Transit Lane Warrants Study
Roads ACT
1 February 2012

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Prepared for

Roads ACT

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Executive Summary

Introduction

As road space becomes more congested and travel demands increase there is a need to manage the road network efficiently and effectively. Although the road is used by vehicles it is actually the movement of people and goods that are the most important function of the road network.

A technique to balance the needs of people as compared to providing for vehicles is the provision of dedicated lanes. These lanes are commonly termed as "managed lanes" and can be bus lanes, bus only lanes, freight lanes, truck lanes or Transit lanes, (requiring a minimum number of people per vehicle to be present in order to use the dedicated lane).

The Legislative Assembly have expressed an interest in the Adelaide Avenue T2 lanes that were converted from bus lanes during the upgrading of Glenloch interchange

The specific issues raised by the Assembly included:

- *Develop and publish Government guidelines for the appropriate locations and uses for transit lanes and bus lanes in the ACT, which have reference to safety, congestion, and transport sustainability goals; and*
- *Assess options to resolve any road safety issues affecting the T2 lane on Adelaide Avenue.*

AECOM have been briefed by TaMSD to review criteria that may apply to allocate bus lanes in the ACT and identify if any could become Transit lanes.

Literature Review

A review of past and present experience with Bus / Transit lanes has been undertaken to identify Australian and overseas practice / warrants, current use of bus and T2 lanes in the ACT and opportunities to convert bus lanes to T2 lanes. To summarise, the network and availability of managed lanes (or High Occupancy Vehicle [HOV] / Transit lanes as they are more commonly known in Australia) has expanded significantly in both Australia and the rest of the world since Shoukrallah's report was prepared in 1993. Whilst the concept of a HOV lane in the form of a bus lane had been around for many years the concept of a transit lane in a T2 / T3 configuration was still a relatively new concept outside of the USA at that time. Australia was only just beginning to implement their first form of transit lanes (T2 / T3) across the major cities of Sydney, Brisbane and Melbourne. In the UK, the first transit lane (T2 / T3) was not introduced until 1998 and the network of transit lanes still remains very small limited to just two different locations Leeds and Bristol. On the other hand, the network of transit lanes in the USA has continued to expand significantly and now stands in the region of 136 HOV schemes which are implemented in 19 different states, covering a total of 1139 miles (1256 lane miles or 2021 lane kilometres) with a further 105 proposed sites covering 966 miles (1970 lane miles 3170 lane kilometres). This is a significant expansion in the availability of transit lane network from what was 340 miles (547 km) reported by Shoukrallah in 1993.

For many countries the use of HOV / Transit lanes is now common within their transport network and is a form of travel demand management utilised to provide for people rather than just vehicles and hence vehicles with higher occupancies have a quicker and more efficient journey between their origin and destination. Since 1993, the use of transit lanes has expanded from just providing priority along a congested corridor to providing priority to strategic sections of the network, priority through intersections and priority to the CBD of large cities. The measure has become one that provides for continuity along the journey. New Zealand authorities have combined the use of transit lanes with ramp metering to provide transit vehicles with priority to strategic parts of the network such as the State Highways. (Ramp meter restricts the flow of entering traffic onto roads such as Tuggeranong Parkway or Adelaide Avenue)

In Australia, the network of transit lanes has grown significantly since 1993:

- Sydney: network has expanded to 53km of HOV lanes;
- Melbourne: network has expanded to include new T2 lanes on Hoddle Street and Tullamarine Freeway;
- Brisbane: network has expanded significantly and includes no fewer than six new T3 and eleven T2 facilities;
- Gold Coast: was not featured in the 1993 review however now has a T2 facility starting at Steven Street in Southport and running to Harley Street in Labrador and a new T3 facility on Smith Street in Southport;
- Perth: no change since 1993; and

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- Adelaide: extensive amount of Bus Lane and bus priority measures, no T2/T3 or T4 facilities identified.

Enforcement

Occupancy verification – One of the most challenging aspects of HOV lane enforcement is verification of vehicle occupancy. There are different options for this:

- **Manual** – at present, police or enforcement officers carry out enforcement manually. This is particularly difficult with night-time operations, tinted windows, panel vans and high-speed conditions. Apart from the difficulty in verifying the occupancy, the cost in enforcement is also very high.
- **Automatic** – Over the last few years, research projects have been carried out to develop an automated system that could identify illegal occupancy. At the moment, two systems are being developed:
  - **Video recognition** - This is a semi-automated system, which consists of three or more cameras to capture images of the front windshield, the side window and the rear licence plate. This system would require human input to identify the number of occupants.
  - **Infrared imaging** - A similar system has been developed both in the UK and the US. This involves using a camera, which would take infrared images. Although some fine-tuning is still required to achieve near 100% correct identification, it can be assumed that an effective system would be available in the near future.

In the ACT these techniques would require amendments to legislation before their introduction. Additionally, most authorities prefer 'T' lanes to be adjacent to the verge to allow easier apprehension of violations. A median location requires vehicles to weave across other traffic lanes to safely stop.

Evaluation Criteria

AECOM undertook a comprehensive review of past and present evaluation tools used to assess the need and type of HOV facility that is required or would best suit a corridor. During this review a number of similarities between the previous studies were identified, the work undertaken by Shoukrallah (1993), Austroads, the AITPM and in the USA to develop a set of criteria / guidelines to assess when and if a HOV lane should be implemented had a number of similar assessment criteria, however UK experience indicates that it is almost impossible to adopt a uniformly standard approach. This is because the UK approach is a philosophical one where the best use of road space to move people and goods is the basic evaluation tool. Utilising elements from of all sets of research, AECOM believes that the three key evaluation criteria that is consistent throughout the researched material identified previously include:

- Number of lanes along the corridor;
- Level of congestion / observed delay / LoS along the corridor; and
- Bus Journey Times and LoS along the corridor.

Preliminary Evaluation – Flemington Road

The results of the surveys completed during both the AM peak period along Flemington Road would suggest that currently the designated bus lane that stretches for approximately 1.3km for the length of the corridor provides little journey time savings to the users when compared to the general traffic lanes. However, the bus lane does provide the user with a reliable travel time and consistent travel speed for the duration of the corridor and as the surveys suggest this does not occur within the general traffic lanes; where there is a difference of approximately 30 seconds between the quickest and slowest journey time along the corridor.

The private car is clearly the dominant mode of travel constituting 93.4% of all vehicles, public transport buses make up 1.8 %. A total of 1770 private vehicles carried 2400 occupants in the median lane, giving rise to an average occupancy rate of 1.36. It is of note that this is significantly higher than surveys conducted in the 70's when the average vehicle occupancy was about 1.2.

ACTION advised that 34 buses carried approximately 2050 passengers during the survey period (assuming 90% occupancy) and experience verifies these loading levels. The investigation assumed that all HOV lane (T2 or T3) eligible vehicles will use such a lane, if it was introduced. The results of lane utilisation by vehicles and persons for the three scenarios; i.e. bus lane, T2 HOV lane and T3 HOV lane are as follows:

Currently, buses constitute a small percentage (1.8%) of all vehicles on Flemington Road, yet they carry about half (46.6%) of all persons travelling on Flemington Road. If a T3 HOV lane was introduced, it will carry a slightly higher percentage of vehicles (9.8%) and persons (53.9%). It is unlikely that such an arrangement would impact on buses travel times and timetables.

However, if a T2 was introduced about 600 vehicles would be eligible to use the lane. Austroads indicates in Guide to Traffic Management part 3 that the maximum flow rate for level of Service B is approximately 720 vehicles per hour for a 70 km/hr road and 830 vehicles per hour for an 80 km/hr road. Austroads reports that at this flow rate the average speed is still 70 km/h hence there should be no impact on bus travel times under ideal conditions. .

Furthermore, a bus stop is currently located (within the bus lane) near the entrance to EPIC on this section of Flemington Road. During the time of the surveys, no buses used this stop. There was, therefore, no interruption to traffic on that lane. The success of the current Park and Ride facility that has been established opposite EPIC will be dependent on buses being able to stop at this location. Although an indented bus bay would be appropriate for the number and frequency of stopping buses, indented bays are generally only provided where there is a bus lane adjacent to the bus bay. A future flow rate of 770 vph at LoS B would adversely impact on the ability of a bus within the indented bay re-entering the traffic stream and hence a T2 lane is not considered appropriate. This may result in unsafe weaving manoeuvres in and out of the lane to avoid a stationary bus at this location.

Preliminary Evaluation – Adelaide Avenue

The results of the surveys completed during both the AM and PM peak periods along Adelaide Avenue would suggest that currently the designated T2 transit lane that stretches for approximately 4.5km in both directions of the corridor provide little journey time savings to the users when compared to the general traffic lanes. However, the transit lane does provide the user with a reliable travel time and consistent travel speed for the duration of the corridor and as the surveys suggest this does not occur within the general traffic lanes; where there is a difference of approximately 15 seconds in both the AM and PM peak periods between the quickest and slowest journey time along the corridor.

In the AM peak hour 933 vehicles would have been eligible to use the T2 Transit lane along Adelaide Avenue out of a total of 4772 vehicles. If all had done so then the travel speed of buses may have reduced as the maximum number of vehicles to maintain LoS B is approximately 830 vehicles per hour – even though Austroads reports that for 80 km/h roads traffic can maintain 80 km/h at LoS C. Thus LoS would decrease to LoS C if all eligible vehicles used the T2 Lane

During the PM peak the number of eligible vehicles would decrease to 856 out of a total of 4244 vehicles during the peak hour. This would likely maintain a LoS B and thus be consistent with a policy that required LoS B to be maintained for Frequent bus services.

If however traffic levels increased so as to become congested in the adjacent lanes (LoS D maximum of 1700 vph in three lanes) then the proportion of vehicles eligible to use the T2 lane of 1275 vph would exceed the maximum to maintain LoS B. i.e a total demand of 6375 across 4 lanes of which one is a T2 lane would result in adverse travel time impacts for buses.

Preliminary Evaluation – Barry Drive

The results of the surveys completed during the AM peak period along Barry Drive would suggest that currently the designated Bus lane that stretches for approximately 2.2km towards the CBD along the corridor provides a slight journey time saving to the users when compared to the general traffic lanes. The Bus lane also provides the user with a reliable travel time and consistent travel speed for the duration of the corridor and as the surveys suggest this does not occur within the general traffic lanes; where there is a difference of approximately 32 seconds between the quickest and slowest journey time along the corridor.

In the AM peak hour there were a total 904 vehicles that would have been eligible to use a T2 Transit lane along Barry Drive. If all eligible vehicles had utilised the T2 facility, then the average travel speeds of buses may have reduced as the maximum number of vehicles to maintain LoS B is approximately 840 – even though Austroads reports that for 80 km/h roads traffic can maintain 80 km/h at LoS C. Thus LoS would decrease to LoS C if all eligible vehicles used the T2 Lane. A T2 lane is therefore not considered appropriate. A T3 lane could be considered from traffic flow perspective however at Kingsley Street the kerbside lane will become a trap right turn lane for buses only. There is therefore little benefit in a T3 lane on Barry Drive.

As Gungahlin continues to grow it is expected that traffic on the GDE / Belconnen Way / Barry Drive route into the City will continue to increase thus the benefits of the bus lane are expected to continue to increase over time.

Conclusions on candidate T lanes

- When considering examples of Best Practice there is now a number of examples from around the world where the success of HOV / Transit or managed lanes have been implemented successfully;
- After reviewing the various evaluation criteria and techniques that are utilised around the world when considering HOV facility implementation AECOM believes that there are three key criteria for considering HOV lane implementation, these include:
    - Number of lanes along the corridor;
    - Level of congestion / observed delay / LoS along the corridor; and
    - bus journey times and LoS along the corridor.
- AECOM has developed a evaluation tool based on the above criteria that the ACT Government can utilise in the decision making process when implementing HOV lanes within the ACT;
- Key policy objectives should be considered to aid the implementation of HOV facilities with the ACT, these include:
    - Maintaining transit lane flows less than 600 vehicles per hour within a transit lane; and
    - Maintaining a LoS C or above in all traffic lanes along a corridor.

Adelaide Avenue Bus Lanes Safety Assessment

Concern has been expressed about the road safety risks arising from general traffic weaving in and out of the bus lanes on Adelaide Avenue. The situation has been assessed and the following conclusions drawn:

For the inbound direction traffic can enter the T2 lanes from the Carruthers Street overpass at Curtin, Cottter Road overpass, Kent Street overpass and Hopetoun Circuit underpass. Traffic can only exit from the T2 lanes to Hopetoun Circuit or to State Circle. Traffic can legally enter and leave the T2 lanes at any location even though they cross an unbroken line. This exemption to crossing unbroken lines is considered an undesirable and confusing feature of the Australian Road Rules (it is an generally an offence to cross an unbroken line and in the view of the authors of this report such exemptions to general criteria lead to broader driver non compliance). Although the number of vehicles using the T2 lanes is relatively low, conflicts arise when traffic attempts to enter the T2 lane from a very slow moving adjacent lane into a lane where buses and other T2 traffic is travelling at 80 km/h. This situation only arises during the AM peak. As there is little advantage to traffic entering the T2 lane from the Kent Street ramp, risks could be reduced by banning this movement – however this is difficult to achieve. For traffic attempting to enter from the Cotter Road on ramp vision is restricted by the curve in the connection from Yarra Glen to Adelaide Avenue and it is at this location where the speed differentials are likely to be highest due to congestion arising from entering Cotter Road traffic – a situation that is likely to become more severe with the development of Molonglo with resultant higher volumes of traffic travelling along Cotter Road.

This situation is likely to change as a consequence of the current investigations into a median located bus stop on Yarra Glen under the Cotter Road overpass. If a bus station was to be constructed then buses would be travelling slower than 80 km/h where the other T2 traffic may wish to merge however general traffic would be travelling more quickly. Under this situation of the proposed median bus station the merge of slow buses and high speed T2 traffic is considered a road safety risk and that the station is incompatible with T2 lane.

On the outbound carriageway traffic is generally diverging from the T2 Lane – little traffic enters from Hopetoun Circuit – and hence traffic exiting from the T2 lane may reduce speed to enter the slower moving traffic stream. Similarloy to the inbound carriageway it is considered that a T2 lane is incompatible with a median located bus station on Adelaide Avenue because slow moving buses will be entering a high speed T2 lane and bus drivers will not be abvle to achieve a clear view of the T2 traffic in the lane that they are about to enter.

T4 Lanes AECOM were requested to review the potential to install T4 lanes in the AC. The Australian Road Rules do not provide for T4 lanes to be installed. Whilst it would be possible for the ACT to provide supplementary legislation to permit T4 lanes, such a decision would be inconsistent with the objective of consistent and uniform road rules across Australia. This study has concluded that T4 lanes are therefore not appropriate.

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1.0 Introduction

1.1 Background

As public funds become more constrained, road space is at a premium and there is a focus on energy efficiency, there is a need to increase the efficiency of the existing road space and network that is available. This is being achieved in many jurisdictions by the application of "managed lanes" or "smart roads". Managed lanes include bus lanes (taxis and motorcycles permitted), bus only lanes, transit lanes (or High Occupancy Vehicle [HOV] or minimum number of vehicle occupants), truck lanes, freight lanes, tolled lanes etc.

The Legislative Assembly have expressed an interest in the Adelaide Avenue T2 lanes that were converted from bus lanes during the upgrading of Glenloch interchange.

The specific issues raised by the Assembly included:

- *2) Develop and publish Government guidelines for the appropriate locations and uses for transit lanes and bus lanes in the ACT, which have reference to safety, congestion, and transport sustainability goals; and*
- *(3) Assess options to resolve any road safety issues affecting the T2 lane on Adelaide Avenue.*

Roads ACT commissioned AECOM to undertake review and update previous work investigating the potential use and benefits of converting existing bus lanes to HOV Lanes in Canberra and to establish evaluation criteria that is suitable for application to the selection of future bus or HOV lanes across the ACT region.

1.2 Study Purpose

The purpose of the study is to investigate and complete the task outlined below:

- A review of the work undertaken in the study completed by the Transport Policy Branch of Transport and Works ACT Government entitled 'an investigation into the possible introduction of HOV lanes in Canberra'(1993);
- An updated high level literature review highlighting examples of best practice Transit Lanes both internationally and within Australia;
- Re-evaluate the criteria recommended in the 1993 study, update as required and conduct a case study on two or three potential locations;
- Examine the 2 – 3 potential locations for possible conversion of bus lanes to T2/T3/T4;
    - investigate in terms of journey times,
    - efficiency of lane utilisation,
    - traveller versus vehicle throughput,
    - taxi and motorcycle implications; and
    - assess these case studies to indicate benefits;
- Case studies of least Flemington Road and Adelaide Avenue;
- Reporting on Vehicle Occupancy surveys and Journey Time surveys at the identified locations (Flemington Road to assist with highlighting the benefits that may come as a result of T2/T3/T4 implementation.
- Reporting on bus stop
    - locations and impacts (indented versus in lane),
    - Park and Ride (particularly at Flemington Road),
    - minimum lengths,
    - enforcement protocols in assessing potential sections,
    - separation of lanes (linemarking, tactile raised kerbs); and
    - Consistency and uniformity.

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1.3 Policy Context

The ACT Governments document entitled 'Transport for Canberra: Transport for a sustainable city' sets out the transport priorities for the Region for over the next 20 years (2011 – 2031) with the objective of achieving sustainable transport targets by reducing individual private car travel and substituting travel by walk, cycle, public transport modes and increasing vehicle occupancy. Within this policy the Government identifies transit lanes as an important measure in managing travel demand across the ACT road network. In addition a key objective of the document is development the frequent public transport network which would include measures such as queue jumps, public transport priority, priority and coordinated signals all of which will improve the efficiency of High Occupancy Vehicles (HOV) across the transport network. It is unusual for Transit Lanes to be installed in the absence of high demand bus usage, and hence Transit Lanes are generally only applicable on important bus routes or links used by the Frequent Rapid Services.

This study therefore is generally consistent with the overall ACT Governments objective to manage travel demand and increase the efficiency of movement of people across the road network and recommends measures to assist in the delivery of those key objectives presented in the Transport for Canberra Policy Documents.

1.4 Report Structure

The report has been structured as outlined below, to address the issues above.

- **Chapter 1** – This chapter includes a review of the 'purpose of HOV / Transit or Managed lanes' and also a review of previous HOV studies that have been completed by the ACT Government.
- **Chapter 2** – This chapter discusses the purpose of HOV lanes and previous studies undertaken by the ACT Government;
- **Chapter 3** – During this chapter a comprehensive literature review has been completed investigating and undertaking analysis of existing HOV lanes within Australian and the rest of the World. This section also revisits the work undertaken previously by the ACT Government to update and expand on their findings completed in 1993. Examples of best practice and success rates will also be highlighted within this section.
- **Chapter 4** – This chapter outlines the existing situation within Canberra highlighting areas where managed lanes have already been implements and also reviewing the existing transport network across the region.
- **Chapter 5** – This section of the report outlines and analyses the results of the Journey Time and Vehicle Occupancy surveys that were completed as part of this study.
- **Chapter 6** – The section of the report revisits the work undertaken by the ACT Government in 1993 on developing an evaluation criteria and also highlights other examples from across the world where similar criteria have been developed for evaluating HOV lanes pre and post implementation. In addition, this section looks at the current policy measures in place to assist with evaluating transit lanes.
- **Chapter 7** – As in 1993 the ACT Government identified numerous transport corridors for consideration of HOV facilities, this chapter re-visits the work undertaken in 1993 and updates, expands and identifies the transport network that may be suitable for consideration and further investigation for hosting a HOV facility.
- **Chapter 8** – Outlines the main conclusions from the report and also outlines a number of recommendations which have been developed from the research completed during this study.

2.0 Purpose of HOV and Review of Previous Reports

2.1 Purpose of HOV lanes

Managed lanes are traffic lanes that are restricted to particular types of vehicle use and provide improved travel conditions to eligible users. Eligibility can be based on the number of people in a car, type of vehicle, users who are willing to pay a toll, or other criteria. Managed lanes come in numerous configurations including:

- **Bus Lane** - a traffic lane intended for the use of buses;
- **Busway –** a special type of bus-only lane that is segregated from general purpose lanes;
- **HOV Lane** - a traffic lane limited to carrying High Occupancy Vehicles (HOVs) and certain other qualified vehicles;
- **HOT Lane** - in addition to operating as an HOV lane, High Occupancy Toll (HOT) lanes are used by fee paying designated vehicles that do not meet the occupancy requirements (and are not used in the ACT at this time);
- **Freight Lane** (or Truck Lane) - a traffic lane intended for the use of freight vehicles (heavy goods vehicles); and
- **"No-Car" Lane** - a traffic lane intended for the use of freight and public transport vehicles – cars are not allowed.

A managed lane approach looks at capacity in terms of people carrying capacity of a traffic lane and not vehicle flows. The allocation of road space is then based on passengers as opposed to vehicles. **Figure 1** illustrates how a managed lane differentiates from a general traffic lane in terms of journey time as vehicle flows increase.

