Guide to Traffic Management Part 5

Road Management

Austroads

Guide to Traffic Management Part 5: Road Management

Austroads

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Guide to Traffic Management Part 5: Road Management

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Abstract

The *Guide to Traffic Management Part 5: Road Management* is concerned with traffic management on sections of road between major intersections. It focuses on traffic management issues and treatments related to various situations but does not provide dimensions or other details for the design of treatments as these are provided in the *Guide to Road Design*. Guidance on traffic management at intersections is provided in the *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings*.

Part 5 presents detailed information and guidelines relating to the factors that need to be considered in applying traffic management techniques and treatments to road types that include motorways and expressways, urban arterial roads, urban local roads, rural highways and rural local roads. It considers the needs of all road users including pedestrians, cyclists, motorcyclists, heavy vehicles and public transport. It provides the guidance under the four key areas of access management, road space requirements for general traffic use, allocation of road space between road users, lane management and speed limits.

Keywords

Access management, road space allocation, off-road space, road users, lane management, tidal flow, lane control, on-road parking control, speed limits, speed zones, speed limit signs, auxiliary lanes, medians, outer separators, pedestrian space, shoulders, one-way roads, high occupancy vehicle lanes, buses, trams, trucks, bicycles, cyclists, motorcyclists, rest areas, turns, clearways

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Edition 3.1 of the Guide has been updated with Safe System content, including:

- Revisions to Section 6.1 The Safe System and Safe Speeds and Section 6.2 Implementation Framework to increase emphasis of the Safe System
- Information added to Section 6.3 General Philosophy of Speed Limits about the role of speed limits and pedestrian and cyclist accessibility, and the *Guide to Road Safety Part 3: Speed Limits*.
- Revisions to Table 6.4 Urban roads – risk-based selection of speed limits for different road categories and functions, to align content with speed-survivability charts

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

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1. Introduction

This Part (Part 5) of the *Guide to Traffic Management* has been given the title *Road Management* to define the limitations on its scope within the context of:

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

The structure and content of the *Guide to Traffic Management* is discussed in *Part 1: Introduction to Traffic Management*. The 13 Parts are summarised in Table 1.1.

The Guide is primarily focussed on mid-block traffic management issues that apply to a single length of road. While it refers to issues covered in other Parts, it is distinguished from:

- Part 4, which covers issues considered at the network level such as whether heavy vehicles should be restricted to specific roads
- Part 6, which deals with traffic management issues relating to the use and design of intersections, interchanges and rail, pedestrian and bicycle crossings
- Part 9, which covers traffic operational matters such as traffic signals and incident management
- Part 10, which provides guidance on the design and use of traffic control and communication devices.

The scope of the Guide is therefore traffic management at a mid-block location along an individual road. The definition of mid-block, however, is loosely interpreted as meaning 'between significant intersections', so that issues associated with vehicles turning to enter or leave minor roads or access driveways to roadside properties (for example) are addressed. It also discusses the important role of major intersections in relation to access management, while recognising that good traffic management practice for intersections is covered in the *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings (AGTM Part 6)* (Austroads 2017f).

In the context of the other Guides in 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 recognised that it is difficult, if not impossible, to discuss many aspects of traffic management without reference to road design and/or safety issues. Therefore, the view is taken that within the *Guide to Traffic Management* any consideration of such issues should be brief and be supported by reference to the *Guide to Road Design* and/or the *Guide to Road Safety* (refer to the scope statements in these Guides).

Within the above limits, the scope of this Guide is broad, addressing both urban and rural environments and the full range of situations to be found in each, including:

- motorways[1], expressways, arterial roads and local roads
- all categories of vehicles and road users including cars, trucks, public transport, cyclists, motorcyclists and pedestrians
- different speed management environments, for example, school zones, linear shopping centres along roads and roadwork zones
- other important uses of roads such as parking.

1 The term 'Motorways' in this Guide also refers to 'freeways'. It is noted that some jurisdictions may continue to use the term freeway to describe a motorway-grade facility.

Table 1.1: Parts of the Guide to Traffic Management

Part	Title	Content
Part 1	Introduction to Traffic Management	• 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	• 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	• 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	• 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	• 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	• 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	• 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	• 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	• Applications used in traffic operations. • System configuration and operation guidance. • Current practice for common systems including network monitoring, traffic signals, congestion management, incident management, motorway management and traveller information. • Related systems integration and interoperability issues.
Part 10	Traffic Control and Communication Devices	• Signing and marking schemes. • Traffic signs, static and electronic. • Pavement markings and delineation. • Traffic signals and islands.
Part 11	Parking	• Parking policy. • Demand and supply. • On-street and off-street. • Parking guidance and control devices.
Part 12	Traffic Impacts of Developments	• 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	• 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 the *Guide to Road Safety*.

Roads may be developed that have limited access (i.e. no driveways or minor streets that intersect the highway) with access provided only at roundabouts, traffic signals or interchanges. In some jurisdictions, these roads are called expressways (e.g. New Zealand and Western Australia) and provide a level of service between that of a motorway and a conventional arterial road. They may provide an interim stage pending ultimate development to a motorway. The principles in this Guide also apply to expressways. It is also noted that motorway is a legal term in New Zealand.

A final issue in relation to scope is that this document provides guidelines to good practice in traffic management, rather than specifying mandatory practice. Aspects of practice which are mandatory (for example the form and placement of speed restriction signs) may be mentioned but their specification is the province of Australian Standards, or legislation such as the New Zealand Land Transport Rule: Setting of Speed Limits 2003, as is recognised by appropriate references within the Guide (e.g. references to the Australian Standards and New Zealand Land Transport Rules).

1.1 Jurisdictional Supplements

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

In addition to supplements, jurisdictions may have specific guidance on subject matter outlined in the Guide. For example, the NZ Transport Agency has released the *Speed Management Guide* (NZ Transport Agency 2016) which may contain some differences to this Guide. Practitioners should therefore be aware of guidance released by jurisdictions.

Where a discrepancy exists between the content of the Guide and practice outlined by the jurisdictional guidance, the latter takes precedence.

1.2 Movement and Place

The *Guide to Traffic Management Part 4: Network Management (AGTM Part 4)* (Austroads 2016b) provides the high-level strategies and objectives for managing road networks; this includes the Movement and Place framework and Network Operation Planning (NOP).

The need to provide for all users of the road network in an equitable and balanced manner is a challenge in urban areas and regional centres. There are various types of users of the road network and their needs vary depending on their mode of travel. At times, needs may conflict.

The Movement and Place framework (as shown in Figure 1.1 and outlined in further detail in Austroads (2016b)) recognises that roads serve two primary roles for users:

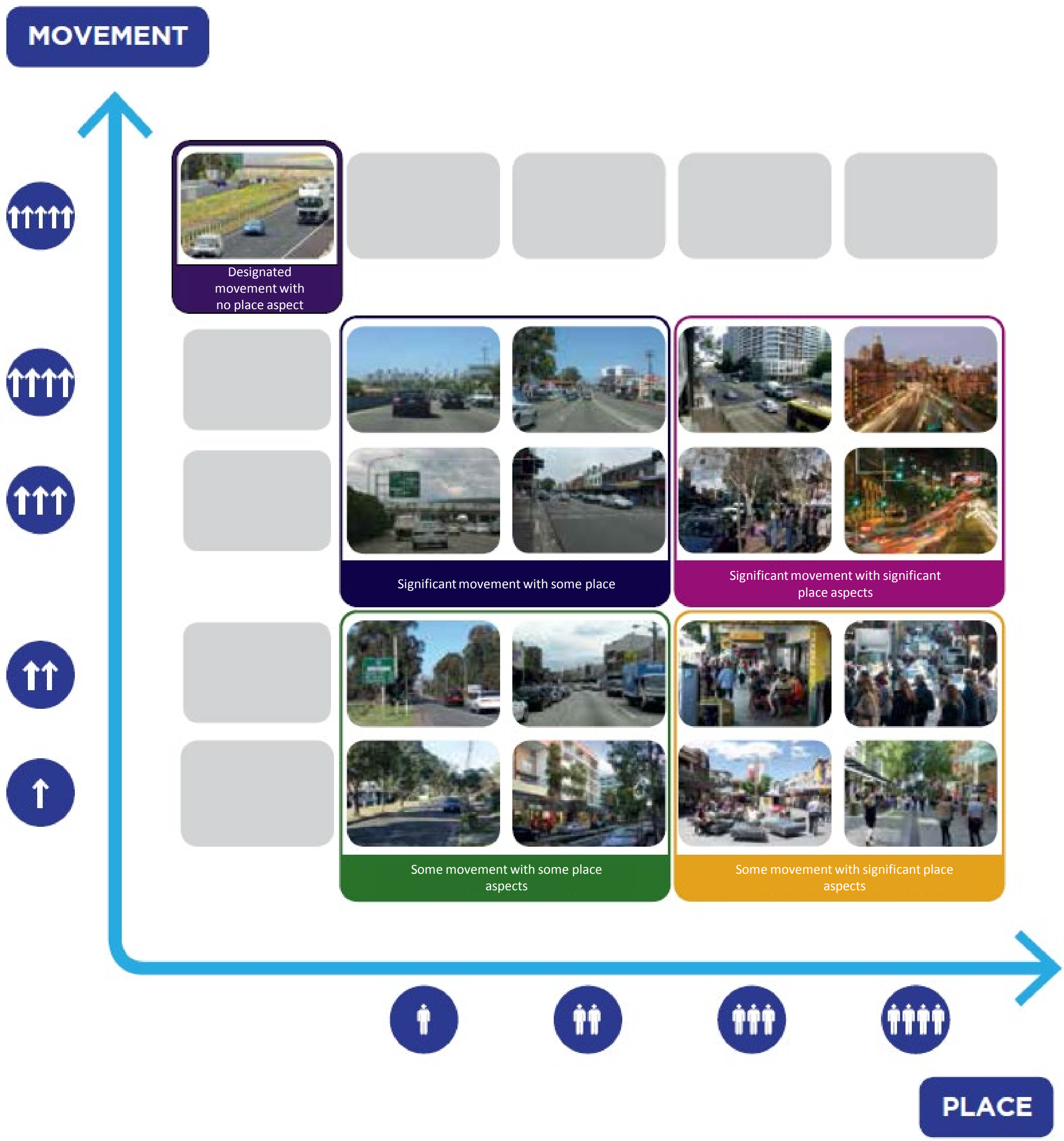
- facilitate the **movement** of people and goods
- act as **places** for people.

The movement function is determined by the strategic significance of the road within the network. This is identified by the volume of people and goods moved and the longer journeys that it serves. Movements include all forms including those of pedestrians and cyclists.

The place function is determined by the strategic significance and community value of a place. Roads can be places and are often located within areas such as urban activity centres, strip shopping centres, transport hubs, educational institutes and community centres.

The framework considers the relative priorities of the movement of people and goods to their destination (often referred to as the Link and Place framework) and identifies the road types within the road network that are best suited to the users' journey needs, community-defined places, values and transport modes. Victoria's SmartRoads tool provides guiding principles to categorise roads in accordance with the Movement and Place framework which is discussed further below.

Figure 1.1: Movement and Place framework



Source: Adapted from Transport for NSW (2016).

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

For motorways, the primary objective is the safe movement of people and goods, however for other categories, roads may serve a combination of other functions including:

- 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 1.2(a). Roads generally provide mobility and access functions to various levels as illustrated in Figure 1.2(b).

While the Movement and Place framework provides the general principles of a network that is equitable and balanced for the various users (referred to as priorities), a NOP aims to guide the operation and development of road/transport networks towards managing competing priorities. An NOP (which is sometimes also referred to as a Plan of Operational Management) 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 improvement of the network
- processes to review and update the NOP.

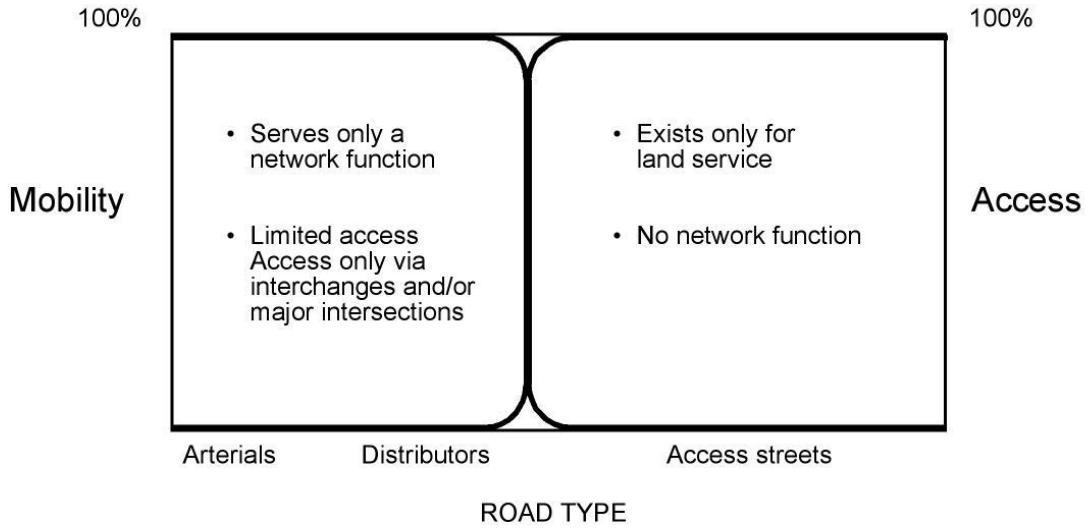
An NOP underpins higher-level strategic plans and should be developed in full consultation with stakeholders and the community. The key planning principles in an NOP are:

- move people and goods instead of vehicles
- see transport as supporting broader community goals, e.g. encourage active transport
- prioritise the competing demands of various road user groups for limited road space and time in accordance with broader community goals
- implement thinking of networks rather than corridors, routes, links or nodes
- undertake stakeholder consultation as a key input to the planning process
- collaborate with transport partners (e.g. bus operators, related agencies)
- provide safer road travel for all road users and move towards the broader application of the Safe System approach to the road network by reducing the risk of death and serious injury
- define the operational intent which then determines the priority, design and scale of network improvement projects
- undertake fit-for-purpose management based on adoption of agreed road use hierarchies and networks.

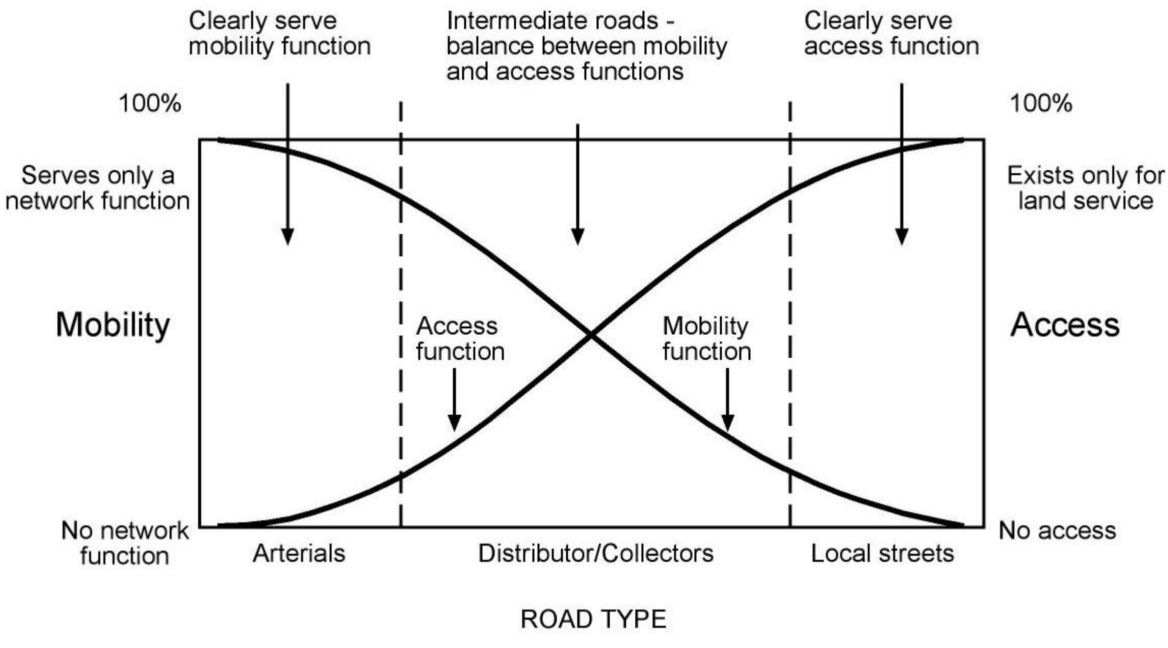
In a hierarchical sense the *AGTM Part 4* (Austroads 2016b) is above this Guide. Moreover, an NOP is above any individual road management plan and guides how a road should be managed to meet the objectives of the NOP.

Austroads (2016b) embraces the concept that traffic management needs to address all transportation needs across all modes and across an extended geographical area. Network management principles as reflected in an NOP aim to optimise the existing road network infrastructure 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.

Figure 1.2: Road type and function



(a) Two class model of road types



(b) Road type and function – mobility vs. access

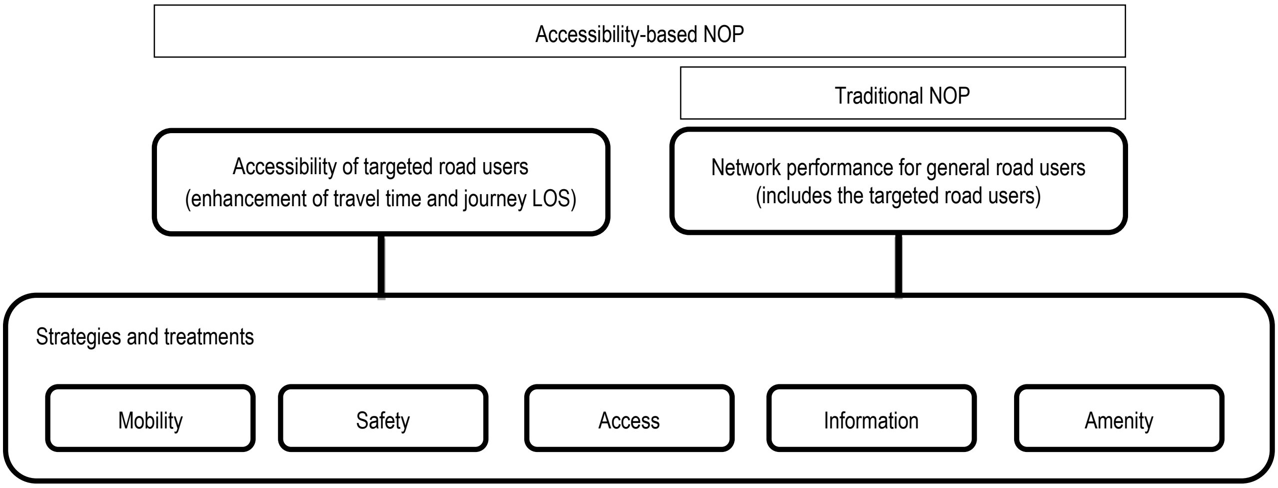
Source: Brindle (1987).

