Author: Andrew Somers
Affiliation: Institute of Transport Studies
Monash University
Contact: andrew.somers@eudoramail.com
Mobile: 0429990004

IMPROVING UTILISATION OF EXISTING PUBLIC TRANSPORT INFRASTRUCTURE BY ALLOWING BUS ACCESS TO TRAM RIGHTS-OF-WAY

Abstract

Allocation of limited road space to competing user groups such as motorists, freight operators and public transport represents a growing challenge for transport engineers. This paper investigates one aspect of this, allowing buses to access tram rights of way. Despite the narrow field examined, the results of this investigation have relevance across a wider range of situations involving access to the same road-space by two user categories.

The investigation searched for examples of shared operations both within Australia and internationally. This was followed by extensive consultation with a wide range of stakeholders and visits to a number of sites to examine specific issues. A number of key areas of consideration were found and examined:

- The need to have infrastructure that is compatible for shared use, with consideration given to shared use in the design stage to avoid future costs,
- The requirement for an operating regime that allows for shared use and the potential form of this regime, and
- The importance of the institutional framework to achieving agreement between government and bus and tram operators. This extends also to achieving union agreement to proposals.

Bus operators were the proponents for this investigation; their aim is unsurprisingly, for more reliable and faster bus operations. Shared use was found to be one tool for delivering this, and certain examples were found to also have potential benefit to trams and other road users. The findings and the process of this investigation are relevant to a number of shared use situations specifically and to transit priority broadly.

1.0 Introduction

This paper investigates bus access to tram rights of way (also referred to as joint operations). It examines the benefits, disadvantages and issues with joint operations, aiming to define the questions as much as to answer them. Three key themes in transport engineering act as drivers for this report:

- Integrated Transport
- Increased Public Transport Ridership
- Road Space Allocation

The first two of these themes are key policy objectives of the Bracks Government in Victoria, amongst others; the third is a growing area of transport research.

The method of investigation adopted for this paper is intended to give the outcomes greater general applicability, not only to different specific implementations of bus and light rail joint operations, but to conflicting road space allocation situations, particularly where a variety of institutions are involved.

Three distinct processes were followed in collecting and analysing the data and information used in producing the report (Somers, 2003) on which this paper is based:

- Review of previous findings and research
- Consulting stakeholders through interviews
- Examination of issues through case examples

Although the case examples have been drawn upon in developing the findings, due to space limitations they have not been included in this paper.

2.0 International Examples of Shared Use

A literature review of international examples of shared use between light rail vehicles and trams was conducted as the initial stage of the investigation. It was hoped that relevant experience would be found which could highlight pertinent issues for further examination in the context of Melbourne.

A number of public transport systems currently feature shared use, for instance Amsterdam, Ghent (Belgium) and the Croydon tram in London, however few details could be located regarding these. The literature available concerned proposals for shared use that have not yet been implemented, for conversion of busways to light rail operations in both Seattle and Brisbane. The studies conducted as part of these proposals provide useful insights into some of the relevant issues. In addition to these busway projects, pertinent literature was found on operational issues for joint use and on transit signal priority.

2.1 Seattle Transit Tunnel

The Seattle Transit Tunnel was constructed in the late 1980s for bus use in the short to medium term. The longer term intention was to convert the tunnel for light rail and tracks were embedded in the tunnel floor to provide for this. The tunnel is currently served by dual powered buses, which use diesel engines for street running and trolley poles and electric motors for the underground section.

Niles, Nelson and MacIsaac (2001) proclaimed the tunnel a success since it reduced bus travel times and increased patronage. The King County Council propose to convert the tunnel to dual LRT/bus operation, which would involve track relaying to ensure that disability access requirements are met. A consultant's report (SoundTransit and King

County, 2001) highlighted additional costs and safety concerns in the confined tunnel space compared to bus only operation. Issues of crash compatibility of the buses and LRT vehicles were raised, especially due to the difference in mass. It is important to note when considering crash compatibility that the LRT vehicles proposed are larger than those operating in Melbourne. Niles et al (2001) modelled bus only, LRT only and joint operations and found that in order to maintain safety, combined operations required compromises in operations characteristics, reducing allowable frequencies and capacity. SoundTransit and King County (2001) found that there would be delays to both LRT vehicles and buses compared to their respective exclusive operations. In the simulations, the LRT vehicles were given absolute priority, but had their operating characteristics reduced to match those of the buses.