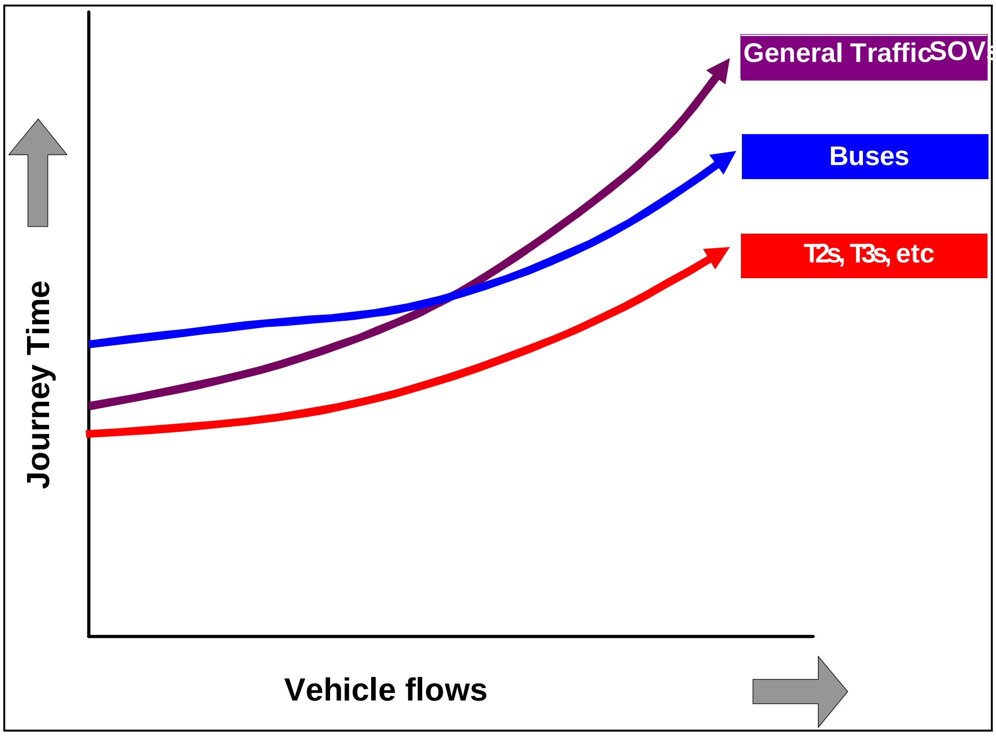

Figure 1 **Journey time and reliability of HOV lanes**

SOV = Single occupant vehicles

Figure 1 illustrates that:

- As flows increase, provision of bus lanes or HOV lanes protect public transport and high occupancy vehicles from impacts of increasing congestion; and
- Reliability for these vehicles is maintained as the road network becomes saturated.

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The life cycle of managed lanes can be illustrated through a series of graphical illustrations as shown by **Figures 2 - 5**. **Figure 2** illustrates the initial period after implementation of a HOV lane that illustrates that vehicles with two occupants make up the majority of users within the managed lane approximately 20-30% whilst buses and vehicles with 3 or more occupants make up a small percentage of users between 10-15% each respectively.

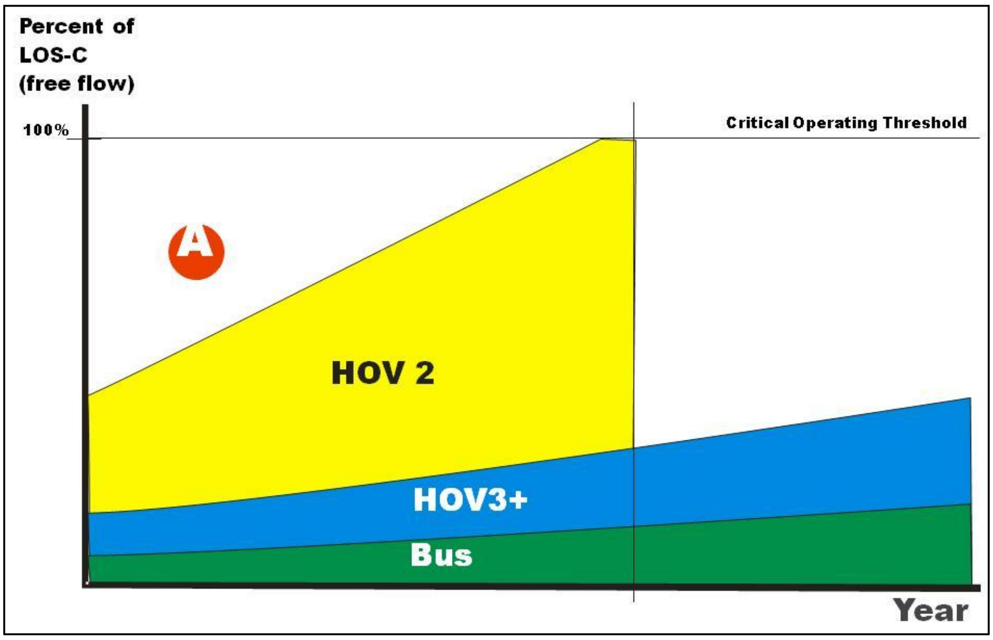

Figure 2 Lifecycle of a managed lane

During the initial period after implementation of an HoV lane the lane is underutilised, represented by 'A' in **Figure 2.** After a number of years eventually the managed lane will reach it critical operating threshold as vehicles with two or more occupant's increases significantly and buses and vehicles with three or more occupants increase gradually over the same period. **Figure 3** illustrates the potential use for the available capacity during the early years following implementation and its impacts on the managed lane critical operating threshold.

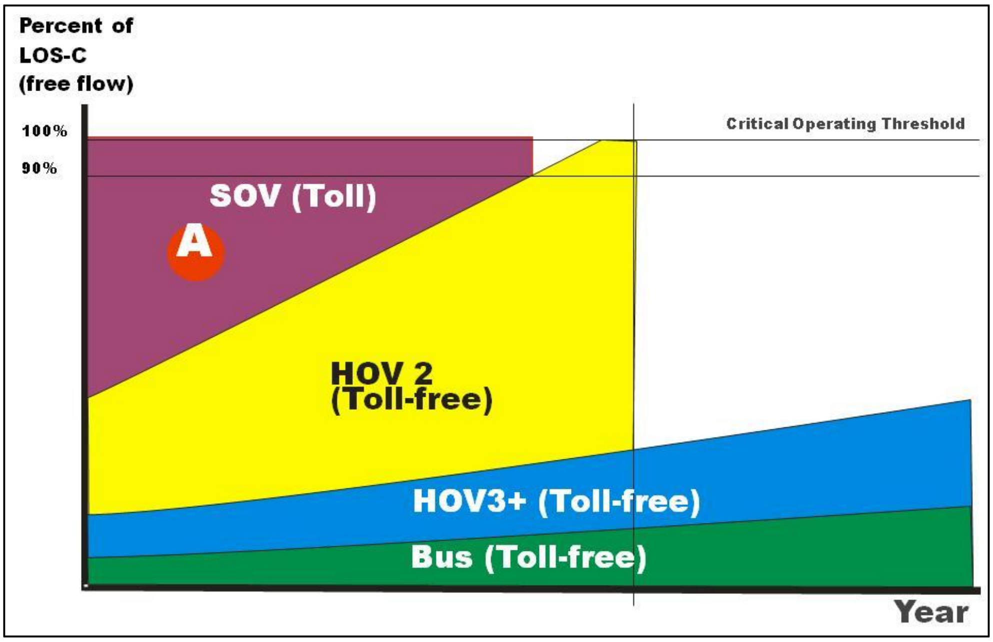

Figure 3 Increasing utilisation with SOVs

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Utilising the spare capacity within the managed lane by allowing signal occupancy vehicles (SOV's) into the managed lane for a toll would maximise the lane utilisation and get maximum use from the network. The area on the chart marked 'A' represents the use of SOV's to maximise lane utilisation which could be managed through increasing or decreasing a toll, therefore as the number of vehicles with two or more occupants and buses increase the toll could be increased to decrease the number of SOV's within the lane keeping the lane operating under the critical threshold and at a LoS C or above. At this point in time when there are no toll roads in the ACT, there is no opportunity to introduce this type of managed lane.

Once the managed lane reaches the critical operating threshold the next step would be to put a toll on Single Occupancy Vehicle (SOV) and HOV 2 as shown in **Figure 4**. This would enable even greater efficiency and utilisation within the lane as buses and vehicles with three or more occupants would continue to rise which would result in increased vehicle occupancy but still higher travel speed for the managed lane.

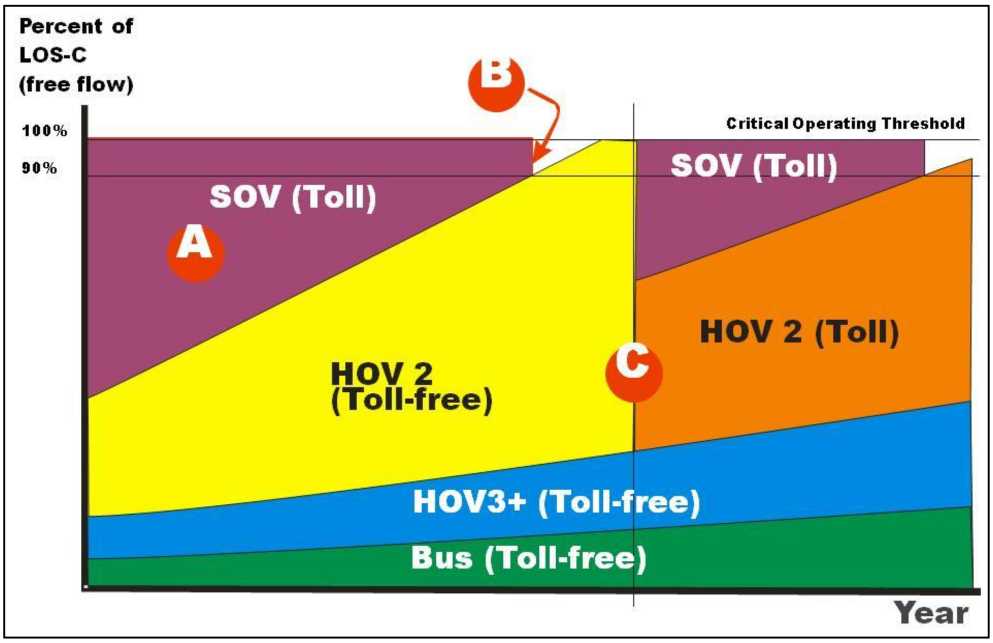

Figure 4 the introduction of Tolls on SOV and HOV 2

An alternative approach to that displayed in **Figure 4** could be to increase the lane utilisation by allowing energy efficient vehicles into the managed lane toll free. An example of this would be to allow hybrid and electric vehicles to utilise the spare capacity within the lane whilst the HOV 2, HOV 3 and buses increase over time. This may not result in higher average vehicle occupancy for the lane as might be achievable within the Toll scenarios displayed above however it does have other benefits such as lowering emissions and other environmental factors of the managed lane.

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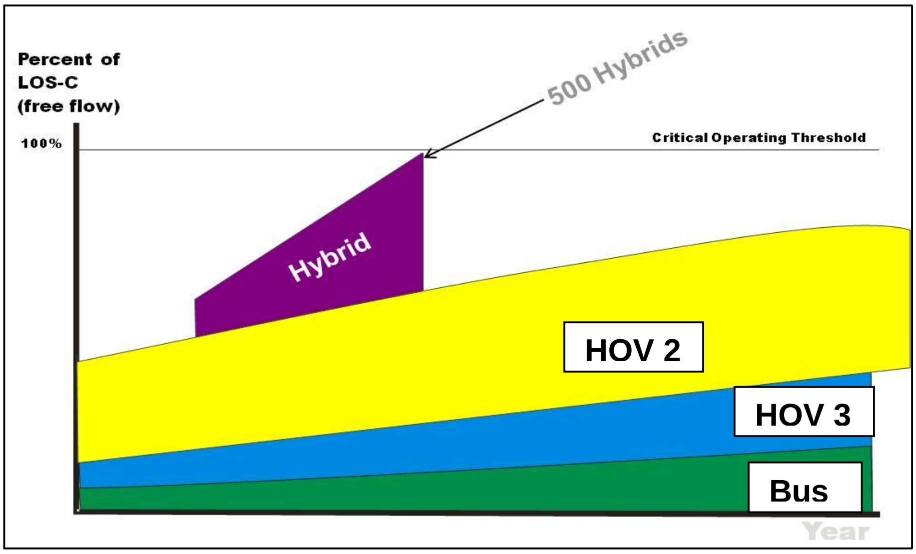

Figure 5 Increasing utilisation with Hybrids or more environmentally sustainable vehicles

Overall the purpose of a managed lane is not only reduce travel times but also to achieve reliability whilst at the same time increasing the average vehicles occupancy levels of the traffic lane. The focus of managed lanes should be to provide for people movement rather than vehicles and also improve traffic flow and efficiency along the corridor.

2.2 ACT previous review

The Roads and Transport Branch of the Department of Urban Services completed a report entitled *'An investigation into the possible introduction of HOV lanes in Canberra'* in July 1993 (Shoukrallah, 1993) which undertook a comprehensive review of the benefits associated with HOV Lanes and evaluated the need for converting existing bus lanes and key corridors in Canberra to accommodate HOV facilities.

The key conclusions from the report included:

- There were many examples of Australian Cities introducing HOV lanes in an attempt to reduce total person delays and provide a system that encourages public transport patronage and increasing vehicle occupancies. The majority of the projects discussed in the report were examples of a kerbside general traffic lane being converted to a HOV lane during peak periods;
- The research showed that HOV Lanes generally improved travel times along the corridor is some cases as much as 34%. There was also a small increase in vehicle occupancy along the corridor generally between 3 and 4%. Research also showed that illegal usage was high between 23% and 53% and this highlighted the need for enforcement; and
- The report illustrated that key criteria for a viable HOV lane included a travel time saving of 10 minutes per trip or 40 seconds per KM. The report showed that at the time that the investigation was undertaken that all candidate roads within Canberra were unlikely to achieve travel time savings of this proportion. Of all the candidate roads assessed during the report, Adelaide Avenue had the most potential of meeting the key criteria.

Shoukrallah (1993) also made a number of key recommendations which included:

- That HOV Lanes are not introduced on Canberra's roads;
- That taxis could be allowed to use all existing bus lanes in Canberra;
- That travel demand management efforts are intensified and a focus on increasing vehicle occupancies and facilitating public transport through the provision of further bus lanes and bus priority measures where possible; and
- That the possibility of introducing HOV lanes in Canberra is further investigated in the future.

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The work completed by Shoukrallah (1993) forms the basis of this study and the content included within this report. A main aim of this study is to update and review his work to identify if the conclusions and recommendations outlined above are still applicable.

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3.0 Literature Review

3.1 Introduction

A High Occupancy Vehicle (HOV) lane can be described as a traffic lane managed to 'discourage single or low occupancy car use by providing priority to vehicles with more than a minimum number of occupants (usually two or three) and to buses' (Leeds University, 2011). The aim of an HOV lane is to provide a reduced journey time for the user over a general traffic lane and thus would encourage users to switch to car sharing or public transport modes. As a result, it is anticipated there would be a 'reduction in cars on the network and demand for road space which would result in a reduction in overall congestion, fuel consumption and environmental impacts' (Leeds University, 2011). Despite still a relatively new concept and not widely accepted by all, HOV lanes or transit lanes have become far more widespread in the last 10 years particularly in the USA and increasingly in Europe, Australia and New Zealand.

There are a number of ways that a HOV lane can be implemented including:

- Conversion of an existing general traffic lane;
- Adding additional lanes to the inside or outside of a existing road corridor; or / and
- Conversion of an existing bus lane, bus only lane or bus-way.

HOV lanes can also be implemented in a number of forms which include:

- **T2 / T3** – these lanes permit any vehicle with two (T2) or three (T3) occupants within the vehicle to utilise the HOV lane. This generally includes buses, taxis, bikes and bicycles as well as some freight (HCVs).
- **Bus lane** – these lanes only permit buses, taxis and motorbikes.
- **Bus only lane** – these lanes permit only buses**.**

In the USA it is common for HOV lanes to be part of a motorway or strategic corridor, whilst in Europe HOV lanes are generally implemented along strategic corridors into City Centre areas (Leeds University, 2011). There are further categories of HOV lanes called HOT lanes where for drivers to benefit from the lane they pay a toll – hence the term High Occupancy Toll lanes. HOV lanes can be implemented under a number of different scenarios including:

- **Permanent** – where the HOV lane operates under the designated conditions 24 hours day;
- **Peak periods** – where the HOV lane operates under the designated conditions for the AM or / and PM peak hours which are generally considered to be between 7am – 10am and 4pm – 7pm; and
- **Tidal** – where the HOV lane operates under the designated conditions in an inbound direction during the AM peak (generally towards the City / Town centre) and outbound in the PM peak.

Since their introduction, HOV lanes have had varied results. Reports suggest that generally HOV lanes reduce vehicle trips between 4% – 30%. Generally, the occupancy levels along the corridor increase whilst journey times decrease especially for vehicles utilising the HOV lanes. Evidence does suggest however that the best results are achieved in those areas or corridors that are heavily congested and the effectiveness of the HOV lane decreases with the amount of congestion occurring on the corridor (Leeds University, 2011).

3.2 Enforcement

Occupancy verification – One of the most challenging aspects of HOV lane enforcement is verification of vehicle occupancy. There are different options for this:

- **Manual** – at present, police or enforcement officers carry out enforcement manually. This is particularly difficult with night-time operations, tinted windows, panel vans and high-speed conditions. Apart from the difficulty in verifying the occupancy, the cost in enforcement is also very high.
- **Automatic** – Over the last few years, research projects have been carried out to develop an automated system that could identify illegal occupancy. At the moment, two systems are being developed:

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- **Video recognition** - This is a semi-automated system, which consists of three or more cameras to capture images of the front windshield, the side window and the rear licence plate. This system would require human input to identify the number of occupants.
- **Infrared imaging** - A similar system has been developed both in the UK and the US. This involves using a camera, which would take infrared images. Although some fine-tuning is still required to achieve near 100% correct identification, it can be assumed that an effective system would be available in the near future.

In the ACT these techniques would require amendments to legislation before their introduction. Additionally, most authorities prefer 'T' lanes to be adjacent to the verge to allow easier apprehension of violations. A median location requires vehicles to weave across other traffic lanes to safely stop.

3.3 Austroads Guide on HOV's

In Australia, Austroads have provided a number of guidance documents outlining use and design of transit lanes across Australia and New Zealand. In 2002, Austroads published a document entitled a guide on High Occupancy Vehicles which provides traffic engineers with a guide to successfully implement a HOV facility along a transportation corridor. The document sets out a number of objectives that the introduction of a new HOV facility should look to achieve, these include:

- Increasing the people moving capacity of existing and planned roads;
- Increasing the use and efficiency of road based public transport;
- Reducing the consumption of non renewable transport fuels per person trip;
- Reducing vehicle emissions and improve air quality;
- Providing travel time savings and more reliable trip times;
- Not unduly impact on the roadway general purpose lanes;
- Not adversely affect safety of general purpose lanes;
- Establish public support or the HOV plan and project; and
- Establish cost effective HOV facilities (Austroads, 2002).

More recently, Austroads have published a Guide to Traffic Management that supercedes the 2002 reference. This later reference provides detailed guidance on the allocation of road space between different users and also guidance on lane management practices. Within these sections the guidance sets out a number of general traffic management goals for roads including:

- To optimise mobility through efficient traffic movements;
- To maximise road safety;
- To provide priority / or specific road space for non car modes where appropriate; and
- Provide traffic flow conditions commensurate with the road functional classification.

To document continues to provide guidance on the road space requirements of HOV lanes and these include:

- HOV lanes are for use by buses only or for use by any HOV usually including buses, taxis and other vehicles carrying at least two occupants;
- HOV lanes encourage greater efficiency of vehicle use (more people moved in less vehicles) and benefits such as:
    - Increased throughput of people;
    - Travel time savings;
    - Increased travel time reliability;
    - Reduced air pollution; and
    - Cost savings.

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- HOV lanes can be implemented as either concurrent flow or contra flow lanes; and
- Are generally operated on a time of day basis.

3.4 The Australian Experience

In 1993 the study undertaken by the Roads and Transport Branch identified that only Sydney, Melbourne and Brisbane had recognised and dedicated T2 or T3 HOV lanes. Whilst the Cities of Adelaide and Perth did have some dedicated HOV lanes they were generally reserved for bus use only. Today, the network of HOV lanes has increased significantly and is increasingly becoming a traffic management tool used by Local Road Traffic Authorities (RTA's) across Queensland, New South Wales, and Victoria. The remainder of this chapter provides a summary of the network and type of HOV lanes that have been fully implemented within various Cities across Australia.

3.4.1 Sydney

In 1993 Shoukrallah reported that Sydney had 23.8km of fully operational HOV lanes in either a T2 or T3 form with the operation of the majority of lanes restricted to between a 6am – 10am period with the exception of two which were operational between 3pm and 7pm. The location of these HOV lanes included:

- Epping Road, inbound only;
- Spit / Military Road, inbound and outbound;
- Burnt Bridge, inbound only;
- Victoria Road, inbound only;
- Pacific Highway, outbound only;
- Warringah Freeway, inbound only; and
- Windsor Road, inbound only.

