

Guide to Traffic Management Part 4

Network Management



Austroads



Guide to Traffic Management Part 4: Network Management



Austroads

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Guide to Traffic Management Part 4: Network Management

Fourth edition prepared by: David Green

Fourth edition project manager: Andrew Wall

Abstract

The Austroads Guide to Traffic Management consists of 13 parts and provides a comprehensive coverage of traffic management guidance for practitioners involved in traffic engineering, road design and road safety. Part 4: Network Management provides guidance on traffic management at a network level. It addresses network needs of the various categories of user, the characteristics of various types of network and, importantly, describes a planning process for balancing or prioritising the competing needs of different users based on a movement and place framework view of the road network. It describes the Network Operation Plan, which provides a framework for defining the intent of operation of the network, the priorities accorded to the various road user groups, network strategies, and the action plan that defines how the network is to be managed, operated and developed.

Keywords

Network management, transport networks, travel demand management, supply management, road classification, urban networks, rural networks, public transport networks, heavy vehicle networks, bicycle networks, pedestrian networks, network operation, access management, signal operations, lane management, parking management, event management, road user information, Network Operation Plan, road use priority, movement and place framework.

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This fourth edition includes minor and editorial revisions of text, minor updates to guidance and miscellaneous updates. Major changes include: providing linkages to asset management and Safe Systems (Section 1.3), introducing the movement and place framework (Section 2), modification to the content and structure of Section 3, improved guidance on NOP (Section 4).

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Publisher

Austroads Ltd.
Level 9, 287 Elizabeth Street
Sydney NSW 2000 Australia

Phone: +61 2 8265 3300

austroads@austroads.com.au
www.austroads.com.au



Austroads

About Austroads

Austroads is the peak organisation of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

Austroads is governed by a Board consisting of senior executive representatives from each of its eleven member organisations:

- Roads and Maritime Services New South Wales
- Roads Corporation Victoria
- Department of Transport and Main Roads Queensland
- Main Roads Western Australia
- Department of Planning, Transport and Infrastructure South Australia
- Department of State Growth Tasmania
- Department of Transport Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Australian Government Department of Infrastructure and Regional
- Australian Local Government Association
- New Zealand Transport Agency.

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1. Introduction

1.1 Scope and Context

Part 4 of the Austroads *Guide to Traffic Management* has been given the title *Network Management* to define the limitations on its scope within the context of:

- the 13 different parts of the *Guide to Traffic Management* (the guide)
- other Guides spanning the range of Austroads publications (see subject areas listed at www.austroads.com.au).

The structure and content of the 13 parts of the Guide are discussed in *Part 1: Introduction to Traffic Management*. The contents of these 13 parts are listed in Table 1.1.

In the context of the Guide, *Part 4: Network Management* addresses traffic management at a network level. Whilst Part 4 refers to issues covered in other parts, it is distinguished particularly from:

- Part 5 (Austroads 2014a), which deals in detail with mid-block traffic management issues that apply to individual lengths of road
- Part 6 (Austroads 2013a), which deals with traffic management issues and solutions at intersections, interchanges and crossings
- Part 7 (Austroads 2015a), which deals with the planning and traffic management of activity centres and associated transport nodes including the principles for various types of centres.
- Part 8 (Austroads 2008a), which deals with issues related to local areas and their networks of local roads
- Part 9 (Austroads 2014b), which covers the operational management of road space for all users and describes current practice for common systems including traffic signal systems, congestion management systems, incident management systems and traveller information systems
- Part 10 (Austroads 2009b), which provides guidance on the design and use of traffic control and communication devices
- Part 13 (Austroads 2015b), which deals with traffic management practice under the Safe System philosophy.

The scope of Part 4 is therefore **traffic management at a network level**. It addresses network needs of the various categories of user, the characteristics of various types of network and, importantly, describes a planning process for balancing or prioritising the competing needs of different users. Traffic management solutions and tools used to address needs at the network management level include land-use access, traffic signals, parking and lane allocation measures. These are discussed in general terms in this part, particularly in the context of the network management planning process. More detailed descriptions of tools used to implement the actions arising from this planning process at a road section or intersection level are found in other parts of the Guide, particularly Parts 5, 6 and 9 (Austroads 2014a, 2013a and 2014b).

In the context of the other Guides within the Austroads range of publications, this Guide is restricted to traffic management advice, and refers only briefly to issues more appropriately addressed in other Guides. It is difficult to discuss many aspects of traffic management without reference to road design and/or safety issues, and within this Guide any such reference is brief and is supported by references to the *Guide to Road Design* (Austroads 2008–15) and/or the *Guide to Road Safety* (Austroads 2006–13). Road safety, in particular, is treated as an overarching value in this part and should be considered at every step with every network management proposal tested against road safety outcomes.

Table 1.1: Parts of the Guide to Traffic Management

Part	Title	Content
Part 1	Introduction to Traffic Management	<ul style="list-style-type: none"> • Introduction to the discipline of traffic management. • Breadth of the subject and the relationship between the various Parts of the Guide.
Part 2	Traffic Theory	<ul style="list-style-type: none"> • An introduction to the characteristics of traffic flow and the theories, models and statistical distributions used to describe many traffic phenomena. • Processes that practitioners should consider.
Part 3	Traffic Studies and Analysis	<ul style="list-style-type: none"> • Traffic and transport data collection surveys and studies. • Traffic analysis for mid-block situations (including motorways). • Analysis of signalised and unsignalised intersections, including roundabouts.
Part 4	Network Management	<ul style="list-style-type: none"> • Broad strategies and objectives of managing road networks to provide effective traffic management for all road users. • Network needs for heavy vehicles, public transport users, pedestrians, cyclists and private motor vehicles. • Guidance on transport networks and network operation planning.
Part 5	Road Management	<ul style="list-style-type: none"> • Guidance on managing mid-block traffic conditions. • Good practice for access management, allocation of space to various road users, lane management. • Application of speed limits.
Part 6	Intersections, Interchanges and Crossings	<ul style="list-style-type: none"> • Types of intersection and selection of intersection type. • Appropriate use and design of various intersection types. • Traffic management issues and treatments for intersections, interchanges and other crossings.
Part 7	Traffic Management in Activity Centres	<ul style="list-style-type: none"> • Principles for planning the management of traffic in activity centres and associated transport nodes. • Techniques for traffic management in activity centres. • Examples and key considerations for various types of centres.
Part 8	Local Area Traffic Management	<ul style="list-style-type: none"> • Planning and management of road space in a local area. • Guidance on selection, design, application and effectiveness of traffic control measures on an area-wide or at least whole-of-street basis.
Part 9	Traffic Operations	<ul style="list-style-type: none"> • Applications used in traffic operations. • System configuration and operation guidance. • Current practice for common systems including network monitoring, traffic signals, congestion management, incident management, freeway/motorway management and traveller information. • Related systems integration and interoperability issues.
Part 10	Traffic Control and Communication Devices	<ul style="list-style-type: none"> • Signing and marking schemes. • Traffic signs, static and electronic. • Pavement markings and delineation. • Traffic signals and islands.
Part 11	Parking	<ul style="list-style-type: none"> • Parking policy. • Demand and supply. • On-street and off-street parking. • Parking guidance and control devices.
Part 12	Traffic Impacts of Developments	<ul style="list-style-type: none"> • Guidance on the need and criteria for impact assessment. • Detailed procedure for identifying and assessing traffic impacts and mitigating their effects. • Assessment of safety, infrastructure and environmental effects.
Part 13	Road Environment Safety	<ul style="list-style-type: none"> • Principles and management of the safety of road environments within a traffic management context. • Links to relevant sections of the Guide to Road Design and Guide to Road Safety.

Similarly, it is difficult to discuss some aspects of traffic management at a network level without reference to some transport planning issues, and in this part such references are brief and supported where necessary by references to more detailed material in the *Guide to Road Transport Planning* (Austroads 2009a). It is noted that the *Guide to Road Transport Planning* will be superseded by the National Guidelines for Transport System Management which as of 2016 are currently being developed.

Finally, the contribution of this Guide to sustainability issues is mainly indirect. Sustainability in road transport is largely an issue addressed through travel demand management, an overview of which is provided in this part and also discussed in the context of traffic generating developments in Part 12 of the Guide (Austroads 2009c), but which is addressed in more detail in *Travel Demand Management: A Resource Book* (Austroads 2002). Traffic management at a network management level contributes to sustainability by working towards the most effective and efficient use of infrastructure and, with appropriate determination of network operating objectives and road use priorities, ensuring a management focus on the movement of people and goods.

Further on the linkage of transport planning and travel demand management to network management and the content of this Guide, it is noted that broader policy considerations such as urban planning and policy solutions to promote non-car based travel have a significant impact on network management outcomes, both in terms of how the network is planned and subsequently managed. There is a need to plan and manage segments of the road network for the different users and at different levels depending on the segment and the road use priorities. For example, increased urban density around major public transport hubs should cater for non-car based transport such as walking, cycling and on-road public transport. Industrial areas should cater for road-based transport such as car and freight use. Discussions on the various transport networks and network operation planning as outlined in this Guide will assist in providing guidance.

Within this part of the Guide, several references are made to the Australian Standard AS 1742 *Manual of uniform traffic control devices* (see Reference list for details of Parts). In New Zealand, the equivalent references are the *Traffic Control Devices (TCD) Manual* (NZ Transport Agency 2008) and the *Traffic Sign Specifications* (NZ Transport Agency n.d.); or Land Transport Rule: Traffic Control Devices 2004, Land Transport (Road User) Rule 2004, or Land Transport Rule: Setting of Speed Limits 2003 (available at <http://www.nzta.govt.nz/resources/>).

Road network operations form the foundation of the World Road Association's (2003) *Road Network Operations Handbook*, a focus of which is the shift in emphasis from the traditional road agency's role of building and maintaining the road network to a service-oriented policy towards the road user. The relationship between the term 'road network operation' and related terms used in the Handbook, namely traffic management, network management and traffic operations requires definition. Road network operation is defined by the World Road Association as all traffic management and user support activities intended to permit, improve, or facilitate the use of an existing network, whatever its conditions of use. Its scope includes, in addition to traditional notions of traffic management, such activities as:

- reducing the adverse effects of weather, roadwork, emergencies and disaster situations
- effectively managing maintenance and construction work to minimise the impact on safety and congestion
- eliminating bottlenecks due to inadequate road geometry
- providing reliable and convenient public transport services
- influencing the choices that road users make regarding mode, route and time of travel.

In this guide **network management** refers to traffic management at a network level while **traffic operations** as discussed in detail in the *Guide to Traffic Management Part 9* (Austroads 2014b), refers to the use of tools and techniques such as traffic signals, congestion management, incident management and traveller information systems to provide road user services with a major focus on real-time operation. The systems are usually, but not necessarily, applied and operated at a network level.

Aspects of road network operation and transport system management not explicitly falling within the scope of this part of the Guide are addressed in other Austroads publications as follows:

- road serviceability and safety – *Guide to Asset Management* (Austroads 2006–09) and *Guide to Road Safety* (Austroads 2006–13)
- co-ordinating transport agency operations – *Guide to Traffic Management Part 9* (Austroads 2014b)
- incident management – *Guide to Traffic Management Part 9* (Austroads 2014b)
- traveller information – *Guide to Traffic Management Part 9* (Austroads 2014b).

1.2 Jurisdictional Supplements

Jurisdictions may have variations to practices outlined in this Guide. These are typically contained in jurisdictional supplements along with other complementary material. Readers should refer to such supplements relevant to them, in order to best understand their relevant jurisdictional practice.

1.3 What is Network Management?

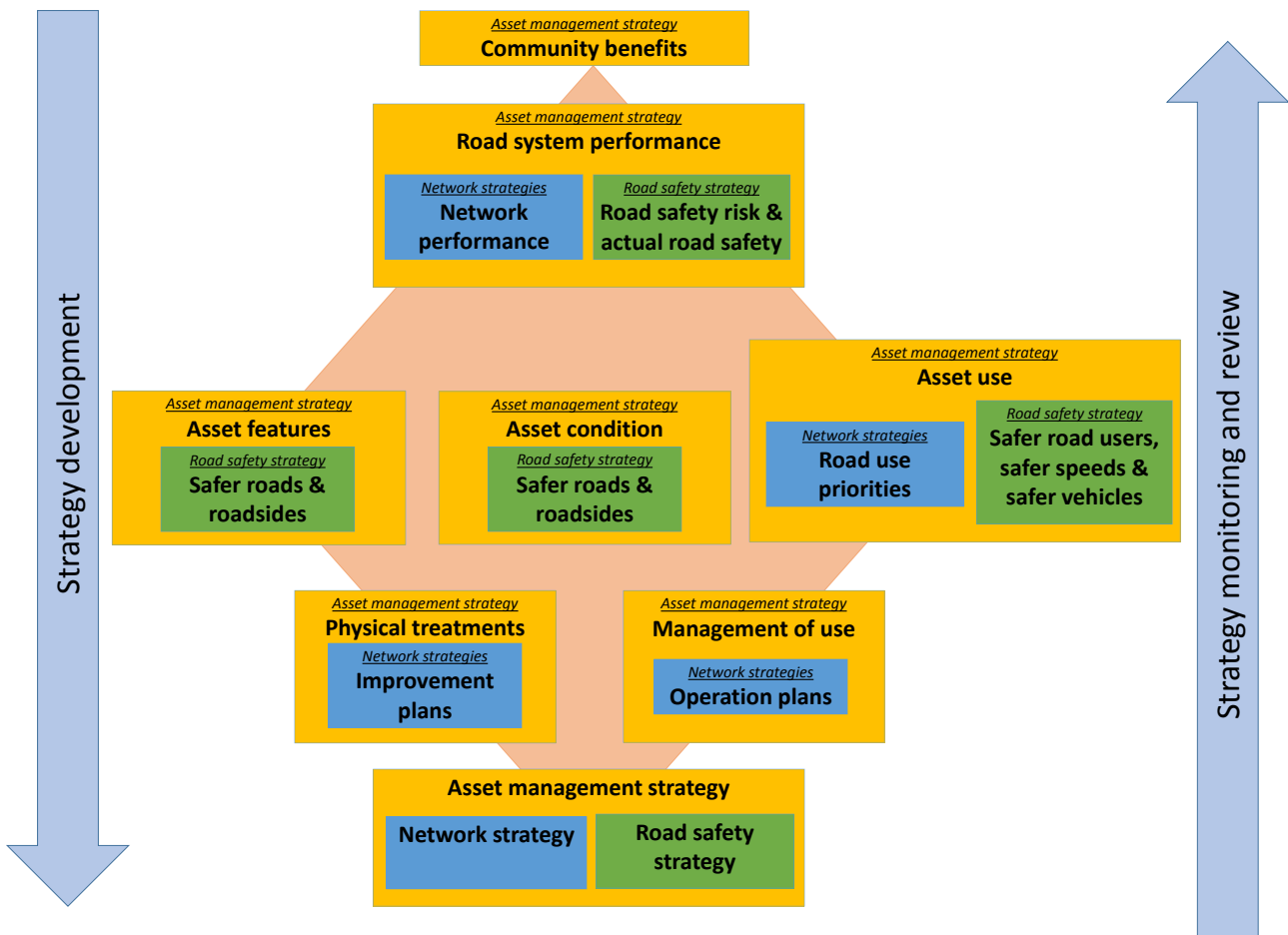
The road network is the primary infrastructure for the movement of people and goods and for personal mobility. Most people need to travel to get to work or to conduct business, or to attend education or leisure activities. Carriage of goods includes both large freight consignments and lighter distribution loads, and the efficiency of their movement affects the cost of goods. With economic growth comes growth in the number of trips on the network, usually reflected in traffic growth. Road transport was estimated to account for 93% of the passenger transport task in Australian capital cities (measured in passenger-kilometres of travel) and 80% of the total passenger task in Australia in 2009–10, as well as 36% of the domestic freight task in 2008–09 (measured in tonne-kilometres) (Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2015).

From a network management perspective, this Guide embraces the concept that traffic management needs to address all transportation needs across all transport modes and across an extended geographical area. Network management aims to optimise the existing road network infrastructure in order to service the developed land use and road users' needs. It does this by using a 'toolkit' of transport improvement options to ensure the movement of people and goods is effective and optimal for all users. The toolkit is often applied at an individual route segment and junction level, and details of these are to be found in Part 5 (Austroads 2014a) and Part 6 (Austroads 2013a) of the *Guide to Traffic Management*. The toolkit can also include intelligent transport systems (ITS), details of which can be found in Part 9 (Austroads 2014b). However, it is the overall operational improvement needs of the network and its components and how this can be achieved through network operation planning that is the subject of this Part.

Traditionally the objectives of roads were met through road construction and maintenance as indicated by the asset management framework. As shown in Figure 1.1 strategies that encompass asset management, network management and safety are intertwined in order to provide community benefits through the road system.

Figure 1.1 outlines the traditional elements of asset management for road networks and shows the linkages between asset management, network management and Safe System strategies.

Figure 1.1: Linkages between asset management strategies and network management and Safe System strategies



The Safe System approach recognises that humans, as road users, are fallible and will continue to make mistakes. As a result the Safe System aims to achieve safe roads and roadsides, safe vehicles, safe speeds and safe road users in order for road users to avoid serious injury or death in the event of a crash. The Safe System approach incorporates principles which can be applied in order to manage vehicles, roads and roadside infrastructure, and speeds to reduce death and serious injury. Further details on the Safe System approach in the context of Traffic Management can be found in the *Austrroads Guide to Traffic Management Part 13: Road Environment Safety* (Austrroads 2015b). In order to apply the Safe System approach the asset management framework and hence network management need to be applied. This is in order to achieve safer speeds and safer roads across the network and therefore safer travel.

Due to the linkage between network management, Safe Systems and asset management, there is a need for network managers and developers of network management strategies to be engaged with and cognisant of other strategies associated with the road network, in particular asset management strategies and road safety strategies. This is because the network management strategy will influence, along with other strategies, how the network assets will be managed in order to achieve the road system performance characteristics, which will collectively achieve the benefits being sought by the community.

2. Movement and Place

The need to provide for all users of the road network in an equitable and balanced manner is a particular challenge in urban areas and regional centres. There are various types of user of the road network and their needs vary depending on their mode of travel. The various users and their needs in terms of transport networks are discussed in Section 3. At times a particular user's needs may conflict with another's.

A framework that considers the relative priorities of the movement of people and goods to their destination (often referred to as the Movement and Place framework or Link and Place framework) will identify the road types within the road network that are best suited to the users' journey needs, community defined places and values and transport modes.

Implementation of a framework will enable more effective management of infrastructure and operational issues to prioritise the user's journey needs, reduce potential user conflicts and facilitate safe and timely journeys with minimum disruption.

Roads serve two primary roles for the users, that being to either:

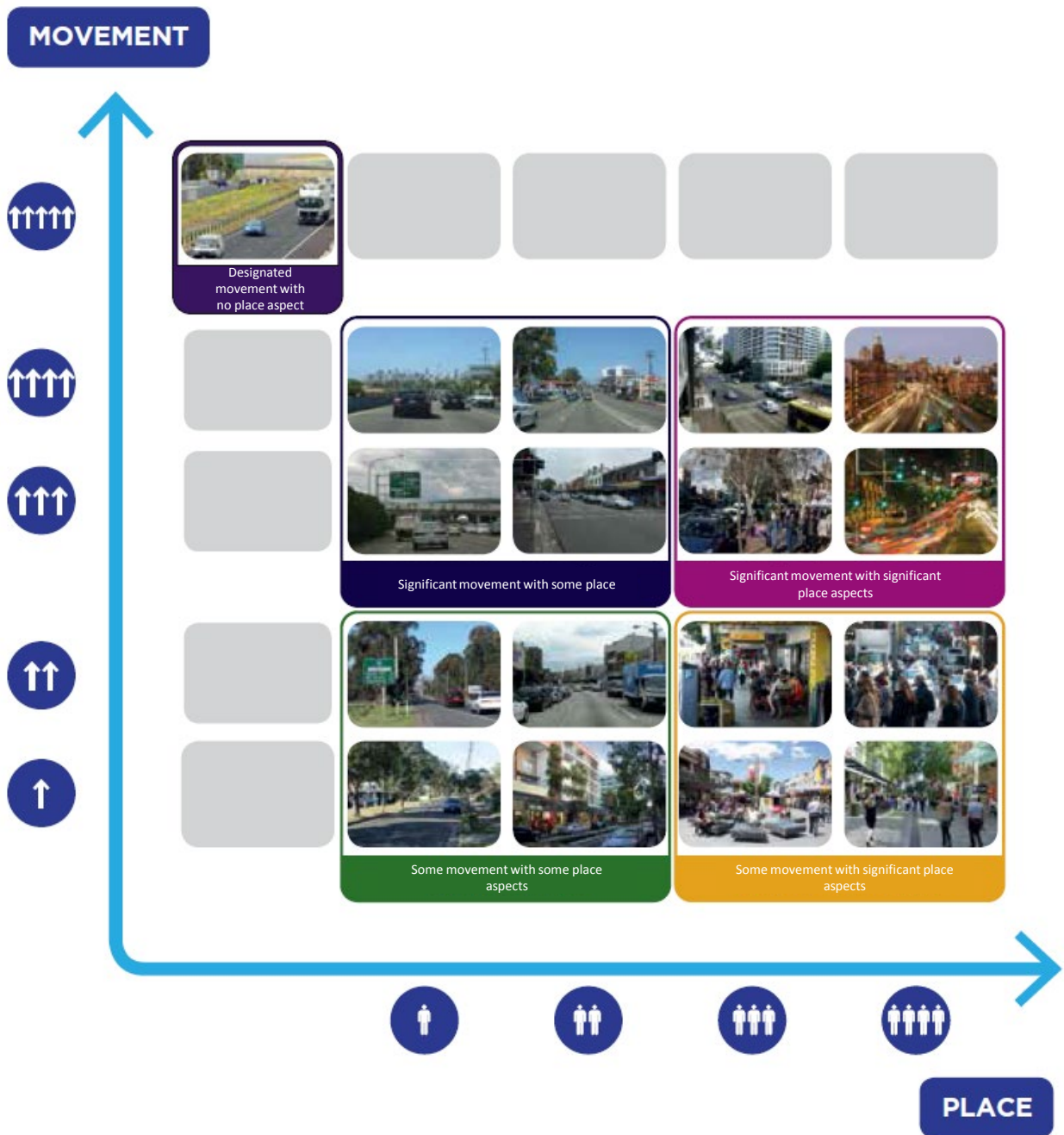
1. facilitate the **movement** of people and goods, or
2. act as **places** for people.

For this reason the Movement and Place or Link and Place Framework has been developed in order to manage the ranging priorities. The framework considers the different function of each road type within the road network and how it performs its function to meet the community's, as well as users' needs. This is undertaken in order to transform conditions for more sustainable modes of transport while also ensuring that vehicles can still get about reliably and productively.

The Movement and Place Framework identifies the role of each road through a movement and place matrix (as shown in Figure 2.1). This is based on the strategic significance of the road to move people and goods and the strategic significance of the land use interacting with the road. With respect to Figure 2.1:

- The position of a road or street on the **movement axis** is determined by its strategic significance within the road network as indicated by Figure 2.2. The strategic significance of a road is identified by its role in the broader road network, the overall volume of people and goods it moves and the proportion of longer distance journeys it serves. It is noted that movements include all movements not just car-based, so some roads may be high on the movement axis as a result of the strategic significance and intensity of cycling or pedestrian flows.
- The position of a road or street on the **place axis** is determined by the strategic significance and community value of a place as indicated by Figure 2.3. Places can be urban activity centres that generate pedestrian activity, traditional strip shopping centres, transport hubs such as airport precincts or central railway stations, educational institutions and community centres.

Figure 2.1: Movement and Place Framework



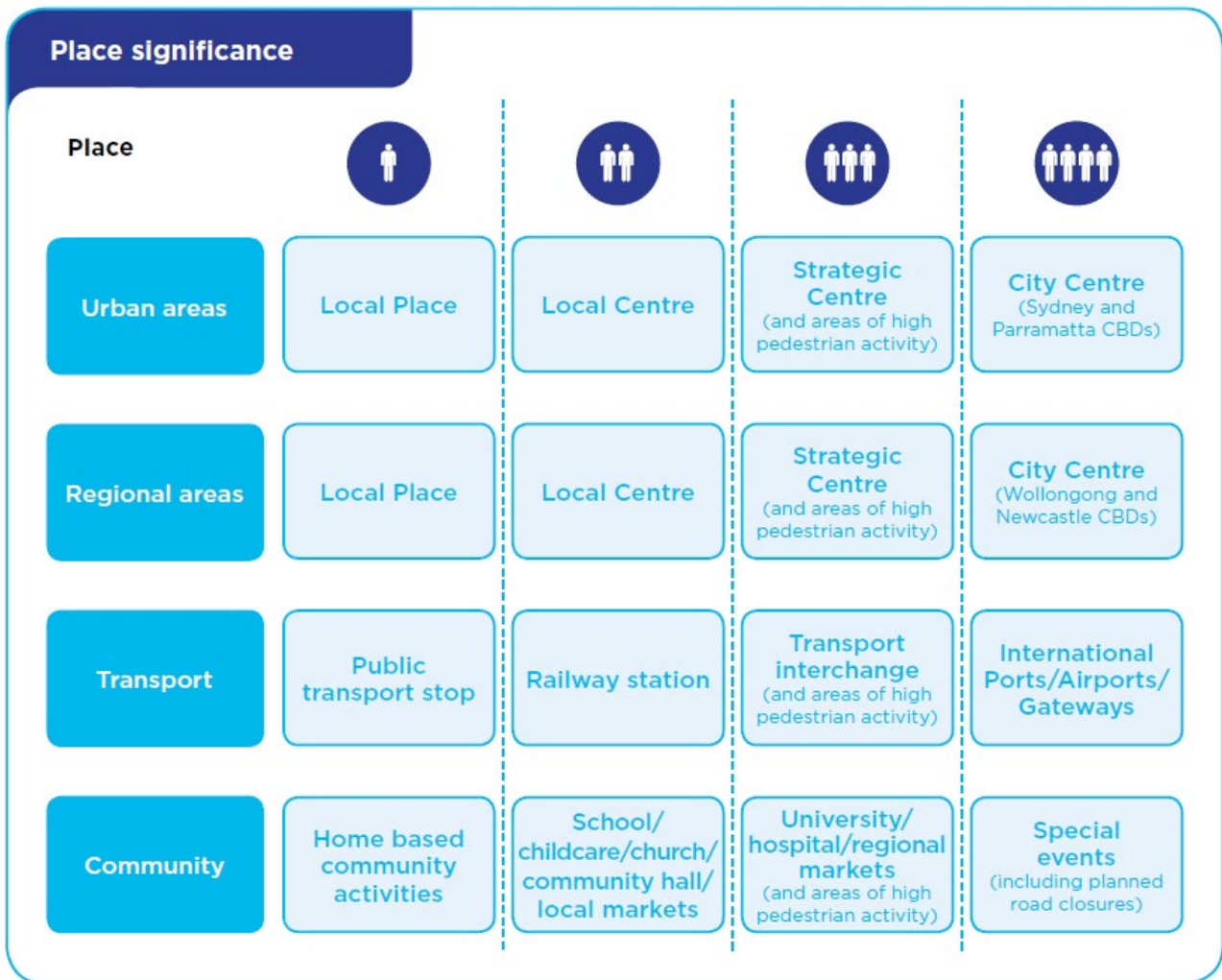
Source: Adapted from Transport for NSW (2016).

Figure 2.2: Functions of the various road types used in the movement and place framework

Type	Image	Colour	Description
Designated movement with no place aspects			Move people and goods rapidly over long distances with motorways playing a strategically significant function within the road network.
Significant movement with some place aspects			Provide safe, reliable and efficient movement between and within regional centres and urban areas.
Significant movement with significant place aspects			High demand for movement and high pedestrian activity with often limited road space result in vibrant streets within urban and regional areas.
Some movement with significant place aspects			High pedestrian activity and lower levels of vehicle movement create places people enjoy, attract visitors and are places communities value.
Some movement with some place aspects			The streets where people live their lives and that facilitate local access to their communities.

Source: Adapted from Transport for NSW (2016).

Figure 2.3: Strategic significance of the place



Source: Transport for NSW (2016).

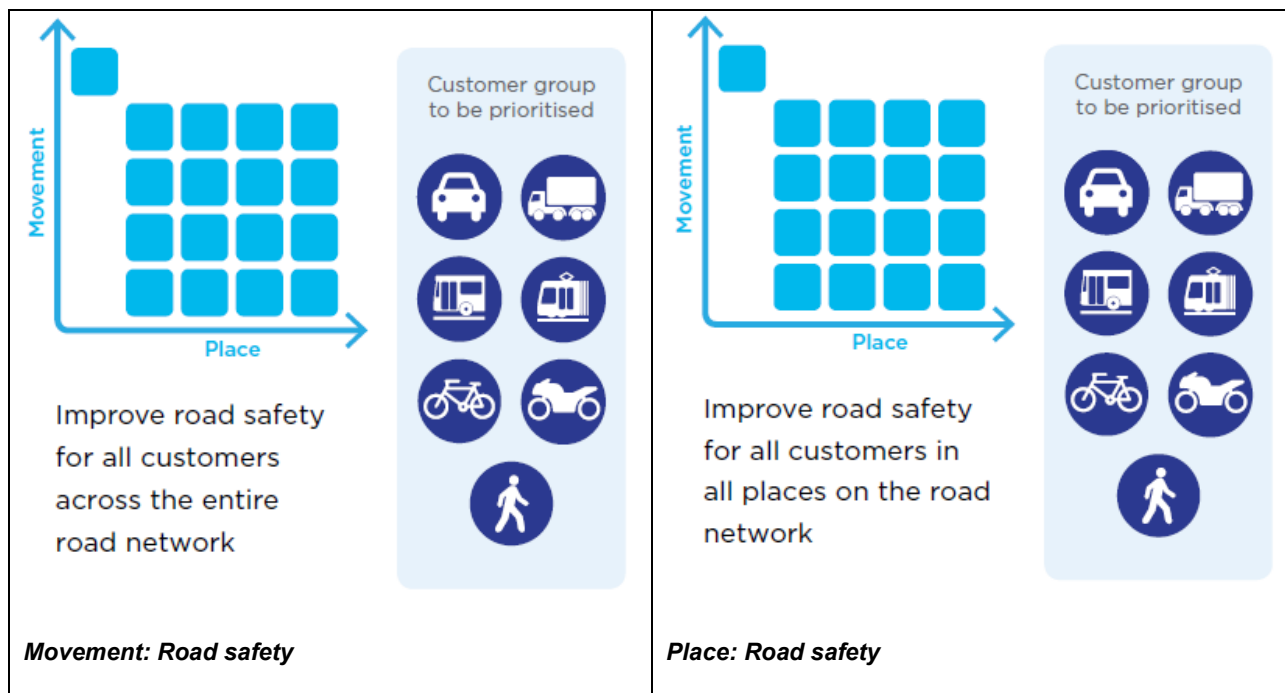
2.1 Prioritising Using the Movement and Place Framework

The Movement and Place Framework provides the basis for proactively managing the road network and encouraging road users to travel on the road type that best suits their chosen mode of travel (i.e. the right road for the right travel need).