SoundTransit and King County (2001) detail that the tunnel control would be through signalling similar to that used for railways (trams in Melbourne use largely visual safeworking on exclusive rights of way). LRT vehicles would be detected through track circuits, buses through transponders. Due to LRT vehicles having priority, at merge locations special signals would indicate to buses to wait for an approaching LRT vehicle. The report proposed that all vehicles would use the same platforms (at 350mm height). In stations, buses would have the ability to overtake LRT vehicles stopped in stations through a central passing lane.

2.2 Brisbane Busway

Mathews and Asche (2000) conducted a study into the design of the Brisbane busway system, detailing the design changes necessary to allow for future combined operations or exclusive use by LRT vehicles. A number of infrastructure design issues were identified in their investigation, largely relating to different design geometry requirements for buses and LRT vehicles. By highlighting the differences in the design phase, Matthews and Asche (2000) were able to propose solutions that took into account the requirements for both bus and LRT operation, with only minor modifications to the original proposal.

In addition to the infrastructure design issues, Matthews and Asche (2000) examined operational considerations and found a number of areas relating to the performance and sight-lines which needed to be addressed. Furthermore, the detection and vehicle monitoring systems were required to allow for both types of vehicles, which also depended on coordination between the relevant transport operators.

2.3 Literature on Operational Considerations

Research by Khan (1993) found economic benefits in operating buses in reserved lanes in Ottawa-Carleton, due to reduced travel time and increased reliability of schedule times. Fernandez (2000) found the ability for buses to overtake other buses (stationary) on a busway was a significant factor in increasing busway capacity to similar levels as LRT. Prohibiting vehicles from passing, as is likely for joint bus and LRT operations, significantly reduced capacity and increased travel times. This concurs with the research by Niles et al (2001) and SoundTransit and King County (2001) with regard to proposed operations for the Seattle Transit Tunnel.

Walter (1992) detailed the importance of ease of transfer between LRT and bus operations in the context of bus feeders to LRT mainlines. A key finding was that joint platforms, such as would be achieved through having common bus and tram stops, were an optimal approach from a transfer perspective.

2.4 Literature on Transit Signal Priority

Transit Signal Priority was not considered in the initial stage of the literature review, but was incorporated later due to being a recurring topic in the consultation stage of the investigation. Many of the suggestions for implementation of joint operation suggested by stakeholders of buses and trams focussed on providing a queue jump facility.

ITS America (2002) found that in the studied cases of public transport signal priority in Europe, travel-time savings of 6-42% had been achieved for the public transport vehicle. These savings came at the expense of a minimal (<3%) increase in travel time for cars. Signal priority implementations were found, through economic evaluation, to pay back the implementation costs in well under ten years (less than three years for some cases). Public transport priority was found to perform best when transport system capacity was examined in terms of person rather than vehicle movements.

3.0 Melbourne Context

Since the research has been conducted in Melbourne this paper focuses on that city, and examines the effects of introduction of bus operations in addition to the existing light rail services, as opposed to the introduction of light rail vehicles onto a busway. Many of the points made remain valid for the opposite direction, with a slightly different focus. The words tram and light-rail are used interchangeably here as there is little distinction in their everyday usage.

Melbourne has the fourth largest tram system in the world with over 250 track kilometres, with possibly the greatest length of on-street running in mixed traffic in the world. The tram system has a variety of forms, including converted cable tram and railway routes, mixed in with recent extensions. The tram fleet includes wooden vehicles from the middle of the 20th century and brand new articulated fully low floor vehicles, with a range of models in between. A large part of the city is built around a grid pattern of arterials; the tram network runs along most key arterials in the grid in some inner suburbs and the CBD. This urban structure provides for the tram system to operate as local services as well as trunk services (the tram routes are all considered part of the principle public transport network).

In addition to its unique tram system, Melbourne’s institutional framework for public transport is complicated and currently undergoing change. The relationships between the various entities impact significantly upon joint operations, particularly with regard to what the different operators deem acceptable.

Exclusive tram rights of way are relatively limited in Melbourne for the size of the system. The tram operators, in particular Yarra Trams, are advocating an increase. Their reasons are similar to those of the bus operators who want access to tram rights of way – improve travel times and reliability of those times.