In November 2011, Roads and Maritime Services of New South Wales reports that Sydney has 53km of HOV lanes which are fully implemented and operational. The current network of HOV lanes includes:

CBD

- Sydney Harbour Bridge
- York Street
- George Street
- Clarence Street
- Elizabeth Street
- Park Street
- Druit Street

Arterial Roads

- Anzac Parade
- The Pacific Highway
- Spit Road
- Epping Road
- Victoria Road
- Great Western Highway
- Pacific Highway
- Military Road
- Windsor Road

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- M2 (under construction)
- Gore Hill
- Epping Road
- Anzac Bridge

Despite a significant increase in the length and availability of HOV lanes within Sydney since 1993, the length of HOV lanes has reduced over the past 5 years, it is worth noting that the reduction in HOV lane length between 2009-2010 and 2010-2011 was due to the conversation of the M4 HOV lane to a general traffic lane and the upgrade of the Victoria Road HOV lane to a bus lane. However, the network of bus lanes has been increasing substantially over this period. **Table 1** illustrates the length of bus / bus only lane and HOV lanes in Sydney since 2006.

Table 1 Total length of available HOV lanes since 2006

Indicator	2006 – 2007	2007 – 2008	2008 – 2009	2009 – 2010	2010 - 2011
Bus Lane / Bus only length (km)	98	112	126	133	147
HOV Lane Length (km)	64	70	69	58	53

(RTA, 2011)

Note: The Roads and Traffic Authority (RTA)was restricted into the Roads and Maritime Services (RMS)

The Roads and Maritime Services Roads Directorate {legacy Roads and Traffic Authority (RTA) for New South Wales (NSW)} Annual Report for 2010 – 2011 suggests that the RTA does not have any current plans to expand on its current HOV lane network and anticipates that the length and availability of HOV lanes within Sydney will remain at 53kms for 2011-2012. However it is proposed to also provide a T2 lane as part of the M2 widening project rather than a bus lane over 9km in 2011/2012 between Beechcroft Road and the Toll Plaza as part of the M2 widening project.

The latest surveys of bus and HOV lanes show that some are very successful, such as the Victoria Road morning-peak T3, which saves users of the T3 lane more than 20 minutes. The Military Road morning T3 lanes are also efficient, saving drivers nearly 15 minutes, while Epping Road HOV lane users can save 11 minutes. However, despite the success of the previous HOV lanes, the HOV lane in T2 configuration on William Street between Dowling Street and College Street during the AM peak period has an average speed of 10.9kmh. When compared to the general traffic lane which has an average speed of 21.1 km/h this means that journey times for the drivers in the HOV lane take two minutes longer – but is affected by down-stream intersection operation particularly that of Elizabeth Street / Park Street.

Shoukrallah reported in 1993 that illegal use of HOV lanes within Sydney remained high with between 23% and 53% of users being illegal. In 2002, illegal use of Sydney’s HOV lane network increased with some designated lanes recording up to 73% of users being illegal (PCA, 2005). Today, HOV lane enforcement has remained a contentious issue. A recent survey found that there are still nearly 70% of the private cars in the lane during the morning peak carry only one person meaning that 56% of the people travelling in it are there illegally (SMH, 2002). Similarly, on the city-bound T2 on the Great Western Highway up to 65% of cars carry only one person, and traffic on some stretches travels 5kmh slower than on the normal highway (SMH, 2002). The Epping Road T3 from Vimiera Road to Pittwater Road has the worst figure for illegal usage of any HOV lane with 82% (SMH, 2002). Bus lanes generally have less illegal usage than HOV lanes with up to 46% but some also move slower than general traffic (SMH, 2002).

Kerbside locations of Transit lanes are strongly preferred by the Roads and Maritime Services Directorate to enable enforcement to reduce the high abuse levels. Median located transit lanes are difficult to enforce because they require mobile units to apprehend drivers whereas kerbside can be policed by stationary officers.

3.4.2 Melbourne

In 1993, Shoukrallah reported that Melbourne only had one Transit lane which opened in 1992 operating Monday – Friday 7:00am to 9:30 am between Bulleen Road and Wellington Street. Early surveys suggested that travel time savings up to nine minutes were achieved in the new facility and vehicle occupancy increased 0.04 (Shoukrallah, 1993). Today, Melbourne now has a network of 7.5kms of transit lanes which are of T2

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configuration. The lanes currently occupy the Eastern Freeway which is operational during the AM peak period, Hoddle Street which is currently only operational during the PM peak period and the Tullamarine Freeway (the Age, 2009).

In 2009, the Australian Transport Council (ATC, 2009) completed an investigation into the benefits of the Eastern Freeway transit lane which is Melbourne's major east-west arterial road in the east of the City. The HOV lane (a T2 Transit lane) on the Eastern Freeway has been in operation for over fifteen years. The T2 lane extends over six kilometres from Burke Road to Alexandra Parade and operates in the inbound direction during the morning peak, between the hours of 7:00am and 9:30am. The T2 lane was created through the re-allocation of an existing general purpose traffic lane and occupies the lane closest to the centre median. It is identified by signage and road markings and can be used by vehicles with two or more occupants, buses, taxis and motorcycles. However, route buses travelling to the city in the morning peak do not generally use the T2 lane as they are permitted to use the emergency lane on the Eastern Freeway.

The ATC report completed in 2009 reports that a survey of the Eastern Freeway T2 transit lane completed in 2007 found that vehicles in the T2 lane saved about 5 minutes (and up to 9 minutes at the height of the peak) compared to vehicles in the other lanes during the morning peak. Approximately 81% of vehicles permitted to use the T2 lane did so. Vehicles using the T2 lane saved on average 5 minutes and up to 9 minutes in the middle of the peak. The T2 lane reduced the person time in the corridor by 8% on the morning of the survey (i.e. compared with the hypothetical scenario if there were no T2 lane that day). This is equivalent to a 64 person hour saving over the morning peak (ATC, 2009).

Despite the obvious travel time benefits reported by ATC (2009) the report explains that there have been a number of operational issues. One of the key issues is despite police enforcement of the T2 lane once a week. About 35% of vehicles observed in the T2 lane were private vehicles without any passengers. An automated occupancy detection system, possibly using infrared technology, could be implemented to replace manual enforcement and increase motorist compliance. A separate study found that some of the reasons eligible motorists were not using the T2 lane were difficulty getting onto and out of the lane, no perceived time benefit, and safety concerns resulting from speed differentials between adjacent lanes. Motorists exiting the Eastern Freeway at Hoddle Street would also have to merge across multiple traffic lanes at the exit ramp (ATC, 2009).

The ATC (2009) also completed some analysis around potential environmental benefits that could result from increasing Melbourne's Average Vehicle Occupancy including if the car occupancy for journey to work trips increases by 10% in Melbourne (from 1.08 to 1.19), up to 90,000 cars could be taken off the road during the peak periods (ATC, 2009). These estimates are based on 2006 Census data and assume that additional car occupants exclusively replace car drivers. In comparison, the number of public transport users for journey to work was approximately 200,000 in Melbourne in 2006 (ATC, 2009). The ATC (2009) reports that a study commissioned by the Department of Premier and Cabinet in 2007 modelled potential strategies to reduce Greenhouse Gas Emissions. The modelling indicated that a 10% reduction in private vehicle use as a result of carpooling encouraged by transit lanes and information/education could be expected to reduce Victorian CO2 equivalent emissions by 1% by 2050 (ATC, 2009).

The ATC (2009) concludes its report by stating that HOV lanes (such as T2 lanes) can be an effective tool in managing road congestion and reducing carbon emissions. The success of a HOV lane is dependent on many conditions, including the characteristics of the road (including frequency of access points), regular enforcement and implementation of the HOV lanes and at least three lanes available at points where there is recurring congestion. HOV lanes are most effective where they act as a queue jump/bypass facility; accordingly on managed freeways/motorways HOV lanes are typically installed on the entry ramps. Internationally, HOT (high occupancy + tolled single occupancy) lanes have proven more effective than HOV lanes, under certain conditions. Evaluation of the congestion impacts of interventions is a complicated exercise, with available indicators often representing project operational performance (eg. patronage, vehicle occupancy) rather than the impact of the project on accessibility or transport network congestion. A current Austroads project is developing accessibility measures (essentially an integration of transport and land use) which should assist this challenge. The case study demonstrates the importance of enforcing compliance with relevant interventions to deliver lower congestion levels. It also reinforces that commuters must perceive a genuine benefit from congestion interventions before they will fully embrace the measures. In the case of the Eastern Freeway HOV lane, user safety concerns regarding access to the lane may have initially limited its effectiveness (ATC, 2009).

3.4.3 Brisbane

In 1993, Shoukrallah reported that despite plans for a number of HOV lanes in Brisbane, only one had been implemented along Lutwyche Road. Analysis of this HOV lane following its implementation concluded that an overall travel time saving of 28 seconds was achieved for buses and also a 9 second reduction in travel times for general traffic. Brisbane's HOV lane network has grown significantly since 1993 and currently has 13 HOV lanes in the form of T2 or T3 and in addition to these a further 29 bus lanes. The total network length comprises of 36kms of HOV lanes in the form of T2 / T3 and a further 9kms of bus lane / priority measures excluding segregated busways. **Table 2** summarises the T2 / T3 facilities that are fully implemented with their operational times.

Table 2 HOV lanes that are fully implemented within Brisbane in 2011 with their length

Road	Facility Type	Length (kms)	Operational Hours
Lutwyche Road inbound	T3	1.6	7AM – 9 AM
Kelvin Grove Road Inbound	T3	1.3	7AM – 9 AM
Kelvin Grove Road Outbound	T3	1.3	4PM – 7PM
Waterworks Road Ashgrove Inbound	T2	4.8	7AM – 9 AM
Waterworks Road Ashgrove Outbound	T2	4.8	4PM – 7PM
Waterworks Road Windsor Inbound	T2	1.4	7AM – 9 AM
Waterworks Road Windsor Outbound	T2	1.4	4PM – 7PM
Tiber St, Canara St & Crown St Norman Park Outbound	T2	0.95	7AM – 9 AM
Crown, Canara and Tiber St Norman Park Inbound	T2	0.85	4PM – 7PM
Pacific Motorway Dutton Park On-Ramp Outbound	T3	0.1	24 hours
Pacific Motorway Holland Park West On – Ramp Inbound	T3	0.3	24 hours
Mains Road Macgregor	T3	2.9	7AM – 9 AM
Mains Road Nathan	T3	1.5	24 hours
Pacific Motorway Upper Mt Gravatt Inbound	T2	5	24 hours
Pacific Motorway Upper Mt Gravatt Outbound	T2	3.5	24 hours
Pacific Motorway Eight Mile Plains On-Ramp Inbound	T2	0.1	24 hours
Anzac Avenue Rothwell / Kippa –Ring Inbound	T2	2.2	24 hours
Anzac Avenue Rothwell / Kippa-Ring Outbound	T2	2.4	24 hours

3.4.4 Perth

The designated HOV lanes in Perth are generally for public transport use only. The Department of Transport Public Transport Plan states that there are now 29km of bus priority lanes within the City with an expectation for this to continue to grow further in the future. Generally, the lanes are located on the approaches to signalised intersections where there are significant delays to buses. Queue jump facilities should generally have a daily patronage of more than 3,000 people, whilst dedicated bus priority lanes are prioritised for routes with more than 6,000 daily passengers (DoT PT Plan, 2011).

The Public Transport Plan sets out Perth's City ambition to have public transport as the mode of choice of Perth residents. Currently there appears to be no intention to introduce or convert any of the designated bus lanes to HOV lane (T2 or T3) as the focus is on providing an efficient and quick public transport network and mass HOV facilities.

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3.4.5 Adelaide

In 2002, the Austroads guide for traffic engineers on HOV lanes states that Adelaide had a number of HOV facilities in place, these included:

- Bus lane on Goodwood Road;
- Bus pre-emption signals at selected traffic lights;
- Short bus lanes at selected traffic lights;
- West lakes busway; and
- Adelaide O-Bahn.

It is worth noting that from the research undertaken no T2/T3/T4 facilities were identified in Adelaide and the HOV facilities currently in place are or bus use only.

3.4.6 Gold Coast

In addition to the major cities noted above, HOV lanes both T2 and T3 lanes have recently been implemented in the Gold Coast to assist with improving public transport and encouraging car pooling to ease congestion across the City. The locations of the new facilities include:

- A 3.5km T2 facility starting at Steven Street in Southport and running to Harley Street in Labrador which operates 24 hours a day and is enforced with penalties between $100 and $2000; and
- A new T3 facility on Smith Street in Southport which is the first T3 facility on the Gold Coast's and is now fully operational 24 hours a day.

The introduction of the new T2 facility was the result of a vehicle occupancy study carried out in 2004 found almost 40 per cent of vehicles already had two or more people on weekdays and the percentage on weekends increased to 50-60 per cent. These vehicles identified in the study will now benefit from immediate travel time savings by utilising the T2 HOV lanes (Queensland Government, 2011).

3.5 International Experience

3.5.1 Introduction

While they have been in use in the US since late 1970's, High Occupancy Vehicle (HOV) lanes are still a relatively new traffic management technique in the UK. Interest in promoting car-pooling both in the UK and the US began in the mid-1970's in response to fuel shortages. There was great interest in the UK as that time in encouraging drivers to share their vehicles to reduce congestion and conserve fuel. But research carried out concluded that the net impact on the transportation system of the government encouraging ride sharing would be minimal. After the release of these studies, UK government interest in actively encouraging car-pooling appears to have diminished significantly.

The research carried out was not focussed on the impacts of HOV lanes and was conducted over 20 years ago when car usage was much less than present levels and location / activity patterns were also considerably less dispersed. It is believed that under current conditions of increased private vehicle usage, increased congestion levels and increased dispersal of jobs that there would be greater scope for implementing HOV lanes.

In 1998, two HOV lanes were opened in the UK, one in Leeds and the other in Bristol. A third HOV was opened in 2001 in Bristol. These lanes only operate during peak periods and all three lanes are very short in length (all under 2 km) compared to their US counterparts. After the success of the two experimental HOV lanes in Leeds and Bristol, many areas in the UK are considering the construction of HOV lanes as a strategy for reducing congestion and improving the environment. This includes current proposals from the Highways Agency for HOV lanes on the M1. West Midlands has the highest traffic flow in the country outside London. Car ownership per capita is the highest of all metropolitan areas and rising. Congestion has became a serious problem in recent years, it has been estimated that congestion has cost industry and business in the West Midland £2 billion per annum.

Along with other traffic management measures, HOV lanes are seen as a way forward in reducing congestion and pollution.

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- **Mode shift** – The implementation of HOV lanes could have significant impact on travel behaviour. The most noticeable impact would be the increase number of HOVs. There is general perception that this increase is caused by drivers switching to car sharing, but the fact that people may be switching from public transport to car sharing cannot be ignored.
- **Route Shift** - The journey time benefits brought by HOV lanes might attract HOVs currently using other corridors to reroute. The reverse could also happen to General Traffic (GT), especially if the HOV facility is converted from a General Purpose (GP) lane.
- **Public acceptance** - Public acceptance is important due to political reasons. A technically successful scheme does not necessarily have public support. It needs to be emphasised that HOV lanes do not have to look full to be effective and queuing traffic on GP lanes does not mean that HOV lanes are ineffective.
- **Safety** - Studies from the US suggested that there is no adverse effect on safety conditions that could be attributed to HOV lane operation. But HOV lanes in the US are quite different in scale and context relative to those built so far in the UK. A target should be set for accident rates within HOV lane, they should be equivalent to those occurring in the adjacent GT lanes based on the comparison of vehicle miles travelled.
- **Air pollution** - Based on previous studies, it has been found that the impact of HOV lane on air pollution is minimal because the total numbers of vehicles have not changed significantly. Although the air quality is unlikely to see any improvement caused by a HOV lane, it will certainly improve energy efficiency, as person throughput would be higher than without HOV lane.

3.5.2 Auckland, New Zealand

Currently, both Auckland Transport and the New Zealand Road Transport Agency (NZTA) are utilising both T2 and T3 HOV lane configurations on a number of corridor including:

- Tamaki Drive, T2 Lane;
- Akoranga Drive, T2 Lane;
- Constellation Drive, T2 Lane;
- Shakespeare Road, T2 Lane;
- Onewa Road, T3 Lane;
- Forrest Hill Road, T2 Lane;
- East Coast Road, T2 Lane; and
- Lake Road, T3 Lane (Connects to Onewa Road).

In addition to the above, a number of the ramp metered on - ramps along State Highways 1, 16 and 18 all have T2 HOV lanes that operate during the AM peak period between 7am and 10am. The lanes provide priority for buses over queuing traffic, HCV's, motor bikes and private vehicles carrying two or more occupants when accessing the State Highway network. As well as the HOV lanes, Auckland has implemented a number of bus lanes within the CBD region and also a segregated busway that provides a dedicated public transport corridor linking the area of the North Shore to the CBD.

There are no current studies that have identified the level of compliance specifically on the HOV lanes of T2 / T3 configuration in Auckland. However, driver compliance of bus lanes in Auckland has been consistency high between 97-98% (AT, 2011)

3.5.3 US

HOV lanes were first implemented in the United States in the 1960's in Virginia, New Jersey and California. Most of the earliest projects were bus-only lanes to alleviate congestion associated with nearby road construction projects. In the 1970's many new HOV lanes were designed for 4 or more and 3 or more occupants per vehicle (HOV-3 and -4) as federal law required at least HOV-3 on interstate highways. In response to evolving travel patterns, the law was changed in 1987 to allow HOV-2. At that time, the majority of HOV-3 facilities converted to HOV-2. Today, a great majority of US HOV lanes permit use by HOV-2 vehicles (Fuhs and Obenberger, 2002).

In 2005, a Transport Research Laboratory report entitled *'Literature review of HOV Lanes' stated that* US HOV schemes primarily exist in three formats:

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- **Separated flow HOV lanes** – these lanes are usually separated from the general purpose lanes by either a physical barrier or very wide painted strip of road usually known as a buffer. These HOV lanes are most commonly reversible flow lanes to help ease the morning traffic into, and the evening traffic out of an area. They are also used for two-way traffic, and often have their own merge / diverge ramps;
- **Contra Flow HOV lanes** - Contra-flow HOV lanes use an existing lane on the off-peak carriageway for traffic in the peak direction. This is usually the offside lane. A moveable barrier is used to separate the contra-flow and GP lanes during peak hours. This type of lane is generally a bus only lane, however, HOV versions exist in several locations including Honolulu, New Jersey and Boston. Contra-flow lanes generally operate in peak hours only. Often overhead signals on gantries are used to indicate that the lane is in operation. Signs carrying information on the operating times are located at merge points to the road and also reminders are placed along the carriageway; and
- **Concurrent Flow HOV lanes** - The most common design of HOV lane is a concurrent flow lane. This is a lane in the same direction of travel as the GP lanes on the same carriageway. Like the contra-flow lanes, it is usually the offside lane. It is not physically separated from the general purpose (GP) lanes, but rather there is a narrow buffer, or markings on the road. Concurrent flow lanes are often referred to as diamond lanes because of the markings on the road.

Table 3 summarises typology of US HOV lanes determined by TRL.

Table 3 Typology of US HOV lanes

Type of HOV lane	% of US schemes
Separated Flow	15%
Contra flow	5%
Concurrent Flow	80%
24 hours	30%
Peak hour only	70%

The TRL report found that there were ‘136 HOV schemes in the USA, in 19 different states, covering 1139 miles (1256 lane miles), and a further 105 proposed sites covering 966 miles (1970 lane miles)’. These number include mostly freeway limited access lanes that were developed with federal funds. There are is no comprehensive inventory of HOV lanes on arterials and other non-limited access roads in the US.

Over the last forty years, many US HOV facilities have changed in both physical form and policies such as minimum number of occupants and operating hours. Most changes have been in response to changing travel patterns, however public interest in traffic issues is strong, and has sometimes played a role. According to Fuhs and Obenberger (2002), up to 5 percent of HOV lanes implemented in the US since 1969 have been converted into general purpose lanes.

To assist with managing the growing inventory of HOV lanes, the Federal Highway Administration, together with many of the States’ transport agencies, has published a guide to considering occupancy requirements and operating hours for new and existing HOV facilities (US FHWA, 2003) The guide advises that vehicle occupancy requirements “should be maintained at a level that will encourage use of the facility and the formation of new carpools, but that will not create a demand level that would make the lane congested.” (p. 5). For operating hours, the guide offers benefits and limitations of different opening hours scheme, and highlights the importance of both user understanding and public perception of the HOV facility.

The US Transit Cooperative Research Program (2006) of the Transportation Research Board publishes the standard reference transit service planning, the Transit Capacity and Quality of Service Manual. The TCQSM evaluates HOV lanes for their suitability for providing transit service. The summarised guidelines generally require 40 to 60 buses per hour for bus lanes on free flow facilities, and 30 buses per hour for curb side bus lanes and 60 buses per hour for median bus lanes on arterial roads (pp. 4-35 to 4-37). **Table 4**Table **5** illustrate the guidance.