Figure 2.4 through to Figure 2.7 show various movement and place strategies and where to focus priority in the Movement and Place Framework for various road users. For example to improve:

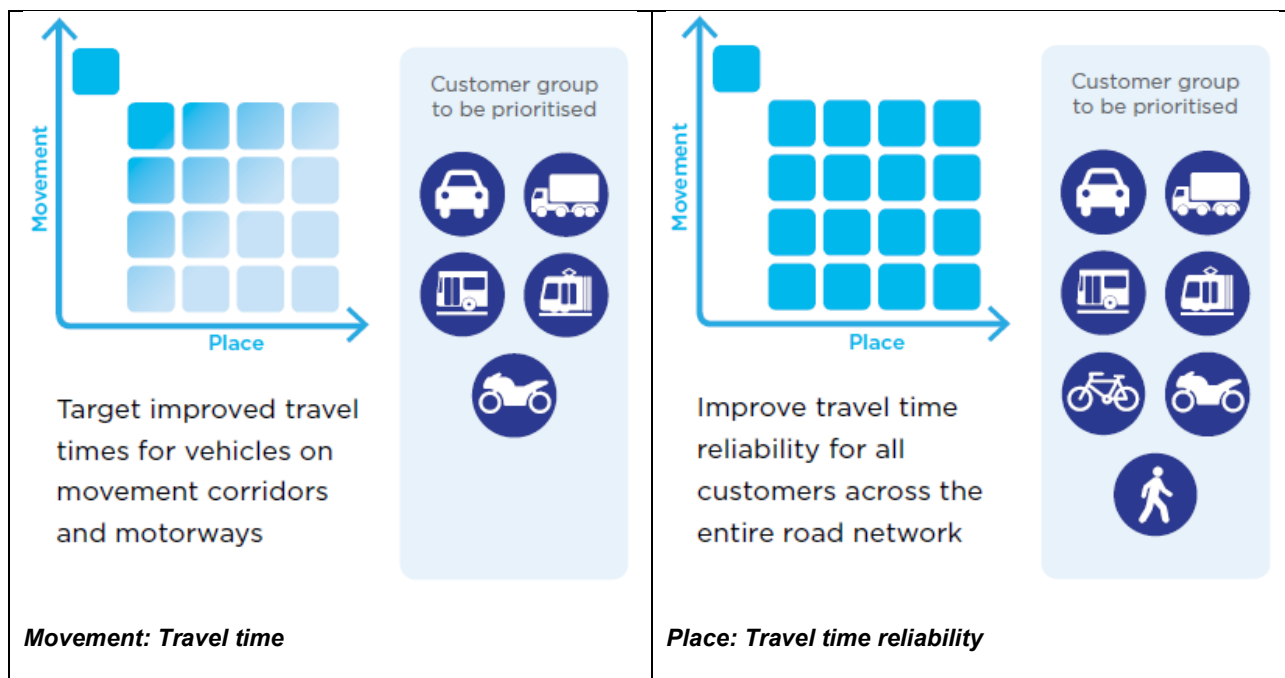
1. road safety for all road users, focus needs to be on prioritising road safety across all road types and functions
2. travel time for motor vehicles, the focus needs to be on prioritising their use for movement of vehicles
3. connectivity and flow for pedestrians, the focus needs to be on prioritising their use as places rather than just used for moving vehicles
4. loading and parking facilities for motor vehicles, the focus needs to be on prioritising their use as places and decreasing their use for moving vehicles
5. facilities for pedestrians, focus needs to be on prioritising their use as primarily places.

Figure 2.4: Prioritising movements and places to improve road safety



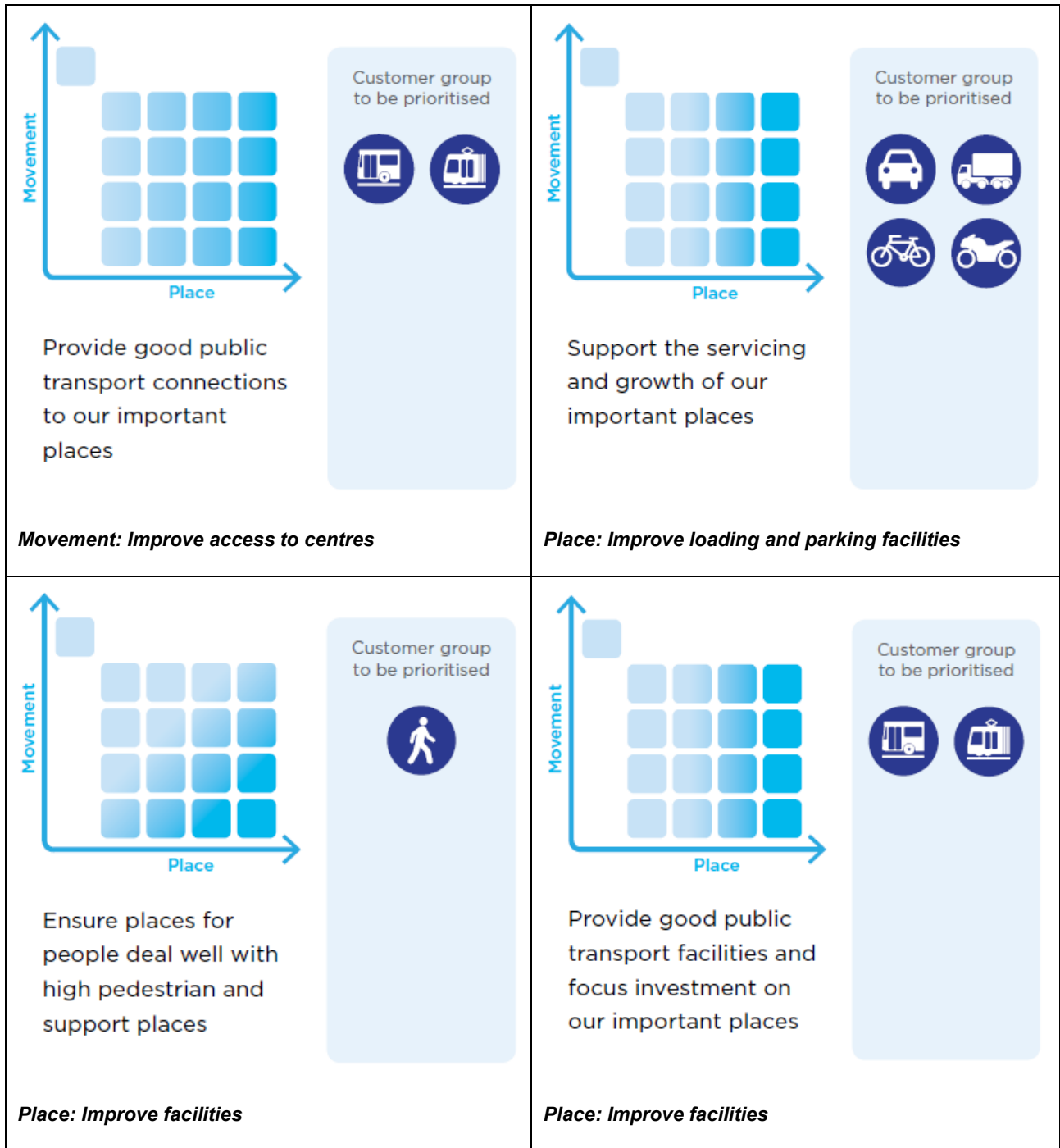
Source: Adapted from Transport for NSW (2016).

Figure 2.5: Prioritising movements to improve travel time (longer journeys) and travel time (reliability)



Source: Adapted from Transport for NSW (2016).

Figure 2.6: Prioritising movements to improve access to centres, loading and parking facilities and general facilities



Source: Adapted from Transport for NSW (2016).

Figure 2.7: Prioritising movements to improve connectivity and flow, environment/facilities and environment



Source: Adapted from Transport for NSW (2016).

The Movement and Place Framework provides a standardised framework in which road agencies can understand which user type should have which priority within a certain place. The priority may change by time of day as the role and primary purpose of place changes emphasis throughout the course of the day, for example established urban road networks where key ‘movement’ roads have major ‘place’ uses abutting the road (e.g. significant strip shopping centres). These locations create a need for balancing competing demands for movement and place by time of day and day of week. Table 2.1 outlines an example of a jurisdiction’s priorities for user types and places based on route type and time of day. Each jurisdiction would need to develop their own priorities through stakeholder engagement and consultation.

These priorities can then be assigned relative level of service (LOS) goals based on their relative priority as outlined in Table 2.2.

Table 2.1: VicRoads priorities for user types and places based on route type and time of day

Time of day	User type	Place significance			
		Low (e.g. residential or outside activity centre)	Moderate (e.g. small to medium activity centre)	High (e.g. large activity centre and key city destinations)	Very high (e.g. Metropolitan activity centre and the expanded city centre)
AM peak	Bicycle	Strongly encourage	Encourage	Encourage	Encourage
AM peak	Bus	Strongly encourage	Strongly encourage	Encourage	Encourage
AM peak	Car	No encouragement	No encouragement	Encourage local access only	Encourage local access only
AM peak	Pedestrians	No encouragement	No encouragement	Encourage	Strongly encourage
AM peak	Tram	Strongly encourage	Strongly encourage	Encourage	Encourage
High off-peak	Bicycle	Strongly encourage	Encourage	Encourage	Encourage
High off-peak	Bus	Strongly encourage	Encourage	Encourage	Encourage
High off-peak	Car	No encouragement	Encourage local access only	Encourage local access only	Encourage local access only
High off-peak	Pedestrian	No encouragement	Strongly encourage	Strongly encourage	Strongly encourage
High off-peak	Tram	Strongly encourage	Encourage	Encourage	Encourage
Off-peak	Bicycle	Strongly encourage	Encourage	Encourage	Encourage
Off-peak	Bus	Strongly encourage	Encourage	Encourage	Encourage
Off-peak	Car	No encouragement	No encouragement	No encouragement	No encouragement
Off-peak	Pedestrian	No encouragement	No encouragement	Encourage	Encourage
Off-peak	Tram	Strongly encourage	Encourage	Encourage	Encourage
PM peak	Bicycle	Strongly encourage	Encourage	Encourage	Encourage
PM peak	Bus	Strongly encourage	Encourage	Encourage	Encourage
PM peak	Car	No encouragement	No encouragement	Encourage local access only	Encourage local access only
PM peak	Pedestrian	No encouragement	Encourage	Strongly encourage	Strongly encourage
PM peak	Tram	Strongly encourage	Encourage	Encourage	Encourage

Source: VicRoads (personal communication 2015).

Table 2.2: Relative mobility LOS associated with relative priority

Relative priority (RP)	Goal relative mobility LOS
Strongly encourage	A
Encourage	B
No specific encouragement	C
Encourage local access only	D
Local access only	D-
No priority	E

Source: VicRoads (personal communication 2015).

A gap analysis can then be undertaken to compare the current measured LOS with the goal LOS using a tool such as the SmartRoads tool (further information on the SmartRoads tool can be found in Appendix A). The LOS can be measured using the framework referred to in Commentary 1 although currently the SmartRoads tool focuses on mobility and does not extend to the other four measures of safety, access, information and amenity. With a gap analysis undertaken road agencies can target which areas are worth increasing LOS in, while understanding the trade-offs such actions will have for other road users. Such an approach enables agencies to target strategies that not only aim to achieve the desired LOS outcome for the specific user and LOS measure but minimise undesired degradation of LOS outcome for other users and/or other LOS measures.

[see Commentary 1]

2.2 Application of the Movement and Place Framework

Application of the Movement and Place Framework to the road network can aid in road agencies defining the strategic objectives and directions for each road within the network and the broader network as a whole. These strategic objectives should be developed with consideration given to asset management strategies and the Safe System approaches.

The strategies used to achieve the strategic directions can be categorised as either demand management or supply management as outlined in Section 2.3 and Section 2.4 respectively.

2.3 Travel Demand Management

Historically, road transport system management in Australia and New Zealand has predominantly been focused on the 'supply side', attempting to meet the demand for motor vehicle travel by supplying new roads or increasing the capacity of existing roads. However, it has been recognised that increases in road capacity are quickly taken up by latent demand, and that communities do not have the economic capacity to remove road traffic congestion through the continual provision of additional road capacity.

Travel demand management (TDM) seeks to answer the question of how urban transport, travel and accessibility can be better managed to reduce travel delays and reduce the negative impacts of motor vehicle use on urban communities within an environment where little additional road capacity can be provided over time.

TDM involves managing the transport and traffic task through:

- reducing dependence on the private car for many trips
- encouraging people to better organise their travel so they make fewer trips, make shorter trips, use one vehicle to carry more people and combine journey purposes
- using more sustainable forms of transport (e.g. buses).

While TDM was initially almost totally aimed at reducing the demand for private travel by car, Austroads (2002) provides the following broader definition:

Travel Demand Management is intervention (excluding provision of major infrastructure) to modify travel decisions so that more desirable transport, social, economic and/or environmental objectives can be achieved, and the adverse impacts of travel can be reduced (Austroads 2002).

TDM is largely concerned with behavioural change programs that influence the decision to travel (e.g. pricing in the form of tolls, parking fees or fees to enter areas) and mode choice. However, it may also include infrastructure strategies such as reductions in network capacity or allocation of road space to other modes and uses (e.g. public transport priority, cycle lanes, transit lanes), or limitations on car parking space in developments where public transport can play a significant role, such as in city centres. It may also include application of technologies to travel demand objectives, (e.g. the use of traffic signal systems to provide priority to buses, and traveller information systems to better inform travellers of the mode choices available).

Commentary 2 includes examples of potential applications of travel demand management measures on a link, route, corridor or area-scale.

[see Commentary 2]

Austroads (2002) provides a more detailed discussion of candidate measures and case studies that may assist in their implementation. Austroads (2007b) provides a framework for appraisal and evaluation of TDM measures.

It is clear that TDM initiatives may have a significant impact on traffic management, particularly in inner areas of cities, and that they need to be considered in the development of transport and traffic strategies at a network level.

Further discussion on TDM as the background to managing traffic in relation to land use developments and in activity centres is provided in Part 7 (Austroads 2015a) and Part 12 (Austroads 2009c) of the Guide.

2.4 Supply Management

Traffic management of road networks is usually aimed at 'getting the best out of the system'. Fundamentally, the measures traditionally employed are supply management measures directed at marginal increases in capacity or level of service (or improved safety or environmental amenity) for the prevailing or forecast level of demand, without substantial road infrastructure investment. With the exception of high occupancy vehicle (HOV) lanes and public transport priority measures, commonly used traffic management strategies do not directly reduce car dependency.

Supply side strategies to achieve the strategic directions typically include:

- hierarchy of use of roads in the network
- more effective access controls
- kerbside parking management
- lane use management (e.g. reversible lanes, shoulder lane use)
- optimisation of peak flows on major arterials
- optimisation of traffic signal timing
- improved incident management
- improved freeway management (e.g. ramp metering, speed management through variable speed limits)
- improved driver information
- increased vehicle occupancy

- implementing special lanes and/or facilities for non-motorised traffic:
 - cycling routes
 - pedestrian areas

A planning framework for selection and implementation of appropriate strategies to achieve the higher level strategic directions is presented in Section 4.

2.5 Movement and Place Network Users

All journeys involve use of the road-based component of the movement and place network for the whole or part of the trip. The trips are undertaken by a wide variety of users using a variety of modes. The transport network infrastructure comprises of roads, footpaths, off-road bicycle paths, pedestrian paths, on-road public transport facilities and off-road public transport facilities. The following discussion is based on the road-based component of the movement and place network.

The roads and the road reservation serve several roles including:

- safe and efficient movement of people and goods by road-based transport modes
- access to abutting land
- on-street parking
- access to non-road-based public transport
- support for other non-transport related activities (e.g. footpath cafes)
- provision for and access to above-ground or underground infrastructure for public utility services.

Network management must recognise all these roles in order to meet the needs of the various users including passenger vehicle drivers, heavy vehicle drivers, bus passengers, taxi passengers, light rail passengers, walkers and cyclists. In a survey of road users undertaken by Transport for NSW (TfNSW) (2016), the various aspects that the users value most for their travel mode were identified. While there were some differences the users had similar objectives with respect to wanting safe journeys that can be undertaken in a direct, timely and reliable manner. Table 2.3 outlines the findings of the TfNSW (2016) research with respect to what is valued most by various road users. These values directly correspond to the user's needs.

Table 2.3: What is valued most by various users: based on TfNSW research

User	Trip purpose and characteristics	Network used	Valued most – listed in decreasing preference for the top four preferences with the most valued at the top
Passenger vehicle drivers	Carriage of people: full range of purposes except heavy goods.	Urban and rural networks	<ul style="list-style-type: none"> • Good roads and networks (most valued) • Synchronised and steady flow • Safety and enforcement • Predictability and convenience.
Bus passengers	Carriage of people: maybe line-haul or feeder service. Also tourism.	Public transport networks	<ul style="list-style-type: none"> • Time (most valued) • Systems and efficiency • Reassurance • Comfort.
Light rail passengers	Carriage of people, line-haul function.	Public transport networks	<ul style="list-style-type: none"> • Systems and efficiency (most valued) • Reassurance • Time • Comfort.
Heavy vehicle drivers	Carriage of bulk goods between major distribution centres.	Heavy vehicle networks	<ul style="list-style-type: none"> • Good roads and networks (most valued) • Synchronised and steady flow • Safety and enforcement • Predictability and convenience.
Cyclists	For commuting to work and educational centres, for trips to commercial centres and for general sports training, recreation and tourism-type cycling. Generally for shorter trips.	Bicycle networks	<ul style="list-style-type: none"> • Safe connectivity and flow (most valued) • Safe behaviour • Supporting facilities • Health, well-being and knowledge.
Walkers	Most individual trips, unless undertaken by a vehicle fully from origin to the destination, include a walking section either as the predominant part of the journey or the first, middle and/or last section of the journey.	Pedestrian networks	<ul style="list-style-type: none"> • Connectivity and flow (most valued) • Pedestrian safety and personal security (equally most valued) • Health and well being • Supporting facilities.

Source: Adapted from *Transport for NSW (2016)*.

While motorcyclists predominantly value the same aspects in a network as passenger vehicle drivers, as they have a greater potential for loss of control and injury they value the added elements of a road alignment or layout with minimal to no surprises (e.g. avoiding transitioning a high speed straight section of road directly into a low speed curve). They also desire standard treatments without need for complex decision-making, adequate and accurate signage, and safety.

In addition to the values as outlined in Table 2.3, Austroads (2015d) outlines the level of service (LOS) descriptions for various user groups and across various transport needs (mobility, safety, access, information and amenity). The LOS descriptions make up the LOS framework that may be used in network operation planning. Commentary 1 outlines the LOS framework, with a brief discussion on how to use it in network operation planning as discussed in Section 4.2. How the LOS framework relates back to this discussion is outlined later in this section.

2.6 Mobility and Access – A Subsidiary of Movement and Place

While the purpose of roads has historically been seen as facilitating the movement and passage of people and goods, the modern interpretation adds the:

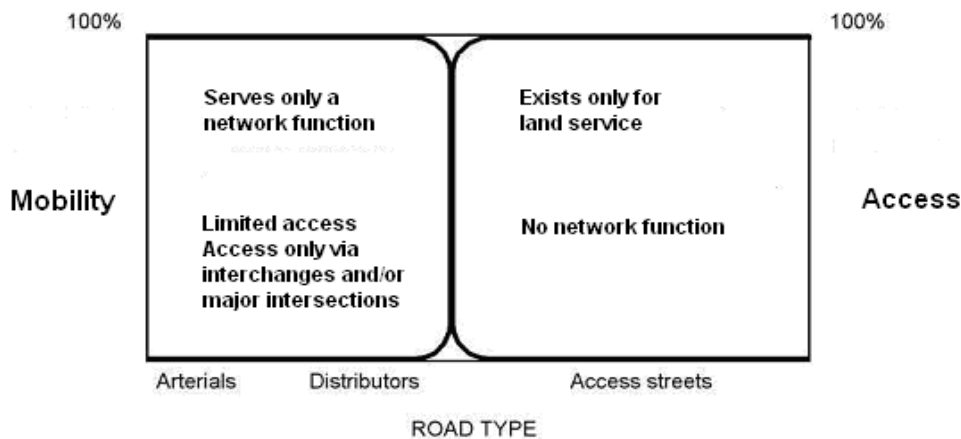
- provision of access to abutting land
- provision for loading, unloading and parking
- use of the road as public open space and space for trading and commerce, entertainment, informal recreational use, and in more densely populated areas is seen as part of the living space.

Therefore the two essential functions of a road when viewed from the movement component of the Movement and Place Framework are to provide:

- 'mobility', which is concerned with the movement of through-traffic and is focused on the efficient movement of people and freight
- 'access', which relates to the ease with which traffic from land abutting roads can enter or leave the road.

Mobility and access are considered as subsidiaries of movement and place and the historical functional classification of roads (i.e. arterials, distributors or access streets) generally reflects these needs as illustrated in Figure 2.8.

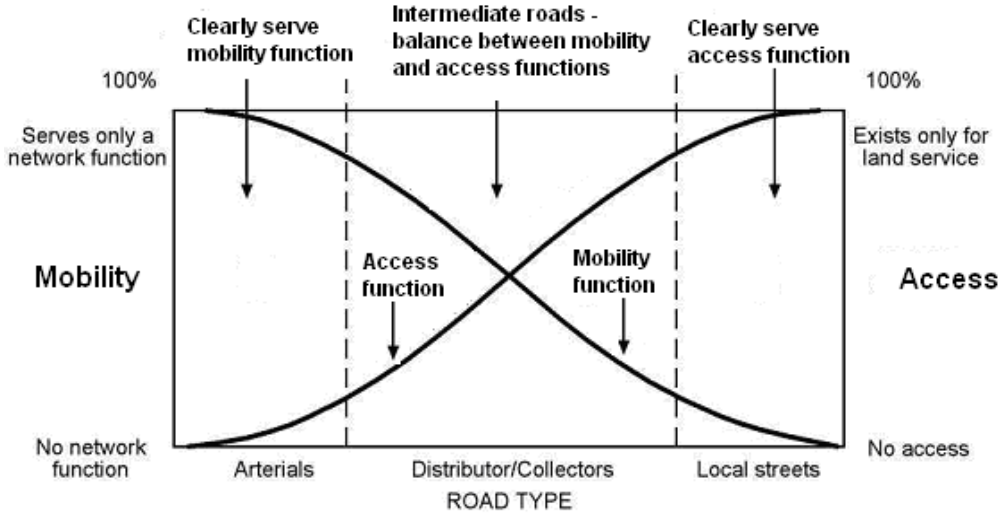
Figure 2.8: Road type and function: two-class model



Source: Brindle (1987).

In reality, roads do not fit neatly into the historical classification of arterial, distributor or access from a movement perspective. Many roads have been developed with a mixed traffic/access function, and Australasian practice in the management of the road network and its environment has been based on recognition of this as illustrated in Figure 2.9.

Figure 2.9: Road type and function: the reality



Source: Brindle (1987).

As mobility and access are subsidiaries of movement and place and focus on the movement component, the function of place by a road are in addition to that outlined under mobility and access, with roads that play more of an access role serving the function of a place rather than movement. Conversely roads that play more of a mobility role serve more of a movement function.

3. Movement and Place Considerations

As outlined in Section 2, the Movement and Place Framework is used to manage the various users and uses of the road network.

Application of the Movement and Place Framework needs to take into consideration the various users, their requirements and therefore their networks. This section discusses the road classification systems before discussing the transport networks that make up the road network that need to be managed in order to meet the needs of users. The networks discussed include:

- urban networks
- rural networks
- public transport networks
- heavy vehicle networks
- bicycle networks
- pedestrian networks.

For each network the role and key management principles required to meet the primary needs of users as outlined in Table 2.3 are discussed.

3.1 Road Classification Systems

3.1.1 Functional Classification

Classification systems vary from one road/traffic agency to another. Some use a three-level classification system, while others use four or five levels. Similarly, the terminology used to describe the road classes varies. It is useful to treat motorways as a distinct class because of their pure mobility function with no access function. Discussion of traffic management strategies in this Guide is therefore based on the following four-level functional classification system:

- motorways
- arterial roads
- distributor/collector roads
- local roads and streets.

Further discussion of road classification issues can be found in Commentary 3 and Part 5 (Austroads 2014a) of the Guide.

[see Commentary 3]

3.1.2 Administrative Classification

In any discussion on road classification it is necessary to differentiate between legal or administrative road classifications, and functional classifications. Legal or administrative road classifications are usually determined by national or state governments as a means of allocating funds and in determining the responsible agency for the care and management of various parts of the road network. Functional classification involves the relative balance of the traffic mobility function and amenity or access functions of streets and roads. Ideally, these classifications should be compatible but this is rarely fully achieved.

An example of an administrative classification system and its relationship to functional classification is given in Commentary 4, along with its accompanying classification guidelines.

[see Commentary 4]

3.2 Urban Networks

3.2.1 Introduction

While urban road networks only represent 16% of the total road network in Australia (BITRE 2015), the urban road networks are characterised by significantly higher traffic volumes than the rural road networks. Further, in urban areas, arterial roads (including highways) comprise 15% of the total urban road networks, but carry a significant proportion of the travel. It is not surprising then that the focus of mobility issues in traffic management, particularly congestion management, lies with arterial roads.

As outlined in Table 2.3, the passenger vehicle users of urban networks value the following elements:

- good roads and networks (most valued)
- synchronised and steady flow
- safety and enforcement
- predictability and convenience

Therefore, the role and management principles of the urban network need to meet the needs of its users. Guidance on the management of urban networks in order to achieve this is discussed further in Section 3.2.2 and Section 3.2.3.

It is noted that segments of the urban network also comprise of public transport networks (Section 3.4), heavy vehicle networks (Section 3.5), bicycle networks (Section 3.6) and pedestrian networks (Section 3.7) to varying degrees. These are discussed in the various sections.

3.2.2 Role

In order to meet the needs of the users of the urban road network, the network needs to achieve movement and place functions and therefore is comprised of road classes, undertaking roles as outlined in Table 3.1.

Note that the priorities accorded to different trip purposes may also vary from one road class to another. See for example one such set of priorities in Table C4 1 of Commentary 4. Trip function priorities are a matter for each road agency to determine for the roads under its control and this may also vary from one urban area to another.

Table 3.1: Roles of urban roads

Road class	Movement and place type	Role
Motorways	Designated movement with no place aspects	<ul style="list-style-type: none"> Provide for major regional and inter-regional traffic movement in a safe and operationally efficient manner. Full access control.
Arterial roads	Significant movement with some place aspects	<ul style="list-style-type: none"> Provide for major intra-urban and inter-urban movements in a safe and operationally efficient manner. Provide direct access to commercial or industrial access requirements. Where a service road is not provided, provide direct access to directly abutting properties. Provide for local public transport particularly where priority is given to public transport. May also be used by cyclists as a movement corridor.
	Significant movement with significant place aspects	<ul style="list-style-type: none"> Where the arterial road passes through an area where there is a high number of pedestrians then there may be a need to downplay the movement function in favour of priority for non-vehicle based users such as pedestrians and cyclists. This downgrade in function may take place on a fixed basis or flexible basis such as by time-of-day and day-of-week. Provide a network for the movement of pedestrian and cyclists.
Distributor / collector roads	Significant movement with significant place aspects	<ul style="list-style-type: none"> Streets that do not easily fall into either the arterial or the local road category. Where the distributor/collector road passes through an area with a high number of pedestrians then the distributor/collector road provides vehicles access to the area, although priority may be given to non-vehicle users such as pedestrians. Priority may be fixed or vary depending on time-of-day and day-of-week. Provide a network for the movement of pedestrian and cyclists.
	Some movement with some place aspects	<ul style="list-style-type: none"> Streets that do not easily fall into either the arterial or the local road category. Distribute traffic and bus services within the main residential, commercial and industrial built-up areas and link traffic on local roads to the arterial road network. Local roads with the additional traffic functionality of serving major traffic generators or providing for some non-local traffic movements⁽¹⁾. Provide a network for the movement of pedestrian and cyclists.
Local roads and streets	Some movement with some place aspects	<ul style="list-style-type: none"> Provide vehicular access to abutting property, to other properties within a local area, to other local streets, such as cul-de-sacs⁽²⁾ and provide access for emergency and service vehicles.
	Some movement with significant place aspects	<ul style="list-style-type: none"> Local roads and streets that may serve the functions of providing places for pedestrians and cyclists, a means to enable social interaction within a neighbourhood (e.g. serving as a play area or community open space), a visual contribution to the 'living' environment.
Tourist routes	Some movement with significant place aspects	<ul style="list-style-type: none"> Provide routes to and along attractions that are considered a great place to be and that are of significance and desired by locals and visitors alike.

1 Problems often arise with intermediate streets, as their design usually promotes the traffic movement function, while the residents and sometimes the local council, consider the street to be a local street with emphasis on the need for low traffic speed and restricted width. Alternatively, in newer growth areas they may sometimes be under-designed in response to a desired emphasis on local road functions, resulting in operational and safety problems for the higher traffic volumes that must use them.

2 A street that provides access to several other streets will have a more prominent vehicle movement role than a small cul-de-sac.

3.2.3 Management Principles

While individual motorways and arterial roads may be managed by the one road agency within a region, they can be managed by different groups within road agencies. Road operators should be focussed on managing the road network (in particular the motorways and arterial road network) as a single network rather than separate facilities in order to achieve network optimisation and to better manage the interface between roads of varying roles. This will require the cooperative working arrangement between the groups managing the various arterial roads and motorways. Some of the fundamental guiding principles for achieving network optimisation for urban networks include:

- manage and balance the traffic management of the road according to the movement and place category of the road
 - for example roads that are primarily used for movement and have no or only some aspect of place they should be managed in order to give higher precedence to the movement of traffic, while roads that serve a significant place aspect should be managed to give decreasing precedence to the movement of traffic and increasing precedence to being places for people depending on the level of movement
 - balancing the management of roads according to the varying movement and place category may vary depending on location, time-of-day and day-of-week and therefore management may need to be fixed or flexible
- maximise road safety as the highest priority so far as is reasonably practicable
- integrate the movement of vulnerable road users such as pedestrians and cyclists safely and efficiently into the road network
- maximise the movement of people and goods, across the whole network
- achieve an equitable balance of traffic flow efficiency across the network
- establish a road hierarchy based on maximising the movement of people and goods and not just traffic volumes and manage the road network according to the hierarchy including optimising through-traffic operations for high-priority traffic routes
- manage the interface between road classes, in particular between managed motorways and arterial roads as outlined in Austroads (2014d) (a summary of the findings of this report is outlined in Figure 3.1)
- ensure the network operations planning framework is guided by these principles to facilitate whole-of-network optimisation
- as motorways typically provide greater per lane capacity than other road classes, and hence more opportunity to minimise whole-of-network delays, the freeway/motorways and associated interchange intersections and ramps should also be prioritised over other road classes
- improve road performance reliability (i.e. consistent travel time), rather than increasing travel speed or reducing delays, particularly during weekday peak periods when congestion may occur
- work across government departments, in particular with planning departments, to achieve travel times to key destinations, such as from home to places of employment, that are not only within acceptable benchmarks but are also reliable
- support and facilitate the achievement of 'place' objectives.

Figure 3.1: Summary of key findings from Austroads *Operational Management of Arterial/Managed Motorway Interfaces for Network Optimisation* report

Motorways and arterial roads have different flow characteristics and management strategies which present significant challenges to their integration. As such, it is often at these interfaces where operational inefficiencies occur, resulting in traffic flow inefficiencies propagating across the wider road network. It is therefore essential to harmonise the arterial and motorway traffic control operations at these interfaces if overall network optimisation is to be achieved.

Coordinating the operations of motorways and arterials requires overarching strategies that manage the motorways and their adjoining arterials as single corridors and not as individual, separate facilities.