This Guide provides the toolkit for the management of the mid-block sections of individual lengths of road for the various user groups. As outlined earlier, the *AGTM Part 6* (Austroads 2017f) provides the toolkit for intersections and the *Guide to Traffic Management Part 9: Traffic Operations (AGTM Part 9)* (Austroads 2019b) provides the toolkit for intelligent transport systems.

The *Guide to Traffic Management Part 12: Traffic Impacts of Developments (AGTM Part 12)* (Austroads 2019d) guides the practitioner in identifying and managing impacts on the road system caused by land use developments. Guidance is given on design, development and management of a variety of land use developments, highlighting the needs for access to the land developments as opposed to 'last mile' access. The South Australian Freight Council (2015) defines first or last mile access as the short distance required to connect a business, farm or similar facility (a freight origin point) to an existing heavy vehicle route, and/or to connect the heavy vehicle route to a port, freight yard, silo or drop-off point (a key freight destination point).

An accessibility-based NOP extends the 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 level of service (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 1.3).

Figure 1.3: Network Operation Plan with consideration of accessibility needs of targeted road users



Source: Austroads (2015d).

The *AGTM Part 4* (Austroads 2016b) provides a LOS framework that allows users to assess the LOS measures for five types of road users (private motorists, transit users, pedestrians, cyclists and freight operators) and across the five needs (mobility, safety, access, information and amenity). The LOS framework enables users to measure gaps as a result of implementing road strategies and in doing so understand the trade-offs of LOS for road users and their needs. This enables practitioners to implement an accessibility-based NOP.

The LOS gap analysis can be undertaken to compare the current measured LOS with the goal using a tool such as SmartRoads. The tool, which was originally developed by VicRoads:

- provides an interactive planning environment to visualise road use priorities, operation gaps and impacts of treatments
- facilitates the consistent application of the NOP 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 NOP. A current Austroads project will develop the business case and specifications for the next generation NOP tool. It will also support the application of the current SmartRoads tool, including upgrades and technical support. Further information on the SmartRoads tool being developed by Austroads can be found in Austroads (2016b) and on the Austroads website (Austroads 2017a).

The LOS framework incorporates safety as a user need and the framework is consistent with Safe System principles. By expanding the framework to include various road users, practitioners can determine the effects that different strategies will have on road users.

Development of the Accessibility-based Network Operations Planning Framework (Austroads 2015d) provides example case studies applied at a neighbourhood and metropolitan level.

1.3 Mobility and Access – a Subsidiary of Movement and Place

Transport and other functions served by roads, the needs of abutting land uses, along with wider government strategic objectives, all influence how roads are managed.

The most important arterial roads (e.g. inter-regional roads, urban motorways and expressways) focus on mobility of traffic while other roads exist primarily to provide access to properties. Indeed, the balancing of these two main functions is fundamental to traffic management. Direct access to arterial roads (via driveways or local streets) provides the most convenient level of access for land abutting them but it may also lead to traffic infiltrating into local areas. The restriction of access to local streets that intersect with arterial roads can improve the amenity of these areas.

Recent developments in policy and strategic planning initiatives are aimed at giving greater recognition to walking activity in road and transport planning. This has arisen from policy settings in the transport and health sectors recognising the need to move towards more sustainable forms of transport (by foot, bicycle or public transport) and towards healthier activity (walking, cycling) by the community generally (Austroads 2013).

This has led to recognition of the need for planning and providing a road network which caters for the potential increase in active travel such as walking and cycling. This is a fundamental factor for consideration in striving for balance between the mobility and access functions.

This is particularly relevant to local roads and streets in the urban network where pedestrian activity, and the potential for conflicts, is greatest.

The primary function or balance of different functions may be reflected in the classification of a road. In its simplest form, road classification may consist of two basic road types which have fundamentally different traffic and environmental goals:

- arterial roads, the main function of which is to provide for the safe and efficient movement of people and freight
- local roads, which provide direct access to abutting land uses and which contribute to the overall functioning of areas bounded by arterial roads or other barriers. The basic function of a local road is to provide a good environment in which to live or conduct a business and to enable vehicular access to abutting land.

The classification (two tiers) is illustrated in Figure 1.2(a) and while this model could lead to a high level of mobility on arterial roads it may not lead to the type of road system and road environment desired by communities. Historically, Australasian practice for the management of the road environment has been based on a mixed function, as illustrated in Figure 1.2(b), providing both a mobility function and an access function. Some road classification systems attempt to reflect the mixed function and the design and management of the roads and their networks also need to reflect the mixed function.

Figure 1.2(b) demonstrates that for some roads there are competing legitimate demands for a strong emphasis on mobility on the one hand, and increased emphasis on local amenity on the other. This inevitably creates debate and problems with respect to the traffic management required to achieve an appropriate balance. As a result of the inherent conflict between the functions in the conventional ‘continuum’ concept of road classes (Figure 1.2(b)), there has been a trend in the planning of some new urban developments towards the basic two-level functional classification system (Figure 1.2(a)).

Within the two-level model, a framework for arterial road access management based on access management categories described in Section 2.1.3 and Table 2.1 may provide the basis for categorising and managing specific routes and sections of road within arterial networks, and for resolving the balance to be achieved between the mobility and access functions.

Further guidance on the functional classification of roads is provided in the *AGTM Part 4* (Austroads 2016b).

1.4 Linkage to Other Road Strategies including the Safe System

In addition to providing mobility and access, a road needs to be managed and maintained so that mobility and access can be provided in a safe manner. The *AGTM Part 4* (Austroads 2016b) provides an overview of the linkages between the asset management, network management and Safe System strategies.

The Safe System approach which recognises that humans, as road users, make mistakes, aims to achieve safe roads and roadsides, safe vehicles, safe speeds and safe road users so that road users avoid serious injury or death in the event of a crash. The Safe System incorporates principles which can be applied to manage vehicles, roads and roadside infrastructure and speeds to reduce death and serious injury. Further details on the Safe System in the context of traffic management can be found in the *Guide to Traffic Management Part 13: Road Environment Safety* (Austroads 2015b). At a road level, as opposed to a network level, the Safe System is implemented through safer speeds and safer roads across the network. This Guide discusses the principles of access management, road space allocation, lane management and speed limits to implement the Safe System and therefore provide safer travel. In addition, practitioners may refer to the following Austroads reports:

- *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice* (Austroads 2016e) for examples of engineering treatments that may be used to achieve Safe System speeds on urban arterial roads (refer to Appendix A)
- *Methods for Reducing Speeds on Rural Roads: Compendium of Good Practice* (Austroads 2014a) for examples of engineering treatments that may be used to achieve Safe System speeds on rural roads (refer to Appendix B)
- *Guide to Traffic Management Part 8: Local Area Traffic Management (AGTM Part 8)* (Austroads 2016c) for guidance on the use of local area traffic management to provide safe roads.

The accessibility-based NOP LOS framework as described in the *AGTM Part 4* (Austroads (2016b) incorporates safety as a key part of the user needs and is based on Safe System principles. By including various road users and their needs, the framework assists practitioners in understanding the appropriate safety LOS for users relative to the intended function and role of the road. The role may change by location, day, and time along a road. For example, while a road may be classified as an arterial or highway, it may go through an activity centre and therefore its function will change. This may result in local area traffic management facilities being put in place to improve safety, mobility, amenity and access to the activity centre for vulnerable road users.

2. Access Management

Access management is the process of controlling the movement of traffic between a road and adjacent land. The purpose of access management is to protect the safety and efficiency of the traffic function of the road, while acknowledging the needs and amenable use of adjacent land, (particularly safe and appropriate access).

The traffic in question may include pedestrians and vehicles of any type, motorised or non-motorised, including trams, bicycles and mobility scooters. The traffic movement between the road and adjacent public or private properties is achieved through some form of intersection. The intersections may include interchanges, major and/or minor at-grade intersections, driveways or paths directly connecting the two, or may be indirect, via one or more local roads. In some cases, intersections may be created to serve only the traffic associated with a property development.

The mobility, safety and amenity of road users and occupiers of abutting land are influenced by the provision for access to and from roads. Given this, the objective of access management is to achieve a level of interaction between the road and abutting land that is consistent with the function of the road, as discussed in Section 1.

The need for access planning and management arises because vehicle movements generated by abutting properties can potentially create interruptions in the traffic flow along a road. On many roads, these interruptions are of little or no concern. However, on arterial roads carrying high traffic volumes or fast-moving traffic, where traffic efficiency is of greater importance, these interruptions can create a greater risk of crashes, inefficiencies and other costs to the community. An effective access management strategy for a road or site contributes to the best outcome for the community by protecting the level of traffic service on important through traffic routes while providing road users with safe and appropriate access to adjacent land.

It is also important to manage the type of development on roads so that vulnerable road users are not subjected to an unacceptable crash risk. For example, the provision of services such as food and rest rooms on only one side of major divided highways can lead to unsafe crossings of the road by pedestrians.

While access management is applied to roads or sites, it is an integral element of the larger transport and land use planning framework and is influenced by broad planning policies and objectives.

Refer to Commentary 1 for further information on access related to crashes and Commentary 2 for further information on planning access management on arterial road developments.

Commentary 1 and Commentary 2

2.1 Application of Access Management

2.1.1 Current Approach

Access management is generally achieved by:

- Access control by statutory or planning regulations pertaining to a road or road class or the general development of abutting land. These may fully or partially prohibit or restrict driveways, local roads and paths from having direct access to an arterial road. In some cases (if allowed under relevant legislation) access may be controlled by implementing statutory land use zoning controls such as vegetation reserves within the road reservation.
- Access control by geometric design, either through the cross-section arrangement (e.g. by the provision of service roads or raised medians) or by grading design (e.g. by placing an arterial road in a cutting). In this method access is focussed at the more important intersections or at other suitable locations where service roads or side roads may be permitted to join the major road.

- For roadside developments, by including conditions for access provision in planning permits issued by planning authorities.
- Access control by traffic regulation, for example, by erecting ‘no right turn’ or ‘no entry’ signs, or islands that physically prohibit the entry of certain traffic movements.

Refer to Commentary 3 for further information on access management objectives.

Commentary 3

2.1.2 Strategic Approach

A strategic approach to access management for the road network and road corridors has been proposed in recent years. It provides basic steps and factors for the consideration of new planning development applications and for assessing proposals. It proposes that the classification of roads by a designated access category is the foundation of an effective access management program. Access categories are defined in terms of a combination of performance requirements and indicative physical characteristics.

Table 2.1 illustrates this approach, providing a description of possible access management categories for road types ranging from motorways, expressways, mixed function roads, to local roads. Table 2.1 is based on the Austroads functional classification system as outlined in the *Guide to Road Design Part 2: Design Considerations (AGRD Part 2)* (Austroads 2015a). It is noted that state road agencies may categorise their roads differently.

The access management categories identified in Table 2.1 could be readily applied to the development of new roads and new road networks. However, their application to existing roads and networks would require that an appropriate and practicable access management category be assigned to sections of road. Nevertheless, it may be possible to use access management categories to change a road’s interface with land use through statutory planning over a substantial period.

2.1.3 Access Management Practice

In addition to describing possible access management categories spanning the range of road types, Table 2.1 also identifies access management tools appropriate to each category and provides advice on good practice in the implementation of the tools.

As is evident from the entries in the typical road type and function column, Table 2.1 applies to both urban and rural roads. The treatment of motorways and expressways (Category 1A) is similar in both contexts but, in other categories, there are differences in access management for urban and rural roads in the same category, largely due to the much higher density of abutting development and the closer spacing of intersections in urban areas. Commentary 4 and Commentary 5 discuss the nature of access management for urban and rural roads respectively.

Commentary 4 and Commentary 5

Table 2.1: Access categories as a basis for planning policy and development control

Category	Generic description	Typical road type and function	Specific access control tools	Good practice in implementation
1A	**Roads with minimal access** – roads with no driveway or minor road connections (i.e. no access between major intersections, full access control), a median and grade-separated intersections.	Motorways and expressways. In rural areas, provide for interstate or inter-regional movement of people and freight. In urban areas, are the highest-order arterial roads that carry the highest volume of traffic.	• High-speed entry and exit ramps as the sole form of access. • Access bans, or road usage controls, for one or more specific road user categories (e.g. cyclists, pedestrians, farm machinery). • Entrance ramp metering (use of on-ramp signals to control rate and regularity of vehicle entry to motorways and expressways).	• Sufficient separation (refer to the *AGTM Part 6* (Austroads 2017f)) between adjacent entry and exit ramps to avoid problems for weaving traffic and/or other detrimental effects on motorway and expressway capacity. • Permit access to specific user types only if appropriate road facilities are provided (e.g. shoulder bicycle lanes, ramp crossing points). • Timing of ramp metering release to trade off the reduced probability of breakdown of motorway and expressway flow against the increased entry ramp capacity.
1B	**Roads with minimal access** – roads with no driveway or minor road connections, a median, some at-grade intersections and some grade-separated intersections to meet network needs.	Rural or urban roads. Stage the construction of rural highway toward full access control. Rural motorways and expressways that have same function as Category 1A in rural areas but have at-grade intersections at some locations where interchanges are not economically viable in the short to medium term.	• High-speed entry and exit ramps at some locations. • Signals or other controls on at-grade intersections that provide access. • Access bans, or road usage controls, for one or more specific road user categories (e.g. cyclists, pedestrians, farm machinery).	• Adequate spacing of entry/exit ramps as for Category 1A. • At-grade intersection control to best trade off the minimisation of impact on major road flow against adequacy of capacity for movements to, from or on the intersecting road. • Permit access to specific user types only if appropriate road facilities are provided, as for Category 1A.

Category	Generic description	Typical road type and function	Specific access control tools	Good practice in implementation
2A	**Roads with restricted access** – roads with no direct access to a major road except via intersecting major or minor roads, service road exits/entries, or driveways constructed as junctions (80 km/h and above). With median and subject to longer spacing of access points (e.g. 400 to 800 m) and higher design standards (including deceleration/acceleration lanes), consistent with higher-speed and higher-quality traffic operation.	Higher-speed urban arterials, functioning as primary arterials, with access only via intersecting roads and service road entries/exits at wide spacing. Rural highway (non-motorway and expressway): • provide for interstate or inter-regional movement of people and freight • with infrequent road junctions that may serve as a collective entrance to several properties with infrequent entries serving land uses other than farms or rural residences (e.g. commercial or industrial) • most access movements are left-in left-out.	• Service roads with a limited number of access points. • Medians preventing right-turns except at selected locations. • Indented deceleration/turn lanes in medians where turns are allowed. • Some median openings for U-turns only. • Right-turn bans from and into major urban roads at specified times.	• All driveways and some side roads have access to service road only. • Large spacing of access points from service roads to minimise effects on the major road traffic flow. • Acceleration/deceleration lanes at entry/exit points to allow high-speed joining with/separation from traffic on the major road. • Ideally, have U-turn slots shortly prior to intersections at which other traffic will enter and leave the major road. • Median openings may be provided for right-turns into intersecting side roads remote from major intersections at times when major road traffic is light, but such right-turns may be banned when the major road flow is heavy.

Category	Generic description	Typical road type and function	Specific access control tools	Good practice in implementation
2B	**Roads with restricted access** – roads with no direct access to a major road except via service road exit/entry, minor road junction or driveway constructed as a junction (70–80 km/h). With medians and subject to restricted provision of access points (e.g. 200 to 500 m) and median design standards, consistent with intermediate speed and moderate traffic service.	Intermediate-speed urban arterial providing a primary arterial function at a lesser level of service to Category 2A roads, with more frequent median breaks, minor junctions and regulated driveways. Not normally applicable to non-urban areas.	• Service roads with a limited number of access points to the major road. • Some minor side roads have access only to the service road. • Medians preventing right-turns except at selected locations. • Median-opening geometry allowing right-turns in one direction only. • Indented turn lanes in median where turns are allowed. • Some median openings for U-turns only. • Turn bans may apply at specified times.	• All driveways, some side roads have access to service road only, as for Category 2A. • Closer spacing of access points from service roads than for Category 2A but still check effects on the major road traffic flow. • At lower major-road speeds, angled median openings can be used to allow exiting right-turns while preventing entering right-turns. This may be appropriate, for example, where sight distance is restricted in one direction. • At the lower speeds for Category 2B roads compared with 2A, long deceleration lengths are not needed in right-turn or U-turn slots indented in the median. • Locate U-turn slots and apply time-specific right-turn bans as advised for Category 2A roads.
3A	**Roads with frequent but regulated direct access** and median control/protection of right-turns.	Mixed function urban or rural secondary arterial roads with medians, serving both community and traffic roles.	• Median preventing right-turns except at selected locations. • Some median opening geometry allowing right-turns in one direction only. • Some median openings for U-turns only. • Right-turn bans may apply at specified times.	• As property driveways directly access the major road, use a median to ensure that, generally, only left-turns are used to enter or exit driveways of abutting properties. • Good practice for Category 2B roads in relation to angled median openings, median right-turn or U-turn slots and time-specific right-turn bans, also apply to Category 3A roads.

Category	Generic description	Typical road type and function	Specific access control tools	Good practice in implementation
3B	**Roads with frequent but regulated access** but no median and generally without right-turn restrictions.	Mixed function secondary urban arterial roads without medians, serving both community and traffic roles. Primary and secondary rural arterial roads serving inter-regional traffic movement and providing direct access to abutting property.	• Signage and/or central linemarking at specific, dangerous locations to disallow right-turns or U-turns at all times or at specified times. • Control of driveway locations to meet safety objectives (sight distances, separation from intersections etc.). • Minimisation of number of driveways by combining driveways of adjacent properties.	• While Category 3B roads generally have no medians, it may be appropriate to use linemarking or even short lengths of raised median, with or without signage, to legally and perhaps physically prevent right-turns over a limited length of road. This may be appropriate, for example, where sight distance is restricted. • Minimisation of driveway numbers and control of their locations reduces conflicts between the traffic and access functions.
4	Roads with unrestricted access.	Local roads, the primary function of which is to provide access to local areas and property. May comprise circulatory and access roads in commercial, industrial and residential areas.	• Minimisation of driveway numbers and control of their locations to meet safety objectives (as for Category 3B roads).	• Minimisation of driveway numbers and control of their locations reduces conflicts between the traffic mobility and access functions.