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Table 4 General Planning Guidelines for Bus Preferential Treatments: Uninterrupted Flow Facilities (Excerpt)

Treatment	Minimum one way peak hour bus volumes	Minimum one way peak hour passenger volumes	Related land use and transportation factors
Exclusive busways on special right of way	40-60	1600-2400	Urban population – 750000 CBD employment: 50000 1.85 million m^2 CBD floor space congestion in corridor; save buses 0.6min/km or more
Exclusive busways within freeway right of way	40-60	1600-2400	Freeways in corridor experience peak hour congestions; save buses 0.6min/km or more
Busways on railroad right of way	40-60	1600-2400	Potentially not well located in relation to service area. Stations required.
Freeway bus lane, normal flow	60-90	2400-3600	Applicable upstream from lane drop. Bus passenger time savings should exceed other road user delays. Normally achieved by adding a lane. Save buses 0.6min/km or more
Freeway bus lanes, contraflow	40-60	1600-2400	Freeways with six or more lanes. Imbalance in traffic volumes permits freeway LoS D in off peak trave direction. Save buses 0.6min/km or more.

Table 5 General Planning Guidelines for Bus Preferential Treatments: Urban Streets

Treatment	Minimum one way peak hour bus volumes	Minimum one way peak hour passenger volumes	Related land use and transportation factors
Bus Street pr malls	80-100	3200-4000	Commercially orientated frontage
CBD curb bus lanes, main Street	50-80	2000-3200	Commercially orientated frontage
Curb bus lanes, normal flow	30-40	1200-1600	At least 2 lanes available for other traffic in same direction
Median bus lanes	60-90	2400-3600	At least 2 lanes available for other traffic in same direction; ability to separate vehicles turn conflicts from buses
Contraflow bus lanes short segments	20-30	800-1200	Allow buses to proceed on normal route, turnaround, or bypass congestion on bridge approach
Contraflow bus lanes, extended	40-60	1,600 – 2400	At least 2 lanes available for other traffic in opposite direction. Signal spacing greater than 150m intervals

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Case Study: El Monte Busway (US FHWA, 2003a)

The history of the El Monte busway in suburban Los Angeles is illustrative of the considerations, changes, and outcomes that have come into play in 4 decades of US HOV usage. The busway opened in 1973 on the San Bernardino (I-10) Freeway. Soon after opening, In 1976, the busway was opened to HOV-3 carpools. In 1999, the California Legislature lowered the vehicle-occupancy requirement to HOV-2. In 2000, the vehicle-occupancy requirement was changed back to HOV-3 during the morning and afternoon peak periods and HOV-2 at all other times.

A monitoring program tracked travel speeds, vehicle volumes, and person movement on both the busway and the general-purpose freeway lanes. Overall, lowering the vehicle-occupancy requirement from 3+ to 2+ full time had a detrimental effect on the busway. At the same time, significant improvements were not realized in the general-purpose freeway lanes. Travel speeds in the busway declined from free flow conditions over 100 km/h to approximately 40 km/h in the peak periods, with no corresponding increase in speed in the general-purpose lanes. Vehicle flow increased, but passenger flow decreased. Bus operating speeds, travel times and on-time performance were also negatively impacted.

Effects on Vehicle Occupancy

A review of 22 HOV facilities in the United States found that HOV lanes may help to increase vehicle occupancies in the corridors in which they operate. AM peak hour vehicle occupancy for the HOV and general purpose lanes combined increased, on average, 9 percent after HOV facilities were implemented (TCRP, 2006).

Managed Lanes

Similar to the progression from exclusive busways to HOV-3 and HOV-2, US transport officials are currently seeking to utilise excess capacity through "managed lane" arrangements which allow varying vehicle occupancies through pricing and time of day restrictions.

One application of managed lanes is High Occupancy Toll (HOT) Lanes, which allow single occupancy vehicles (or HOV-2 vehicles where HOV-3 is required) pay a toll use high-occupancy lanes. Toll pricing can be adjusted (via a schedule or in real time) to maintain free flow conditions in periods heavy traffic. HOT lanes can be implemented through conversion of general purpose or HOV lanes, or by new construction. As of 2003, there were four HOT lane facilities operating in the United States (US FHWA 2003):

- State Route 91 (SR 91) Express Lanes – Orange County, California: a 10-mile, four lane, HOT facility located in the median of an existing highway.
- I-15 FasTrak – San Diego, California: converted from an eight-mile 2-lane HOV facility to a peak-period reversible HOT.
- Katy Freeway QuickRide – Harris County, Texas: a 13-mile, 6-lane freeway with a 1-lane reversible median HOT lane which initially operated at HOV 2.
- Northwest Freeway (U.S. 290) QuickRide – Harris County, Texas: a one-lane, barrier-separated, 15.5 mile, reversible HOT lane, converted from HOV in 2000.

By 2007, three new HOT lane projects were opened(Fluor/Transurban/VDOT):

- MN 394 in Minneapolis, Minnesota
- I-25 in Denver, Colorado
- I-15 in Salt Lake City, Utah

Currently, HOT lanes (both new facilities and retrofits of existing HOV lanes) are being considered by in many metropolitan areas. Promotional literature for a HOT lane project to add capacity to the Washington, DC Beltway (Fluor/Transurban/VDOT) indicates that 17 HOT projects are in development across the United States.

Another current issue is allowing low emission vehicles such as electric vehicles and hybrid electric vehicles into managed lanes. This has been particularly popular in California and in the Virginia suburbs of Washington, DC. Federal legislation in 2005 stipulated that the low emission vehicle qualification must be revoked where HOV lanes were experiencing average speeds below 45 miles per hour (72 km/h) for more than 10% of operating periods. A recent study (Jang and Cassidy) has found that removing low emission vehicles from HOV lanes will decrease both vehicle and passenger throughput in a managed lane corridor by decreasing speeds in general

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purpose lanes to such an extent that friction from general purpose lanes further degrades speeds in the HOV lanes. The study was widely discussed both in traffic management circles and in the popular press.

3.5.4 UK

The UK has a variety of HOV lane configuration to assist in managing vehicle movements on the transport network across the country. Despite HOV lanes in the form of T2 / T3 configuration being a relatively new concept to the UK (first introduced in Leeds in 1998) they now form part of a wide range of managed lanes that are used to manage vehicles movements across the UK. **Table 6** provides a summary of the typical types of managed lanes that are now visible on the UK road network and the vehicles that are permitted to use these facilities.

Table 6 Summary of the available HOV facilities seen on the UK transport network and permitted vehicles for their use

	Bus	Coach	Motorcycle	Cycle	Light Goods Vehicle	Heavy Goods Vehicle	Taxi	Cars	High Occupancy Vehicle (2+)
Bus Lane (London)	✓	*Varies*	✗	✓	✗	✗	✓	✗	✗
Bus Lane (City of London)	✓	*Varies*	✗	✓	✗	✗	✗	✗	✗
Bus Lane (Bristol)	✓	✓	✓	✓	✗	✗	✓	✗	✗
Priority Vehicle Lane (Nine Elms Lane)	✓	✗	✗	✓	✗	✓	✓	✗	✗
No Car Lane (Newcastle)	✓	✓	✓	✓	✓	✓	✓	✗	✗
High Occupancy Vehicle Lane (Leeds)	✓	✓	✗	✓	✗	✗	✓	✗	✓
High Occupancy Vehicle Lane (Bristol A4174)	✓	✓	✓	✓	✗	✗	✓	✗	✓

As illustrated by **Table 6** there are now two fully implemented and operational T2 facilities within the UK a summary of which has been provided within the next two sections of this report.

3.5.4.1 Leeds

Context

In 1998, the UK's first HOV lane in the form of a T2 configuration was introduced on the A647 Stanningley Road and Stanningley By-Pass which form the principal radial route to the west of Leeds City Centre and are part of the route linking Leeds and Bradford (see **Figure 6**). The scheme was experimental at first but has since become permanent. The road experiences severe congestion during the peak period and there were few public transport priority measures. The HOV lane scheme was a total of 1.5km in length along a 2.0km stretch of dual carriageway in two sections. The HOV scheme operated in both peak periods, in the morning (07:00 – 10:00) and evening (16:00 – 19:00) during the usual working week Monday to Friday. The HOV lane was only for use by buses, coaches, other vehicles carrying two or more people, motorcycles and pedal cycles are allowed on these lanes (HGVs over 7.5T are not permitted). (TRL, 2005, Leeds University 2011).

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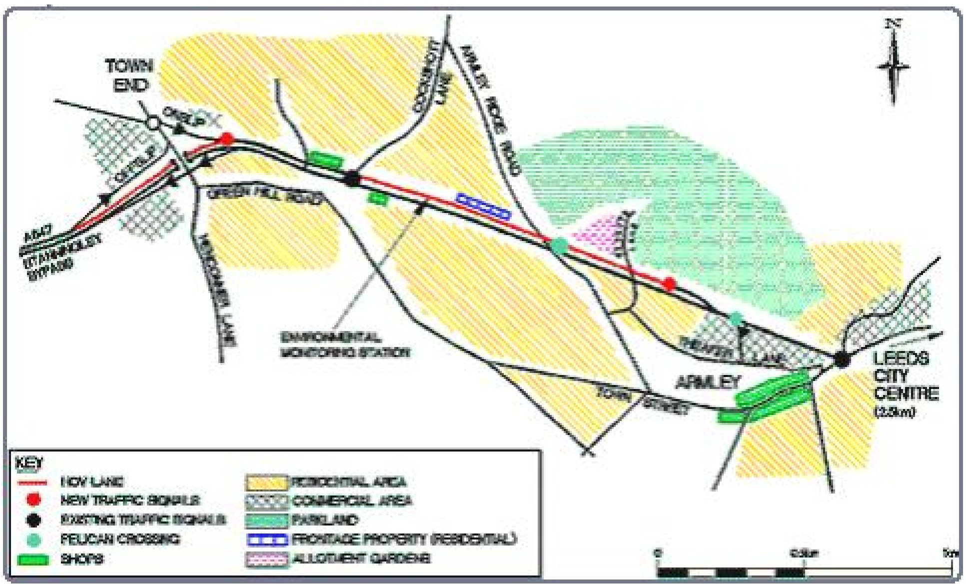

Figure 6 **Location of the A647 HOV Scheme in Leeds (*source: Leeds University*)**

Figure 7 – 8 illustrate the HOV scheme that was implemented in Leeds in 1998.

Figure 7 **Illustration of the Leeds T2 facility (*source: JMP Consultants Ltd via Leeds University*)**

Figure 8 **Illustration of the Leeds T2 Facility signage (source: Leeds University)**

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Figure 9 **CCTV picture of new facility**

Impacts on demand

Leeds University (2011) reports that prior to implementation of HOV lane, 30% of cars on the A647 (Stanningley Road) had 2 or more occupants. With the inclusion of buses, one-third of all vehicles carried two-thirds of all people (2225 of 3645) in the morning peak period. The journey in free flow conditions could take about 3 minutes, regularly had taken over 10 minutes. Therefore a priority lane such as an HOV lane would benefit a majority of the travellers in terms of journey times. However single occupant drivers (total of 1420) would be expected to suffer some additional delay due to capacity reduction caused by the HOV lane.

To complete an analysis on the effectiveness of the HOV lane a 'Before' survey that took place in May and June 1997 and 'After' survey that took place in May and June 1999. The data that was collected during these surveys included:

- traffic counts in the morning and evening peak periods;
- vehicle occupancy;
- journey times;
- queue lengths; and
- Personal injury accidents.

Leeds University (2001) continued to say that in addition to the above surveys, public attitudes and driver behaviour information were analysed from household and roadside interview surveys. Air quality was monitored by an environmental monitoring station on the route.

Table 7 provides a detailed summary of the results of the before and after surveys and analysis done by Leeds City Council (Leeds University, 2011). Leeds Council reported that, after an initial reduction, traffic levels gradually increased to its previous levels with about 5% increase in HOVs. This might indicate that there was an exchange of HOV and non-HOV traffic between the A647 and parallel routes. On the other hand, 26% of HOV interviewees were apparently new car pools and cited the HOV lane as the reason for forming them. Relatively low support amongst HOV drivers (about 66%) might have resulted from the fact that these drivers also made peak period journeys as non-HOV drivers. When doing so, they did not benefit from the journey time savings observed.

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Table 7 Leeds HOV lane impacts (Bus Priority Initiative case study, (LCC, 2002))

Indicators	Results
Morning Peak Traffic Flows (7am – 10am)	- Immediately after opening 20 % traffic reduction (due to driver avoidance). - By late 1999, traffic flows returned to prior levels. - Sight increase in scheduled bus services, motorcyclists and cyclists.
Evening peak traffic flows (4pm to 7pm)	- 10 % reduction at scheme inception. - By June 1999, traffic flows returned to the 'before' level. - By June 2002 traffic flow increased by a further 14%.
Occupancy and mode share	- Between 1997 and 1999, HOVs in AM peak period increased by 5%. - Average car occupancy rose gradually from 1.35 in May 1997 to 1.43 by June 1999 and 1.51 in 2002. - Bus patronage increased by 1% in the first year of operation (There are indications of further growth in bus patronage since 1998 but no real data available to analyse).
Journey Times	- AM peak journey time savings for buses and other HOVs were 4 minutes (comparing 1997 to 1999 data) - Reduction of One minutes in non-HOV journey times in the same period.
Queue Lengths	- By giving priority to HOVs, two queues of equal length have been transformed into a long queue in the non-HOV lane and a short queue in the HOV lane. - No evidence of non-HOV queues extending.
Accidents	- Reduction of 30 % in casualties in a period of three years after scheme implementation.
Enforcement	- Lane violation levels were low in the months following implementation. - In 2002, lane violation levels were still less than 6 % despite a relaxation of enforcement.
Public Attitudes	- An increase from 55% to only 66 % in HOV drivers support for HOV lane (results from roadside interviews in 1999).
Air Quality	- Little change in air quality. - A noticeable noise reduction coinciding with both the morning and evening periods of HOV lane operation.

(source: Leeds University (2011))

Figure 10 illustrates the Journey Time savings that were achieved with the implantation of the new HOV facility. Leeds University (2011) report that in 1998, morning peak HOV journey time savings were 3½ minutes for a 5km trip from the Leeds Outer Ring Road to the Inner Ring Road. In 1999, the time saving increased to just over 4 minutes. The figure also indicates that the journey time savings starts after the first 2.5 -3 km and changes sharply from time lost to time gain.

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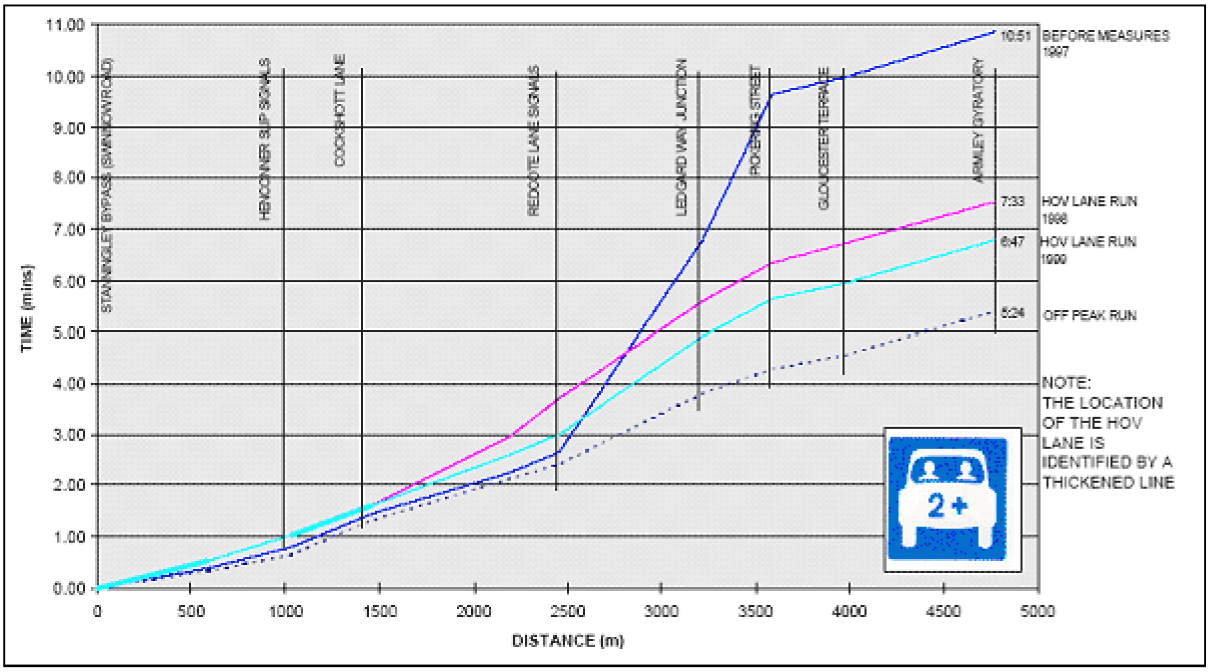

Figure 10 **A647 AM peak HOV journey times *(source: Leeds University 2011)***

Figure 11 illustrates the journey time change for vehicles travelling in the general purpose lanes (outside lanes) within same sections of A647. In 1999, overall inbound non-HOV journey times did not increase and were total of 1½ minutes shorter in the morning peak for the same 5 km long journey.

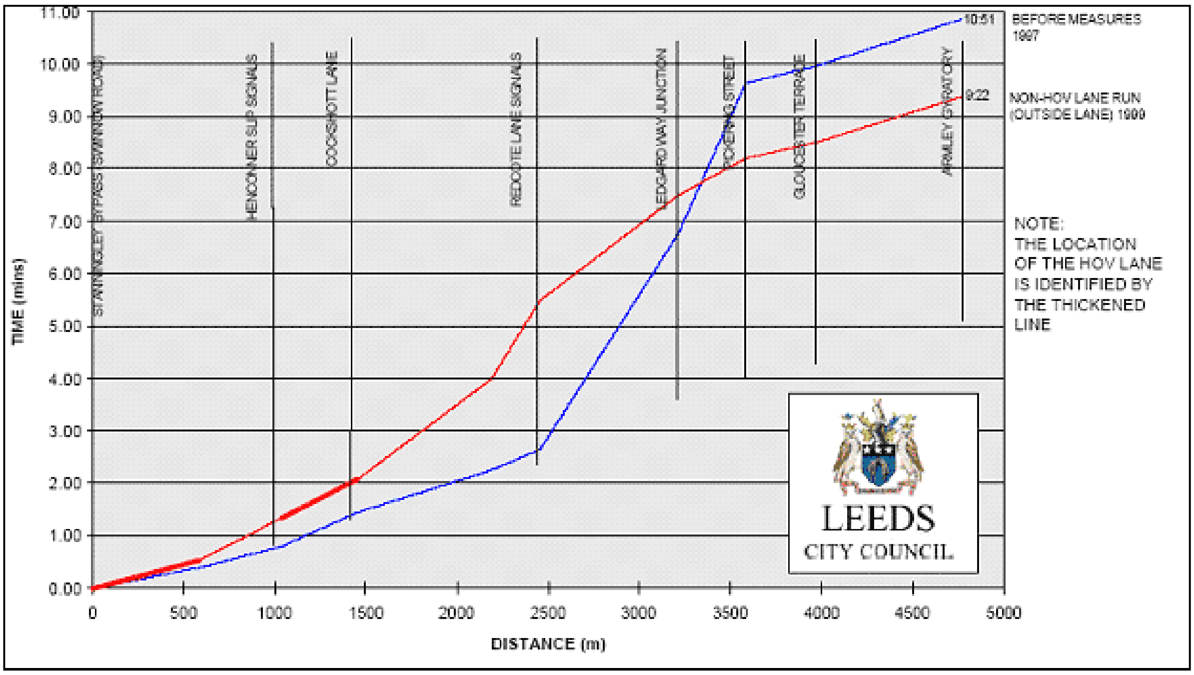

Figure 11 **Journey Time change in the general purpose lane (source: Leeds University (2011)**

3.5.4.2 Bristol

TRL (2005) and Leeds University (2011) have both reported on the success of the HOV lane implemented on the congested dual two-lane Avon Ring Road near Bristol. The local South Gloucestershire Council wanted to implement a bus lane in the first instance but bus frequencies were too low to justify reallocating road space to buses alone. As a result in 1998 the local council opened an HOV lane for buses, taxis and cars with 2+ occupants with HGV's over 7.5 tonnes excluded. This 2+ HOV lane is approximately 1.75km in length and operates in one direction in the morning peak only.

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Table 8 illustrates the average vehicle occupancy since the implementation of the HOV scheme in Bristol.

Table 8 Average vehicle occupancy since scheme opening

	3+ occupants	2+ occupants	SOV
Before	3%	17%	80%
After	2%	28%	68%

The lane has led to an increase in efficiency and as a result the proportion of SOV's has fallen from 80% to 68%, and traffic levels have increased by 10% (as a result of vehicles re-routeing from parallel roads) as the lane has 'smoothed' flows and allowed higher throughput.

Leeds University (2011) report that journey times for all vehicles has fallen from 20 minutes to 6 in the HOV lane and 12 in the mixed use lane.