A fundamental issue is the separate management of motorways and arterial roads which exists in many jurisdictions. Therefore there is the need for cooperative working arrangements between the road agency managing the arterial roads and the road agency managing the motorway. This is essential to ensure the correct strategies and treatments are applied to these interfaces. By taking a system-wide approach that considers the entire network as a whole, the road agencies will likely optimise their own road networks in the process of optimising the overall network system.

Source: Austroads (2014d).

Road agencies need to implement strategies to manage and optimise the operation of the road network. This may be undertaken through:

- defining the context of the road within an integrated road network management system
- defining the operational objectives of the road
- outlining the key elements of a road
- outlining the required foundation systems and infrastructure
- defining the typical warrants for management and operating system intervention (e.g. intelligent transport systems)
- outlining how to plan for and design a road management and operating system.

For managed motorways which use information, communication and control systems incorporated in and alongside the road to manage motorway operations, the Austroads *Development of Guide Content on Managed Motorways* (Austroads 2014c) provides guidance on this and acts as an interim Austroads guide for managed motorways.

Guidance on the choice of intersection control in urban networks may be found in Part 6 of the *Guide to Traffic Management* (Austroads 2013a) and in AS 1742.2.

Guidelines relating to the use of these traffic control devices are given in *Part 10: Traffic Control and Communication Devices* (Austroads 2009b).

Guidelines relating to the management of traffic in activity centres are given in *Part 7: Traffic Management in Activity Centres* (Austroads 2015a).

Facilitate informed route choice

In order to best maximise the urban road network and meet the needs of the users, the urban road network needs to facilitate informed route choice for the users.

In urban networks, drivers tend to have a variety of route options and travel mode choices. Unlike in rural networks, various route options and travel mode choices in urban networks may comprise of similar distances. However they may differ from one another in their ease of navigation, suitability for the journey, average travel time based on road functions and travel mode and travel time based on traffic conditions. To reduce the travel time of individual journeys and increase the productivity of the network (maximise the speed and flow of vehicles), requires that drivers distribute themselves around the network in a manner that results in them choosing a route that will enable them to efficiently reach their destination. To achieve this, drivers need effective network guidance, not only to navigate a series of individual roads that may comprise a route but to also choose which route is optimum for their journey.

Network guidance is not all the responsibility of the road agency and can be achieved through means such as using (listed in no particular order):

- street name signage
- a street directory
- suburb name signage
- landmarks
- a guide direction and/or tourist signage
- a passenger during the trip
- friends or family prior to the trip
- route numbers
- internet navigation sites prior to the trip
- miscellaneous information from the internet prior to the trip
- in-car satellite navigation systems
- familiarity with the route.

It is expected that the growth in use of in-car satellite navigation systems will change usage patterns, however at least in the short to medium term it is not expected to fully replace the need for suburb and street name signage. These will continue to fulfil a primary guidance role for some, and also provide a confirmation role for in-car navigation users.

The high rates of usage of street name and suburb name signage, often in conjunction with a street directory, highlight the need for comprehensive and coherent direction signage designed at a network level to guide road users to their destinations via strategically selected focal points. Processes for developing such schemes can be found in *Part 10: Traffic Control and Communication Devices* (Austroads 2009b).

Real-time travel information, including travel time estimates, provided via variable message signs (VMS) and other media may modify the route choices otherwise made by motorists. The use of VMS in this context is further discussed in *Part 9: Traffic Operations* (Austroads 2014b) and *Part 10: Traffic Control and Communication Devices* (Austroads 2009b).

3.3 Rural Networks

3.3.1 Introduction

Rural road networks are characterised by lower traffic volumes than urban networks, higher operating speeds, longer average trip lengths (particularly on the arterial road component of the network), lower connectivity (the degree to which streets or areas are interconnected and easily accessible to one another), and lower abutting development density.

Similarly to the passenger vehicle users of urban networks, the passenger vehicle users of rural networks value the following elements:

- good roads and networks (most valued)
- synchronised and steady flow
- safety and enforcement
- predictability and convenience

Therefore, the role and management principles of the rural network need to meet the needs of its users. Guidance on the management of rural networks in order to meet user needs is discussed further in Section 3.3.2 and Section 3.3.3.

It is noted that segments of the rural network also comprise of public transport networks (Section 3.4), heavy vehicle networks (Section 3.5) and bicycle networks (Section 3.6) to varying degrees. These are discussed in the various sections.

3.3.2 Role

The rural road operating characteristics and lower traffic volumes drive the network management focus for rural networks.

The rural arterial road hierarchy typically comprises of M, A, B or C roads. It is noted that not all road agencies may use all four tiers. Below this are local roads used for rural access. Table 3.2 outlines the movement and place categories, road class and role of the rural road network.

Table 3.2: Roles of rural roads

Road class	Movement and place type	Role
M routes	Designated movement with no place aspects	<ul style="list-style-type: none"> • These are divided carriageway roads, generally forming part of the main links between capital cities, or from a capital city to a key regional centre. All motorways should be designated as M roads.
A routes	Significant movement with some place aspects	<ul style="list-style-type: none"> • These would be expected to form the principal routes within regions that are not of M road standard. They would be expected to form links between capital cities or between key regional centres or between key centres and a capital city.
B routes	Significant movement with some place aspects	<ul style="list-style-type: none"> • These would be expected to form the primary connections between major regions not served by 'A' routes.
C routes	Significant movement with some place aspects	<ul style="list-style-type: none"> • These are the other roads in the arterial network.
Local roads	Significant movement with significant place aspects	<ul style="list-style-type: none"> • These are also sections of the arterial road network that may go through major regional centres and therefore provide for places with high pedestrian numbers.
	Some movement with significant place aspects	<ul style="list-style-type: none"> • These are also sections of the arterial road network that may go through towns or hamlets and therefore provide for places for people to stop, walk or cycle around, purchase goods and generally enjoy the amenity of the area. • These are roads that are not part of the rural arterial road network but also serve as tourist routes for visitors.
	Some movement with some place aspects	<ul style="list-style-type: none"> • These are roads that are not part of the rural arterial road network and therefore serve as access to destinations such as private property, parks, beaches or campgrounds etc.

In order to meet the needs of the users of rural networks, the objectives of these networks fall into five categories:

- Safety: characteristics of the road and its surroundings which could affect the frequency and severity of traffic related crashes.
- Traffic operations: the level of service at volumes less than capacity. This is reflected by the travel time or journey speed over a road section, and the extent of congestion experienced by the traffic and the ability to overtake.
- Capacity: the ability of the road to carry the volume of traffic wishing to use it.
- Quality of service: road features which affect road user amenity, interest, convenience and comfort.
- Heavy vehicles: to provide for the mobility and access of heavy vehicles to destinations across and within rural locations.

3.3.3 Management Principles

Table 3.3 summarises the major network management issues for rural roads in terms of these objectives, with an emphasis on arterial roads.

Note from Table 3.3 the predominance of road safety issues. This measure largely drives the traffic management focus for rural networks.

Note also that rural networks have a much lower degree of connectivity with greatly reduced intersection spacing compared to urban networks. Links are accordingly longer and many of the issues take on the characteristic of route issues rather than network issues. The 'toolbox' to address them is therefore to be found largely in Part 5 of the Guide (Austroads 2014a).

Road user guidance

An essential component of rural network management from a road user's perspective is a system of route identification to assist unfamiliar motorists to navigate through the network. The assignment of a system of numbers to particular routes or roads forms part of such a 'way-finding' system. Way-finding is the art and science of organising signs and other traveller information to communicate what visitors want and need to know (it can also include printed material such as brochures and maps).

Rural arterial roads do not respect state borders, and guidelines have therefore been developed to assist Australian state and territory road agencies to implement principles for a national approach to rural route numbering. These principles provide a multi-tier arterial route classification reflecting the functional importance of the route, to be used on route signage and mapping, commonly known as the M, A, B and C system (Austroads 2003) as outlined in Section 3.3.2.

The driving principle in developing the guidelines is that they assist road users. Drivers should be able to anticipate the driving conditions they are likely to encounter, and expect better conditions on the busier, more significant roads. The national approach to rural route numbering therefore provides for route signing and map information that reflects:

- route continuity across borders
- the functional importance of the route
- the road standard of the route

For further reading on the M, A, B and C route identification system, see Austroads (2003). For guidance on development of direction signing schemes, see Part 10 of the Guide (Austroads 2009b) and for detailed standards regarding use, see AS 1742.15-2007.

Table 3.3: Management principles for rural roads

Principle	Description	Objective addressed				
		Safety	Traffic operations	Capacity	Quality of service	Heavy vehicles
Cater for safe long-distance driving	Travel on rural arterial roads generally involves longer distances and higher speeds than in urban areas. The mixture of local and long-distance traffic and the need for overtaking opportunities on two-lane roads create strong interactions between faster and slower vehicles.	✓	✓			✓
Provide roads of a consistent standard that matches driver expectations	Road standards can vary substantially over a journey, and the driver needs cues from the road where changes occur. Careful engineering is required to maintain, wherever possible, a consistent road standard that matches driver expectations.	✓				
Provide good road signing and delineation so that the road can be read even without road lighting or driver familiarity	The combination of varying road standards, the absence of road lighting, and the unfamiliarity of many drivers creates an increased need for road signing and delineation.	✓	✓		✓	
Provide roads that allow for safe operation in peak demand periods	Rural arterial roads rarely operate at capacity but, where problems do exist, they generally affect a large number of road users. The most common capacity constraints occur at peak recreation periods on approaches to large towns and cities, and at local bottlenecks caused by towns, intersections, substandard road sections and roadside land uses. Traffic congestion at flows less than capacity is usually of greater concern, particularly on recreational routes and roads in urban fringe areas. This is affected by overtaking opportunities as well as capacity constraints. In these conditions, reduced overtaking opportunities under increased flows also lead to less safe operation.	✓	✓	✓		✓
Cater for safe roads that reflect the operation (speed and volume) of the road	The combination of high speeds and low volumes presents particular problems for safety-directed traffic management on rural arterial roads. Because of high speeds, road crashes tend to be more severe than on urban roads. However, the low volumes lead to a low crash probability at any given location, so that only relatively low-cost safety countermeasures can be justified in economic terms.	✓				✓
Provide for adequate driver facilities on long distance routes	Long travel distances and associated driver fatigue also create a need for motorist support services such as fuel, food and various types of roadside stopping places. Traffic management should also provide for tourists and those simply 'going for a drive' as a form of recreation.	✓			✓	✓
Provide for alternative routes in the event of a road closure	Lower connectivity within rural networks places increased importance on the availability of alternative routes to maintain access between towns. Natural disasters such as flood and fire, and traffic-related crashes can easily block rural roads at any level of the road hierarchy. Incident management plans providing for implementation of planned diversion routes are an essential component of rural network management.		✓		✓	✓

3.4 On-road Public Transport Networks

3.4.1 Introduction

Increasing the use of public transport is one successful measure to address the competing demands for road space. The provision of highly effective and efficient public transport is becoming core business for road and transport agencies, and the traffic engineering discipline and practitioners must have a sound understanding of the characteristics of public transport networks.

As outlined in Table 2.3, the user of on-road public transport values the following elements:

- time (most valuable)
- systems and efficiency
- reassurance
- comfort.

Therefore the role and management principles of the public transport network needs to meet the needs of its users. Guidance on the management of public transport networks in order to achieve this is discussed further in Section 3.4.2 and Section 3.4.3.

3.4.2 Role

There are three modes of transport categorised by type of usage:

- private transport – privately owned vehicles operated by owners for their own use
- for-hire transport – provided by an operator, available to anyone prepared to meet the specified hire conditions and without a fixed route (e.g. taxi, hire car)
- common carrier transport – provided by an operator, available to a number of independent passenger groups for an established fare, generally with a fixed route (e.g. bus, tram, train).

While 'public transport' is generally recognised as including the second and third of these categories, most of the considerations in Part 4 of the Guide address only category 3.

In order to meet the needs of on-road public transport, the road network must provide on-road public transport (ORPT) facilities in accordance with the movement and place functions as outlined in Table 3.4.

Three broad categories of right-of-way are provided for the ORPT to operate (Currie 2003):

- Category A – fully controlled with no at-grade crossings and no legal access by other vehicles; often called 'exclusive right-of-way', 'private' or 'segregated'.
- Category B – longitudinally separated by kerbs, barriers, etc., but with at-grade crossings for other vehicles and pedestrians.
- Category C – on surface streets with mixed traffic, where public transport vehicles may travel with other traffic. However, this may include some allocation of priority to public transport vehicles (e.g. bus lanes) excluding physical segregation.

Traffic engineers and managers will generally be concerned with the common carrier type of usage operating in Category B and Category C right-of-way conditions.

On-road public transport planning

With transport planning issues as opposed to management issues being addressed in the *Guide to Road Transport Planning* (Austroads 2009a), it is necessary at this point to provide some background for on-road public transport (ORPT) planning to give context to subsequent discussions of network management issues.

Table 3.4: Roles of on-road public transport

Road class	Movement and place type	Role
Motorways	Designated movement with no place aspects	Long haul, high capacity bus routes.
Arterial roads	Significant movement with some place aspects	High capacity, lower speed (60 to 80 km/h) ORPT routes.
	Significant movement with significant place aspects	ORPT connects places, so many ORPT routes will use arterial roads that also provide significant place functions (e.g. CBD) for some sections as they approach major public transport hubs.
Distributor/collector roads	Significant movement with significant place aspects	Many ORPT routes will use distributor/collector roads that also provide significant place functions (e.g. transport hub within a shopping area) for some sections as they approach major public transport hubs.
	Some movement with some place aspects	Connecting people to services.
Local roads and streets	Some movement with some place aspects	Connecting people to services.
	Some movement with significant place aspects	Low speed, highly accessible ORPT.
Tourist routes	Some movement with significant place aspects	ORPT may use tourist routes as part of their service and therefore typically travel at lower speed (50 to 80 km/h) to allow passengers to enjoy the area, while also transporting passengers to key attractions along the route.

Strategic planning

Strategic planning for ORPT as part of an integrated transport system for an urban area is the process of defining the broad nature of the role ORPT will play in the total system. It is beyond the scope of this Guide. See instead, Currie (2003).

Network planning

Planning the ORPT network for a given urban area must consider the role to be taken by ORPT within the total public transport network. Larger cities (in terms of both population and geographical area) generally require public transport to undertake both line-haul and feeder functions. While the relatively lower capacity, shorter distance feeder services are almost always provided by ORPT; the high capacity, longer distance line-haul services may be ORPT but often will be provided by light rail or commuter rail systems, or increasingly busways operating in exclusive rights-of-way.

The general form of the total public transport network for a city is largely determined by the urban form and structure, particularly the shape of the city and the number and locations of its major activity centres. Other factors, such as the presence or absence of natural barriers, e.g. steep ridges or rivers, and the form of the road network (grid, ring-radial) can also be important. Some typical urban network forms are:

- linear network
- radial network
- multi-centred network
- ring-radial network.

Characteristics of each and their implications for public transport can be found in Commentary 5.

[see Commentary 5]

The networks for ORPT are constrained by the nature of the existing road and street network. If the ORPT has a line-haul function, it usually will operate on the arterial road network; however, if it is providing feeder services, it may operate on both the arterial and local street networks.

On a highly connective road network (offering many alternative routes between two points), the form of the ORPT network is less constrained. For example, a grid road network can accommodate a grid ORPT network, as in Figure 3.2, or a radial ORPT network, as in Figure 3.3.

Figure 3.2: Grid ORPT network on grid road network

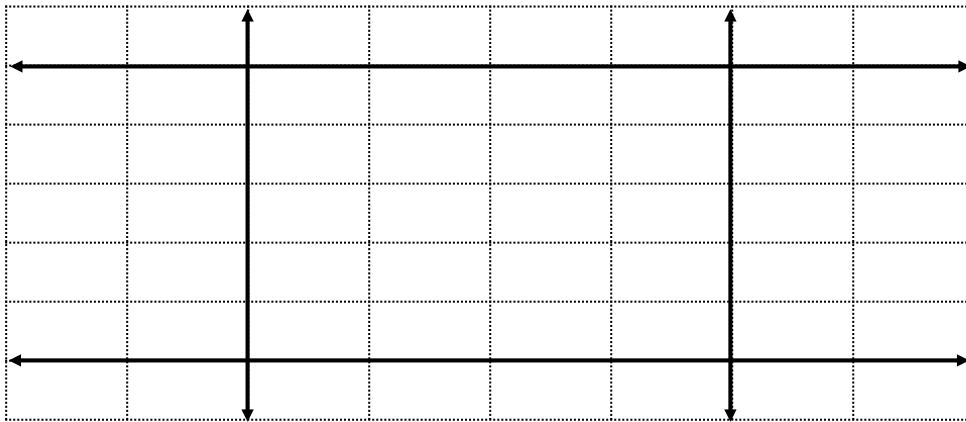
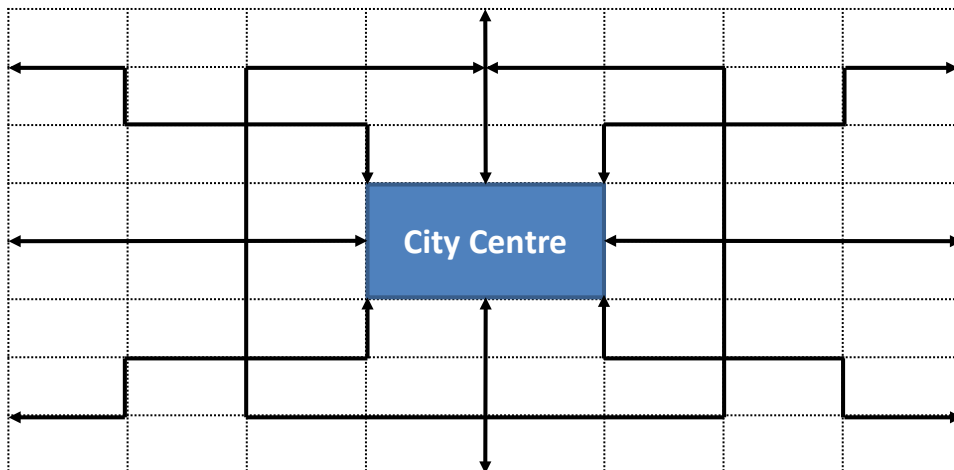


Figure 3.3: Radial ORPT network on grid road network



Line-haul ORPT services should ideally operate on routes that are as straight and direct as possible within the constraints of the road network. Radial or ring-radial road networks generally facilitate this directness. However, grid networks do so only in the primary directions of the grid. Where the straight line between the origin and destination is diagonal to the road grid, travel distance is necessarily longer but travel time can be reduced by minimising the number of left and right turns, consistent with the travel demands to be served along the way.

Nevertheless, a grid street network is a very efficient street layout for bus operations. Maximum permeability is provided with grid road systems because they are effective in spreading traffic loads throughout networks and decreasing concentrations of congestion.

Where parallel ORPT routes are provided on a grid network, their spacing should be such as to provide reasonable walking distances to ORPT stops from all residences. With the typical, reasonably short distances between stops along a route, the spacing between adjacent, parallel routes should be about twice the maximum reasonable walking distance. For example, a one kilometre spacing of distributors through suburban areas permits achievement of a bus stop within 500 m of 95% of residences.

When undertaking on-road public transport (ORPT) network planning consideration should be given to the type of ORPT vehicle used (e.g. controlled access bus which may only have access to a specific road) and the impact that some ORPT vehicles may have on broader traffic management (e.g. double decker buses may have increased dwell times). This needs to be considered along with catchment and route service, in addition to demand and frequency of services.

Route planning

Having determined the general nature of the ORPT network, the next stage is planning the specific routes to be taken by the various services. Typically, the following issues are considered:

- Bus and tram routes should be as short and direct as practicable, producing a fast, efficient service, thus reducing total travel time to a minimum.
- The route should be chosen with due regard to land use factors and associated travel demands; passing through land use cells such as residential estates and shopping areas, rather than going around them. This will reduce running costs and maximise patronage. Ideally, no passenger should have to walk further than 800 m to reach a stop.
- Stopping patterns will need to be determined to suit the primary function of the particular route. Requirements will differ for school bus services, say, compared to commuter, shopping or intercity services. Similarly, bus stop locations, separation, design and facilities will also vary depending on the circumstances. These issues will be dealt with in greater detail in subsequent sections of this Guide.
- If possible, bus and tram stops should be positioned closer than vehicle parking facilities to major trip attractors, such as regional centres and educational institutions.
- Local and district distributor roads should be considered for ORPT routes, as their use will enable services to best penetrate residential catchments and achieve optimum coverage.
- In considering the potential for inclusion in a route of arterial road sections, the scope for the use of traffic signals and/or roundabouts should be assessed to assist ORPT operations, including pedestrian movements.

Infrastructure

The fixed infrastructure of an ORPT system comprises the following:

- right-of-way
- passenger transfer points
- vehicle storage and servicing facilities
- control systems.

Vehicle storage and servicing facilities are outside the scope of this Guide. Control systems, particularly those related to provision of active bus or tram priority, are discussed in Part 9 of the Guide (Austroads 2014b). Table 3.5 summarises key characteristics of right-of-way and passenger transfer point infrastructure.

Table 3.5: Public transport infrastructure characteristics

Infrastructure	Type	Characteristics
Right-of-way	The right-of-way may be: <ul style="list-style-type: none"> • a strip of road shared with general traffic • a reserved lane designated by signage and line-marking • an exclusive lane within the roadway but separated from other traffic by kerbing, etc. • a completely separate exclusive facility such as a busway. 	Right-of-way planning interacts strongly with network, route and vehicle fleet planning – once the vehicle type, network and routes have been selected, some key aspects of the right-of-way are defined. However, important planning issues remain in terms of such things as the lateral location within the road reserve of the ORPT track (which has interaction with the planning of passenger transfer points), the type of right-of-way (shared, reserved or exclusive) and the general treatment at intersections (at-grade or grade separated).
Passenger transfer points	Passenger transfer points, which may be called ‘stations’ on high-demand, line-haul routes or ‘stops’ on lower volume, feeder routes, may have a number of roles – terminus, interchange, standard or minor station/stop, or operational stops. Some of their characteristics are as follows.	
	Terminus	Stations at the beginning or end of the ORPT route can require longer dwell times (for drivers to take meal breaks, obtain change-of-destination information and download trip information, and for layovers). There may also be a requirement for buses to wait at this site prior to entering into service at peak periods.
	Interchange	These are stations where passenger movements take place between vehicles of the same (bus-bus, tram-tram) or different modes (train-bus, ferry-bus). Vehicle dwell times may be longer to ensure passenger connectivity.
	Standard station/stop	Standard stations/stops are on-line or off-line facilities providing a range of services along the route. Typically, they serve local residential catchments where the bulk of passengers walk to the station.
	Minor station/stop	At minor stations/stops, minimal infrastructure is provided to support passenger pick-up and set-down. Typically, these are the lowest in the hierarchy of stops and are often kerb-mounted with basic structures such as a shelter, seat, bus-stop sign and passenger information. They are normally associated with non-exclusive routes. Minor stations/stops may be classified as any one of the following: <ul style="list-style-type: none"> • standard – standard stop for pick-up and set-down purposes • part-time – peak stop only, school days only, special-purpose (tourist) only • special – only for servicing specialist high-activity sites (e.g. sports stadiums) as required • set-down – where passengers are set down only (e.g. at the end of a service run).
	Park-and-ride	Park-and-ride facilities may be provided at any of the transfer points listed above, but are particularly suited to stations/stops where there are limited interchange facilities and in fringe metropolitan areas.
	Operational stop	Operational stops serve as schedule timing points, lay-overs, driver or vehicle changeover points, and require vehicles to dwell longer, even if the stop or dwell time is not associated with passenger volumes. They may require additional bus stands with independent pull-in/pull-out capabilities for bypass by other ORPT vehicles. If they are driver changeover points, driver car parking is needed in the general traffic area adjacent to the stop.

3.4.3 Management Principles

There are a number of issues affecting public transport, some with direct relevance for traffic management and some indirect, of which traffic engineers and managers should be aware. The following list is based on Currie (2003):

- Traffic interference – In the absence of priority measures, ORPT modes travel at lower speeds than general traffic. Bus services travelling on surface streets in mixed traffic run at speeds of about 15–20 km/h (including stopping, travelling and dwell times), falling to 10 km/h in congested conditions. Delays arise from general traffic delays and from the need for buses and trams to stop to allow passengers to board and alight. Traffic delays occur mainly at intersections, so public transport priority at signalised intersections is a major focus for improvement programs.
- Reliability – Slow speeds are a deterrent to ORPT use, but the more significant deterrent is unreliable services. Passengers perceive the value of different types of delay differently (Currie 2003):
 - travel time in the vehicle – perceived value is 1.0 times actual travel time
 - unexpected waiting time (due to traffic delays) – perceived value is 4–6 times actual unexpected waiting time.
- Traffic delays incurred by one public transport vehicle can create a positive feedback loop compounding delays for subsequent vehicles and causing bunching of transit vehicles, resulting in the first vehicle in a delayed series being overcrowded and subsequent vehicles being increasingly empty. Commentary 6 demonstrates how this feedback loop operates.

[see Commentary 6]

- The peak period problem – Public transport services are costly and financial returns are typically low at best (except in very high volume and high density situations such as Singapore and Hong Kong). Costs are largely driven by crew and vehicle costs. Vehicle fleet and crew requirements are driven by passenger demand, which unfortunately is highly peaked, resulting in low utilisation for the balance of the day. Typically, more than 50% of the fleet is only used for around five hours of a typical 20-hour weekday. Public transport operators are therefore highly focused on the peak periods to minimise their total fleet requirement.
- Vehicle utilisation – The peak period problem focuses public transport operators on ensuring efficient vehicle utilisation. Vehicle reliability is an important consideration. If vehicle breakdowns disrupt schedules, then some vehicles will be overcrowded and some will be empty, and service reliability will suffer.
- Vehicle accessibility – Public transport vehicles are among the larger vehicles on the road. Larger, high capacity vehicles designed mainly around their line-haul function must sometimes also penetrate narrower suburban streets. This has implications for local street design and local area traffic management. See Part 8 of the Guide for guidance on local area traffic management issues (Austroads 2008a). It also has implications for temporary road closures and interruptions arising from roadworks, where sufficient advance notice to arrange alternative routing is essential.
- Route productivity – An essential characteristic for a route to be productive is that the route has passenger-attracting features along its full length. Routes that cross low density areas are less productive in this sense than routes that penetrate higher density areas. Routes that terminate in car parks will be less productive than those that stop at the pedestrian entrance to a major shopping centre.
- Passenger comfort – This requires adequate shelter, lighting and seating at transit stops. Vehicles and stops must also satisfy requirements for access for people with a disability.
- Passenger safety – This area covers not only safety within public transport vehicles, but also while waiting and, importantly for traffic engineers, safe passage to and from stops. Attention to pedestrian crossing points is important. Crossing points should be located near stops, as passengers must cross the road at least once for each return journey.

Measures to address on-road public transport

A distinction should be 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 removal of existing road system barriers to efficient bus travel and the inclusion of bus-oriented design principles for new roads. Active bus service priority relies on the introduction of road infrastructure and traffic management techniques to positively discriminate in favour of buses.

The physical dimensions and performance characteristics of buses (for example, acceleration, deceleration, turning circle dimensions, etc.) are different from those of the private car. However, it is often the private car for which roads are designed and constructed. If bus travel times are to be improved, roads should be designed with bus and bus passenger dynamics as the limiting design factor.

The term ‘facilitation’ refers to the removal of bus service impediments that may exist as a result of road standards and construction methods focused on motor vehicle performance characteristics. In such cases, buses may find difficulty negotiating parts of the road network, for example, due to tight radius curves or traffic-calming devices that have been designed to slow motor vehicles but which present significant impediments to convenient bus travel.

In this respect, it is the impact on bus passengers, especially standing passengers and the elderly, which is of importance. Road design and traffic management measures implemented without regard for the idiosyncrasies of bus dimensions and bus performance characteristics can detract from the comfort of a bus journey and impose unnecessary (though usually minor) delays.

Measures to facilitate bus travel essentially involve the removal of unnecessary impediments to a safe, comfortable and undelayed bus journey, while ensuring that other objectives, for example, road safety, are not undermined.

With respect to bus travel priority (as opposed to facilitation), area-wide or corridor schemes promoting coordinated action in favour of bus travel should be developed.

The assessment of the relationship between bus travel times and road infrastructure needs to take account of the distinctions illustrated in Table 3.6, which includes a simple, but not exhaustive, matrix of bus facilitation and priority measures. The table provides an illustration of the nature of the distinction between ‘strategic’ and ‘local-level’ interventions, and between interventions directed towards bus service facilitation and active bus service priority.

Table 3.6: Relationship between bus travel time facilitation and active priority

	Bus travel facilitation	Bus travel priority
Strategic road network	<ul style="list-style-type: none"> • Bus-friendly road standards • Bus infrastructure standards, e.g. bus stops, entry/exit tapers • Efficient route design • Real-time bus information • Other measures. 	<ul style="list-style-type: none"> • Busways • Bus lanes • Bus access ramps • Network signal priority • Traffic/parking control • Other measures.
Localised road network	<ul style="list-style-type: none"> • Bus-friendly local area traffic management (LATM) • Bus-friendly traffic calming • Bus-friendly road standards • Other measures. 	<ul style="list-style-type: none"> • Queue-jump lanes • Local signal priority • Local traffic/parking control • Bus-only streets • No-turning exemptions • Other measures.

Source: BSD Consultants (1996).

Issues commonly encountered by traffic engineering and management practitioners include bus and tram lanes, bus and tram stops, and bus priority at traffic signals. Guidance on these can be found in the following Guides:

- bus and tram lanes – Part 5 (Austroads 2014a)
- bus and tram stops – Part 5 (Austroads 2014a)
- bus priority at signals – Part 9 (Austroads 2014b)
- buses in the context of local area traffic management – Part 8 (Austroads 2008a).

3.5 Heavy Vehicle Networks

3.5.1 Introduction

The importance of freight to national, regional and local economies underpins traffic management objectives for truck movements; and the management of freight routes as part of a network must be seen in this light. The transport, postal and warehousing Australian and New Zealand Standard Industrial Classification (ANZSIC) sector typically represents around 5% of the Australian gross domestic product based on ABS data from 06/2007 to 10/2011 (Australian Bureau of Statistics 2012).

As outlined in Table 2.3, the user of heavy vehicle networks value the following elements:

- good roads and networks (most valued)
- synchronised and steady flow
- safety and enforcement
- predictability and convenience.

While many of these needs are met in the facilitation of urban and rural networks as discussed in Section 3.2 and Section 3.3, guidance on the management of heavy vehicle networks in order to meet the needs of heavy vehicle users is discussed further in Section 3.5.2 and Section 3.5.3.

3.5.2 Role

The role of roads in the overall freight transport scene can be seen from Table 3.7.

Table 3.7: Australian and New Zealand domestic freight task by mode

	Road	Rail	Air	Sea	Total
Australia					
Tonnes carried ('000), 2009–10 ⁽¹⁾	2 092 000	815 300	200	52 100	2 959 600
Tonne-km (million), 2011–12 ⁽²⁾	199 300	290 600	300	100 900	591 000
New Zealand					
Tonnes carried ('000), 2012 ⁽³⁾	215 600	16 100	N/A ⁽⁴⁾	4 300	236 000
Tonne-km (million), 2012 ⁽³⁾	18 500	4 200	N/A ⁽⁴⁾	3 600	26 300

1 2009–10 was the latest full data set available from BITRE as of 2016.

2 2011–12 was the latest full data set available from BITRE as of 2016.

3 2012 was the latest data set available from the Ministry of Transport as of 2012.

