Public Transport Authority

Bus Planning and Design Guidelines for Efficient People Movement

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Foreword

Patronage on Perth's public transport system has grown by 75% in the decade to 2015, as the Perth and Peel population has passed 2 million people. During this time there has been a significant but much smaller growth of car travel of 20%, generally in line with population growth. Currently bus travel accounts for 57% of all public transport trips and almost 50% of the distance travelled by public transport.

The Department of Planning is predicting that Perth's population will grow 45% to 2.9 million by 2031. During this time the mode share of public transport is estimated to grow from 6.5% to 10% of all trips, resulting in a likely growth of public transport patronage of over half a million daily trips to more than 1 million trips per day.

The high population growth in Perth is resulting in increasing levels of congestion. Infrastructure Australia has documented that the cost of congestion in Perth would grow from $1.8 billion in 2011 to $15.9 billion in 2031 in the absence of additional network capacity and demand management beyond that already committed.

Growth of congestion reduces reliability for bus travel because buses are obliged to travel along fixed routes on the road system. This publication documents how the Public Transport Authority (PTA) intends to work with its partners – Local Government, Department of Transport and Main Roads WA to make travel by bus more efficient and to move more people, more reliably in fewer vehicles and thus assist in improving accessibility whilst mitigating congestion.

Over the last 20 years, the PTA, working with other stakeholders, has gained extensive experience on a variety of bus priority measures, other system improvements and street design to accommodate safe and efficient bus movements. These guidelines document that experience for the benefit of all stakeholders who are involved in managing the movement of people on the road network. As the demand for travel increases, it is imperative we all work together to find more effective ways to utilise limited road space.

The application of these guidelines will ensure that public transport infrastructure can be continuously improved to meet growing future demand for bus travel on the network in a cost effective manner.

The PTA remains committed to working with its partners to deliver an effective and efficient public transport system for the benefit of the community. This document will be updated on a regular basis to reflect improvements in knowledge and technology.

Managing Director

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Executive Summary

These guidelines on bus planning and design have been developed by Jacobs for the Public Transport Authority (PTA) to assist in the development of efficient movement of people by buses. The intention is to help the PTA to work with partners, such as Local Governments, the Department of Transport and Main Roads WA to increase the overall efficiency and capacity of the transport system by moving more people by bus and in so doing assisting in the mitigation of congestion by reducing the proportion of people travelling by private car.

The WA Government has developed a suite of policy initiatives to improve the efficiency of the Perth transport system and mitigate growing congestion. A key component of these initiatives is to move more people more efficiently in fewer vehicles.

Travel by public transport in Perth has increased by more than 110% in the decade to 2013. Currently more than 450,000 trips each day are by public transport. The table below provides an estimate of travel by public transport in Perth in 2011 and 2031.

Proportion of Travel by Public Transport	2011	2031
Daily Travel	7.5%	12.5%
Peak Hour Travel	12.5%	20%
Peak Hour Distance Travel	20%	30%
Travel to Central Perth	50%	70%

Source: Public Transport in Perth 2031

Currently bus travel accounts for 57% of all public transport trips and almost 50% of the distance travelled by public transport. On key bus routes in and around the Perth CBD, the number of people travelling in buses approaches or exceeds the number of people travelling in cars.

Street	Location	Time	% of total people moved by bus
Wellington Street	Near Sutherland Street	7:30-8:30	43%
Mounts Bay Road	Near Rotary	7:30-8:30	42%
St George's Terrace	Near Irwin Street	7:30-8:30	75%
Causeway	East End	7:30-8:30	46%
Fitzgerald Street	Near Newcastle Street	7:30-8:30	67%

NOTE: St George's Terrace at midday carries 44%.

Intent of this Document

This bus planning and design guidelines document is not intended as a replacement for existing road and street guidelines. It is intended to be used as guidance alongside current and future road regulations, planning and road design guides, including:

- Main Roads Western Australia (MRWA) road and traffic engineering standards, which address (among other variables) geometric design and traffic management requirements [Available: http://standards.mainroads.wa.gov.au/NR/mrwa/frames/standards/standards.asp?G={E582C897-FF5E-4C02-8B46-51E88C1E5DD8]
- Austroads Guides as follows [Available: www.austroads.com.au/]:
    - Guide to Road Design Series
    - Guide to Traffic Management Series
- Australian Standards AS1742 series (*Manual of Uniform Traffic Control Devices*) and AS1428 series (*Design for Access and Mobility*) [Available: www.standards.org.au/]
- Disability Standards for Accessible Public Transport, 2002 [Available: www.comlaw.gov.au/ComLaw/Legislation/LegislativeInstrument1.nsf/0/617AEF1A18E5D654CA256FC40009B824?OpenDocument&VIEWCAT=attachment&COUNT=500&START=1]
- Liveable Neighbourhoods (2009) [Available: www.planning.wa.gov.au/Plans+and+policies/Publications/1594.aspx]
- Road Traffic Code 2000 [Available: www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_2007_homepage.html]
- PTA publications that provide more detailed planning and design guidelines on constructability, interchange design and public transport bus stop layout guidelines.

Role of Bus Travel

In Perth's integrated transport system buses will continue to provide the following important roles:

- Providing convenient affordable access to work, education and other activities.
- Providing a reliable service to people in the community who choose not to drive, do not have access to or are unable to drive a car.
- Public transport will align with urban development and buses should be integrated in activity centre planning.
- Providing increased transport system capacity, along crowded corridors and within centres where road capacity is at a premium.
- Reducing congestion in city centres and along major arteries by providing an efficient alternative to car travel.
- Increasing the people moving capacity of the train system by providing efficient access to and from rail stations.

Key Bus Planning Principles

Bus travel can become more attractive and efficient through:

- Improved service frequency.
- More comprehensive, legible and direct route coverage.
- On street priority for buses to reduce travel time and improve reliability.
- Provision of quality bus interchanges, stations and stops to improve passenger comfort and ease of interchange between services.

Bus Infrastructure Design Principles

Buses are large vehicles designed to carry large numbers of passengers per vehicle. **Chapter 3** in the guidelines provides some basic principles for use by bus infrastructure designers. These include the physical space requirements for bus travel on the street system and in the bus interchanges and bus stations. Guidance is provided for a range of features including lane widths, turning circles, intersection design, vertical clearance, bus stops and when different types of bus priority measures may be warranted.

Bus Priority Measures

As congestion increases, bus priority measures become a more important part of an efficient bus operating system. Bus priority makes bus travel faster, more reliable and more attractive to users. It also reduces the cost to bus operators by reducing the number of buses required along otherwise congested routes.

A number of different bus priority options are described including:

- Bus transitways or busways
- Bus lanes (all day)
- Bus lanes (peak times with parking allowed off peak)
- Bus queue jump lanes
- Bus only streets or transit malls
- Traffic signal priority for buses
- Parking restrictions and clearways.

It is often possible to permit bus lanes and bus streets to be used by nominated road users, such as cyclists, taxis and motorcyclists. Exceptions include where the section of bus lanes provides access to a bus station or interchange. In dense city centre areas where there are large numbers of buses and taxis care will need to be taken to ensure high occupancy buses are not unduly delayed by relatively low occupancy taxis. In these circumstances it would be necessary to prohibit taxi use of that section of bus lane, which should be signed accordingly.

Cyclists are vulnerable road users and some feel uncomfortable sharing space with buses. However, on some occasions there are limited or poor alternative options to the use of the bus lane by cyclists. In such circumstances cyclists' use of the bus lanes can be permitted. On very busy bus lanes with insufficient room for buses to pass cyclists, or in suburban areas with higher operating speeds, it may be preferable on balance to prohibit bicycles from using particular bus lanes.

The Department of Transport is currently working with the PTA on the use of bus lanes by motorcyclists. Motorcyclists are also vulnerable road users and share some of the same problems outlined above by cyclist use of bus lanes. However the problems are not as extreme as motorcyclists are a larger vehicle than cyclists and can travel at the same speed as buses, even in suburban bus lanes.

Consultation and Agreement

A partnership agreement has been developed which defines the roles and responsibilities for planning, installation and maintenance of bus stop infrastructure. This document is to be used by the PTA and local Authorities to determine roles and responsibilities. A link to the finalised document will be provided in future updates. (Refer to PTA-LGA Deed of Agreement)

Bus Interchanges and Stations

Bus interchanges and stations are used by large numbers of buses and passengers. They should be located and designed so that conditions are optimised for both passengers and buses. The guidelines discuss design principles for different types of bus stations and bus/bus and bus/train interchanges. In all cases easy and comfortable transfer between services is a high priority.

Seating and shelter should be provided at all train platforms and bus stands. Escalators should be provided at busy interchanges and lifts should be provided to meet the needs of people with disabilities where required.

Specific guidelines are provided for the movement of buses within the station or interchange as well as at the entrance and exit to the interchange from the street system.

A number of different layouts are discussed in the guidelines by the way of example. Generally the dog bone, the anti-clockwise layout or the multi-platform options are likely to offer the greatest benefits. However, the planner/designer should take account of the specific site constraints and user requirements.

Street Planning for Buses

This section of the guidelines will be of particular interest to local government personnel, as local governments have the care, control and management of most streets used by buses, in some cases, the road or street will be under the care, control and management of Main Roads WA and Main Roads WA engineers will also have an interest in this section.

Roads and streets that are intended for use by buses must be planned and designed to facilitate bus movement in a safe and efficient manner. This guidelines document is not intended as a replacement for road and street design guidelines. Bus planning and design will depend on the type of street in the road hierarchy with guidance provided on planning and design of facilities on the following street types:

- Primary distributors (freeways and semi-rural highways)
- Integrator arterials (urban higher speed)
- Integrator arterials (urban lower speed)
- Neighbourhood connectors
- Access streets.

There is limited use of freeways by buses in Perth, largely because the two main freeway corridors are served by train lines. However, there may well be advantages in implementing freeway bus priority in the future. Facilities of this type would require significant planning and design involving the DoT, PTA and MRWA. The impact of dedicated bus lanes would need to be fully assessed using modelling to demonstrate the impacts. Accordingly only general advice is provided in these guidelines.

Semi-rural highways are not well suited for use by buses because of the high speed differential of stopping buses and general traffic and because of the difficulty passengers have in crossing the road safely. Where no suitable alternative exists to running bus services along semi-rural highways consideration should be given to providing custom built bus stations with grade separated access or to locating bus stops on the far side of traffic signals, in conjunction with a lowering of the speed limit near the signals and bus stops.

Integrator arterials are well suited for use by buses as they are usually direct and provide safe crossing places for bus passengers to cross the street. On high volume integrator arterials bus stops should generally be placed on the far side of traffic signals (either intersection signals or pedestrian signals). On lower volume two lane integrator arterial street, traffic signals or zebra crossings may be used to assist bus passengers to cross the street.

As a general rule, buses should stop on the carriageway on integrator arterials streets. This enables buses to retain their place in the traffic stream to some extent and avoids the need for buses to pull out and into the traffic stream. Bus embayments should be provided at timed bus stops where buses may need to dwell for longer periods of time, on higher speed (80km/h) streets or where there are particular safety reasons requiring the need for bus embayments.

Bus travel can be disrupted by on street parking on integrator arterial streets. However, street parking is often required on streets of this type for adjacent residents and or businesses an appropriate compromise may be to provide priority for buses in the peak direction during peak times and permit parking at other times. This is a matter that will require discussion between the local government and the PTA.

Where buses are required to make right turns onto integrator arterial streets, traffic signals or roundabouts will be necessary to allow safe access. These would need to be fully assessed before the decision of whether a control mechanism (traffic signals or roundabout) is installed. In some instances similar devices will be necessary to permit buses to turn right off integrator arterial streets.

The issue regarding design of traffic management on neighbourhood connectors are similar to on integrator arterials. In some instances, the local authority may wish to install traffic calming devices to slow down traffic along neighbourhood connector streets. Such devices can hinder bus movement and can result in discomfort for passengers. Where installation of traffic calming devices is being considered, it is suggested that discussion on the need and type of traffic calming device be discussed with the PTA. Where traffic calming devices are deemed necessary, road cushions or raised platforms may offer the best design option for use on bus routes.

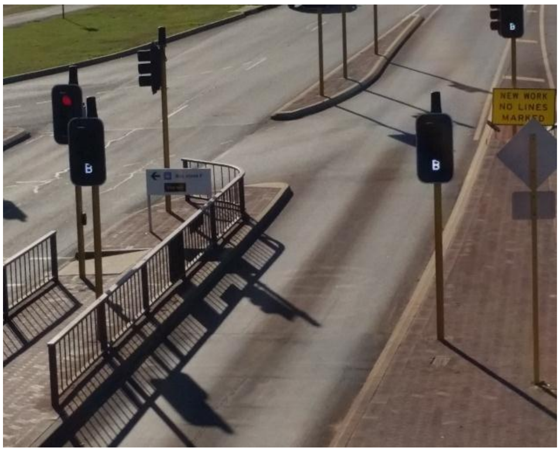
Intelligent Transport Systems

Intelligent Transport Systems (ITS) offer a significant opportunity to operate a more effective and efficient transport network that makes better use of existing physical infrastructure and supports the moving people agenda. The option of Traffic Signal Priority would need to be assessed and its impact on the overall performance of the network considered.

A trial of real time tracking and traffic signal priority on 130 buses from Karrinyup Depot between 2012 and 2015 demonstrated that significant improvement to operational performance could be delivered. While it is not possible to determine if all improvement was due to real time tracking and traffic signal priority systems, on the Scarborough Beach Road corridor the following benefits have been achieved:

- Average journey time was reduced by up to 20%
- Average journey time variability was reduced by up to 60%
- Percentage of buses more than four minutes late reduced by 50%.

In 2015 the entire Transperth fleet will be fitted with upgraded on-board equipment that offers a number of opportunities for enhancing the passenger experience.

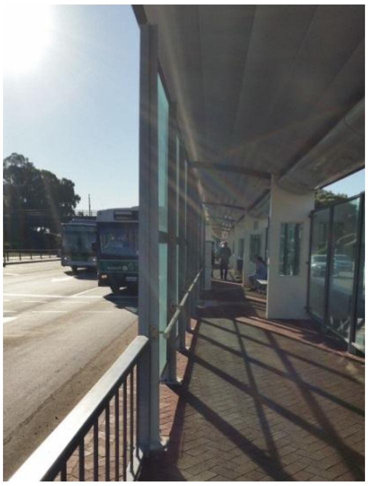


The following ITS tools that can be introduced to improve bus performance are discussed in chapter 8 of the guidelines:

- Real time tracking
- Traffic signal priority (using loops, GPS or B signals)
- Automatic fare collection
- Dynamic stand management at bus interchanges.

Constructability

This guideline is an outline of PTA's accumulated knowledge of maintaining existing public infrastructure buildings and selected associated elements. It provides guidance to designers, engineers and project managers in order to ensure future projects are less problematic and have a longer useful asset life. The document covers material selection, details problems encountered with some materials, reasons for the selection and issues affecting maintainability.



1. Introduction

These guidelines on bus planning and design have been developed by Jacobs for the Public Transport Authority (PTA) to assist in the development of efficient movement of people by buses. The intention is to help the PTA to work with partners, such as Local Governments, the Department of Transport and Main Roads WA to increase the overall efficiency and capacity of the transport system by moving more people by bus and in so doing assisting in the mitigation of congestion by reducing the proportion of people travelling by private car.

The focus of this document is on bus movement and in particular on how bus movement can be made more efficient through a range of measures including:

- Operation of efficient high frequency bus services
- Provision of a range of bus priority measures
- Development of high quality bus interchanges
- The increased use of intelligent transport systems to reduce bus delay at traffic signals and to provide bus passengers with readily accessible information to make their journey easier and more convenient.

Current transport policy is focused on improving transport efficiency by moving more people in fewer vehicles. These guidelines provide practical information on how this can be achieved by improving the efficiency of the bus system. The guidelines are intended to assist transport and town planners, engineers and bus service providers to work together to achieve this aim.

These guidelines recognise the difficulties and complexities of integrating improved bus networks and services into a constrained network that is often congested with a variety of different vehicle types. Whilst separate facilities for buses are desirable and have proven benefits in improving bus reliability and reducing travel times for bus passengers, they are not always feasible. A range of facilities, which includes intelligent transport systems to improve priority for buses and reduce delay at traffic signals will need to be considered. Similarly, the approach being advocated by the Department of Transport (TransPriority), can deliver bus priority lanes during peak periods, whilst for example, providing kerb side parking that is considered important to retail traders outside of peak times.

The principles and guidelines within this document can be used to guide planning in new development areas, as well as retrofitting for transit streets in established areas.

Although not as large as trains or light rail, buses are large vehicles. This is necessary for the efficient movement of large numbers of people in one vehicle. There are practical minimum lane widths and turning circles required to accommodate these vehicles even at low speeds. It is important to note that the absolute minimum widths and turning radii should only be used where there is no practical alternative. The guidelines also advocate desirable dimensions and radii for use where this is achievable.

A number of technical terms and acronyms are used throughout this document. A technical glossary of definitions and acronyms is attached as **Appendix A**.

These guidelines have been developed and presented in a single document. It takes account of good practice in Perth, other Australian Cities and some overseas cities. It replaces and updates previous documents which were produced by the PTA between 2003 and 2011.

A bibliography of reference material used in preparation of these guidelines is included in **Appendix B**.