3.6 Conclusions

To summarise, the network and availability of managed lanes or HOV / Transit lanes as they are more commonly known in Australia has expanded significantly in both Australia and the rest of the world since Shoukrallah's report completed in 1993. In 1993, whilst the concept of a HOV lane in the form of a bus lane had been around for many years the concept of a transit lane in a T2 / T3 configuration was still a relatively new concept outside of the US. Australia was only just beginning to implement their first form of transit lanes (T2 / T3) across the major cities of Sydney, Brisbane and Melbourne. In the UK, the first transit lane (T2 / T3) was not introduced until 1998 and the network of transit lanes still remains very small limited to just two different locations Leeds and Bristol. On the other hand, the network of transit lanes in the US has continued to expand significantly and now stands in the region of 136 HOV schemes which are implemented in 19 different states, covering a total of 1139 miles (1256 lane miles) with a further 105 proposed sites covering 966 miles (1970 lane miles). This is a significant expansion in the availability of transit lane network from what was 340 miles reported by Shoukrallah in 1993.

For many countries the use of HOV / Transit lanes is now common within their transport network and is a form of travel demand management utilised to provide vehicles with higher occupancies a quicker and more efficient journey between their origin and destination. Since 1993, the use of transit lanes has expanded from just providing priority along a congested corridor to providing priority to strategic sections of the network, priority through intersections and priority to CBD of large Cities. In New Zealand, they have combined the use of transit lanes with ramp metering to provide transit vehicles with priority to strategic parts of the network such as the State Highways.

In Australia, the network of transit lanes has grown significantly since 1993:

- Sydney: network has expanded to 53km of HOV lane facilities;
- Melbourne: network has expanded to include new T2 lanes on Hoddle Street and Tullamarine Freeway;
- Brisbane: network has expanded significantly and includes no fewer than six new T3 and eleven T2 facilities;
- Gold Coast: was not featured in the 1993 review however now has a T2 facility starting at Steven Street in Southport and running to Harley Street in Labrador and a new T3 facility on Smith Street in Southport;
- Perth: no change since 1993; and
- Adelaide: extensive amount of bus Lane and bus priority measures, no T2/T3 or T4 facilities identified.

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4.0 Existing Situation

4.1 Background

Since 1993 Canberra's population has grown significantly from 290,000 to 363,000 in 2011 (ABS, 2011) which is approximately a 20% growth over the past 18 years. The transport system remains largely based on the urban structure of the City as reported by Shoukrallah (1993). Since 1993 there has been extensive expansion of the Canberra primarily with the development of Gungahlin but also the current development within Molonglo.

As reported in 1993, Canberra still remains a very car dependant City – although the whole structure of Canberra was based on a high quality, high speed intertown public transport system and employment self containment within each of the town centres. The 2006 census reported that approximately 70% of journeys to work were taken either by car as a driver or by car as a passenger (ABS, 2011). Although this level of vehicle dependence is high compared to the other capital cities (Brisbane, Perth and Adelaide) it is low when compared to cities of comparable scale such as Wollongong, Newcastle, Gold Coast, Sunshine Coast etc. There are many reasons for the increase in car dependency including changing social needs with younger families availing themselves of child care which necessitates drop off and pick up of children, increasing proportion of linked trips and changes in social networking and the incomplete integrated public transport network which currently only has sections of the network with all of the required infrastructure such as new routing and bus lanes in place to provide public transport priority. Many of these elements are currently being implemented under the proposed network 12 proposals and the Transport for Canberra Projects. However there are signs of Canberra experiencing congestion during the AM and PM peak periods with traffic flows remaining constant for more than an hour on key Canberra roads such as Northbourne Avenue and Parkes Way.

The first bus lane in the ACT was installed on Adelaide Avenue in 1974 as a policy measure to generate increased public transport usage. The measure saved over 5 minutes off the Woden to City journey – partly due to the elimination of the bus stops on Hopetoun Circuit for the intertown routes. The measure required the first change to ACT legislation to provide for bus only lanes.

4.2 Existing Travel Demand Measures

Since the previous report into Transit Lanes in 1993, travel demand measures have expanded significantly in Canberra. These measures include bus lanes, park and ride, parking pricing and the ACT parking Vehicle and Access general code reducing car parking requirements in the town centres.

4.2.1 Bus Lanes

In 1993 there were four bus lane facilities in operation across Canberra these included:

- A separate right of way facility parallel to Joynton Smith Drive; and
- Bus lanes along
  - Athllon Drive between Sulwood Drive and Beasley Street and
  - Adelaide Avenue from Capital Circle to Cotter Road overpass.
- Short bus lane on Commonwealth Avenue at the Albert Hall
- Exclusive bus roads in the City, Belconnen and Woden bus interchanges

Today there are currently 8 bus lane installations and one t2 lane in operation this includes:

- A continuous concurrent flow T2 lane along Adelaide Avenue / Yarra Glen / State Circle;
- A continuous concurrent flow dedicated bus lane inbound along Barry Drive
- Inbound bus lane on Flemington Road
- A short bus only lane along Northbourne Avenue at the intersection with Barton Highway
- Bus lane and B signal on Belconnen Way at GDE inbound
- Exclusive bus lane outbound on Belconnen Way at GDE
- Short bus lane and B signal for outbound buses at Clunies Ross Street / Barry Drive

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- Short bus lane and B signal at College Street / Haydon Drive
- Short bus only approach lanes on Athllon Drive at Drakeford Drive
- A bus lane along Barry Drive between Fairfax Street to Clunies Ross Street.

However the Joynton Smith Drive section that was present in 1993 has been decommissioned and closed due to changes in Belconnen Town Centre road network and the Westfield's expansion. There are also a number of projects and studies currently being undertaken in line with the Transport for Canberra program, including:

- Bus lanes along Barry Drive from Clunies Ross Street to the City via a bus only station in ANU Exchange (this is currently in design and construction);
- City to Belconnen transit Priority (Feasibility Study currently ongoing);
- Transit Priority measures for Canberra Avenue (currently in design and part construction);
- City to Gungahlin Transit Corridor (light Rail / bus rapid transit feasibility study ongoing);
- Freeway stops feasibility for Adelaide Avenue; and
- Flemington Road bus priority (Gungahlin to Mitchell forward design).

4.2.2 Park and Ride

In 1993, Canberra had four designated Park and Ride (P&R) in Belconnen, Woden, Tuggeranong Town Centre and Jamison Shopping Centre which were reported to be moderately successful. There was also ambition to utilise suburban car parks in Woden and Tuggeranong as unofficial P&R locations and these were established in 1992.

Today, Canberra currently has twelve designated P&R locations at locations across the City including:

- Charnwood Centre;
- Belconnen Town Centre;
- Kippax Centre;
- Jamison Centre;
- Curtin Shops;
- Woden Town Centre;
- Kambah Centre;
- Tuggeranong Town Centre;
- Kambah Village Shops;
- Mawson;
- Chisholm Shops; and
- Calwell Shops.

In addition to the above a number of site have been earmarked to host park and ride facilities and these include:

- Kippax expansion, Moyes Cr;
- Belconnen, Purdue St;
- University of Canberra, College St;
- Mitchell, Well Station Dr;
- Molonglo, Kitkpatrick St;
- Erindale, Ricardo St; and
- Calwell Expansion, Webber St.

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4.2.3 Bike and Rides

In 1993, there were no Bike and Ride (B&R) locations in Canberra. Today, Canberra now has a number of recognised B&R locations at locations across the City which are displayed in **Figure 12.**

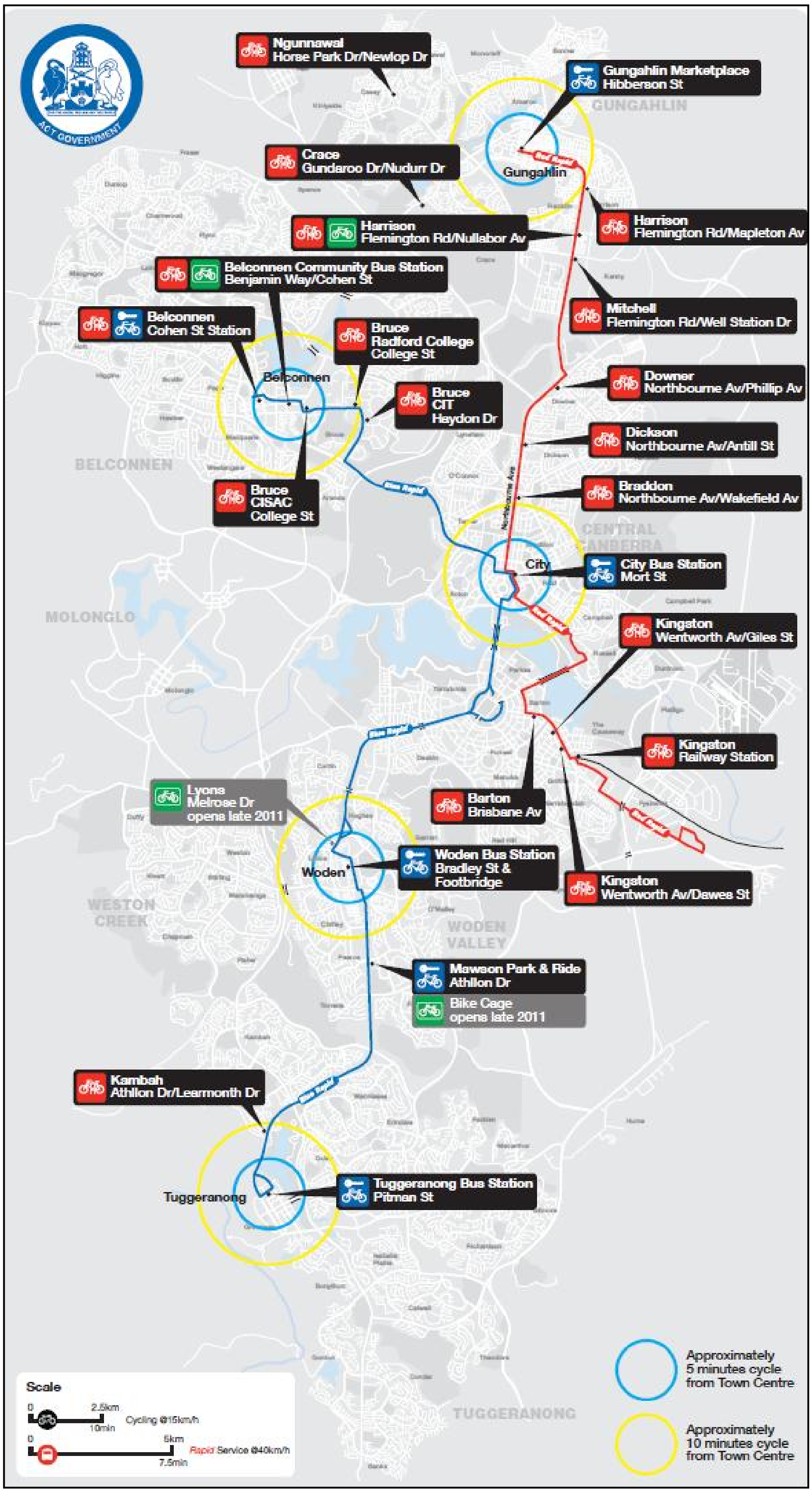

Figure 12 Existing and future bike and ride location in Canberra

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4.2.4 Parking

The first paid parking area in Canberra was introduced in Canberra City in 1974. It was introduced to control the duration of short stay parking. Today all Town Centres (excluding Gungahlin) have paid parking either publicly owned or private parking structures. However there is still free parking at key employment centres of Parkes, Barton and Russell that are contributing to traffic generation and resultant congestion.

The pricing of public parking tends to have been set at values not associated with travel demand reduction. Combined with this trend the supply and control of parking has tended to shifted from the public to the private sector.

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5.0 Vehicle Occupancy and Journey Time Surveys (Example Sites)

5.1 Introduction

The ACT Government commissioned and compiled Vehicle Occupancy and Journey Time Surveys along Flemington Road to understand the way in which the roads are being used and the balance of vehicles and passengers. In addition, AECOM commissioned ISG to carry out and compile Vehicle Occupancy Surveys and Journey Time Surveys along Adelaide Avenue and Barry Drive to further understand the balance of vehicles and passengers on two further corridors that could potentially host a HOV lane. A summary of these surveys is provided within this chapter and this data will later be used to assess the potential and need for the corridors to host HOV lanes in the form of T2 or T3 configuration.

5.2 Flemington Road

Flemington Road is a key corridor linking the areas of North Canberra to the CBD via Northbourne Avenue. The corridor is four lanes wide between Gungahlin and Mitchell which then forms a single lane carriageway northbound between Northbourne Avenue and Randwick Road a two lane (1 bus lane and 1 general traffic lane) southbound between Sandford Street and Northbourne Avenue. Bus priority signals are provided at the Flemington Road / Northbourne Avenue intersection to give buses a jump start n the general traffic lanes.

Currently, the corridor is largely uncongested during the peak hours with very little queuing and congestions along the length of the corridor. However, it is worth noting that the area to the north of Canberra is largely undeveloped and it should be noted that once all the development in areas such as Gungahlin, Harrison and Franklin are complete traffic across the area is likely to grow significantly.

5.2.1 Survey Results

Vehicle Occupancy and Journey Time Surveys were undertaken along Flemington Road by the ACT Government and the result provided to AECOM on the 24th of November 2011. The surveys were undertaken during 1.5 hours of the AM (7:45 – 9:15) Peak Period and **Table 9** illustrates the results of the vehicle occupancy counts.

Table 9 Summary of the Vehicle Occupancy Surveys for Flemington Road

TIME INTERVAL	CAR (1)	CAR (2)	CAR (3+)	TRUCK	TAXI	M/C	BUS	TOTAL
7:30-7:45	211	63	11	10	3	5	7	**310**
7:45-8:00	207	66	11	9	3	5	6	**307**
8:00-8:15	174	75	18	7	0	6	5	**285**
8:15-8:30	174	85	32	9	1	4	4	**309**
8:30-8:45	199	69	28	8	0	5	6	**315**
8:45-9:00	233	54	9	6	2	3	6	**313**
Total 1 hour flows	**780**	**283**	**87**	**30**	**3**	**18**	**21**	**1222**
Total vehicles over survey period	**1198**	**412**	**109**	**51**	**9**	**28**	**34**	**1841**
Persons	**1198**	**824**	**327**	**51**	**18**	**28**	**2050**	**4496**

The results illustrates that the majority of vehicles (65%) travelling along Flemington Road during the AM peak period are of single occupancy. Approximately 28% of private vehicles (cars) travelling along the corridor during the AM peak period have a vehicle occupancy of two or more persons per vehicle. The average vehicle occupancy of passenger vehicles on Flemington Road is 1.37. This is significant because the 2006 ABS Census showed that the average vehicle occupancy of passenger cars for journey to work trips was 1.14 thus indicating about one person in every four vehicles may be a student or person on non work related trips.

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Thus for a two lane road of which one lane is a Transit Lane one could expect that the transit lane would carry 30% of the traffic and the general purpose lane 70%. If the general purpose lane is full at say 1800 vph then one would expect that the Transit Lane would then carry 770 vph. This is at the upper end of LoS C.

The results of the journey time surveys are illustrated in **Table 10.**

Table 10 Summary of the Journey Time surveys for Flemington Road

Sandford St to Northbourne Ave (1.45 km)	Traffic Lane (sec)	Bus Lane (sec)	Time Saving (Sec)
7:45am	85	87	- 2
7:50am	90		3
8.15am	115		28
8:20am	100		13
8:50am	95		8
9:00am	90		3
Average Travel Time	**95.8**		**8.8**
Average Speed	**54.5 km/h**	**60 km/h**	

The results of the journey time analysis illustrate that there is a very minor difference between the observed journey times in the general traffic lane and the bus lane. The surveys show that the bus lane is approximately 9 seconds and 6km/h quicker than the general traffic lane over a distance of 1.3km during the AM peak period.

5.2.2 Analysis

The results of the surveys completed during both the AM peak period along Flemington Road would suggest that currently the designated bus lane that stretches for approximately 1.3km for the length of the corridor provides little journey time savings to the users when compared to the general traffic lanes. However, the bus lane does provide the user with a reliable travel time and consistent travel speed for the duration of the corridor and as the surveys suggest this does not occur within the general traffic lanes; where there is a difference of approximately 30 seconds between the quickest and slowest journey time along the corridor.

The private car is clearly the dominant mode of travel constituting 93.4% of all vehicles, public transport buses make up 1.8 %. A total of 1770 private vehicles carried 2400 occupants in the median lane, giving rise to an average occupancy rate of 1.36. It is of note that this is significantly higher than surveys conducted in the 70's when the average vehicle occupancy was about 1.2.

ACTION advised that 34 buses carried approximately 2050 passengers during the survey period (assuming 90% occupancy) and experience verifies these loading levels. The investigation assumed that all HOV lane (T2 or T3) eligible vehicles will use such a lane, if it was introduced. The results of lane utilisation by vehicles and persons for the three scenarios; i.e. bus lane, T2 HOV lane and T3 HOV lane are as follows:

Table 11 Summary of eligible vehicles by HOV Facility type

TOTAL			BUS/HOV LANE ELIGIBLE				BUS/HOV LANE NON-ELIGIBLE			
VEHICLES	PERSONS	Lane Type	VEHICLES		PERSONS		VEHICLES		PERSONS	
			No.	%	No.	%	No.	%	No.	%
1841	4496	BUS	71	3.9	2096	46.6	1770	96.1	2400	53.4
		T3	180	9.8	2423	53.9	1661	90.2	2073	46.1
		T2	592	32.2	3247	72.2	1249	67.8	1249	27.8

Note includes motor cycles and taxis in estimate for bus lane

Currently, buses constitute a small percentage (1.8%) of all vehicles on Flemington Road, yet they carry about half (46.6%) of all persons travelling on Flemington Road. If a T3 HOV lane was introduced, it will carry a slightly

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higher percentage of vehicles (9.8%) and persons (53.9%). It is unlikely that such an arrangement would impact on buses travel times and timetables.

However, if a T2 was introduced about 600 vehicles or approximately 1100 persons would be eligible to use the lane. Austroads indicates in Guide to Traffic Management Part 3 that the maximum flow rate for level of Service B is approximately 720 vehicles per hour for a 70 km/hr road and 830 vehicles per hour for an 80 km/hr road. Austroads reports that at this flow rate the average speed is still 70 km/h hence there should be no impact on bus travel times under ideal conditions at this time. However as Gungahlin grows the number of eligible vehicles to use the T2 lane will increase and in the future it is likely that the demand will reduce bus travel speeds.. .

Furthermore, a bus stop is currently located (within the bus lane) near the entrance to EPIC on this section of Flemington Road. During the time of the surveys, no buses used this stop. There was, therefore, no interruption to traffic on that lane. The success of the current Park and Ride facility that has been established opposite EPIC will be dependent on buses being able to stop at this location. Although an indented bus bay would be appropriate for the number and frequency of stopping buses, indented bays are generally only provided where there is a bus lane adjacent to the bus bay. A flow rate of 770 vph at LoS B would adversely impact on the ability of a bus within the indented bay re-entering the traffic stream. This may result in unsafe weaving manoeuvres in and out of the lane to avoid a stationary bus at this location.

5.3 Barry Drive

Barry Drive is a very busy road carrying about 3200 -3300 vehicles per hour in the AM peak hour. Although currently relatively free flowing at these traffic levels minor incidents can result in significant traffic disruption. The greatest delays occur at the intersection of North Road / Barry Drive and Mc Caughey Street.

5.3.1 Survey results

Vehicle Occupancy and Journey Time Surveys were undertaken on Wednesday 14th of December during the AM (7:45 – 9:15) Peak Period along Adelaide Avenue. **Table 12** illustrates the results of the vehicle occupancy counts.

Table 12 Vehicle occupancy survey results

TIME INTERVAL	CAR (1)	CAR (2)	CAR (3+)	TRUCK	TAXI	M/C	BUS	TOTAL
7:45-8:00	455	160	15	3	6	12	6	657
8:00-8:15	527	189	29	0	3	20	9	777
8:15-8:30	546	190	25	1	7	20	9	798
8:30-8:45	470	150	26	1	2	19	7	675
8:45-9:00	457	117	16	7	7	22	7	633
9:00-9:15	368	85	11	4	9	9	5	491
Total 1 Hour Flows	2000	689	95	5	18	71	31	2909
Total vehicles over survey period	2823	891	122	16	34	102	43	4031
Persons	2823	1782	391	27	57	104	1800	6984

Table 12 illustrates that the majority of vehicles (70%) travelling along Barry Drive during the AM peak period are of single occupancy. Approximately 25% of private vehicles (cars) travelling along the corridor during the AM peak period have a vehicle occupancy greater than two persons per vehicle. The average vehicle occupancy of passenger carrying vehicles is 1.3 which again is significantly higher than the 2006 journey to work average of 1.14.

The results of the journey time surveys are illustrated in **Table 13.**

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Table 13 Journey time survey results

Barry Drive towards CBD - for length of bus lane 2.2km	Traffic Lane (sec)	Bus Lane (sec)	Time Saving (Sec)
7:40	107	100	7
8:03	132		32
8:15	120		20
8:27	100		0
8:42	114		14
Average Travel Time	**114.6**		**14.6**
Average Speed	**69km/h**	**79km/h**	

The results of the journey time analysis illustrate that there is a very minor difference between the observed journey times in the general traffic lane and the transit lane. The surveys show that the transit lane on average is approximately 15 seconds and 10km/h quicker than the general traffic lane over a distance of 2.2km during the AM peak period.