Notes:
It is noted that state road agencies may categorise their roads differently to the categories outlined in the table.
In reference to Categories 1A and 1B the term 'limited access road' has a specific legal meaning in New Zealand.

Source: Adapted from Austroads (2000).

2.1.4 Treatments Used for Access Management

Research by Jurewicz and Zivanovic (2011) indicates that there is a relationship between the number of access points to the roadside and the relative risk of casualty crashes. Various methods of achieving access control, including geometric design, are listed in Section 2.1.1. Geometric elements and design may be used to achieve the required level of access management for any given location or length of road. Treatments that may be used include:

- interchanges – usually for very large developments (e.g. shopping centres)
- signalised intersections – vary in size depending on types of roads and traffic demand
- unsignalised intersections – stop, give-way or roundabout control
- raised medians – to restrict right-turn movements to specific locations
- service roads with outer separators – to remove minor turning movements from the major road and control entry and exit movements to specific locations
- dividing lines to either restrict right-turn movements to property (where provided for in legislation) or permit right-turns through painted right-turn lanes
- left-in/left-out traffic island and signs to prohibit right-turns into or out of a driveway or minor side road
- fencing to direct pedestrian and cyclist access movements to appropriate locations
  - although this should be used as a last resort, due to the potential increase in drivers' speed and a reduction in streetscape and amenity
- where turning movements are restricted and U-turns are permitted, based on a risk assessment at near-by locations, the U-turn facility should be designed to cater for all vehicles permitted to undertake the U-turn, to be able to perform the manoeuvre in a safe and efficient manner. Where large freight vehicles are present this may require the implementation of localised widenings to cater for the swept path of the freight vehicle.

These methods of access control help in reducing the likelihood, severity and/or exposure of the road user i.e. left-in/left-out traffic islands reduce the likelihood of crashes occurring due to the reduction in conflict points and the severity of a crash due to the traffic island directing the angle of the car. This is in line with the Safe System approach; if the access can be managed, the risk becomes closer to zero.

Road agency practitioners should apply accessibility-based NOP principles when considering access management treatments. This is to understand the impact that implementing access management treatments will have on road users.

Accessibility-based NOP should fully explore the impact that treatments will have on all road users and their needs. This can be undertaken through applying the LOS framework outlined in the *AGTM Part 4* (Austroads 2016b). In doing so, practitioners should understand the trade-offs and explore the treatments that minimise the negative impacts of LOS for some users.

A major issue for freight is last mile access which may be due to elements such as the:

- structure of the road (including pavement and bridge structure)
- geometric layout (e.g. horizontal and/or vertical alignment)
- turning restrictions to and from the main road to the industrial precinct.

Practitioners should explore options that not only achieve the desired safety objectives through access management control but also enable freight to access industrial precincts and areas where goods vehicles need to drop off and/or pick up goods. This may require practitioners to implement treatments specifically designed for freight vehicles, for example:

- left and right-turn bays, taking into consideration the acceleration and deceleration characteristics of the freight vehicle
- swept path of the freight vehicle undertaking the manoeuvre to allow the vehicle to undertake the manoeuvre without hitting infrastructure; this may include using mountable kerbs
- timing of traffic signal phasing and operation, in particular right-turns, to allow a freight vehicle to clear the signalised intersection safely before the opposing phase commences.

As noted previously, the *AGTM Part 12* (Austroads 2019d) guides the practitioner in identifying and managing impacts on the road system caused by land use developments.

3. Road Space Requirements for General Traffic Use

Road space allocation is the management of available road space on a road or road network by the application of traffic management techniques, in a manner which ensures that the necessary balance is achieved to meet the mobility, accessibility, safety and priority needs of road users.

Decisions about the allocation of road space need to be based on an integrated approach with the aim of improving the current level of service for all road users, or for specified categories of road users. This concept and some of the broad management issues that may need to be considered are outlined further in Commentary 6.

Commentary 6

The allocation of road space can be considered more specifically as the sharing of the available surface area of a road for two different uses:

- to allow for the different types of activities to occur on a road such as travelling along the road, turning or parking
- to provide for the needs of different road users such as car occupants, truck and bus operators, pedestrians and cyclists.

The activity needs and road user requirements will vary depending on the type of road and road function under consideration (e.g. motorway and expressway, arterial or local road) which in turn will determine the type of traffic management measures to be used.

The following sections provide a more detailed outline of this with respect to the types of road space and road user needs that exist in the context of the road type, road user groups and the forms of traffic management measures that may be appropriate.

The road space allocation topics are addressed under two categories:

- traffic function considerations influencing the provision of road space for traffic flow purposes (e.g. general traffic lanes, auxiliary lanes, turning lanes) and access purposes (e.g. parking, pedestrian movement, property access)
- traffic management considerations in the provision of road space for road users (e.g. bus/high occupancy vehicles/transit lanes, toll lanes, tram lanes, truck lanes, and bicycle lanes).

It should be recognised that there may be some commonality between road space allocation and lane management (Section 5) particularly when considering allocation of road space for the provision of various types of traffic lanes. For the purpose of clarification between the two sections, road space allocation topics generally address the provision of road space for different uses, while lane management is about controlling the use of traffic lanes.

For this Guide, the concept of road space allocation is also applied to areas within the road reservation provided for the movement of road users (e.g. footpaths, bicycle facilities and public transport infrastructure).

While crossings of the road are an important aspect of sharing road space through the allocation of priority and time (as in the case of signalisation) these facilities are only briefly introduced in this Guide and are covered in detail in the *AGTM Part 6* (Austroads 2017f).

This Guide is concerned with the traffic management aspects of road space allocation. For information on the design of facilities and dimensions of design elements, practitioners are referred to *Guide to Road Design Part 3: Geometric Design (AGRD Part 3)* (Austroads 2016a).

Traffic engineering actions on roads generally aim to achieve a balance between providing for traffic travelling along the road and providing for activities that occur beside and across the road. Road agencies typically respond to these competing requirements by defining road networks for the various users and attempting to meet their needs on the roads forming part of the network. These different needs, expressed in terms of road functions, are reflected in the classification of a road.

The general traffic management goals for roads are to:

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

There are various traffic engineering actions that allocate available road space for mobility and access of general traffic without special regard to the specific needs of road user groups. These actions are largely related to the provision of traffic lanes and other road space (e.g. paths) and address potential vehicle conflicts that arise on the road network.

The actions can also extend to the management of parking space in the context of it competing with the mobility and safety needs of road users in general.

The road space requirements for the mid-blocks of road environments are presented in Section 3.2 to Section 3.8. For information on the selection of intersection treatments, practitioners should refer to the *AGTM Part 6* (Austroads 2017f).

3.1 Off-road Space for Road Users

Off-road space within road reservations has traditionally been used to accommodate a range of elements associated with road design (refer to *AGRD Part 3* (Austroads 2016a)) and traffic management, as well as public utility services. However, the roadside and median often are required to accommodate facilities related to the transportation and safety of road users. For example:

- footpaths, shared paths, separated paths, or bicycle paths
- public transport reservations, stops and interchanges
- car parking facilities in service roads or medians
- service centres, rest areas and truck stops (usually in rural areas)
- pedestrian fencing used to control and direct pedestrian movements (refer to Commentary 7 for further information).

Commentary 7

3.2 Road Space Requirements for General Traffic Lanes

For motorways and expressways in both urban and rural applications, the basic number of lanes provided is four or more (total lanes in both directions). The breakdown of the number of lanes by road type is as follows:

- Rural motorways and expressways will normally have a four-lane or six-lane divided cross-section.
- Urban motorways and expressways may have up to eight mid-block lanes plus auxiliary lanes.
- The number of lanes required in each segment between interchanges is determined through capacity and level of service analysis as described in the *Guide to Traffic Management Part 3: Traffic Studies and Analysis* (Austroads 2017e).
- An increase in the basic number of lanes is required where traffic builds up sufficiently to warrant an extra lane in each direction over a substantial length of the route.

- The basic number of lanes should be maintained through interchanges to minimise the number of decisions to be made by drivers in these complex areas.
- Changes in the basic number of lanes should only be considered where two-lane exit or entry ramps occur.

Lane balancing needs to be maintained at the exits and entrances to the motorway to minimise flow breakdown. When planning exits and entrances for motorways, consideration should be given to the use of auxiliary lanes and whether there is a need to check lane capacity for lane saturation and weaving. The *AGTM Part 6* (Austroads 2017f) provides further guidance on this.

For urban arterials, roads can vary markedly in standard but generally comprise multi-lane divided roads, multi-lane undivided roads or two-lane undivided roads operating under interrupted flow conditions.

Local roads in urban areas are generally two-lane, two-way with widths that can vary significantly to serve a variety of functions including:

- movement (access and service) functions
- amenity and social functions associated with the use of the road space and the land abutting the road.

Narrow roads can be one-lane, one-way to better meet required functions.

Rural highways are usually two-lane, two-way roads, in the absence of any auxiliary lanes. Multi-lane rural highways in Australasia may be divided or undivided and typically have two lanes in each direction as the base number. If three or more lanes are necessary in each direction over a long distance, construction to motorway and expressway standard would normally be considered.

Local roads in rural areas are typically two-lane, two-way.

3.3 Road Space Requirements for Auxiliary Lanes

For motorways and expressways in both urban and rural applications:

- Auxiliary lanes are often not provided at low-volume rural entry and exit ramps where a basic treatment is appropriate.
- Acceleration lanes at an entry ramp:
  - are adjacent to the left-side through lane
  - are provided for a length that enables entering vehicles to accelerate to a speed that is sufficient for them to join safely with the through traffic.
- Deceleration lanes at an exit ramp:
  - are adjacent to the left-side through lane
  - are provided for a length that enables exiting vehicles to separate from the through traffic and to decelerate to an appropriate speed at the exit ramp, and to enable any traffic queues that may extend back from the ramp terminal intersection to store clear of through traffic.
- Weaving areas may need to include auxiliary lanes:
  - to allow drivers to make lane changes to the left or right to satisfy their wishes for entry to or exit from a motorway or expressway
  - as they are critical to the smooth operation of the main motorway or expressway where traffic density increases, and increased lane changing creates turbulence
  - that may be continuous between an entrance ramp and exit ramp where the distance between the two ramps is short, as is often the case on urban motorways and expressways.

Auxiliary lanes for urban arterials consist of median turning lanes or two-way right-turn lanes (Australia only) which can be used:

- to maintain capacity and level of service for the through lanes by removing the obstruction caused by a right-turning vehicle
- to provide shelter for vehicles exiting from an access road
- in commercial and residential areas where there are closely spaced access points.

However, use of two-way right-turn lanes is limited in that:

- they should not be introduced without consideration to existing and future land use as they can reduce the level of service and safety on an arterial road by allowing unrestricted access
- they should be restricted to the urban environment with travel speeds of 70 km/h or less
- through roads should have no more than two lanes in each direction, resulting in a total of five lanes
- on new heavily travelled arterial roads through commercial and industrial areas with widely spaced access points, a raised median, with openings and deceleration lanes at appropriate locations is preferred.

Service roads, where provided, allow the separation of through traffic from local access movements and/or parking manoeuvres:

- where there is access to intense abutting developments along important arterial roads and provision is made in a plan of subdivision or development
- to improve the safety and operational efficiency of arterial roads and access to property.

For rural highways, overtaking lanes:

- are any form of lane added in one or both directions of travel to increase overtaking opportunities
- may reduce overtaking opportunities in the opposite direction since overtaking in both directions should be prohibited at the start and end of overtaking lanes
- can be justified on operational or safety grounds
- may be provided in any terrain, and include climbing or descending lanes on grades and short four-lane road sections up to about 5 km in length
- are more cost-effective if provided in the form of several relatively shorter overtaking lanes rather than fewer longer lanes
- should be located to appear logical to the driver avoiding low-speed curves or long straights.

For guidance on what constitutes a short or long overtaking lane or slow-vehicle turnout, refer to the *AGRD Part 3* (Austroads 2016a) for further information.

Overtaking and passing lanes located near intersections should be carefully considered and designed as traffic flow can be interrupted due to vehicles slowing to turn. See the *AGRD Part 3* (Austroads 2016a) and the *Provisional Passing and Overtaking Guidelines* (NZ Transport Agency 2008b).

Climbing lanes and descending lanes are special cases of overtaking lanes mainly provided for trucks (see also Section 4.3).

Roads with '2+1' configurations are where two lanes are provided for one direction of travel with one lane provided for the other direction. This arrangement alternates for each direction along the length of the road. Where used:

- wire rope safety barrier is erected in a narrow median and on the left edge of the road where required
- gap separation is only provided in some cases.

This treatment provides a high level of safety with respect to head-on crashes and run-off-road crashes as well as providing frequent opportunities to overtake safely.

The definition of overtaking and climbing lanes and guidance for their design can be found in Commentary 8.

Commentary 8

Slow-vehicle turnouts:

- are very short sections of paved shoulder or added lanes that are provided to allow slow vehicles to pull aside and be overtaken
- differ from an overtaking lane in its short length, usually different signing, and the fact that vehicles are not encouraged to enter in the turnout lane
- may be provided on divided roads or on two-lane, two-way roads
- are especially suited to recreational routes, where tourist vehicles are generally willing to allow faster vehicles to overtake
- should be located where adequate sight distance is provided for both through traffic and the traffic turnout
- should not be located on curves which can cause problems for vehicles using the turnout in identifying vehicles in their side mirrors
- should have their terminations located so that adequate visibility is available between drivers in the turnout terminal and other vehicles approaching from the rear.

Basic intersection layouts, which provide space for a turning-design vehicle but have no additional lanes for turning traffic, are the minimum treatments that should be provided.

Intersections with auxiliary lanes:

- involve the addition of lengths of turning lanes to a basic intersection
- can improve safety, especially on high-speed roads and where sight distance to turning traffic is limited by road geometry
- allow traffic to bypass a vehicle waiting to turn right, or slowing to turn left, or both
- can be confused with an auxiliary lane for overtaking and should only be used at locations where the lane’s function will be recognised
- should not be in advance of overtaking lanes due to the confusion which could be generated if drivers misidentify the turning lane as an overtaking lane.

Guidance on the key traffic management considerations in the selection of intersection type is contained in the *AGTM Part 6* (Austroads 2017f) and warrants for the provision of auxiliary lanes at unsignalised intersections are contained in the *Guide to Road Design Part 4: Intersections and Crossings* (Austroads 2017g).

For rural local roads:

- Basic intersection layouts, which provide space for a turning design vehicle but have no additional lanes for turning traffic, are the minimum treatments that should be provided.
- Auxiliary lanes may be provided at property accesses and intersections.

For urban local roads:

- On urban local road networks, most lane management actions are related to intersections.
- Possible exceptions include the provision of:
  - mid-block slow points and other local area traffic management (LATM) devices that, through their channelisation, force vehicles to follow a travel path
  - on-road truck parking or turning space in local roads that serves industrial activities.

3.4 Road Space Requirements for Medians (Dividing Strips)

For motorways and expressways located in urban and rural areas, road space requirements for medians are that:

- Medians may be depressed, flush or stepped (where there is a difference in level across the divided road).
- Medians are a form of dividing strip generally provided to:
  - ensure a safe level of separation between opposing flows
  - provide a recovery area for errant vehicles
  - provide space for frangible planting to counter headlight glare.
- Vegetation and landscaping in medians must be frangible and located so that adequate sight distance is available both at mid-block locations and intersections.
- In special situations, the medians (comprising a barrier and/or separation device) may be moveable to allow an additional lane or lanes to be allocated to traffic travelling in the peak direction, where justified.

For the application of medians in rural highways:

- The functions of rural medians are like those on motorways and expressways. Depressed or flush medians are normally provided. Medians may be used:
  - with safety barriers to improve traffic safety
  - to shelter right-turn lanes
  - to shelter crossing traffic.
- Raised medians may be used at major intersections but require more space and are of higher cost.
- Wide centreline treatments are parallel lines taking the appearance of standard centrelines with a wider spacing between the lines. The purpose of the treatment is to provide separation between opposing traffic flows and a recovery space for vehicles encroaching towards the opposing lane. Their objective is to improve safety by reducing the potential for head-on crashes. To improve their effectiveness the wide centreline treatments should be used in conjunction with audio-tactile linemarkings (ATLM) on the centreline. Wide centreline treatments can sometimes be applied in long lengths through inexpensive 'paint only' treatment. This depends on the existing seal width being sufficient. This is a very cost-effective way of reducing head-on crash risk on a route, particularly on longer routes where drivers can become fatigued.
- Wide centreline treatments could be considered for use on high-speed roads where head-on collisions are an issue, or a major risk of becoming an issue, and where other measures such as providing a physical obstruction (e.g. wire rope barrier) or adding an additional lane are not warranted or economical. Unlike the provision of a physical obstruction, such as a wire rope barrier, wide centrelines may be designed to permit drivers to cross into the opposing travel lane to perform overtaking manoeuvres using broken, wide centrelinemarkings. Care should be taken to ensure that overtaking is only permitted at appropriate locations.
- Factors that should be considered in the implementation of wide centreline treatments include:
  - Risk assessment: The treatment should be used where there is a high risk of head-on crashes (provided it is not initially from losing control when leaving the road to the left), over a minimum section of road.
  - Alignment: As some widening may be required, consideration should be given to culverts and bridges. Taper lengths at these locations should comply with the design speed.
  - Signposting structures: As most roads will need to be widened to cater for the minimum width of seal, this may place existing signs within the clear zone and they may require additional protection.
  - Services: With the widening of the road, there may be a need to relocate services.

Further details on wide centreline treatments may be found in the *Guide to Traffic Management Part 10: Traffic Control and Communication Devices* (AGTM Part 10) (Austroads 2019c).