2. Integrated Transport Planning Approach

Key State Transport and Planning Objectives:

- Reduce dependency on use of cars
- More jobs in outer Perth closer to where people live
- Transit oriented development around train stations and along activity corridors
- Improve efficiency by moving more people in less vehicles
- Improve priority for high efficiency bus and future light rail
- Rail improvements for mass transit
- Car parking policy

The Western Australian Government has embraced an integrated transport planning approach for Perth, which includes:

- Integrated land use and transport planning.
- Multi-modal transport planning to reduce car dependency and increase use of public transport, walking and cycling.
- Road network planning to accommodate safe movement by pedestrians and a range of vehicle types, in a way that maximises the movement of people and freight, rather than vehicles, on the network.
- A TransPriority approach that provides priority for different travel modes (e.g. public transport) at different locations and times of the day.

2.1 Directions 2031 and Beyond (WAPC, 2010)

Directions 2031 and Beyond sets a high level planning framework for Perth with the objective of:

- Creating an overall higher level of density, including in existing inner areas.
- Developing 14 strategic metropolitan centres to complement Perth City (see **Figure 2.1**).
- Creating transit oriented developments around train stations and along activity corridors served by high frequency buses and potentially, future light rail.
- Linking good urban planning and transport planning.

A major reason for this form of development is:

- It will encourage much more walking and cycling in the mixed use centres.
- It will enable many more people to live and work in close proximity to high frequency public transport, thereby increasing its use
- It will allow and encourage a more balanced transport system with reduced dependence on cars that will assist in mitigating congestion as Perth grows to a population beyond 3.5 million people.

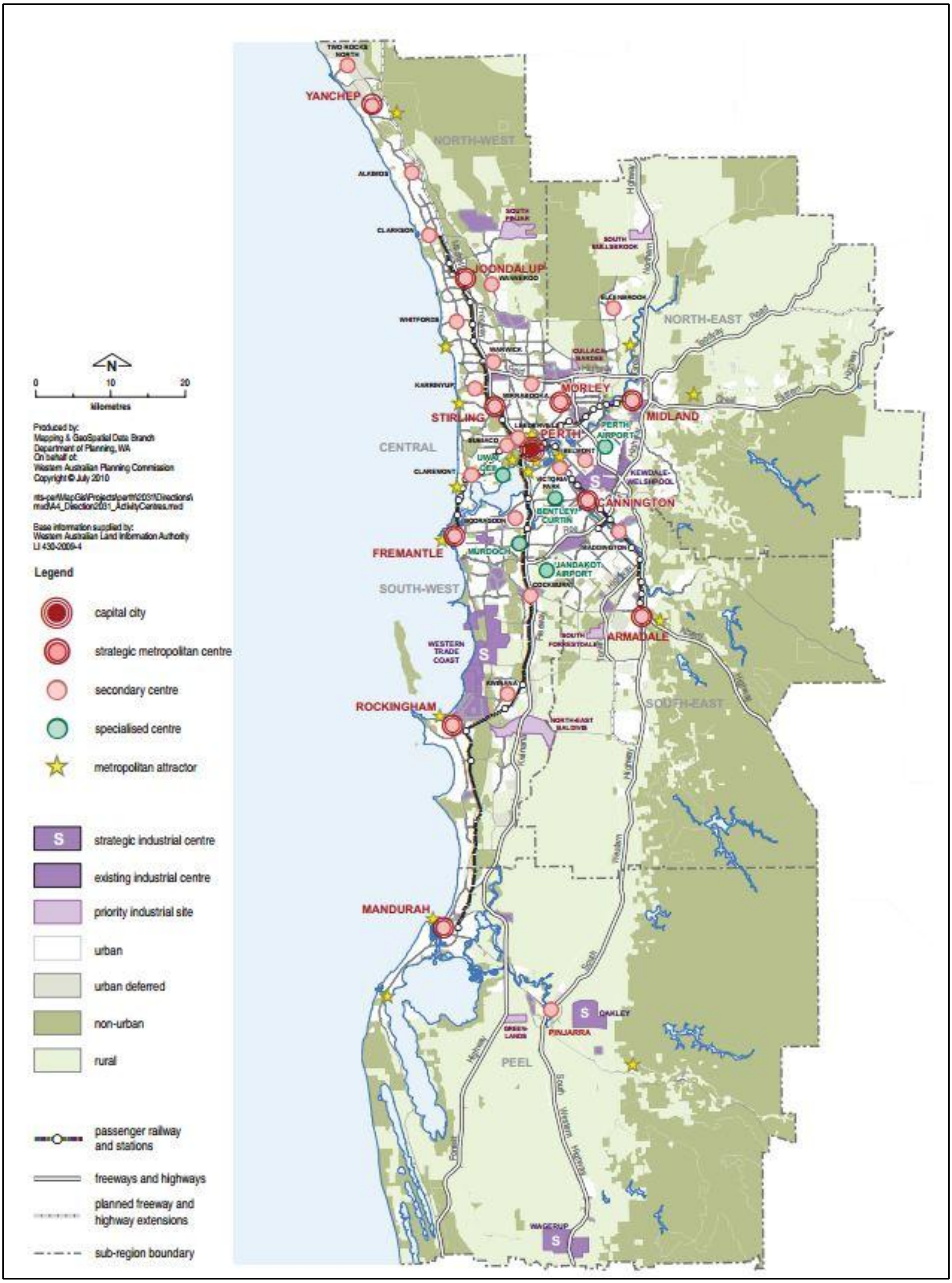


Figure 2.1: Map identifying 14 existing and future strategic metropolitan centres (Directions 2031)

2.2 Transport Planning Framework

Current integrated transport planning seeks to mitigate congestion by increasing the capacity of the networks (supply) and by managing the demand for travel (see **Figure 2.2**).

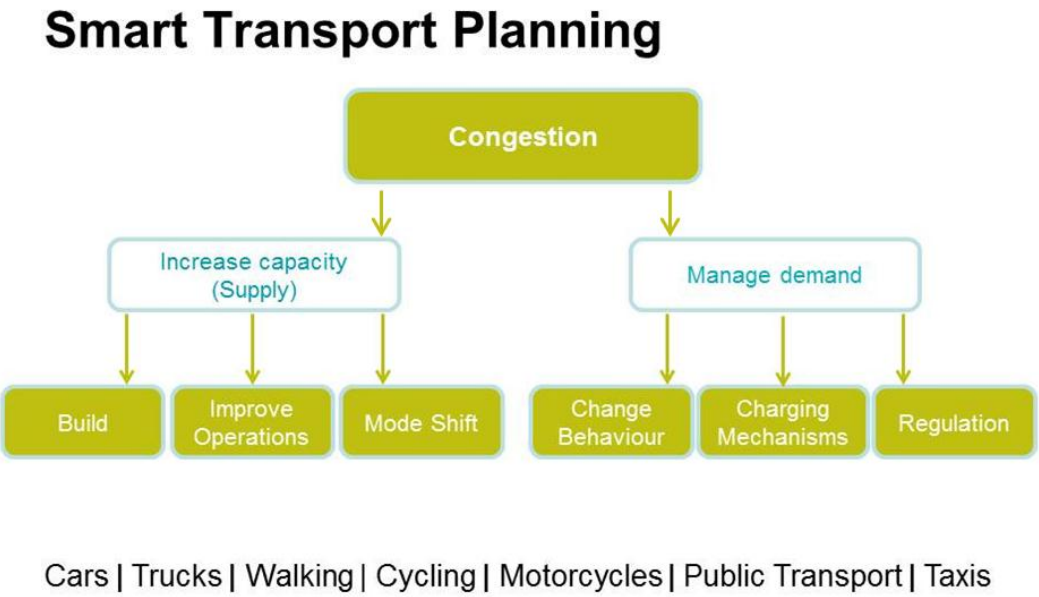


Figure 2.2: Smart Transport Planning (2015)

Figure 2.3 provides an outline of the current network transport planning framework.

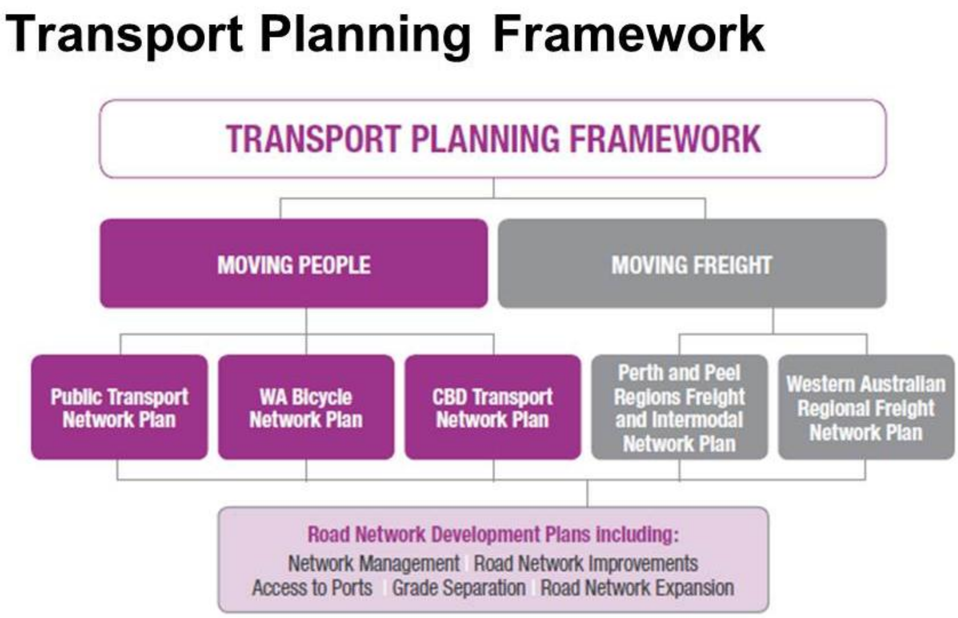


Figure 2.3: Transport Planning Framework (2015)

The emphasis is on moving people and moving freight rather than moving vehicles. A key component of the current transport policy is to increase the capacity of the network by moving more people in less vehicles. Overall network efficiency is improved because the space occupied by vehicles moving the same number of people is reduced (see **Figure 2.4**).

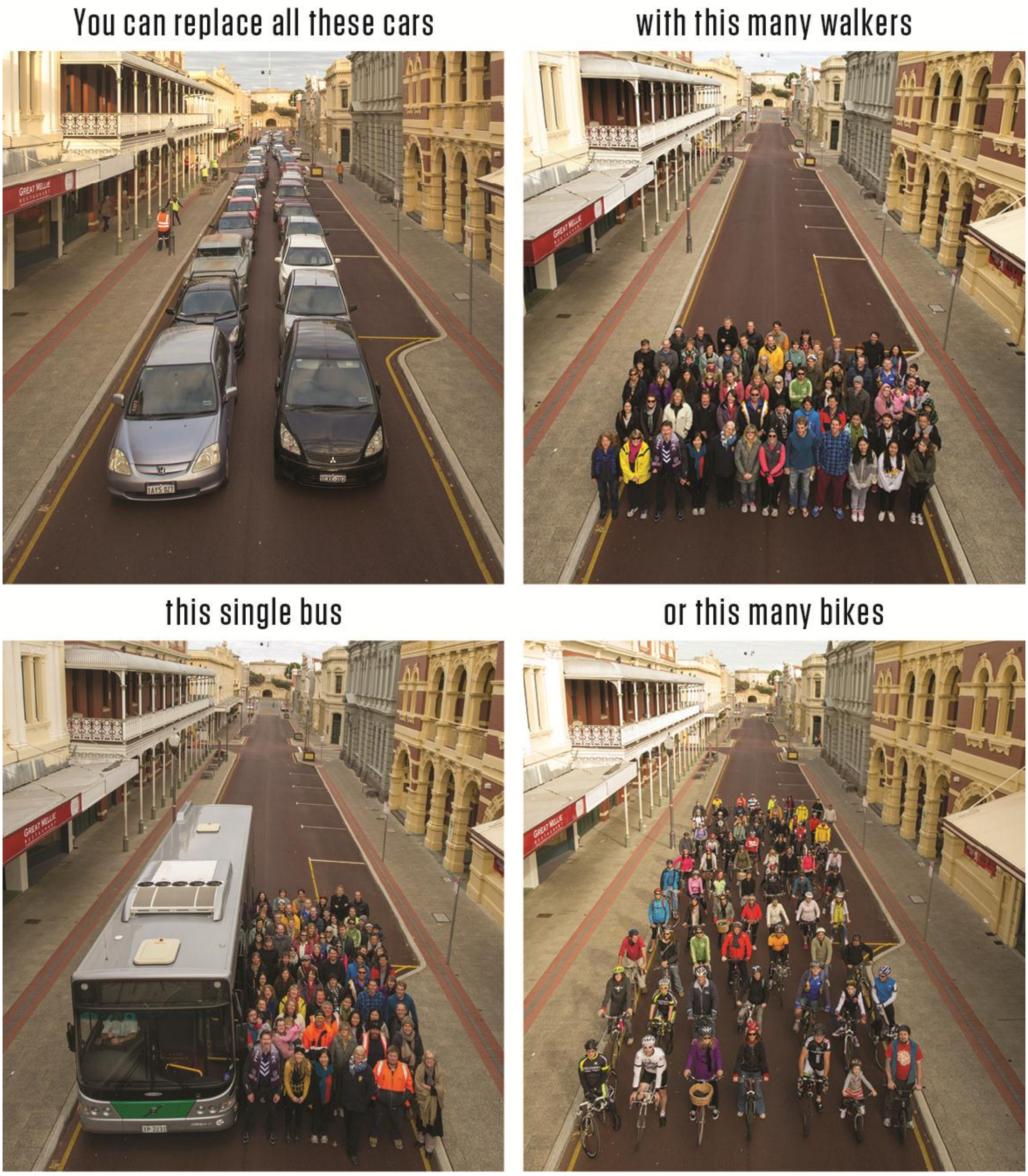


Figure 2.4: Walk over October poster showing how many cars one bus will replace (City of Fremantle)

The railway in the centre of the Mitchell and Kwinana Freeways and the bus lanes in the centre of the Causeway are examples of efficient use of transport corridor space.

More people move in the peak period by rail than by car in half the space.

Approximately half of peak people movement across the Causeway by bus in half the road space.

Figure 2.5: Mitchell Freeway Corridor and Perth Causeway

There are a variety of streets in and around the Perth CBD where bus travel, measured by the movement of people approaches or exceeds the person movement by cars during the peak periods. Some of these streets have bus priority but the majority do not.

Street	Location	Time	% of total people moved by bus
Wellington Street	Near Sutherland Street	7:30-8:30	43%
Mounts Bay Road	Near Rotary	7:30-8:30	42%
St George's Terrace	Near Irwin Street	7:30-8:30	75%
Causeway	East End	7:30-8:30	46%
Fitzgerald Street	Near Newcastle Street	7:30-8:30	67%

Table 2.1: Percentage of People that Travel By Bus – Perth Central Area (Source: Information provided by PTA)

2.3 Draft Public Transport Network Plan, 2031 (Currently Under Review)

In 2011 the Western Australian Government released a draft long term public transport plan. The aim of the plan (Public Transport for Perth in 2031) is to increase the proportion of people moved by public transport from 6% in 2010 to 10% by 2031 and to 14% by the time Perth reaches a population of 3.5 million, sometime beyond 2040.

Figure 2.6 shows that travel by public transport in Perth remained static between 1970 and 1992 whilst the population grew by 80%. This resulted in a reduction in the mode share of travel by public transport from around 9% in 1970 to 5% in 1992.

From 1992 to 1999 public transport patronage grew by 20%, but because of strong population growth, the mode share of public transport continued to decline to 4.5%.

From 1999 to 2012 public transport patronage grew by more than 100% and the mode share of travel by public transport also grew from 4.5% to 6.5%.This growth was in part due to the opening of the Perth to Mandurah railway, improved service and frequency of buses, introduction of bus priority along major transport routes and other public transport supportive policies.

The draft public transport plan has proposed:

Some expansion of the rail network;

- Development of an improved on-road network of approximately 300km of priority bus and light rail services.
- Continued improvement in frequency of bus services.
- Development of more bus/rail interchanges and park and ride interchanges to maximise use of the system.