4.0 Rationale for Joint Operations

In examining the feasibility of joint operations and the issues involved, it is important to first determine what benefits might accrue from joint operations to support their introduction. These benefits can be grouped in to three categories:

(1) Win-win solutions that benefit both bus and tram (although with potential disbenefits for other road users)

(2) Solutions that provide benefits to buses at no disadvantage to trams

(3) Solutions that provide net benefits but at a cost to trams

Category one solutions are likely to be welcomed by all parties, depending on the costs involved; similarly category two solutions may be welcomed by bus operators and overall transport authorities with minimal resistance from tram operators. Category three benefits are cause for debate, as tram operators may need to be compensated by bus operators in order to offset any disadvantage. How solutions falling in these three categories are viewed depends heavily on the institutional framework – whether it is fragmented or allows more of an overall system approach.

All stakeholders identified improvements in bus travel times and the reliability of those times as a key benefit. These improvements come through allowing buses to bypass congestion. Even at restricted operating speeds on tram tracks, bus times can often be improved compared to the mixed traffic lanes. In addition, the variation in travel times falls for the bus as it is subject to fewer external influences when in the tram lanes. In some situations, using tram lanes all day would increase off-peak travel times, however the reduction in peak travel times is likely to outweigh this.

Improving travel time and reliability provides flow on benefits:

- A strong likelihood of increased patronage,
- The ability to use the same number of buses to offer an increased frequency, further benefiting patronage,
- Lower operating costs to provide the same frequency as previously,
- Improving reliability, aiding transfers to other routes or modes, and
- A reduction in the passengers' perception of delays.

Delays to buses (and trams) occur not only in service, but also in positioning vehicles for service. Solutions that make inroads on these out of service delays also allow a more frequent service to be provided using the same number of vehicles.

An examination of patronage figures on the Eastern Freeway bus services run by National Bus in Melbourne illustrate the importance of travel time savings achieved through reserved lanes. In the morning peak, inbound services use a bus lane for much of the inner-city part of the routes. This allows a bus to beat a car from the Eastern Freeway into the city by 17 minutes (National Bus, 2003). There are no bus lanes for the outbound runs in the evening peak – which has patronage 15% lower. Even allowing for some dispersion of passengers, much of the difference would appear to arise from the increased travel times. Commuters have made an effort to shape their travel patterns around the congestion experienced by the buses in the evening peak.

Figure 1: Superstop showing raised platform and passenger infrastructure

Using common stops for buses and trams also offers benefits. Providing a common location makes it easier for passengers (particularly infrequent users) and requires less infrastructure overall. Combining stops allows expensive implementations such as Superstops (see Figure 1) to serve more people for the same outlay. The greater number of passengers waiting at the stops should also increase the feeling of security. At interchange points, co-locating stops allows for easier transfers, a feature that is of high importance for service. The co-location of stops also provides for a common identity for the public transport system as a whole, aiding the perception of integration.

There are a number of ways of achieving win-win solutions, affording benefits to both buses and trams. A key to achieving this is to use joint operations as a driver for improvements. Three examples of this are:

- Signal priority alterations at an intersection benefiting both buses and trams (undertaken as part of the introduction of joint operations)
- Infrastructure improvements for trams (eg. upgraded track) as part of changes to permit joint operations
- Creation of new tram lanes or enforcement of existing tram lanes as part of introducing joint operations

These examples do not consider the financial cost of the solution nor the impact upon other road users – these should be taken into account as part of the evaluation of specific implementations.

The costs associated with congestion are increasingly becoming an issue in transport engineering. Benefits that joint operation can offer to the efficient operation of the transport system as a whole will therefore be of increased importance. The benefits of public transport solutions are often increased by considering congestion and capacity in terms of person rather than vehicle movements.

5.0 Issues to be Addressed

The review of previous findings and research identified three categories of issues associated with joint operations – infrastructure related, operational regimes and the relationships of the institutions involved. Individual issues were then identified and examined through a series of face-to-face interviews with stakeholder groups. The stakeholders interviewed represented government (VicRoads and Victorian Department of Infrastructure), transport operators (Yarra Trams, National Bus, Bus Association of Victoria) and the lead transport advocacy group in Victoria, the RACV. The participation of these stakeholders in the interview process is much appreciated.