4 Measurement of air freight was not defined in the 2014 published study but as an indication in 2006–07 tonnes carried ('000) was 100 and tonne-km (million) was 80 with a change in total tonnes carried ('000) and tonne-km (million) from 2006–07 to 2012 being 5 and –2% respectively.

Source: Bureau of Infrastructure Transport and Regional Economics (2015), Ministry of Transport (2014).

Freight traffic is much more diverse in its characteristics (e.g. vehicle types, vehicle performance, and distribution/delivery patterns) and needs than general road traffic. This diversity can impact on the needs of the freight vehicles and must be incorporated into route planning processes.

Road agencies have identified a number of types of freight activity that warrant particular attention due to their distinctive characteristics or needs. These include major freight route networks in urban areas, rural networks, high wide load networks, and commodity networks for agriculture and extractive industries. In time, this list could expand as freight route markets are further segmented and agency responses are tailored to specific industry needs.

The route type that freight uses can comprise of either:

- 'primary networks': serving interstate, strategic industrial areas, freight terminals and hubs
- 'distribution networks': serving the numerous origins and destinations in a regional or local area.

The characteristics of the route type used by freight are summarised in Table 3.8.

Table 3.8: Freight route characteristics

Route type	Movement and place type	Route characteristics
Primary freight networks	Designated movement with no place aspects	<ul style="list-style-type: none"> • Link strategically important economic regions (key freight centres, industrial, agricultural and manufacturing areas, intermodal terminals, sea and airports), within and external to a state. • Have a relatively high volume of heavy freight vehicles through most of the 24-hour period. • Provide access for long distance freight vehicle movements.
	Significant movement with some place aspects	<ul style="list-style-type: none"> • For some primary freight networks with a low place function the movement and place category may be a movement corridor (e.g. urban highway / major arterial road).
Distribution (secondary) freight networks	Significant movement with some place aspects	<ul style="list-style-type: none"> • Supplement primary freight networks. • Provide sub-regional (urban and rural) access to primary freight networks. • Provide sub-regional (urban and rural) links between freight destinations. • May have a relatively lower proportion of heavy freight vehicles than primary routes.

Source: Adapted from Austroads (2007a).

3.5.3 Management Principles

Due to the significantly larger size of trucks compared to passenger cars, truck movement in urban areas can potentially:

- raise issues regarding allocation of road space and capacity between freight, public transport, private vehicles and cyclists
- impede traffic flow at signals because of their poorer acceleration
- impede traffic when stopped to load or unload
- generate noise and vibration problems disproportionate to their numbers.

Conversely, congested traffic conditions lead to stop-start conditions, disproportionately increasing truck operating costs and giving rise to other costs from the need for freight terminals to operate for longer hours to offset the truck delays. Further, the road freight industry incurs significant costs trying to avoid using congested roads in peak periods.

While arterials were designed to a higher standard to better accommodate trucks, much of the urban infrastructure is old; and increases in dimensional limits of modern trucks do not always match the rate of infrastructure upgrading. As a result, trucks encounter a range of network problems from their perspective, some associated with road design and some with traffic management practice for general traffic, as summarised in Table 3.9. Not all of these problems are confined to trucks; some are applicable to general traffic, but impact on trucks in particular.

Table 3.9: Urban trucking problems

Problem area	Issues
Road networks	<ul style="list-style-type: none"> • Narrow lanes, 'trap' lanes (abrupt termination of a through lane). • Inadequate pavement marking, especially at night (optimum viewing angles for retro-reflectivity of pavement markings are disadvantageous to high driving positions). • Sub-standard overhead and side clearances. • Inadequate direction and street name signage.
Traffic signals	<ul style="list-style-type: none"> • Minimum green and gap times suited to cars, not slowly accelerating trucks. • Inability of the signal controller to extend green time to allow for an approaching truck with its longer dilemma zone than for cars, with possible safety implications arising from drivers entering the intersection well into the yellow period. • Coordinated signal systems: <ul style="list-style-type: none"> • often operate at a rate of progression ill-suited to the acceleration and speed profiles of trucks • sometimes favour a peak general traffic direction opposite to the peak truck direction • give no preferential treatment to trucks.
Intersection design	<ul style="list-style-type: none"> • Inadequate geometry for larger turning trucks. • Inadequate roundabout geometry, particularly on lower order collector and local roads where trucks must still operate to service the local area.
Parking and loading	<ul style="list-style-type: none"> • Rarely sufficient loading zones to accommodate all demands. • Older buildings rarely have adequate off-street loading docks. • Insufficient parking capacity at truck terminals, resulting in drivers parking at or near their homes, with consequent environmental amenity and safety concerns. (Note that driver convenience can also contribute to this problem). • Clearways, while offering significant benefits to moving vehicles, can create problems for trucks servicing adjacent premises and cause a significant reduction in truck productivity.

Source: Adapted from Ogden (2003).

While it is recognised that high productivity vehicles (HPV) reduce the number of truck trips required for a given task, they are usually larger and/or heavier and thus have different interaction behaviours. These may include less overall lane space, potentially slower acceleration at traffic lights, can create more hesitation from other road users which slows them down and presents less opportunity for incidents as there are less trucks etc. The merits or otherwise of increasing the utilisation of higher productivity vehicles on the traffic/network management task need to be considered along with the impacts that larger trucks may have on the network and users. In order to address this, HPVs are generally limited to specific routes as discussed in further detail later in this section.

Strategies for freight movement

Strategies that can be applied to address the problems encountered by trucks and thereby improve freight productivity can be classed in four categories (Ogden 2003):

- network strategies
- local or site strategies
- parking or loading strategies
- removal of physical impediments.

In this part of the Guide, the focus is on the first category, together with some discussion on those local strategies which, when applied consistently across a network, could be regarded as network strategies.

Network strategies

Network strategies usually involve the nomination of specific routes for use by trucks. There are two approaches, advisory and statutory. They can be applied to both urban and rural networks.

The advisory approach involves the identification of a network of routes that are, or can be made, attractive for truck use with the aim of drawing trucks away from other routes where truck traffic is less desirable. In practice, most arterial roads would form part of an advisory network. The nomination of primary and secondary freight routes by jurisdictions is an example of the advisory approach.

There are two strands to the statutory approach. The first involves the prohibition of trucks from those routes or areas which are unsuited to their operation, or on which the impacts on environment and amenity are unacceptable. The second involves the statutory designation of routes to which high productivity vehicles are restricted, for example, B-double routes and road-train routes.

In practice, a combination of the advisory and statutory approaches is quite common. Designated truck routes define the preferred primary and secondary freight routes, while prohibitions, usually implemented by way of load limits or length limits (with or without time limits on either), apply to sensitive routes or areas.

Truck routes

The following factors require consideration in the identification and selection of truck routes, and in planning for their improvement (Ogden 2003):

- They should comprise most, if not all, motorways and main arterial roads with connecting and access links as necessary.
- They should serve the major generators of truck traffic in a convenient and direct manner.
- The roads should be in good condition, with adequate geometric layout and pavement strength for truck operation.
- Steep grades should be avoided, especially in locations where noise is a problem.
- Abutting land uses should be considered; residential and retail land uses and areas with high pedestrian activity should be avoided as much as possible.
- Traffic volumes on the roads and the capacities of intersections, and the impact of increased truck volumes on these, should be considered.
- Truck routes should have good connectivity throughout the network and as few sharp turns as practicable.
- Truck routes should have priority over all minor side streets and be controlled by traffic signals or have grade separations at major intersections.
- They should have easily accessible driver and vehicle facilities along the longer routes.
- Effective signing, and supporting maps and public information should advise of the network and its conditions.
- An appropriate design vehicle should be used to check existing road geometry and planned improvements.
- Routes should have good manoeuvring and access at origin and destination points.
- Truck route networks should be developed in close consultation with local governments and the trucking industry.

A comprehensive process for the identification and planning of truck routes can be found in Austroads (2007a), which also reports several case studies of successful approaches by road agencies to the identification and protection of freight routes and networks. They encompass freight routes at national, state, regional, metropolitan and provincial city levels.

For truck route signposting standards and guidelines, see the following Australian Standards:

- High wide load routes – AS 1742.15-2007 Clause 4.2.3.
- Alternative and by-pass route numbering (often used by trucks to avoid town centres) – AS 1742.15-2007 Clause 4.3.3.
- Localised alternative route or detour signposting for heavy, high, long, wide, etc., vehicles due to a constriction on the road ahead – AS 1742.2-2009.

High productivity truck routes

There is tension between the regulatory restrictions on the dimensions and mass of vehicles suited to network-wide use, and the interests of economic efficiency and productivity, which may suggest that over-dimensional or higher mass vehicles be allowed on a limited part of the network. Classes of over-dimensional vehicles that enable higher productivity in the freight task include B-doubles, B-triples and road trains. The designation of routes on which these vehicles can be permitted to operate is clearly of benefit. For example, in the case of B-doubles (Roads and Maritime Services 2012):

- Two B-doubles are equivalent to three conventionally articulated vehicles, thereby reducing total lane occupation, crash exposure and environmental impact while improving transport productivity.
- B-doubles result in a reduction in the extent of pavement damage potential per tonne of road freight moved, when compared to conventionally articulated vehicles.
- The double articulation makes B-doubles more stable than conventionally articulated vehicles, contributing to improved safety performance.
- B-doubles are subject to vehicle and operating conditions over and above those imposed on conventionally articulated vehicles, resulting in an improved safety and environmental performance. It is noted that careful consideration should be given to the safety implications of permitting the use of B-double or larger trucks on routes that do not have suitable overtaking facilities for the demand.

However, high productivity vehicles are not suited to all routes and can also attract adverse community reaction as a result of their size. Routes need to be tested for their ability to accommodate these vehicles. An example of guidelines for route assessment in respect of design and traffic management factors is given in Commentary 7.

[see Commentary 7]

Up-to-date maps and public information should be available to operators advising of the network and its conditions. The road agency's website can be well-suited to this purpose.

High wide load routes

High wide load (HWL) routes have a number of names including OSOM (over size over mass) and ODOM (over dimension over mass). In this Guide, HWL is used. These routes are used by restricted access vehicles that require a permit from the jurisdiction to access that set of roads.

With very large consignments from time to time, routes servicing ports or heavy industrial areas may be required to accommodate HWL or over-mass movements. Typically these will require individual consideration by the road agency but in the context of providing for them, particularly in urban areas, routes could be developed that have no overhead restrictions and where parts of the infrastructure are constructed for easy removal to accommodate the larger swept paths and physical dimensions. Main Roads Western Australia (2012) provides an example of design and route assessment criteria for HWL routes.

HWL routes should be signposted in conformity with AS 1742.15-2007 Clause 4.2.3, and supporting up-to-date maps and public information should also advise of the network and its conditions. The road agency's website can be well-suited to this purpose.

HWL movements have potential to impact negatively on traffic flow and the safety of other road users. It is therefore necessary to consider and plan for the management of these impacts. The overall efficiency and safe operation of the road network must be managed by the balancing of:

- availability of holding bays, seal widenings and other passing opportunities
- the number of HWL movements, and temporal allocation (time of day/week) for HWL movements
- adequate traffic management plans that manage impacts and minimise delays to other traffic.

It is usual for the traffic management plan to be prepared by heavy haulage operators when undertaking the movement of a high wide load. Its scope will depend on the size of the load and the route taken. A major part of the plan will be steps taken to minimise delay and annoyance to other road users. This includes arranging for other traffic to bypass the load, safety considerations, and the direct problems of getting the convoy along the route. An example of guidelines for the preparation of a traffic management plan can be seen in Main Roads Western Australia (2012).

Hazardous load routes

The objective in selecting routes for the movement of hazardous loads is to concentrate their movement on roads where the risk of crashes and/or the consequential risk of damage following a crash are lower than would be the case if movements were unregulated. With this in mind, candidate routes for hazardous load movement would generally satisfy criteria for the selection of general truck routes. In addition:

- All motorways and limited access roads should be included.
- Preference should be given to more direct routes, other things being equal.
- Routes in less populated areas should be preferred, other things being equal.
- Routes should be free of physical characteristics that commonly contribute to crashes.
- Routes should avoid, where practicable:
 - centres of concentrated population or activity, such as schools, hospitals, shopping centres, etc.
 - railway level crossings
 - open water supply canals and other vulnerable facilities
 - tunnels and confined spaces.

The guiding principle should be that in selecting a route from a number of candidates, the choice should account for exposure to risk in terms of distance travelled, the number of people exposed, and environmental impacts of a crash.

Dangerous goods loads must be carried in vehicles correctly marked with information regarding the nature of the load and signs warning other traffic. A road crash, spillage or emergency involving such a vehicle could invoke emergency services such as police, ambulance and fire services, together with vehicle and load recovery (or removal). This could necessitate road or lane closure and possibly the implementation of traffic diversions and will usually require some form of manual traffic control on-site.

Restriction of heavy vehicle access

In the statutory approach to truck network management, there are several techniques available to prevent access by larger vehicles to roads that are either physically unsuited or whose land use and associated community activities are considered incompatible with heavy vehicles. These can be regulatory such as 'no trucks' signs (with an accompanying vehicle mass limit), or physical such as height limiting or width restricting barriers. The needs of service or utility vehicles should be considered prior to implementing physical restrictions.

Clearly there is a need to be able to provide for trucks servicing locations within a restricted area or route, for example, deliveries within the restricted area. Road rules therefore provide for an exemption from 'no trucks' restrictions for trucks that have a destination beyond the restriction sign and no unrestricted alternative route (National Transport Commission 2012).

Restrictions need to be accompanied by good advance signing. Detailed sign requirements can be found in Australian Standard AS 1742.2-2009.

Local access

Commercial and industrial developments usually generate significant volumes of truck traffic and it is therefore important that careful consideration is given to the local needs of trucks, their impact on the traffic operation of the road, and any adverse effect on the amenity of areas adjacent to the development.

In this regard, it is essential that developments adjacent to arterial roads are designed to provide satisfactory and efficient access for trucks. In particular:

- For commercial developments, heavy vehicle access should largely be separated from that used by customers of the development.
- All movements at the access intersections should be designed for the largest truck likely to make deliveries to the centre, without the truck encroaching into opposing traffic lanes.
- All trucks should drive only forward when entering and leaving the development.
- For smaller developments in older areas, trucks should not reverse from the arterial road into loading facilities, or unload whilst standing on the road pavement.

Truck access routes should be located so that conflict with pedestrian movements is eliminated, or at least minimised.

3.6 Bicycle Networks

3.6.1 Introduction

The purpose of a bicycle network is to enable people of a wide range of abilities and experience to cycle. The basis of a bicycle network is the road network (made up of local and arterial roads), augmented by special (in some cases separated or coloured) on-road facilities together with dedicated infrastructure such as off-road paths, and footpaths (where permitted). In addition the bicycle network may be augmented by the public transport network.

As outlined in Table 2.3, the user of bicycle networks value the following elements:

- safe connectivity and flow (most valued)
- safe behaviour
- supporting facilities
- health, wellbeing and knowledge.

Therefore, the role and management principles of the bicycle network need to be such that they meet the needs of users. Guidance on the management of bicycle networks in order to achieve this is discussed further in Section 3.6.2 and Section 3.6.3.

3.6.2 Role

Table 3.10 details features that are important to form a good bicycle network.

Table 3.10: Bicycle network features

Route feature	Comments
Safety	Minimal risk of traffic-related injury, low perceived danger, space to ride, minimum conflict with vehicles.
Coherence	Infrastructure should form a coherent entity, link major trip origins and destinations, have connectivity, be continuous, signed, consistent in quality, easy to follow, have route options.
Directness	Routes should be direct, based on desire lines, have low delay through, routes for commuting, avoid detours, have efficient operating speeds.
Attractiveness	Lighting, personal safety, aesthetics, integration with surrounding area, access to different activities.
Comfort	Smooth skid resistant riding surface, gentle gradients, avoid complicated manoeuvres, reduced need to stop, minimum obstruction from vehicles.

Infrastructure for cycling should:

- improve cycling safety
- improve cycling comfort
- improve cycling efficiency
- encourage people who do not currently cycle

The bicycle network should accommodate a range of rider experience and skill levels. In some instances, it may be warranted to provide more than one cycling facility on the same route to allow for differing skill levels. For example, a shared-use path may be provided to allow primary and secondary students to cycle in an environment separated from motor vehicles and yet the same road may have an on-road bicycle lane for more experienced riders. The varying cyclist types and their characteristics and riding environments are outlined in Appendix B. The bicycle network should provide connectivity that allows for a variety of trip purposes. The same piece of bicycle infrastructure may be used for both transport cycling and recreational cycling.

There should be a relationship between the functions of the component parts of a bicycle network and the functions of the road network hierarchy. Where bicycle routes run along or cross the road network, the operational facilities should reflect the network functions for both the road and the bicycle route cycleway. Table 3.11 outlines the functions of various types of routes that make up the bicycle network hierarchy and aligns the various route types with movement and place functionality.

Table 3.11: Bicycle network functions

Route type	Movement and place type	Network function	Cyclist operating speed
Regional bicycle network ⁽¹⁾	Significant movement with some place aspects	High-quality, high priority routes to permit quick unhindered travel between and within (for large areas) the major regions of cities, towns or urban areas utilising arterial roads.	25–40 km/h
Local bicycle routes	Some movement with some place aspects	High quality routes with seamless connections to regional routes. These routes connect the local street system to the major regional routes.	20–30 km/h
Mixed environments	Some movement with some place aspects	Low speed, low volume local access to residential destinations in a 'low stress' shared environment.	< 20 km/h
	Significant movement with significant place aspects	Low speed, high volume access to key destinations (such as within a CBD) often shared with other users such as pedestrians and motorised vehicles.	
	Some movement with significant place aspects	Low speed, high volume access to key destinations often used for other uses (e.g. strip shopping centre).	

¹ Principal bicycle network in some jurisdictions.

Source: Adapted from NSW Bicycle Guidelines (Roads and Traffic Authority 2005).

3.6.3 Management Principles

The following objectives are relevant to the planning, design and operation of bicycle networks:

- a designated regional network of roads and paths that serves longer distance commuter and recreational trips
- designated local networks and routes designed to provide low stress routes, to feed the regional network, and to provide for shorter local trips to shopping centres, recreational activities, and public transport hubs
- full construction of route sections between origins and destinations, consistent with the route purpose
- convenient access into and through residential, commercial and industrial subdivisions, and major developments
- access and facilities to travel with bicycles on public transport
- secure long- and short-term parking facilities at major destinations
- safe routes to schools
- well-defined bicycle facilities on arterial roads where significant cyclist demand exists, including for commuter trips
- appropriate maintenance practices which result in smooth surfaces
- calming in local streets
- paths that are interesting, which include rest areas at appropriate intervals on regional routes, and are designed to appropriate geometric standards
- implementation of regulatory, warning and guidance signage on paths

These objectives are generally outlined in bicycle strategies and plans which then influence the type of facility required as outlined in the following sub-sections.

Bicycle strategies and plans

Bicycle strategies and plans attempt to incorporate the concepts and put forward a framework in order to encourage cycling as a viable means of transport and/or exercise for various categories of cyclist users and/or transport purposes. The strategies generally provide an action statement on encouragement, education, engineering and enforcement.

There are various levels of bicycle strategies as outlined below:

- **National:** These are strategic documents which try to increase the number of people cycling by providing nationally consistent guidance for stakeholders (state and local governments) to develop their own strategies. The Austroads *Australian National Cycling Strategy 2011–2016* (Austroads 2010) is one such national strategy.
- **State/Territory:** State and territory strategic documents set the direction and framework within which various responsible agencies can plan and work. Road agencies may provide guidance on developing plans and strategies for cycling.
- **Local:** Local strategic bicycle plans can be developed on a municipal basis or a regional basis where a number of municipalities share resources. The purpose of these plans is to translate many of the aims of the state wide strategies into practical programs at the local level.

Further discussion on the planning for and management of cycling facilities can be found throughout the Austroads:

- *Guide to Traffic Management*, in particular this part and parts 3, 7, 8 and 12 (Austroads 2008a, 2009c, 2013c and 2015a)
- *Guide to Project Evaluation*, in particular *GPE Part 8* (Austroads 2006)
- *Guide to Road Design* (Austroads 2008–15), in particular *GRD Part 6A*
- *Guide to Road Safety* (Austroads 2006–13), in particular *GRS Part 4*.

Type of facility required

When considering the type of bicycle facility, such as cycle tracks (a physically separated bicycle-only facility), bicycle lanes or shared user paths, the two guiding principles are: separating cyclists from motor vehicles and pedestrians, and providing a high level of priority for cyclists across driveways and through intersections.

The design of bicycle facilities should be based on context sensitive design principles (outlined in the Austroads *Guide to Road Design Part 2: Design Considerations* (Austroads 2008–15)) with the appropriate bicycle facility determined through a full network operation planning process which takes into account the level of service desired for bicycles based on cyclist demand (both actual and potential), cyclist type, priority granted for cyclists on the particular road and other users of the road including on-street car parking. Commentary 8 provides guidance to practitioners on how to select the appropriate bicycle facilities for the preferred bicycle route based on the roads' expected/actual volume and speed. Guidance in Commentary 8 does not replace the need to design bicycle facilities.

[see Commentary 8]

Further, experienced road cyclists are unlikely to use off-road facilities as an alternative to routes where the road carries high volume, high speed traffic, unless the off-road route is suitably designed for their needs with appropriate directness and priority, thereby providing a faster alternative. Even with the provision of high quality separated facilities, some riders (particularly when riding in groups) will prefer to ride on the road and may require on-road bicycle lanes or suitable road shoulders.

Signage and network information

Signing of bicycle network facilities provides the information and control support that regulates riders on the network, thereby making it safe and easy to use. The three main functions of signage are:

- to regulate and advise the type of facility within the context of the overall road system, e.g. whether a facility is shared with pedestrians or for the exclusive use of cyclists
- to warn users of identifiable potential hazards within the riding environment
- to guide users around the network

Bicycle routes should be signposted to indicate destinations and, if required, distance to them. Uniformity of design and application of signs is desirable to avoid confusion and potential hazardous situations, applicable particularly for cyclists travelling away from their local area. Australian Standard AS 1742.2-2009 provides the basic layout and key elements for bicycle wayfinding signage. Australian Standard AS 1743-2001 provides the specifications for bicycle wayfinding signage. The Austroads (2015e) *Bicycle Wayfinding* report provide details guidance on Bicycle Wayfinding signage¹.

Network and route mapping

As with any transport system, accurate and comprehensive information concerning the bicycle network is essential. Maps should be available to cyclists showing the route, facilities and points of interest, including the relationship to the surrounding road system and community facilities. The scope of bicycle route and network maps can be local or regional but should always adopt a network approach and aim to present through-routes and access locations.

Combining bicycle travel with public transport

Multi-mode travel, where people cycle to interchanges and transfer to public transport, can substantially increase the range of bicycle travel. Public transport authorities should make provision for the carriage or storage of bicycles² in conjunction with the inclusion of transport hubs at specific destinations within the bicycle route network.

Jurisdictions should consider identifying and designing bike routes with key bicycle facilities to encourage people to combine bicycle travel with public transport. The focus for this should be within a defined catchment area of public transport terminals.

End-of-trip parking facilities

Bicycle parking for cyclists falls into four categories:

- all-day parking at trip destinations (e.g. for employees and students)
- all-day/part-day parking at public transport stations or interchanges
- short-term parking at shopping centres, offices and other institutions
- overnight parking at residences and other accommodation.

1 It is proposed to incorporate some of the guidance from the Austroads (2015e) *Bicycle Wayfinding* report into the Austroads' Guide to Traffic Management Part 10: Traffic Control and Communication Devices (Austroads 2009b). It is proposed to have a revised version released in the second half of 2016.

2 For example, easy-to-use on-board storage facilities, easy access to stations with secure long-term weatherproof parking or parking rails for the short-term.

All-day parking should provide a high level of security to prevent others from tampering with the bicycle, or stealing the bicycle or parts of it. Long-term parking therefore involves the provision of personal bicycle lockers, cages, or compounds ideally not more than 100 m from the destination. Cages and compounds should not only have a locked gate but also provide for the frame and both wheels to be locked to a rail within the enclosure. Short-term parking provides a lower level of security by means of parking rails to which the frame and both wheels may be locked.

Information on the design of both off-street and on-street bicycle parking facilities is contained in Part 11 of the Guide (Austroads 2008b).

Australian Standard AS 2890.3-2015 contains information on bicycle parking.

Bicycle programs

Bicycle programs may address a range of 'hard' infrastructure improvements such as cycle paths or 'soft' improvements such as education, enforcement and encouragement. The objective is to make cycling safer, more convenient and hence an attractive alternative means of transport. Programs generally address issues relating to education, encouragement, enforcement and engineering but these four Es should usually be regarded as interrelated components of the same program, rather than separate programs. For example, as a network of bicycle routes is developed within a city or town (engineering) it will be necessary to:

- promote it through advertising, pamphlets and maps (encouragement)
- teach people who use it how to ride safely and courteously (education)
- insist that all road users obey relevant laws and regulations (enforcement).

Further guidance on engineering, encouragement, education and enforcement bicycle programs can be found in Appendix C.

3.7 Pedestrian Networks

3.7.1 Introduction

In this Part, pedestrians are covered as a generic group but should be taken to include not only people on foot but also people using wheelchairs, and people in or on wheeled recreational devices (rollerblades, roller-skates, skateboards, scooters and the like) or wheeled toys (pedal cars, tricycles and similar). The needs of all who are legally entitled to use pedestrian networks must be considered in the planning, design and management of pedestrian networks.

As outlined in Table 2.3, the users of pedestrian networks value the following elements:

- connectivity and flow (most valued)
- pedestrian safety and personal security (equally most valued)
- health and well being
- supporting facilities

Therefore, the role and management principles of the pedestrian network need to be such that they meet the needs of users. Guidance on the management of pedestrian networks in order to achieve this is discussed further in Section 3.7.2 and Section 3.7.3.

3.7.2 Role

Most trips, whatever the primary transport mode used, begin and/or finish with a walk section and, although walking is the slowest form of transport, it can be the most flexible and it may be the quickest means of making short trips. A key feature of pedestrian demand is the highly random patterns that pedestrian movements demonstrate. The relationships between flow, speed and density are difficult to define in networks. Rapid fluctuations in flow can occur with high peaks existing for very short periods. Pedestrians generally do not confine themselves to specific routes but follow the shortest and most direct path, with minimal effort and travel time between their origin and destination. Thus, footways and footpaths should be aligned as directly as possible between the main trip origins and destinations.

Routes should be planned so as to allow both close and distant views of features of interest. Pedestrians tend to be concerned about personal safety and routes should be developed that will be used by reasonably substantial and predictable flows of people. Dark corners or structures where individuals might not be visible to others should be avoided. A clear and consistent system of naming of streets should be in place, together with guidance to key pedestrian destinations.

The role of the various components of the road network to serve pedestrians is outlined in Table 3.12.

Table 3.12: Role of pedestrian networks

Road class	Movement and place type	Role
Motorways	Designated movement with no place aspects.	No pedestrian access.
Arterial roads	Significant movement with some place aspects.	Provide pedestrian access but not part of the primary pedestrian network.
	Significant movement with significant place aspects.	Primary pedestrian networks.
Distributor / collector roads	Significant movement with significant place aspects.	Primary pedestrian networks.
	Some movement with some place aspects.	Connecting pedestrian networks.
Local roads and streets	Some movement with some place aspects.	Connecting pedestrian networks.
	Some movement with significant place aspects.	Primary pedestrian networks.
Tourist routes	Some movement with significant place aspects.	Primary pedestrian networks.

3.7.3 Management Principles

The pedestrian network needs to be separated from, yet integrated with the main road and public transport systems. This will necessitate regular crossings in order to sustain the coverage and continuity of the network for walking. The measures that can be adopted to facilitate movement will be influenced by functional road hierarchy considerations, such as the access and movement functions of the road.

Note, however, that facilities can also sometimes be shared between pedestrians and other traffic, including motorised traffic. Such facilities include malls and shared zones where all traffic may be permitted but with regulated control over motorised traffic, and shared paths where both cyclists and pedestrians have access.

Pedestrians with special needs

Three categories of pedestrians require special consideration and these are discussed in Table 3.13.

Table 3.13: Pedestrians requiring special consideration

Category	Difficulties	Consideration
Children	Inability to understand consequences, lack of cognitive ability.	Require supervision. Safe routes to school.
Pedestrians with disabilities	Mobility (wheelchairs), vision impaired.	Require access to all pedestrian areas. Need additional infrastructure to provide guidance. Continuity of treatment.
Aged pedestrians	Mobility (low speed, walking frames, wheelchairs), reduced vision, loss of confidence and more easily confused.	Low incline routes. Access to public transport. Personal safety.

All users require an integrated and continuous treatment throughout the pedestrian network, but especially people with disabilities suffering some form of functional loss or mobility impairment.

Hazards encountered by pedestrians

Pedestrians are counted among the more vulnerable road users and care needs to be taken so that unnecessary hazards are not presented to them, including:

- footpaths which constrain movement and visibility due to street furniture and other obstacles
- facilities which are inaccessible or hazardous for use by people with disabilities
- inadequate provisions and safeguards around construction areas
- residential streets without footpaths
- absence of kerb ramps
- traffic signal timings that do not allow adequate time to cross

Walking facilities within and outside of road reserves

The pedestrian transportation network consists of a number of elements:

- footpaths
- elevated walkways and subways
- stairs
- ramps
- escalators
- elevators/lifts
- travelators

All of these elements can be encountered within the road reservation or within off-road zones (such as rail stations or shopping centres) and are exclusively for the use of non-motorised traffic.

Further details on pedestrian facilities within road reserves can be found in Part 5 of the Guide (Austroads 2014a).

4. Network Operation Plan

As there are often competing priorities between transport modes and adjacent land uses a Network Operation Plan (NOP) aims to guide the operation and development of the road/transport network towards managing competing priorities.

While an NOP contains the short-term initiatives and services that guide day-to-day operations, an NOP may also include longer term improvement works that would facilitate or support the day-to-day operation of the network.

An NOP describes the following:

- the intent of the operation of the network, which includes the network operation objectives and the relative priorities of transport modes
- network performance
- network strategies that would guide the implementation of priorities of transport modes and reduction of performance gaps
- plans for the management and operation of the network by time-of-day and day-of-week
- an action plan for the physical improvement of the network
- processes to review and update the NOP

Any network of roads that have operational dependencies on each other can have an NOP. An NOP could be developed for a specific area (e.g. Sydney CBD); a local government area (e.g. City of Yarra); or for a whole city or town (e.g. Adelaide greater metropolitan area).

A short-term (i.e. 1–5 years) planning horizon is recommended for an NOP, and the initiatives are generally operational in nature and scale. Longer term planning horizons (i.e. > 10 years) are used when network improvements requiring major civil works would form part of the NOP.

An NOP is sometimes also referred to as a Plan of Operational Management or the outcome is referred to as Planning for Operations in some jurisdictions.