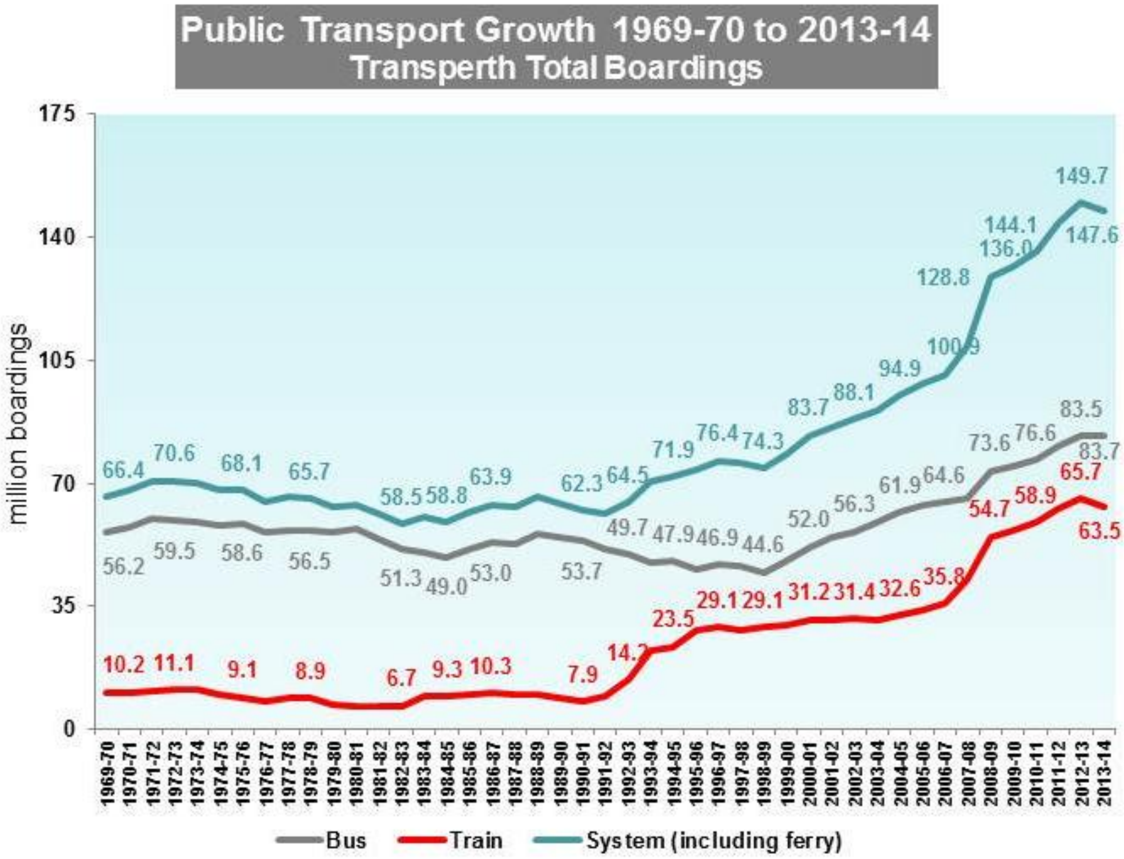


Figure 2.6: Public Transport Growth 2013/14

2.4 Integrated Transport and Land Use Planning

Developing an efficient and integrated transport system is as much about developing an efficient distribution of land use types as it is about developing efficient transport networks. Importantly land use and transport planning must be co-ordinated and integrated.

Guidelines for the Preparation of Integrated Transport Plans (Department of Planning, 2012) sets out a number of important objectives for efficient land use transport integration (LUTI). They include:

- Creating more jobs in the outer sub-region of Perth (currently the outer sub-region has 50% of Perth's population, but only 30% of jobs)
- Creating as many jobs as possible in centres and along corridors that are well served by public transport
- Creating higher residential density in close proximity to rail stations and along corridors well served by high frequency buses
- Locating major retail centres in mixed us activity centres that are well served by public transport

There is emerging evidence that the walking catchment of train stations and high frequency bus corridors is larger than was previously believed to be the case.

Mean and 85th Percentile Walking Distance

Source: Matthew Burke and A.L. Brown (2007)

Significant long term planning is now taking place across metropolitan Perth by local authorities and the WAPC to develop structure plans for centres and activity corridors. Amongst other things these long term plans establish long term public transport needs and the space required to provide for public transport priority.

2.4.1 Case Study – Scarborough Beach Road Activity Corridor

The planning process which has taken place over a number of years has established land use and population targets with higher density along the corridor that is well served by public transport. The adopted transport principles have been used to guide long term planning and design.

ADOPTED TRANSPORT PRINCIPLES

1. Improve the health and fitness of the community by creating enjoyable and safe places for people to walk and cycle.
2. Reduce energy consumption and greenhouse gases from transport.
3. Reduce car dependency and use by providing a high level of accessibility by public transport, walking and cycling.
4. Constrain vehicular traffic to levels that can be accommodated on streets designed for all modes of transport while retaining a human scale.
5. The level of car and bicycle parking provided reflects the needs of mixed-use transit-oriented development.
6. Provide a fine-grained network of streets and lanes adjacent to road.
7. Scarborough Beach Road be designed to be compatible with adjacent land uses along its length and to accommodate and support all modes of transport, with connectivity for vehicle traffic taking precedence over speed and capacity.
8. Give priority to public transport over private transport along Scarborough Beach Road.
9. Ensure safe and effective access to existing and future land uses.

Future street cross sections have been developed to provide priority for public transport along a corridor as well as provision for the safe movement of pedestrians, cyclists and cars. Changes to the MRS are being proposed to enable road widening to take place over time as properties are developed.

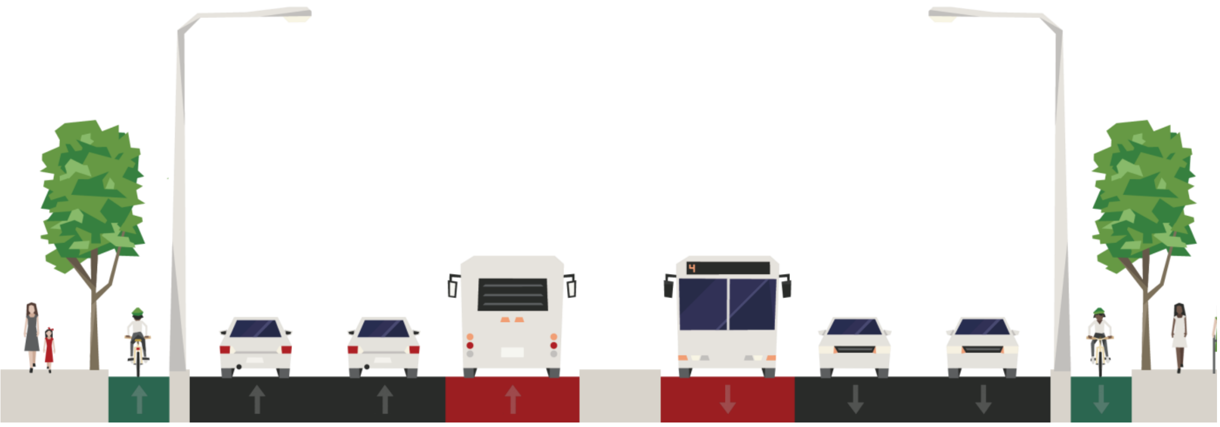


Figure 2.7: Proposed Long Term Street Cross Section in Doubleview, west of Odin Road

A sustainable mobility management approach incorporates four key transport strategies to manage transport in the corridor over the longer term.

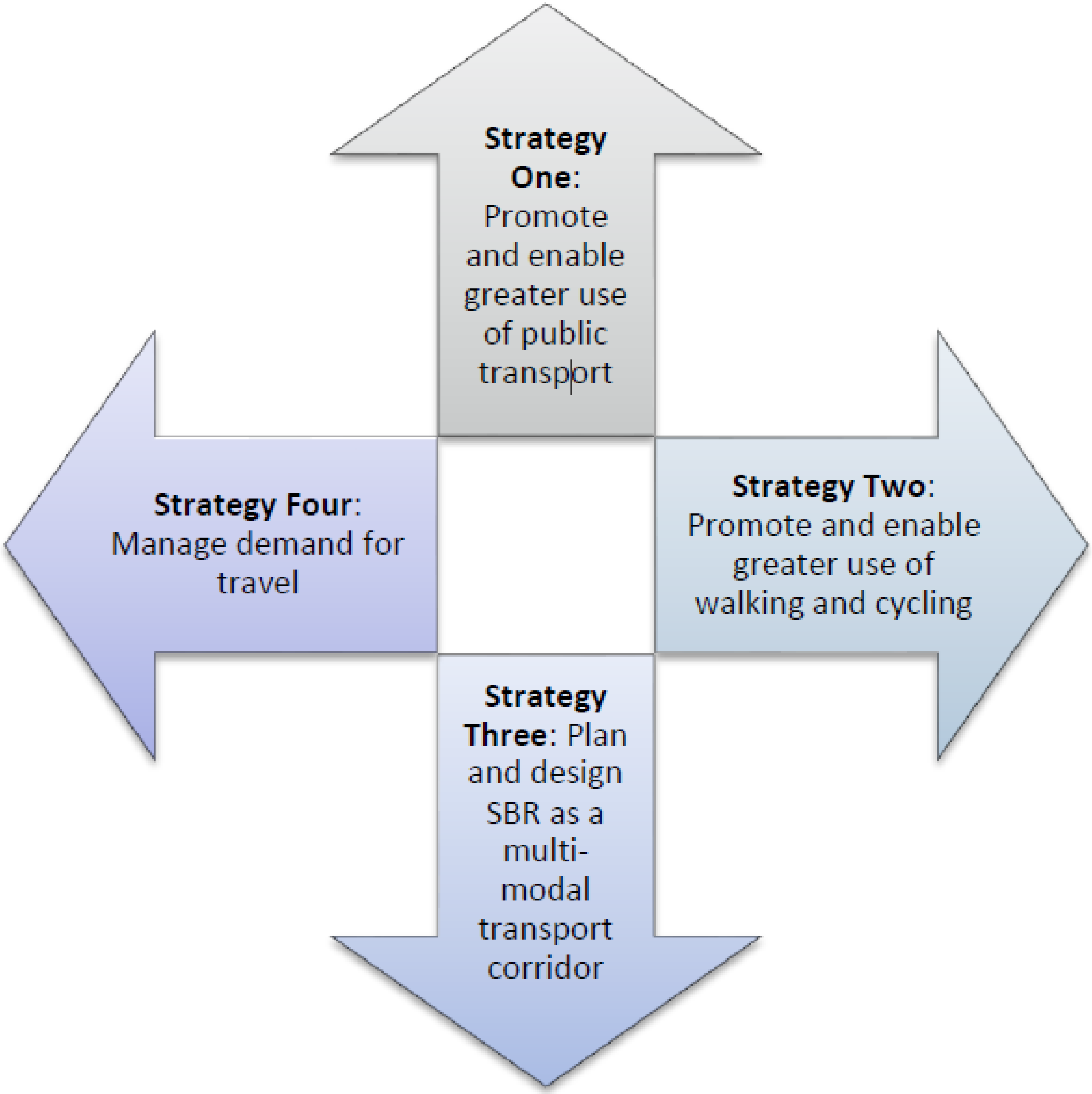


Figure 2.8: Key Transport Strategies

2.5 Perth Parking Policy (1999)

The Perth Parking Policy was developed in 1999 and enshrined in legislation in the State Parliament. It has been updated on a number of occasions since that time. Up-to-date copies of the policy can be downloaded from the Department of Transport website (www.transport.wa.gov.au/projects/perth-parking.asp).

The Perth Parking Policy is a joint agreement by the City of Perth and the State Government. Its primary intention is to improve accessibility and the continued economic viability of the City of Perth with reduced levels of car access.

It was introduced in 1999 following a period of high growth of car parking bays in the City which resulted in higher volumes of traffic on City streets and increased congestion on approach roads to the City as well as on City streets. Since its introduction, there has been a small reduction of non-residential parking bays within the City of Perth (**Figure 2.9**).

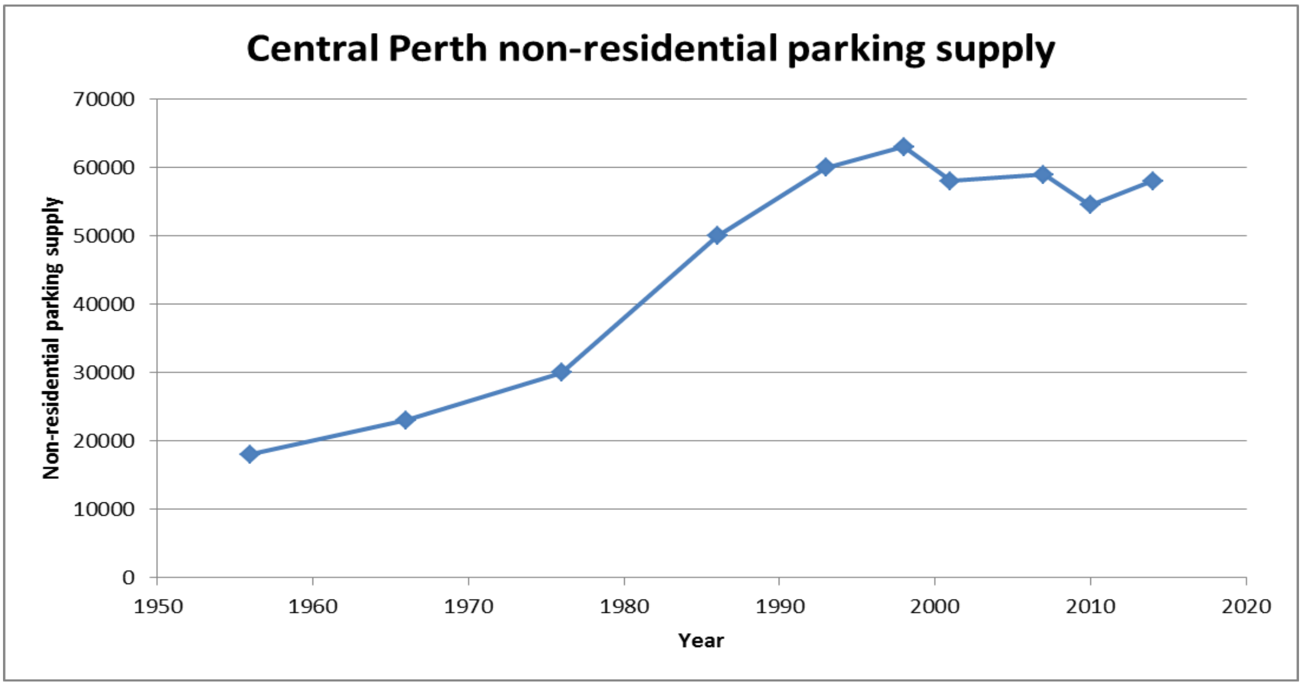


Figure 2.9: Non-residential parking supply in City of Perth

The Perth Parking Policy is designed to manage the demand for car travel to/from the City of Perth. Currently the policy applies to the City of Perth area shown in **Figure 2.10**.

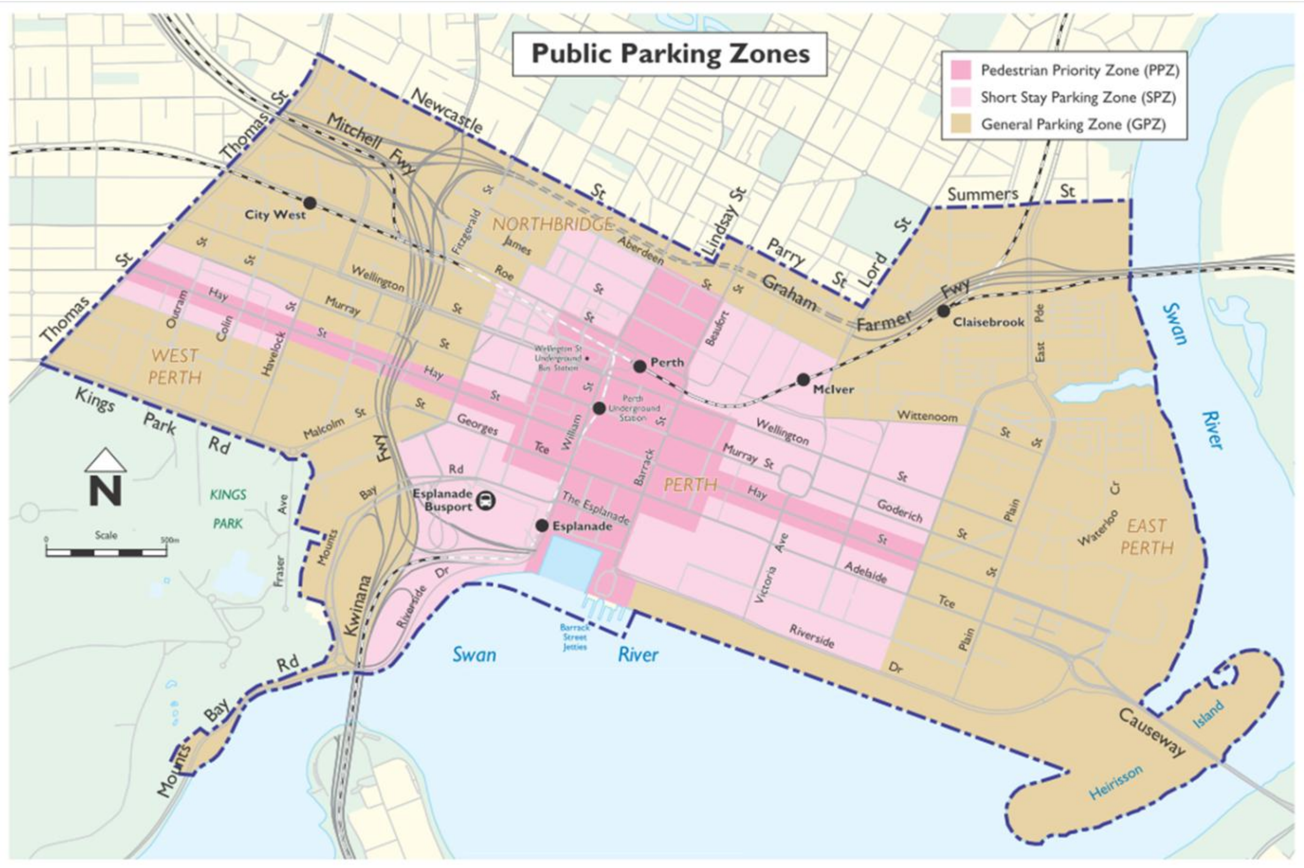


Figure 2.10: Perth Parking Policy Management Area

The main demand management components of the Perth parking Policy are:

- Maximum levels of non-residential car parking are set based on land area, regardless of development intensity
- Long term public parking is restricted to peripheral areas bordering the City Centre
- All parking bays (other than residential bays) are licensed
- A license fee to all non-residential off street and on-street bays with few exceptions.

All revenue obtained from the license fees is hypothecated for expenditure CAT and free bus system and other expenditure on walking, cycling or public transport improvements within the City of Perth.