If the bus lane was to be converted to a T2 lane then there would be 904 vehicles eligible to use this lane leaving approximately 2000 vehicles in the remaining two lanes. i.e all lanes would be fairly uniformly utilised at the high end of LoS C under current traffic demands. With traffic levels at the lower end of LoS C in the potential T2 lane there is a risk that the performance of buses would be adversely affected by the traffic levels.

5.3.2 Analysis

The results of the surveys completed during the AM peak period along Barry Drive would suggest that currently the designated Bus lane that stretches for approximately 2.2km towards the CBD along the corridor provides a slight journey time saving to the users when compared to the general traffic lanes. The Bus lane also provides the user with a reliable travel time and consistent travel speed for the duration of the corridor and as the surveys suggest this does not occur within the general traffic lanes; where there is a difference of approximately 32 seconds between the quickest and slowest journey time along the corridor.

In the AM peak hour there were a total 904 vehicles or approximately 2590 persons that would have been eligible to use a T2 Transit lane along Barry Drive. If all eligible vehicles had utilised the T2 facility, then the average travel speeds of buses may have reduced as the maximum number of vehicles to maintain LoS B is approximately 840 – even though Austroads reports that for 80 km/h roads traffic can maintain 80 km/h at LoS C. Thus LoS would decrease to LoS C if all eligible vehicles used the T2 Lane. However, despite the decrease in LoS the average vehicle occupancy for the lane would have been in the region of 2.8 which is significantly higher than the corridor at 1.3. This would be a significant increase in the efficient movement of people along the corridor without any significant distribution or performance of the traffic lanes.

As Gungahlin continues to grow it is expected that traffic on the GDE / Belconnen Way / Barry Drive route into the City will continue to increase thus the benefits of the bus lane are expected to continue to increase over time.

5.4 Adelaide Avenue

Adelaide Avenue and the Yarra Glen form a major arterial corridor linking the Woden Valley to South Canberra, Capital Hill and City via Commonwealth Avenue. The corridor is access-controlled and grade-separated from its southern terminus, the Yarra Glen / Yamba Drive / Melrose Drive roundabout, to its northern terminus at Capital Circle. The corridor has two general traffic lanes in each direction from the southern end to Hopetoun Circuit, and widens to three lanes from Hopetoun Circuit to the northern terminus at Capital Circle. Single T-2 transit lanes in each direction run in the median from Curtin to Capital Circle.

Additionally, cycle lanes are provided in each direction through most of the length of the corridor. Currently, the corridor experiences congestion only in a narrow portion of the peak period, and is uncongested outside of peak hours. According to traffic volumes measured in 2005 by Roads ACT, Adelaide Avenue carried 25,000 vehicles

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per day northbound and 20,000 vehicles southbound. Peak hour volumes were 3,500 vehicles northbound and 2,400 vehicles southbound.

5.4.1 AM Peak Survey

Vehicle Occupancy and Journey Time Surveys were undertaken on Wednesday 14th of December during the AM (7:45 – 9:15) Peak Period along Adelaide Avenue. **Table 14** illustrates the results of the vehicle occupancy counts.

Table 14 Vehicle occupancy survey results

TIME INTERVAL	CAR (1)	CAR (2)	CAR (3+)	TRUCK	TAXI	M/C	BUS	TOTAL
7:45-8:00	699	138	5	7	6	19	7	881
8:00-8:15	898	159	8	6	7	28	10	1116
8:15-8:30	980	188	16	4	12	19	14	1233
8:30-8:45	933	187	16	3	8	22	7	1176
8:45-9:00	1011	183	9	4	13	20	7	1247
9:00-9:15	879	131	21	9	14	11	7	1072
Total 1 Hour Flows	3822	717	49	17	40	89	38	4772
Total vehicles over survey period	5408	986	75	34	60	119	52	6374
Persons	5408	1972	256	44	89	120	2200	10089

Table 14 illustrates that the majority of vehicles (85%) travelling along Adelaide Avenue during the AM peak period are of single occupancy. Approximately 17% of private vehicles (cars) travelling along the corridor during the AM peak period have a vehicle occupancy of two or more persons per vehicle. The average vehicle occupancy was observed at 1.24 persons per vehicle but for passenger carrying vehicles it was 1.18 which is significantly closer to the 2006 journey to work average of 1.14.

The results of the journey time surveys are illustrated in **Table 15 .**

Table 15 Journey time survey results

Adelaide Avenue towards CBD – for length of Transit lane 4.5km	Traffic Lane (sec)	Bus Lane (sec)	Time Saving (Sec)
8:00	208		16
8:20	207		15
8:36	192	192	0
8:48	203		11
9:01	191		-1
Average Travel Time	**200.2**		**8.2**
Average Speed	**81km/h**	**84km/h**	

The results of the journey time analysis illustrate that there is a very minor difference between the observed journey times in the general traffic lane and the transit lane. The surveys show that the transit lane is approximately 8 seconds and 3km/h quicker than the general traffic lane over a distance of 4.5km during the AM peak period.

5.4.2 PM Peak Survey

Vehicle Occupancy and Journey Time Surveys were undertaken on Wednesday 14th of December during the PM (16:30 – 18:30) Peak Period along Adelaide Avenue. **Table 16** illustrates the results of the vehicle occupancy counts.

Table 16 Vehicle occupancy survey results

TIME INTERVAL	CAR (1)	CAR (2)	CAR (3+)	TRUCK	TAXI	M/C	BUS	TOTAL
16:30 – 16:45	586	143	5	4	9	17	6	770
16:45 – 17:00	743	161	19	1	11	22	7	964
17:00 – 17:15	838	146	12	2	11	25	9	1043
17:15 – 17:30	961	204	15	1	7	22	17	1242
17:30 – 17:45	800	156	11	0	12	19	8	1006
17:45 – 18:00	771	142	8	0	6	17	9	953
18:00 – 18:15	609	108	18	1	10	5	8	759
18:15 – 18:30	498	107	15	2	5	7	8	642
Total 1 Hour Flows	3342	667	57	4	41	88	41	4255
Total vehicles over survey period	5805	1167	111	11	71	138	72	7375
Persons	5805	2334	333	16	115	138	3000	11741

Table 16 illustrates that the majority of vehicles (79%) travelling along Adelaide Avenue during the PM peak period are of single occupancy. Approximately 17% of private vehicles (cars) travelling along the corridor during the AM peak period have a vehicle occupancy of two or more persons per vehicle.

The results of the journey time surveys are illustrated in **Table 16 .**

Table 17 Journey time survey results

<table>
<tr><th>Adelaide Avenue away from CBD – for length of transit lane 4.1km</th><th>Traffic Lane (sec)</th><th>Bus Lane (sec)</th><th>Time Saving (Sec)</th></tr>
<tr><td>5:08</td><td>200</td><td rowspan="5">187</td><td>13</td></tr>
<tr><td>5:22</td><td>210</td><td>23</td></tr>
<tr><td>5:32</td><td>200</td><td>13</td></tr>
<tr><td>5:48</td><td>195</td><td>8</td></tr>
<tr><td>Average Travel Time</td><td>201.2</td><td>14.2</td></tr>
<tr><td>Average Speed</td><td>73km/h</td><td>79km/h</td><td></td></tr>
</table>

The results of the journey time analysis illustrate that there is a very minor difference between the observed journey times in the general traffic lane and the transit lane. The surveys show that the transit lane is approximately 14 seconds and 6km/h quicker than the general traffic lane over a distance of 4.5km during the PM peak period.

5.4.3 Analysis

The results of the surveys completed during both the AM and PM peak periods along Adelaide Avenue would suggest that currently the designated T2 transit lane that stretches for approximately 4.5km in both directions of the corridor provide little journey time savings to the users when compared to the general traffic lanes. However, the transit lane does provide the user with a reliable travel time and consistent travel speed for the duration of the corridor and as the surveys suggest this does not occur within the general traffic lanes; where there is a difference of approximately 15 seconds in both the AM and PM peak periods between the quickest and slowest journey time along the corridor.

In the AM peak hour 933 vehicles or approximately 2720 people would have been eligible to use the T2 Transit lane along Adelaide Avenue out of a total of 4772 vehicles or approximately 6680 persons. If all had done so then the travel speed of buses may have reduced as the maximum number of vehicles to maintain LoS B is approximately 830 vehicles per hour – even though Austroads reports that for 80 km/h roads traffic can maintain 80 km/h at LoS C. Thus LoS would decrease to LoS C if all eligible vehicles used the T2 Lane. However, despite the decrease in LoS the average vehicle occupancy for the lane would have been in the region of 2.9 which is significantly higher than the corridor at 1.24. This would be a significant increase in the efficient movement of people along the corridor especially if the corridor was at capacity where it would be expected over double the number of people would be transported along the corridor with a T2 lane as opposed to without.

During the PM peak the number of eligible vehicles would decrease to 856 however the number of people would remain largely the same at approximately 2730, which is out of a total of 4244 vehicles or approximately 6200 persons during the peak hour. This would likely maintain a LoS B and thus be consistent with a policy that required LoS B to be maintained for Rapid Frequent bus services. However, despite the decrease in LoS the average vehicle occupancy for the lane would have been in the region of 3.2 which is significantly higher than the corridor at 1.24. As with the AM peak, this would be a significant increase in the efficient movement of people along the corridor especially if the corridor was at capacity where it would be expected over double the number of people would be transported along the corridor with a T2 lane as opposed to without.

If however traffic levels increased so as to become congested in the adjacent lanes (LoS D maximum of 1700 vph in three lanes) then the proportion of vehicles eligible to use the T2 lane of 1275 vph would exceed the maximum to maintain LoS B. i.e a total demand of 6375 across 4 lanes of which one is a T2 lane would result in adverse travel time impacts for buses.

5.5 Safety Aspects of Adelaide Avenue

Concern has been expressed about the road safety risks arising from general traffic weaving in and out of the bus lanes on Adelaide Avenue. The situation has been assessed and the following conclusions drawn:

For the inbound direction traffic can enter the T2 lanes from the Carruthers Street overpass at Curtin, Cotter Road overpass, Kent Street overpass and Hopetoun Circuit underpass. Traffic can only exit from the T2 lanes to Hopetoun Circuit or to State Circle. Traffic can legally enter and leave the T2 lanes at any location even though they cross an unbroken line. This exemption to crossing unbroken lines is considered an undesirable and confusing feature of the Australian Road Rules (it is an generally an offence to cross an unbroken line and in the view of the authors of this report such exemptions to general criteria lead to broader driver non compliance). Although the number of vehicles using the T2 lanes is relatively low, conflicts arise when traffic attempts to enter the T2 lane from a very slow moving adjacent lane into a lane where buses and other T2 traffic is travelling at 80 km/h. This situation only arises during the AM peak. As there is little advantage to traffic entering the T2 lane from the Kent Street ramp, risks could be reduced by banning this movement – however this is difficult to achieve. For traffic attempting to enter from the Cotter Road on ramp vision is restricted by the curve in the connection from Yarra Glen to Adelaide Avenue and it is at this location where the speed differentials are likely to be highest due to congestion arising from entering Cotter Road traffic – a situation that is likely to become more severe with the development of Molonglo with resultant higher volumes of traffic travelling along Cotter Road.

This situation is likely to change as a consequence of the current investigations into a median located bus stop on Yarra Glen under the Cotter Road overpass. If a bus station is to be constructed then buses would be travelling slower than 80 km/h where the other T2 traffic may wish to merge however general traffic would be travelling more quickly. Under this situation of the proposed median bus station the merge of slow buses and high speed T2 traffic is considered a road safety risk because bus drivers will have difficulty in selecting a safe gap in the T lane because the bus is entering traffic from the left side of the bus restricting driver sight lines. Thus it is c0ncluded that a median located bus station is incompatible with median located T2 lane.

Further the median location of the T2 lane is more difficult to enforce because it requires an apprehended driver to weave across two other traffic lanes to the shoulder. As discussed in Chapter 2, median located T lanes are not favoured because they are difficult to enforce.

On the outbound carriageway traffic is generally diverging from the T2 Lane – little traffic enters from Hopetoun Circuit – and hence traffic exiting from the T2 lane may reduce speed to enter the slower moving traffic stream. Similarly to the inbound carriageway it is considered that a T2 lane is incompatible with a median located bus

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station on Adelaide Avenue because slow moving buses will be entering a high speed T2 lane and bus drivers will not be able to achieve a clear view of the T2 traffic in the lane that they are about to enter.

5.6 T4 Lanes

Although AECOM were requested to review the potential to install T4 lanes in the ACT, the Australian Road Rules do not provide for T4 lanes to be installed. Whilst it would be possible for the ACT to provide supplementary legislation to permit T4 lanes, such a decision would be inconsistent with the objective of consistent and uniform road rules across Australia. This study has concluded that T4 lanes ar therefore not appropriate.

6.0 Evaluation Criteria

6.1 Introduction

The ACT Governments Transport for Canberra policy document sets out a vision for the transport network in Canberra over the next 20 years. A key objective of this strategy is to increase the efficiency of the movement of people, goods and vehicles across the network. Transit lanes will be key tools in managing both demand and increasing the efficiency of people and vehicles across the transportation network. The work undertaken during this study aligns closely with the policy vision set out by the ACT Government in the Transport for Canberra document supporting the need for transit lane implementation. It will assist both the ACT Government and various other users in the decision making process when deciding what type of transit facility will obtain the optimum efficient and people / vehicle throughput along key transport corridors across Canberra.

This section of the report explores the relationship between the theories and results set out in this report and the current Transport Policy in Canberra to ensure that they are both aligned and whether any amendments are required to support the implementation of transit lanes across the ACT.

6.2 Transport for Canberra

The Transport for Canberra document will form the foundation for transport planning in the ACT over the next 20 years. The document supersedes the previous Sustainable Transport Plan which was published in 2004 and will sit alongside the recently updated Canberra Spatial Plan (ACT Planning Strategy). The document sets out a number of key policy directions up to 2031, these include:

- Transport and land use integration through the Frequent Network of public transport corridors;
- Social inclusion and transport disadvantage, including a draft 'minimum coverage standard' to ensure public transport services meet those with the highest social need for transport;
- Active travel to make walking and cycling easiest travel options;
- Strategic management of the road network, parking, motorised vehicles and freight to create an efficient transport system;
- Travel demand management across all modes of transport including transport pricing;
- Transport systems performance measurement and reporting, including new mode share targets for 2016 and an annual transport report card; and
- An action plan detailing the 32 proposed policy actions.

Specifically, the current Transport for Canberra Policy document sets out a number of key objectives supporting and encouraging the implementation of transit lanes:

- To facilitate the implementation of a Rapid Bus Network across the region;
- As a travel demand management tool;
- To increase the vehicle occupancy rates across the network.

6.3 Policy Discussion

The work undertaken as part of this study has shown that in order to maintain an effective and efficient road network, as set out in the key objectives above, roads that are carrying significant bus routes and services need to maintain the traffic lanes in which buses are operating at Level of Service High C or Low B. In Canberra most bus lanes carry fewer than 60 buses an hour and in the future it is expected that this may increase along some key intertown routes such as Barry Drive and Adelaide Avenue to 80 services and hour within the TfC horizon of 2026. Maintaining bus or transit lanes at traffic flows less than 600 vehicles per hour is thus considered to be the overriding policy objective. Although the Transport for Canberra document does not explicitly state the levels of flows expected within its bus or transit lanes this does align with the objective to improve efficiency and increase vehicle occupancy rates across the network.

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The analysis presented in Chapter 5 shows that with a four lane road there is virtually no risk to bus travel times being adversely affected by converting one lane from a bus lane to a T2 lane which aligns with the ACT government to implement T2 / T3 lanes without detriment to bus journey times /priority along a corridor.

On a six lane road there is a likelihood of a marginal impact arising from the conversion of a bus lane to a T2 lane. On an 8 lane road there is a high risk that the conversion of a bus lane to a T2 lane would adversely impact the performance of buses, however there would be no impact from the conversion to a T3 lane. Adelaide Avenue is the only 8 lane road in Canberra of which the median lane is a T2 lane. Despite the analysis showing that bus journey times would be impacted marginally with the implementation of Transit Lanes on six and eight lane corridors which does not align wholly with the policy objectives above, consideration would need to be given to the level of impact and delay expected as it is possible that vehicle occupancy rates and overall corridor efficiency would significantly improve, thus meeting some of the objectives set out in the Transport for Canberra document.

As well as maintaining traffic flows within the Transit Lane another key policy objective should be to maintain a consistent LOS across all traffic lanes with an aim to maintain a LOS C or above in all traffic lanes. The implementation of HOV lanes can assist with this by providing additional capacity and efficient movement of HOV vehicles along a corridor which will ultimately increase the capacity in the general purpose lanes by removing HOV vehicles

6.4 Existing Practice

As part of the analysis contained within this chapter of the report, AECOM has revisited the work undertaken by Shoukrallah in 1993 to examine the suitability of Canberra’s roads for the introduction of HOV lanes. Shoukrallah (1993) developed a set of criteria / guidelines which would assist in his evaluation of the roads in Canberra to identify suitable corridors for consideration of HOV lane implementation. This will also meet the ambitions of the ACT Government as set out in the recently published Transport for Canberra Policy document to:

- Develop a Efficient Rapid Transit Network in Canberra, and
- Manage travel demand through increasing vehicle occupancy

In the first instance this chapter will re-visit the criteria / guidelines developed by Shoukrallah (1993) and investigate whether these are still applicable and in need of updating. Following this, the new criteria / guidelines will then be outlined which will later be used to evaluate potential corridors within Canberra for HOV lane implementation. These corridors will include those considered by Shoukrallah and any further corridors that are considered as suitable candidates. The aim of this section is develop a tool which can be utilised by the ACT Government in delivering their Transport for Canberra objectives.

6.5 HOV Lane Evaluation Criteria Background and Review

6.5.1 ACT Government Criteria / Guidelines

Shoukrallah (1993) developed a number of key criteria / guidelines in which to assess the degree of which a road corridor meets the requirements to be a candidate for HOV lane implementation. This criteria / guidelines were developed from a comprehensive literature review which considered the general criteria / guidelines for appropriate HOV lane conditions from both within Australia and Internationally. The criteria included:

- Roads generally greater than two lanes wide (in one or both directions);
- Bus volumes should exceed 45 per hour;
- Extensive delays on the roadway so as to interfere with bus time tabling;
- Roads on which driveway access to adjoining developments do not exist or at least are limited;
- Land and / or opportunities are available for the inclusion of HOV lane facilities;
- Little (less than 5%) heavy commercial vehicles;
- A high proportion of commuter movement by “HOV vehicles” or a significant potential for increasing levels;
- HOV lane time savings should exceed 40 seconds per Km or 10 minutes cumulative;
- Implementation of a HOV lane should not substantially reduce the level of service in other lanes; and
- Travel speed in the non-HOV lane should be less than 50kph.

In addition to the above, the ACT Government also has a number of guidelines and warrants in which it uses to decide when a bus lane or priority scheme can be implemented. **Table** 18 illustrates the existing warrant criteria that are used to decide when a facility can be implemented.

Table 18 Current bus lane / priority warrants

Bus Priority Category and Supporting Policy Position	Warrants (Indicative)	Reviewer Comments
Segregated Busway. When warrants are met a busway should be investigated for the corridor	**All of the following conditions met** - > 75 buses per one hour peak direction at time of commissioning - > 80% increase in-bus travel time in congested conditions without bus priority - < 85% of buses arrive on time	Timetables often take account of congestion. A preferred criterion is < 85% of buses arrive at target arrival time which may be the same travel time as off peak. Also requires a definition of one time. Qantas for example consider flights on time if they are within 15 minutes of schedule – which is considered an inappropriate margin for buses.
Conversion of traffic lane. Conversion of an existing general traffic lane to an exclusive bus lane is preferred. Dependent upon the location (such as physical, environmental financial considerations) conversion to transit / HOV lane may be acceptable, if similar outcomes with exclusive bus lane	**Bus lane if three or more of the following are met**: - The bus carries 65% - 80% of the volume of people being moved in the adjacent general traffic lane - > 12 buses per hour - There is a 35% - 65% increase in bus travel times in congested conditions without bus priority - < 75% of buses arrive on time without bus priority **HOV if the following exist** - The bus services carry 40% - 65% of the volume of people being carried in the adjacent general traffic lane - > 10 buses per hour - < 40% increase in bus travel times when conditions are congested and no bus priority	Same comment as above re "on time" Comparison with off peak schedule or achievable time is considered a preferred target
Conversion of traffic lane When an additional traffic lane is being provided (i.e.) road widening) the preference is for this additional lane to be converted to an exclusive bus lane If warrants are not met then a transit lane should be considered in the additional lane being provided	**Bus lanes if the following is met** - The bus services carry more than 50% of people being carried in the adjacent traffic lane - 10 buses per hour There should be a plan for the corridor to move public transport towards a medium level of warrant (> 80% of people being carried in adjacent general traffic lane and > 15 buses / hour	Suggest should be titled Road Widening
Queue Jump Should be provided when travel times or service reliability improvements can be achieved	**Queue jumps are warranted where:** > 50% of people being carried in the adjacent traffic lane > 10% increase in travel time when congestion is present	
Signal Priority Should be provided when	**Signal Priority is warranted where:** - Queue jumps are already in place	

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Bus Priority Category and Supporting Policy Position	Warrants (Indicative)	Reviewer Comments
travel times or service reliability can be improved	- > 10% increase in travel time when congestion is present	
Bus bays To be provided on corridors with bus or transit lanes where they improve the efficiency of bus operations or the safety of buses, general traffic cyclists or passengers	**Bus Bays are warranted where**: - If the service headway is less or close to the average dwell time, bus bays are warranted - If a road safety audit identifies the need for a bus bay - Where parking consistently hinders access to bus stops	In NSW bus bays are generally restricted to when the bay is adjacent to a BUS ONLY lane. Suggest could also consider where the bus bay is at the beginning of a lane add – especially if the lane add is a bus lane

HOV : High Occupancy Vehicle

Source TaMS

6.5.2 Austroads

In 2002, Autroads published a guide for traffic engineers entitles 'Road Based Public Transport and High Occupancy Vehicles', the purpose of the guide was to ensure that road based public transport and HOV schemes achieve maximum effectiveness when implemented across Australia and New Zealand. The study that informed the guidance document carried out a comprehensive literature review of traffic engineering best practices from around the world and a detailed examination of the measures that have been implemented to enhance the efficiency of HOV schemes (Austroads, 2002).