5.1 Infrastructure Issues

Vertical and horizontal clearances were found to be a key question when considering the suitability of infrastructure for joint operations. These clearances relate to the dynamic envelopes for the vehicles, particularly when turning. Vertical clearances for single deck buses are not perceived to be a problem in Melbourne, given the experience of buses running under the existing tram overhead power supply.

5.1.1 Track Bed

Tram tracks in Melbourne can be broken into three categories – part of the road pavement, separate ROW with tracks laid in mass concrete, separate ROW with tracks mounted on sleepers on ballast. The first two of these categories can support bus operations, ballasted track requires relaying in mass concrete at significant cost, which can be mitigated if done as part of a track renewal cycle.

5.1.2 Overhead Power Poles

Experience on Burwood Highway (DOI, 2003) has shown that unprotected central poles pose a hazard for buses. This setup is found on much of the reserved track in Melbourne. The issue is one of horizontal clearances - although the trams are slightly wider (around 150mm) than buses, they have the advantage of a fixed guidance system.

The cost of relocating poles is significant and therefore counts as a factor against implementations where this would be required. The collision risk is anticipated to be lower at lower speeds and on straight sections of track; curved track at higher speeds would therefore require further increased clearances. Additional space may be able to be provided by widening the pavement to the left, avoiding the need to relocate poles.

There are guidance technologies available for buses that could lessen the risk of using sections with central poles. These take the form of both physical guidance systems (as seen in Adelaide's O-Bahn) and electronics based systems (sometimes called wire or optical guidance depending on the technology). An alternative is a collision protection system, provided by central barrier kerbing (potentially with additional barriers) to prevent the buses from straying off course – this kerb may however pose a hazard in itself.

5.1.3 Stop Design

Two issues emerge with the design of existing tram stops – horizontal clearances and the platform height at the new Disability Discrimination Act (DDA) compliant superstops. Experience from bus operators indicates that the high level of the platforms (around 300mm compared to standard 150mm kerb) causes problems as the buses are designed to load wheelchairs from standard height kerb (through kneeling). A simple solution is already under consideration by the Department of Infrastructure and supported by bus operators. It provides for a short extension to the area of platform at the stop at standard kerb height, to accommodate the front door only of the bus.

Horizontal clearances also pose a potential problem for buses using existing tram stops. Although buses are marginally narrower than the trams in use in Melbourne, manual guidance by drivers is not as precise as track guidance for trams. The issue is not only of physical clearances, but also of the perceptions of passengers waiting at the stops. Low speed operation of buses through stop areas should mitigate any clearance issues (both physical and perceived) without being a significant impost, as many buses would be stopping anyway.

5.1.4 Maintenance Agreements

Introducing buses to existing light rail infrastructure changes the maintenance requirements for that infrastructure. The institutional framework and particularly the system of payments to public transport operators in Melbourne complicates this, by emphasising the importance of determining who is responsible for cost of maintenance or repairs, both scheduled and emergency.

5.1.5 Entry/Egress to/from ROW

Buses using tram lanes need to be able to enter and exit the area safely and without significant delay. In addition, it is important that the entry point reinforces that only authorised vehicles may use the tram ROW. Entry and exit points for the joint operations section of the ROW can be located either mid-block or at intersections.

Where the tram ROW is used as a queue jump facility, the exit point for buses will frequently be through the intersection – either as a straight movement back onto the shared traffic lanes or as a turn onto a different road. In most cases, a special signal phase will need to be provided for the bus to safely complete this manoeuvre, whilst also having the potential to provide priority. Entry to the tram ROW at intersections is a similar situation to exits at these points. A special signal phase may be required, not only to allow the bus to execute the manoeuvre safely, but to prevent other vehicles from following. To realise the benefit of a special phase, an exclusive use lane may need to be provided for the bus on the approach. Depending on the intersection layout, provision of an exclusive lane may remove the need for a special phase.

For exits positioned mid-block, the bus will need to be able to re-enter mixed traffic both safely and without significant delay, otherwise the benefits of the joint operation section are reduced. Mid-block entries must set back sufficient distance from the intersection to allow the bus to bypass the congestion and provide a queue jump advantage. The entry must also be designed to provide sufficient sight distance for the bus to avoid entering the ROW too close in front of an approaching tram. Both entry and exit points need to be coordinated with stop locations to allow the bus to safely cross the traffic lanes in the intervening distance.