The Perth Parking Policy has been successful in reducing the level of car driving to/from Perth City, since its introduction in 1999, Figure 2.11. In 2011 there were less car driving trips to/from the City of Perth than in the mid to late 1990s, during a time when employment grew by 30%. The reduced traffic levels has enabled the implementation of bus priority measures and wider footprints to provide benefit for higher numbers of bus passengers and pedestrians.

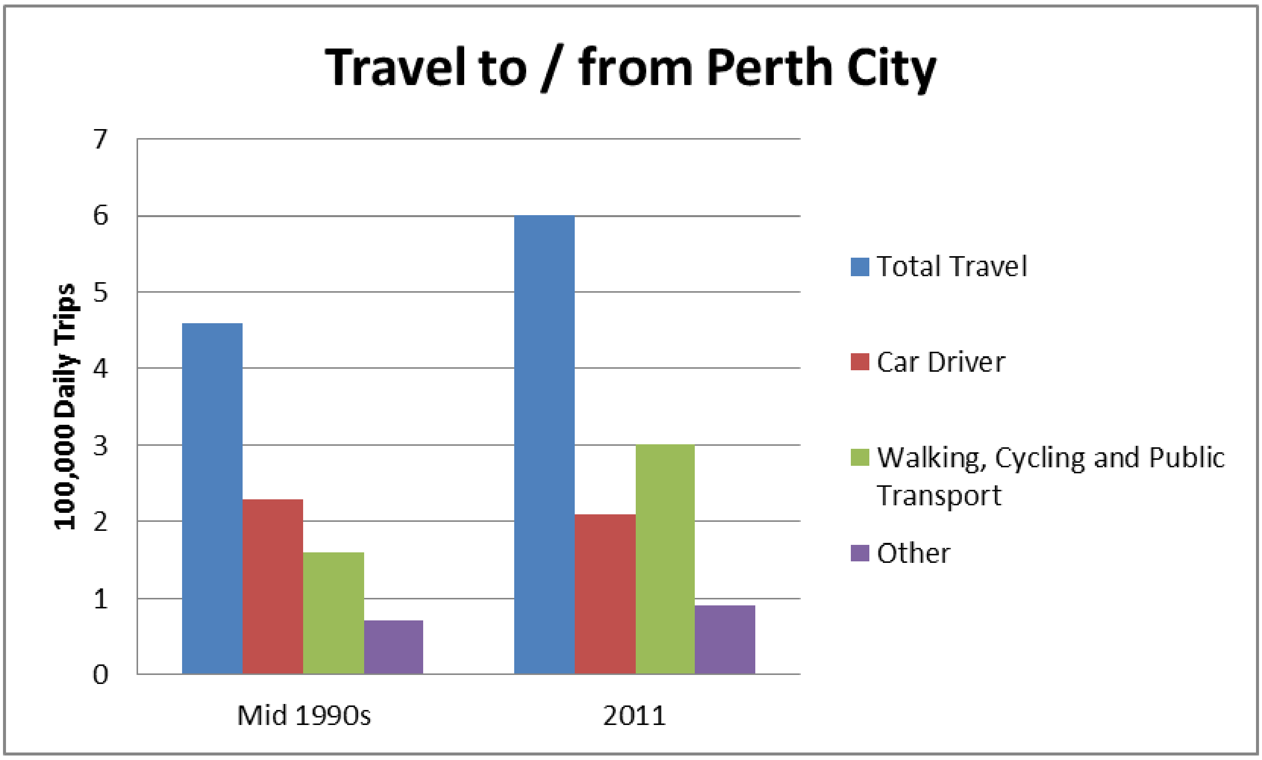


Figure 2.11: Travel to/from Perth City

3. Bus Planning and Infrastructure Design Principles

This section covers:

- The role of buses within an integrated transport system
- Service planning principles when designing bus routes and service levels
- Bus stop design and accessibility

Buses currently (2015) carry 57% of all public transport trips and account for almost half of public transport kilometres travelled by public transport in Perth.

By providing these guidelines it is hoped that stakeholders will assist in the objective to increase the proportion of people travelling by public transport and to reduce the proportion of people travelling by car. Perth's public transport is highly integrated, with many people travelling by both bus and train during the same journey. The fully integrated ticketing system and comfortable bus/rail interchanges make transfer between buses and trains convenient and comfortable. The expanding system of buses and trains (and light rail in the future) will provide improved choices for customers and continue to increase patronage and mode share of public transport.

3.1 The Role of Buses

Buses provide a variety of roles in Perth's integrated transport system, including:

- Providing convenient affordable access to work, education, recreation and other activities for a growing number of Perth people either for the entire journey of for part of the journey in association with other transport modes (eg trains, bicycles).
- Providing a reliable service to people in the community who, for whatever reason, do not have access to or are unable to drive a car.
- Providing increased transport system capacity, along crowded corridors and within centres where road capacity is at a premium.
- Reducing congestion in city centres and along major arteries by providing an efficient alternative to car travel.
- Increasing the people moving capacity of the train system by providing efficient access to and from stations.
- Integration of cyclists at bus stops.

3.2 Bus Planning

Bus Planning Issues

There are a number of issues either real or perceived that can reduce the attractiveness of bus travel and in so doing, limit the growth of public transport, including:

- Frequency of bus services, including at peak periods, during the day, in the evenings and at weekends.
- Bus network coverage (distance to nearest bus stop).
- Indirect travel routes, often due to lack of circumferential routes.
- Transfer penalty between services/ modes.
- Slow or unreliable services due to congestion and lack of bus priority on the network.
- Inconvenient, uncomfortable network or uncoordinated bus interchange, bus/rail interchange facilities or bus stops.
- Uncomfortable bus travel due to inappropriate or excessive use of traffic management devices along the bus route.
- DDA Accessibility – buses, stops, facilities.
- Bicycle parking at major bus stops and interchanges.

It is not always possible to address these issues fully, due to funding limitations and the need to choose between differing passenger preferences. For example, providing increased coverage or reduced maximum distance to a bus stop will have the effect of reducing frequency, with the same level of funding. In low density parts of Perth, a bus stop within no more than 400 metres of every resident, whilst desirable may prove to be impractical. It is acknowledged that the following bus planning principles are an inevitable compromise between operational efficiency and equity issues and may not be fully achievable in the short term.

Key Bus Planning Principles

- Along high demand corridors, a high level of bus frequency should be provided with an objective of increasing bus and overall public transport usage. Desirable minimum frequencies on such services are:
  - 10 minutes in peak periods
  - 15 minutes during inter peak, early evening and peak weekend times
  - 30 minutes at other times
- Bus feeder services to bus/ train interchanges should be coordinated to minimise waiting times for buses and trains. During peak periods desirable minimum bus frequencies are:
  - Morning – 10 minutes
  - Evening – 10 minutes
- On streets where there are 12 buses or more per hour bus priority should where possible be provided to bypass congestion and facilitate this high frequency. Bus priority is particularly important at entrance / exits to bus interchanges and along long bus routes through centres, to maintain timetables and reliability.
- Buses should have the facility to communicate with traffic signals to detect approaching buses and be designed to minimise delays to buses along major bus routes. The impact on other traffic must be considered with adjustments to signals.
- In higher density inner city areas, high frequency bus routes should generally operate no more than 1 kilometre apart.
- Proximity of bus stops should be determined based on minimising delay to passengers on the bus and providing convenient access to stops by boarding/ alighting passengers.
  - In higher density mixed use areas, bus stops should generally be placed conveniently to serve high demand activity areas, but should generally be no more than 500 metres apart.
  - Bus stops on feeder bus routes in residential areas should generally be spaced no further than 400 metres apart. Typically bus stops are located between 275-350 metres apart.
- At bus stops on arterial or distributor roads or in city centres, buses should stop on the carriageway, rather than in embayed areas, unless safety reasons dictate otherwise or it is a timed stop where buses may need to stop for extended periods. This helps maintain the position of the bus in the queue of traffic.
- On busy arterial or distributor roads, bus stops should be provided where possible, close to traffic signals on departure side or zebra crossings with kerb to enable safe access to stops by pedestrians.
- Seating and shelters should be provided at all inbound bus stops to stations and centres and at all bus interchanges.
- Kerbs and paths must be provided at all bus stops to provide convenient, safe access for people with disabilities.
- Buses should be provided with appropriate traffic management devices to enter or leave busy roads with safety (e.g. Traffic signals).
- Traffic management devices installed on bus routes, with the purpose of reducing vehicle speeds, should be mindful of the needs of the comfort of bus passengers.
- Land acquisition may be required to facilitate bus planning and consideration must be given to the potential need for land or any requirements where land may be needed.

3.3 Accessibility – Bus Stops and Facilities

The design of bus infrastructure needs to consider the overall end-to-end journey that passengers make in order to access the bus network. Car parking/ pick up/ drop off along with bicycle access may need to be considered at key locations, typically bus interchanges/ stations. However, the vast majority of passengers access bus stops by walking to the stop, which means that the bus stop should where possible be positioned in a location that takes into account the immediate environment. This means that good lighting is provided in the immediate vicinity, there is shelter from the elements (rain, wind and sun) and the stop is clearly visible so that passengers feel safe while waiting for the bus.

The other aspect is that walking routes to/ from bus stops and key trip attractors and main residential areas should be considered. Passengers should be provided with a safe means of crossing roads, good lighting, a footpath so they don't have to walk in the road and shade should be provided where possible (trees/ awnings, etc.), which also impacts the impact of rain and wind. It is recognised that passengers movements will disperse as they move further away from the stop, so the main focus should be on the immediate approach connecting the stop to the key nodes where passengers can complete their journey. At major nodes signage should be considered to assist passengers with locating the stop.

3.3.1 Commonwealth Disability Discrimination Act 1992 (DDA)

In designing for bus priority it is important for project managers, planners, designers and other project and design staff to understand the requirements of the Commonwealth *Disability Discrimination Act 1992* (DDA) which is to:

- Enhance accessibility of transport infrastructure for people with disabilities.
- Achieve consistency in the planning, design and construction of access for people with disabilities in transport infrastructure projects.
- Facilitate compliance with the State Government commitment, action plans and policy statements aimed at enhancing access for people with disabilities.
- Provide a range of information and resources for more detailed requirements.
- Reduce the likelihood of a complaint lodged under the DDA.

Figure 3.1: DDA Compliant Bus Stop Perth

3.4 Design Considerations

Perth buses are large vehicles and need some specific design requirements when considering road infrastructure. A Perth standard bus has 41 seats and carries 82 passengers and has the following specifications:

Length:	12.3m
Width:	2.5m (excluding mirrors @ 230mm each) thus the total width is close to 3 metres.
Height:	3.14m

An articulated bus is considerably longer but is of similar width carrying 120 passengers:

Length:	18m
Width:	2.5m (excluding mirrors @ 230mm each) thus the total width is close to 3 metres.
Height:	3.3m

There are some basic principles which must be incorporated into the design of bus infrastructure measures, which guide the process and which underpin the 'whole' network effect. It is important to provide a simple and stable inter-connected network of bus movement corridors, with a structure and timetable that is easy for users to learn and understand. Fundamentally the infrastructure for a bus should provide for:

- A desirable traffic running lane of 3.5 metres (minimum of 3.2m)
- A desirable minimum turning circle of 14.0 metres (minimum of 12.5m)
- A minimum height clearance of 3.7 metres.

Simplicity means that buses follow direct routes that can support optimum operating speeds with clear interaction with other modes and with infrastructure that gives reliability to journey times and good connectivity.

Importantly many bus travellers will need to transfer between services (bus or train) to access their selected destination. To this end the key principles in design are:

- Simple and direct with good local access
- Plan for consistency and reliability

- Coordinate convenient transfers and good interchanges between bus/rail and walking and cycling.
- Provide clear, ubiquitous and reliable information on bus departure times.

To assist in design principles the following table has been provided which highlights design features and desirable design provision for specific features:

Design Feature	When to apply	Design Provision	Design Variation
Traffic lane width	Roads where bus routes are present	Desirable minimum lane width 3.5 metres	3.2-3.5 metres may be appropriate depending on site-specific requirements, contingent on agreement with the PTA
Bus Shelters		A minimum 1.9m horizontal clearance from kerb face to bus shelter including roof overhang A minimum 1.5m clear footpath width either in front of or behind the shelter for pedestrians walking parallel to the road	
Setback of signage, trees, street furniture, pedestrian areas and cycle ways from kerb adjacent to bus route	Avoid contact between buses (i.e. wing mirrors), and objects and people within the verge	0.6 metres Refer to MRWA Standards for routes under the care and control of MRWA	
Bus Turning Circles and U Turns	All road designs	Desirable minimum inner horizontal circle of 14.0m	Consideration can be given to a smaller turning radii where space is limited and usage and speeds are low
Vertical clearance	Provision of clear height for transit vehicle movement beneath structures such as bridges	3.7 metres for bus-only routes As per MRWA Standards for all other routes	
Roundabouts		7.5 metre radius to central island is preferred	Smaller arterial islands can be provided where bus right turns are not required. An appropriate template should be used for design

3.5 Bus Stop Placements - Principles

Guidelines for the placement of bus stops and bus embayments are provided in **Chapter 6**.

Prior to design, confirmation from PTA is required in relation to the proposed location, size and other requirements for new or relocated bus stops and embayments. Consultation must also take place with the local government authority (LGA) regarding all aspects of bus shelters that may be located at the bus stop site.

A minimum 1.5m clear footpath width either in front of or behind the shelter for pedestrians walking parallel to the road. Where shelters are placed adjacent to shared paths (pedestrians and cyclists) consideration should also be given of a clearance of 1m from the edge of the bus shelter to the edge of the shared path.

Importantly the bus shelter position must not impede the Entering Sight Distance of any driver joining the road from a nearby driveway or side street. (**Figure 3.2**)

Figure 3.2: Issues to Consider at Bus Stops (Adapted from Transport for London Accessible Bus Stops)

3.5.1 Public Transport Bus Stop Site Layout Guidelines (PTA, 2010)

The PTA have a comprehensive guideline document to assist and help improve bus to bus stop accessibility by making the general bus stop area free of impediments that can act as mobility barriers to people using bus services.

The PTA's Public Transport Bus Stop Layout Guideline were revised in February 2010, following detailed consultation with representatives of the disability community, access consultants and other transport agencies across Australia. This resulted in a significant change to the bus stop layout designs previously adopted by the PTA. This document can be located at http://www.pta.wa.gov.au/PublicationsandPolicies/DesignandPlanningGuidelines/tabid/109/Default.aspx and importantly provides a series of design layouts appropriate to bus stop operations and layouts that will provide a consistent approach to design. The document includes advice on:

- Bus Stop Signs
- Kerb heights
- Tactile paving
- Bus Embayment
- Shelter design
- Ramps
- DDA and accessibility for wheelchairs.

Advice should be sought from Transperths signage and information team if you are considering installing any new or relocating any existing bus stop infrastructure.

3.6 Bus Priority Enforcement

Parking & infringement fines to ensure that vehicle parking/standing prohibitions are effective on designated bus routes and at designated bus stops, appropriate enforcement programs and penalties are required to serve as effective deterrents.

Driving in a bus lane is governed by the WA Road Code and enforced by the WA Police. It is an offence to drive more than 100 metres in a bus lane with a loss of 1 demerit point and a fine. It is permissible to enter a bus lane for the purpose of entering/ exiting a side street or driveway (WA Road Traffic Code, 2000). All vehicles are required to give way to buses leaving a bus embayment.

The siting of bus stops can significantly influence bus travel times and help bus priority. This should consider adjacent land uses, traffic volumes and passenger demand and road geometry. Where possible bus stops should be located down-stream of an intersection, especially an intersection with bus priority signalisation. The impact on all traffic requires consideration in bus stop location.

The use of bus embayment requires discussion with MRWA and local governments.

4. Bus Priority Measures

In this section, the ways in which buses can be provided with priority are presented. This gives some examples of facilities and case studies which have been successfully used in Perth and other cities globally.

4.1 Bus Priority Provision and benefits

A bus priority measure is the provision of infrastructure and/or traffic control and management systems designed to improve the performance, efficiency, cost and image of bus travel. The key aims for bus priority measures are to generate greater use of public transport and encourage modal shift from private car to bus and public transport more generally. Bus priority measures also improve reliability and reduce bus operating costs, designed to give higher priority to bus services (high capacity/high efficiency) over low occupancy vehicles particularly along congested sections of the street.

There is also emerging evidence that there are road safety benefits from bus priority. Goh, Currie, Sarvi and Logan (Transportation Research Record: Journal of the Transportation Research Board No 2352, Washington DC, 2013) in a study undertaken in Melbourne has shown that accidents reduced by 18% following the introduction of bus lanes. The more serious fatal and injury accidents dropped by 31 per cent. The analysis was undertaken on accidents one year before and one year after the installation of the bus lanes. Goh et al identified very few studies worldwide on changes in accidents following installation of bus lanes. However, they reference a study by Booz Allen Hamilton that shows accidents involving buses reduced by 12% following the installation of bus lanes.

There is clear evidence that bus priority measures improve the attractiveness and efficiency of bus travel and result in a mode shift from car to public transport that reduces dependency and use of cars which is a key transport strategy of the WA Government in the longer term.

Bus priority measures can be applicable in a variety of circumstances, but are particularly important along congested transport corridors, in city and town centres and on the approach and departure to transit interchanges used by large numbers of buses.

4.1.1 Priority for Public Transport

In order to maximise limited road space in moving people, rather than vehicles and to meet customer demands for direct, reliable public transport services with bus travel times, it is necessary that a range of priority interventions are selectively applied to bus services across the public transport network.