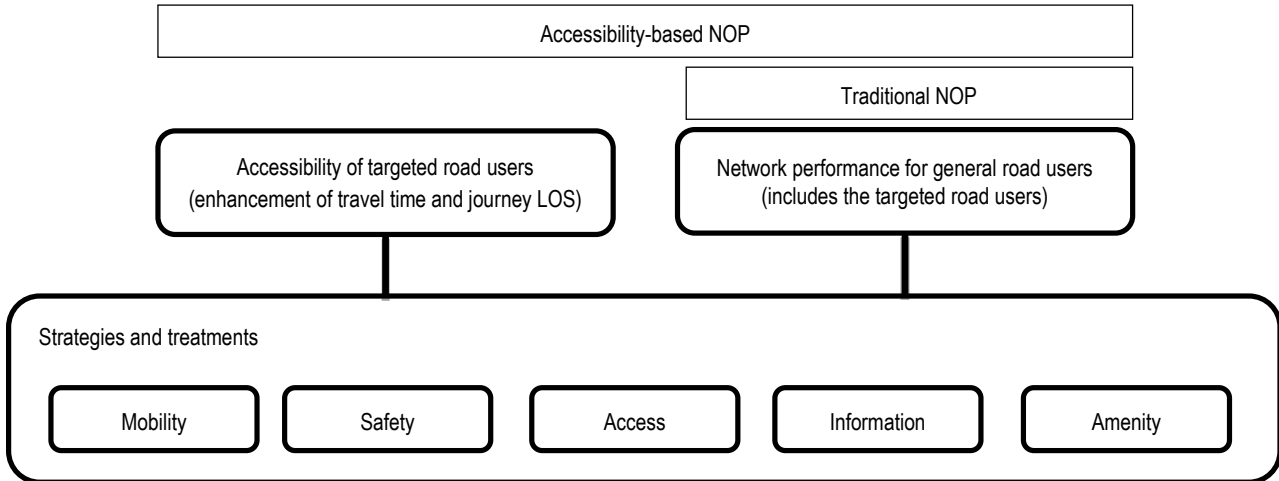
An NOP underpins higher level strategic plans. The key planning principles in an NOP are:

- moving people and goods instead of vehicles
- seeing transport as supporting broader community goals
- balancing the competing demands of various road user groups for limited road space and time
- thinking ‘networks’, rather than corridors, routes, links or nodes
- stakeholder consultation as a key input to the planning process
- collaboration with transport partners (e.g. bus operators, related agencies, etc.)
- providing safer road travel for all road users and moving towards the broader application of the Safe System approach to the road network by reducing the risk of death and serious injury to road users
- operational intent determines the priority, design and scale of network improvement projects
- ‘fit for purpose’ management based on adoption of agreed road use hierarchies and networks

Case examples of NOPs can be found in the Austroads report *The Application of Network Operations Planning Frameworks to Assist with Congestion Management and Integrated Land Use and Transport* (Austroads 2013b). More case examples in Victoria can be found in Bittner, Burdan and Witono (2011), Fitts (2012) and Wall (2011).

Accessibility-based NOP extends traditional NOP by focusing on targeted road users and their journeys rather than on just links. By extending the NOP process to journeys, it looks at travel time and journey LOS in addition to traditional NOP measures such as mobility, safety, access information and amenity. This can be used to inform the development of operational strategies and treatments (Figure 4.1). Safe System principles have a particular influence on the safety NOP measures. Asset management is intertwined throughout all NOP measures as the different measures have different performance LOS elements as outlined in further detail later.

Figure 4.1: Network Operation Plan with consideration of accessibility needs of targeted road users



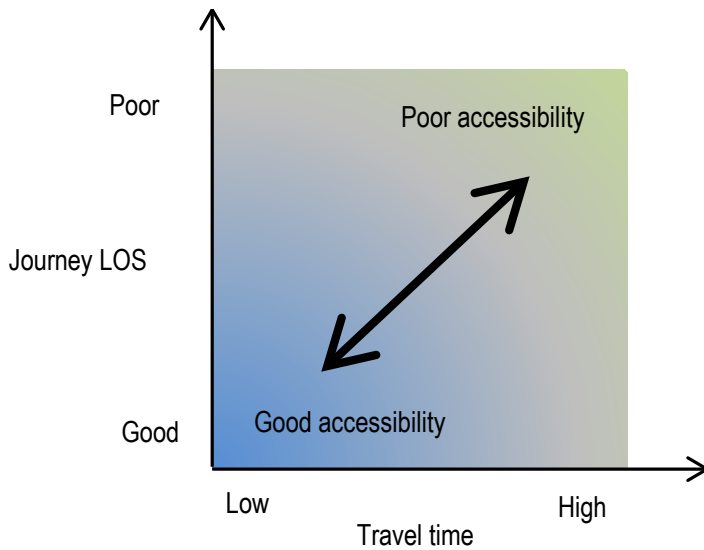
Source: Austroads (2015d).

Consideration of the accessibility of targeted road users requires detailed understanding of their origins, valued destinations, routes, travel time requirements and journey LOS needs. Typical valued-destinations include:

- employment
- schools
- retail and recreation
- health and community services
- freight gateways and distribution centres

The operation of the road network contributes positively to accessibility if the travel times and the LOS of the journey to these destinations are acceptable (Figure 4.2). It is ideal that the operational strategies and treatments aim at improving accessibility of the targeted road users and also support the needs of the general road users. It is possible that operational strategies and treatments that enhance accessibility of the targeted road users will have negative impacts on the general road users. These trade-offs need to be resolved with community and stakeholder participation.

Figure 4.2: Quality of accessibility based on travel time and journey LOS



Source: Austroads (2015d).

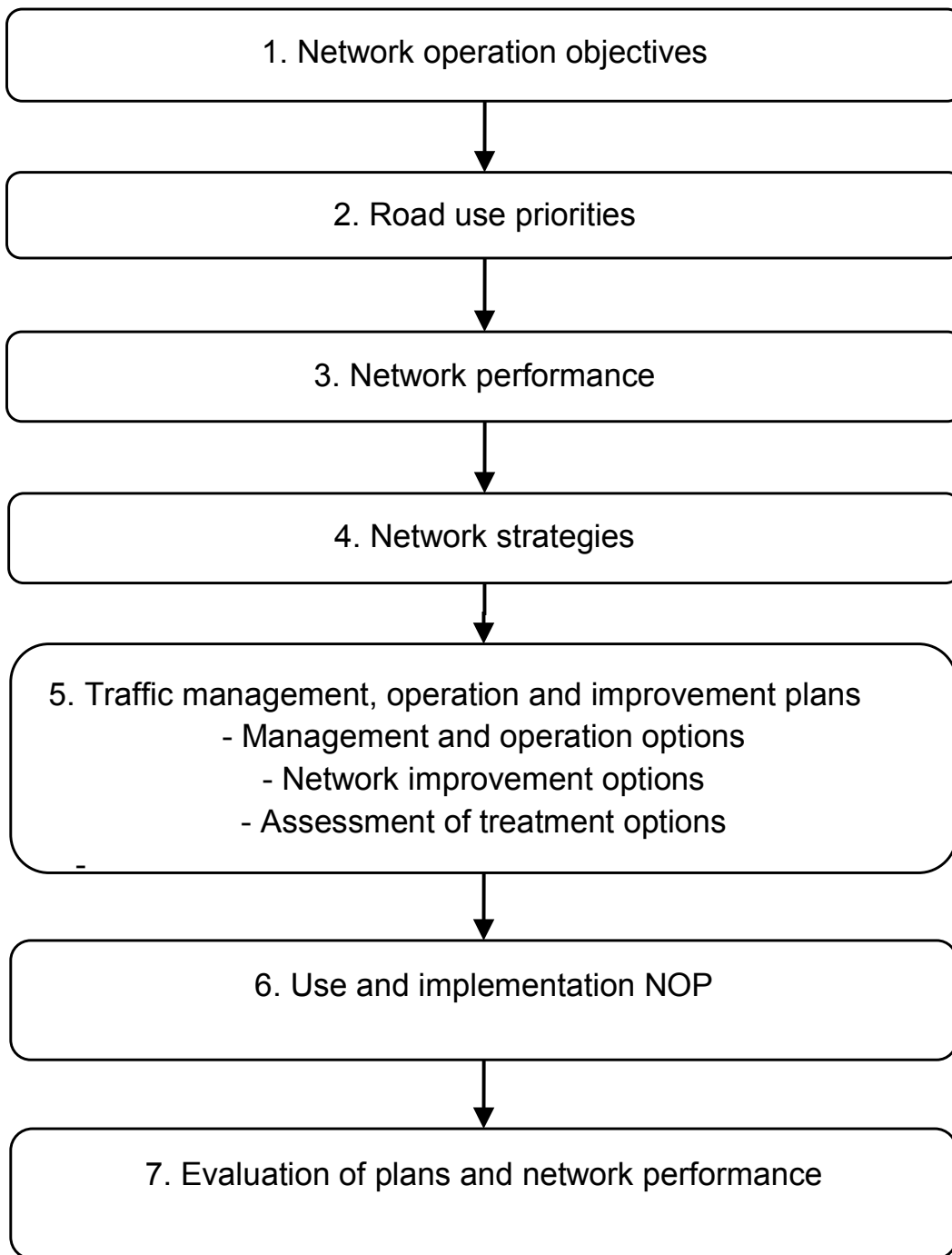
Further details of accessibility-based NOP for consideration of use by road agencies as part of NOP is outlined in Austroads (2015d). This includes defining the accessibility-based NOP framework.

4.1 Network Operation Planning Process

The NOP process can be expressed in seven phases, as shown in Figure 4.3. The process begins with the expression of network operation objectives, which is developed into specific traffic management schemes and civil works. Linkage with network operation objectives is emphasised such that traffic/transport operation schemes and civil works are in line. Collaboration across agencies and stakeholder consultation is integral in the network operation planning process. Elements of the NOP process such as road use priorities and network performance closely align with asset management as discussed in Section 1.3.

A comparative study on examples of NOP processes in Australia can be found in the paper titled, A comparative study of four network operations planning frameworks/guidelines (Weeratunga & Luk 2010).

Figure 4.3: Network operation planning process



Source: Based on the proposed NOP planning framework in Austroads (2013b).

4.2 Network Operation Objectives

The network operation objectives relate to transport outcomes sought by the government and the community. Network operation objectives therefore incorporate the following:

- government policies and objectives
- road user group requirements (all modes)
- traffic and road-based transport productivity targets
- road function
- overall performance of the network

Network operation objectives are reflected in the road type, to facilitate movement and the place type to define the significance of the place as outlined in the Movement and Place Framework discussed in Section 2. The objectives are developed in response to higher level planning documents and are established through stakeholder consultation. The primary network operation objectives relate to the transport function and can include improving travel efficiency and road safety, amongst others. Secondary network operation objectives enable transport to support broader goals, which can include improving aesthetics, amenity and environment, amongst others.

It is useful to elaborate the network operation objectives for each of the various road user groups. Road user groups include the following:

- motorised users (including commuters, business, recreation and tourists using cars and motorcycles)
- transit users (including bus, tram and taxi)
- pedestrians
- cyclists (including commuter, school and recreational cyclists)
- freight transporters (including heavy vehicles and couriers)

Examples of network operation objectives, with an indication as to whether it is a movement or place objective or both, are as follows:

- encourage walking in activity centres (place objective)
- optimise vehicular throughput and reduce delay (movement objective)
- improve freight access to ports for industries (movement objective)
- encourage cycling as an alternative mode for short trips accessing activity centres (place objective)
- give priority to bus services accessing activity centres (primarily a place objective but it is also a movement objective)

Network Operation Planning can aid in implementing the Safe System approach through providing safer roads and roadsides and implementing safer speeds by achieving the following:

- defining roads that suit their function and are in accordance with a broader road hierarchy. For example, through roads are built for travelling long distances (typically at high speed, ideally on a motorway); distributor roads serve districts, regions and suburbs; and local roads allow access to properties
- implement strategies to ensure homogeneous use of the carriageways. For example differences in vehicle speeds, direction of travel and vehicle mass on carriageways should be minimised
- implementing strategies to ensure that roads are predictable for the users. For example the function and rules of a road should be clear to all road users.

This is achieved through NOP by defining the network operation objectives for the various links within the network. Once the objectives are established strategies can be implemented to ensure that there is a move towards safer roads through consideration of the network operation objectives along with balancing road user demands and moving towards broader application of the Safe System approach.

Definitions of measurable performance benchmarks clarify the desired outcomes for the network. Network operation objectives are assigned specific performance metrics and targets. Network performance in network operation planning is quantified for the various road user groups, including metrics for the following:

- mobility (e.g. travel time and travel time reliability)
- safety (e.g. crash rate)
- access (e.g. bus service availability)
- information (e.g. availability of travel time information)
- amenity (e.g. level of aesthetics, security features, etc.)

The choice of metric is to be discussed and agreed upon by stakeholders. A typical approach to performance metrics for network operation planning can be level of service (LOS). LOS is usually defined by a six-bin rating, labelled A to F, similar to the LOS used in traffic studies. The advantage of LOS is that it provides a non-technical language to be applied to the operation of a road network that enables a broad range of stakeholders to be engaged in network operation planning. LOS A and LOS F represent the best conditions and worst conditions, while LOS C could be interpreted as 'acceptable' performance.

Commentary 1 outlines a LOS framework that may be used in network operation planning and in the various steps of implementing a project. For example the LOS framework may be used:

- in high level planning to define the functional requirements of a project (e.g. increase cycle LOS through implementing bicycle priority or increase transit LOS through implementing bus priority). The use of the LOS framework will supplement, rather than replace, the need for use of detailed computer modelling analysis tools to verify the impacts of proposed changes without implementing schemes as part of the design process
- to quickly examine a range of proposed treatments to shortlist for more detailed analysis if needed. This ensures that a broad range of proposals are examined against the full spectrum of road user requirements and network operation objectives
- after the design and even the build, as a checklist, to verify that the functional objectives of the project were met.

The various road user groups perceive LOS differently, and consider LOS based on diverse sets of needs and measures. In a constrained environment, it becomes necessary to trade-off between the needs of the various road user groups, as well as trade-off between the different needs of a particular road user group. As such the LOS framework is comprehensive in order to be sensitive to the trade-offs in performance.

In this respect the LOS needs are defined from the perspective of the road user and are therefore independent of the road class. It should not be expected that a road would achieve good LOS across all needs, but rather balance or trade-off various LOS needs to achieve the operational intent of the network.

The network operation planning process is participatory; hence the LOS measures are intuitive so that they can be broadly understood by the stakeholders involved. The LOS framework enables assessments to be undertaken with or without data collection or surveys through the use of qualitative measures. While, in some cases the descriptions of the measures may be supplemented by quantitative measures, it is the descriptive aspects that resonate best to a broad set of stakeholders, rather than the quantitative aspects of an LOS framework.

Use of the LOS framework along with higher level strategic documents and consultations with stakeholders will aid in a better understanding of what the community considers to be an appropriate level of customer service in managing the road network. This will enable road agencies to be better informed to implement improvements to the management and operation of road networks that better balance the competing demands for road space and functionality. Road agencies should work with stakeholders to establish agreed and realistically achievable LOS targets, as defined by the LOS framework for the various links within the road network and for the various road users and LOS measures.

4.3 Road Use Priorities

Developed through the application of the Movement and Place Framework and based on the network operation objectives, priorities around the use of the roads are developed for the various road users for each link and node in the network (Figure 4.4). These priorities need to recognise existing functional road hierarchies and road management arrangements. The road use priorities can be shown as a map which is sometimes referred to as a road use priority map or road use hierarchy map in some jurisdictions.

It is often the case that the requirements of the various road user groups could not be accommodated due to limited road space. The road use priorities differentiate the role of the links and nodes in the network such that they identify the most important road user group to focus operation of the particular links and nodes. Allocating road use priorities to different routes or areas, and by time-of-day or day-of-week, enables the network to operate efficiently in support of the network operation objectives. The priorities accorded to road user groups are developed in the context of the network operation objectives, which accounts for various policy directives, and is undertaken in consultation with stakeholders.

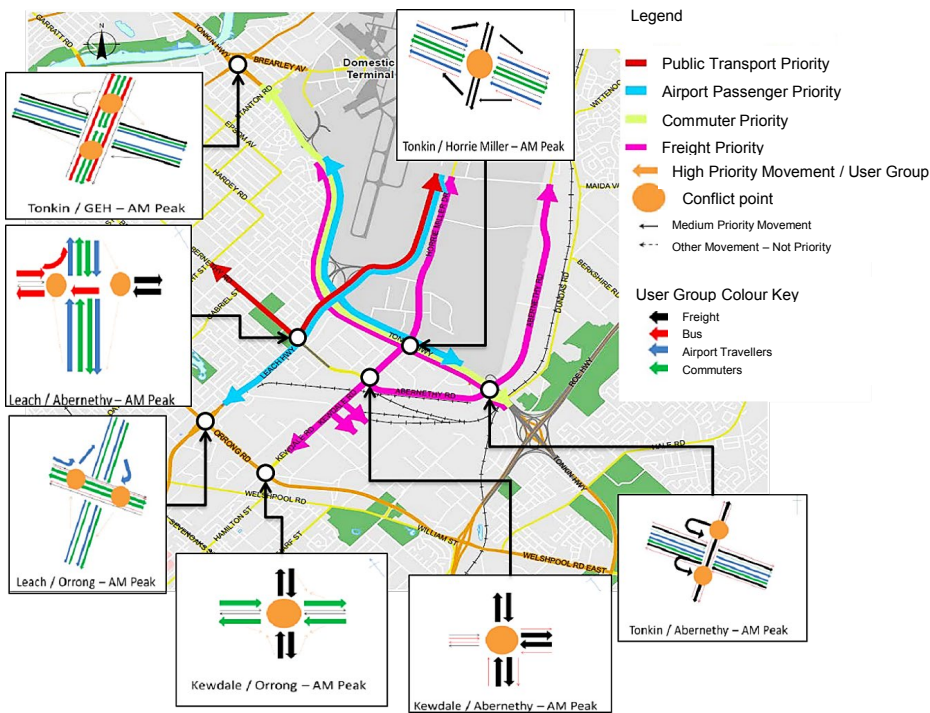
It can be useful to develop the road use priorities at two levels. The first level provides a simple, high level view of the strategic priorities on a road network. This can be shown as a map illustrating the most important road users on each link without reference to time and day. This high-level view is often used as an engagement tool with stakeholders, the community or non-technical groups. The second level is time-of-day and day-of-week road use priorities. These priorities differentiate direction of movement (e.g. inbound movements are given higher priority during the morning peak). Typically, road user group priorities are set for the following time periods:

- morning peak period
- business peak period
- afternoon peak period
- off-peak
- weekend peak periods.

The development of road use priorities should ideally aim to segregate priority modes onto separate links or different time periods. Where there are conflicting movement priorities in the same time period, then the relative importance of each road user group should be identified.

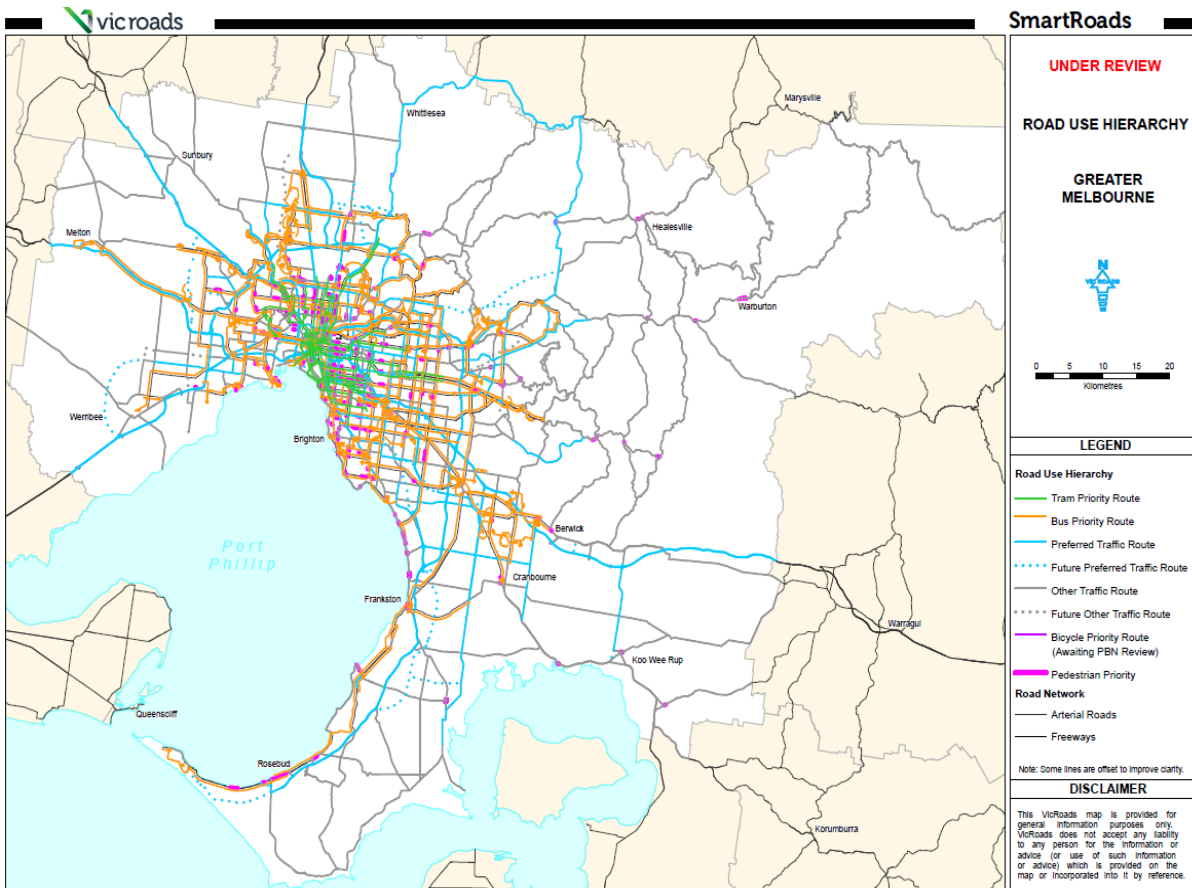
The high-level road use priorities can often be developed for much broader road networks due to the simpler nature of these priorities, for example see Figure 4.5. The second level time-based priorities can then be developed individually for sub-areas of the broader network.

Figure 4.4: Road user priority map showing AM peak priority



Source: Gateway Vision (2012a and 2012b).

Figure 4.5: Metropolitan road use priority map



Source: VicRoads (2008).

4.4 Network Performance

A performance gap is the difference between the baseline and target performance metric. Performance gaps are calculated for individual links and road user groups, and can be used to help identify problem areas or prioritise investment decisions.

Performance assessment is conducted under existing and future conditions. Assessment of existing conditions helps to identify immediate problems. Changes in demand and network configuration in the future can affect network performance; hence, network performance assessment under future conditions is useful given the lead times involved in securing funding and approvals for projects. Network performance assessment based on a five-year planning horizon with a sensitivity check for ten years is reasonable.

Traditional network performance gaps can be quantified by weighting the metric by the number of people being moved or the value of goods being transported, as well as the priority assigned to that road user group. By using LOS as a metric, the performance gaps for mobility, safety, access, information and amenity could be compared and aggregated within, as well as, across different user groups. The gap analysis for accessibility based NOP as defined in Austroads (2015d) is modal based and therefore not weighted across transport modes.

The performance gaps identify the general location of operational problems, the time and day they occur, and the road user groups that are most impacted. The nature of the problems then needs to be understood to guide the succeeding network operation planning phases. It is useful to examine the nature of problems broadly by examining the performance gaps in relation to:

- low mobility
- safety concerns
- limited or lack of access
- unavailable or inadequate traveller information
- limited or lack of amenity

It is useful to analyse gaps at the network level, by aggregating LOS and performance gaps of links and nodes. A network-level LOS and gap analysis allows performance trade-offs to be better understood across the network and a network-wide optima can be pursued.

4.5 Network Strategies

The road use priorities indicate the relative level of encouragement that should be given to each road user group by time and day. The performance gaps highlight where and when emphasis should be given to these priorities. To provide guidance on how these priorities should be implemented, network strategies are devised.

Network strategies provide guidance in developing traffic management, operation and infrastructure solutions. They do not specify particular solutions at this stage of the NOP process. This allows traffic, transport and planning professionals to be creative, innovative and responsive in developing ideas and solutions. Because network strategies indicate how the network needs to operate, rather than outlining detailed treatments, there is scope for different options to be identified to achieve the agreed objectives for the network. Network strategies need to consider each of the following outcome areas, particularly in outcome areas that have been identified as problematic:

- strategies that address problems of low mobility
- strategies to reduce safety concerns
- strategies that enhance access
- strategies to provide sufficient, timely and relevant traveller information
- strategies to improve amenity.

Strategies could include:

- restricting traffic flow from one part of a road network to another
- maximising traffic flow through particular corridors
- encouraging road users to make alternative route choices
- smoothing traffic flow
- encouraging mode shift.

Network strategies may be applied to areas, corridors, routes or control points in a road network. Defining homogeneous sub-networks can be a useful way of breaking larger road networks down into manageable areas for the development of strategies.

4.6 Development of Traffic Management, Operation and Improvement Plans

The NOP contains initiatives to manage the operation of the network. These include operational treatments and infrastructure projects that support the network operation objectives. It is important that network strategies (described in Section 4.5) are established prior to determining options/solutions. Having an agreed network strategy as the context of identifying options/solutions, facilitates understanding and consensus building amongst stakeholders. The emphasis of NOP is then on operational treatments with infrastructure projects supporting or facilitating the various operational treatments.

4.6.1 Traffic Management and Operation Options

The network strategies are used as the basis to identify traffic management and operation options. Examples of traffic management and operation options to meet network strategies are in Table 4.1. These traffic management and operation options are assessed, and the set of options with the best-fit and best value-for-money is included in the NOP.

Table 4.1: Examples of management and operation options for network strategies

Network strategy (examples)	Management and operation options (examples)
Restricting flow from one part of a road network to another	<ul style="list-style-type: none"> • Gating by signal control • Traffic calming techniques.
Maximising traffic flow through particular corridors	<ul style="list-style-type: none"> • Operation of traffic signals and the use of other intelligent transport systems (ITS) (see example in Figure 4.6) • Improved freeway management (e.g. ramp metering, speed management through variable speed limits).
Encouraging road users to make alternative route choices	<ul style="list-style-type: none"> • Information provided to road users on options • Pricing (e.g. congestion pricing).
Smoothing traffic flow	<ul style="list-style-type: none"> • Control of access onto the road network from abutting land • Incident, roadwork and event management.
Encouraging mode shift	<ul style="list-style-type: none"> • Allocation of road space through management of traffic lanes, and parking (see examples in Figure 4.7 and Figure 4.8) • Transit improvements.

Figure 4.6: Signal operation plan for a region



Source: VicRoads (2008).

Figure 4.7: Lane management plan for a region



Source: VicRoads (2008).

Figure 4.8: Parking management plan for a region



Source: VicRoads (2008).

4.6.2 Network Improvement Options

The network improvement options include infrastructure or build treatments (e.g. intersection modification, new links, pedestrian bridges, new transit service, etc.) that support the operational intent of the network. Options are developed based on the network strategies, and to facilitate and support the proposed traffic management and operation options. Projects that have already been proposed, planned and committed are also considered as options, including potential redesign of these projects to make them better suited to support or facilitate proposed management and operation options.

4.6.3 Assessing Treatment Options

The traffic management and operation options and network improvement options are assessed. The assessment of these options can be done in at least two ways. First is a 'network fit assessment', and the second is a benefit-cost analysis.

In the case of a network fit assessment, the impacts of treatments (either projects or operational services) on performance gaps are assessed, typically through expert panel judgment. Traffic and transport modelling is applied if resources are available and if a more detailed assessment is desired to give greater confidence in the outcome. Treatments are labelled based on their impact on performance gaps, which could be positive or negative. An example is the VicRoads methodology, shown in Table 4.2, for categorising project impacts based on the potential change in LOS levels. If there is uncertainty in the assessment of project impacts, then low-end, likely and high-end estimates are useful to indicate the range of possible impacts. It is important to examine both the primary and secondary impacts of treatments. Primary impacts are impacts in the immediate vicinity of the treatment, while secondary impacts are impacts on other parts of the network. Treatment options that reduce the most performance gaps across all road user groups are given a higher rank in being adopted and implemented. Figure 4.9 is an example of an assessment of mobility impact based on the VicRoads methodology.

Table 4.2: VicRoads methodology for labelling project impacts

Impact label	Description
High positive (H+)	Improvement by 2 or more LOS levels
Medium positive (M+)	Improvement by 1 LOS level
Low positive (L+)	Improvement by less than 1 LOS level
Very low positive (VL+)	Improvement by less than 1/3 LOS level
None (N)	No or minimal change
Very low negative (VL-)	Worsening by less than 1/3 LOS level
Low negative (L-)	Worsening by less than 1 LOS level
Medium negative (M-)	Worsening by 1 LOS level
High negative (H-)	Worsening by 2 or more LOS levels

Source: VicRoads (personal communication 2015).

Cost of implementation is considered in the comparison and selection of treatment options in a multi-criteria analysis of cost and impacts on performance gaps. Typically, network operation planning covers only traffic engineering measures and minor civil works; hence, project cost tends to be low and may not be a major factor. If project cost is high, then a benefit-cost analysis is warranted.

Network fit assessment is useful to quickly screen the traffic management and operation options and network improvement options to work out which treatments are viable. In some simpler situations, network fit assessment is sufficient to identify the best set of treatments to include as part of the NOP. Performance gaps that have not been addressed or that have been insufficiently addressed can also be identified as part of a network fit assessment and additional traffic management and operation options or network improvement options can be proposed.

In some cases, the costs of implementing the various options are high enough to be a factor in evaluating the best set of options to include in the NOP. This is particularly the case in the treatments that involve civil works. In these cases, benefit-cost analysis is useful to gauge the viability of projects and rank them based on value-for-money. Options with good benefit-cost ratios are given a higher rank when selecting treatments to include in the NOP. Benefit-cost analysis also facilitates the selection of the best set of treatments under a given budget constraint.

Guidance for identification and assessment of signal management options is provided in the *Guide to Traffic Management Part 9: Traffic Operations* (Austroads 2014b).

4.7 Use and Implementation of the NOP

The NOP guides the operational services and activities that relate to the day-to-day management of the road network. The NOP may also include a prioritised list of projects that can be implemented through project-based programs.

The NOP can also be used to guide general decision-making on a range of operational, customer, project proposal, planning, and policy issues. Decisions that are likely to impact the operation of the network can be tested against the NOP to determine the extent to which a possible response will support (or otherwise) the operational objectives of the NOP.

Figure 4.9: VicRoads network fit assessment output

Network Fit	Criteria	Example
Good network fit	The total worst and best cases are both positive values and the difference between the two cases is less than the worst case value (e.g. +3 to +5 has a difference of 2 which is less than the worst case value of 3).	<p>Level 2, AM Peak Option 2 - Good Fit</p>
Positive network fit	The total worst and best case are both positive values and the difference between the two cases is greater than or equal to the worst case value (e.g. +1 to +3 has a difference of 2 which is greater than the worst case value of 1).	<p>Level 2, AM Peak Option 2 - Positive Fit</p>
Neutral network fit	The total worst case value is negative and the best case value has a higher absolute value (e.g. -3 to +4); i.e. the midpoint of the range is positive.	<p>Level 2, AM Peak Option 2 - Neutral Fit</p>
Negative network fit	The total worst case value is negative and the best case value has a lower absolute value (e.g. -5 to +1 or -7 to -4); i.e. the midpoint of the range is negative.	<p>Level 2, AM Peak Option 2 - Negative Fit</p>

Source: VicRoads (personal communication 2016).

4.8 Evaluation and Feedback

Post-implementation of the NOP should be conducted. The review of implemented treatments checks how they have contributed to reducing the performance gaps.

The network operation objectives and the road use priorities should also be reviewed, as community and government values can change over time. Based on the review, the NOP may need to be revised.

4.9 Use of Network Operation Plans for Designing for Operations

Part 2 of Austroads *Guide to Road Design* (Austroads 2008–15) identified context sensitive design (CSD) as an approach that provides flexibility to encourage independent designs tailored to particular situations.