5.1.6 Delineation

A recurrent issue in the stakeholder interviews was a feeling that car drivers view buses as a part of mixed traffic – this makes delineation of tram lanes critical for any application of joint operations. Cars mistakenly or deliberately following buses into tram lanes will lead to delays to public transport and an increased risk of collisions.

There was agreement from the interviewed stakeholders that the low level of delineation provided for Melbourne's fairway system has led to increased numbers of drivers disobeying the provisions and entering the reserved lanes, either accidentally or deliberately. This adds to the public perception of buses as normal traffic and creates a need for a high level of linemarking (such as coloured pavements) or physical separation.

Physical separation offers a clear barrier to car drivers to an extent unachievable with linemarking. Physical barriers also prevent cars from turning across tram lanes, bringing safety benefits, although creating a loss of mobility for other traffic. Both raised track and a separation strip (which was found in consultation to pose a tripping hazard) are used in Melbourne. Raised track is more expensive to construct, but there is potential to incorporate this as part of a renewal of infrastructure. Alternative approaches include the use of rubber posts, as used for bus lanes in Perth.

It is important to recognise that there is an occasional need for other vehicles to use the tram ROW for short periods to avoid obstacles. This is permitted in the road rules and is particularly relevant in areas where the roadway is narrower or double parking is more common, for instance in the CBD. Raised track with mountable kerbs would not prohibit such use, but would impose greater barriers than simple linemarking.

5.1.7 Guidance for Buses

The provision of a guidance system for buses would overcome many of the clearance issues discussed in this section and may allow for higher speed operations on shared sections. The cost of implementing such a system restricts it to consideration as a longer-term solution. The technology of electronic guidance systems is developing further and appears to offer a strong alternative to more traditional physical guidance systems. In a stakeholder interview, Steve O'Callaghan of National Bus indicated that bus operators would be reluctant to pay for such a system, but would be receptive to approaches by government.

5.1.8 Interchanges

Bus/tram interchanges are an area that offers a potential win-win outcome for operators. The Victorian Department of Infrastructure believes that providing convenient transfers leads to increased passenger numbers, supported by Walter (1992). In addition, they have found that good interchanges allow passengers to create travel patterns beyond the imagination of transport planners.

Two well-developed bus/tram interchanges with significant infrastructure were found during the development of this report – one in Moonee Ponds and one in Queens Parade in Clifton Hill. No patronage figures are available at these locations, however National Bus indicated that 10% of their morning commuters on Victoria Parade (equivalent to 1200 passengers) transfer to tram services at the St Vincents Plaza tram interchange, where there is no formal interchange and minimal bus facilities at this location. Clearly, whilst bus/tram interchanges are not as widely examined as those for bus/rail, it is important to give them due consideration.

The literature on transfer points, eg Walter (1992), stresses the importance of minimising walking distances at the interchange and of coordinating services to minimise out of vehicle waiting times. Shared stops offer the ability to achieve a zero walking distance solution. They also offer opportunities for shared shelters and shared information systems – leading to a clear linkage between services for the passengers. Care needs to be taken to prevent delays on routes with a high volume of public transport vehicles.

5.2 Operational Issues

5.2.1 Operating Rules

For sites where joint operations are to be implemented, it is necessary to develop a set of operating rules to ensure that the joint operations area functions safely and efficiently. The existing joint operations site on Queensbridge Street in Southbank provides an example of operating rules:

- Buses are not to exceed 30km/h
- Trams have priority over buses
- Buses must not exceed 8km/h through safety zones (stop areas)
- Buses may use the signal phase provided by the T light (also provided for in the road rules)

There are also rules which detail safe following distances, interestingly the bus operator did not have these to hand, indicating perhaps that this operating regime was necessary to have joint operations approved and is not so important in day to day operations. The speed limit for buses of 30km/h is practical over short distances, especially where the tram lane serves as a queue jump facility. At such sites, even at low speeds, bus travel times are reduced. For longer shared use sections, a higher speed limit might be appropriate, however the key is to match bus and tram operating characteristics – modelling for the Seattle Transit Tunnel (Niles, Nelson and MacIsaac, 2001) found this to provide the best capacity and safety outcomes. Bus operators have indicated a willingness to accept tram priority as a part of joint operations.

5.2.2 Crash Compatibility

This paper does not make a detailed examination of crash compatibility of buses and trams. It is mentioned here as it is an important issue raised by many of the stakeholders in the interviews.