One of the basic challenges in urban transport is to ensure a sustainable balance between public and private modes of travel. To achieve this, there is a strong argument that public transport should be provided with priority to ensure it can operate at least as efficiently as the private car.

4.1.2 Buses and Traffic Congestion

The level of general traffic congestion that impedes the efficient flow of buses determines the potential benefit of bus priority service, its facilitation and/or priority measures. Where congestion is high, bus journeys take significantly longer than might otherwise be the case. More significantly for passengers and potential passengers, schedule reliability is adversely affected and the degree of confidence with which passengers can depend upon a timely bus system is eroded.

Indeed, the elasticity of demand for bus services tends to be greater for time and schedule reliability than for price, or bus fare level. To redress bus travel time problems resulting from traffic congestion, numerous cities have developed plans to facilitate bus services and/or for the provision of active priority for bus services. Importantly the impact of implementing bus priority should be modelled to demonstrate the affect.

Figure 4.1: Bus in congested traffic – Canning Highway, Victoria Park

Unless priority for buses can be improved, bus operators will be faced with increased costs to run their services as traffic congestion increases. Increased congestion causes increases in run times-resulting in more buses and staff (increasing operating costs) to maintain a service that will be less popular due to the longer running times. The resulting unpredictability of this increased congestion will cause a great deal of detriment to achievable reliability - causing loss of patronage, and an increase in passenger dissatisfaction and complaints.

It is clear that good dialogue between bus operators and local governments needs to be achieved in order to bring about necessary improvements to reduce the effects of congestion on bus services. This might be through bus priority, congestion control or improved interchanges and locations for buses to layover in busy town centres. A great deal of improvements to running times, and thus reliability, can also be achieved through methods of reducing boarding and alighting times.

4.1.3 Maintaining existing capacity

It is possible to provide bus services with a significant level of priority without imposing serious delays on other traffic. The capacity of the road network for general traffic is, to a large extent, maintained through a combination of balanced design and reductions in car travel demand due to improved public transport service level and some marginal increase in delay along the bus priority route.

A philosophy often adopted in continental Europe acknowledges that bus priority measures may reduce road capacity for general traffic and may impose increased delays on non-bus modes. It is accepted that general traffic can, in response, redistribute to other roads, travel at other times, not travel at all, or drivers may switch to the priority mode – bus or train. Increased delays for general traffic are, in effect, accepted as part of the “trade-off” of providing an enhanced public transport system designed to achieve desired and sustainable mode-share targets.

4.1.4 Defining “Priority”

Significant improvements to bus travel times and, moreover, significant improvements to all aspects of the bus travel experience, require coordinated planning and action on many fronts. However, an important purpose of these guidelines is to focus specifically on “bus priority”. In addressing this purpose, a distinction is drawn between genuine bus service “priority” measures designed to provide a special advantage to bus services and to ameliorate the delays caused by traffic congestion and, measures implemented to “facilitate” bus services.

Bus service “facilitation” may be defined as the design of streets and traffic management measures that can help and support the movement of buses efficiently by controlling parking, the speed of cars, pedestrian access and remove obstructions to the bus in the carriageway. Importantly parking plays an important role in bus movement as poorly located this can reduce road width, obstruct the carriageway, create visual narrowing’s creating areas of potential conflict, that make it difficult for the bus to negotiate.

Moreover, bus priority measures may operate at the “local” level (for example, the bus plug on the Circle Route in Adie Court, Bentley that provides improved access to Curtin University) and/ or at the “regional” level (eg. the Fremantle-Rockingham Bus Transitway) within the transport system.

Figure 4.3: Bus Gate in Adie Court, Bentley

The foregoing techniques for providing bus priority have been implemented successfully in many bus priority schemes. These, and other, techniques form the focus of these guidelines.

4.2 Principles of Bus Priority provision

The principle of bus priority improvement and of bus travel time can be expressed where bus travel times achieve one, or all, of the following:

- Increase in bus schedule reliability
- Reduction in total bus journey time
- More efficient use of buses, drivers, etc. result in improved operating costs.

Many bus priority schemes involve comprehensive packages of measures and focus on bus service enhancement within entire areas, or corridors. In such cases, road planning and design, traffic management, and planning for all modes of transport are “orchestrated” with bus priority as a major, and transparent, objective. This comprehensive bus priority approach to an area, or corridor, may involve road system planners, traffic managers, bus operators, and bus system planners at both the State and Local Government levels.

The Public Transport Authority of Western Australia applies a holistic approach to the improvement of bus system levels of service and should also include planning for:

- Quality of buses and other public transport infrastructure
- Fares and ticketing integration, including payment systems
- Comprehensive public transport operational integration
- Bus service user information systems
- Bus service promotion and marketing
- Vehicle parking policy, and state and local government planning
- Road system and traffic management facilities, and state and local government planning
- Land use planning, and state and local government planning
- Transport system pricing policies.

4.3 Bus Priority Measures

4.3.1 Busways

Busways (sometimes referred to as bus transitways) may be defined as a dedicated right-of-way for buses, usually constructed as a separate bus facility in a freeway reserve, or on a new alignment through a greenfields area. Busways are dedicated to line-haul bus services and offer:

- High standard carriageways
- Physical separation from other traffic

In addition, they often provide:

- High-speed design
- Grade-separated access

Segregated busways offer the highest possible level of bus priority. Where segregated busways have been provided, buses can offer a premium quality service, bypassing congested urban arterial routes used by general traffic. The busways provide virtually delay free and reliable point-to-point journey times combining operating, system and physical elements into a permanently integrated system with a strong image and identity.

Figure 4.4: Brisbane Busway – Queensland Cultural Centre

It is generally recognised that the most successful bus systems worldwide employ extensive use of segregated bus priority measures. Essentially, segregated measures involve separating the bus service from general traffic on dedicated busways (bus only roads), which have the following core benefits:

- Excellent reliability
- High operating speeds
- Short dwell times at bus stops/stations (step free access/egress)
- Dramatically reduced journey times.

Figure 4.5: Brisbane South Eastern Busway

Busways, whilst relatively uncommon in WA, can offer buses an unimpeded, relatively high- speed environment where bus delays are minimised and schedule adherence is enhanced. A busway may be grade-separated, or at-grade, or a combination of both. Running times may be decreased by 50 per cent, or more, compared with a conventional bus service. However, costs are relatively high and are dependent on the degree of grade-separation used, the use of traffic signal priority, the number and quality of specialised on-route stopping facilities, and other busway system components. On the other hand busways designed to these specifications have a capacity that is considerably greater than a four lane arterial road.

A transitway that, through its physical design and user regulatory controls, is accessible only to approved buses and emergency vehicles. Design characteristics include:

- Physical barrier-separation from general traffic which prevents entry from adjoining traffic lanes.
- Access to the transitway is limited to approved transitway vehicles operated by approved transitway drivers.
- Vehicle entry and exit often occurs only at designated transitway stations.
- Slip lanes and interchanges provide appropriate acceleration and deceleration lanes.
- Grade separation applies for all transitway crossings by general traffic.

4.3.2 Bus lanes

Allocation of dedicated bus lanes – in the road, either as median lane(s) or in the kerb-side lane(s) to provide priority passage to the movement of buses. Bus lanes separate buses from other traffic, enabling them to avoid traffic congestion. By using the lanes, buses have shorter journey times and improved reliability against their timetables. The lanes are clearly marked (usually) kerb-side lanes and may operate in the direction of the peak traffic flow. Bus lanes generally have coloured pavements for easy identification. Parking or stopping in the lanes is prohibited during the times they operate.

Bus lanes may be differentiated with respect to several major characteristics:

- Location within the roadway (kerb-side; median; or centre-lane) Concurrent-flow or contra-flow operation.
- Method of separation from general traffic (barrier-separated; line-separated).
- Time of operation (24-hour; 12-hour; Peak-period only).
- Vehicle eligibility (buses and emergency vehicles only; or, with provision of a sign, taxis, bicycles and motorcycles).
- Cars turning left into side streets and dwellings are permitted to use the kerbside bus lanes.
- Bus Lane; Contra-Flow bus lanes allow buses to travel in the opposite direction to the general flow of traffic.

4.3.3 Bus Only Streets

A dedicated bus only street is used exclusively for buses and provides a comprehensive bus priority measure.

Bus only streets provide a dedicated facility for the bus only. A good example of this is Contest Parade in Rockingham which links the rail station with and through the city. Bus only streets separate buses from other traffic, enabling them to avoid traffic congestion. By using the lanes, buses have shorter journey times and improved reliability to keep to their timetables.

Figure 4.6: Image of Contest Parade, Rockingham

Figure 4.7: Image of Bus Only Street on entrance to Shenton Park bus only bridge

4.3.4 Bus queue jump

Traditional bus queue jump lanes are often provided on the approach to congested intersections. An example is shown in Figure 4.8. The key features are:

- Dedicated bus lane on approach to controlled intersection
- Dedicated bus lane downstream of controlled intersection
- Length of lanes is governed by:
    - Traffic queue length
    - Road reservation capacity
    - 100m (min) recommended.

Figure 4.8: Queue jump lane – Fitzgerald St, Mount Lawley

4.3.4.1 Bus Pre-Signals

An alternative queue jump facility is through provision of pre-signals that enable the bus to advance past the queue.

Pre-signals to allow buses to be the first in the queue at a signalised junction, without loss of intersection capacity. A bus advance area is a priority measure that enables buses to go to the front of the queue at traffic lights.

An extra set of traffic lights, with a special bus signal, is installed about 50 metres before the intersection to hold other traffic back while buses go to the front.

A bus lane is provided as far as the pre-signals. The pre-signal and bus advance area effectively re-order the traffic stream by giving buses priority over other vehicles to reach the main intersection traffic signals. The measure is particularly useful for right-turning buses.

This could include repositioning of pedestrian crossings or redesigning them to create different arrangements. It will be important to understand pedestrian desire lines at the intersection and in particular access to bus stops.

4.3.5 ITS Options

See Chapter 7 for opportunities that use ITS systems to provide bus priority.

4.3.5.1 Traffic Signal Priority – "B" Light

This method is effective when buses are provided with a dedicated lane, in order to avoid situations where a bus is given the signal to proceed, but is blocked in by other vehicles.

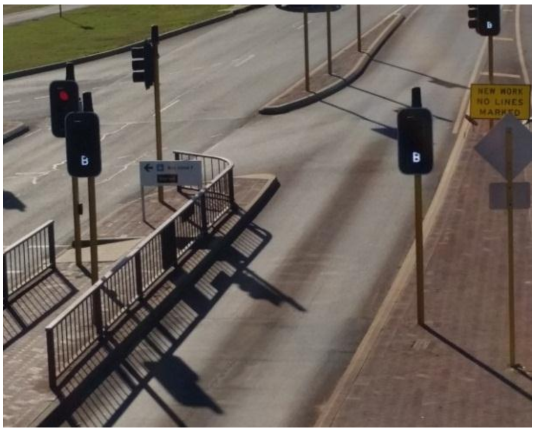


Figure 4.9: "B" lights used at the Causeway, Victoria Park

4.3.5.2 Traffic Signals – Right Turn for Buses Only

Dedicated Right Turn Lane utilising offside general traffic lane (or with new lane arrangements).

An option is to have a dedicated right turn lane to maximise bus benefits but this may have an impact on general traffic under the existing layout. If the carriageway could be widened it may be appropriate to provide two right turn lanes, one for buses and one for traffic, but care needs to be taken to ensure this does not have a detrimental impact on pedestrians.

Figure 4.10: Albany Highway, right turn into Nicholson Road.

4.3.6 Whole-of-corridor approach

Bus priority can be looked at in isolation but the whole-route approach ensures that if bus priority is implemented in one location, dispersed traffic does not adversely affect other parts of the route. Queue relocation methods can be used. Examples of the components of a whole corridor approach include:

- High quality bus stop environments, including pedestrian crossing facilities to improve accessibility.
- High level of physical priority for buses.
- High level of traffic signal bus priority.
- Rationalisation of on-street parking and loading restrictions.
- High quality of regulatory markings and signs.
- High levels of enforcement, using on-bus and roadside CCTV cameras and on-street enforcement officers.
- High quality of bus driving and customer care.
- High quality of operational management of the service.
- High quality running surfaces for buses.

Figure 4.11: Bus lanes through central Brisbane busway on approach to central Brisbane

4.3.7 Shared-use lanes

These are generally of use on arterial roads and can result in a more efficient use of capacity, particularly if bus frequency is low. Examples of shared use include High Occupancy Vehicle (HOV) lanes and lanes that may be used by designated classes of vehicle, for example, “car pool” vehicles with two or more passengers are usually implemented in freeway locations where HOV lane is separated from general traffic. High occupancy lanes on arterial roads are virtually impossible to enforce and often results in significant illegal use, which is detrimental to buses. For these reasons they have not been used in WA.

Bus nibs: By introducing a bus nib (or boarding area jutting out from the kerb) buses do not need to pull into a stop and are unhindered by parked vehicles. Passengers do not need to step into the road to board the bus. Further, they aid passenger access, particularly on low-floor bus routes, by reducing the step height at the entrance of the bus.

The enhancement of bus travel times requires examination of all time components of the bus journey, especially including bus stopping time. For example, in Australian conditions, about 25% of the bus journey time can be consumed whilst buses are stationary at bus stops. (Ogden & Taylor, 1996) Therefore, whilst not exclusively a bus “priority” measure, the following traffic and bus service management interventions are supportive of “affirmative action” bus priority measures and may be essential if an investment in bus priority is to achieve tangible improvements in bus travel times.

4.3.8 No-Stopping Restrictions on Priority Bus Routes

Imposing "No Stopping" restrictions can significantly improve bus travel times on high volume, or priority, bus routes. This approach is successfully employed on the London Red Route Network (LRRN) and the London Bus Priority Network and is now in use in Perth CBD on corridors such as St Georges Tce/ Adelaide Tce and parts of Beaufort St and Fitzgerald St. Restrictions may be applied throughout the day, or as a peak-period bus travel time enhancement measure.

Figure 4.12: London Red Route (Source: TFL)

4.3.9 Bus Stop Clearways

A bus stop clearway is a clearly marked bus stop box, with strict parking restrictions. They may be enhanced by coloured road surfaces.

As with bus lanes, stopping or parking on bus clearways is prohibited during peak traffic times. Prohibition of the parking or standing of a vehicle at bus stops has been successfully applied in the United Kingdom to avoid conflicts between buses and parked vehicles.

In South Australia, creation of a Bus Zone is considered the preferred intervention, as it is more obvious. (Passenger Transport Board, South Australia, 2002) Beaufort Street, Inglewood provides a Perth-based example of a Bus Stop Clearway successfully contributing to priority flow for buses.

4.4 Case Study examples

4.4.1 Beaufort Street

Holistic bus planning that combines use of bus lanes with provision of more frequent and legible bus services can result in major increases in patronage.

In 2014 the PTA with the cooperation of the Cities of Perth, Vincent and Stirling introduced a new bus service (the 950 service) that connected Morley to UWA and QEII Hospital through Perth City. This service was provided with peak period/ peak direction bus lanes along the whole length of Beaufort Street from Roe Street in Perth to the City of Bayswater boundary.

Figure 4.13: Beaufort Street Peak Hour Bus Lane

The route 950 replaced 4 other services (services 21, 22, 78 and 79). It operates every 4 minutes during peak periods, 7/8 minutes all day and every 10 minutes on weekends. It has achieved a 40% increase in total patronage in the first year of operation and patronage continues to increase.

Figure 4.14: 950 Route Map

A big part of the success has been the "through routing" through the City of Perth which was made possible by improved time table reliability due to operation of the bus priority measures.

The bus lanes improved travel times and bus reliability and the through routing, eliminated the need to transfer between buses in central Perth, resulting in a more convenient and efficient service for more people.

Planning and design by the PTA and its local Government partners, resulted in providing full priority for buses at peak times whilst retaining on-street parking to serve shops and businesses along the route at other times.

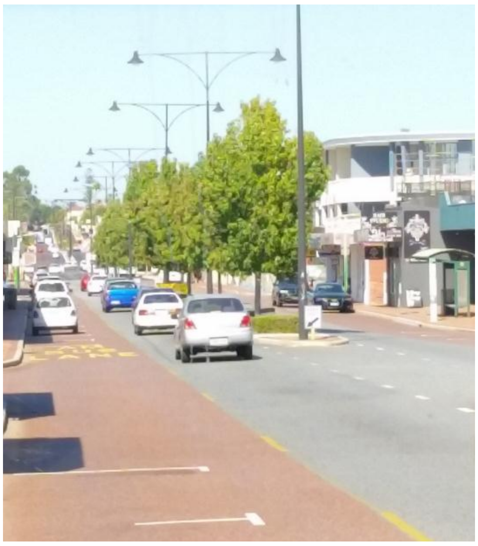


Figure 4.15: Beaufort Street Off Peak Parking

4.4.2 Malmo Bus Priority project

To improve public transport in the urban and suburban area of Malmö bus priority systems were implemented in 42 intersections. The intersections were equipped with new hardware for communication with the buses and the software of the roadside controllers in the intersections was programmed to give buses priority. Onboard the buses the computer managing the destination sign was programmed to communicate with the roadside controller for priority. The communication between the bus and the intersection was managed by the same system used for the real time application.

The key results are as follows:

Key result 1 – Bus priority at intersections increases the travel speed for the buses by 1.4 km/h during the afternoon peak. During other times the travel speed increased by 0.6-0.7 km/h.

Key result 2 – Bus priority does not imply more delay for other traffic. In fact, it meant less delay as a whole for the intersections evaluated. Depending on the intersection, the delay decreased with 0-1% during off peak traffic, 2-14% during morning peak and 0-13% during afternoon peak.