CSD seeks to produce a design that combines good engineering practice in harmony with the natural and built environment, while meeting the required constraints and parameters for the project.

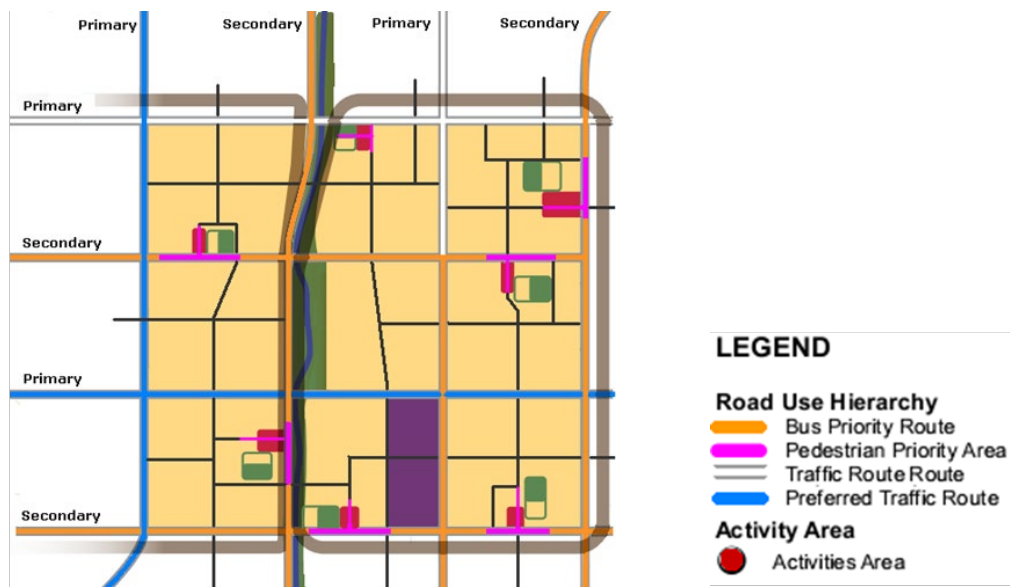
Network operation planning may be used as an aid to road design by outlining the context in which the road should be designed (i.e. context sensitive design). In addition, by enabling road designers to have an understanding of the operational strategies likely to be implemented on the road, it enables road designers to design the road according to the road’s proposed operational strategy.

As Network Operation Plans describe the operational objectives, strategies, road-use priorities and treatments for the network, the development of an aspirational NOP prior to design assists in defining the operational requirements which are incorporated in roadway design. Interaction of designers and stakeholders of the NOP throughout project development facilitates designing for operation.

An example of an aspirational road-use hierarchy plan of a planned development area is shown in Figure 4.10. The Figure highlights the road use hierarchy used to support the activity centres (shown in the red). For example the key bus priority routes are shown in beige, the key pedestrian priority routes are shown in purple, while the preferred traffic routes are shown in blue.

The aspirational road-use hierarchy plan can be further developed, wherein stakeholders can agree on the corresponding operational treatments that will be applied to the network. Further discussion with respect to the impact of ITS operations (in the context of network operation planning) on road design is contained in *Austroads Guide to Road Design Part 2: Design Considerations* (2008–15).

Figure 4.10: Aspirational road use hierarchy for planned network development



Source: VicRoads (personal communication 2015).

The advantages of incorporating NOP into traditional design processes include:

- increasing the benefits derived from a given investment
- designing a better facility to respond to incidents and roadworks
- reducing the cost of future deployment of ITS
- improving effectiveness of operational schemes.

Further discussion with respect to network operation planning and design is contained in Part 2 of Austroads *Guide to Road Design* (2008–15).

4.10 Use of Network Operation Plans in Asset Management

Network Operation Planning can be used in asset management through application of Reliability-Centred, Maintenance (RCM) strategies. A general principle underlying RCM is to adopt a systematic approach and focus on managing the consequences of failure rather than the failures themselves. RCM also aims to direct attention to high consequence failures even if they occur infrequently.

NOP can aid in the application of RCM through designating the road use priorities for each route. Once the priority is identified, the criticality of a failure of a road asset can be determined based on the asset itself and the priority of the route. Other factors such as volumes and road type can also be considered to determine the criticality of an asset failure.

Once the criticality of an asset failure is known, maintenance regimes can be put in place to focus effort on critical assets rather than treating all likeminded assets as equal. This can then minimise the impact on priority routes and key road network locations, therefore minimising the impact on road users. Appendix D provides an overview of a VicRoads approach to the use of the above concept for the maintenance of traffic signals.

4.11 Benefits of Network Operation Plans

Planning processes of the type exemplified in the preceding sections assist in the development of network improvements and network operation initiatives in line with movement and place objectives of the road network and consistent with higher level strategic objectives. They optimise the user benefits of efficiency, safety, reliability and productivity sought by each user group.

They also have the following additional benefits for network managers:

- assurance that the network is being managed in a way that addresses strategic objectives
- improved consistency and transparency around responses to community and stakeholder issues concerning traffic operation
- improved consistency between practitioners
- ability to foster consistent management plans across administrative boundaries
- more proactive approach and effective operation of the road network
- more effective infrastructure investment decisions
- potentially reduced or deferred need for major capital investment
- a strategic context and objective basis for the assignment of access management policies to roads
- clear guidance to traffic signal engineers and others on configuring the signal system
- a tool to guide discussions with other stakeholders
- a holistic basis for a review of the networks for specific modes to more efficiently and safely cater for their particular needs in the light of all other modes
- provides guidance for approving plans for maintenance work and other events
- by developing the plans in a GIS format, they can be 'living' documents, fully accessible to agency staff and relevant stakeholders through a browser.

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Appendix A SmartRoads Tool

The SmartRoads tool was originally developed by VicRoads to assist in the application of network operation planning. The tool:

- provides an interactive planning environment to visualise road use priorities, operation gaps and impacts of treatments
- facilitates the consistent application of the network operation planning framework including jurisdiction-specific specifications and standards
- assesses road network operations improvement opportunities for general traffic, buses, freight vehicles and active transport
- creates tables, figures and reports to support recommended improvements to the network.

The SmartRoads tool is being increasingly adopted by jurisdictions as the basis for network operation planning. As SmartRoads gets applied in more varied contexts and as the application of network operation planning becomes more sophisticated, a need has been identified to develop the next generation tool. Austroads project NS2003 will develop the business case and specification for the next generation NOP tool. Austroads project NS2003 will also support the application of the current SmartRoads tool, including upgrades and technical support.

A.1 Accessing the Tool

The SmartRoads tool can be downloaded and used for free. The tool requires a configuration file, which defines weightings, priorities, occupancy factors, etc. Currently there are two pre-defined configuration files available, one developed by VicRoads and another developed for NZTA. Users are free to define and design their own configuration file. Users can download either configuration file and modify the configuration file to suit.

Currently there are two versions available, version 6.2.6 and 7.1.3. Version 6.2.6 was developed by VicRoads. Subsequent to this version, ARRB developed version 7.1.3 to enhance the interface of version 6.2.6 with GIS tools. The purpose of version 7.1.3 was to facilitate the use of GIS tools to create/edit networks and to allow users to export analysis outputs. The methodology and formulas in version 6.2.6 and version 7.1.3 are the same. Users of version 7.1.3 are suggested to review the version 6.2.6 user manual to understand the method and formulas used.

Both versions of the tool are available through the Austroads website at the following link:

<https://austroads.com.au/network-operations/network-management/smartroads-tool>.

Appendix B Categories and Characteristics of Cyclists and Their Type of Trips

This Appendix contains two tables. The first describes cyclist types and their characteristics and riding environments. The second describes the various cycling trips and their characteristics.

Table B 1: Categories of cyclist experience levels and their characteristics

Rider level	Examples	Characteristics	Suitable infrastructure
Immature	<ul style="list-style-type: none"> Primary school student 	Cognitive skills not developed. Little or no understanding of road rules. Requires supervision.	Separation from motor vehicles is more important than speed. <ul style="list-style-type: none"> shared paths and separated paths footpaths (where permitted).
Novice	<ul style="list-style-type: none"> Secondary school student Beginner adult rider 	Skills are basic. Will seek separation from motor vehicles. Desire off-road paths, but can manage occasional crossing of roads with varying traffic conditions.	Separation from motor vehicles is more important than speed. <ul style="list-style-type: none"> shared paths and separated paths footpaths (where permitted).
Intermediate	<ul style="list-style-type: none"> Advanced secondary school student Average adult rider 	May seek separation from motor vehicles or may be comfortable in mixed traffic environments.	Separation from motor vehicles or speed may be important to different riders. <ul style="list-style-type: none"> shared traffic (low speed/volume) bicycle lanes separated bicycle paths.
Advanced	<ul style="list-style-type: none"> Experienced commuter Experienced sports rider Experienced touring rider 	Less affected by motor vehicle traffic and will sometimes avoid off-road paths where their travel speed may be reduced. Riders are able to share lanes with vehicles, although are likely to prefer to have dedicated space. Although they may prefer to ride on non-congested roads which can enable undisrupted or minimally disrupted cycling (e.g. long links without traffic signals such as non-metropolitan and/or rural roads) they may be prepared to ride on non-preferred roads (e.g. heavily trafficked routes) to get to their preferred route. Facilities should be designed and well maintained to facilitate reasonable and high riding speed.	Speed is more important than separation from motor vehicles. <ul style="list-style-type: none"> shared traffic bicycle lanes sealed shoulders.

Table B 2: Cycling trip types and their characteristics

Purpose	Function	Definition	Characteristics
Commuting	Transport	A regular trip made to a place of work or study.	<ul style="list-style-type: none"> • Most trips are under 10 km with few over 20 km. • Skill levels vary from novice primary school riders to experienced road riders. • Commuter trips are generally made alone or in small groups. • Riders may be carrying bags with clothes, laptops etc. • Riders may carry repair kits. • All-day secure bicycle parking is required. • Shower and change facilities are often required. • Trips may be combined with a public transport trip to extend the range of the trip.
Utility	Transport	A trip made to a particular destination such as a shop, restaurant, friend's house etc.	<ul style="list-style-type: none"> • Most trips are under 5 km with very few over 10 km. • Skill levels vary from a novice primary school student to an experienced road rider. • Utility trips are generally made alone or in small groups. • Riders may be carrying bags with shopping, clothes etc. • Riders are less likely to carry repair equipment. • Short-term bicycle parking is required. • Shower and change facilities are not required. • Trips may be combined with a public transport trip to extend the range of the trip.
Training	Recreation	A trip that does not serve a transport purpose and is primarily taken to provide high-intensity training.	<ul style="list-style-type: none"> • Training trips are usually over longer distances, sometimes more than 100 km. • Training trips may be taken as an individual rider or in groups known as 'pelotons', where riders tend to ride two-abreast and in multiple rows. Pelotons seek to remain visible and predictable to other road users by placing the group in the centre of travel lanes, particularly if no appropriate road shoulder is available. • Training riders usually carry a repair kit but do not tend to carry a bicycle lock. They tend not to use bicycle parking facilities. • Training riders tend to be more advanced riders but can also be younger or inexperienced.
Touring	Transport Recreation	A ride that is conducted over more than one day and has a tourism function.	<ul style="list-style-type: none"> • Most trips are over 20 km with some over 100 km (per day). • Rider skill levels are usually intermediate to advanced. • Bicycles are often laden with luggage to allow multi-day travel. • Riders will almost always carry a repair kit. • Overnight bicycle parking is required at the accommodation. • Shower and change facilities are required at the accommodation. • Trips may include public transport trips at the start and end or to avoid sections of the route that are impassable by bicycle.
Recreation	Recreation	A ride that does not serve a transport function (no destination) but is not used for high-intensity training (e.g. Sports riding).	<ul style="list-style-type: none"> • Trip length may vary greatly depending on the level of experience of the rider. • Skill levels vary from a novice primary school student to an experienced road rider. • Riders may or may not carry repair equipment. • Short-term bicycle parking is sometimes required. • Shower and change facilities are not required. • Trips may include a car or public transport trip at one or both ends to allow riders to ride in a preferred location.

Appendix C Bicycle Programs

As outlined in Section 3.6.3 of GTM 4 in order to make cycling safer, more convenient and hence an attractive means of transport, bicycle programs across engineering, encouragement, education and enforcement need to be undertaken. Further details on these are outlined below.

C.1 Engineering programs

Development of comprehensive engineering programs to provide networks, continuous routes, safer and smoother roads and paths is critical in order to cater for and encourage cycling. In addition to providing en-route cycling infrastructure, provision of adequate end-of-trip facilities such as showers and secure parking is also important in order to make cycling an attractive form of everyday transport (e.g. commuter transport).

An example of a bicycle network evaluation can be found in the Austroads *Guide to Project Evaluation Part 8: Examples* (Austroads 2006).

C.2 Encouragement programs

A major objective of bicycle programs is to achieve increased levels of community participation in cycling for both transportation and recreation. Initiatives to encourage cycling may include:

- ongoing promotion of the environmental, recreational and health benefits of cycling to the individual and community
- promotion of the opportunities of using the bicycle for recreation, tourism, commuting, social and practical purposes
- development of systems, fare structures and other conditions to make multi-modal travel (e.g. bicycle/train) attractive
- individualised marketing campaigns such as travel demand management programs
- the organisation of special bicycle rides and other events such as national conferences
- provision of a comprehensive set of education programs
- introduction of 'change time' to allow employees to book a certain amount of time to shower and change when commuting using a bicycle
- provision of information, maps and signs to guide cyclists to appropriate routes and facilities.

C.3 Education programs

Initiatives relating to the education of the community regarding cycling may include:

- bicycle riding education programs in primary schools
- bicycle riding education programs in secondary schools including development of on-road skills
- courses for inexperienced adult cyclists
- development of a cyclist code of behaviour
- ongoing education of motorists and cyclists to better understand each other's needs
- media campaigns on critical issues.

C.4 Enforcement programs

Bicycles are defined as vehicles under road traffic regulations and cyclists are therefore required to comply with the law. Further, enforcement programs and enforcement agencies should aim to achieve compliance through education and encouragement rather than by applying penalties alone. Examples of education and encouragement programs include:

- seminars to educate police in the role they can play in bicycle strategies and plans to improve cycle safety
- ongoing media promotion of laws, responsible and defensive riding, etc.
- promotion of safer cycling by personal contact with young and adolescent cyclists
- development of police patrols on bicycles in inner city areas and on busy paths
- special promotional campaigns with rewards for safer cycling (e.g. raffle of cycling goods)
- a police-in-schools program as part of general traffic safety education, including bicycle safety checks and basic road law.

Appendix D Example of the Use of NOP in Asset Management – VicRoads Traffic Signals

VicRoads outsources asset management of its traffic signals to contractors. The contractor must develop maintenance plans to ensure public safety, minimise the rate of deterioration of assets, sustain functional requirements and understand the requirements of road users.

Contact administration is based on Key Performance Indicators (KPIs) and Key Result Areas (KRAs), whereby payment to contractors is proportional to the target achieved which takes into consideration factors such as the duration and frequency of faults in addition to the criticality of the asset.

The criticality of each asset is decided by a weighted score, which takes into consideration the aspects listed in Table D 1. The highest weighting is assigned to priority routes, with the highest priority given to public transport and emergency services. NOP is used to ascertain priority of each route so that the asset management strategy can be applied across the road network.

Table D 1: Weighting of aspects considered in site criticality

Aspect	Classification	Weight	Score
Asset Type	INT	20	10
	POS		5
	Speed Sign		5
	Ambulance Signal		5
	Fire Signal		5
	Other		3
Road Type	Freeway	10	10
	Major Highway		7
	Main Road		4
	Local		2
	Other		2
Priority Routes	PTFN	30	10
	PPTN		10
	Bus Priority		5
	Tram Priority		5
	Preferred TR		10
	Emergency Routes		10
Features	DoJ Camera	10	10
	Railway Connection		10
Vehicle Volumes (/day)	< 5 000	20	1
	< 10 000		2
	< 25 000		4
	< 50 000		6
	< 100 000		8
	< 1 000 000		10
Pedestrian Volumes (/day)	< 100	10	2
	< 500		4
	< 1 000		6
	< 10 000		8
	> 10 000		10

Source: VicRoads (2015).

Commentary 1

This commentary presents the LOS framework defined as part of Austroads project NT1788 (Austroads 2015c). The LOS framework allows users to make an assessment of various LOS measures of five road users (private motorist, transit users, pedestrians, cyclists and freight operators) and across five needs (mobility, safety, access, information and amenity).

The LOS assessment is undertaken for the scenario of without the proposed works and then a hypothetical assessment of the scenario with the proposed works. The user uses the LOS framework to determine which of the six LOS levels is assigned for each measure for both scenarios. Completion of the LOS framework allows the user to understand the LOS measurements of various measures and then to understand the LOS trade-offs of either scenario.

While the LOS framework follows a step-function approach of six LOS levels the framework permits the use of sub-levels in between LOS levels (e.g. LOS B+ or LOS B++, in practice).

The LOS framework utilises objective and subjective measures as follows:

- Objective measures (e.g. 50 to 67% of free flow operating speed) were utilised where suitable information is readily available in existing LOS frameworks. Objective measures (e.g. possibility for a maximum of 25% increase in travel time) were also established in cases where the panel of reviewers suggested and agreed to specific estimates.
- Subjective measures (e.g. good wheelchair access and meets Disability Discrimination Act (DDA) requirements) were used in cases where no suitable objective measure can be determined or agreed upon by the panel of reviewers. In network operation planning, the LOS assessment is reviewed and agreed by planners and stakeholders. The reasons and justifications of subjective LOS assessments are documented and well-understood by the planners and the stakeholders.

The LOS framework is outlined in Table C1 1.

Table C1 1: LOS framework and worksheet for network operation planning

Road user	LOS needs	LOS measure	Rating	Service measure values
Private motorists	Mobility	Congestion	A	<ul style="list-style-type: none"> For motorways a condition of free-flow in which drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high, and the general level of comfort and convenience provided is excellent⁽¹⁾. For arterial roads generally free flow conditions with operating speeds at least 80% of the free flow speed. Vehicles are unimpeded in manoeuvring in the traffic stream and delay at intersections is minimal.
			B	<ul style="list-style-type: none"> For motorways a condition of stable flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is a little less than with level of service A⁽¹⁾. For arterial roads relatively unimpeded flow with operating speeds between 50–80% of the free flow speed. Manoeuvring in the traffic stream is only slightly restricted and intersection delays are low.
			C	<ul style="list-style-type: none"> For motorways a condition of stable flow, but where most drivers are restricted to some extent in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience declines noticeably at this level⁽¹⁾. For arterial roads stable operating conditions but with manoeuvring becoming more restricted and motorists experiencing appreciable tension in driving. Operating speeds are between 30–50% of the free flow speed. At signalised intersections, vehicles generally have to stop in a queue but clear the intersection in one signal cycle.
			D	<ul style="list-style-type: none"> For motorways a condition that is close to the limit of stable flow and approaching unstable flow. All drivers are severely restricted in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is poor, and small increases in traffic flow will generally cause operational problems⁽¹⁾. For arterial roads small increases in traffic volumes can significantly increase delay. Operating speeds are between 20–30% of the free flow speed. At signalised intersections, vehicles always join the back of an existing queue and take about two signal cycles to clear the intersection.
			E	<ul style="list-style-type: none"> For motorways a condition where traffic volumes are at or close to capacity, and there is virtually no freedom to select desired speeds or to manoeuvre within the traffic stream. Flow is unstable and minor disturbances within the traffic stream will cause breakdown⁽¹⁾. For arterial roads conditions are characterised by significant delays with operating speeds between 10–20% of the free flow speed. At signalised intersections, vehicles take three or more signal cycles to clear the intersection⁽¹⁾.
			F	<ul style="list-style-type: none"> For motorways a condition of forced flow, where the amount of traffic approaching the point under consideration exceeds that which can pass it. Flow breakdown occurs, and queuing and delays result⁽¹⁾. For arterial roads traffic flow at this level is at very low speeds (less than 10% of the free flow speed). At signalised intersections, vehicles can take three or more signal cycles to clear the intersection and backups from downstream significantly impact traffic flow.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.

Road user	LOS needs	LOS measure	Rating	Service measure values
Private motorists (continued)	Mobility (continued)	Travel time reliability	A	<ul style="list-style-type: none"> Travel time is nearly always the same.
			B	<ul style="list-style-type: none"> Travel may possibly encounter unexpected delays but there is no need to adjust expected travel time for time sensitive journeys.
			C	<ul style="list-style-type: none"> Travel is likely to encounter unexpected delays and there is a possibility for a maximum of 25% increase in travel time.
			D	<ul style="list-style-type: none"> Travel is likely to encounter unexpected delays and there is a possibility for a maximum of 50% increase in travel time.
			E	<ul style="list-style-type: none"> Travel is likely to encounter unexpected delays and there is a possibility for a maximum of 75% increase in travel time.
			F	<ul style="list-style-type: none"> Travel is likely to encounter unexpected delays and there is a possibility for a greater than 75% increase in travel time.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Travel speed	A	<ul style="list-style-type: none"> High travel speeds of over 80 km/h.
			B	<ul style="list-style-type: none"> Medium to high travel speeds of 70 to 80 km/h.
			C	<ul style="list-style-type: none"> Medium travel speeds of 60 to 70 km/h.
			D	<ul style="list-style-type: none"> Low to medium travel speeds of 50 to 60 km/h.
			E	<ul style="list-style-type: none"> Low speeds of 40 to 50 km/h.
	F	<ul style="list-style-type: none"> Very low speeds of less than 40 km/h. 		
	N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
	Safety	Crash risk	A	<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> road design appropriate for the intended and actual road use and speed environment minimal instances of conflict. Conflict refers to times where vehicles can potentially collide with another vehicle, pedestrian or cyclist. Conflicts can be mitigated, for example, by grade separation, divided roads, separating movements, controlling movements through signalisation or restricting direct access. There are also low instances of conflict in low congestion conditions forgiving road environment relative to the speed environment (i.e. in case of a crash or potential crash there is limited risk or there is sufficient protection against serious injury or death). Examples of rural road features that could achieve a LOS A are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS A are outlined in Austroads (2015c).
B			<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> minimal to some instances of conflict but there is good visibility/sight distance (including potential visual obstruction caused by other vehicles) minimal instances of conflict and there is poor visibility, however measures are in place to mitigate crash risks due to poor visibility (such as a low speed limit) generally forgiving road environment relative to the speed environment but there are minor factors that may cause serious injury or death in case of a crash. Examples of rural road features that could achieve a LOS B are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS B are outlined in Austroads (2015c). 	

Road user	LOS needs	LOS measure	Rating	Service measure values
Private motorists (continued)	Safety (continued)	Crash risk (continued)	C	<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> some to frequent instances of conflict but there is good visibility/sight distance (including potential visual obstruction caused by other vehicles) some instances of conflict and there is poor visibility, however measures are in place to mitigate risks due to poor visibility (such as a low speed limit) generally forgiving road environment relative to the speed environment but there are some factors that may cause serious injury or death in case of a crash. Examples of rural road features that could achieve a LOS C are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS C are outlined in Austroads (2015c).
			D	<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> frequent instances of conflict but there is good visibility/sight distance (including potential visual obstruction caused by other vehicles) some to frequent instances of conflict and there is poor visibility, however measures are in place to mitigate risks due to poor visibility (such as a low speed limit) unforgiving road environment relative to the speed environment with frequent roadside hazards. Examples of rural road features that could achieve a LOS D are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS D are outlined in Austroads (2015c).
			E–F	<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> frequent instances of conflicts and poor visibility/sight distance (including potential visual obstruction caused by other vehicles) unforgiving road environment relative to the speed environment with frequent and severe roadside hazards. Examples of rural road features that could achieve a LOS E-F are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS E-F are outlined in Austroads (2015c).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
	Access	Ability to park close to destination (on-road or off-road)	A	<ul style="list-style-type: none"> For the majority, parking is readily available within close walking distance to key destinations on the road.
			B	<ul style="list-style-type: none"> For the majority, parking is readily available within some walking distance to key destinations on the road.
			C	<ul style="list-style-type: none"> For the majority, parking is available within some walking distance to key destinations on the road but may require some queuing, waiting or looking for an available parking slot.
			D	<ul style="list-style-type: none"> For the majority, restricted parking is available within some walking distance to key destinations on the road or may require substantial queuing, waiting or looking for an available parking slot.
			E	<ul style="list-style-type: none"> For the majority, free parking is not available but reasonably priced paid parking is available within some walking distance to key destinations on the road.
			F	<ul style="list-style-type: none"> For the majority, free parking is not available and expensive paid parking is available within some walking distance to key destinations on the road or may require substantial queuing, waiting or looking for an available parking slot.

Road user	LOS needs	LOS measure	Rating	Service measure values
Private motorists (continued)	Access (continued)		N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Ability to access near-road land or ability to access departures at an intersection	A–B	<ul style="list-style-type: none"> Partial to full access at mid-blocks and access to all departures at an intersection.
			C–D	<ul style="list-style-type: none"> Limited to partial access at mid-blocks and access to some minor street departures restricted at an intersection.
			E–F	<ul style="list-style-type: none"> No access at mid-blocks (e.g. freeway with long distances between ramps) and access to some major departures restricted at an intersection.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
	Information	Traveller information available	A–B	<ul style="list-style-type: none"> Real-time traveller information (with respect to road works, traveller information and travel time) is available. Adequate and suitable directional, regulatory and traffic information signage is available for the road environment.
			C–D	<ul style="list-style-type: none"> No real traveller information (with respect to road works, traveller information and travel time) is available. Adequate and suitable directional, regulatory and traffic information signage is available for the road environment.
			E–F	<ul style="list-style-type: none"> Signage is inadequate or missing (e.g. some or many directional, regulatory or traffic information signage are missing or in poor condition).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
	Amenity	Aesthetics	A–B	<ul style="list-style-type: none"> Clean and aesthetically pleasing (e.g. greenery, view, etc.).
			C–D	<ul style="list-style-type: none"> Clean.
			E–F	<ul style="list-style-type: none"> Unclean (graffiti, garbage, etc.).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Driving stress	A–B	<ul style="list-style-type: none"> Low stress road environment (e.g. average 3.3 to 3.5 m lane widths, signalised intersections where vehicles exiting a link can rely on the signals to stop opposing traffic, vehicles do not need to manoeuvre across a path used by other road users as manoeuvres are fully controlled or separated, no obstruction, e.g. right-turning vehicles blocking through movement, to desired movement).
			C–D	<ul style="list-style-type: none"> Medium stress road environment (e.g. average 3 to 3.3 m lane widths, non-signalised intersections where vehicles exiting a link may have some difficulty picking a gap, vehicles need to manoeuvre across a path lightly used by other road users such as performing a filtered right turn across a path lightly used by cyclists and/or pedestrians, some obstructions to desired movement and obstructions are relatively easy to go around).
			E–F	<ul style="list-style-type: none"> High stress road environment (e.g. narrow < 3.0 m lane widths, non-signalised intersections where vehicles exiting a link may find it hard to find a gap, vehicles need to manoeuvre across a path heavily used by other road users such as performing a filtered right turn across a path heavily used by cyclists and/or pedestrians, frequent obstructions that are difficult to go around).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Pavement ride quality	A–B	<ul style="list-style-type: none"> Smooth ride.
			C–D	<ul style="list-style-type: none"> Road defects noticeable only at high speeds.

Road user	LOS needs	LOS measure	Rating	Service measure values
Private motorists (continued)	Amenity (continued)	Pavement ride quality (continued)	E–F	<ul style="list-style-type: none"> Road defects or poor pavement conditions noticeable at low speeds.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
Transit users	Mobility	Service schedule reliability	A	<ul style="list-style-type: none"> Headway < 10 min. Transit vehicle travel time is nearly always the same where headway schedule is > 10 min.
			B	<ul style="list-style-type: none"> Transit vehicle may possibly encounter unexpected delays but generally users would not need to adjust expected travel time where headway schedule is > 10 min.
			C	<ul style="list-style-type: none"> Transit vehicle is likely to encounter unexpected delays and there is a possibility for a maximum 25% increase in travel time where headway schedule is > 10 min.
			D	<ul style="list-style-type: none"> Transit vehicle is likely to encounter unexpected delays and there is a possibility for a maximum 50% increase in travel time where headway schedule is > 10 min.
			E	<ul style="list-style-type: none"> Transit vehicle is likely to encounter unexpected delays and there is a possibility for a maximum 75% increase in travel time where headway schedule is > 10 min.
			F	<ul style="list-style-type: none"> Transit vehicle is likely to encounter unexpected delays and there is a possibility for a greater than 75% increase in travel time where headway schedule is > 10 min.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Operating speed	A	<ul style="list-style-type: none"> Exclusive right of way with infrequent stops.
			B	<ul style="list-style-type: none"> Exclusive right of way with frequent stops.
			C	<ul style="list-style-type: none"> Non-exclusive right of way on a moderately congested road with infrequent stops.
			D	<ul style="list-style-type: none"> Non-exclusive right of way on a moderately congested road with frequent stops.
			E	<ul style="list-style-type: none"> Non-exclusive right of way on a congested road with infrequent stops.
			F	<ul style="list-style-type: none"> Non-exclusive right of way on a congested road with frequent stops.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
Safety	Crash risk of transit vehicle	A	<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> road design appropriate for the intended and actual road use and speed environment minimal instances of conflict. Conflict refers to times where vehicles can potentially collide with another vehicle, pedestrian or cyclist. Conflicts can be mitigated, for example, by grade separation, divided roads, separating movements, controlling movements through signalisation or restricting direct access. There are also low instances of conflict in low congestion conditions forgiving road environment relative to the speed environment (i.e. in case of a crash or potential crash there is limited risk or there is sufficient protection against serious injury or death). Examples of rural road features that could achieve a LOS A are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS A are outlined in Austroads (2015c). 	

Road user	LOS needs	LOS measure	Rating	Service measure values
Transit users (continued)	Safety (continued)	Crash risk of transit vehicle (continued)	B	<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> minimal to some instances of conflict but there is good visibility/sight distance (including potential visual obstruction caused by other vehicles) minimal instances of conflict and there is poor visibility, however measures are in place to mitigate crash risks due to poor visibility (such as a low speed limit) generally forgiving road environment relative to the speed environment but there are minor factors that may cause serious injury or death in case of a crash. Examples of rural road features that could achieve a LOS B are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS B are outlined in Austroads (2015c).
			C	<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> some to frequent instances of conflict but there is good visibility/sight distance (including potential visual obstruction caused by other vehicles) some instances of conflict and there is poor visibility, however measures are in place to mitigate risks due to poor visibility (such as a low speed limit) generally forgiving road environment relative to the speed environment but there are some factors that may cause serious injury or death in case of a crash. Examples of rural road features that could achieve a LOS C are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS C are outlined in Austroads (2015c).
			D	<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> frequent instances of conflict but there is good visibility/sight distance (including potential visual obstruction caused by other vehicles) some to frequent instances of conflict and there is poor visibility, however measures are in place to mitigate risks due to poor visibility (such as a low speed limit) unforgiving road environment relative to the speed environment with frequent roadside hazards. Examples of rural road features that could achieve a LOS D are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS D are outlined in Austroads (2015c).
			E–F	<ul style="list-style-type: none"> Roads that have the following: <ul style="list-style-type: none"> frequent instances of conflicts and poor visibility/sight distance (including potential visual obstruction caused by other vehicles) unforgiving road environment relative to the speed environment with frequent and severe roadside hazards. Examples of rural road features that could achieve a LOS E-F are outlined in Austroads (2015c). Examples of the combination of intersection features that could achieve a LOS E-F are outlined in Austroads (2015c).
		N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	
		Crash risk of transit users while accessing/egressing	A	<ul style="list-style-type: none"> Fully protected to access both sides of the road where the station/stop is located (e.g. located at a signalised pedestrian crossing).
			B	<ul style="list-style-type: none"> Fully protected to access one side of the road where the station is located and with protected pedestrian crossing facilities nearby.