The difference in mass between buses and trams has been an area of concern in foreign joint operation proposals (for instance the Seattle Transit Tunnel). The trams used in Melbourne are generally smaller and lighter than those found overseas, although larger light rail vehicles are currently being introduced in small numbers.

Introducing buses into what are now currently exclusive tram lanes increases the number of potential conflicts and hence the probability of collisions. Balancing this is the likelihood of reduced conflicts for the buses that are no longer operating in a mixed traffic environment. Due to the level of mixed traffic operations for trams in Melbourne, trams currently operate in environments featuring buses, as well as trucks, cars, bicycles and pedestrians. It is likely that any joint operations regime for buses and trams would prove safer than mixed traffic operations – hence the impact on the safety of the overall system would be minimal.

5.2.3 Signal Priority and Special Phases

Intersections generally form the critical points in the road-based transport network in Melbourne (Daly, Interview 2003). For this reason, it is difficult to look at road-based public transport improvements without dealing with the area of signals and particularly signal priority. Interviews with stakeholders from the bus industry indicated that one of the key outcomes they were seeking from joint operations was access to certain queue jump measures – indeed signal priority measures alone had the potential to deliver the improvements they were seeking from joint operations.

In implementations of joint operations there is a need for the signal control system to recognise multiple vehicles at one time, potentially of different types and requiring different movements. This would allow trams to get a higher level of priority (which would also be afforded to buses which were delaying trams). Bus operators indicated that they were prepared to receive a lesser level of priority than trams, as it would still be an improvement on their current situation. This would mitigate the impacts on other road-users while providing a high level of public transport priority. Signal control systems are increasing in functionality (for instance upgrades to the SCATS system used in Melbourne), allowing for more innovative and adaptive transit signal priority solutions.

Signal priority can be either absolute or conditional. In conditional priority, priority or a higher level of priority than standard is granted to late running vehicles. The intention of this is to increase the reliability of travel times, reducing the need for a schedule that incorporates waits at time points. This approach is not always favoured by the operators, who want to see signal priority used to improve travel times for buses in addition to reliability of times. Conditional priority is currently used in Melbourne on the SmartBus project. Feedback from this project indicates the importance of providing adequate lengths to queue jump facilities to allow public transport vehicles to bypass the congested area. Without sufficient length, the advantages of queue jump and signal priority implementations are significantly reduced.

Providing exclusive signal phases to public transport necessarily comes at the cost of signal time for other road users. If an intersection is not at capacity, then the effect of this loss of signal time can be minimal. Given that signal priority and queue jump measures are most relevant when intersections are operating at or near capacity, the effects on other road users of public transport priority must be evaluated. The general benefits of transit signal priority (ITS America, 2002) have already been dealt with in Section 2.4.

5.2.4 Coordination of Control and Monitoring Systems

An issue identified in the stakeholder interviews was a need for coordination in the fleet control and monitoring systems for buses and trams in order to achieve optimal joint operation. One reason behind the need for coordinated control and monitoring systems is to allow effective responses to difficulties in the network. For instance, if a tram is broken down on a shared section of track, the bus operators need to know this so that buses can be routed around the problem. When an incident of any nature occurs on a shared system, there is a need for efficient and effective information flow to allow a coordinated response, and in this case the dissemination of information to drivers and passengers of both modes.

A further need for this coordination is due to the current institutional and contract framework for public transport in Victoria, which places great emphasis on on-time running for calculation of performance payments or penalties. This emphasis leads to concern by tram operators that in joint operations, buses may delay trams, leading to financial penalties to the tram operators. The Department of Infrastructure expressed a need to be able to account for delays to trams as a result of buses so that performance payments could be calculated appropriately – similarly for delays to buses caused by trams. The issue of not only how to track the cause of delays, but the financial effect of the attribution of a delay would need to be resolved before the commencement of joint operations.

5.3 Institutional Issues

5.3.1 Institutional Framework

The institutional framework for public transport in Melbourne is complicated and multilayered. A government body (Department of Infrastructure) has responsibility for both the long term planning of the system and administration of the operating contracts. Private operating companies are contracted to operate the system and have control over both vehicles and infrastructure (for trams). A separate government body (VicRoads) is responsible for the road traffic system, which incorporates elements of tram infrastructure including the detectors for signals. The payments for private operators are based on contractual agreements, but include a share of centrally collected fare revenue and performance payments for on-time running.