Key result 3 – Bus priority means increased punctuality. The variation of driving times for a specified distance is smaller with bus priority and as a result of that, the percentage of departures "in time" (departure not earlier than 30 seconds and not later than 3 minutes after time table) have increased by 2-5% for the bus line studied.

4.4.3 Cardiff, UK

Cardiff is the capital city of Wales with a population of 315,000 inhabitants. It installed the largest GPS based bus priority and real time passenger information system in the UK in early 2000s. The system concentrated in the northern corridor of the city included 191 buses and 46 signalised junctions. The junctions were controlled under the SCOOT UTC system where bus priority was provided by the method of extensions and recalls. The system architecture illustrated in **Figure 4.16** has a GPS-based AVL system to locate buses within a specified locational accuracy of 5 metres.

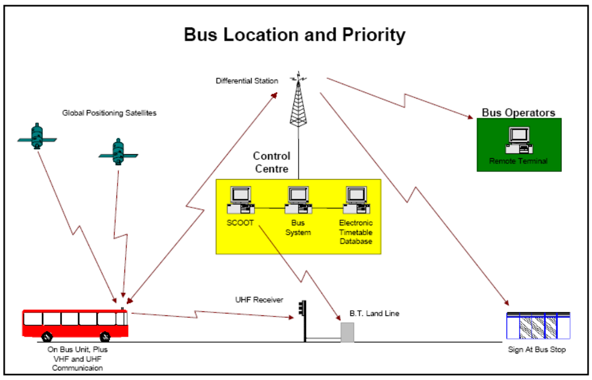


Figure 4.16: Bus location and priority system in Cardiff

In the system, bus priority is triggered when a bus is detected within a predefined virtual detector zone stored in the on-board computer. A bus is then given priority with a pre-determined priority level taking account of its lateness. The lateness calculation is carried out in the control centre on the basis of bus locations obtained by regular polling of all buses at a pre-set slot. The system also has the potential to implement different priority levels according to lateness and passenger loading (through an interface with the ticket machine). Results showed bus journey time savings of 3-4% for average weekdays, including 11% in the peak period.

4.4.4 Helsinki, Finland

Helsinki accommodates one-tenth of the inhabitants (approximately 546,200) of Finland. The public transport telematic system in Helsinki called HeLMi (Helsinki Public Transport Signal Priority and Passenger Information) was launched in 2000. HeLMi provides several public transport telematic functions such as real time passenger information, bus and tram priority at traffic signals and schedule monitoring. The HeLMi system is based almost solely on wireless communication. The system configuration of HeLMi is shown in **Figure 4.17**.

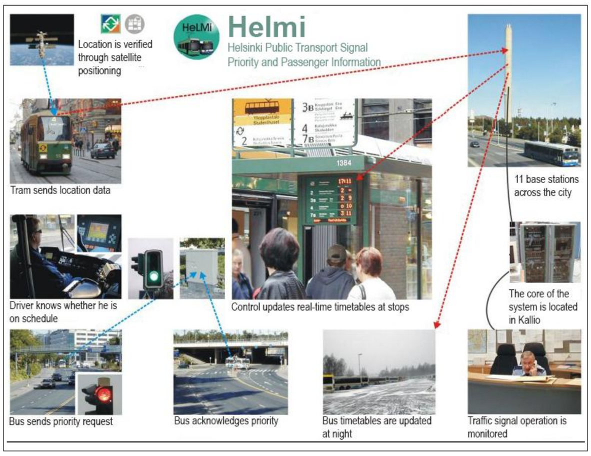


Figure 4.17: System Configuration of Helsinki's bus priority system (HeLMi)

In the system, the location of a bus is determined in three steps:

1. GPS-satellite navigation plots the bus roughly on the right bus stop window (a section of the route before and after the bus stop).
2. Bus door opening at the bus stop locates the bus exactly on the right position along the route.
3. The bus location along the route is based on the odometer counting the accurate distance of the bus from the preceding bus stop.

Each bus is polled by the central equipment every tenth second. So the central computer has continuously the data of the exact position of each bus along the route. Traffic Signal Priority is based on the request of the approaching bus sent via radio modem direct to the next junction [32].

The first message is sent 150-250 metres before the junction. According to the stage of the signal cycle that the message is received, the signal controller either calls or extends the green for buses. In complex junctions, even a special bus stage can be called during the signal sequence. The second message is sent just after the stop line as an indication that the bus has passed signals and the green for bus can be terminated. The signal priority is not given to buses which are ahead their time-table.

The system's effects have been studied particularly on tram line 4 and bus line 23 [34]. Benefits remained minor on the tram line due to previously existing signal priorities. On bus line 23, travel times fell by 11 percent and traffic light delays by 48 percent while an improvement of 20 percent was seen in regularity and 58 percent in punctuality. Passenger volume increased by 11 percent as a result of the system and one bus could be cut from the route thanks to reduced travel time.

A smart system has been trialled in Perth at Scarborough Beach Road on Transperth buses in 2015. The introduction of a GPS based Vehicle Location System will enable a metro wide system post 2016.

4.4.5 Zurich, Switzerland

The City of Zurich in Switzerland has a population of some 0.55 million inhabitants. It has developed and implemented a very strong policy of support for road-based public transport (trams and buses), based on the objectives of: promoting a change from the car to public, environmentally-friendly transport. The strong support for local public transport has been consolidated in a series of referendums and public campaigns in Zurich since the 1970's. This mandate has led to the application of imaginative urban traffic management and modern information technology to benefit public transport in three main ways:

- The use of individual routes, separate bus lanes and parking controls to create unhindered travel between junctions.
- Preference for buses and trams at signalised junctions, with the aim of ensuring 'waiting time zero' for public transport.
- The introduction of a tram and bus operation control system based on AVL, to optimise fleet management, aiming for maximum adherence to timetable.

Figure 4.18: High capacity light rail and bus transitway, Zurich

Zurich has implemented a fully centralised traffic signal operating system which controls 7 areas within the city, each in a duplex system and with about 60 traffic signals. The operating system involves some 14 process computers, 2 central co-ordination computers and over 3000 detectors in the road surface permit completely dynamic signal program switching. Full tram and bus priority is implemented at traffic signals throughout Zurich. In addition, 'access control' is implemented using traffic signals to meter traffic into any area of the city which would otherwise become overcrowded. These facilities, together with a goal of keeping pedestrian waiting times as short as possible, have produced conditions for private traffic which have encouraged a modal change towards public transport; around 42% of trips in Zurich are by local public transport.

4.5 Use of Bus lanes by Cyclists, Taxis and Motorcycles

Permitting bicycles to use bus lanes is predominately a safety concern and is based on how the two can use and move within the bus lane without adversely affecting the other. Over a longer distance, the two modes average around the same speed but the vulnerability of the cyclists, its travel patterns and differences of size can put the two into conflict.

Desirably bus lanes should be 4.5 metres in width if cyclists are permitted to use them to avoid buses passing cyclists with insufficient space.

Figure 4.19: Shared use lane sign (Beaufort St, Highgate)

Figure 4.20: Shared use bus lane (London)

The alternative to allowing cyclists to use the bus lane is to require them to travel along adjacent streets, or in a dedicated segregated cycle lane on the street verge.

The Department of Transport is currently reviewing the practice of use of bus lanes by others (eg. Motorcyclists), and the PTA is conducting an experimental period in Perth allowing motorcycles to use selected lanes.

The practice in Perth is to permit taxis in bus lanes where possible. Exceptions to this rule is where bus lanes load into bus stations or bus interchanges or in very high occupancy bus lanes in or near the city centre where taxis can impede the efficient movement of buses through CBD intersections.

4.6 Implementation issues

4.6.1 Other Localised Measures

The value of a two-pronged approach to bus priority employing, as appropriate, (i) coordinated, whole-of-route planning, and (ii) attention to localised bottlenecks, must be emphasised.

In this respect, the Public Transport Authority (PTA) of Western Australia has indicated that significant bus priority benefits will be pursued through bus priority remedies to localised bottlenecks. The introduction of bus priority interventions at the local level, and in denser inner-urban areas like Beaufort Street, Mount Lawley, will be a focus of action for the PTA to achieve the objective of significant bus travel time savings without the need to introduce large-scale, big budget infrastructure projects.

It is emphasised that a combination of integrated, corridor-wide bus priority measures, and localised bus priority measures aimed at specific congestion spots, will both be legitimate and valuable components of bus priority planning. The following table provides a schedule of potential measures that could be implemented along a corridor to assist whole route planning:

Measure	Benefit	Issue
On street parking control, including new and extended waiting and loading restrictions.	Eases traffic flow on the approach to junctions and on road links especially at peak times. Helps to maintain junction approach capacity.	Possible difficulties at public consultation stage. Removal of residents parking.
Bus stop accessibility improvements including bus stop clearways.	Enables buses to pull up close to the kerb at stops. Makes boarding and alighting of buses easier and quicker. Especially beneficial to elderly and less mobile passengers. Reduces obstruction to following traffic.	Low floor buses would be required to achieve the full benefit.
Relocation of bus stops to better suit bus movements at junctions and help to reduce obstruction to traffic flow caused by stopped buses.	Enables buses to make quicker and safer lane changes and manoeuvres on the approach to junctions. Also helps to maintain junction approach capacity.	Could be difficult to find alternative bus stop locations. Could impact negatively on walking routes to bus stops. Desire lines and access to bus stop issues etc.
Minor kerb works / road widening to assist bus turning movements.	Turns can be made more smoothly with reduced delay to buses. Plus, less over-running of kerbs. Wider footways for passengers	Possible impact on underground plant etc.
Minor re-timing of traffic signals to better favour bus movements. No new controller required.	Junction delays would be reduced for traffic streams which include buses. Junction optimisation to favour buses.	Possible slight dis-benefit to non-bus traffic on other approaches.
Yellow box junction markings and signing.	Helps to prevent junction blocking.	Enforcement issues.
Banned turns.	Simplifies junction operation and improves junction efficiency.	Need to provide alternative traffic routes. Enforcement issues.
Bus only movements.	Enables buses to save time by making turns that other vehicles cannot make.	
Removal of traffic signals where appropriate.	Overall vehicle delays at the junction could be reduced, especially during the off-peak.	Could impact on bus reliability especially at peak times. Need to carefully consider junction safety and pedestrian movements.

4.6.2 Consultation and Agreement

Consultation with key stakeholders is an important part of developing bus priority measures along a section of road. As a minimum the following should be involved in discussion with the designer or proponent;

- Local governments
- Main Roads WA
- Business and community groups.

Bus Priority Program –Formal Agreement

The following provides some notes on the Deed of Agreement established between PTA and Local Government Authorities (LGAs) for individual bus priority projects

Purpose

- Binding agreement between PTA and LGA that covers the design, construction and maintenance requirements for a bus priority infrastructure project
- Defines the works, roles, obligations and funding contributions of each party and others.

Design Phase

- Design typically undertaken by PTA but can by agreement be undertaken by LGA.
- Standards – Meet all LGA/MRWA standards as appropriate.
- Design to be approved by the LGA prior to construction.

Construction Phase

- Construction typically by PTA using its Bus Priority Program Construction Panel but can by agreement be delivered by LGA.
- Construction to be in accordance with statutory requirements and best practice in terms of traffic management, noise management, etc.
- Following Practical Completion of the works formal handover of asset to LGA.

Operations/Maintenance Phase

- Bus lanes to remain in operation unless agreement from both parties to revert to original use.
- PTA to maintain bus services including bus stands and associated fittings and fixtures using the bus priority infrastructure.
- LGA obligation to maintain the roadway, signs and lines for the bus priority infrastructure to required operating standards for the life of the asset.

"Standard Clauses"

- Typically PTA as constructor will, in liaison with LGA, undertake community consultation with all affected residential and commercial property owners/tenants in relation to the works.
- Approvals – The PTA to obtain and comply with all necessary approvals for the works. The City to provide all necessary internal approvals required for the works.
- Variations to works - costs attributed to the party initiating the change, otherwise shared.

"Special Clauses"

Clauses to define additional work by agreement or other matters (e.g. to undertake an upgrade of drainage under the roadway as requested and funded by LGA in conjunction with the necessary roadway re-construction).

4.7 When to apply a specific treatment

The following table provides an indicative guidance only on when to consider a particular treatment:

Bus priority treatment	Desirable Minimum Transit level
Bus gate Bus only link (bus plug) Turning movement ban exemption	≥ 4 bus services during peak hour in each direction
Transit mall	≥ 8 bus services during peak hour in each direction
Queue jump (see Section 4.3.4)	≥ 3,000 passengers per day in both directions, or ≥ 500 passengers during peak hour in both directions, or ≥ 6 bus services during peak hour in peak direction
Installation of traffic signals	Delay to bus movement at non signalised intersection during peak hour ≥ 60 sec (averaged across hour) Installation of traffic signals should not be implemented independently of MRWA warrants for traffic signals.
ITS Active and passive bus priority (see Section 7)	In situations where traffic volume is close to capacity, active and passive bus priority could help to improve traffic flow benefiting bus movement to a Level of Service (LOS) "D" or better
Transit lane (additional lane)	6,000 passengers per day in both directions, or ≥ 1,000 passengers during peak hour in both directions, or ≥ 15 buses during peak hour in peak direction
Transit lane (conversion of existing lane)	9,000 passengers per day in both directions, or ≥ 1,500 passengers during peak hour in both directions, or ≥ 22 buses during peak hour in peak direction These figures are indicative and the important factor is that the impact of the transit Lane is modelled and discussed with MRWA to quantify the impact. Conversion of an existing traffic lane may potentially impact traffic to a greater degree than provision of an additional lane.
Bus Rapid Transit	≥ 10,000 passengers per day in both directions, or ≥ 1,500 passengers during peak hour in both directions, or ≥ 20 buses during peak hour in peak direction

*Indicative guidance only.

5. Bus Interchanges and Stations

This section includes an overview of considerations and design principles that need to be taken into account when designing bus interchanges and stations.

Bus Stations and Interchanges should be located and designed so that conditions are optimised for buses and passengers. This chapter describes the general principles and standards that should be applied to bus interchange layout to achieve a good design outcome. There are a number of different categories of Interchanges.

Bus – Rail Interchanges

The primary function of Interchanges at these locations is to allow passengers to transfer between buses and railway services. The Interchange should be designed so that passengers have direct, covered access between rail and bus services. This is to maximise passenger comfort, to minimise total travel time for passengers and encourage passengers to use public transport for their entire journey. Examples of these Interchanges can be seen at almost all railway stations on the Mandurah and Joondalup lines.

CBD and Hub Stations

These are usually serviced by a mixture of terminating and through services with terminating usually making up the majority of movements. The main purpose of these interchanges is to provide passengers with access to the CBD or a major regional centre with a secondary purpose being to enable passengers to transfer between modes. Examples of these are Perth Busport (under construction), Victoria Park Transfer Station and Esplanade Busport.

Bus Layover

To ensure efficient movement of buses between services, layover spaces are required in close proximity to the bus stands. Where possible, layover bays should be provided within the bus station/ interchange. Typically one layover bay is provided for every two bus stand positions and allowances must be made for some articulated vehicles. Designated positions are required for special events in close proximity to sport stadiums, arenas, etc.

5.1 Design Principles

Pedestrians

Good level access should be provided for pedestrians and cyclists to enable them to easily access the facility through provision of good, direct, well lit and shaded walking routes between main demand generators and the facility. At locations where a significant proportion of passengers are likely to take the first leg of their journey by modes other than bus parking should be provided for bicycles and cars. Space should also be provided so that passengers can be dropped off by cars.

Within the facility sheltered waiting areas with seating should be provided for passengers with shelter design taking into account prevailing wind conditions. Walking routes should be clearly identified with barriers used where required to prevent unauthorised access into sections of the facility that present a safety risk.

Toilets may need to be provided at the facility, this will partly be determined by availability of alternative facilities. Fixed information boards with written information will need to be provided at a central point in the facility to enable pedestrians to obtain information. In addition electronic information screens should be provided for passengers (and drivers where they need to view rail arrivals to ensure connections) to view real time departure information. Designers should engage with PTA to determine requirements.

Staff

Safe walking routes should be provided to enable staff to access buses that are parked on Layover Stands. In addition toilets and a room may need to be provided for staff so they are able to take breaks between trips. Any driver break facilities should be designed so they are separated from passengers.

Buses

Congestion free access to the facility should be provided on the main approach roads with priority measures considered if required to ensure reliable journey times. Bus movements within the facility should be separated from general traffic and the number of pedestrian crossings minimised where possible.

The number of stands required will be determined by the existing and projected future number of bus routes using the facility. Typically one departure stand with space for one bus will be required to enable passengers to be picked up for each group of routes that operate to similar destinations.

In addition a set down stand will be required to enable passengers on terminating services to be dropped off. A single stop is usually provided, although space for multiple buses to stop simultaneously may need to be provided although drivers usually set down on departure stands if the set down stand is occupied on arrival.

Where the bus interchange is to be used by terminating services, buses will require layover stands where they can park between trips. Layover Stands are vital as they allow recovery time to enable buses to operate reliably and also allow significant operational savings to be achieved by allowing operators to schedule meal breaks without the need for buses to the depot out-of-service between trips.

Stands

When designing bus stations, set-down stand sizes must be made to safely enable buses to enter and then exit from the stand. Advice should be sought from Transperth regarding required stand size as it will vary by location. In addition it may be possible to shorten the length of the stand if it is the last stand in the group as space for a bus behind to get out won't need to be provided.

All active passenger stands must comply with DDA requirements, refer to PTA Bus Stop Layout Guidelines.