Road user	LOS needs	LOS measure	Rating	Service measure values
Transit users (continued)	Safety (continued)	Crash risk of transit users while accessing/egressing transit vehicle (continued)	C–D	<ul style="list-style-type: none"> Fully protected to access one side of the road where the station is located and with no protected pedestrian crossing facilities located nearby; but, there are low-to-medium speeds and traffic volumes on the road (such as a residential street).
			E–F	<ul style="list-style-type: none"> Fully protected to access one side of the road where the station is located but with no protected pedestrian crossing facilities nearby; and, there are high speeds and high traffic volumes on the road (such as a primary arterial road).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
	Access	Service availability (urban services only)	A	<ul style="list-style-type: none"> 10 min headway.
			B	<ul style="list-style-type: none"> 10 to 15 min headway.
			C	<ul style="list-style-type: none"> 15 to 25 min headway.
			D	<ul style="list-style-type: none"> 25 to 40 minute headway.
			E	<ul style="list-style-type: none"> 40 to 60 minute headway.
			F	<ul style="list-style-type: none"> > 60 minute headway.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Level of disability access	A–C	<ul style="list-style-type: none"> Good wheelchair access and meets DDA requirements.
			D–F	<ul style="list-style-type: none"> Poor wheelchair access and does not meet DDA requirements.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Access to transit user stops/stations from key origins and destinations	A	<ul style="list-style-type: none"> Stop or station located at the key origin or destination.
			B	<ul style="list-style-type: none"> Stop or station located within 200 m of the key origin or destination.
			C	<ul style="list-style-type: none"> Stop or station located between 200 m and 400 m of the key origin or destination.
			D	<ul style="list-style-type: none"> Stop or station located between 400 m and 600 m of the key origin or destination.
			E	<ul style="list-style-type: none"> Stop or station located between 600 m and 800 m of the key origin or destination.
			F	<ul style="list-style-type: none"> Stop or station located in excess of 800 m of the key origin or destination.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Information	Traveller information available	A–B
	C–D			<ul style="list-style-type: none"> On-board and roadside traveller information, in addition to information on timetable, fare, directions and maps; but no real-time traveller information.
	E–F			<ul style="list-style-type: none"> Limited, incomplete or missing traveller information on the roadside and no on-board traveller information on the transit vehicle.
N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 			
Amenity	Pedestrian environment	A–B	<ul style="list-style-type: none"> Good to very good pedestrian environment (e.g. sealed path, well lit, good drainage). 	

Road user	LOS needs	LOS measure	Rating	Service measure values
Transit users (continued)	Amenity (continued)	(also refer to pedestrian LOS)	C–D	<ul style="list-style-type: none"> Fair to good pedestrian environment (e.g. sealed path but with some defects or unsealed but well maintained, fair to good lighting, fair to good drainage).
			E–F	<ul style="list-style-type: none"> Poor pedestrian environment (e.g. sealed path but with significant defects or unsealed and poorly maintained, poor drainage and poor lighting).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		On-board congestion	A–B	<ul style="list-style-type: none"> Transit vehicle not crowded.
			C–D	<ul style="list-style-type: none"> Transit vehicle moderately crowded.
			E–F	<ul style="list-style-type: none"> Transit vehicle crowded.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Seat availability	A–B	<ul style="list-style-type: none"> Easy to find and select a seat on the transit vehicle.
			C–D	<ul style="list-style-type: none"> Only a few seats available on the transit vehicle.
			E–F	<ul style="list-style-type: none"> Difficult to obtain a seat.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Security	A–C	<ul style="list-style-type: none"> Good to high level of security (well-lighted, security personnel presence, security cameras, no or limited history of criminality or disturbance, sufficient number of transit users, etc.).
			D–F	<ul style="list-style-type: none"> Poor to fair level of security.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Comfort and convenience features	A–B	<ul style="list-style-type: none"> Good comfort and convenience features (e.g. a shelter and seat with additional amenities such as a toilet, noise protection, food/newspaper stalls, cycle facilities, park-and-ride, etc.).
			C–D	<ul style="list-style-type: none"> Adequate comfort and convenience features (e.g. includes a shelter and seat).
			E–F	<ul style="list-style-type: none"> Poor to fair comfort and convenience features (e.g. sign only and no shelter and seat).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Aesthetics	A	<ul style="list-style-type: none"> Clean and aesthetically pleasing (e.g. greenery, view, design, artwork, etc.).
			B–C	<ul style="list-style-type: none"> Clean.
			D–F	<ul style="list-style-type: none"> Unclean (graffiti, garbage, etc.).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Ride quality	A–B	<ul style="list-style-type: none"> Smooth ride.
			C–D	<ul style="list-style-type: none"> Road defects noticeable only at high speeds.
			E–F	<ul style="list-style-type: none"> Road defects or poor pavement conditions noticeable at low speeds.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.

Road user	LOS needs	LOS measure	Rating	Service measure values
Pedestrians	Mobility	Footpath congestion	A	<ul style="list-style-type: none"> Ability to move in desired path, no need to alter movements (e.g. > 5.6 m² per pedestrian etc.).
			B	<ul style="list-style-type: none"> Occasional need to adjust path to avoid conflicts (e.g. 3.7–5.7 m² per pedestrian etc.).
			C	<ul style="list-style-type: none"> Frequent need to adjust path to avoid conflicts (e.g. 2.2–3.7 m² per pedestrian etc.).
			D	<ul style="list-style-type: none"> Speed and ability to pass slower pedestrians restricted (e.g. 1.4–2.2 m² per pedestrian etc.).
			E	<ul style="list-style-type: none"> Speed restricted, very limited ability to pass slower pedestrians (e.g. 0.75–1.4 m² per pedestrian etc.).
			F	<ul style="list-style-type: none"> Speed severely restricted, frequent contact with other users (e.g. < 0.75 m² per pedestrian etc.).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Grade of path	A–B	<ul style="list-style-type: none"> Flat grades.
			C–D	<ul style="list-style-type: none"> Flat to steep grades.
			E–F	<ul style="list-style-type: none"> Steep grades, including long stretches of stairs.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Crossing delay or detour	A	<ul style="list-style-type: none"> On average no or little delay and/or detour required to cross where there is a demand to cross – refer to Austroads (2015c).
			B	<ul style="list-style-type: none"> On average minor delay and/or detour required to cross where there is a demand to cross – refer to Austroads (2015c).
			C	<ul style="list-style-type: none"> On average minor to medium delay and/or detour required to cross where there is a demand to cross – refer to Austroads (2015c).
	D		<ul style="list-style-type: none"> On average medium to major delay and/or detour required to cross where there is a demand to cross – refer to Austroads (2015c). 	
	E		<ul style="list-style-type: none"> On average major delay and/or detour required to cross where there is a demand to cross – refer to Austroads (2015c). 	
	F		<ul style="list-style-type: none"> On average significant delay and/or detour required to cross where there is a demand to cross – refer to Austroads (2015c). 	
	N/A		<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	
	Safety	Exposure to vehicles at mid-blocks	A	<ul style="list-style-type: none"> No or limited exposure to vehicles. Separate path from bicycles (i.e. not a shared path with bicycles) where located on a principal bicycle network or shared path away from the principal bicycle network. Clear separation (in excess of clear zone requirement for the speed environment) between motor vehicles and pedestrians. None or limited driveway access along the mid-block.
			B	<ul style="list-style-type: none"> Clear separation between pedestrians and motor vehicles with a buffer between pedestrians and vehicles such as a nature strip and/or bicycle lane. However the separation is less than the clear zone requirement for the speed environment. Separate path from bicycles (i.e. not a shared path with bicycles) where located on a principal bicycle network or shared path away from the principal bicycle network.
C			<ul style="list-style-type: none"> Clear separation between pedestrians and motor vehicles, however separation is less than the clear zone requirement for the speed environment. 	

Road user	LOS needs	LOS measure	Rating	Service measure values	
Pedestrians (continued)	Safety (continued)	Exposure to vehicles at mid-blocks (continued)	D	<ul style="list-style-type: none"> No separation between pedestrians and motor vehicles within a low volume and low speed motor vehicle environment (e.g. a typical minor residential street). 	
			E	<ul style="list-style-type: none"> No separation between pedestrians and motor vehicles within a low to medium volume and low speed motor vehicle environment (e.g. a typical collector/sub-arterial road). 	
			F	<ul style="list-style-type: none"> No separation between pedestrians and motor vehicles within a medium to high volume and medium to high speed motor vehicle environment (e.g. a primary arterial road). 	
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	
		Exposure to vehicles at crossings	A	<ul style="list-style-type: none"> Fully protected crossings (e.g. pedestrian operated signalised crossings, signalised intersection with fully controlled right turns or signalised intersections with filtered right turns but with low pedestrian numbers). Regulated crossings (e.g. zebra and pelican crossings) in a low volume and low speed motor vehicle environment such as a residential street). 	
			B	<ul style="list-style-type: none"> Uncontrolled crossing in a low volume and low speed motor vehicle environment such as a residential street. Regulated crossings (e.g. zebra and pelican crossings) in a low to medium volume and low to medium speed motor vehicle environment such as a typical collector or sub-arterial road. 	
			C	<ul style="list-style-type: none"> Uncontrolled crossing in a low to medium volume and low to medium speed motor vehicle environment such as a typical collector or sub-arterial road. Regulated crossing (e.g. zebra and pelican crossings) in a medium volume and medium speed motor vehicle environment such as a minor arterial road. No crossing facility at a major crossing point in a low volume, low speed, and one lane each way motor vehicle environment (e.g. strip shopping centre in a residential street). 	
			D	<ul style="list-style-type: none"> Uncontrolled crossing in a medium to high volume and medium speed motor vehicle environment (e.g. arterial road). No crossing facility at a major crossing point in a medium volume, medium speed, in a two lane each way motor vehicle environment (e.g. strip shopping centre on a minor arterial road). Signalised intersection with high vehicle volumes and high pedestrian volumes located on the through movement which a filtered right turn crosses. 	
			E	<ul style="list-style-type: none"> Uncontrolled crossing in a high volume and high speed motor vehicle environment (e.g. major high speed arterial road). Inappropriate crossing treatment on a medium to high volume and medium to high speed motor vehicle environment (e.g. zebra crossing on an arterial road). 	
			F	<ul style="list-style-type: none"> No crossing facility at a major crossing point in a high volume and high speed multi-lane motor vehicle environment (e.g. strip shopping centre on a major high speed arterial road). 	
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	
			Trip hazards	A–B	<ul style="list-style-type: none"> Well-maintained pavement with good drainage and clear of debris. Kerb ramps provided. Tactile indicators for stairs and hazards.

Road user	LOS needs	LOS measure	Rating	Service measure values	
Pedestrians (continued)	Safety (continued)	Trip hazards (continued)		<ul style="list-style-type: none"> No or limited pavement defects, trip hazards or other miscellaneous hazards that may impact on safety (e.g. clear of street furniture (signage, poles, seats, bins), trees, garbage, parked cars, etc.). 	
			C–D	<ul style="list-style-type: none"> Paved with good drainage with minor defects. Some debris on path. Tactile indicators not provided. Occasional pavement defects, trip hazards or other miscellaneous hazards that may impact on safety (e.g. street furniture (signage, poles, seats, bins), trees, garbage, parked cars etc.). 	
			E–F	<ul style="list-style-type: none"> Footpath that is unpaved, or paved with significant defects such as tree roots, potholes and very uneven surfaces. Significant debris on path. Poor drainage. Frequent or high density of pavement defects, trip hazards, or stationary hazards obstructing the footpath (e.g. street furniture (signage, poles, seats, bins), trees, garbage, parked cars). 	
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	
	Access	Crossing opportunities	A	<ul style="list-style-type: none"> Ability to safely cross the road within 25 m from an origin anywhere along the road (e.g. low speed shopping strip or shared zone where people can safely and freely cross at any location along the road). 	
			B	<ul style="list-style-type: none"> Ability to safely cross the road within 50 m from an origin anywhere along the road. 	
			C	<ul style="list-style-type: none"> Ability to safely cross the road within 100 m from an origin anywhere along the road. 	
			D	<ul style="list-style-type: none"> Ability to safely cross the road within 200 m from an origin anywhere along the road (e.g. medium speed, medium volume sub-arterial road where pedestrians may need to walk 200 m in order to avoid a physical obstruction such as a fence in order to cross the road). 	
			E	<ul style="list-style-type: none"> Ability to safely cross the road within 400 m from an origin anywhere along the road. 	
			F	<ul style="list-style-type: none"> Ability to safely cross the road requires a detour of more than 400 m from an origin anywhere along the road (e.g. high speed, high volume arterial road where pedestrians may need to walk in excess of 400 m to a signal in order to cross the road, or to be able to avoid obstructions preventing a pedestrian from crossing such as a fence or barrier in the median). 	
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	
			Level of disability access	A–C	<ul style="list-style-type: none"> Good wheelchair access and meets DDA requirements.
				D–F	<ul style="list-style-type: none"> Poor wheelchair access and does not meet DDA requirements.
				N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
	Information	Traveller information available including signposting	A–C	<ul style="list-style-type: none"> Adequate and suitable traveller information is fully available (with consideration to the nature of pedestrians and the area, e.g. a tourist area would require more information than a local neighbourhood). Complete and clear signposting with routes and distances. 	
			D–F	<ul style="list-style-type: none"> Traveller information is incomplete, inadequate or missing. Limited or non-existent route signposting. 	
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	

Road user	LOS needs	LOS measure	Rating	Service measure values		
Pedestrians (continued)	Amenity	Footpath pavement conditions	A–B	<ul style="list-style-type: none"> Sealed with good drainage, and comfortable to walk on (e.g. smooth). 		
			C–D	<ul style="list-style-type: none"> Sealed with fair to good drainage, and slightly uncomfortable to walk on (e.g. some small bumps or undulations). Unsealed but well maintained. 		
			E–F	<ul style="list-style-type: none"> Sealed with significant defects, drainage problems and uncomfortable to walk on (e.g. significant bumps and undulations such as tree roots, potholes). Unsealed and poorly maintained. Significant debris on path. 		
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
		Comfort and convenience features	A–C	<ul style="list-style-type: none"> Good comfort and convenience features (shelter, noise protection, benches, food/newspaper stalls, etc.). 		
			D–F	<ul style="list-style-type: none"> Poor to fair comfort and convenience features. 		
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
		Security	A–C	<ul style="list-style-type: none"> Good to high level of security (well-lighted, security personnel presence, security cameras, no or limited history of criminality or disturbance, sufficient number of pedestrians, etc.). 		
			D–F	<ul style="list-style-type: none"> Poor to fair level of security. 		
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
		Aesthetics	A–B	<ul style="list-style-type: none"> Clean and aesthetically pleasing (e.g. greenery, view, design, artwork, etc.). 		
			C–D	<ul style="list-style-type: none"> Clean. 		
			E–F	<ul style="list-style-type: none"> Unclean (graffiti, garbage, etc.). 		
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
		Cyclists	Mobility	Travel speed	A–B	<ul style="list-style-type: none"> High quality, high priority links which permit quick, unhindered travel by bicycle. Typical cyclist operating speeds are largely unconstrained (e.g. can travel at speeds greater than 25 km/h). No or minimal delay at intersections (e.g. grade separated crossing or at-grade crossing of minor local road).
					C–D	<ul style="list-style-type: none"> High quality routes with seamless connections that permit somewhat unhindered travel by bicycle. Typical cyclist operating speeds are somewhat constrained (e.g. cyclist limited to a speed range from 20 to 25 km/h). Some delay at intersections (e.g. at-grade crossing of collector road or minor arterial; short signal phase at signalised intersections or cyclists rarely made to wait a full cycle based on arrival).
E–F	<ul style="list-style-type: none"> Low speed, shared environment which permits only hindered travel by bicycle. Typical cyclist operating speeds are constrained (e.g. cyclist speed less than 20 km/h). Significant delay at intersection (e.g. at-grade crossing of busy arterial road and therefore gap times are long; cyclists likely to wait a full cycle based on arrival). 					
N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 					

Road user	LOS needs	LOS measure	Rating	Service measure values
Cyclists (continued)	Mobility (continued)	Congestion	A–B	<ul style="list-style-type: none"> Cyclists are unimpeded or only slightly restricted to choose their speed.
			C–D	<ul style="list-style-type: none"> Cyclists are somewhat impeded in their choice of speed.
			E–F	<ul style="list-style-type: none"> Cyclists are restricted and their choice of speed is dictated by others.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Grades	A–B	<ul style="list-style-type: none"> Flat grades (e.g. 0 to 2%).
			C–D	<ul style="list-style-type: none"> Flat to steep grades (e.g. 2 to 5%).
			E–F	<ul style="list-style-type: none"> Steep grades; steps or stairs (e.g. > 5% sustained for 50 to 100 m).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
	Safety	Risk of cycle-to-cycle/ pedestrian crash	A–B	<ul style="list-style-type: none"> No to limited risk. Good line of sight. Speed differential low (e.g. similar cyclist type such as all recreational cyclists).
			C–D	<ul style="list-style-type: none"> Medium risk, some platooning of cyclists and cyclists slowing down for pedestrians. Good to fair line of sight. Speed differential medium (e.g. some mixture in cyclist type such as predominantly recreational cyclists with some commuter cyclists).
			E–F	<ul style="list-style-type: none"> High risk, crashes can result in several upstream cyclists to brake abruptly or crash. Poor line of sight (e.g. blind curves). Speed differential high (e.g. mixture in cyclist type such as recreational cyclists combined with family cyclists, commuter cyclists and training cyclists).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
		Risk of crash caused by surface unevenness or slippage	A–B	<ul style="list-style-type: none"> Sealed pavement that is well-maintained with good drainage.
			C–D	<ul style="list-style-type: none"> Sealed pavement with good drainage but with some defects. Some debris on path.
			E–F	<ul style="list-style-type: none"> Unsealed pavement or sealed pavement with significant defects. Significant debris on path. Poor drainage. Significant slippery pavement materials (e.g. tram rails or road markings).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
Risk of crash with stationary hazards	A–B	<ul style="list-style-type: none"> No or limited stationary hazards on the path and adjacent to the path (e.g. clear of street furniture (poles, seats, bins), trees, garbage, parked cars etc.). 		
	C–D	<ul style="list-style-type: none"> Occasional or a low density of stationary hazards on the path or adjacent to the path (e.g. parked cars that are frequently accessed such as in strip shopping centres, street furniture (poles, seats, bins), trees, garbage, etc.). Occasional parked cars or cars coming off parking that can block or hinder the natural path of cyclists. 		

Road user	LOS needs	LOS measure	Rating	Service measure values
Cyclists (continued)	Safety (continued)	Risk of crash with stationary hazards (continued)	E–F	<ul style="list-style-type: none"> Frequent or a high density of stationary hazards on the path or adjacent to the path (e.g. parked cars that are frequently accessed such as in strip shopping centres, street furniture (poles, seats, bins), trees, garbage, etc.). Frequent parked cars or cars coming off parking that can block or hinder the natural path of cyclists.
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
			A	<ul style="list-style-type: none"> Exclusive bicycle facility in a low risk road environment – refer to Austroads (2015c).
		Risk of cycle-to-motor vehicle crash at mid-blocks	B	<ul style="list-style-type: none"> Exclusive bicycle facility in a low to medium risk road environment or no bicycle facility in a low risk road environment – refer to Austroads (2015c).
			C	<ul style="list-style-type: none"> Exclusive bicycle facility in a medium to high risk road environment or no bicycle facility in a low to medium risk road environment – refer to Austroads (2015c).
			D	<ul style="list-style-type: none"> Exclusive bicycle facility in a medium to high risk road environment or no bicycle facility in a medium risk road environment – refer to Austroads (2015c).
			E	<ul style="list-style-type: none"> Bicycle-only lane (not Copenhagen style facility where the bicycle facility is behind a kerb) in a high risk road environment or no bicycle facility in a medium to high risk road environment – refer to Austroads (2015c).
			F	<ul style="list-style-type: none"> No bicycle facility in a high risk road environment – refer to Austroads (2015c).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.
			Risk of cycle-to-motor vehicle crash at intersections and/or driveways	A
		B		<ul style="list-style-type: none"> Crossings limited to driveway crossing only.
		C		<ul style="list-style-type: none"> Uncontrolled motor vehicle crossings at low volume, low speed roads (e.g. give way or roundabout residential street intersection). Fully controlled crossings of motor vehicles at high volume roads, without concurrent movements (e.g. exclusive bicycle movement). Signalised intersection with high volumes, large numbers of cyclists on the through movement but fully controlled right turns.
				<ul style="list-style-type: none"> Uncontrolled motor vehicle crossing at medium volume, medium speed roads (e.g. give way or roundabout collector, sub-arterial road intersection). Fully controlled crossings of motor vehicles at medium volume roads, with concurrent movements (e.g. no exclusive bicycle movement). Signalised intersection with high volumes, large numbers of cyclists on the through movement and filtered right turns.
		E		<ul style="list-style-type: none"> Uncontrolled motor vehicle crossing at medium to high volume roads (e.g. non-signalised arterial road intersection).
		F		<ul style="list-style-type: none"> Uncontrolled vehicles at high volume, high speed intersecting roads (e.g. major high speed arterial road roundabout).
		N/A		<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.

Road user	LOS needs	LOS measure	Rating	Service measure values	
Cyclists (continued)	Access	Access to and ability to park close to destination	A	<ul style="list-style-type: none"> Proper bicycle parking facilities are readily available immediately adjacent to key destinations and can be accessed directly from the bicycle network. Parking is suitable for likely trip purpose (racks for occasional or short-term users, secure cages/lockers for regular or long-term users). 	
			B	<ul style="list-style-type: none"> Proper bicycle parking facilities are readily available within close walking distance to key destinations and can be accessed directly from the bicycle network. Parking is suitable for likely trip purpose. 	
			C	<ul style="list-style-type: none"> Proper bicycle parking facilities are readily available within a moderate walking distance to key destinations and can be accessed directly from the bicycle network. 	
			D	<ul style="list-style-type: none"> Proper bicycle parking facilities are somewhat available within a moderate walking distance to key destinations, or parking at or near a location is a moderate walking distance from the bicycle network. 	
			E	<ul style="list-style-type: none"> Proper bicycle parking facilities are somewhat available within a long walking distance to key destinations, or parking at or near a location is a long walking distance from the bicycle network. 	
			F	<ul style="list-style-type: none"> Proper bicycle parking facilities are not available. 	
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	
			Suitability	A	<ul style="list-style-type: none"> Cycling highly suitable as follows: <ul style="list-style-type: none"> off-road facility for use by bicycles only (e.g. off-road bicycle only path).
				B	<ul style="list-style-type: none"> Cycling suitable as follows: <ul style="list-style-type: none"> off-road shared-use path with low pedestrian numbers on-road bicycle lane separated from car parking or road shoulder with no car parking on a low-volume road on-road shared-traffic environment marked on a low-speed or low-volume road.
				C	<ul style="list-style-type: none"> Cycling moderately suitable as follows: <ul style="list-style-type: none"> off-road shared-use path with medium pedestrian numbers on-road bicycle lane shared with minimal car parking or road shoulder with minimal car parking on a low-volume road on-road shared-traffic environment on a medium-volume road or low speed road.
	D	<ul style="list-style-type: none"> Cycling moderately unsuitable as follows: <ul style="list-style-type: none"> off-road shared-use path/zone with high pedestrian numbers or speed restrictions (e.g. 10 km/h) on-road bicycle lane or road shoulder on high-volume road on-road shared-traffic environment on a medium to high volume or medium to high speed road. 			
	E	<ul style="list-style-type: none"> Cycling unsuitable as follows: <ul style="list-style-type: none"> cycling significantly impeded due to physical obstructions that require getting off the bike (e.g. steps) cycling is unsuitable due to inadequate separation from traffic that is either high speed or high volume. 			
	F	<ul style="list-style-type: none"> Cycling highly unsuitable or prohibited <ul style="list-style-type: none"> cycling prohibited cycling is unsuitable due to inadequate separation from traffic that is both high speed and high volume. 			
	N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 			

Road user	LOS needs	LOS measure	Rating	Service measure values		
Cyclists (continued)	Information	Traveller information available, including signposting	A–B	<ul style="list-style-type: none"> Complete and clear signposting with routes and distances is fully available (with consideration to the nature of cyclists and the area, e.g. a tourist area would require more information than a local neighbourhood). 		
			C–D	<ul style="list-style-type: none"> Signposting with routes and distances is partially available. 		
			E–F	<ul style="list-style-type: none"> Signposting with routes and distances is inadequate or missing. 		
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
	Amenity	Aesthetics	A–B	<ul style="list-style-type: none"> Clean and aesthetically pleasing (e.g. greenery, view, design, artwork, etc.). 		
			C–D	<ul style="list-style-type: none"> Clean. 		
			E–F	<ul style="list-style-type: none"> Unclean (graffiti, garbage, etc.). 		
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
		Comfort and convenience features	A–C	<ul style="list-style-type: none"> Good comfort and convenience features (bike parking, noise protection, change facilities, lockers, etc.). 		
			D–F	<ul style="list-style-type: none"> Poor to fair comfort and convenience features (no parking, excessive noise, no change facilities, no lockers, etc.). 		
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
		Security	A–C	<ul style="list-style-type: none"> Good to high level security (e.g. well-lighted, no or limited history of criminality or disturbance, sufficient number of cyclists, etc.). 		
			D–F	<ul style="list-style-type: none"> Poor to fair level security (e.g. not well-lighted, with history of criminality or disturbance, low number of cyclists, etc.). 		
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
		Pavement ride quality	A–B	<ul style="list-style-type: none"> Road surface is smooth and even. 		
			C–D	<ul style="list-style-type: none"> Road surface is moderately smooth and even. 		
			E–F	<ul style="list-style-type: none"> Road surface is not smooth and even. 		
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 		
		Freight operators	Mobility	Congestion	A	<ul style="list-style-type: none"> For motorways a condition of free-flow in which drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high, and the general level of comfort and convenience provided is excellent⁽²⁾. For arterial roads generally free flow conditions with operating speeds at least 80% of the free flow speed. Vehicles are unimpeded in manoeuvring in the traffic stream and delay at intersections is minimal.
					B	<ul style="list-style-type: none"> For motorways a condition of stable flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is a little less than with level of service A⁽²⁾. For arterial roads relatively unimpeded flow with operating speeds between 50–80% of the free flow speed. Manoeuvring in the traffic stream is only slightly restricted and intersection delays are low.

Road user	LOS needs	LOS measure	Rating	Service measure values	
Freight operators (continued)	Mobility (continued)	Congestion (continued)	C	<ul style="list-style-type: none"> For motorways a condition of stable flow, but where most drivers are restricted to some extent in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience declines noticeably at this level⁽²⁾. For arterial roads stable operating conditions but with manoeuvring becoming more restricted and motorists experiencing appreciable tension in driving. Operating speeds are between 30–50% of the free flow speed. At signalised intersections, vehicles generally have to stop in a queue but clear the intersection in one signal cycle. 	
			D	<ul style="list-style-type: none"> For motorways a condition that is close to the limit of stable flow and approaching unstable flow. All drivers are severely restricted in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is poor, and small increases in traffic flow will generally cause operational problems⁽²⁾. For arterial roads small increases in traffic volumes can significantly increase delay. Operating speeds are between 20–30% of the free flow speed. At signalised intersections, vehicles always join the back of an existing queue and take about two signal cycles to clear the intersection. 	
			E	<ul style="list-style-type: none"> For motorways a condition where traffic volumes are at or close to capacity, and there is virtually no freedom to select desired speeds or to manoeuvre within the traffic stream. Flow is unstable and minor disturbances within the traffic stream will cause breakdown⁽²⁾. For arterial roads conditions are characterised by significant delays with operating speeds between 10–20% of the free flow speed. At signalised intersections, vehicles take three or more signal cycles to clear the intersection⁽¹⁾. 	
			F	<ul style="list-style-type: none"> For motorways a condition of forced flow, where the amount of traffic approaching the point under consideration exceeds that which can pass it. Flow breakdown occurs, and queuing and delays result⁽²⁾. For arterial roads traffic flow at this level is at very low speeds (less than 10% of the free flow speed). At signalised intersections, vehicles can take three or more signal cycles to clear the intersection and backups from downstream significantly impact traffic flow. 	
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	
			Travel time reliability	A	<ul style="list-style-type: none"> Travel time is nearly always the same.
				B	<ul style="list-style-type: none"> Travel may possibly encounter unexpected delays but there is no need to adjust expected travel time for time sensitive journeys.
				C	<ul style="list-style-type: none"> Travel is likely to encounter unexpected delays and there is a possibility for a maximum 25% increase in travel time.
				D	<ul style="list-style-type: none"> Travel is likely to encounter unexpected delays and there is a possibility for a maximum 50% increase in travel time.
		E		<ul style="list-style-type: none"> Travel is likely to encounter unexpected delays and there is a possibility for a maximum 75% increase in travel time. 	
		F		<ul style="list-style-type: none"> Travel is likely to encounter unexpected delays and there is a possibility for a greater than 75% increase in travel time. 	
		N/A		<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed. 	
		Travel speed	A	<ul style="list-style-type: none"> High travel speeds of over 80 km/h. 	
			B	<ul style="list-style-type: none"> Medium to high travel speeds of 70 to 80 km/h. 	
			C	<ul style="list-style-type: none"> Medium travel speeds of 60 to 70 km/h. 	