The guidance document set out a number of successful indicators that could be utilised as evaluation criteria. These indicators were developed from the comprehensive research undertaken and include;

- The HOV facility forming part of an area – wide, or corridor wide, transportation plan;
- The scheme having significant support from politicians, the community and transport agencies;
- The scheme was usually implemented in areas of significant congestion, with volumes in excess of 1,500 vehicles/hr/lane on freeways and 1,000 vehicles/hr/lane on arterials and average speeds of less than 50kph;
- Time savings of at least 5-7 minutes when the total journey time is between 40-60 minutes;
- The scheme avoiding the 'empty lane syndrome';
- Strict enforcement and minimal illegal use; and
- Introducing an additional lane on the corridor for HOV instead of converting an existing lane (Austroads, 2002).

The document also lists a number of criteria that should be taken into consideration during the assessment of prospective HOV schemes. These criteria include the following:

- Traffic Volumes;
- Level of Service;
- Traffic Speeds;
- Bus and bus passenger numbers;
- Ride – share potential;
- Number of traffic lanes;
- Congestions on parallel road route;
- Occupancy eligibility threshold adopted;
- Travel time, reliability, cost and convenience improvements;
- Peak HOV lane demand;
- Impacts on general traffic lanes; and

- Benefit – cost ratio.

6.5.3 Australian Institute of Traffic Planning and Management (AITPM)

The Australian Institute of Traffic Planning and Management (AITPM) undertook a similar study to that completed by Shoukrallah (1993) which was entitled *'High Occupancy Vehicle Lanes – An Overall Evaluation Including Brisbane Case Studies'* (2005). This study carried out a similar literature review and also developed an evaluation framework bases upon issues surrounding HOV lanes drawn from a literature review. The framework also included a number of 'measures of effectiveness' (MOE) which were developed to comprehensively assess the feasibility of a HOV project. **Table 19** displays the evaluation framework developed during the AITPM (2005) study and **Table 20** displays the MOE that were developed to assess the HOV lanes.

Table 19 AITPM HOV lane evaluation criteria

Objective	MOE	Target Performance	
		Qualitative	Quantitative
Person Moving Efficiency	Average Vehicle Occupancy (AVO)	Increase in AVO	>2.5% increase
	HOV Market Share	Increase in HOV market Share	>2.5% increase
Travel Time Savings	Travel Time Difference	HOV travel time must be less than GP travel time. Travel Time difference must not be too small to generate "empty lane syndrome"	At least a 10% travel time saving and no greater than 20% travel time saving
Travel Time reliability	Travel Speed Standard Deviation	HOV Travel Speed should be more reliable than the GP speed	75% or greater reduction in travel speed deviation between HOV and GPO lane
Transit Efficiency	Vehicle Productivity	Improvement in operating cost per passenger	
	Bus reliability	Improvement in bus schedule adherence	
Overall Corridor Efficiency	Per – lane Efficiency of Total Corridor	Increase the efficiency of all lanes	>20% for add - - lane No decrease for take a lane
Impact on GP lanes	LoS on GP lanes	No decline in GP LoS	
	GP travel speed	No decrease in GP travel speed	
Public opinion	Percentage Support for HOV lane	Support for the facility among users, non-users, general public and policy makers	Majority support the HOV facility >50%
Enforcement	Violation Rate	Low violation rates so as to maintain the integrity of the HOV facility	<15% violation rate
Environmental	Vehicle Emissions	Reduction on HOV implemented	-
	Vehicle Distance Travel	Reduction on HOV implemented	-
	Vehicle Hours of Travel	Reduction on HOV implemented	-
	Total Fuel Consumption	Reduction on HOV implemented	-

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Objective	MOE	Target Performance	
Safety	Accident Rate	No increase in accident rate or severity	-

Table 20 AITPM Measure of Effectiveness

MOE	Information required to Assess MOE	Experiment/s Required to obtain Information
Average Vehicle Occupancy (AVO)	Average Vehicle Occupancy	Vehicle occupancy counts, Traffic volume counts
HOV Market Share	% HOVs, Buses & GP vehicles	Vehicle Occupancy Counts
Per – lane Efficiency of Total Corridor	AVO	Vehicle occupancy counts, Traffic volume counts
Travel Time Difference	Average Travel Speed	Travel Time Runs – HOV vs. GP
	Vehicle Frequency	Vehicle Occupancy Counts, Traffic Volume Counts
	Average Trip Times	Travel Time Runs – HOV vs. GP
Average Travel Speed Difference	Average Trip Times	Travel Time Runs – HOV vs. GP
Travel Speed Standard Deviation	Average Trip Times	Travel Time Runs – HOV vs. GP
Violation Rate	% of vehicles not Permitted in HOV Lane	Vehicle Occupancy Counts

In completing their research Bauer et al (2005) found that ‘No universally accepted evaluation method was found for measuring the success or failure of HOV facilities. However, a number of common elements appear to be assessed including effectiveness, safety, public opinion, enforcement and environmental issues’. These elements were then collated into an evaluation framework which is displayed in **Table 19** to assist in the development of a MOE.

6.5.4 Guide for HOV Facilities (USA, 2004)

The American Association of State Highway and Transportation Officials developed and published a book entitled *‘Guide for high-occupancy vehicle (HOV) facilities’* in November 2004. Within the guide they have developed a list of key criteria which should be used when determine whether a HOV lane is appropriate for a given transport corridor. The guide suggests that not all the criteria needs to be used when determining whether a HOV lane is appropriate within a corridor, however combining a number of the criteria could provide the evidence base to proceed or dismiss a HOV lane facility from a corridor. The criterion includes:

Congestion Levels – Levels of existing congestion should influence whether there is a requirement for a HOV lane. As a general guide where a corridor has a LoS D or below and average speeds of 50kmh in the peak hour this should be considered a good candidate for HOV lane implementation;

Bottlenecks – Bottlenecks usually result in significant congestion and a HOV should be considered to provide priority for buses and HOV’s;

Level of HOV Service – A high number and frequency of buses or HOV vehicles along a given corridor could demand the need for a HOV vehicle especially when they are experiencing significant delay. Criteria for HOV lane implementation could include number of buses or / and ridership levels;

Travel Patterns – Analysis of origin and destination of the vehicles utilising a corridor is crucial in determining the viability of HOV lane for that corridor and also alternatives to the HOV lane.

Current Bus and Carpool Volumes – Existing HOV services, carpools and vanpools in a corridor could be used to determine the demand for a HOV facility along a corridor. Vehicle Occupancy Counts and other data / information on other vehicles such as bus numbers and patronage should be used to assist in determining the need for a HOV facility;

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Volume Operating Thresholds – As a minimum for a new T2+ facility, the lane should look at carrying 50% of the traffic levels in the general traffic lane otherwise the lane would be considered as underutilised. Consideration should be given to the demand to determine the type of facility required and assist in justifying the new facility and maximising efficiency;

Travel – Time savings and Travel Time Reliability – Estimating the potential travel time savings as a result of a HOV lane implementation can assist in determine whether a HOV facility is required. As a rule a HOV facility should provide a travel time saving of at least five minutes. For travel time reliability, if the HOV facility can either improve or assist HOV vehicles in meeting their schedules then this could justify the implantation of such facility;

HOV Delay – the HOV lane should look to reduce the delay to HOV's. When considering the location of a new facility consideration should be first given to the current / existing contributors to the delay of the HOV's. One the problems have been identified this will assist in identifying an approach to addressing these problems;

HOV Lane System Connectivity – The success of an HOV lane may be further enhanced if it is part of a larger network / system of HOV lanes. Consideration should be given to other elements that could assist in the success of the HOV lane for example a Freeway based HOV lane may need an arterial HOV lane to link it to a major activity centre;

Roadway Improvements or New Development – HOV lanes could potentially be considered as part of a new road corridor, road corridor upgrade or as part of new infrastructure serving a new development. Consideration should be given to implementing HOV lanes as part of planned upgrades or new projects;

Overall Trip Distance – Average distance of commuter trips in the corridor can provide a good indication of the possible candidates for HOV lanes. Longer distance trips may result in greater travel time saving whilst shorter HOV lane treatments would assist in addressing specific bottleneck problems and provide the basis for extension in the future;

Person Throughput – A HOV facility should increase the person – moving capacity of a corridor or facility. The design of the HOV facility should be to increase the carrying capacity in fewer vehicles than adjacent gereral traffic lanes;

Projected Demand – the projected demand of the new facility should be a key criteria in determining the need for HOV facility.

Agency and Public Support – consideration should be given to the amount of support or discontent that may result from the implementation of a HOV facility;

Financial Viability – The costs associated with implementing HOV facilities should be considered and can also be a tool for differentiating between options;

Enforcement –Enforcement should be considered during the planning stage as it is a component that determines the success of the HOV facility. Consideration should be given to the ease with which enforcing of the HOV facility can be carried out once implemented;

Cost Effectiveness – a benefit to cost ration could be calculated as a comparison tool to understand the economic savings and benefits of introducing a HOV lane alone a given corridor;

Physical Characteristics of the Corridor Roadway – Ensuring that the HOV facility can be fully accommodated within the current road reserve or corridor should be assessed during the evaluation stage;

Support Facilities and Services – an assessment of other travel demand management measures such as work placed travel plans, park and ride lots, restricted parking at destination should be assessed as these will contribute towards the success of the HOV facility;

Safety – consideration should be given to any safety issues that may arise from HOV lane implementation including design and operation.

System Staging and Scheduling – consideration should be given to the construction staging of a new facility and its timing in terms of any further upgrades planned for the corridor. This will ensure that the facility effectiveness is maximised from day one;

Environmental Issues – examining the potential environmental benefits of establishing a HOV lane on various corridors could assist in differentiating where to implement the new facility; and

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Other Modes – a thorough assessment of the various markets and an understanding of potential demand will assist in ensuring that the new HOV facility is compatible rather than competitive with other transport modes.

6.6 Advantages and Disadvantages of the HOV facilities

Following the completion of the surveys and the comprehensive literature review AECOM has produced a table below illustrating the advantages and disadvantages of the various types of HOV facilities explored during this report.

Table 21 Bus only lane advantages and disadvantages

Advantages	Disadvantages
Provides full priority to buses which will result in quicker overall journey times and average speeds	Lane utilisation will remain low unless there are a significant number of buses utilising corridor. Public perception could be there are so few buses that it should be allocated to cars
Increases people throughput of the lane and corridor. One bus every 3 minutes on the rapid corridors is 1400 - 2000 people per hour depending upon bus size, compared to cars every 2 seconds carrying 2160 persons per lane. Total throughput 2 lanes up to 4160 persons / hour.	Not likely to improve journey times or average speeds of the general traffic and could actually cause significant delays if scheme is a road space re-allocation
Allows buses to progress through intersections on the next green signal.	Benefits diminished unless there are indented bus bays
Easy to enforce by police, cameras or peer pressure.	
Assists progress of emergency vehicles.	
Largely self regulating	

Table 22 T2 advantages and disadvantages

Advantages	Disadvantages
Significantly increases the people throughput of the corridor. On a road with 2 lanes each way, one of which is a T2 lane and one bus every 3 minutes the lane can carry about 2260 - 2950 people per hour assuming the four lanes would be full mof public traffic. This compares to a normal full traffic lane carrying 1800 people per hour (all single occupant). Total throughput in 2 lanes up to 4880 persons per hour	Could potentially cause delays to buses but does depend on utilisation of the facility
Increases capacity of the general purpose traffic lanes by removal of T2 vehicles	Diminishes legibility of transport policy putting public transport first
Likely to decrease journey times along the corridor along increasing average speeds	Open to abuse e.g. (manequins, dolls)
Difficult to enforce if not the kerbside lane	Benefits diminished unless there are indented bus bays

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Table 23 T3 advantages and disadvantages

Advantages	Disadvantages
Will increase the people throughput of the corridor, but less than T2. One bus every 3 minutes and T3 lane can throughput 1830 - 2430 persons per hour compared to the general full traffic lane of 2150 persons. Total throughput in 2 lanes up to 4600 persons per hour.	Likely to have less impact than the T2 facility due to fewer vehicles carrying three occupants. No significant difference I person through put between lanes.
Increases capacity of the general purpose traffic lanes	Could cause slight delays to buses depending on utilisation
Likely to decrease journey times along the corridor and increase average speeds.	Benefits diminished unless there are indented bus bays
Difficult to enforce if not the kerbside lane	Open to abuse

Table 24 T4 advantages and disadvantages

Advantages	Disadvantages
No significant advantage over Bus lane as the proportion of T4 eligible users is low at less than 0.5%. Will increases the people throughput of the corridor	Likely to have less impact than the T2 and T3 facility due to fewer vehicles carrying four occupants
A slight Increases in capacity of the general purpose traffic lanes could be expected	Could cause slight delays to buses depending on utilisation
Likely to slightly decrease journey times along the corridor and increase average speeds	Australian Road Rules do not cover T4 lanes

6.7 Evaluation Criteria for HOV Lanes

There are a number of similarities between the work undertaken by Shoukrallah (1993), Austroads, the AITPM and in the US to develop a set of criteria / guidelines to assess when and if a HOV lane should be implemented; however UK experience indicates that it is almost impossible to adopt a standard approach. This is because the UK approach is a philosophical one where the best use of road space to move people and goods is the basic evaluation tool. Utilising elements from of all sets of research, AECOM believes that the three key evaluation criteria that is consistent throughout the researched material identified previously include:

- Number of lanes along the corridor;
- Level of congestion / observed delay / LoS along the corridor; and
- Bus Journey Times and LoS along the corridor.

Using the three key criteria above AECOM have developed a basic evaluation tool which enables the ACT Government to assess when and what type HOV facility, if any, is most suitable to be implemented along a transport corridor. **Figure** 13 illustrates the tool developed in the form of a flow chart to assist in evaluating the type of HOV most suitable for the type of transport corridor under consideration. This process ensures that the decision to implement an HOV lane is based upon the providing for the maximum number of people in the most efficient manner. This is quite different to an approach that maximises movement of vehicles.

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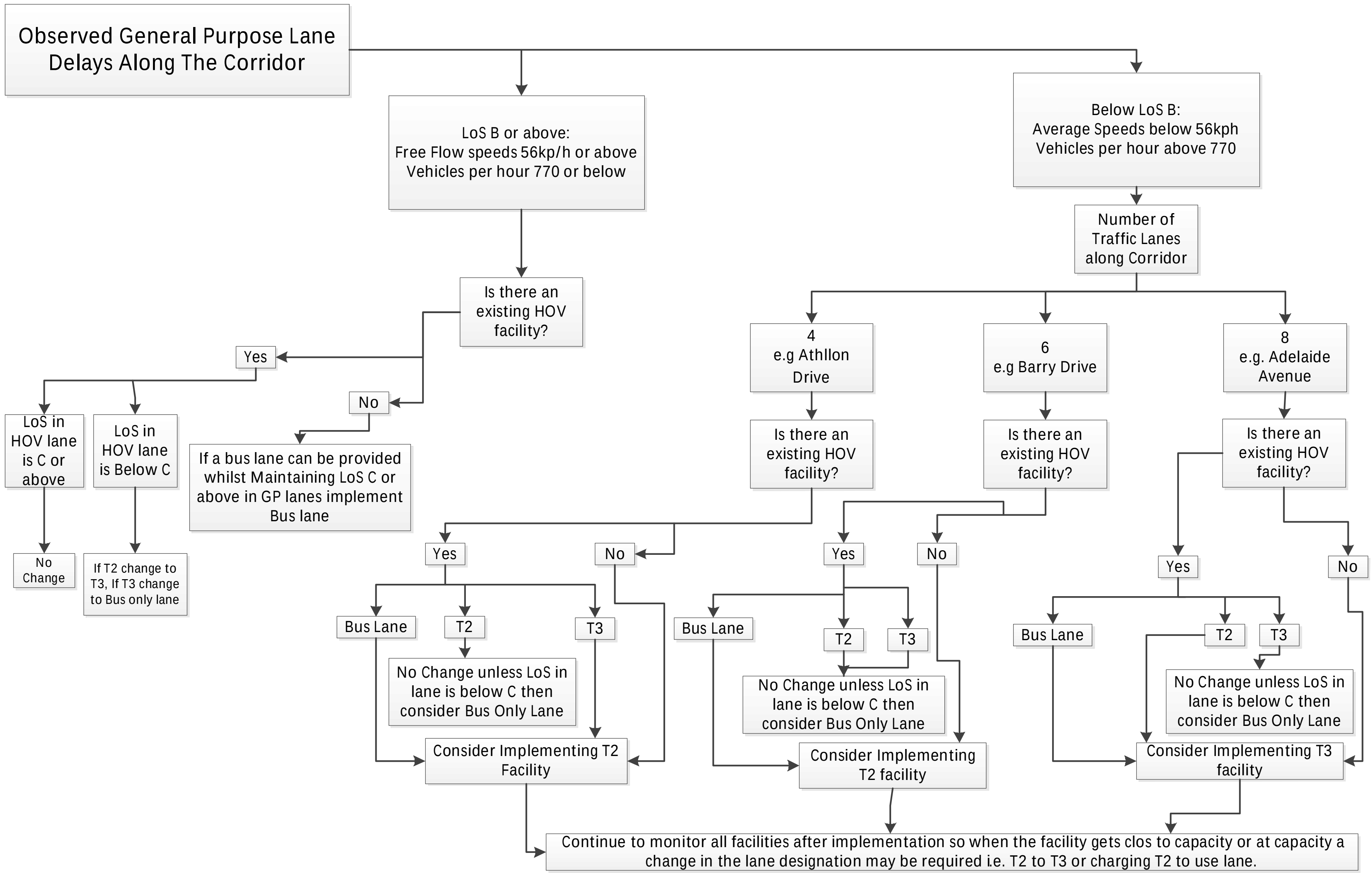

Figure 13 Evaluation Tool

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6.8 Conclusions

The analysis presented in Chapter 5 shows that with a four lane road there is virtually no risk to bus travel times being adversely affected by converting one lane from a bus lane to a T2 lane which aligns with the ACT government to implement T2 / T3 lanes without detriment to bus journey times /priority along a corridor.

On a six lane road there is a likelihood of a marginal impact arising from the conversion of a bus lane to a T2 lane. On an 8 lane road there is a high risk that the conversion of a bus lane to a T2 lane would adversely impact the performance of buses, however there would be no impact from the conversion to a T3 lane. Adelaide Avenue is the only 8 lane road in Canberra of which the median lane is a T2 lane. Despite the analysis showing that bus journey times would be impacted marginally with the implementation of Transit Lanes on six and eight lane corridors which does not align wholly with the policy objectives above, consideration would need to be given to the level of impact and delay expected as it is possible that vehicle occupancy rates and overall corridor efficiency would significantly improve, thus meeting some of the objectives set out in the Transport for Canberra document.

The tool developed by AECOM (**Figure 13**) takes account of the comments outlined above to provide guidance on implementing different types of HOV facilities along various types of corridors. It is important to consider the movement of people rather than vehicles and to also make the most efficient use of the road space available.

As well as maintaining traffic flows within the Transit Lane another key policy objective should be to maintain a consistent LoS across all traffic lanes with an aim to maintain a LoS C or above in all traffic lanes. The implementation of HOV lanes can assist with this by providing additional capacity and efficient movement of HOV vehicles along a corridor which will ultimately increase the capacity in the general purpose lanes by removing HOV vehicles.

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7.0 Candidate Corridors / Locations and Evaluation

7.1 Introduction

In 1993 Shoukrallah identified a number of potential corridors for consideration to implement a transit / HOV lane along their length. The candidate roads identified were divided into three categories:

- Approaches to the City Business Districts (Civic);
- The parkway system; and
- The existing bus only lanes.