When examining a proposal such as joint operations, there is a need to deal with many parties and the contract-based relationship between parties makes aspects not covered explicitly in those contracts difficult to implement. The current contractual framework also appears to encourage operators to pursue their own financial concerns at the cost of the big picture approach. For instance, joint operations have the ability to lead to net benefits for public transport at the cost of some disadvantage to trams. Under the current framework, tram operators would be hurt financially by this change, leading to apprehension about joint operations.

Traditionally the attitude of those involved in public transport in Melbourne has been to view the modes as separate, with buses and trams being potential competitors. This is being partly addressed through attention being focussed on integrated transport solutions, however the contractual framework and institutional structures act as a brake on this attitude change.

Unions have a significant impact on public transport operations and have affected the outcome of previously considered proposals for joint operations. Any proposal should seek union input at an early stage to produce a constructive and mutually agreed outcome. A number of attempts were made to include both the Rail Tram and Bus Union and the Transport Workers Union in the consultation process, however no response was received from either organisation.

5.3.2 Planning

Many of the infrastructure issues and some of the operational issues identified in this report can be eliminated through planning that takes into account the potential for joint operations. This is important as modification of infrastructure after construction often proves far more expensive than changes incorporated during the design phase.

In Melbourne, examining the implications of bus operation on existing tram rights of way reveals many issues similar to those identified in Brisbane. As stated above, addressing these issues at design stage is likely to be the most cost-effective approach. There is a need to design tram infrastructure to allow for flexibility in future operations. Even where no buses operate in the area, tram design needs to take bus compatibility into account. All tram routes are subject to occasional tram replacement, and bus routes change over time, hence a future need may arise.

A recent example of a failure to take account of buses in tram infrastructure design is the Exhibition Street extension. The DOI noted that during the construction phase, the rerouting of Bus 605 down the tram right of way was investigated and found unfeasible due to incompatible infrastructure.

In addition to infrastructure design, tram and bus vehicle design must recognise the need to operate safely in a variety of situations. Mixed traffic is likely to be the critical design case. This report is unable to assess current crash compatibilities, however indications from stakeholders suggest that the situation is suboptimal.

DOI have indicated that in their longer range planning joint operations have the potential to become part of the focus on integrated transport solutions. As part of this, they envisage adding bus friendly designs to the standard toolkit used for tram infrastructure projects. Infrastructure design should be considered bus friendly if it allows for joint operations with a minimum of change. No change should be required after construction that necessitates service relocations or other high cost procedures. Whilst ideally infrastructure would allow bus operation without any change, this may not be possible unless a specific proposal is available at the time of design.

5.3.3 Road Rules

Provision need to be made in the road rules to allow joint operations of trams and buses whilst protecting against unauthorised use of reserved lanes or special transit signal phases. The Victorian road rules generally provide for this, with minor inconsistency relating to bus operations through safety zones (at tram stops).

6.0 Conclusion and Transferability of Findings

This report has found that a significant number of aspects need to be considered for joint operations:

- Horizontal and vertical clearance requirements,
- The suitability of the tram track bed for bus operations,
- The siting and protection of tram overhead power poles to allow safe bus operations,
- The design of shared stops,
- Maintenance agreements between operators,
- The design of entries and exits to tram lanes for buses,
- Delineation of tram lanes,
- Positioning or guidance systems for buses,
- Bus/tram interchanges,
- Operating rules,
- Crash compatibility of buses and trams,
- Signal priority and signal phases,
- Coordination of control and monitoring systems,
- The institutional framework,
- Implications on public transport planning and transport planning generally, and
- Potential changes to the road rules.

The length of the list above might lead some to confine joint operations to the too-hard basket. This would be a mistake, as the potential benefits of joint operations warrant perseverance. All the items in the list above can be addressed to provide good outcomes.

The number of issues in the list above is not the only challenge for advocates of joint operations. Recent candidates for joint operations have been rejected. Proposals for joint operations as part of both the Box Hill and Vermont South tram extensions were floated but not pursued. There is also a fear from the tram operators that buses are the thin end of the wedge, with taxis and commercial vehicles to follow with gaining access to what are currently exclusively tram reserved lanes. On the flip side of this, there is potential for an extended network of high productivity vehicle reserved lanes. As expected with a change process, the fear of losing benefits creates a level of resistance that outweighs the potential but unspecified benefits from a driver for the change. Generally in Melbourne, trams get a higher level of special treatment over mixed traffic than that which is offered to buses. This situation is reflected in the attitudes of the operators – the tram operators have previously gained benefits that they wish to guard (and build improvements upon) whereas the buses are looking to gain any improvements, off a generally low base.