Layouts

There are a number of different options for bus station layouts, these can include; one way, clockwise loop, anti-clockwise loop, multiple platforms and dog bone. The preferred layout should be determined by the available land and integration with surrounding infrastructure.

6. Street Planning for Buses

Buses operate on a variety of street types that need to be custom designed for safe travel by buses:

- Integrator arterials with speeds of 60km/h or lower are most suitable for high capacity bus routes.
- Neighbourhood connectors and some local streets can require adaptation to accommodate local bus services.
- Traffic signals or roundabouts can provide safe intersection treatments for buses and other road users.
- It is preferable for buses to stop on the carriageway on most urban streets rather than in embayments.

Buses are a large vehicle designed to carry a large number of people. Roads and streets that are intended for use by buses must be planned and designed to facilitate bus movement in a safe and efficient manner. Bus priority measures are not discussed in this section (refer Section 4).

6.1 Street Hierarchy

The following street hierarchy is proposed in liveable neighbourhoods.

- Primary distributors
- Integrator arterials
- Neighbourhood connectors
- Access streets

In new subdivisions or master planned developments bus routes are generally planned along integrator arterials or neighbourhood connector streets. In existing areas, some of which were planned many years ago, buses will occasionally be required to travel along local (access) streets for a part of their journey.

Bus planning and design is discussed for each of the following road types:

- Primary distributors (freeways and semi-rural highways)
- Integrator arterials (urban higher speed)
- Integrator arterials (urban lower speed)
- Neighbourhood connectors
- Access streets

In each case, the main issues for bus travel will be identified and discussed including:

- Desirable traffic speed for buses and general traffic
- Appropriate intersection control for buses and other vehicles, including bus movement between different street types.
- Location of bus stops, taking account of pedestrian access across busy streets and whether bus embayments are desirable.

6.2 Primary Distributor Roads

Primary distributor roads are the highest road category in the hierarchy. They are planned and designed to carry large volumes of traffic for movement of passengers and freight at relatively high speeds – generally between 70 and 100 km/h. They include freeways and semi-rural highways with large at grade intersections, or occasionally grade separated intersections.

6.2.1 Freeways

In Perth there are few scheduled bus routes on the freeway system with no stops along the freeway length of the route. However, the design of Freeways can have a direct influence on the performance of bus routes on adjacent streets and intersections.

As Freeways are primarily used by cars any measure that affects journey times for shorter car journeys may have an adverse effect on buses as vehicles making shorter journeys may have a viable alternative route that involves using roads used by buses. Therefore Freeways and the road network should always be designed in a way that ensures that cars are encouraged to use Freeways where possible rather than local roads.

Ramp metering where cars are held on on-ramps to maintain running speeds on the Freeway is currently being investigated in Perth and creates two potential issues for buses unless it is designed and managed effectively. Firstly, queues could be created on the ramps that block the intersections on the Freeway entry road. If the intersection is used by buses (and often there is an Interchange) then buses could be delayed. As a general rule, where there is access to a bus interchange, bus priority should be incorporated at the access points if ramp metering occurs. In addition, ramp metering is likely to improve journey time of cars undertaking longer journeys at the expense of shorter journeys meaning that motorists may seek alternative routes creating congestion issues.

Figure 6.1: Freeway shoulder bus priority Ottawa

Prior to the introduction of both the Joondalup railway and the Perth to Mandurah railway, express buses used both the Mitchell and Kwinana Freeways, but these have now been largely replaced by railways. For a period of time a busway was planned and operated on the Kwinana Freeway between the City and South Street with stations at Canning Highway and South Street. This busway operated until 2005 when it was decommissioned for construction of the Mandurah railway line.

Express busways of this type are common in various other cities around the world, including Melbourne and it is quite possible they could be reintroduced in Perth along sections of freeway where rail does not operate in the median. Key features of these systems could include:

- Central priority bus lanes, similar to the Kwinana Freeway busway, other priority lanes or mixed use with other freeway traffic
- Priority entry and /or exit lanes for buses at selected crossing streets or intersections.
- Bus stations at crossing streets with provision for bus interchange.

Figure 6.2: Bus and Taxi freeway entrance ramp, adjacent to Glendalough Train Station (currently used exclusively by train replacement services)

A project of this size and complexity would require significant planning and design involving the DoT, PTA and MRWA.

Figure 6.3: Bus exit lane from Kwinana Freeway, Canning Highway

6.2.2 Semi-rural Highways

These roads are generally high speed roads on the periphery of Perth with a speed limit of 90 to 100km/h. An example is the Mandurah/Fremantle Road between Rockingham and Mandurah.

The designs of roads of these types are generally dictated by design standards for general freight traffic. Reference should be made to the relevant Austroads standards.

These roads are not particularly well suited for use as bus routes, unless custom built bus stations with grade separated crossings for pedestrians are provided. Routes of this type generally have few traffic signals and as a result:

- Safe pedestrian access to bus stops for pedestrians requiring to cross the road is generally not provided:
- There is a major speed differential for buses entering and leaving bus stops that can result in safety issues.

Figure 6.4: Mandurah/Fremantle Rd at Bus Stop Departure Side of Traffic Signals

Alternative options, such as local feeder services to trains or parallel bus routes, should be investigated prior to the introduction of bus routes along high speed semi-rural highways. However, suitable alternatives do not always exist.

Specific design issues that should be considered to assist buses include:

- Provision of suitable tapers to enable buses to enter and leave bus embayments.
- Provision of acceleration lanes where buses turn right or left onto the highway.
- Provision of adequate deceleration lanes and turn pockets where buses turn off the highway.

6.3 Integrator Arterials (Urban high speed roads)

These roads are generally 4 or 6 lane dual carriageway roads with a speed limit of 70 or 80km/h. Examples include Marmion Avenue and Leach Highway.

In terms of bus operations these roads have similar problems to the semi-rural highways although not as severe. They generally have traffic signals at between 1 and 2 km spacings. This allows for some pedestrian crossing to bus stops; located close to traffic signals, however pedestrian crossing of the road at bus stops between signals remains problematic. In higher density areas on busy bus routes, pedestrian signals or grade separated crossings should be considered. Where the street network permits, it may be preferable to route buses along alternative streets.

On some high speed urban distributor roads with speed limits of 80km/h it may be necessary to provide bus embayments at bus stops. However this can result in speed differentials and resulting safety problems for buses leaving bus stops. Consideration should be given to reducing the speed limit to 70km/h or less at bus stops. On integrator arterials with a speed limit of 70km/h or less it is preferable that buses stop in the traffic lane. This will enable buses to partially retain their place in the traffic queue and will assist in reducing traffic speeds. Exceptions to this occur at timed bus stops where buses can be expected to stop for periods of 90 seconds or more. Where bus embayments are used they should have a width of no less than 3 metres. Partial bus bays can encourage motorists to pass buses whilst partially crossing into an adjacent traffic lane, thereby creating safety problems.

Buses entering high speed integrator arterials from the right should always be provided with traffic signals or a roundabout. An exception to this could be if the road has a very wide median (13.5m on routes operated by rigid buses only and at 21m on routes operated by articulated buses).Signals are generally preferred because they provide safe crossing for pedestrians. Where buses enter these roads from the left or leave them to the left or right, the need for traffic signals (or a roundabout) should be considered based on traffic safety and delay considerations.

The kerb side lane on higher speed integrator arterial streets should be a minimum of 3.5 metres.

6.4 Integrator Arterials (Urban lower speed streets)

These streets are generally 2 or 4 lane dual carriageways but in some older areas are 4 lane undivided streets (i.e. no median). The speed limit on these streets is generally 60km/h, but locally through centres this can be reduced to 50km/h or 40km/h as the case in Beaufort Street through Highgate. These roads are generally considered to be the most suitable for high capacity bus travel because they provide direct travel to and between centres and provide good accessibility to and from bus stops.

Along these streets it is generally desirable to have traffic signals spaced at around 1km on average (less in inner areas and through centres and more in outer areas). Between traffic signals it may be desirable to provide pedestrian signals or zebra crossings near bus stops to assist pedestrians crossing of the street. Austroads notes that, in Australia, zebra crossings are not favoured on high speed/high volume urban arterial roads.

On lower speed integrator arterial streets, buses should stop on the carriageway (i.e. no bus embayments) unless there is a timed stop where the dwell time of buses may exceed 90 seconds. This will enable buses to keep their place in the queue and help to slow down traffic.

Figure 6.5: Bus stop on carriageway, Barnes Road, Innaloo

Figure 6.6: Bus embayment at timed stop outside Glendalough Train Station

Traffic signals (or roundabouts) should always be provided to assist buses entering these streets from the right. Other entrances would often be controlled by traffic signals, but designer discretion can be used based on traffic volumes and safety considerations.

The kerb side traffic lane width in mixed flow or for bus lanes along busy integrator arterial streets with high volumes of buses should desirably be 3.5 metres. However in established areas, kerb side lanes or bus lanes can be as low as 3.2 metres. Whilst it is acknowledged that buses can and do operate in 3.2 metre wide lanes in existing, mostly inner, urban areas, wider lanes are desirable where sufficient street width exists.

Parking

Bus travel can be disrupted by on street parking on bus routes along distributor streets particularly through strip shopping centres. An appropriate compromise is to provide priority for buses during peak direction, peak flow and to allow parking during other times. In these circumstances a 3.2 metre bus lane adjacent to a 3.0 metre mixed traffic lane during peak times can convert to a 2.2 metre parking space adjacent to a 4.0 metre mixed traffic lane during non-peak periods. This represents the situation along Beaufort Street between the City and Inglewood. Whilst these bus lanes are not ideal for buses they represent a reasonable compromise because of the priority achieved by bus lanes during peak periods.

Figure 6.7: Beaufort Street peak period bus lane (mid-day parking)

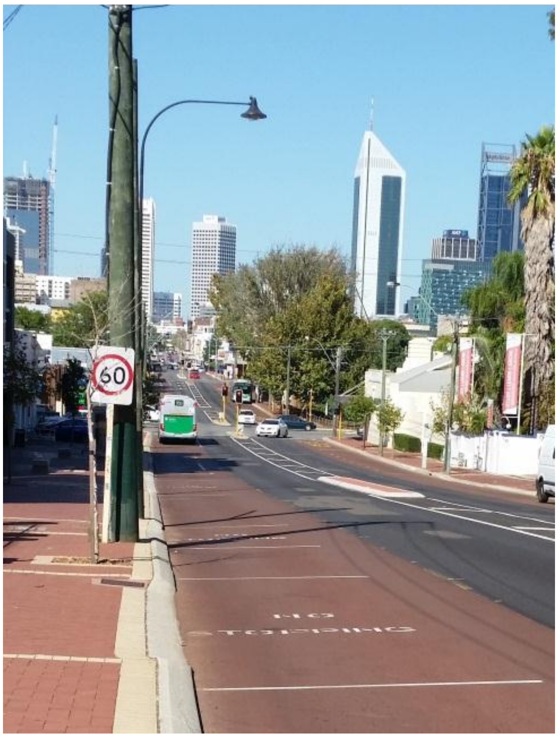


Figure 6.8: Beaufort Street peak period bus lane (am peak)

Bicycles

The use of bicycles is increasing, particularly in inner city areas and this is likely to continue in the future. Austroads Guide to Traffic Management recommends that separate off street bicycle paths be implemented on streets with traffic volumes of more than 5000vpd at speeds of 60km/h or more. Nevertheless most integrator arterial streets where buses operate in Perth have no off street facilities for cyclists. Whilst cyclists use of most of these streets is not high, because most potential cyclists will not ride on streets or this type because of concern for their safety, it does create a problem for local governments and others with responsibility for design and management of these roads. The preferred long term solution is to provide off street paths on the verge. In the meantime provision and signing of alternative, safer nearby routes may be the most acceptable approach.

Bicycle riders safety on integrator arterial streets is particularly compromised where through design or expediency they travel adjacent to parked cars. This can results in “dooring”, the expression used when drivers open their car door without warning in front of an approaching cyclist. This can have serious safety implications as cyclists can be thrown sideways into the path of other vehicular traffic, including buses.

Sometimes this strip parking along integrator arterial streets only occur for short distances. Where space exists, road authorities could consider construction of short one way sections of bicycle paths between the parked vehicles and the footpath with a minimum clearance of 0.7 metres from the parked cars to eliminate “dooring”. Alternatively where bicycle movements are high, consideration may need to be given to removing the on-street car parking and providing a raised one way off street bicycle lane outside of the traffic lane. Where this occurs the bicycle path would need to be diverted around bus stops and shelters on the footpath side.

Whilst cycling on arterial roads is a significant and growing issue to address, this document, as noted in the introduction, is principally about planning and design for buses and it is not feasible to go into bicycle planning and design in any more detail.

6.5 Neighbourhood Connectors

Neighbourhood connectors are generally 2 lane streets that carry up to about 7000vpd. The speed limit on neighbourhood connectors is usually 50km/h, although it can be lower through centres.

Neighbourhood connectors would not normally carry the large volumes of buses that could be expected on integrator arterial streets. They would normally carry only a single or perhaps 2 local bus routes or feeder routes with a peak hour capacity of no more than six or seven services per peak hour in each direction.

Neighbourhood connectors pass through local communities and local authorities often have an objective of keeping traffic speeds below 50km/h. At the same time the street must be designed to provide for comfortable travel for bus passengers. A good way of keeping traffic speeds low is to provide a median with tree planting that prohibits overtaking. The median can be either continuous or broken to provide access to properties. If a median is provided a carriageway width of 4.7 metres comprising a traffic/bus lane and the 3.2 metres adjacent to or on street cycle lane of 1.5 metres is acceptable.

Where car parking is required, the carriageway should be widened to a minimum of 5.6 metres to provide a 3.4 metre traffic space. Buses, cars and bicycles would share the 3.4 metre lane with this treatment. If it is considered that separate bicycle facilities are required it is preferable they be positioned between the car parking and the footpath.

MRWA Local Area Traffic Management Guidelines has guidelines for which the intent is a design of the bus lane to be either narrow enough for the cycle to take the lane or wide enough to accommodate both. This should be discussed with MRWA in the detailed planning.

Figure 6.9: Hampden Road, Nedlands (bus in mixed traffic)

Not all neighbourhood connectors have a median constructed. A common treatment is a two way street with a width between 7.0 and 7.4 metres. Generally these streets do not have much parking on the carriageway but occasional parked vehicles can be permitted in residential areas. If there is a demand for parking at neighbourhood centres for example it would be desirable to provide indented parallel parking or provide a small off street car park to serve the centre.

Local authorities sometimes find it difficult to keep speed limits below the desired 50km/h speed limit and they are sometimes requested by residents to install traffic calming devices. Slow points or chicanes cannot be designed adequately to both slow traffic and permit the passage of buses and should not be installed on bus routes. Similarly vertical slowing measures such as Watts profile road humps result in discomfort for bus passengers and are not considered acceptable on bus routes. Whilst traffic calming devices are undesirable on bus routes the following devices could be considered if traffic speeds of general traffic is considered to high:

- Road cushions

Figure 6.10: Road cushions, Elliot Road, Trigg

- Raised platforms with shallow ramps and a raised portion of greater than 10 metres.

Figure 6.11: Raised platforms, Hay Street, Perth

Local governments who wish to install traffic calming devices on bus routes are requested to liaise with Transperth in relation to the type of device, the design and proximity to other devices and the number of bus passengers that will be impacted by the device.

Roundabouts can be an appropriate device on bus routes to slow down traffic and to provide priority entrance at intersections. The design of roundabouts should comply generally with Austroads publication Guide to ROAD Design Part 4b, – Roundabouts.

Roundabouts should be designed to limit the deflection for a through running bus. Design of roundabouts on bus routes should be based on a turning template of 15m for through movements which equates to a 15km/h design speed for buses. A clearance of 0.3m should be allowed at each of the pinch points.

Roundabouts of different sizes are possible depending on whether a bus passes through or turns at an intersection. **Figure 6.13** below shows a typical roundabout for use on bus routes.

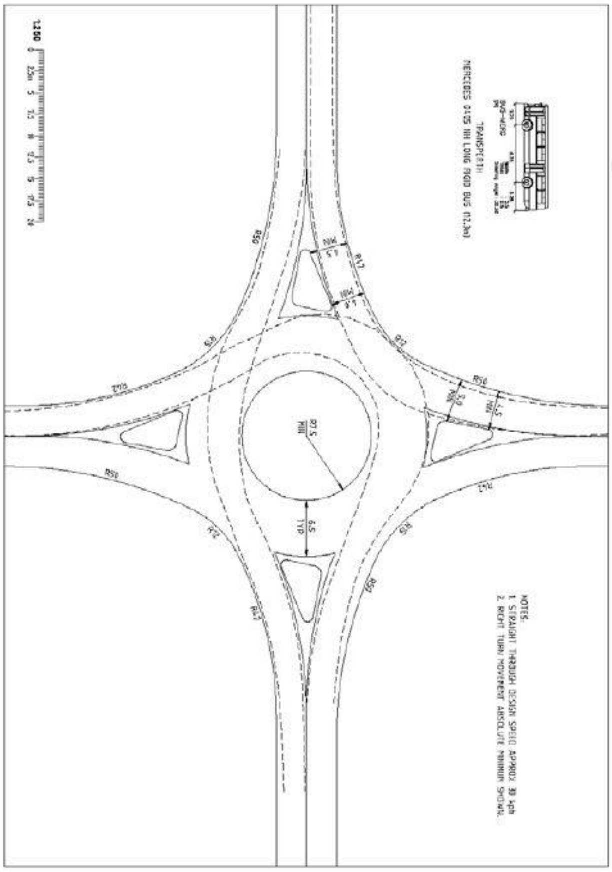


Figure 6.12: Template for Design

Figure 6.13: Typical Roundabout on bus route, Pearl Parade, Scarborough

It is generally acceptable for buses to stop on the carriageway in neighbourhood connector street without the need for bus embayments. Embayments should be provided at timed stops where buses may be required to stop for 90 seconds or more and at locations where there are safety concerns with passing a stationary bus on a two way street.