For urban arterial roads:

- Medians may be raised or flush with the road surface.
- Raised medians are provided on roads that are divided over a considerable distance, or they may be used locally to control traffic movements and/or improve safety on a relatively short section of road, including intersections.
- The main traffic management functions of medians, particularly where they are raised with kerbs, are to:
  - shelter right-turning and crossing vehicles at intersections
  - prevent indiscriminate crossing and turning movements, or prohibit certain traffic movements at less important intersections
  - provide a pedestrian refuge that enables pedestrians to cross the road one direction of traffic at a time
  - shelter traffic control devices, such as signs (including large direction signs and their supports), traffic signals, and road lighting
  - separate and reduce conflict between opposing traffic flows, effectively reducing the possibility of head-on collisions
  - provide an area to accommodate a safety barrier
  - provide a recovery area for errant vehicles.
- Median widths vary according to the width that can be made available and the purpose of the median (refer to the *AGRD Part 3* (Austroads 2016a).
- The spacing of median openings should be resolved in the context of access categories (refer to Section 2.1.3 and Table 2.1). Median openings are determined in the first instance by the location of major intersections. Additional openings may be provided between major intersections to enable vehicles to U-turn and access minor side roads or properties on the opposite side of the road.
- The spacing of median openings needs to consider:
  - interference to traffic flow if openings are closely spaced
  - increased travel distances for local traffic and excessive demand for turning manoeuvres at intersections if openings are spaced too far apart.
- Moveable medians may be appropriate at transitions at the ends of reversible lane treatments to provide physical separation of opposing traffic flows and an improved level of safety. In some cases, this may involve use of reversible-flow traffic lanes adjacent to a median to provide an additional lane for the peak direction of traffic flow.

3.5 Road Space Requirements for Outer Separators

An outer separator (a form of dividing strip) is a raised island between the major road and the service road for urban arterials and its purpose is to:

- provide a degree of access control to reduce crashes by separating through traffic from local traffic and other frontage activities. This is essential where the service road operates as a two-way road
- allow space for vegetation and landscaping to shield abutting development from the visual effects of through traffic and for sound attenuation
- provide space for a pedestrian refuge
- provide an alternative location for lighting poles and space to erect signs and other devices close to through traffic.

3.6 Road Space Requirements for Pedestrians

Pedestrian space should adequately cater for the needs of all types of users defined as pedestrians under legislation applying within the relevant jurisdiction. The road space for general traffic takes pedestrians into consideration.

The guidance for road space requirements for pedestrians is given in Section 4.5.

3.7 Road Space Requirements for Parking Allocation

On motorways and expressways, the guidance for parking allocation is as follows:

- Drivers are not permitted to stop on motorways and expressways other than in an emergency for specific purposes described in road rules.
- Parking requirements associated with rural motorways and expressways are provided through the provision of shoulders, rest areas, service centres and truck stopping areas (refer to *Guide to Road Design Part 6: Road Design, Safety and Barriers (AGRD Part 6)* (Austroads 2010)).
- Urban motorways and expressways are often provided with emergency stopping lanes (ESL) to enable drivers to stop in an emergency. A driver is not permitted to stop in an ESL unless the condition of the driver, a passenger, the vehicle, or any other factor makes it necessary for the driver to stop in the interest of safety.
- Where an ESL does not exist, or is used to carry traffic on a full-time or part-time basis, emergency stopping bays should be provided. The bays are typically located at 500 m spacing and at help-phone locations.

For urban arterial roads, the primary function is the efficient and safe movement of people and goods. However, many instances arise where on-street parking has traditionally served abutting properties. In such cases an appropriate balance must be achieved between traffic movement and property requirements at various times of the day and week.

Where practicable, off-street parking is desirable to minimise on-street parking and improve the efficiency of urban arterial roads. This approach may be feasible in the case of new roads or the renewal of existing urban areas and arterial roads. However, in the case of existing roads it usually requires a medium to long-term approach through planning schemes.

Parking demand from frontage land use is accommodated by parking (usually parallel) in the kerb lanes.

Indented parking bays, including bus stops and loading zones, may be an effective way to safely provide for parking on some arterial roads where restrictions exist due to space constraints or the presence of traffic control devices.

Wherever possible, angle parking should be avoided unless an adequate dedicated area is provided in which drivers can manoeuvre their vehicles clear of through traffic or in situations where the road is of sufficiently low volume and speed. Without such an area, parking manoeuvres can cause safety and/or operational problems such as:

- poor visibility for drivers reversing out
- vehicles protruding into the through lane and affecting traffic flow when being backed out
- vehicles interfering with traffic flow when being reversed into a space, where this arrangement exists.

Parking may be designated for off-peak general parking or for specific purposes such as taxi zones and loading zones during off-peak periods.

Parking lanes can operate as traffic lanes or clearways during peak periods. Clearways are usually implemented over relatively long lengths of more important urban arterial routes, where warrants are met. Table 3.1 is a guide to their provision.

Table 3.1: Clearways on two-way and one-way roads

Number of moving traffic lanes available before clearway (one-way)	Consider clearway when total one-way traffic flow (veh/h)
1	800*
2	1600*
3	2400

** Reduce to 600 veh/h and 1200 veh/h respectively where trams are involved.*

Clearways should only be implemented where the road downstream has adequate capacity to accommodate the increased traffic flow resulting from the clearway.

Clearways often apply to peak periods (2–4 hours in am and pm peaks) but may apply for longer periods up to 24-hour operation (e.g. motorways and expressways). For example, they may apply for 13 hours and for either five or seven days per week.

Where a full clearway is not warranted, owing to the short length over which the need applies, restrictions may be imposed on parking or stopping of vehicles to maximise the through traffic capacity at a location. On arterial roads, this is usually done by installing regulatory no-stopping or no-parking signs on the approaches and departures of important intersections, or on other sections of road where necessary (e.g. peak-hour parking restrictions on roads that pass through shopping strips). Further information on the operation of the clearway can be found in Commentary 9.

Commentary 9

On urban local roads, it is desirable that appropriate off-street parking is available. The extent of the off-street parking should depend on the characteristics of the road and the nature of abutting land use.

Generally, on-street parking supports the primary activities and land uses in urban local roads (e.g. inner city residential areas where off-street parking may never have been available). Regulatory and safety requirements must be met in determining the space available for parking.

Some of the measures described under urban arterials may apply to local roads (e.g. no-stopping signs on approaches and departures at signalised intersections).

Regulation and use of on-street parking should be prioritised to support those with needs for high levels of access such as public transport, taxi operators, couriers and service-vehicle users, people with disabilities and emergency services.

Competing demands for kerbside space should be prioritised as follows:

- The safety of all road users should be given the highest priority at all times.
- Bus stops, taxi zones, loading zones and parking for people with disabilities should take precedence.
- In residential areas, preference may be given for resident parking in accordance with the state and territory regulations and local guidelines for resident parking permit schemes.
- In commercial areas, parking associated with business should take priority including short-term parking for clients or customers.
- In industrial areas, depending on the extent of off-street parking, priority is given to short-term parking for clients and long-term parking for employees to avoid a spill of all-day parking into adjacent non-industrial areas.

Forms of parking can include:

- Parallel kerbside parking
- Parallel kerbside parking in the direction of traffic flow is the most common form of on-street parking.
- Angle kerbside parking
- Angle parking involves parking at angles other than zero degrees (parallel parking).
- Indented parking bays
- Indented parking bays are an effective way to safely provide for parking on roads where restrictions exist due to space constraints or the presence of traffic control devices.
- Centre-of-road parking
- Centre-of-road parking should only be considered on low-speed non-arterial roads with little through traffic unless the parking area can be well separated from the through traffic flow and access points can be well designed and kept to a minimum number of locations. Where centre-of-road parking is provided, drivers are required by road rules to enter and leave the area by driving forward. Physical boundaries such as bollards or raised medians can also be used to delineate between through traffic and the centre-of-road parking. Pedestrian access to the parking should also be considered.

Shoulders of rural highways are intended as recovery areas for errant vehicles and for use as refuges during emergency stops. They are not intended for parking, particularly in high-speed areas. Because most vehicles standing on road shoulders are making discretionary stops, it is desirable to take every opportunity to provide areas at intervals where drivers can stop completely clear of the traffic lanes and shoulders. Parking is therefore usually accommodated by the establishment of rest areas. Parking around roadside stalls should be restricted in a way to discourage people crossing to the stalls from parked vehicles. Adequate signed off-road parking should be provided around key vistas that can attract tourists.

Safe and adequate bus stop areas should be provided on rural highways where buses can stop well clear off traffic lanes, and where appropriate, wide shoulders should be provided for the vehicles waiting to collect passengers.

Additional shoulder width should be provided at rural mail boxes for the parking of postal delivery vehicles and people posting mail.

Categories of rest area include:

- major rest areas, including service centres
- minor rest areas
- truck parking bays.

On a given highway route, all three rest area facilities should normally be:

- spaced at intervals dependent on the category of rest area provided, the volume and mix of traffic and the demand for parking and rest opportunities
- located to maximise road safety and ease of access and with regard to the physical characteristics of the road and rest area site.

Towns along a route provide opportunities for drivers to stop and rest and the facilities available in towns should be considered in determining the location of rest areas.

On rural local roads, the requirements for parking allocation are to provide shoulders to cater for emergency/casual parking.

There are no special provisions for these roads other than addressing identified safety needs and ensuring that parking does not occur in locations that would obstruct traffic or cause hazardous situations for other road users.

Bus stops on rural local roads, including school bus stops, should have an adequate area for buses to stand clear of moving traffic, for passengers to safely wait for and alight from buses, and for parents to pick up and set down children in a safe environment.

Where required, areas should be provided for enforcement purposes (e.g. weighbridge, driver impairment testing).

3.8 Road Space Requirements for Shoulders

On motorways, expressways, rural highways and rural local roads shoulders provide:

- an initial recovery area for any vehicle that may get out of control
- an area set aside for stopped vehicles on a firm surface at a safe distance from traffic lanes
- an area for use by emergency vehicles
- space for cyclists (sealed shoulders only) – note that cyclists may or may not be permitted on motorways and expressways
- clearance to lateral obstructions
- for road train routes, additional tracked width required by these vehicles.

On motorways and expressways, the use of shoulders is restricted to emergency stopping in accordance with road rules. Consideration may be given to the provision of stopping bays for truck drivers to check their loads clear of traffic (refer to the *AGRD Part 3* (Austroads 2016a)).

3.8.1 All-lane Running

All-lane running is the use of the emergency lane as a trafficable lane either on a full-time or part-time basis.

Although it is preferred to maintain an emergency lane on motorways, expressways, rural highways and rural local roads, in cases such as urban motorways, increasing congestion along with constrained road space and inability to increase the number of trafficable lanes has seen a need to open the shoulder for trafficable use (i.e. all-lane running) or alternatively build new motorways with an additional trafficable lane in lieu of an emergency lane. This strategy supports the smart motorway objectives to make better use of existing infrastructure while maximising motorway capacity, productivity and efficiency (throughput).

Opening the emergency lane for general traffic provides additional capacity (i.e. 2000 veh/h for a managed motorway), when applied to extended lengths and across interchanges. In comparison to limiting the lane for emergency use only, the benefits of opening the emergency stopping lane for general traffic are worth considering when widening of the motorway is not a viable option.

In cases where the emergency lane is open for trafficable use either on a dynamic and/or full-time basis, this is generally supported through one or many measures, depending on safety risk, such as geometric upgrades, a reduction in speed limits, lane use management systems (LUMS) incorporating variable speed limits (to indicate when the shoulder is open or closed and altering (lowering) the speed limit accordingly), systems to monitor the use, and emergency stopping bays. These systems are put in place to address the potential risk of implementing all-lane running and ensure that it can be implemented safely. When making the emergency lane open for trafficable use, the adequacy of the existing assets should be assessed. These include the allowable spread widths for drainage and the minimum offset that is required to avoid cars accidently hitting the safety barriers.

Where all-lane running is implemented, a reduction in the speed limit and implementation of the other measures where required should be considered based on a risk assessment. The *Guide to Smart Motorways* (Austroads 2016d) provides further guidance on all-lane running.

3.8.2 Emergency Stopping Bays

Where all-lane running is implemented and there is no shoulder provided, emergency stopping bays can be installed to store vehicles clear of the trafficable lanes in the event of a vehicle emergency (such as a vehicle breakdown). The benefit of emergency stopping bays is that they do not take up the full length of the motorway and therefore may be able to be implemented within other constraints. Their use, including their intermittent spacing along the motorway, should be based on a risk assessment. They should be designed to enable a vehicle to park in the bay clear of the trafficable lane and allow an emergency responder or vehicle occupant to walk around and attend to the vehicle, similar to a full-width shoulder. The emergency bay should also have support facilities such as help phones, CCTV and vehicle detectors so that the traffic management centre can monitor occupants in the bay and communicate with them. Austroads (2016d) provides guidance on when they might be used, based on a risk assessment, their spacing, design issues and what supporting facilities should be provided.

4. Allocation of Road Space between Road Users

The ultimate aim in the management of a road network or individual road length is to achieve a balance in the competing needs of road user groups. In the past, it was normal to have a mix of vehicle types on the roadway, with pedestrians alone accommodated on paths, when they were provided.

The groups that need to be considered, in addition to car drivers, are:

- public transport service providers/users
- pedestrians, including people who have a vision or mobility impairment
- cyclists
- heavy goods vehicle drivers/operators
- motorcyclists
- emergency services.

Through studies and working with these groups, practitioners have developed an understanding of the road environment needs of each individual group as well as general community expectations.

Many issues confront each group. For public transport and heavy vehicles, a major issue is the predictability and reliability of travel times and obtaining priority through congested parts of the road network. For pedestrians and cyclists, a continuous and safe network of separated or shared space is particularly important.

Road agencies recognise the need to better accommodate all road users within road reservations. While road space should be shared, practitioners have become better equipped with traffic management techniques that enable them to provide for specific needs.

Different roads or sections may require the needs of a group to be given priority, or for the needs of users to be balanced in accordance with an agreed strategy. Where available road space is limited, this may mean that one transport mode is favoured ahead of others.

Determination of the appropriate allocation of road space needs to be undertaken having regard to the overall context of the road environment, road users and the overall safety and efficiency of roads.

Allocation of space may also apply to movements across a road where provision may be required for road users to join or cross. This may involve the permanent allocation of space (e.g. pedestrian refuge or median for staged crossings) or the allocation of space on a time or priority basis (e.g. pedestrian signals, pedestrian zebra crossings).

The hierarchy of road users is determined by jurisdictions for each road link in consultation with stakeholders, using the Movement and Place framework and NOP as discussed in Section 1.2 and outlined in further detail in the *AGTM Part 4* (Austroads 2016b).

Sections 3.2 to 3.8 outlined the traffic management measures that can assist in providing road space for different road user groups.

4.1 Road Space Requirements for High Occupancy Vehicle Lanes

High occupancy vehicle (HOV) lanes (transit lanes under the Australian Road Rules) may be used on urban arterial roads including motorways and expressways.

The use of HOV lanes is regulated through road rules.

Where drivers are charged a toll, the lane is referred to as a HOT lane (i.e. high occupancy toll lane).

Exclusive-use lanes can be provided which:

- are for use by buses only or by any HOVs usually including buses, taxis and other vehicles carrying at least two or three occupants and also motorcycles and bicycles in some jurisdictions
- encourage greater efficiency of vehicle use (more people moved in less vehicles) and benefits such as
  - travel time savings
  - increased travel time reliability
  - reduction in air pollution
  - cost savings
- may be implemented as either concurrent flow or contra-flow lanes
- may be operated on a time-of-day basis in peak periods but may be permanent
- have the potential to increase the person throughput of the lane
- can also be implemented on entry ramps of motorways and expressways to reduce delay to applicable vehicles entering the motorway. This is similar to a queue-jump lane on arterial roads
- can be affected by illegal usage of HOV lanes. It can be difficult to enforce HOV lanes (especially determining whether passenger vehicles carry at least the minimum required number of occupants). It is easier to identify and enforce compliance with HOV lanes based on vehicle type (refer to Austroads (2008a) for more information).

'Environmentally friendly' lanes or similar treatments can also be considered, where only vehicles such as smaller cars, electric or hybrid cars, would be allowed.

4.2 Road Space Requirements for Public Transport

The following sections provide guidance on the road space requirements for public transport.

Commentary 10 covers the local area traffic management devices that can affect the operation of buses.

Commentary 10

4.2.1 Bus Lanes on Motorways, Expressways and Urban Arterials

Key considerations for the allocation of road space for bus lanes on motorways, expressways and urban arterials are as follows:

- They have a similar use and the same advantages as HOV lanes for motorways and expressways.
- Bus-only lanes are areas of the roadway set aside for their exclusive use enabling travel through congested sections of road without being held up by general traffic.
- Under the Australian Road Rules drivers of other vehicles may use a bus lane for a distance of 100 m if it is necessary to drive in the lane, particularly to enter or leave the road or move from one part to another.
- Depending on the circumstances, bicycles and other vehicles (e.g. taxis) may be permitted to use bus lanes. However, where space can be made available it may be preferable that both buses and bicycles have designated exclusive lanes but, where this cannot be done, a wider, shared bus/bicycle lane should be provided (refer to the *AGRD Part 3* (Austroads 2016a) for appropriate lane width).
- Bus lanes may be operated on a time-of-day basis, corresponding to the periods of peak congestion, through appropriate signing and marking.
- Most bus lanes are designed so that buses flow in the same direction as other traffic, often at the kerbside, the latter being necessary where buses need to stop to set down or pick up passengers.

- Where a bus lane terminates or commences at the end of a motorway, expressway or at a ramp terminal, it should be given priority through design of the intersections and signal phasing and timing.
- While it is generally better to control all entry flows, priority access lanes at on-ramps can be allocated to buses where there is a strategic need. In addition, if a strategic need does exist, preference is generally given to providing a metered priority access lane or a partially controlled/free-flow bypass lane, rather than free-flow access, to ensure control of all entry flows. The *Guide to Smart Motorways* (Austroads 2016d) provides further guidance on the use of priority access lanes at on-ramps.

4.2.2 Bus Routes on Arterial Roads

Key considerations for the allocation of road space requirements for bus routes on arterial roads are as follows:

- Many bus routes on arterial roads share traffic lanes with general traffic through the installation of dedicated bus lanes, and it has the potential to increase the person throughput in the lane.
- As many of the factors involving bus delay are located at certain road segments, priority should be considered at intersections including provision of short ‘queue-jump lanes’ which are short lengths of bus lane at an intersection for the exclusive use of buses enabling them to bypass congestion points, traffic signal priority, and efficient bus stops (perhaps located in traffic islands).
- Bus stops should be located on the far side of a signalised intersection following traffic signal priority, otherwise the signal priority may be ‘wasted’ while the vehicle is picking up or setting down passengers. On busy arterial roads, indented bus bays can result in buses having difficulty re-entering the traffic stream, while on-road bus bays may result in congestion issues.
- By allocating certain roads as being key public transport routes, priority can be given, especially during peak times, to public transport over other modes, reducing delays for those modes.
- The success of queue-jump lanes is often dependent upon the ability of the bus to re-enter the traffic stream. Signal priority is often used in conjunction with queue-jump lanes for this purpose.
- Signal priority is often given to a bus at congested intersections, enabling it to enter the intersection prior to general traffic. The signals can also help the bus perform difficult manoeuvres in traffic, such as turning right as the bus would need to cross a number of lanes of traffic.
- Communication between buses and infrastructure can also enable even greater priority for buses which are behind schedule.