There is also a difference in how the operators view implementations of joint operations. Yarra Trams suggested that buses leave tram lanes at intersections to avoid delaying trams, yet it is at intersections that the bus operators want their vehicles to enter tram lanes, for queue jump and signal priority benefits.

The do-nothing approach forms an alternative to joint operations, but not a desirable one. The support the consultation process received is indicative of recognition in the industry that action is necessary. The current situation is untenable if the Victorian Government's target of 20% of mode share (of motorised trips) for public transport by 2020 target (or any other significant increase in public transport patronage) is to be achieved. Further alternatives to joint operations include transit lanes or bus lanes, which keep the buses and trams separated. These alternatives have implications of their own, for which an assessment needs to be made.

Joint operations should be considered as an approach to improving public transport in Melbourne; the choice of option and the specifics of its implementation need to be examined on a site-by-site basis. For a joint operation proposal to succeed, there is a need for one person or organisation to act as a sponsor for the proposal. This sponsor would have the responsibility for consulting with and achieving agreement from the stakeholders for that proposal. The sponsor would also need to coordinate the evaluation of the proposal, including an economic analysis and examination of the impact on other road users.

The process followed in this paper is applicable to many situations where there are competing users being asked to share the same road space:

- Investigation of relevant examples to highlight potential benefits and issues
- Consultation with affected stakeholders
- Engineering feasibility investigation
- Site investigations

Note that this is not a sequential process, as inputs from various stages feed back to refine the proposal or raise new issues.

The three categories of issues raised are also relevant to a range of situations:

- Suitability of the infrastructure
- A safe and efficient operating regime which is acceptable to all parties
- The relationships between the parties involved with the proposal

This paper has illustrated the complexity of issues surrounding competing demands for road space, even in a situation where those competing demands can in fact be made to be complementary. The importance of being able to take a whole system approach to dealing with competing demands and the problems posed to this by a series of single purpose institutions has also been highlighted.

References

Fernandez R (2000) *A bus-based transitway or light-rail: the engineering view,* Road and Transport Research, Vol 9 Iss 1, pp.112-3

ITS America (2002) *An Overview of Transit Signal Priority*

Khan A (1993) *Cost-efficiency and service level comparisons of transitway and light rail transit,* 6th World Conference on Transport, Lyons 1992

Matthews A and Asche H (2000) *Co-Location of Busway/LRT – Design and Conversion Implications,* Smart Urban Transport Conference, Brisbane

Niles J, Nelson D and MacIsaac J (2001) *Light Rail or Buses in the Downtown Seattle Transit Tunnel: Assessment of Benefits to King County Metro and Regional Public Transportation,* http://www.globaltelematics.com/tunnelteam.htm

Parascandolo, S (2003) *Croydon Tramlink – The Unofficial Site,* http://www.croydon-tramlink.co.uk

Somers, A (2003) *Final Year Project Report - Investigation into Bus Access to Tram Rights of Way,* Monash University

SoundTransit and King County (2001) *Evaluation of Joint Operations in the Downtown Seattle Transit Tunnel*

Walter M (1992) *Planning and Design of On-Street Light Rail Transit Stations,* Transportation Research Record, No 1361, pp. 125-7

The following parties were interviewed during the consultation process:

Group	Persons Interviewed	Position
Bus Association Victoria	John Stanley Russell Coffey	Executive Director Marketing Manager
VicRoads	Alistair Cumming	Road Based Public Transport
Department of Infrastructure (DOI)	Louise Curotte Graeme Vellacott Geoff Newbegin Graham Brown Trisha Brett	Assistant Franchise Manager – Trams Senior Project Manager, Office of Director of Public Transport Project Coordinator, Office of Director of Public Transport Regional Manager Buses – Eastern Safety
National Bus Company	Steve O'Callaghan	Business Development Manager
Yarra Trams	Les Kulesza	Manager Traffic Planning
RACV	Peter Daly Dan Przychodzki	Chief Engineer, Traffic and Roads Research Engineer, Traffic and Roads