6.6 Access Streets

Access or local streets are not generally designed for the passage of buses. Where a bus service is required along a local street, the bus route planning and any modifications to street design must be discussed between the PTA and the local authority. The design guidelines for a local street used by service buses could be expected to be similar to those for neighbourhood connectors. Local government designers are required to liaise with the PTA regarding bus turning templates, where appropriate.

7. Intelligent Transport Systems

This section provides an overview of the opportunities provided by ITS to:

- Improve bus priority and efficient movement of buses
- Provide enhanced information to passengers and management

Intelligent Transport Systems offer a significant opportunity to operate a more effective and efficient transport network that makes better use of existing physical infrastructure and supports the moving people agenda. A trial of real time tracking and traffic signal priority on 130 buses from Karrinyup Depot between 2012 and 2015 demonstrated that significant improvement to operational performance could be delivered. While it is not possible to determine if all improvement was due to real time tracking and traffic signal priority systems, on the Scarborough Beach Road corridor the following benefits have been achieved:

- Average journey time was reduced by up to 20%
- Average journey time variability was reduced by up to 60%
- Percentage of buses more than four minutes late reduced by 50%

In 2015 the entire Transperth fleet will be fitted with upgraded on-board equipment that offers a number of opportunities for enhancing the passenger experience.

7.1 Real Time Tracking System

The real time tracking system will enable bus locations to be tracked in real time using GPS with the information supplied to passengers and operators.

Real time stop arrival and departure information will be supplied via the Transperth website and Transperth App so that passengers at bus stops can view up to date information on real time arrival times at their stop. Real time tracking is expected to make the bus system more attractive as passengers will be better informed and will be able to reduce wait time at bus stops.

Operators will be able to respond quickly to disruptions and delays, which will assist in recovery from incidents and enable pro-active action to be taken to ensure buses operate to time.

7.2 Traffic Signal Priority

7.2.1 SCATS & STREAMS

MRWA use a system called SCATS to control the traffic signals in Perth. The system uses a system of loops at traffic signals and different strategies at different times of day to maximise efficient signal operation. SCATS will shortly be migrated to sit under the STREAMS integrated traffic management platform, which integrates variable messaging signage, traffic signal priority and SCATS.

MRWA are currently carrying out a signal review with the aim of co-ordinating signal operation on major corridors with the aim of improving vehicle journey times. In addition technology is being introduced that records number plates allowing MRWA to record average journey times (rather than just flows). The system also differentiates vehicle type so the number of people being moved can be estimated.

The management strategy on each bus corridor shall be undertaken to balance the need to maximise the movement of people alongside potential impact on signal efficiency. The objective should be to maximise the people moving capacity of the corridor and reduce the delay for the most people, which may mean favouring phases that give the most benefit to buses. Car drivers also usually have the option of using an alternative route, which is not available to buses. Bus priority systems at traffic signals could also be used.

7.2.2 GPS

Traffic signal priority will enable buses that are running late to make requests for priority at specific trigger points as they approach intersections using the GPS. The MRWA SCATS system (that controls the traffic signals) then decides whether to provide priority based on current traffic conditions. Once the bus has passed through the intersection a clearance trigger cancels the request.

MRWA will work with the PTA to determine whether priority can be provided at a location-by-location basis. Traffic Signal Priority can take the following forms;

- If the signal is already green for the bus then the green phase can be extended until the bus has passed through the location.
- If the signal is red for the bus then SCATS can reduce the green time for other phases during the cycle to reduce the wait time for the bus.
- If the signal is red for the bus then SCATS can go straight to a phase where a bus is given a green signal skipping other intermediate phases.
- The trigger could be set to call a specific bus only signal, where only buses and selected other movements can take place simultaneously, for example a B-Light.

Infrastructure should be designed in a way that enables buses to fully benefit from traffic signal priority if it is installed;

- Stops should be located after the traffic signals to ensure that the request trigger can be placed well in advance of the intersection stop line.
- To fully realise the benefits of traffic signal priority physical priority measures should be considered where appropriate.

7.2.3 Loops

At present traffic signal requests are made using loops in the ground, which are installed immediately before the stop line. When a vehicle arrives the loop detects the vehicle and a request is sent to SCATS, with the signals changing at a time that is determined by the business rules for the specific infrastructure. These are effective in providing priority to buses at locations where they have their own dedicated lane, but cannot distinguish by vehicle type.

The ability for buses to request priority using GPS has two distinct advantages;

- Buses can be given priority over other vehicles where lanes are shared.
- Buses can request priority in advance of arriving at the stop line, meaning there is potential for the priority request to avoid the need for the bus to stop if a signal is red.

As a general principle loops may be a more effective method of priority when buses are not likely to have an uninterrupted run of at least 50 metres to a stop line. If loops are to give priority to buses over other traffic then they need to be positioned in dedicated bus only lanes as loops cannot identify the difference between different vehicle types.

7.2.4 B-lights

B-lights are used to give priority to buses over other traffic as buses are the only vehicle able to proceed when a white B-Light is displayed. B-Lights are usually deployed so they are linked to a loop, which sends a request for a go signal when a bus activates the loop and are commonly used to allow buses to exit from stations and interchanges onto the network. The B-Light can also be displayed as the default setting except when a request is made for an alternative phase by other traffic.

7.2.5 Selective Vehicle Detection (SVD)

- On detecting a bus, green signal time can be extended, or red time reduced, to eliminate, or reduce, the waiting time of the bus.
- Use of Selective Vehicle Detection (SVD) to permit access by buses only.

The SVD has the ability to detect the presence of buses on the approach and on detecting a bus, green signal time can be extended, or red time reduced, to eliminate, or reduce, the waiting time of the bus.

The specific treatment would be dependent upon traffic control system. Intersection currently operates under and the ability to detect the presence of buses on this approach. A number of different strategies could then be deployed following the bus being detected in order to reduce bus delays (e.g. hurry calls, stage skipping, etc.).

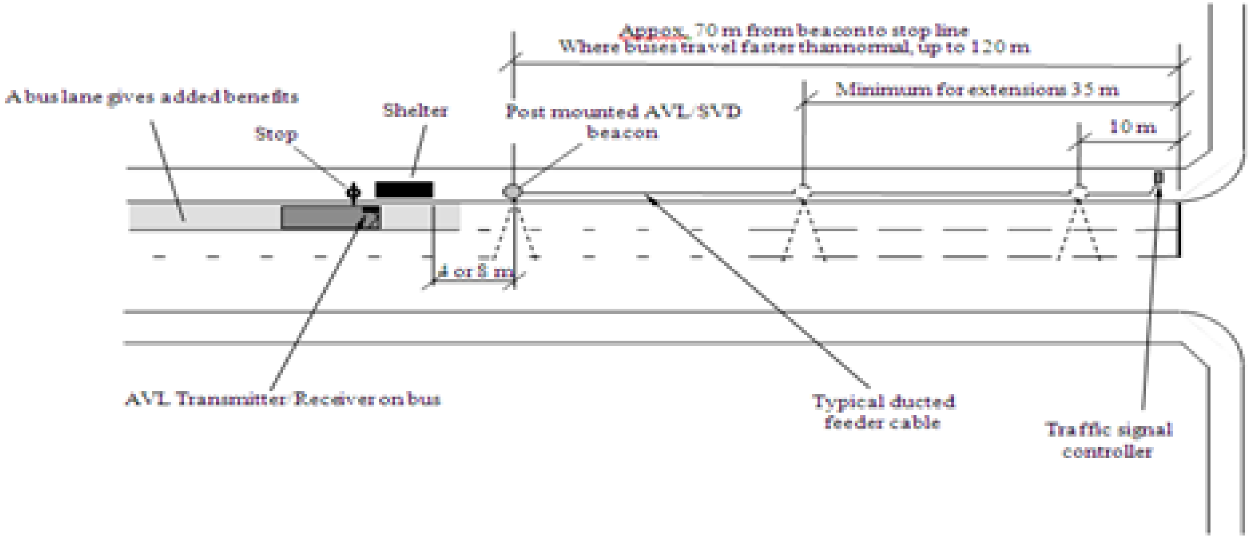


Figure 7.2: Typical SVD layout: UK

7.3 Automatic Fare Collection

A new electronic ticket machine (Infigo) is being installed, which has enhanced GPS connectivity, a colour display for driver instructions and ability to connect to Wi-Fi or 3G/ 4G mobile signal.

The SmartRider system will continue to allow point-to-point passenger journey data to be collected and used to support infrastructure investment decisions. This information should be utilised when planning or prioritising infrastructure investment to calculate potential passenger benefits.

The new system will mean that upgraded card readers (no funding currently allocated) could be installed in the future that would support EMV (debit and credit card) payment and provide real time updates on the number of passengers on a bus to be used to assist in managing the bus network.

The upgraded system will continue to allow SmartRiders to be used while minimising wait times at bus stops.

7.4 Dynamic Stand Management System

The dynamic stand management system uses tags on the buses and marker/ readers within Perth Busport to detect buses then allocate them to stands. The system based on a GPS system, will increase utilisation of bus stands increasing the number of buses that can pass through the facility.

The dynamic stand management system has been designed so that it can be deployed at additional facilities if required. It could be considered as an option where land value is at a premium in busy bus stations or on bus streets to reduce the number of stands required.

To maximise efficiency the point where buses are allocated to stands should be designed to be as close to the stands as possible, with space for buses to wait if stands are at capacity. Space should also be provided for overhead marker/ readers to be fitted along with information screens for passengers and drivers.

7.5 The Future

In the longer term it is likely that driverless vehicles will start to have an impact on optimum street design, driver behaviour and mode shares. Planning for these developments is currently in the early stages so this report will be updated as rules and regulations are changed and the likely impact of these technologies is understood.

8. Constructability

This section provides a number of key points which the designer should consider appropriate to construction and provides a link to a typical partnership agreement which can be used to agree maintenance responsibilities.

The effectiveness of the bus infrastructure in providing for passenger travel efficiently is closely aligned with the quality of the environment, ease of use for passengers and how well the associated infrastructure is both built and used is important. The provision of all the supporting bus individual elements in terms of their ability to withstand the elements, work well for users and be constructed to high quality making it easier for people to understand the systems and therefore to use.

The designers should consider all other aspects of the passenger experience including waiting area, bus stops and buildings and not just those primarily related to access between the footway and the bus. The environment of the passenger waiting area is an important component of passengers travel experience.

Figure 8.1: Bus Shelter at Canning Bridge Station

8.1 Construction

This section provides some indicative design principles which can help in providing in design of those elements and constructability.

A number of key points for construction, which are in front of line for passengers include;

Street lighting: Poorly constructed, or inadequate, street lighting can contribute to issues of personal security. Good levels of illumination and construction of lighting should be provided at bus stops.

Litter: A clean passenger waiting area improves the passengers' environment. Litter bins should be provided but care needs to be taken in locating litter bins to reduce nuisance, such as smells and flies, and avoid obstruction to pedestrian and passenger movement.

Services' equipment: Construction of bus stop posts and passenger shelters can be affected by underground utilities. Service covers can also create long term problems at the bus stop owing to access requirements to equipment. Construction of these should avoid the boarding/alighting zone to avoid access difficulties during maintenance works.

Drainage: Poor drainage construction, resulting in water ‘ponding’ on the footway around the passenger waiting area or at the carriageway kerbside, can affect the passenger environment. Ponding may result from poor drainage, defective carriageway repairs, rutting or blocked drains.

Developers and local authorities are encouraged by the PTA to consider the innovative use of materials or appropriate construction materials. This could be supported by local authorities adopting a wide palette of local and natural materials, bearing whole-life costs in mind. However, it is recommended that all construction materials meet the following requirements:

- easy to maintain;
- safe for purpose;
- durable;
- sustainable (including the manufacturing process and energy use); and
- appropriate to the local character

8.2 Maintenance

Constructing facilities for buses is a key stage in delivering a fully accessible bus service. The PTA is responsible for the bus operations and maintenance of bus stations/ interchanges but the local governments have responsibilities for maintenance of bus shelters at normal bus stops. This can include street cleaning, maintenance of the footway and carriageway surfaces in the vicinity of the bus stop, and overall maintenance. The carriageway, and potentially the kerb, in the vicinity of the bus stop are subject to particular stresses from the repeated manoeuvres of buses.

Materials used in these areas should be durable and any faults quickly remedied.

A partnership agreement on maintenance and bus stop infrastructure is in place between PTA and Local Government.

More detailed information relating to construction and maintenance of bus facilities can be found on the PTA website.

Technical Glossary and Acronyms

Access Street: A road primarily providing access to properties.

Arterial Road: A road that has a function to carry traffic as opposed to providing vehicular access to properties.

Austroads: The Association of Australian and New Zealand Road Transport and Traffic Authorities.

AVL: Automatic Vehicle Location

Bus bay: A specially-designed or designated location at a transit stop, station, terminal or transfer centre at which a bus stops to allow passengers to board and alight.

Bus embayment: A bus bay that is provided outside the general traffic lane. Such a bay needs to be flared on the approach and departure to allow the bus to manoeuvre out of and into the general traffic stream.

Bus gate: An entry obstacle (e.g. bollard or signal) to a transit link that is deactivated using a selective detection device, which may be, for example, a transponder on board the bus service, or an appropriate loop system.

Bus lane: A lane adjacent to a general carriageway (provided either next to the kerb or median), which is designated for use by buses. While general traffic is banned from using the bus lane except for allowances to turn into and out of intersecting streets and/ or property accesses, cyclists and/ or taxis are sometimes permitted. Bus lanes sometimes only operate during peak times in the direction of priority movements (tidal flow bus lanes). Outside of peaks, the lanes can be available for use by general traffic or car parking.

Busway: A special roadway designed for use by buses. While general traffic is banned from using the busway, cyclists and/ or taxis are sometimes permitted. A busway may or may not be aligned with a road corridor.

Call: When a phase is “called”, it will be the next active phase for a set of traffic signals at an intersection.

CBD: Central Business District.

Contra-flow bus lane: A bus lane that operates against the flow of traffic.

Cycle: The set of phases at a set of traffic signals controlling an intersection.

DoT: Department of Transport

GPS: Global Positioning System

High Occupancy Vehicle (HOV) lane: Traffic lane designated for use by vehicles carrying more than one person (e.g. a car pool vehicle, operating taxis and buses).

HOV: High Occupancy Vehicle (e.g. more than one occupant)

Integrator Arterial: A road designed primarily to carry traffic but which can also provide access to properties.

Intelligent Transport Systems (ITS): Information and communication technologies that facilitate bus priority and are often combined with hard infrastructure (e.g. on-board transponders that „talk‟ to bus gates to activate them).

ITS: Intelligent Transport System

km/h: Kilometres per hour.

LGA: Local Government Authority

Liveable Neighbourhoods: The Western Australian Planning Commission’s operational policy to be followed in relation to the design and approval of structure plans and subdivisions for urban development.

Local Street: A road generally classified as a Local Distributor or Access Street.

Mobility: The ability of a passenger to readily access infrastructure.

MRWA: Main Roads Western Australia.

MTS: Metropolitan Transport Strategy (Perth, 1995)

Neighbourhood Connector: A road that carries traffic and provides access to properties.

Peak Period: A time of day, either (or both) in the morning (AM) or evening (PM), when traffic and/ or passenger volumes are highest.

(Signal) Phase: A part of the cycle for a set of traffic signals at an intersection that provides flow for one set of directions at the intersection.

(Signal) Priority: A controlled change to the normal duration of phases for a set of traffic signals at an intersection. The change is designed to allow a vehicle requiring priority to pass through the intersection unimpeded. Priority in this regard is also known as signal pre-emption.

PTA: Public Transport Authority

Real time: Able to respond immediately to input data. For bus operations, real-time signage are dynamic devices that are constantly updating to show the current waiting time before the next transit service arrives at the stop where the signage is installed.

Rural: For the purpose of this document a non-built up area is define as where vehicle speeds are generally 90km/h and greater, eg Mandurah/Fremantle Road.

SCATS: Sydney Coordinated Adaptive Traffic System

Slow Point: A traffic management device, that reduces a vehicle's speed by requiring horizontal or vertical deflection. Typical "slow point" treatments include mid block "blister" islands and platforms.

SmartRider: Transperth's electronic smartcard ticketing system that utilises stored value for fare payment and can be used on all metropolitan public transport services.

Speed Environment: The speed at which most traffic on a road travels. The 85th percentile travel speed is commonly used as a measure of this.

SVD: Selective Vehicle Detection

Sydney Coordinated Adaptive Traffic Systems (SCATS): A proprietary system developed and distributed by the Roads and Traffic Authority (RTA) of NSW, which enables manipulation/ coordination of traffic signals to respond to traffic conditions and demands, including the approach of buses.

Transit mall: A bus-only link, entry to which is often controlled by bus gates. The link may incorporate retail strips and pedestrian activity, and/ or a stop/ station.

Transperth: A division of the Public Transport Authority that coordinates the operations of the bus, ferry and rail public transport systems.

Urban: For the purpose of this document a built up area is defined as where vehicle speeds generally no greater than 80km/h.

UTC: Urban Traffic Control system

WAPC: Western Australian Planning Commission

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