4.2.3 Tram Lanes

Key considerations for the allocation of road space requirements for tram lanes are as follows:

- Tram lanes may be terminated in advance of signalised intersection stop lines (say 30 m) to allow through and turning vehicles to use the centre lane.
- Traditionally they have been located at the centre of the roadway, but the provision of kerbside tramlines could be considered in appropriate circumstances. (e.g. where the best option for achieving a raised platform to enable wheelchair access is to raise the level of an existing verge and path, and there are no other constraints such as property access).
- Trams should be given priority through the design of intersections and signal phasing
  - signal phasing should take into consideration the stopping capability of the tram at the desired operating speed. It is noted that trams may require longer stopping distance and therefore the signal phasing needs to be such that it reduces the risk of a tram proceeding through the intersection without right of way as determined by the signal phasing.
- Tram lanes may be operated full-time or part-time. They may be provided, usually as part-time, on roads with a single lane clear of the tram tracks and this is typically achieved in conjunction with clearway provisions prohibiting kerbside parking.

- When a tram lane is in operation, other road users are not allowed to travel in the lane, but may use it to enter or leave the road, to avoid an obstruction, or to make a right-turn or a U-turn (if progress of trams is not impeded).
- On other roads, trams share the road with r traffic, but traffic laws regulate motorist behaviour near trams.

The allocation of road space requirements for tramways is as follows:

- Trams and light rail vehicles sometimes run for parts of their route in segregated reservations, or along medians (i.e. on raised medians or at road level and separated by a kerb).
- Such arrangements are provided for the exclusive use of trams, with other vehicles permitted to cross the tracks only at specific controlled locations.

4.2.4 Busways

Busways (which may also be called transitways):

- are dedicated roadways for the exclusive use of buses and include high-standard bus stations similar to railway stations
- are facilities that allow buses the flexibility to continue their journey on the road system after exiting the busway, often connecting to a system of bus lanes on the arterial road network
- need to be supported by bus priority measures.

4.2.5 Bus Routes on Urban Local Roads

Bus routes on urban local roads:

- provide direct access to public transport for residents
- can take more time because of the progressive implementation of LATM measures
- need to be managed to achieve a balance between efficiency and environmental quality of residential roads (e.g. impacts of increased noise, bus stops removing residential parking spaces)
- need appropriate LATM devices that are safe and comfortable for passengers and do not cause damage or turning problems for the bus.

Bus lanes may also be provided on urban local streets.

4.2.6 Bus Stops

While buses have priority under the Australian Road Rules (but not in New Zealand) to re-enter the traffic stream from the side of the road, this may be difficult in many situations. Key considerations for bus stops are as follows:

Bus stops:

- should be located and orientated so that bus drivers have adequate sight distance through side mirrors to traffic approaching from the rear, and passengers are provided with a safe crossing (i.e. sight distance available, crossing facility provided)
- may be located close to the departure side of signalised intersections to reduce delays to buses re-entering the traffic stream.

Bus stops at mid-block sites:

- should be located to provide safe and convenient pedestrian access
  - for further information on the provision of pedestrian and cyclist crossings of roads at mid-blocks, refer to the *AGTM Part 6* (Austroads 2017f)
- should be designed so that they are compliant with relevant legislation (in Australia the *Commonwealth Disability Discrimination Act 1992*), providing equitable access to persons who have a disability
- require that a sufficient length of kerb line is free of parking to accommodate the number of buses that are likely to be using the stop at the same time
- should generally be within a 400 m walk-up catchment area
- high-usage bus stops should be indented, otherwise they can cause delays to other traffic using the same lane, including other buses
- should ensure that drivers approaching buses at bus stops, including those on school bus routes, have adequate sight distance to the stop and to passengers moving across the road prior to boarding or after alighting from the bus.

For mid-block sites the following factors should be considered in locating stops:

- bus stops should not be located on sharp curves or just beyond curves where bus drivers are unable to view approaching traffic through side rear-view mirrors
  - this can only be resolved by locating a bus stop away from the curve or by constructing it at an angle such that it is aligned with the road preceding the curve
- where bus stops are required on both sides of an undivided road they should be staggered with the rear of the buses opposite so that passengers are encouraged to cross the road behind the bus where sight distance between passengers and other traffic is best
- bus stops on undivided roads should be staggered as this can also minimise obstruction to other traffic
- if possible, bus stops should not be located at the bottom of steep hills where braking to enter the stop and acceleration to re-enter the traffic stream may be more difficult and hazardous
- bus stops on busy roads should preferably be located close to pedestrian crossings with the crossing to the rear of the bus to maximise sight distance to the crossing and pedestrians
- consideration should be given to the safety and legality of bus stops where they must be located opposite double barrier lines or central traffic islands on roads with only one traffic lane in each direction
- where the arterial road has a sealed shoulder or parking lane, this may require an extension of the kerb line towards the traffic lane to provide a waiting area and/or access for passengers.

Key considerations for pedestrian needs for access to bus stops are as follows:

- safe and convenient pedestrian facilities that are provided at or close to bus stop locations
- design of pedestrian facilities that takes account of the specific circumstances, usage and location of the bus stop
- adequate space for waiting passengers and placement of shelters
- adequate width to segregate users if the path is used as a bicycle facility.

Bus stops near minor road intersections should be located:

- so that buses and shelters do not impede sight distance for other roads users (it is often preferred to locate the stops on the departure side)
- with consideration to the bus route beyond the intersection (e.g. bus turns at the intersection).

Location of bus stops in local roads should be coordinated with the placement of LATM devices to minimise delays.

For location and design of bus stops at major intersections refer to AGTM Part 6 (Austroads 2017f).

Depending on the function of the road and its characteristics it may be preferable for bus bays to be in the left-hand traffic lane. This may occur in shopping centres where parking may be indented and the resulting kerb extensions used as waiting areas for bus passengers, clear of the normal pedestrian flow along the path. Although this treatment may cause delay to other traffic it may be acceptable in shopping centre environments.

Indented bus bays may be used in urban or rural situations and allow buses to stop clear of normal traffic lanes while setting down or picking up passengers. This can:

- enhance the effective capacity of the road and reduce the likelihood of both rear-end and lane-change collisions
- reduce delays or inconvenience to all road users in the kerbside lane, including other bus services, which may be a reason to prefer this type of stop
- also reduce delays and hazardous situations for cyclists blocked by stationary buses in the left lane
- overcome a source of frustration to drivers of other motor vehicles from stopped buses at kerbside bus stops
- cause bus drivers difficulty in re-entering the traffic stream from the indented bus bay, resulting in delays to bus passengers, which is also an important consideration in the choice of treatment
- increase the risk of sideswipe crashes as the bus has to pull back out into moving traffic.

4.2.7 Tram Stops

Road space at tram stops at mid-block sites:

- provides a means of access
- can be located at tram safety zones which are narrow islands between the tram tracks and the adjacent traffic (usual where there are tram lanes) although these do not comply with *Commonwealth Disability Discrimination Act 1992* requirements
- on narrower arterial roads, requires pedestrians to walk across the left lane after the tram and other traffic has stopped at designated tram stops (kerbside stops).

Specific road rules apply to kerbside stops and to safety zones.

Pedestrian needs for access to tram stops are:

- safe and convenient facilities that are provided at or close to tram stop locations
- design of pedestrian facilities that takes account of the specific circumstances, usage and location
- adequate space for waiting passengers and the placement of shelters
- adequate width to segregate tram users from cyclists if the path is used as a bicycle facility as well as from other people on the footpath.

Where possible and practicable, safe connections should be provided to allow pedestrians to safely move between the tram stop and footpath.

Major tram stops should be designed to enable unimpeded access for persons who have disabilities (in accordance with relevant legislation), including persons with visual and ambulatory disabilities. This generally requires a raised platform with gentle ramps and tactile ground-surface indicators.

For location and design of tram stops at major intersections refer to the *AGTM Part 6* (Austroads 2017f).

For information on planning and design for public transport, including tram stops, refer to Austroads (2008a), Department of Infrastructure (2006), Department of Transport (2008, 2010), and VicRoads (2013).

4.2.8 Passenger Shelters

The allocation and provision of shelters for passengers is an important element of a public transport system. Care needs to be exercised in positioning bus and tram shelters at the roadside to ensure that they:

- are not too close to traffic lanes
- do not obstruct sight distance to nearby intersections or driveways
- do not excessively obstruct pedestrian use of paths
- protect passengers from prevailing weather conditions
- are located to ensure that adequate width is available to segregate users if the path is also used as a bicycle facility.

4.2.9 Taxi Zones

Taxi zones should be provided where there is a significant demand for their services. Typical locations include:

- railway stations and other public transport modal interchanges
- locations in central business districts
- entertainment precincts including night clubs.

A taxi zone usually comprises the allocation of kerbside parking space through the erection of signs in accordance with road rules, AS 1742.11-2016 and in New Zealand the *Traffic Control Devices Manual* (NZ Transport Agency 2008a).

4.3 Road Space Requirements for Heavy Goods Vehicles

Trucks on major transport links can be given priority through truck lanes and other measures, enabling less congestion for freight. These lanes have the potential to enable trucks to pass congested areas on freight routes carrying high numbers of vehicles, but their provision is usually impracticable (refer to AS 1742.12-2017).

Consideration may also be given to priority access lanes on entry ramps. However, as it is generally better to control all entry flows, priority access lanes should not be provided unless there is a strategic need. In addition, if the need does exist, preference is generally given to providing a metered priority access lane or a partially controlled/free-flow bypass lane, rather than free-flow access, to ensure control of all entry flows. The *Guide to Smart Motorways* (Austroads 2016d) provides further guidance on the use of priority access lanes at on-ramps.

Overtaking lanes are:

- a form of auxiliary lane (see Section 3.3)
- more acceptable to practitioners than truck lanes because of the greater benefits of overall smoother traffic flow
- defined to include climbing or descending lanes on grades.

Where provision of an overtaking lane is not practicable (e.g. in mountainous terrain), a slow-vehicle turnout lane (or bay) may be considered. This is a short section of paved shoulder or added lane that is provided to allow slow vehicles to pull aside and be overtaken.

Driver fatigue is an important issue for road safety – it has been estimated that up to 20% of rural road crashes are due to fatigue (Williamson 2002, cited in National Transport Commission 2004). Fatigue is an issue for both the drivers of cars and heavy vehicles. While many other factors are involved in the management of driver fatigue, the provision of rest facilities at frequent intervals on major rural arterial roads is generally accepted as an essential measure in addressing the issue.

For detailed guidelines on the provision and design of these facilities refer to the *AGRD Part 6* (Austroads 2010).

Provision of these areas:

- relates primarily to road safety as part of a package of measures to address driver fatigue as a cause of road crashes in rural areas
- facilitates short rest breaks (15–30 minutes) to assist truck drivers to comply with regulations and enable drivers to check loads to ensure they are secure, thereby improving road safety.

4.4 Road Space Requirements for Cyclists

In general, cyclists have six basic requirements, which apply equally on roads and on paths (Austroads 2017h):

- space to ride
- a smooth surface
- speed maintenance
- sight lines
- connectivity
- information.

In addition to the above requirements, to encourage cycling there is a need to provide cycling infrastructure that is perceived to be safe.

Facilities for cyclists should be designed from the outset for new streets and roads.

A complete on-road cycling network should be provided. While the lack of on-road cycling links should not preclude the use of on-road bicycle lanes, nearby links will also be helpful.

The provision of cyclist facilities should be based on the hierarchy of needs, delivered in order of the level of safety and priority (refer to the *AGRD Part 3* (Austroads 2016a)).

New motorway and expressway developments should include bicycle networks alongside but separate from the new road. An example of this is the Eastlink tollway in Melbourne.

For more information regarding cyclists on motorways and expressways refer to Austroads (2012a).

Use of motorways and expressways by cyclists varies between jurisdictions with some road agencies permitting it, while others ban it. Cyclists may be permitted on rural motorways and expressways subject to risk assessments where:

- wide, sealed shoulders provide cyclists adequate clearance from vehicles in the adjacent lane – shoulders may be marked as a designated bicycle lane
- there is a good quality riding surface
- conflict between motor vehicles and bicycles at entry and exit ramps is minimal or is able to be managed through traffic control or design measures (refer to the *AGTM Part 6* (Austroads 2017f) for further information).

The crossing of interchange entry and exit ramps is an aspect of cyclists' use of motorways and expressways that requires careful consideration. In rural areas, sufficient safe gaps in ramp traffic will usually be available. Where volumes are relatively high, a traffic assessment based on gap acceptance analysis may be necessary. Treatments for ramp crossings are described in the *Guide to Road Design Part 4: Intersections and Crossings: General* (Austroads 2017g).

Road agency policy often bans cyclists from urban motorways and expressways.

4.4.1 On-road Bicycle Lanes

The design of bicycle facilities should be based on context-sensitive design principles (outlined in the *AGRD Part 2* (Austroads 2015a) with the appropriate bicycle facility determined through a full NOP 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. Physically protected bicycle lanes provide a safer riding environment than bicycle facilities which do not provide separation between bicycles and vehicles. Commentary 11 provides guidance on bicycle lanes and their advantages.

Commentary 11

Figure 4.1 provides guidance to practitioners on the separation between bicycles and motor vehicles for the preferred on-road bicycle facility. It is based on the road's expected/actual volume and actual or planned 85th percentile speed. Use of Figure 4.1 does not replace the need for engineering judgement in the design of bicycle facilities.

As with car drivers, aspects such as a good surface, directness, comfortable gradients and minimal disruptions are key LOS issues for cyclists. The LOS framework referred to in Commentary 1 of the *AGTM Part 4* (Austroads 2016b) provides guidance on the LOS levels achieved for bicycle facilities applicable to the road environment.

Practitioners seeking to use Figure 4.1 for guidance should consider the magnitude of exposure cyclists 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 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.

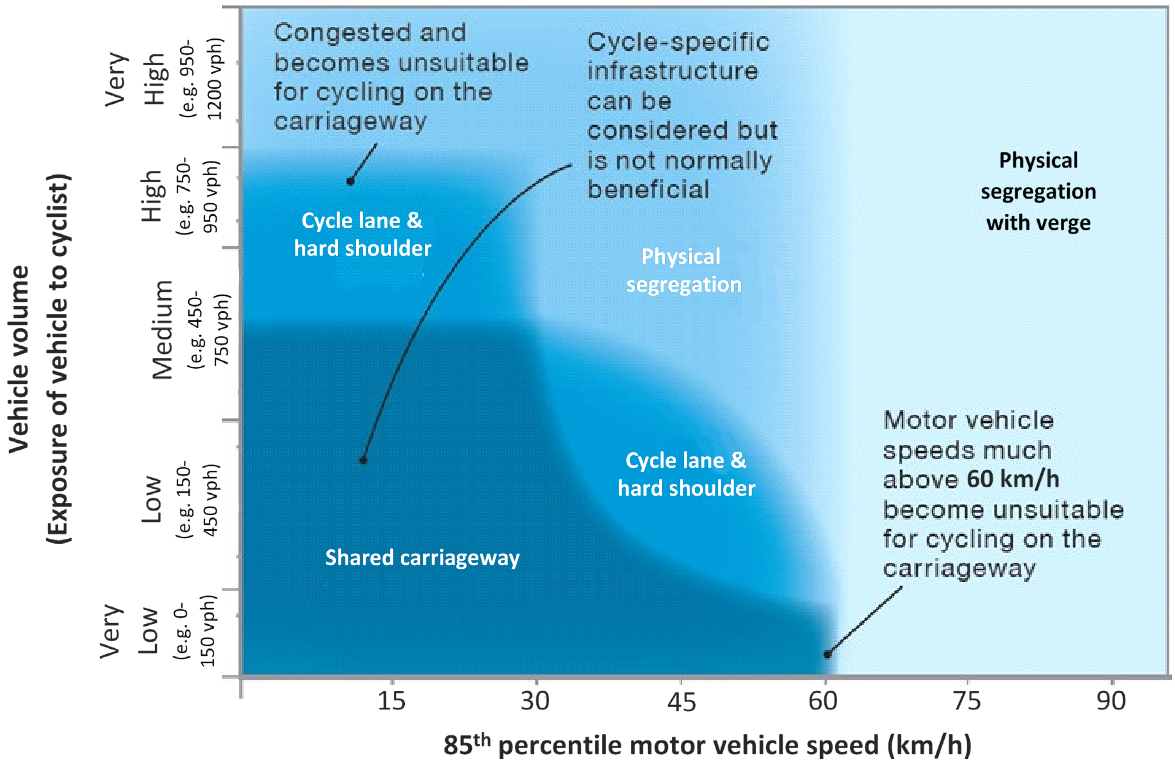
Figure 4.1 depicts the minimum requirements for the separation of cyclists and motor vehicles for the preferred bicycle route. This is not an indication that separation should not be undertaken or that there will be no benefit from it.

Outlined below are guidelines for the use of on-road bicycle facilities that fit into the broad categories outlined in Figure 4.1. They are:

- bicycle lanes and hard shoulders
- physical segregation
- shared carriageways.

Practitioners should refer to Figure 4.1 for guidance on when treatment types should be used. In addition to the information outlined below, practitioners should refer to the *AGRD Part 3* (Austroads 2016a) for information on the design of on-road bicycle lanes.

Figure 4.1: Guidance on the separation of cyclists and motor vehicles for the preferred bicycle route



Source: Adapted from Sustrans (2014).

Bicycle lanes and hard shoulders are signposted special-purpose lanes that are separated from motor vehicle traffic by use of flush longitudinal linemarking or painted islands (chevron safety strips). They may be signposted to operate full-time or part-time. They also may not be signposted but pavement marking may be used to encourage their use and provide awareness to motorists of the possible presence of cyclists on them. Treatments vary as outlined in Table 4.1.