Road user	LOS needs	LOS measure	Rating	Service measure values			
Freight operators (continued)	Mobility (continued)	Travel speed (continued)	D	<ul style="list-style-type: none"> • Low to medium travel speeds of 50 to 60 km/h. 			
			E	<ul style="list-style-type: none"> • Low speeds of 40 to 50 km/h. 			
			F	<ul style="list-style-type: none"> • Very low speeds of less than 40 km/h. 			
			N/A	<ul style="list-style-type: none"> • N/A – The measure is not applicable to the site and the proposal being assessed. 			
	Safety	Crash risk		A	<ul style="list-style-type: none"> ▪ Roads that have the following: <ul style="list-style-type: none"> – road design appropriate for the intended and actual road use and speed environment – minimal instances of conflict. Conflict refers to times where vehicles can potentially collide with another vehicle, pedestrian or cyclist. Conflicts can be mitigated, for example, by grade separation, divided roads, separating movements, controlling movements through signalisation or restricting direct access. There are also low instances of conflict in low congestion conditions – forgiving road environment relative to the speed environment (i.e. in case of a crash or potential crash there is limited risk or there is sufficient protection against serious injury or death). ▪ Examples of rural road features that could achieve a LOS A are outlined in Austroads (2015c). ▪ Examples of the combination of intersection features that could achieve a LOS A are outlined in Austroads (2015c). 		
				B	<ul style="list-style-type: none"> ▪ Roads that have the following: <ul style="list-style-type: none"> – minimal to some instances of conflict but there is good visibility/sight distance (including potential visual obstruction caused by other vehicles) – minimal instances of conflict and there is poor visibility, however measures are in place to mitigate crash risks due to poor visibility (such as a low speed limit) – generally forgiving road environment relative to the speed environment but there are minor factors that may cause serious injury or death in case of a crash. ▪ Examples of rural road features that could achieve a LOS B are outlined in Austroads (2015c). ▪ Examples of the combination of intersection features that could achieve a LOS B are outlined in Austroads (2015c). 		
				C	<ul style="list-style-type: none"> ▪ Roads that have the following: <ul style="list-style-type: none"> - some to frequent instances of conflict but there is good visibility/sight distance (including potential visual obstruction caused by other vehicles) - some instances of conflict and there is poor visibility, however measures are in place to mitigate risks due to poor visibility (such as a low speed limit) - generally forgiving road environment relative to the speed environment but there are some factors that may cause serious injury or death in case of a crash. • Examples of rural road features that could achieve a LOS C are outlined in Austroads (2015c). • Examples of the combination of intersection features that could achieve a LOS C are outlined in Austroads (2015c). 		
				D	<ul style="list-style-type: none"> • Roads that have the following: <ul style="list-style-type: none"> - frequent instances of conflict but there is good visibility/sight distance (including potential visual obstruction caused by other vehicles) - some to frequent instances of conflict and there is poor visibility, however measures are in place to mitigate risks due to poor visibility (such as a low speed limit) 		

Road user	LOS needs	LOS measure	Rating	Service measure values
Freight operators (continued)	Safety (continued)	Crash risk (continued)		<ul style="list-style-type: none"> - unforgiving road environment relative to the speed environment with frequent roadside hazards. • Examples of rural road features that could achieve a LOS D are outlined in Austroads (2015c). • Examples of the combination of intersection features that could achieve a LOS D are outlined in Austroads (2015c).
			E–F	<ul style="list-style-type: none"> • Roads that have the following: <ul style="list-style-type: none"> • frequent instances of conflicts and poor visibility/sight distance (including potential visual obstruction caused by other vehicles) • unforgiving road environment relative to the speed environment with frequent and severe roadside hazards. • Examples of rural road features that could achieve a LOS E-F are outlined in Austroads (2015c). • Examples of the combination of intersection features that could achieve a LOS E-F are outlined in Austroads (2015c).
			N/A	<ul style="list-style-type: none"> • N/A – The measure is not applicable to the site and the proposal being assessed.
	Access	Level of freight access	A	<ul style="list-style-type: none"> • Road permitting A-triple \leq 53.5 m freight vehicles (e.g. Level 4 access road according to the National Heavy Vehicle Regulator Performance-Based Standards (PBS) scheme).
			B	<ul style="list-style-type: none"> • Road permitting A-double \leq 36.5 m freight vehicles (e.g. Level 3 access according to PBS).
			C	<ul style="list-style-type: none"> • Road permitting B-double \leq 26 m freight vehicles (e.g. Level 2 access according to PBS).
			D	<ul style="list-style-type: none"> • Road permitting rigid \leq 20 m freight vehicles (e.g. Level 1 access according to PBS).
			E–F	<ul style="list-style-type: none"> • No freight vehicles allowed or highly regulated access only.
			N/A	<ul style="list-style-type: none"> • N/A – The measure is not applicable to the site and the proposal being assessed.
	Information	Traveller information	A–B	<ul style="list-style-type: none"> • Real-time traveller information is available. • Good signage.
			C–D	<ul style="list-style-type: none"> • Adequate signage.
			E–F	<ul style="list-style-type: none"> • Signage is inadequate or missing.
			N/A	<ul style="list-style-type: none"> • N/A – The measure is not applicable to the site and the proposal being assessed.
	Amenity	Pavement ride quality	A–B	<ul style="list-style-type: none"> • Smooth ride.
			C–D	<ul style="list-style-type: none"> • Road defects noticeable only at high speeds.
			E–F	<ul style="list-style-type: none"> • Road defects or poor pavement conditions noticeable at low speeds.
			N/A	<ul style="list-style-type: none"> • N/A – The measure is not applicable to the site and the proposal being assessed.
		Stress	A–B	<ul style="list-style-type: none"> • Low stress road environment (e.g. average 3.3 to 3.5 m lane widths, signalised intersections where vehicles exiting a link can rely on the signals to stop opposing traffic, vehicles do not need to manoeuvre across a path used by other road users as manoeuvres are fully controlled or separated).
			C–D	<ul style="list-style-type: none"> • Medium stress road environment (e.g. average 3 to 3.3 m lane widths, non-signalised intersections where vehicles exiting a link may have some difficulty picking a gap, vehicles need to manoeuvre across a path lightly used by other road users such as performing a filtered right turn across a path lightly used by cyclists and/or pedestrians).
			E–F	
N/A				

Road user	LOS needs	LOS measure	Rating	Service measure values
Freight operators (continued)	Amenity (continued)	Stress (continued)	E–F	<ul style="list-style-type: none"> High stress road environment (e.g. narrow < 3.0 m lane widths, non-signalised intersections where vehicles exiting a link may find it hard to find a gap, vehicles need to manoeuvre across a path heavily used by other road users such as performing a filtered right turn across a path heavily used by cyclists and/or pedestrians).
			N/A	<ul style="list-style-type: none"> N/A – The measure is not applicable to the site and the proposal being assessed.

- 1 Note some road agencies may choose to elect a percentage of posted speed for motorways to assist in establishing a LOS for private motorists – mobility – congestion measure. For example VicRoads utilises the following percentages to reflect LOS: LOS A = > 80%, LOS B = 70–80%, LOS C = 60–70%, LOS D = 50–60%, LOS E = 40–50% and LOS F = < 40%.
- 2 Note some road agencies may choose to elect a percentage of posted speed for motorways to assist in establishing a LOS for freight operators – mobility – congestion measure. For example VicRoads utilises the following percentages to reflect LOS: LOS A = > 80%, LOS B = 70–80%, LOS C = 60–70%, LOS D = 50–60%, LOS E = 40–50% and LOS F = < 40%.

Source: Austroads (2015c).

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Commentary 2

Further to content contained in Section 2.3, Table C2 1 provides examples of potential applications of travel demand management measures on a link, route, corridor and area scale.

Table C2 1: TDM measure selection table based on where the problem occurs

When does the problem occur?	Link	Route	Corridor	Area/region
Weekday peak	<ul style="list-style-type: none"> • ATMS – signal priority, access metering, lane restrictions • PT and HOV priority lanes • Improved pedestrian and bike facilities • LATM/traffic calming 	<ul style="list-style-type: none"> • ATMS • ATIS • Changing capacity • PT and HOV priority lanes • Improved pedestrian and bike facilities • LATM/traffic calming 	<ul style="list-style-type: none"> • ATMS • ATIS • AUPS • Changing capacity across routes • PT and HOV priority lanes • Improved pedestrian and bike facilities • LATM/traffic calming • Community-based travel behaviour change program (e.g. TravelSmart) 	<ul style="list-style-type: none"> • ATMS • ATIS • AUPS • Physical restraint through area limitations (traffic cells/mazes, area licences) • Parking provision or restraint, control and management and pricing • Changing cost of car travel • Vehicle registration and purchase taxes • Campaigns to raise environmental awareness, reduce GHG or promote PT • Community-based travel behaviour change program (e.g. TravelSmart) • Teleworking • Raising environmental awareness • Promoting walking and cycling for health • Ride-sharing, carpooling or car-sharing • Smart growth or transit oriented development
Weekday off-peak or weekend	<ul style="list-style-type: none"> • ATMS • PT and HOV priority lanes 	<ul style="list-style-type: none"> • ATMS • ATIS 	<ul style="list-style-type: none"> • ATMS • ATIS 	<ul style="list-style-type: none"> • As above
Variable – linked to special event timing or seasonal factors	<ul style="list-style-type: none"> • ATMS • PT and HOV priority lanes 	<ul style="list-style-type: none"> • ATMS • ATIS • Changing capacity • PT and HOV priority lanes • Improved pedestrian and bike facilities 	<ul style="list-style-type: none"> • ATMS • ATIS • AUPS • PT and HOV priority lanes 	<ul style="list-style-type: none"> • As above

Note: Abbreviations used above: ATMS (Advanced Traffic Management Systems) includes signal priority and linking, access metering, lane restrictions to encourage high occupancy vehicles, public transport and/or freight vehicles and discourage low occupancy vehicles; ATIS (Advanced Traveller Information Systems) involves information provision to influence departure time, mode or route choices; AUPS (Advanced User Payment Systems) includes integrated payment and smart charging across modes and/or with parking and tolls along with broader pricing initiatives such as congestion pricing; PT = Public Transport; HOV = High Occupancy Vehicle Lane; LATM = Local Area Traffic Management; GHG = Greenhouse Gas.

Source: Adapted from Austroads (2007b).

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Commentary 3

The primary function of a road is to serve either:

- 'mobility', which is concerned with the movement of through-traffic and is focused on the efficient movement of people and freight
- 'access', which relates to the ease with which traffic from land abutting roads can enter or leave the road.

Where it is accepted that provision for non-local movement should predominate, a road would be classed as an arterial. Roads that provide only for local traffic movements would be classed as local roads or streets.

The classification of roads or streets may be based on a system of road amenity classification, which recognises the roles of different street users (trucks, cars, pedestrians, cyclists, public transport) and the non-traffic functions of streets (landscape, play areas, services or utilities). Further discussion on the concept of amenity can be found in the *Guide to Traffic Management Part 8: Local Area Traffic Management* (Austroads 2008a).

In particular, a road amenity classification system recognises that traffic efficiency and traffic restraint are not generally an 'all-or-nothing' matter. It is possible and quite realistic under this system, that some roads may give a varying balance of different objectives along their length. For example, a road that is an essential link within the arterial system, may have an existing abutting major shopping centre along one section. It may be appropriate to have a different balance of objectives reflecting the differing needs over the length, with suitable traffic management strategies being adopted.

Whatever system of classification is adopted, the following important questions need to be considered:

- Is the road one on which traffic restraint is appropriate, because the living or amenity or local safety goal is recognised as being predominant?
- Is it a road where the efficiency of moving traffic is paramount?
- What are the particular traffic and other characteristics of this road which may influence the type of treatments to be considered?

Road classification studies may readily be able to allocate a large percentage of roads into one category or the other, in response to the first question. Local studies will be required to deal with the third question and to deal with that difficult group of roads which do not fall readily into the 'arterial or local' classification category.

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Commentary 4

The following commentary contains details from an information paper supporting a road classification review by the Roads and Maritime Services of New South Wales (formerly RTA) in 2004. It provides an example of an administrative classification system and its relationship to functional classification (Roads and Traffic Authority 2004).

Functional Road Classification

The identification of State and Regional Roads is based on road function. Functional classification is the process by which roads are grouped into classes or systems according to their function or the character of the service they are intended to provide. Individual roads do not serve travel independently in any major way. Rather, most travel involves movement through a network of roads. It becomes necessary then to encourage this travel to move within the network in a logical and efficient manner. Functional classification helps this process by defining the part that any particular road should play in serving the flow of trips through the network.

Functional classification can be used as a basis for allocating jurisdictional responsibility for roads. The primary, long distance, high traffic routes have strategic importance for the wider economy, and by their nature are more expensive to construct and maintain. Central governments acknowledge this by taking responsibility for the high order roads, while lower order roads remain the responsibility of local councils.

The development of a strongly differentiated hierarchy of roads on a functional basis is essential to maximise the effectiveness and efficiency in the spending of road funds by the differing jurisdictions, to support appropriate traffic management regimes and efficient traffic flow, and to promote road safety.

A generic hierarchy comprises motorways, primary arterial roads, secondary or sub-arterial roads, collector roads and local access roads. The NSW, State, Regional and Local Road administrative system of road classification forms a hierarchy, which generally aligns to the model hierarchy as follows:

- State Roads: Motorways and primary arterials.
- Regional Roads: Secondary or sub-arterials.
- Local Roads: Collector and local access roads.

In addition, there are roads for which the state government may take responsibility because the road serves a special purpose or function rather than because of its general arterial function, e.g. a major tourist access road within a National Park.

There are wide variations in the characteristics and magnitude of services provided by each of these basic functional categories and the way in which road agencies may choose to manage roads within these groups. Some general characteristics are provided later in this commentary. Consideration of these characteristics helps determine the appropriate classification of a road.

Road Classification Guidelines

These guidelines provide criteria for the selection of State and Regional Roads.

The guidelines are descriptive only. More detailed criteria are not appropriate or necessary because:

- There are wide variations in population density, land use, topography, growth rates, etc. across NSW.
- There is no absolutely rigorous method for classifying roads at the interface between classes.

C4.1 State Roads

For the purpose of these guidelines, National Highways will be considered part of the State Road network. The National Highway network is selected by the Federal Government in consultation with state and local government. National Highways comprise the principal connections between Sydney, Canberra, Melbourne, Adelaide and Brisbane.

It is envisaged that the State Road network will be managed in a way that the roads will generally exhibit the following characteristics:

- form a critical network link – closure to through-traffic is not an option
- priority given to safety and efficiency of through-traffic movement
- high flows of general traffic over long distances and high capacity relative to surrounding roads
- continuous and regular spacing in relation to traffic generating density
- access to property and on-street parking restricted as far as practicable
- access available to all general access vehicle types as far as practicable.

Definition

The State Road network (including the National Highways) is formed by the primary network of principal traffic carrying and linking routes for the movement of people and goods within the urban centres of Sydney, Newcastle, Wollongong and Central Coast, and throughout the state.

Criteria

A road may be a State Road if its primary function meets at least one of the following criteria:

- links major commercial, industrial and residential areas and distribution centres and ports within the Sydney, Newcastle, Wollongong and Central Coast urban centres
 - urban centres as defined by the Australian Bureau of Statistics
- primary through-traffic route carrying significant volumes of traffic
- major public transport corridors
- major freight corridors
- connection between major rural arterials and major ports, freight terminals and distribution centres
- significant and essential supplementary route for through-traffic parallel to a primary route as defined by the above, in critical, strategic locations only
- links major NSW towns with Sydney, Newcastle, Central Coast and Wollongong
- links these major NSW towns with each other where there is significant interaction
- major towns population generally in the range 10 000 to 100 000 but may include slightly smaller centres which provide a wide range of commercial, community and administrative functions to an extensive hinterland and primary route exhibiting best operational features and an intention to manage as the major route
- significant economic and social interaction exhibited
- generally minimum AADT greater than 1000, or at least greater than 500 and growing at a faster rate than on surrounding roads
- may include cross-border links to interstate major centres
- links major regions throughout the state with each other

- provides a long distance connection between regions not already provided for in the network defined by the above criteria, or 'missing links' that complete long distance connections between the network already defined by the above
- sustains a high flow of general traffic (generally AADT greater than 500) over long distances (100 km)
- significant long distance freight or coach route
- may include cross-border links to interstate regions.

C4.1.1 Regional Roads

Definition

Regional Roads comprise the secondary network, which together with State Roads, provide for travel between smaller towns and districts and perform a sub-arterial function within major urban centres.

Criteria

A road may be a Regional Road if its primary function meets at least one of the following criteria:

- links smaller towns with the State Road network
- connects smaller towns with each other. Performs a sub-arterial function in major urban centres by:
 - supplementing the State Road network for significant intra-urban flows
 - providing access for significant flows to other commercial and industrial centres
- provides access from the State Road network to major recreation and tourist areas of state significance
- provides a town or suburban centre relief route for significant flows of through-traffic, especially freight vehicles
- provides access for significant flows of freight vehicles to major rural intermodal interchanges and urban distribution areas.

Commentary on Criteria for Urban Areas

This commentary is intended for use as a supporting guide in interpreting the Criteria for Classification of State and Regional Roads in Urban Areas where the classification may not be clear cut. The commentary is based on a study conducted by Connell Wagner P/L in 1995 for the RTA in consultation with councils in the RTA's Sydney Region.

It is NOT intended that this commentary take the place of those Criteria, as the final determination of the classification of a road is based on an assessment of the road's overall functions and not on the application of numerical 'warrants'.

Consideration should also be given to the special circumstances that arise for roads on the Urban Fringe, which may have characteristics of rural roads and could be considered under Rural Criteria.

Road functions

The Connell Wagner study identified five principal functions of the classified road network.

- 'Goods and Services' describes the movement of goods and services including freight, government, business-to-business and business-to-consumer travel.
- 'Mobility' describes the movement of individuals including both drivers and passengers for the journey to and from work, for social and recreational travel.

- ‘Public Transport’ describes the use of public roads by buses, light rail and other public transport modes.
- ‘Tourism’ describes the use of roads to access tourist and recreational facilities.
- ‘Community’ describes the use of roads by the public for access to private property, as pedestrian space and parts of precincts that are dominated by residential, recreational and retail uses.

The relative importance of the above functions (in decreasing order from the top of each column) as identified by the Connell Wagner Study is as shown in Table C4 1.

Table C4 1: Functional priorities

State	Regional	Local
Goods and services	Mobility	Community
Mobility	Goods and services	Mobility
Public transport	Public transport	Public transport
Tourism	Community	Tourism
Community	Tourism	Goods and services

Road Functional Characteristics

There are wide variations in the characteristics and magnitude of services provided by each of the basic functional categories of roads, and in the way in which road agencies may choose to manage roads within these groups. Some general characteristics are:

1. Travel patterns

Roads of higher classification should cater for state-wide and regional traffic movements over relatively long distances. Lower order classifications should cater for local traffic movements over shorter distances and access to abutting property including the access leg to property for long distance trips.

2. Connectivity

The road network functions more effectively if it is connected in a hierarchical fashion. That is, roads should be desirably connected to other roads with the same or similar functions.

3. Through commercial traffic

Long distance commercial vehicle operation should desirably occur on roads of higher classification and be discouraged on local roads.

4. Relative traffic usage

Roads of higher classification, being the principal routes between traffic generating centres, should have higher traffic usage relative to roads of a lower traffic usage in that region, taking account of urban and rural differences.

5. Frontage access

Direct access from adjoining properties to roads of higher classification should desirably be limited in recognition of their through-traffic function, and for traffic safety and flow reasons. Due to historical development, some major roads in urban areas may not currently exhibit this characteristic. Planning policies may nevertheless be directed toward this goal in the longer term.

6. Side road connections

Roads of higher classification should have limited side road connections. They may be grade-separated or be controlled at-grade by traffic lights. Lower classes of road may be controlled at-grade by regulatory signs, or Local Area Traffic Management devices.

7. Route capacity

Roads of a higher classification may tend to be higher capacity routes with relatively higher operating speeds and traffic volumes, and with additional capacity to facilitate traffic flow (such as climbing and passing lanes, and intersection turn bays). Lower classes may tend to have lower capacities with lower operating speeds and traffic volumes.

8. Travel speed

Roads of higher classification with their emphasis on long distance travel, should also tend to have relatively higher travel speeds.

9. Pedestrian/cyclist provision

Roads of higher classification should desirably provide for separate pedestrian/cyclist facilities, while lower classes of roads may not have any special provision for cyclists.

10. Parking

Roads of higher classification should desirably prohibit parking and provide for clearway conditions, while lower classes of road may provide for kerbside parking.

11. Cross-section type

Roads of higher classification should desirably be divided into 4–6 lane roads, ranging through to 2-lane undivided for lower classes of road. This criterion is related to route capacity, as well as manoeuvrability of heavy vehicles.

12. Bus routes

Roads of higher classification should cater for major bus movements, including express buses. Lower classes of road should cater more for local bus operations.

13. Vehicle priority

Roads of higher classification are likely to provide priority capacity for particular uses by way of bus lanes, truck lanes or transit lanes. Lower road classes would generally provide for mixed traffic.

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Commentary 5

Figure C5 1 illustrates a linear city form, much longer than it is wide, providing the opportunity for a very efficient line-haul public transport service (also linear) along the city spine. Because of the linear city form, this single route necessarily passes through or close by all significant activity centres in the city. A large proportion of the population can access the service by walking, and those who access it using other modes will still have relatively short access travel distances.

Figure C5 1: Linear network

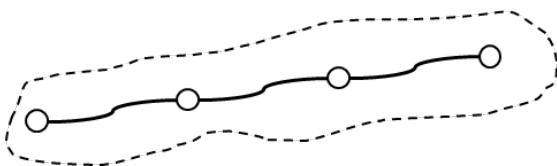
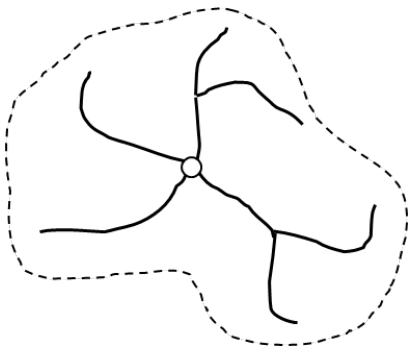


Figure C5 2 illustrates a metropolitan area that has a single, strong activity centre (the CBD), which is the hub of a radial public transport network, i.e. all routes are directed to the CBD, which is the primary travel destination, as well as the primary point of interchange between different routes. In a larger city, the network shown would be that for line-haul services, and access points along each route would typically be provided with feeder services, especially in outer suburban areas where the separation of line-haul routes is the greatest.

Figure C5 2: Radial network



The metropolitan area illustrated by Figure C5 3 has three major activity centres, each of which is provided with essentially radial, local feeder services. Each of the centres is likely to be the primary location for employment, retail, business, social and recreational activities for its local area, but ready access to more distant activity locations is facilitated by the line-haul service indicated by the heavy line connecting the three centres.

Figure C5 3: Multi-centred network

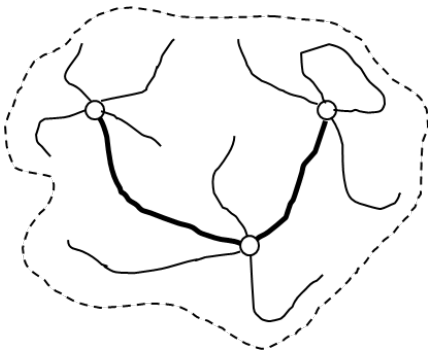
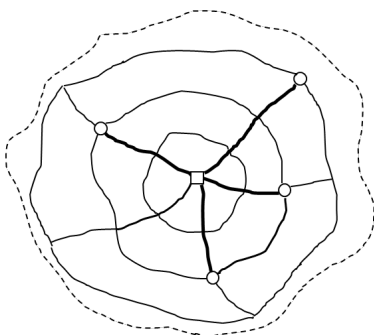


Figure C5 4 illustrates a ring-radial public transport network. This is likely to be suitable for a city that has a dominant central activity district together with a number of other relatively strong activity areas. Because of its high connectivity, it provides public transport travellers with a number of alternative routes for any trip, but often one route will be clearly more efficient than the other options. The capacities of individual links in the network will vary according to levels of interaction between different activity centres.

Figure C5 4: Ring-radial network



The above are a few examples of basic network types. In a real urban situation, combinations of elements of these or other basic types (e.g. rectilinear grid) may be used to provide a public transport network that most appropriately matches the city form and structure, and the social and economic objectives of the community, within the prevailing constraints on resources and other factors.

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Commentary 6

Unreliability in a handful of public transport services can result in a 'snowballing' systematic breakdown. The positive feedback loop operates as follows (Currie 2003).

Traffic delays result in a vehicle running behind schedule:

1. The vehicle arrives late at the next stop.
2. More passengers are at the stop because they have had more time to accumulate.
3. When the vehicle arrives, a larger than expected number of passengers board.
4. This delays the vehicle further as boarding time takes longer.
5. Go back to two.

Small delays thus compound into large delays. Public transport vehicles bunch. Lead vehicles are overcrowded, while following vehicles are increasingly empty.

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Commentary 7

The following commentary contains information extracted from Roads and Maritime Services of New South Wales guidelines that provide an example of guidelines for the assessment of high productivity vehicle (B-doubles and road trains) routes, with particular regard to the design and traffic management factors (Roads and Maritime Services 2012). Similar guidelines also exist for road train route assessment (Roads and Maritime Services 2012).

C7.1 Dimensional Capacity

C7.1.1 Lane and Shoulder Widths

Description	AADT	Min lane width (m)	Min shoulder width (m)
Low volume	< 100	5.5 m formation on straight alignment	
See note		For curves, refer to A3.3.2	
Low volume	100–500	7.0 m formation on straight alignment	
See note		For curves, refer to A3.3.2	
Other	500–2000	3.0	1.0
	2000–6000	3.0	1.2
	> 6000	3.25	1.2

Note: Local and Regional roads carrying low volumes of traffic are to be assessed based on traffic, gradient, lane width, sight distances and other relevant factors.

Lane width is the 'trafficable width' divided by the number of lanes. Shoulder width includes both sealed and unsealed portions of the shoulder. Widths are derived from measurements using the RTA Road Condition (ROCOND) Manual.

In urban areas, the minimum desirable shoulder widths may not apply.

Corners which would be travelled at slow speed are to be checked to ensure that they adequately accommodate the B-double swept path.

C7.1.2 Vehicle Swept Path Requirements

The geometry of curves on low speed and/or low volume roads, intersections, roundabouts, and other traffic management devices should be checked to ensure they adequately accommodate a B-double travelling at low speed. Swept path diagrams for a B-double appear in Austroads Design Vehicles and Turning Path Templates.

A field trial will assist in assessing swept path requirements.

C7.1.3 Railway Level Crossings and Adjacent Intersections

At crossings controlled by signals, the signal warning time is to allow for clearance of the longer vehicle.

At crossings with passive control (signs only), sight envelopes are to be adequate for B-doubles.

There is to be sufficient road length either side of a level crossing to allow the B-double to clear the crossing before having to stop at an intersection, and to clear an intersection before having to stop at the level crossing. Similarly, there is to be sufficient road length between adjacent intersections to allow the B-double to clear the first intersection before stopping at the second.

C7.1.4 Terminals

Persons/businesses wishing to obtain high productivity vehicle (HPV) access to terminals are responsible for ensuring the suitability of terminals. Road managers should ensure that the geometry of the terminal is sufficient to allow entry and exit in a forward direction. Swept path diagrams and/or a field trial may assist the person/business seeking HPV access to identify the suitability of the terminal.

C7.2 Road Safety and Traffic Management

Steep grades that are speed limited for normal articulated vehicles are generally not a constraint for B-double access, as B-doubles are required to meet minimum braking requirements.

C7.2.1 Overtaking Opportunities – Rural Areas

Overtaking opportunities are to be sufficient so that the percentage of vehicles following another vehicle meets the requirements for that route. The Traffic on Rural Roads (TRARR) model can be used to identify the percentage of vehicles following. Particular attention would need to be given to roads with significant proportions of grades exceeding 5%.

It should be noted that sight distance is a major consideration when establishing centreline markings. However, if the route has a significant proportion of double lines, overtaking of B-doubles is no worse than for other vehicles.

C7.2.2 Sight Distances

Horizontal and vertical sight distances at intersections which meet the Safe Intersection Sight Distance standards specified in the RTA Road Design Guide are satisfactory. Sight distances which do not meet these standards can still be considered.

C7.2.3 Traffic Signals

The minimum green time should be sufficient to allow B-doubles to safely clear an intersection from a stop-start position.

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Commentary 8

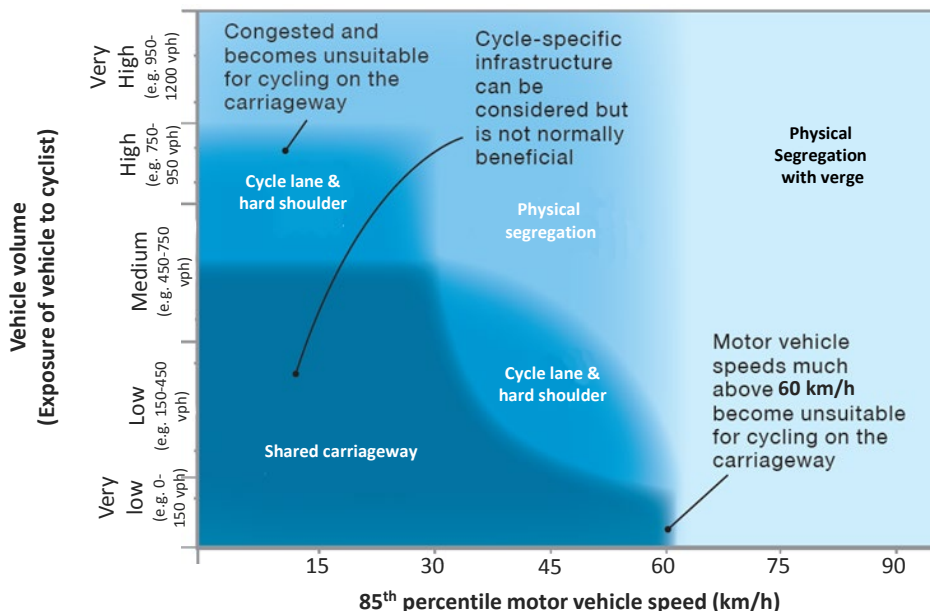
The design of bicycle facilities should be based on context sensitive design principles (outlined in the *Austrroads Guide to Road Design Part 2: Design Considerations* (Austrroads 2008–15)) with the appropriate bicycle facility determined through a full network operation planning process which takes into account the level of service desired for bicycles based on cyclist demand (both actual and potential), cyclist type, priority granted for cyclists on the particular road and other users of the road including on-street car parking.

While *GTM Part 5* (Austrroads 2014a) Section 3.4 Allocation of Road Space between Road User Types outlines various bicycle facilities that could be considered when designing for bicycles, Figure C8 1 provides guidance to practitioners on the separation between bicycles and motor vehicles for the preferred on-road bicycle route. It is based on the roads' expected/actual magnitude of volume and actual or planned 85th percentile speed. Use of Figure C8 1 does not replace the need to design bicycle facilities.

Similarly to car drivers, aspects such as good surface, directness, comfortable gradients and minimal disruptions are key level of service issues for cyclists. The LOS framework referred to in Commentary 1 provides guidance on the various LOS levels achieved for various bicycle facilities applicable to the road environment. Further, experienced road cyclists are unlikely to use off-road facilities as an alternative to routes where the road carries high volume, high speed traffic, unless the off-road route is suitably designed for their needs with appropriate directness and priority, therefore providing a faster alternative. If bicycle facilities such as cycle tracks or bicycle-only paths are poorly designed without appropriate directness and priority, on-road bicycle lanes or suitable road shoulders may still be required in addition to off-road facilities.

Users, seeking to use Figure C8 1 for guidance should consider the magnitude of exposure cyclist would have to passing vehicles. This will need to take into consideration the vehicle flows in the direction of travel of the cyclist and ability for vehicles to pass a cyclist with adequate clearance. This will be influenced by directional splits, lane configurations and width of lanes. The 85th percentile motor vehicle speed can be based on actual posted speed where the road is existing or planned speed where the road is proposed.

Figure C8 1: Guidance on the separation of cyclists and motor vehicles for the preferred bicycle route



Source: Adapted from Sustrans (2014).

Pedestrian and cyclist separation also needs to be considered when planning for off-road shared paths. Practitioners should refer to the *Austrroads Guide to Road Design Part 6A: Pedestrian and Cyclist Paths* (Austrroads 2008–15), which is currently being updated for further guidance.

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Austrroads' Guide to Traffic Management consists of 13 parts and provides comprehensive coverage of traffic management guidance for practitioners involved in traffic engineering, road design and road safety.

Guide to Traffic Management Part 4 : Network Management provides guidance on traffic management at a network level. It addresses network needs of the various categories of user, the characteristics of various types of network and, importantly, describes a planning process for balancing or prioritising the competing needs of different users based on a movement and place framework view of the road network. It describes the Network Operation Plan, which provides a framework for defining the intent of operation of the network, the priorities accorded to the various road user groups, network strategies, and the action plan that defines how the network is to be managed, operated and developed.

Guide to Traffic Management Part 4



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