessment of these solutions relative to the problems associated with kerbside stops. None of the options provides a complete solution to all problems. Safety zones are probably the cheapest conventional alternative but they do not address accessibility issues. Kerb access stops are accessible and also address passenger access safety. However they significantly reduce road space where the kerb lane is used for traffic and hence affect both traffic and tram reliability and travel times. Super Stops address access issues but only partly address access safety and roadspace capacity issues. They are also the most expensive to implement. Clearly there is room for development of an alternative design which would be a practical and cost effective solution for the remaining stops in the Melbourne system.



Safety Zone Stop



Super Stop



Kerb Access Stop

Figure 4 : Conventional Improvements to Kerbside Stops – Melbourne, Australia

4 The Innovative Design

A new design termed the 'Easy Access Stop' was developed by the City of Port Phillip in association with VicRoads and Yarra Trams. Figure 5 and Figure 6 show some photos and plans of the design which has been built as a trial project in Danks Street, Middle Park by the City of Port Phillip. Key design elements are:

- A kerbside shelter and stop where passengers wait for trams to arrive
- A speed hump (or speed cushion) which lies in the road traffic lanes but not the median lanes where trams operate.
- Introduction of a full time tram 'fairway' system (where road traffic is excluded from tram tracks) for a 650m section of the street.
- The speed hump acts as the walk platform for passenger access to/from trams. The height of 290mm is designed to enable near level boarding with low floor trams.
- Flexible bollards are placed at intervals along the platform edge to guide traffic and warn pedestrians of the platform edge.
- 'Separation kerbing' with intermittently placed flexible bollards delineate the traffic lane edge on the approach to platform to warn traffic of the hazard.
- Merge signage and painted road chevron line marking are provided for 20 metres on the tram right of way to encourage traffic to merge into the kerbside lane.
- Kerb side parking is prohibited for the length of the platform and ramp.
- Public lighting has been improved in the area of the tram stop.

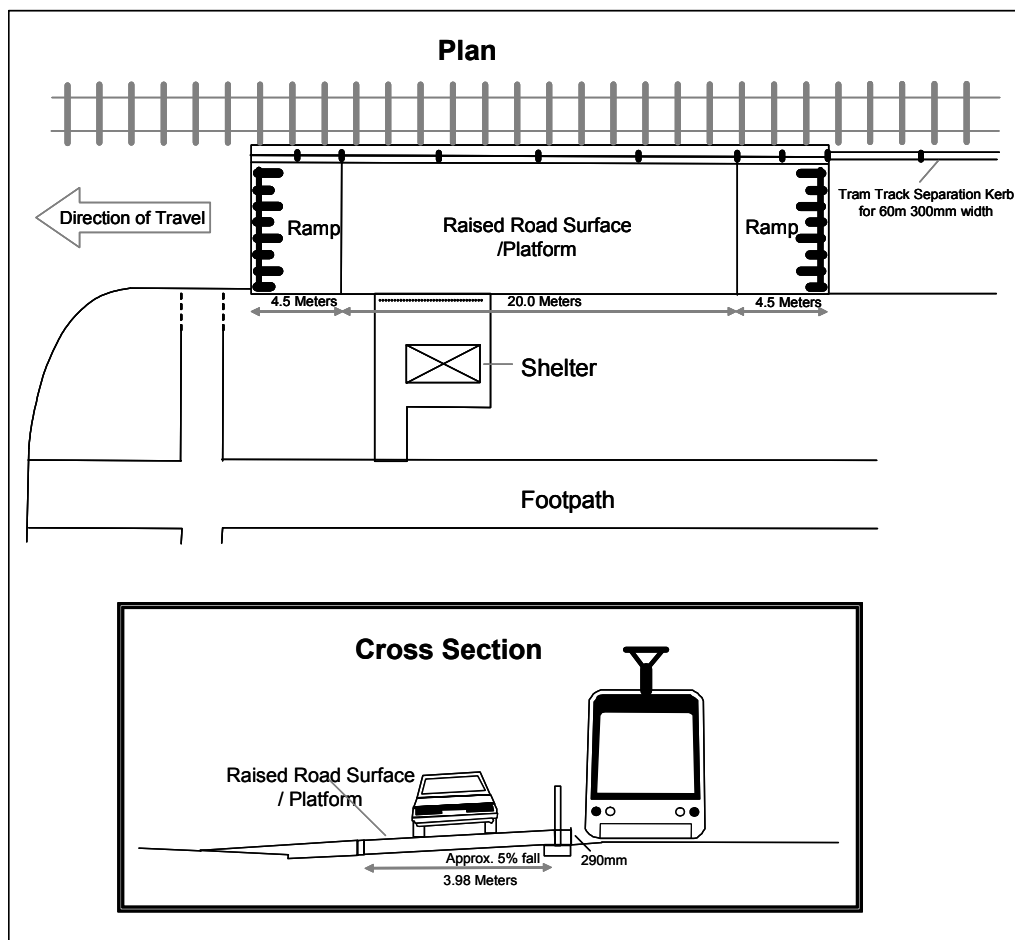


Figure 5 : Schematic Layout of the Easy Access Stop



Kerbside stop, speed hump, tram only right of way and traffic barriers to deter traffic and pedestrian access at the edge of the 'platform' area. The stop for the other direction of travel is at the right of this photo. The stops are 'staggered' by direction with one at either side of an unsignalled intersection.