Table 4.1: Bicycle lanes and hard-shoulder bicycle facilities

Treatment	Details
Exclusive bicycle lanes	Exclusive bicycle lanes: • have largely been installed with success in several locations, and provide a safer riding environment than non-protected lanes by segregating cyclists from general traffic (possibly except at intersections where drivers may not expect cyclists) • can be obtained through several techniques, including adjusting the existing carriageway (making use of the general traffic lanes), upgrading service roads, sealing road shoulders, road widening at the verge or median or the removal of parking or traffic lanes • may be appropriate or highly desirable (depending on site conditions) where: – bicycle traffic is concentrated (e.g. near schools or along major routes near city or town centres) – an existing or future significant demand for bicycle travel can be demonstrated (e.g. where traffic volumes and speeds deter cyclists from using an otherwise favourable route) – there is a need to provide continuity within a bicycle route network – the community wishes to support active transport • may need to be designed and delineated with consideration given to: – crossings at intersections and changes in road layout as these can cause several problems for cyclists because of conflicts with vehicles at ○ squeeze points ○ locations where vehicles overtake and immediately turn left into a side street ○ converge and diverge areas ○ locations where there is a lack of continuity and connectivity

Treatment	Details
Exclusive bicycle lanes (continued)	o places where cyclists may need to cross or join conflicting flows o places where cyclists need to gain position to turn right o locations where cyclists are not being seen by motorists o locations where the speed of cyclists is misjudged by motorists. – head starts and expanded storage areas to improve visibility and awareness of cyclists at intersections to improve safety – the capacity of the bicycle lane in certain locations (e.g. priority cycling routes providing access to capital cities) – colour surface treatment in accordance with the AGTM Part 10 (Austroads 2019c) at key conflict points where motor vehicles routinely cross the bicycle lanes and storage areas.
Bicycle/car parking lanes	Bicycle/car parking lanes comprise a bicycle lane marked between permanent kerbside parking and a traffic lane. They: • provide a means of improving conditions for cyclists where parking occurs • may be provided in conjunction with parallel or angle parking in special circumstances (e.g. low-speed, inner urban) where road and network conditions are suitable • require adequate clearance between the bicycle lane and the parked cars so that doors are not opened into the path of cyclists (i.e. dooring). Clearance can be provided through the provision of a safety strip. Safety strips should be considered when there is – high parking turnover – high bicycle volumes – downhill gradients – areas where cyclists may travel at speeds higher than 30 km/h In areas where safety strips are warranted, but cannot be provided, consideration should be given to designating the traffic lane as a shared lane, marking it accordingly and reducing the speed, if required, so that it meets the guidance outlined in Figure 4.1 • may provide safety and other benefits for other road users due to – improved clearances for parking and unparking manoeuvres, and for the entering and exiting of parked cars by drivers – provision of greater clearances and increased width for vehicle recovery between roadside hazards and motor vehicles – more efficient use of road space on which they are implemented – reduced effective motor traffic lane crossing distance for pedestrians – improved channelisation of traffic and hence more orderly and predictable traffic flow, and often better sight conditions.
Contra-flow bicycle lanes	Contra-flow bicycle lanes: • are exclusive bicycle lanes deployed on one side (to the left of the opposing traffic flow) of a one-way road serving cyclists travelling against what is otherwise the legal direction of travel • are advantageous to cyclists from a network viewpoint • are acceptable in urban environments to achieve inner city links or routes to schools along lightly trafficked service roads • should not be provided along the shoulders of rural or outer urban roads without physical separation • may be provided in special circumstances (e.g. low-speed, inner urban) where road and network conditions are suitable • should be physically protected from motor vehicle lanes in higher-speed environments.
Sealed shoulders (for cyclist use)	Sealed shoulders (for cyclist use): • are suitable for roads without kerbs • should always have an edge line • should be well maintained • do not require regulatory signage on local and arterial roads • may have painted bicycle logos to provide awareness to motorists of the presence of cyclists and to encourage cyclists to use the shoulder – should be continuous over a significant length (preferably > 500 m).

Physically segregated bicycle lanes are signposted special-purpose lanes for use by bicycles that are separated from motor vehicle traffic using raised dividing devices or other means to physically prevent or manage motor vehicles encroaching into the bicycle lane. Raised dividing devices may include kerbs, raised medians, New Jersey barriers and similar devices. Protection may also be provided via on-street parallel parking located between the kerbside bicycle lane and motor vehicle traffic lanes.

Physically segregated bicycles lanes are installed within the width of the road (i.e. not within the verge of the road, where the bicycle lane would be categorised as an off-road bicycle path). The lane takes the form of a protected one-way bicycle lane (in the direction of travel that matches the direction of travel on that side of the road for motor vehicles) or a protected two-way bicycle lane as detailed in Table 4.2.

Table 4.2: Physically segregated bicycle facilities

Treatment	Details
Protected one-way bicycle lane	Protected one-way bicycle lanes are like exclusive bicycle lanes although they provide the additional separation from motor vehicle traffic using a raised dividing strip.
On-road exclusive bicycle path	An on-road exclusive bicycle path is a bicycle facility that may be installed within the existing road width (i.e. between the existing kerb and channel). Key feature of an on-road exclusive bicycle path are as follows: • they are typically signposted with a bicycle-only sign as shown below (designating it as a bicycle path) as opposed to a bicycle-lane sign (which would designate it as a bicycle lane). • are typically installed on one side of a road and typically provide a linkage between two or more separate off-road bicycle facilities terminals that may be separated by a length of road with the terminals located on the same side of the length of the separating road • are protected from motor traffic by a raised dividing strip or some other form of protection • should only be considered where relatively few driveway crossings exist, particularly where the route is used by children.  **Bicycle-path-only sign** Used to designate an exclusive bicycle path. May be used for off-road exclusive bicycle paths and on-road exclusive bicycle paths as described here  **Bicycle-lane sign** Used to designate a bicycle lane not an exclusive bicycle path *Source: AS 1742.9-2000*

Shared carriageways are roadways with no designated bicycle lane facility and where the cyclists share the same space with motor vehicles. They may have no special treatments or they may have wide kerbside lanes and bus lanes that permit bicycle use. Details of wide kerbside lanes and bus lanes that permit bicycle use are provided in Table 4.3.

Table 4.3: Shared carriageway bicycle facilities

Treatment	Details
No treatment	No treatment results in the bicycle sharing the existing lane space lane with other vehicles.
Wide kerbside lane	Wide kerbside lanes: • are a wider than normal traffic lane that can be shared by cyclists and drivers • are only appropriate where parking is either minimal or prohibited during peak periods • are often achieved by relocating lane lines during road resurfacing operations.
Bus lanes that permit bicycle use	Bus lanes that permit bicycle use: • are safer for cyclists to ride alongside a vehicle of similar speed than with higher-speed vehicles in the general traffic lane • may be allowed where it is unreasonable for cyclists to use the adjacent normal traffic lane • are ideally wider to allow for cyclists to overtake buses and vice-versa. A decision to allow use should consider the following factors: • preferences of cyclists using the route • speed of buses and other traffic • location of bus stops • frequency with which buses stop in a length of road • the available width (refer to Austroads (2016a) for appropriate lane width) • alternative options (e.g. if bicycles are not permitted in the bus lane the cyclist will be legally required to ride in the traffic lane between two higher-speed traffic streams).

4.4.2 Off-road Bicycle Facilities

Off-road bicycle facilities may be provided for the:

- safety of inexperienced, young and aged cyclists
- health and enjoyment of recreational cyclists
- convenience of commuter cyclists (e.g. exclusive bicycle path, shared path immediately adjacent to an arterial road to bypass a difficult section for cyclists).

Shared paths may be appropriate where:

- demand exists for both a pedestrian path and a bicycle path but where the intensity of use is not expected to be sufficiently great to provide separate facilities
- an existing low-use path can be satisfactorily modified (e.g. appropriate width and signage) to provide for cyclists.

In some jurisdictions bicycle riders can travel along footpaths. In this case , the width and provision of paths should be related to the nature and type of traffic that the paths are intended to carry. For example, long commuter paths beside a freeway should be wide enough to accommodate efficient, high-volume riders while a path in a residential cul-de-sac can be narrower and of lower quality.

Exclusive bicycle paths:

- are set aside for cyclists only
- may be appropriate where
  - there is a significant cycling demand and very few pedestrians desire to use the path or a separate pedestrian path is provided
  - there is very limited motor vehicle access across the path
  - it is possible to achieve an alignment that allows cyclists uninterrupted and safe travel at around 30 km/h
  - there is significant cycling demand and the path width is too narrow for shared use.

Separated paths:

- are paths on which cyclists and pedestrians are required to use separate designated areas
- are not the most common style of off-road bicycle facilities because they are justified only where there are large numbers of both pedestrians and cyclists desiring to use the path. Several of these are installed in Melbourne (i.e. Bay Trail, Docklands) and Brisbane for example
- should not be used in busy shopping centres where large numbers of pedestrians are expected to cross the path
- may be one-way or two-way.

For the design of these facilities refer to the *Guide to Road Design Part 6A: Paths for Walking and Cycling* (Austroads 2017c).

One or more of the following facilities can assist cyclists in crossing roads:

- grade separation
- a signalised crossing with bicycle detection and lights
- median refuge
- road narrowing of excessively wide roads while also providing for cyclist needs along the road
- on-road lanes or off-road path connections to nearby traffic signals, to be supplemented with bicycle detection and lanterns
- a crossing that gives priority for cyclists in accordance with road rules (refer to the *AGTM Part 6* (Austroads 2017f)).

4.5 Road Space Requirements for Pedestrians

Outlined below is guidance on facilities for road space requirements for pedestrians.

The types of devices generally provided to enhance pedestrian mobility and safety are outlined in AS 1742.10-2009 and the *Pedestrian Planning and Design Guide* (NZ Transport Agency 2009).

When providing for pedestrians, the facilities that need to be catered for include paths for longitudinal facilities and crossing facilities to facilitate crossing the road safely.

4.5.1 Paths

Paths provide a space for pedestrians to walk safely and should be:

- provided on all roads where a pedestrian demand exists
- located to satisfy pedestrian desire lines
- smooth with no tripping hazards for elderly persons and people with a vision or mobility impairment
- have relatively flat gradients and crossfalls where possible (e.g. if the road is too steep, there are not that many cost-effective options available) to cater for elderly persons and people with a vision or mobility impairment, especially when people in wheelchairs are expected
- wide enough to provide adequate capacity and to accommodate people in wheelchairs, motorised devices and walking aids, and people pushing prams.

Where steps and stairs interact or become part of paths, they:

- can be a significant impediment for people with disabilities
- should not be too steep, too narrow or have other inappropriate design features that cause problems for people with limited mobility
- should be well delineated for people with vision impairments.

Refer to AS 1428-2010 Parts 1, 2 and 4 or NZS 4121-2001 for design requirements.

Ramps also interact or become part of paths, they:

- generally, provide the only convenient and economical means of changing levels for people in wheelchairs or with prams
- require landings (flat areas) to break up long inclines
- should have kerbs at the edges where there are no walls as a guide to people in wheelchairs and those with vision impairments
- should have smooth, slip-resistant surfaces
- should have handrails where there is a drop-off at the edge of the ramp.

Refer to AS 1428-2010 Parts 1, 2 and 4 or NZS 4121-2001 for design requirements (e.g. gradient, crossfall, spacing of rest areas).

Shared paths must be wide enough to safely accommodate pedestrians and cyclists (refer to the *AGRD Part 6* (Austroads 2010)).

Where paths are not justified due to low or negligible pedestrian demand, consideration could be given to the provision of an area along the road reservation that may be used by pedestrians on rare occasions (e.g. where a pedestrian may need to walk along the road due to a broken-down vehicle) or during seasonal periods (e.g. during the summer along beach areas). Possible treatments that support occasional use, particularly where sight distance may be restricted, could be a maintained verge clear of overgrown grass, vegetation or table drains, or clear of other obstructions that could make walking difficult. Other considerations could include pull-out areas where pedestrians may seek refuge during periods when a vehicle may be approaching. The extent of the facility will need to be determined considering the potential use by pedestrians and cost.

4.5.2 Crossing Facilities

Crossing facilities allow for pedestrians to safely cross the road. The types of facilities that may be provided at mid-block include:

- pedestrian operated signals
- pedestrian operated signals with pedestrian countdown (where divers do not receive a flashing yellow signal and the flashing red man is replaced with countdown digits to tell pedestrians how long they have to finish crossing the road until the red don't walk symbol is displayed)
- pelican crossings (where traffic signals have a flashing yellow phase for early vehicle start-up if the crossing is clear)
- puffin crossings (where pedestrian presence on the crossing is detected and signal timing for the crossing is adjusted accordingly)
- pedestrian operated school signals
- pedestrian (zebra) crossings
  - the use of zebra crossings or children's crossings on arterial roads, particularly four-lane roads, is not desirable
  - requirements for the installation of zebra crossings or children's crossings, as outlined in AS 1742.10-2009, should be met
- pedestrian (wombat) crossings (raised pedestrian crossing as described in Table A 17)
- children's crossings
- pedestrian refuges (which provide a substantial benefit to pedestrians where other crossing devices are not warranted) can supplement other devices by
  - allowing pedestrians to cross the road in two stages, reducing the number of decisions that need to be made by drivers and pedestrians
  - providing some physical protection and refuge for pedestrians on a wide crossing which is important where elderly people or children are involved
- medians (raised or painted)
- kerb extensions with/without blister islands.

Crossing details including warrants are provided in the *AGTM Part 6* (Austroads 2017f). The most important consideration is that to provide the most benefits, they should be located to follow the pedestrian desire path line, unless this is impossible. In addition, facilities such as bus stops should be located to assist pedestrian safety in crossing roads (e.g. near crossing facilities, adequate sight lines).

For divided urban arterial roads, the crossings at mid-block usually require the provision of higher-level pedestrian facilities such as:

- signalised pedestrian crossings
- pedestrian fencing to direct pedestrians to the mid-block or intersection crossing facility
- grade separations
  - although grade separation should be used as a last resort due to their general dislike by pedestrians, often avoiding them where possible.

For undivided roads, the crossing at mid-block can be quite difficult depending on vehicle activity, without the assistance of a crossing facility. These can be managed through:

- reduced road crossing widths by providing medians suitable to hold pedestrians along hazardous sections of arterial roads
- provision of treatments such as kerb extensions ('blisters'), refuge islands or painted medians
- installation of fencing or other barrier types on the approaches to and departures from signalised pedestrian crossings and other facilities, to encourage crossing at these devices, rather than in nearby zones of high risk.

For crossing facilities, kerb ramps must:

- comply with AS 1428-2010 Parts 1, 2 and 4 or NZS 4121-2001
- be aligned in the direction of travel, be as flat as practicable and meet maximum gradient requirements
- be smooth
- be provided with tactile tiles and tactile direction indicators in accordance with local jurisdiction guides (see the *Guide to Road Design Part 4: Intersections and Crossings: General* (Austroads 2017g) and *RTS 14: Guidelines for Facilities for Blind and Vision-impaired Pedestrians* (NZ Transport Agency 2015)).

While raised medians or refuges with associated kerb ramps and gaps are the preferred treatments, painted medians flush with the road pavement of sufficient width have been demonstrated to provide safety benefits and may be used where a raised treatment is impracticable.

The selection of pedestrian crossing facilities based on safety and level of service is outlined in the *Guide to Traffic Management Part 3: Traffic Studies and Analysis* (Austroads 2017e). This approach is preferred to selection based only on numerical warrants, as provided in the *AGTM Part 6* (Austroads 2017f). Alternatively, the *Pedestrian Facility Selection Tool* (Austroads 2017b) can be used to assess the viability of different types of pedestrian crossing facilities, at mid-blocks and intersections, for physical and operation parameters of a site and the safety performance that can be expected.

For rural roads, urban-type treatments may be required where levels of conflict between pedestrians and vehicles warrant them. Additionally, bus stops on rural highways including school bus stops, should have an adequate area for passengers waiting to board and alighting from buses.

4.5.3 Amenity and Other Considerations

In addition to paths and crossing facilities, pedestrian enhancement measures can be provided to encourage walking within the community. The measures depend on the characteristics and functions of the road and include:

- streetscape improvements such as:
  - road verge and path widening to improve amenity for pedestrians
  - road or lane narrowing to reduce vehicle speeds
  - medians
  - tree planting and kerb extensions
  - perimeter threshold treatments
  - parking
- combinations of any of the above treatments
- urban design, by converting minor roads into pedestrian malls (an example of separating vehicles and pedestrians) or provision of shared zones (integrating pedestrian and vehicular traffic, with priority for pedestrians) or creation of shared spaces (integration by removing demarcation of vehicular and pedestrian areas of the street).

4.6 Road Space Requirements for Motorcyclists

Good traffic management and road maintenance practice should consider the needs of motorcyclists with respect to:

- minimisation of roadside hazards (e.g. number of poles and other fixed objects)
- minimisation of the installation of service covers and deck joints on curves or braking areas
  - riders will need sufficient sight distance to see hazards with adequate manoeuvre time when they cannot be removed or relocated
  - non-slip treatment is also an option
- design and maintenance of road pavements to ensure consistent surface texture, skid resistance and shape, particularly in braking areas
- design and maintenance of intersections and drainage to ensure that vehicle tyres and water do not cause loose gravel to be deposited on the road surface, and that water is efficiently discharged from the surface
- efficient use of road space, for example permission for motorcyclists to use HOV lanes or to park on footpaths.

In addition, the road space requirements for general vehicles also apply to motorcyclists (refer to Sections 3.2 to 3.8). For further guidance on parking refer to the *Guide to Traffic Management Part 11: Parking* (Austroads 2017d).

4.7 Road Space Requirements for Animals

The general requirements for the allocation of road space for animals are as follows:

- Animals (e.g. horses) or animal-drawn vehicles may be ridden/driven on roads subject to the road rules.
- Where permitted, horses may be ridden on shared paths.
- Where significant numbers of horses use a path, consideration should be given to the design to accommodate them safely (e.g. additional width, special signage, segregation at intersections and crossings).

5. Lane Management

Lane management can be defined as the control of the characteristics and usage of lanes on a road to achieve traffic management objectives. It typically involves actions such as the control of:

- the direction of traffic flow in a lane
- movements permitted in or from a lane
- the types of vehicles that are permitted to use a lane or are prohibited from using a lane
- on-road parking.

The purposes and objectives of lane management are the same as those for traffic management generally, that is, to facilitate safe and efficient traffic flow.

Typical issues and situations requiring the application of lane management include the following:

- accommodation of a mix of road user types with different vehicle sizes, speeds and levels of vulnerability
- significant variation in the traffic volumes in each direction at different times of day
- the need to separate through traffic from traffic turning at minor intersections
- conflict between the needs of moving traffic and parked vehicles
- the need to give priority treatment to public transport or another road user group.