Shoukrallah (1993) identified the following routes to the CBD as candidates for consideration:

- Northbourne Avenue;
- Ginninderra Drive;
- Belconnen Way;
- William Hovell Drive;
- Morshead Drive; and
- Commonwealth Drive.

In addition to the above routes towards the CBD the following routes were considered as they were existing parkway systems and bus only facilities:

- Tuggeranong Parkway;
- Monaro Highway;
- Parallel To Joynton Smith Drive;
- Barry Drive;
- Athllon Drive; and
- Adelaide Avenue.

Of the corridors identified and considered by Shoukrallah in 1993, only Adelaide Avenue was considered to meet the evaluation criteria and investigated further for hosting a transit or HOV facility. The following sections of this chapter will now re-visit the corridors identified by Shoukrallah (1993) and also consider any further corridors that may be a suitable candidate for HOV / transit lane implementation.

7.2 Strategic Corridors

Canberra was planned on the basis of satellite towns with sufficient employment and facilities to achieve relatively high levels of employment and retail self containment. Hence travel demand out of the town would be reduced. In addition a intertown public transport corridor was proposed to ensure that a fully independent public transport system could be implemented at some stage in Canberra's growth. The intertown routes are thus the logical routes to examine the functionality of bus, T2 and T3 lanes since these routes were established for the sole purpose of high speed public transport travel.

However to be effective these strategic Public Transport Corridors must be coincident with road corridors. Candidate corridors for Transit lanes have thus been selected on the basis of there being concurrent demands and include:

- Adelaide Avenue / Commonwealth Avenue (Needs to be considered as a continuous route)
- Belconnen Way / Barry Drive
- Athllon Drive
- Canberra Avenue
- Northbourne Avenue

- Flemington Road

7.3 Existing Bus Lanes

The existing bus lanes that currently exist on several Canberra Roads are obvious candidate nominations for conversion to Transit lanes. However some sections are considered unsuitable such as short bus jump lanes as at College Street, Athllon Drive at Drakeford Drive and also the northbound bus lane at the Albert Hall on Commonwealth Avenue.

Since the objective of T lanes is to optimise the performance of the transport network it is necessary to contain the additional traffic that may use the bus lanes to levels that do not jeopardise the maintenance of at least level of Service C in the lane.

7.4 Australian Road Rules

The Australian Road Rules as adopted by the ACT define how managed lanes such as bus or T lanes are to be used and enforced. Managed lanes include bus and Transit lanes. The relevant rules are presented in **Appendix B**. These rules provide for exemptions to general rules such as permitting the crossing of unbroken lines which is considered to potentially lead to driver non compliance elsewhere in the network.

7.5 Candidate Corridors and Evaluation

In general, “T” lanes are implemented where bus facilities in the form of the provision of a managed lane are appropriate. Within the Transport for Canberra context bus lanes, or bus only lanes are generally only appropriate for the Frequent Rapid Service. There may be other instances where bus lanes are also appropriate such as some Expresso routes – especially where there are concurrent routes of the Frequent Local service. It is not expected that bus facilities (Lanes or B signals) will be appropriate for coverage or local services.

Hence the consideration to provide a ‘T’ lane will generally be restricted to the Frequent Rapid Routes. Table shows the bus routes and the potential for a T Lane under the foregoing analysis. Notwithstanding this link based approach it is important that any consideration to introduce ‘T’ lanes across the city needs to also consider the whole of the network. Hence a ‘T’ lane on one link of the route would not be appropriate even if it meets the criteria but the combination of several adjoining links to form a route would be suitable for further consideration. It is also important to note that this is a preliminary list based on the estimated benefits to providing for the most efficient movement of people and not vehicles.

Table 25 Candidate corridors for transit lane facility consideration

Road	Service type	No of lanes in each direction	Suitability				Comment
			Bus	T2	T3	T4	
Southern Cross Drive Starke Street to Kingsford Smith Drive	Frequent Rapid	2	N	N	N	N	60 km/h little congestion Inadequate data
Southern Cross Drive Kingsford Smith Drive to Coulter Drive	Frequent Rapid	3	N	N	N	N	80 km / h little congestion. Inadequate data
Coulter Drive Southern Cross Drive to Nettlefold Street	Frequent Rapid	3	Y	N	N	N	80 Km / h congestion. Length too short for Bus or T lanes
Eastern Valley Way	Frequent Rapid	2	N	N	N	N	60 km/h some congestion. Buses weave from Emu Bank from median to kerb lane. Inadequate data
College Street	Frequent Rapid	1/2	N/Y	N	N	N	Two lane section proposal for bus lane. Inadequate data

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Road	Service type	No of lanes in each direction	Suitability				Comment
Haydon Drive	Frequent Rapid	2	Y	N	N	N	Long term segregated alignment proposed. Additional Bus lane proposed from Purdie Street to Belconnen Way. Inadequate data .
Belconnen Way (Haydon Drive – Barry Drive	Frequent Rapid	3	Y	P	P	N	Heavy volume of exiting traffic towards Macarthur Avenue reduce effectiveness. Additional bus lane at GDE. Inadequate data.
Barry Drive	Frequent Rapid	3	Y	N	Y	N	Existing bus lane. At city end kerb lane is a trap right turn lane and unsuitable for T lane
Marcus Clarke Street	Frequent Rapid	2	Y	N	N	N	Bus lane in bus stop proposed new outbound lane at bus station.
Alinga Street	Frequent Rapid	1	Y	N	N	N	Bus lanes proposed
London Circuit	Frequent Rapid	3	Y	N	N	N	Bus lane possible
Commonwealth Avenue	Frequent Rapid	3	Y	P	P	N	Likely non compliance with high volumes existing / entering King Edward Terrace
Capital Circle	Frequent Rapid	3	Y	P	P	N	Existing T2 lane
Adelaide Avenue	Frequent Rapid	3	Y	N	N	N	Existing T2 lane but incompatible with Cotter Road Bus Station
Yarra Glen	Frequent Rapid	2/ 3	Y	N	N	N	Existing T2 lane inbound but incompatible with Cotter Road Bus station
Melrose Drive	Frequent Rapid	3	Y	N	N	N	Could extend to bus bypass lane at Yarra Glen roundabout. Length to short for T lane
Launceston Street	Frequent Rapid	2	N	N	N	N	Buses need to weave from left lane to median lane and thus not practical
Callam Street	Frequent Rapid	2	Y	N	N	N	High bus volumes, median lane southbound kerbside northbound. Terminating trips in town centre T2 is impractical
Athllon Drive Hindmarsh Drive to Sulwood Drive	Frequent Rapid	2	Y	Y	Y	N	Previously bus lane Sulwood Drive to Beasley Street
Athllon Drive Sulwood Drive to Drakeford Drive	Frequent Rapid	1	N	N	N	N	Single lane unsuitable
Athllon Drive, Drakeford to Anketell Street	Frequent Rapid	2	Y	Y	N	N	Approach to Town Centre will encourage higher vehicle occupancies. Split of Blue rapid services (Athllon Drive and via Erindale) will reduce need for exclusive bus use.
Sulwood Drive Athllon Drive to Erindale Drive	Frequent Rapid	1	N	N	N	N	Single lane unsuitable
Erindale Drive, Sulwood Drive to	Frequent Rapid	2	N	N	N	N	Inbound uphill and other traffic does not slow bus speed. Outbound is downhill with

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Road	Service type	No of lanes in each direction	Suitability				Comment
Sternberg Crescent							long acceleration lane. Uphill lane as T lane will result in potentially unsafe slow speeds.
Erindale Drive Ashley Drive to Anketell Street	Frequent Rapid	1	N	N	N	N	Lower frequency buses and single lane.
Drakeford Drive Hurtle Avenue to Woodcock Drive	Frequent Rapid	2	N	N	N	N	Length too short for T lane
Aikman Drive	Frequent Rapid	1	N	N	N	N	Single lane
Ginninderra Drive Aikman Drive to William Slim Drive	Frequent Rapid	2	N	N	N	N	Buses need to weave from left to right.
William Slim Drive	Frequent Rapid	2	N	N	N	N	4 lanes needed for traffic demand. Additional bus lane proposed at Barton Highway
Gundaroo Drive William Slim Drive to Gozzard Street	Frequent Rapid	2	Y	P	P	N	Inbound bus lane proposed Abena Avenue to Barton Highway. Inadequate data
Hibberson Street	Frequent Rapid	1	N	N	N	N	Town centre road
Flemington Road Hibberson Street to Well Station Drive	Frequent Rapid	2	Y	N	N	N	Bus / Light rail proposed in median. Refer to chapter 5.2
Flemington Road Well Station Drive – Northbourne Avenue	Frequent Rapid	2	Y	N	Y	N	Bus lanes proposed on kerbside. Need to maintain high bus speeds. Refer to chapter 5.2
Northbourne Avenue Flemington Road – Antill Street	Frequent Rapid	2	Y	P	P	N	T2 lane likely to overload bus lane. Inadequate data.
Northbourne Avenue Antill Street – Barry Drive to Alinga Street	Frequent Rapid	3	Y	P	P	N	Could be considered to reduce “through route” capacity” for enhanced CBD environment. Inadequate data.
Constitution Avenue	Frequent Rapid	2	Y	P	P	N	Options being undertaken as part of duplication project. Inadequate data
Kings Avenue	Frequent Rapid	2	Y	P	P	N	High frequency bus use in peak periods. T lanes likely to lead to significant congestion in remaining lane. Inadequate data
Brisbane Avenue	Frequent Rapid	2	P	P	P	N	No significant congestion. Inadequate data
Wentworth Avenue	Frequent Rapid	2	Y	P	P	N	Bus lane being investigated under separate study. Inadequate data
Canberra Avenue Wentworth Avenue to Newcastle Street	Frequent Rapid	2	Y	P	P	N	Bus lane being investigated under separate study. If lane taken from existing likely to lead to significant congestion in remaining lane. Inadequate data
Canberra Avenue Newcastle Street to	Frequent Rapid	2	Y	Y	Y	N	Could be considered when Queanbeyan frequency achieves 5 minute headway.

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Road	Service type	No of lanes in each direction	Suitability				Comment
NSW border							Inadequate data
Bindubi Street Belconnen Way to Littleton Crescent	Frequent Rapid	2	P	P	P	N	Northern end close intersection spacing is impractical, southern end volumes are relatively low. Inadequate data
Bindubi Street Littleton Crescent to William Hovell Drive		1	N	N	N	N	T2 could be considered if Bindubi Street is duplicated. Inadequate data
John Gorton Drive	Frequent Rapid	2				N	Design being undertaken to provide bus priority.
Streeton Drive	Frequent Rapid	2				N	Congestion unlikely to be high enough to result in significant benefits. Inadequate data
Hindmarsh Drive Namatjira Drive to Tuggeranong Parkway	Frequent Rapid	2/3	P	P	P	N	T Lane likely to result in significant congestion in remaining lane. Inadequate data
Hindmarsh Drive Tuggeranong Parkway to Callam Street.	Frequent Rapid	3	Y	Y	Y	N	Likely interference approaching Melrose Drive and Ball Street from turning traffic.
Mouat Street Ginninderra Drive – Northbourne Avenue	Expresso and frequent local	2	N	P	P	N	Bus frequency too low for bus lane but T2 consistent with transport policy. Inadequate data
Barton Highway Gold Creek Road to William Slim Drive	Expresso and frequent local	2	N	P	P	N	Bus frequency too low for bus lane but T2 consistent with transport policy. Inadequate data
Mirrabei Drive Shoalhaven Avenue to Gundaroo Drive	Expresso and frequent local	1	N	P	P	N	If duplicated and bus frequency too low for bus lane but T2 consistent with transport policy. Inadequate data
Gundaroo Drive Gozzard Street to Horse Park Drive	Expresso and frequent local		N	P	P	N	Bus frequency too low for bus lane but T2 consistent with transport policy. Inadequate data
Gungahlin Drive Gundaroo Drive to Well Station Drive	Expresso and frequent local		N	P	P	N	Bus frequency too low for bus lane but T2 consistent with transport policy. Inadequate data

Note T4 lanes are considered unsuitable for the ACT because:

- They are not covered in the Australian Road Rules.
- The number of eligible users is very low at an estimated 0.5% or for a typical full lane fewer than 100 vehicles per hour.

N Unsuitable

Y Suitable

P Possibly: requires surveys and analysis.

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8.0 Conclusions and Recommendation

Roads ACT commissioned AECOM to undertake review and update previous work investigating the potential use and benefits of converting existing bus lanes to HOV Lanes in Canberra and to establish evaluation criteria that is suitable for application to the selection of future bus or HOV lanes across the ACT region. AECOM has completed a comprehensive literature review of the success of existing Transit / HOV facilities and evaluation techniques that have been utilised around the world to assist with the implementation of HOV facilities. Through this review AECOM has developed a evaluation framework that can be utilised by the ACT Government and assist them in the decision making process of when to implement the different types of HOV facilities. A summary of the key conclusions and recommendations that have resulted through our analysis and evaluation is provided within this section.

8.1 Conclusions

- When considering examples of Best Practice there is now a number of examples from around the world where the success of HOV / Transit or managed lanes have been implemented successfully;
- After reviewing the various evaluation criteria and techniques that are utilised around the world when considering HOV facility implementation AECOM believes that there are three key criteria for considering HOV lane implementation, these include:
  - Number of lanes along the corridor;
  - Level of congestion / observed delay / LoS along the corridor; and
  - Bus Journey Times and LoS along the corridor.
- AECOM has developed a evaluation tool based on the above criteria that the ACT Government can utilise in the decision making process when implementing HOV lanes within the ACT;
- Key policy objectives should be considered to aid the implementation of HOV facilities with the ACT, these include:
  - Maintaining transit lane flows less than 600 vehicles per hour within a transit lane; and
  - Maintaining a LoS C or above in all traffic lanes along a corridor.
  - T4 lanes are not supported with the Australian Road Rules and are therefore considered inappropriate.
- The proposed bus station on Yarra Glen at the Cotter Road overpass is likely to result in significant conflicts between T lane private vehicles and buses entering and leaving the station. ‘T’ lanes are therefore not recommended if this station is to proceed.

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Appendix A

Austroads LoS Criteria multi lane roads

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Appendix A Austroads LoS Criteria multi lane roads

Table 4.4: Level of service criteria for multi-lane highways

Free flow speed	Criteria	A	B	C	D	E
100 km/h	**Maximum density (pc/km/ln)**	**7**	**11**	**16**	**22**	**25**
	Average speed (km/h)	**100.0**	**100.0**	**98.4**	**91.5**	**88.0**
	Maximum volume to capacity ratio (v/c)	**0.32**	**0.50**	**0.72**	**0.92**	**1.00**
	Maximum service flow rate (pc/h/ln)	**700**	**1100**	**1575**	**2015**	**2200**
90 km/h	**Maximum density (pc/km/ln)**	**7**	**11**	**16**	**22**	**26**
	Average speed (km/h)	**90.0**	**90.0**	**89.8**	**84.7**	**80.8**
	Maximum volume to capacity ratio (v/c)	**0.30**	**0.47**	**0.68**	**0.89**	**1.00**
	Maximum service flow rate (pc/h/ln)	**630**	**990**	**1435**	**1860**	**2100**
80 km/h	**Maximum density (pc/km/ln)**	**7**	**11**	**16**	**22**	**27**
	Average speed (km/h)	**80.0**	**80.0**	**80.0**	**77.6**	**74.1**
	Maximum volume to capacity ratio (v/c)	**0.28**	**0.44**	**0.64**	**0.85**	**1.00**
	Maximum service flow rate (pc/h/ln)	**560**	**880**	**1280**	**1705**	**2000**
70 km/h	**Maximum density (pc/km/ln)**	**7**	**11**	**16**	**22**	**28**
	Average speed (km/h)	**70.0**	**70.0**	**70.0**	**69.6**	**67.9**
	Maximum volume to capacity ratio (v/c)	**0.26**	**0.41**	**0.59**	**0.81**	**1.00**
	Maximum service flow rate (pc/h/ln)	**490**	**770**	**1120**	**1530**	**1900**

Source: Exhibit 21-2 in the HCM 2000 (TRB 2000).

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Appendix B

Australian Road Rules

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154 Bus lanes

(1) A driver (except the driver of a public bus) must not drive in a bus lane, unless the driver is permitted to drive in the bus lane under rule 158.
Offence provision.
Note 1 ***Public bus*** is defined in the dictionary.
Note 2 Rule 158 provides additional exceptions applying to this rule, and also provides a defence to the prosecution of a driver for an offence against this rule.

(2) A ***bus lane*** is a marked lane, or the part of a marked lane:
(a) beginning at a *bus lane sign* (whether or not there is also a bus lane road marking) and ending at the nearest of the following:
(i) an *end bus lane sign*;
(ii) a traffic sign that indicates the beginning of another special purpose lane; or
(b) beginning at a bus lane road marking (if there is no *bus lane sign*) and ending at the next intersection.

Note ***Intersection, marked lane, special purpose lane*** and ***traffic sign*** are defined in the dictionary.

(3) In this rule:
bus lane road marking means a road marking consisting of:
(a) the letters ‘BL’; or
(b) the words ‘bus lane’; or
(c) the words ‘bus only’.

Note ***Road marking*** is defined in the dictionary.

Bus lane sign

End bus lane sign

Note for diagrams There are a number of other permitted versions of each of these signs — see the diagrams in Schedule 3.

156 Transit lanes

(1) A driver must not drive in a transit lane unless:
(a) the driver is driving:
(i) a public bus, public minibus, motor bike, taxi or tram; or
(ii) if the *transit lane sign* applying to the transit lane is a *transit lane (T2) sign* — a vehicle carrying at least 1 other person; or

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(iii) if the *transit lane sign* applying to the transit lane is a *transit lane (T3) sign* — a vehicle carrying at least 2 other people; or

(b) the driver is permitted to drive in the transit lane under rule 158.

Offence provision.

Note 1 ***Motor bike***, ***public bus***, ***public minibus***, ***taxi*** and ***tram*** are defined in the dictionary.
Note 2 Rule 158 provides additional exceptions applying to this rule, and also provides a defence to the prosecution of a driver for an offence against this rule.

A ***transit lane*** is a marked lane, or the part of a marked lane:
(a) beginning at a *transit lane sign*; and
(b) ending at an *end transit lane sign*.

Note ***Marked lane*** is defined in the dictionary.

Transit lane signs

Transit lane (T2) sign

Transit lane (T3) sign

End transit lane signs

End transit lane (T2) sign

End transit lane (T3) sign

Note for diagrams There are a number of other permitted version of the *transit lane sign* and another permitted version of the *end transit lane sign* — see the diagrams in Schedule 3.

158 Exceptions to driving in special purpose lanes etc

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(1) The driver of any vehicle may drive for up to the permitted distance in a bicycle lane, bus lane, tram lane, transit lane or truck lane if it is necessary for the driver to drive in the lane:

(a) to enter or leave the road; or

(b) to enter a part of the road of one kind from a part of the road of another kind (for example, moving to or from a service road, the shoulder of the road or an emergency stopping lane); or

(c) to overtake a vehicle that is turning right, or making a U-turn from the centre of the road, and is giving a right change of direction signal; or

(d) to enter a marked lane, or part of the road where there is room for a line of traffic (other than motor bikes, bicycles, motorised wheelchairs or animals), from the side of the road.

(2) The driver of any vehicle may drive in a bicycle lane, bus lane, tram lane, transit lane or truck lane if:

(a) it is necessary for the driver to drive in the lane to avoid an obstruction; or

(b) information on or with a traffic sign applying to the lane indicates that the driver may drive in the lane; or

(c) the driver is permitted to drive in the lane under another law of this jurisdiction.

Note ***Obstruction***, ***traffic sign*** and ***with*** are defined in the dictionary.

(3) It is a defence to the prosecution of a driver for an offence against a provision of this Division for driving in a bicycle lane, bus lane, tram lane, transit lane or truck lane if:

(a) it is necessary for the driver to drive in the lane to stop at a place in the lane; and

(b) the driver is permitted to stop at that place under the Australian Road Rules or another law of this jurisdiction, or it is a defence under rule 165 for the driver to stop at that place; and

(c) if the lane is a bicycle lane — the driver drives in the lane for no more than the permitted distance.

Note Rule 165 provides a defence to the prosecution of a driver for an offence against a provision of Part 12 (Restrictions on stopping and parking). The defence is available, for example, if the driver needs to stop to deal with a medical or other emergency.

(4) In this rule:

permitted distance means:

(a) for a bicycle lane or tram lane — 50 metres; or

(b) for any other lane — 100 metres.

147 Moving from one marked lane to another marked lane across a continuous line separating the lanes

A driver on a multi-lane road must not move from one marked lane to another marked lane by crossing a continuous line separating the lanes unless:

(a) the driver is avoiding an obstruction; or

(b) the driver is obeying a traffic control device applying to the first marked lane; or

(c) the driver is permitted to drive in both marked lanes under another provision of the Australian Road Rules or under another law of this jurisdiction; or

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(d) either of the marked lanes is a special purpose lane in which the driver is permitted to drive under the Australian Road Rules and the driver is moving to or from the special purpose lane.