Access to vehicle is across the 'platform' and enables stop free entry onto the vehicle. This shows access to B class tram. Traffic is waiting at the start of the ramp for passengers to clear.

Figure 6 : Easy Access Stop Design, Danks Street, Melbourne

The design is very similar to the 'driver over' or 'false' stops identified by The Association of German Transport Undertakings (2000). The treatment was primarily developed to address significant speed concerns along this local road. A 650m section of Danks Street was considered a 'speed haven' perpetuated by a straight road alignment, wide road reserve, minimal side friction, wide footpath / nature strip and minimal vegetation which supported a safe speeding psychology for motorists. Various traffic management devices were considered to moderate speed. The 'Easy Access Stop' was recommended for the site

because speed reductions would be achieved as well as 'value adding' the site by providing improvements to tram patron safety and tram performance.

The primary benefits of the treatment were:

- Reduces vehicles speeds on the approach to, and through the treatment, enhancing patron safety while boarding and alighting a tram
- Improves motorists perceptions of priority to pedestrians. Vehicles are elevated to the footpath level, rather than pedestrians 'stepping down' to road level
- Raise the profile of public transport by providing a permanent positive solution
- Provides high quality physical infrastructure, proving public transport is valued by the community
- Reduces patron loading and unloading times.

5 Impacts and Performance

An assessment of the performance of the design is provided in Table 4. The design is not as effective as a Kerb Access Stop at reducing passenger access safety concerns however it is as effective as a Super Stop in this regard and equals the Super Stops performance in terms of accessibility and impacts on traffic delays. It is much more cost effective than the conventional approaches; it is 20% the cost of a Super Stop and 50% the cost of a Kerb Access Stop.

In monitoring the performance of the stop the City of Port Phillip have found that:

- Traffic volumes have remained unchanged after implementation of the treatment. The 24 hour traffic volume has increased from 3,100 vehicles per day (vpd, City of Port Phillip , 2001) to 3,450 vpd in 2005. This increase equates to 2.8% pa and is consistent with normal annual average traffic growth in the City of Port Phillip.
- Traffic speeds have reduced significantly. The 85th percentile speed at the mid-block of the treatment location has reduced from 65 – 68km/h to 48 – 57 km/h in the south and northbound direction respectively.
- Passenger perceptions of the stop have been overwhelmingly positive. Correspondence is regularly received by Yarra Trams and the City of Port Phillip noting the added convenience, safety and profile the treatment provides. Observations have suggested tram patrons are more confident with stepping out onto the platform and 'claiming their space' as the tram approaches. It is assumed patrons feel comfortable with this behaviour noting approach vehicle speeds are significantly reduced.
- There are two types of regular complaints received. All are from residents near the stop not tram users:
 - The first relates to the approach to the platform (the 60m of separation kerbing and bollards). Residents have indicated that the task of on-street parking is less safe, given the reduced opportunity for approaching vehicles to 'steer a wide berth' around an opened car door.
 - The second, also from immediately located residents, relates to inappropriate speeds by motorists traversing the platform and ramp area resulting in vehicles 'bottoming out' at the base of the departure side ramp creating safety and noise concerns.
- There have been no reported casualty accidents at or near the easy access stop since implemented (the stop has been operational for 12 months at time of writing). There is also no evidence of property damage accidents. Concerns regarding the possibility of vehicles falling off the platform onto the tram tracks, or straddling the platform / tram track area have proved unfounded at this time.
- Maintenance of the treatment is worth noting. Two aspects, vegetation and bollards have required regular maintenance. The impact absorbing bollards on the approach to the platform area are frequently struck requiring some attention and sometimes replacement.

- Occasionally, vehicles drive in the tram reservation area. The impact of these infrequent incidences has proved negligible in terms of tram performance, safety and confusion for other road users and impact on residential amenity.

The only negative concern of any significance has been the need to reduce parking adjacent to the stop. There were also concerns that vehicle access to adjacent residential properties might be constrained by the stop however the design maintained access in all cases.

6 Conclusions

This paper has reviewed the issue of stop provision on tram and light rail systems which operate in mixed traffic and median track conditions. Melbourne, Australia has one of the worlds largest tram networks with these circumstances. Providing safe and accessible tram stops is problematic. Most existing stops are sub-optimal kerbside designs which generate safety concerns, reduce road capacity and are not accessible. Conventional design solutions are also sub-optimal due to cost and continuing road capacity and feasibility considerations. A new design termed the 'Easy Access Stop' was developed which addresses much of the design requirements for a safer and accessible stop with less impact on road space capacity. Performance to date has been very good.

Although the 'Easy Access Stop' is an improvement over conventional designs it is not an answer to all situations. If implemented to replace each of Melbourne's 1,200 kerbside stops it would generate considerable road capacity restrictions on some of Melbourne's busiest inner urban streets. The stop is best suited to circumstances where road capacity is uncongested and speed is a concern. The ramp gradient could be adapted to a major arterial design to reduce vertical deflection of vehicles passing over the ramp.

The Danks Street, Middle Park 'Easy Access Stop' has now been operating for 12 months. The informal evaluation, including discussions with many stakeholders has deemed the trial application a success. The City of Port Phillip is currently designing the second application of this treatment in a similar operating environment. Installation is expected in 2006.

For the rest of the Melbourne network, the search for a viable solution to replace kerbside stops continues.

7 Acknowledgement

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