There is substantial overlap between road space allocation concepts and lane management concepts, particularly in controlling (or restricting) the use of a lane by a class of vehicle. In general, the approach adopted in this Guide is that:

- issues associated with the provision of road space (or lanes) for different uses are dealt with in accordance with the guidance in Section 3 and Section 4.
- lane management topics in this section focus on *controlling* the way traffic lanes are used.

5.1 Lane Management Context

Lane management practice in this section is categorised in terms of:

- control of movement in or from a lane
- control of speed in a lane
- control of parking in a lane.

Management of the use of a lane by classes of vehicle is dealt with in Section 4.

Lane management practice may also in some instances be dependent on the context in which it is applied, which may include:

- the functional classification of the road (e.g. motorway, expressway and urban arterial)
- the physical characteristics of the road (e.g. divided/undivided)
- the abutting development (e.g. strip shopping, industrial, residential).

These aspects are discussed in Table 5.1 to Table 5.5 which identify traffic management actions for each area and their advantages and disadvantages.

The discussion here relates to the control of movement of vehicles on motorways, expressways and on arterials at minor intersections only. Management of turn movements at major intersections is detailed in the *AGTM Part 6* (Austroads 2017f).

5.2 Lane Management Practice

5.2.1 Movements Permitted

Table 5.1 summarises good practice in lane management in relation to the traffic movements permitted in or from a lane.

Table 5.1: Lane management – movements permitted

Context	Lane management guidelines	Good practice in implementation
General	The possible movements in or from an individual lane on a road are: • straight ahead or through • change lanes (left or right), including a movement across a lane line or continuity line forced by termination of a lane • turn left • turn right • U-turn • merge, where two adjacent lanes become one without the use of a continuity line • diverge, where one lane becomes two adjacent lanes without the use of a continuity line • reversing, generally into parking bays.	The rules defining movements permitted in or from a particular lane are provided in Part 4 of the Australian Road Rules 2012 and the New Zealand Land Transport (Road User) Rule 2004). Lane pavement markings (arrows) are not usually used to indicate to drivers what the road rules already require of them. However, there may be situations where site conditions generate an element of confusion, and it is necessary to reinforce the road rules with pavement markings or signs. This practice should be confined to exceptional cases, as experience suggests that excessive use of lane markings or signs can be counter-productive. In the extreme, it can lead to an expectation that any movement is permitted in or from any lane unless pavement markings or signs suggest otherwise. **Merges** If a reduction in the number of lanes takes place in a low-speed environment, the merge area may not require a continuity line, and the 'zipper' merge rule under the Australian Road Rules will apply (Rule 149). Where traffic speeds are 100 km/h or more, the merge area associated with a lane drop should be marked with a continuity line over its full length. A continuity line should also be provided where there is a significant speed differential between the adjacent lanes. Under the Australian Road Rules a continuity line imposes the same obligations as a lane line, and lane change rules apply. In New Zealand, the New Zealand Land Transport (Road User) Rule 2004 applies and continuity lines are not used. Required forms for pavement markings and signs are set out in AS 1742.2-2009 and the *Traffic Control Devices Manual* (NZ Transport Agency 2008a).

<table>
<tr><th>Context</th><th>Lane management guidelines</th><th>Good practice in implementation</th></tr>
<tr><td>Motorways and expressways</td><td>The possible movements in or from a motorway and expressway lane are:
• straight ahead or through
• change lanes (left or right), including a movement across a lane line or continuity line forced by termination of a lane
• merge, where two adjacent lanes become one without the use of a continuity line
• diverge, where one lane becomes two adjacent lanes without the use of a continuity line
• enter (in Australasia, normally entering traffic moves to its right to join with traffic in the left-hand through lane of the road – may be a lane change or a merge)
• exit (in Australasia, normally left into an exit ramp – may be a lane change or a diverge).</td><td>Remote from entry and exit ramps, only the straight ahead and change lane movements are possible. No pavement markings, apart from the lane lines, are required.
Approaching an exit ramp, there may be a need for traffic control devices permitting different types of movements (e.g. exit only, exit or continue, or continue only) depending on the geometric complexity of the situation.
In the simplest case of an isolated, one-lane exit ramp, advance warning or direction signs make drivers aware of the situation. The only pavement marking required is to replace the continuous edge line with a short-spaced broken line (continuity line) across the ramp entry (between the continuous edge lines of the ramp itself).
In more complex cases – for example, a two-lane exit ramp or where there is a continuous auxiliary lane from an entry ramp to a subsequent exit ramp – traffic control devices (lane pavement markings or gantry-mounted signs), together with appropriate advance signage (e.g. left lane must exit) should be used to make the situation clear to drivers.
Examples of simple and complex exit designs are provided in the AGRD Part 3 (Austroads 2016a) and required forms for pavement markings and signs are set out in Australian and New Zealand standards (refer to AGRD Part 3 (Austroads 2016a), AS 1742.2-2009, and the Traffic Control Devices Manual (NZ Transport Agency 2008a)).
At entrance ramps, two alternative treatments are available:
• Replace the continuous edge line of the motorway and expressway with a short-spaced broken line (continuity line) over the length of entry. Oblique change-lane pavement arrows (supported by signage) may be used where a long acceleration lane is to be terminated ahead. The use of a continuity line means that, under the Australian Road Rules 2012 and the New Zealand Land Transport (Road User) Rule 2004, the entry movement is technically a lane-change movement. The pavement arrows may not be used in some jurisdictions.
• Alternatively, have no continuity line or pavement arrows in the entry area. In this case, the zipper merge in Rule 149 of the Australian Road Rules 2012 and New Zealand Land Transport (Road User) Rule 2004 will apply.
• Western Australia uses this option only.</td></tr>
<tr><td>Arterial roads</td><td>The possible movements in or from an individual lane on an arterial road are:
• straight ahead or through
• change lanes (left or right)
• turn left
• turn right
• U-turn
• merge (not normally encountered unless there is a change in the number of lanes provided)
• diverge (not normally encountered unless there is a change in the number of lanes provided).</td><td>Right-turns
Right-turn movements at intersections with minor roads should be accommodated in indented turn bays if possible (refer to Section 3). The main lanes are then consistently available to through traffic.
If space does not permit provision of an indented right-turn lane, consider whether the median should be closed to prevent the turn, or a no right-turn restriction either full-time or part-time, should be applied. The feasibility of restricting right-turn access from an arterial road to a minor intersecting road will depend on the:
• function of the intersecting road
• availability of alternative routes, that may involve local roads, to serve the restricted movement
• impact of diverted traffic on the roads
• capacity and traffic operation at locations along the alternative routes.</td></tr>
</table>

Context	Lane management guidelines	Good practice in implementation
Arterial roads (continued)	This guideline deals with mid-block locations which, for this purpose, may involve traffic entering from or exiting to minor side roads. Traffic management of intersections is considered in the *AGTM Part 6* (Austroads 2017f).	In simple cases, manual calculations may be sufficient to assess these factors. In more complex cases, usually those involving a package of such measures affecting several intersections, a computer-based traffic model of the local area may be required. If the turn movement must be retained at the minor intersection, consider whether the volume and queuing length and frequency is such as to require an exclusive right-turn from this lane (without indented bay) with right-turn-arrow pavement marking. If the turn movement must be permitted consider whether an S-lane is appropriate (refer to Commentary 12 for further information). Commentary 12 **Two-way right-turns** Right-turns from both (opposing) directions of travel are permitted from a median turning lane (so named because it occupies the space otherwise taken by a median), also known as a two-way right-turn lane. This treatment is particularly applicable: • in commercial and residential areas with closely spaced access points • where arterial roads bisect country-town business and industrial areas and access is required for motels, service centres and adjoining low traffic volume side roads. **Median turning lanes or two-way right-turn lanes** These treatments: • can reduce the level of service and safety on an arterial road by allowing unrestricted access which can also encourage piecemeal land development • should not be used where there is potential conflict with uncontrolled pedestrian movements, such as high-density environments (consideration should be given to existing and future land use) • should not be used where the road has more than two lanes in each direction; resulting in a total of five lanes including the median turning lane • should only be used in 70 km/h or lower travel-speed environments • can be used in conjunction with strategically placed pedestrian refuge islands and/or conventional painted right-turn lanes at key minor intersections. Guidelines for median turning lane design are provided in the *AGRD Part 3* (Austroads 2016a). On new arterial roads in commercial and industrial areas with widely spaced access points, a raised median, with openings at appropriate locations, is preferred. New Zealand uses a different form of median turn lane termed a flush median (refer to the *Traffic Control Devices Manual* (NZ Transport Agency 2008a)). Refer to Commentary 13 for illustration of two-way right-turns. Commentary 13 **Left-turns** Specific provision is rarely made for left-turn movements at minor intersections, other than at rural intersections that incorporate auxiliary lanes (refer to Section 3.3). **U-turns** The Australian Road Rules 2012 (Division 4) allow U-turns except: • where prohibited by no U-turn signs or dividing lines

Context	Lane management guidelines	Good practice in implementation
Arterial roads (continued)		• at traffic signals unless there is a U-turn permitted sign • where there is not a clear view of any approaching traffic. In Victoria and New Zealand U-turns are permitted at traffic signals unless specifically prohibited by a no U-turn sign. Where there is a significant length of limited opportunity for right-turn access, exclusive indented U-turn lanes may be provided. In considering whether to permit or prohibit U-turns, and the need for special U-turn facilities at a location, consider whether the road network provides alternative ways of reversing travel direction, the length and turning path characteristics of U-turning vehicles, and the impact on traffic operations of vehicles unable to U-turn in a single movement.
Local roads	The possible movements in or from an individual lane on a local road are: • straight ahead or through • change lanes (left or right) • turn left • turn right. Merge and diverge movements are not normally encountered on local roads.	Auxiliary lanes may be provided at property access points in the same manner as for some intersections on rural arterials, as discussed in Section 3.3. Also, rural local roads may require consideration of separation linemarking needs (see below). Almost all other local road actions that could be considered as lane management are intersection-related. On urban local road networks also, most lane management actions are intersection-related. Left, right and U-turns are all normally allowed (in accordance with road rules) on local roads, other than where specific restrictions are implemented for safety reasons or to limit access for local environmental amenity reasons. Some urban local roads, while not functioning as arterials, have arterial road cross-sections and access management classifications. In such cases, they may require management in the same manner as described above for arterials. Refer to Commentary 14 for exceptions to the statement that most lane management actions on urban local roads are intersection-related. Commentary 14 On local roads in areas of strip or ribbon development, median turning lanes (two-way right-turn lanes) may provide the same opportunities as for arterial roads (see above).

5.2.2 One-way Roads

Lane management in relation to one-way roads is considered in Table 5.2.

Table 5.2: Lane management – one-way roads

Context	Lane management guidelines	Good practice in implementation
Central business districts and inner areas of larger cities	One-way roads are most commonly operated to provide travel in one direction at all times. Rarely, they may be operated to provide: • for one direction of travel at certain times and in the reverse direction at other times to suit highly directional traffic demands • one direction of travel at certain times but reverting to two-way operation at other times e.g. during off-peak periods.	One-way roads may be used in the central business district and other inner areas of larger cities. They should be used if it is in line with the network operation plan of the area and they are implemented in consultation with stakeholders. One-way roads have their advantages and disadvantages as outlined below. **Advantages** (based on Institute of Transportation Engineers (1976)) The main advantages are: • significant reduction in intersection conflicts and delays with consequent increase in capacity. Capacity increases of 20 to 50% over two-way operation have been reported • improved traffic safety due to completely separating opposing traffic flows. Total road crash reductions of 10 to 50% have been claimed • generally, improved traffic operations, in respect to travel speed and congestion. Travel time reductions of 10 to 50% have been reported. **Disadvantages** (based on Institute of Transportation Engineers (1976)) The main disadvantages are: • travel distances are increased for some trips, including those by bicycle • there may be confusion by unfamiliar drivers leading to wrong-way movements. This is more likely to occur where the one-way roads for opposite directions of travel are widely separated, where inadequate inter-connections are made, or where signing and marking practices are inadequate • may lead to increased speeds that are not consistent with the road environment. One-way road proposals require a thorough study with appropriate community input to establish the relative merits and acceptability of the scheme. They are usually limited to situations where: • the road layout allows nearby parallel roads to be used as a one-way pair preferably not more than one block apart and with adequate interconnections • specific capacity or operational problems are amenable to improvement by the treatment • the arrangement can provide adequate traffic service to the area traversed as well as carrying through traffic • a satisfactory transition back to two-way operation can be provided • on-road public transport operation is not significantly disadvantaged. One-way movement may also be required in laneways used by motor vehicles where there is insufficient width to accommodate two-way traffic.
Local laneways	One-way operation may be provided to enable safe travel in laneways or narrow roads where there is insufficient width to safely accommodate two directions of travel.	Many local laneways originally provided service access to the rear of residential and commercial properties, a need that often has diminished or disappeared. Where lanes continue to carry traffic, they typically provide: • vehicular access to the rear of a property where traffic factors or space limitations inhibit front access • space for pedestrian, bicycle or shared paths.
Context	Lane management guidelines	Good practice in implementation

5.2.3 Tidal Flow Operations

Tidal flow operations on major roads allocate more lanes to the peak direction during peak periods. Good practice is described in Table 5.3.

Table 5.3: Lane management – tidal flow

Context	Lane management guidelines	Good practice in implementation
Motorways and expressways	Where the median is sufficiently wide, additional (reversible) lanes may be developed within the median, operated as additional or 'special use' lanes in the peak period. Alternatively, all lanes in the counter-peak direction of a motorway and expressway may be reversible to provide tidal flow operation.	The higher operating speeds of motorways and expressways make the need for careful design of the terminal areas where tidal flow is transitioned to normal conditions even more important. As with arterial roads, speed limits may require review. Examples of roads undertaking tidal lanes can be found in Commentary 15. Commentary 15
Arterial roads	Tidal flow operation can provide increased capacity in the peak direction by reversing the direction of flow in the centre lanes. This operation is suitable for arterial roads on which the traffic flow is strongly biased in one direction at different times of the day and which are of adequate width and otherwise suitable. A directional split of traffic flow of at least 70/30 favouring the peak direction is generally necessary before tidal flow operation is justified. At least five traffic lanes are required to enable a minimum of two to operate in the counter-peak direction, although reversible centre lanes have also been operated successfully on three-lane bridges. Tidal flow operation can be achieved by overhead lane control signals or by internally illuminated pavement markers, although for temporary or short-term traffic management, manually placed traffic lane delineators or signs may be used.	Tidal flow is best suited to wide, undivided roads. While tidal flow can be implemented on a divided road with contra-flow operation of a median lane, careful consideration of pedestrian activity is necessary. Pedestrians crossing a road do not expect traffic from the right after they have crossed a median. Effective tidal flow operation requires close attention to design detail at terminals where tidal flow conditions are transitioned to 'normal' conditions. In some special cases, moveable medians, operated in conjunction with the overhead lane control signals or the internally illuminated pavement markers, may be used to effectively control the terminal areas. Close attention is also required to the operational design of changeover procedures. The use of a moveable median should reduce the risk of crashes and reduce the reliance on complex signalling (refer to the *AGTM Part 9* (Austroads 2019b). Speed limits may need to be reduced in the light of tidal flow operation. Variable speed limits may be required to safely accommodate both normal and tidal operation. **Advantages** The main advantages are: • increased peak direction capacity • often has lower capital cost than alternative capacity increasing measures such as widening. **Disadvantages** The main disadvantages are: • increased risk of crashes; however, if a moveable barrier is used, the risk of crashes decreases because head-on crashes are prevented, significantly reducing casualties. There is also less need for lane control systems and complex signalling • high ongoing costs, in operation and maintenance of lane control systems, or in operational costs of manually placed traffic-lane delineators or signs. Tidal flow should only be considered after other cost-effective capacity increasing measures have been eliminated • complex signalling arrangements where lane control signals must be integrated with intersection control signals • effectiveness reduced where heavy right-turn movements must be accommodated.

5.2.4 Lane Control Measures and Devices

The measures and devices utilised in lane management include regulations, pavement markings, and lane control signals and signs, as described in Table 5.4.

Table 5.4: Lane management – lane control measures and devices

Context	Lane management guidelines	Good practice in implementation
General	**Regulations** Road rules governing the movement of traffic along a road include rules dealing with: • turn movements • changing lanes • overtaking. The regulations also prescribe the appearance of regulatory signs and markings used in lane management. (Refer to the Australian Road Rules 2012 or New Zealand Land Transport Rule: Traffic Control Devices 2004) **Traffic control devices** Pavement markings employed in lane management include: • lane lines • separation lines • pavement arrows or logos • coloured pavement. Other lane management devices include: • overhead lane control signals • illuminated pavement lights • traffic lane delineators • moveable barriers.	It is critical that any signs and pavement markings used in lane management take note of, and are consistent with, the relevant regulations. Inconsistency between regulation requirements and signs and markings can detract from the efficacy of the lane management measure, result in less safe conditions through added confusion or outright conflict, and expose the responsible authority to legal liability. Issues to note include: • Pavement marking standards and usage guides are provided in AS 1742 and the *Traffic Control Devices Manual* (NZ Transport Agency 2008a). • Pavement markings will only command respect and attention from drivers if they can be readily seen, and if their messages can be comprehended. • Wet weather and wet roads pose problems for the visibility of pavement markings. Be aware of the possibility that markings might not be seen in adverse conditions. Implement markings in higher-visibility materials where their observance is critical. Retroreflective raised pavement markers can be used to supplement lane markings and provide superior performance in adverse weather conditions (refer to the *AGTM Part 10* (Austroads 2019c) or the *Traffic Control Devices Manual* (NZ Transport Agency 2008a)). • The detailed shape of pavement arrows depends on the speed environment in which they are placed. Be aware that on higher-speed roads a different arrow shape is required than on lower-speed roads. Guidelines for other traffic control devices used in lane management can be found in the *AGTM Part 10* (Austroads 2019c) or the *Traffic Control Devices Manual* (NZ Transport Agency 2008a).
Motorways and expressways	**Managed motorways** Managed motorways utilise smart infrastructure technologies to improve the efficiency of major motorways and expressways, thus reducing congestion and improving productivity. Managed motorway systems are widely used in North America, Europe and Japan, while several projects have been/are being undertaken in Australia and New Zealand such as: • M4 (Western Motorway) in Sydney • M1 (West Gate Motorway, Southern Link, Monash Motorway) and M80 (Western Ring Road) in Melbourne • Gateway Motorway in Brisbane • Motorway Network in Auckland.	Several technologies can be used in managed motorways, including: • Ramp metering/signalling: ramp metering regulates the flow of vehicles entering a motorway via traffic signals, enabling easier merging and less effect on motorway traffic flows at on-ramps. • Variable speed signs/limits: variable speed limits can help manage congestion by harmonising traffic to a more consistent speed, reducing stop-and-go traffic. • Travel time information signs: these signs provide congestion and real-time travel information to motorists, enabling them to make educated choices about their route. These signs can be located on the motorways themselves as well as on arterial roads leading up to the motorways. • Variable message signs: these signs provide information and warnings regarding incidents, road works and similar occurrences, enabling motorists to make decisions about their route.

Context	Lane management guidelines	Good practice in implementation
Motorways and expressways (continued)		• Lane use management systems/lane control signals and signs: electronic lane control signals or signs may be used to control traffic flows or to display speed limits in individual lanes, particularly on motorways and expressways, should this be desired. They are often used in relation to incident management where inclined lane arrows and red crosses can be used to progressively notify drivers to change lanes and vacate lanes in advance of an incident, perhaps culminating in drivers being directed to an off-ramp. By smoothing the joining of traffic streams, secondary crashes can be reduced and delays minimised. • Tidal flow lanes: reversible lanes can result in more effective use of the road space when traffic is biased in a direction during peak periods. They are most effective when at least 70% of the peak traffic flow is travelling in one direction. Guidelines for managed motorways can be found in the *AGTM Part 9: Traffic Operations* (Austroads 2019b) and *Freeway Design Parameters for Fully Managed Operations* (Austroads 2009a). Guidelines concerning use of lane control signals and signs can be found in the *AGTM Part 10: Traffic Control and Communication Devices* (Austroads 2019c) or the *Traffic Control Devices Manual* (NZ Transport Agency 2008a). The shapes, colours and meanings of lane control signals and signs are described in Part 11, Division 5 of the Australian Road Rules 2012 or New Zealand Land Transport Rule: Traffic Control Devices 2004. It is important that these conventions be followed). Examples of current good practices and provision guidelines for the above managed motorway technologies can be found in VicRoads (2013) and Main Roads Western Australia (2012).

5.2.5 On-road Parking Control

Table 5.5 describes those aspects of parking control that have the most direct impact on the lane management of arterial roads. For a more complete treatment of these and other parking issues see the *Guide to Traffic Management Part 11: Parking* (Austroads 2017d).

Table 5.5: Lane management – on-road parking

Context	Lane management guidelines	Good practice in implementation
Motorways and expressways	**No stopping** To preserve desired operational characteristics of motorways and expressways, the Australian Road Rules 2012 and New Zealand Land Transport Rule: Traffic Control Devices 2004 prohibit stopping on motorways and expressways except in emergencies. This applies to the shoulder as well as the traffic lanes.	In some jurisdictions, this requirement is supported by the provision of no-stopping or no-turning signs at regular intervals along the motorway and expressway. In others, the shoulder is designated by signage such as 'emergency stopping lane only', and the road rules support the sign.
Arterial roads	**Parking** On urban arterial roads, the needs of people wishing to park are often accommodated through the provision of space for parallel parking in the kerb lanes. The use of this space, which may be designated for general parking or for specific purposes such as taxi ranks and loading zones, is typically time-variant, being available for parking during off-peak periods but operating as a traffic lane or clearway during peak periods.	Parking/unparking conflicts can result in friction which results in loss of not only capacity of the parking lane but also reduced capacity of the adjacent lane. On arterial roads, where the access function is usually subordinated to the traffic function, particularly in peak periods, parking should be a secondary consideration to traffic movement, public transport needs and road delivery demands. Parking/unparking also can result in reduced safety for cyclists both through parking manoeuvres and the opening of car doors into the path of passing cyclists. Wherever practicable a 'safety strip' should be marked between parking bays and a bicycle lane to allow for the opening of car doors (refer to the *AGRD Part 3* (Austroads 2016a)).
	Clearways Clearways may be introduced when the full capacity of all lanes of an arterial road is required. As a guide, on arterial roads with traffic signal control at major intersections, clearways may be introduced when traffic volumes exceed those set out in Table 3.1. Clearways may also be required to support the operation of kerbside bus lanes, transit lanes and the like. Traffic regulations exempt emergency vehicles from clearway restrictions. The standard signing arrangements to be adopted for clearways is provided in AS 1742.11-2016, *Parking Controls* and the *Traffic Control Devices Manual* (NZ Transport Agency 2008a).	Generally, clearways and parking restrictions operate during the peak traffic hours for a direction, to provide an increase in the peak-direction capacity. The times of operation of clearway restrictions should be uniform over as large an area as possible, but should also take account of the fact that sometimes the time of the peak period moves progressively with the traffic towards or away from the centre of a large city. The duration of the clearway restrictions should not be less than one hour. Usually the duration is two to four hours but occasionally, on primary arterials, there may be a need to implement clearways over extended periods. Occasionally a clearway will operate on a 24-hour basis along critical routes. On critical routes, where parking infringements can have an extremely adverse effect on traffic flow and capacity, the clearway signs may be supplemented with tow-away signs that enable offending vehicles to be removed from the roadway. Clearways are usually implemented over relatively long lengths of more important urban arterial routes, where specific warrants are met. The criteria in Section 3.7 may be used as a guide to their justification, although the traffic flow criteria may vary between jurisdictions.

6. Speed Limits

6.1 The Safe System and Safe Speeds

The Safe System approach is the basis for road safety in Australia and New Zealand, and is embraced by the Australian *National Road Safety Strategy 2011–2020* (Australian Transport Council 2011) and *Safer Journeys: New Zealand's Road Safety Strategy 2010–2020* (Ministry of Transport 2010). The Safe System requires a holistic approach with the aim of no person being killed or seriously injured on the road network. All elements of the road system, including safe roads, safe vehicles, safe road use and safe speeds are incorporated with responsibility required from stakeholders, including the responsible agencies, governments and road users.

As outlined in the *Review of the National Road Safety Strategy* (Austroads 2015c) speed management is a core component of a Safe System and remains the best opportunity for a rapid reduction in road trauma. The critical role of speed in the Safe System was recognised by both the Australian National Road Safety Strategy and New Zealand's Safer Journeys road safety strategy; safe speeds were treated as cornerstones in both these documents.

The application of appropriate speed limits forms an integral part of a safe road system. Speed limits are a management tool used to improve road safety, while maintaining the efficiency of the road network that requires the movement of people and goods, and the preservation of amenity. To achieve those objectives, speed limits need to be:

- compatible with harm minimisation principles
- safe and appropriate for the road environment
- cognisant of the road function
- consistently applied throughout the road network
- clear and unambiguous.

If speed limits are set in alignment with these five principles, then an environment will be created where speed limits are credible and compatible with road user expectations.

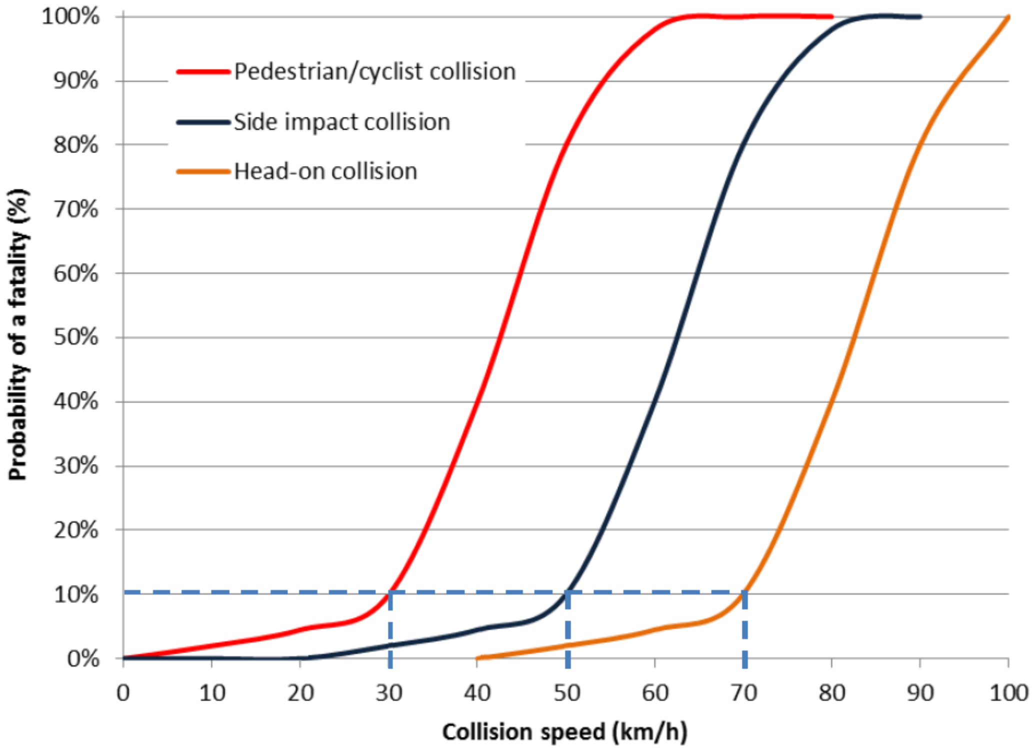
To comply with the Safe System and to achieve a safe road environment, road agencies need to move towards maximising safe mobility. This is a change in focus from the traditional approach to road management which tended to focus on balancing efficiency needs with safety needs.

Research shows that inappropriate higher speeds will result in an increasing number and severity of crashes. Similarly, it is likely that inappropriately high or low speed limits will result in greater variation in speed between vehicles and this could also result in an increased crash rate. Therefore, it is important that speed limits are applied in accordance with guidelines that take safety into account.

We know that even small reductions in travelling speed can have large effects on injury outcomes. The creation of an inherently safe road system is largely dependent on the kinetic energy in the system. The transition towards the Safe System will be dependent not only on the adoption of speed limits compatible with harm minimisation but also the integration of solutions that guarantee safe interaction speeds where conflict occurs or where lane departure is possible (Austroads 2018).

The Wramborg curves (Wramborg 2005) have been adopted internationally to illustrate "survivable" thresholds against impact speeds, as shown in Figure 6.1. A 10% threshold for fatal outcomes appears to have been universally adopted.

Figure 6.1: Relationships between collision speed and probability of a fatality for different crash configurations



Source: Jurewicz, Sobhani et al. (2015) and based on Wramborg (2005)

6.2 Implementation Framework

This section provides implementation details to assist practitioners in establishing, selecting and reviewing speed limits, and outlines how speed limits should be signed including the types and location of speed signs. It is noted that the NZ Transport Agency utilises a classification system that segments the road network into six road types based on function and use. Safe and appropriate speeds are identified for each road type based on the nature of adjacent land use, safety performance and infrastructure risk. Other differences in practice to that outlined in the following sections. New Zealand practitioners should refer to the *Speed Management Guide* (NZ Transport Agency 2016).

Speed regulation is achieved through legislation and associated road rules. In Australia, Part 3 of the Australian Road Rules 2012 specifies national speed limit rules where compliance is required (Rule 20):

- where a speed limit sign applies (Rule 21)
- in a speed limited area (Rule 22)
- in a school zone (Rule 23)
- in a shared zone (Rule 24)
- elsewhere (Rule 25).

In New Zealand, Land Transport Rule: Setting of Speed Limits 2017 sets out the roles and responsibilities of the NZ Transport Agency and road controlling authorities for reviewing and setting speed limits.

In Australia, the responsibility for setting speed limits rests with the state and territory road agencies, with some jurisdictions allowing local authorities to set the limits in certain circumstance. It should also be noted that there may be variations in practice across Australian jurisdictions. Practitioners should therefore be familiar with local practices when undertaking road design and traffic management activities within a jurisdiction. Refer to Commentary 16 for further discussion on vehicle speeds on routes and Commentary 17 on containing vehicle speeds.

Commentary 16 and Commentary 17

The *National Road Safety Strategy 2011–2020* (Australian Transport Council 2011) requires a range of road safety actions or interventions under the following four ‘cornerstone’ areas:

- Safe roads – roads and roadsides designed and maintained to reduce the risk of crashes occurring and to lessen the severity of injury if a crash does occur. Safe roads prevent unintended use through design and encourage safe behaviour by users.
- Safe speeds – speed limits complementing the road environment to manage crash impact forces to within human tolerance, and all road users complying with the speed limits.
- Safe vehicles – vehicles which not only lessen the likelihood of a crash and protect occupants, but also simplify the driving task and protect vulnerable users. Increasingly this will involve vehicles that communicate with roads and other vehicles, while automating protective systems when crash risk is elevated.
- Safe people – encouragement of safe, consistent and compliant behaviour through well-informed and educated road users. Licensing, education, road rules, enforcement and sanctions are all part of the Safe System.
- develop a national public information campaign regarding the benefits of travelling at safer speeds
- review speed limits for high-risk areas
- increase the adoption of lower speed limits in urban areas
- investigate the implementation of intelligent speed assistance/adaptation (ISA) systems
- investigate the usage of point-to-point speed cameras for control of speed over a road section
- improve the use of sanctions/penalty systems to deter breaking speed limits
- improve the enforcement of speed limits (including targeted enforcement e.g. school zones)
- improve the chain of responsibility legislation to deter heavy vehicles breaking the speed limits.

The *Review of the National Road Safety Strategy* (Austroads 2015c) suggested that technological solutions to speed management such as in-vehicle speed warning and ISA systems be promoted to increase take-up and use. Further details on such technology are provided in Commentary 18.

Commentary 18

6.3 General Philosophy of Speed Limits

Within the overarching principles of a safe road system, the general philosophy of speed limits is that they take into consideration a comprehensive range of road environment features, driving conditions and biomechanical factors.

The choice of speed limit and consequent operating speeds on a road not only affect the amenity of areas immediately adjacent to roads but can have a broader impact on the amenity within communities, for example in relation to pedestrian and cyclist accessibility.

Speed limits should not be considered as the primary means to address problems at specific locations along the road which may contribute to crash occurrence or severity. It is always preferable to address such issues through remedial engineering action as indicated in Appendix A of AS 1742.4. In cases where it may not be possible to undertake remedial work due to cost or time constraints, a reduction in the speed limit at high-risk intersections and/or link locations may be considered (as determined by a risk assessment which would take into consideration aspects such as crash history, road use patterns, road features and vehicle speeds).

The *Model National Guidelines for Setting Speed Limits at High-risk Locations* (Austroads 2014b) notes that the safety effects of localised fixed speed limit reductions at intersections have had very limited evaluation to date. There is no robust evidence to support lasting intersection safety improvements from reduced speed limits. However, the NZ Transport Agency has done work using variable speed limit reductions based on vehicles being present on the opposing leg of an intersection which reported positive results. Mackie et al. (2015) reported that the rural intersection active warning system has the potential to reduce fatal and serious casualties at rural intersections by:

- slowing motorists on major road intersection approaches and thus reducing crash likelihood (increasing stopping distance) and severity (less energy on impact)
- increasing driver awareness and therefore preparing motorists for a possible event (effectively reducing reaction time)
- increasing the gaps between potentially colliding vehicles.

The general principles for speed limits are discussed in the *Guide to Road Safety Part 3: Speed Limits and Speed Management (AGRS Part 3)* (Austroads 2008b). The Guide outlines why speed management is important and discusses the links between travel speed and casualties, along with the general principles behind choosing a speed limit and speed signing.

While the functional, geometric and operational characteristics of the road will usually be reflected in the speed limit, a lower limit may be assigned to sections of road or parts of the network that have a high probability of conflict between road users, and hence a higher probability of crashes. In urban areas, these sections and areas have abutting developments that generate substantial vehicle and/or pedestrian movement into and across the road. Examples include areas of high activity such as:

- central business districts of cities and large towns
- roads abutting schools
- shopping centres abutting roads in urban areas and rural towns
- roads that experience large seasonal traffic variations
- roadwork sites.

Due to site considerations and financial constraints, engineering measures may not be feasible. Therefore, lowering speed limits may also be considered a long-term solution to address the safety issues.

Table 6.1 summarises key aspects of good practice that should be observed when applying speed limits.

Table 6.1: Good speed limit practice

Issues	Comment
Practical and equitable enforcement	• Speed zones must be of adequate length. • Signposting must meet regulatory requirements and be clear.
Credibility and homogeneity	• A speed limit should be appropriate for the function of a road and its environment, be homogeneous, and be consistent in application across similar road types and road environments. Speed limits should be reviewed in the context of NOP and involve stakeholder and community input to clarify the function and role of the road and to establish an appropriate speed limit for that function and role. Most importantly speed limits should be set in recognition of major severe crash risks which cannot be reasonably addressed by engineering improvements. • Avoid frequent changes of speed limit. • Use speed limit reminder signs more frequently (although it is noted that New Zealand seeks to use speed limit reminders less frequently where a road is self-explaining) to give motorists the best chance to comply with speed limits particularly in situations where the speed limit may have been reduced or is less than in other similar situations.
Geometric deficiency	• Speed limits should not be applied specifically for compensating for isolated variations in geometry. • It is preferable to rectify a geometric deficiency. • Advisory warning signs and supplementary panels (e.g. indicating the advisory speed) should be used.
Unsealed roads or roads with narrow seals	• Speed limits other than the default urban or default rural limits are not generally applied to unsealed roads or roads with narrow seals. • An exception is roads which are not provided for through traffic that have a speed limit less than 50 km/h.
Increments in speed limit	• All signposted speed limits should be in multiples of 10 km/h. In New Zealand, the preference is for 20 km/h increments above 60 km/h. • Advisory speeds on curve warning signs should be in multiples of 5 km/h in accordance with Clause 4.4.6.3 (a) of AS 1742.2-2009. In New Zealand, advisory speeds are set as increments of 10, but ending in 5 (i.e. 45 ,55, 65, 75 etc.).

6.4 Types of Speed Limits

There are two types of speed limit used in Australia and New Zealand: default limits that are defined in legislation and apply to roads that have no speed limit signs, and signposted limits where the speed limit applying to a length of road or area is defined by signs. In addition, in some cases, lower limits can apply for vehicle or licence classes (i.e. lower limits for learners or provisional licence holders).

Default speed limits are imposed by statute or regulation to various classes of road and are applied in the absence of a signposted speed limit. The default limits apply as follows:

- *default rural speed limit* – applies in other than built-up areas
- *default urban speed limit* – applies in built-up areas which are normally defined in state regulations.

Refer to Commentary 19 for details of state and territory default speed limits.

Commentary 19

Signposted speed limits may be applied to reflect the types of driving conditions or road environments. The signs may be static or variable.

Speed limits indicated by static signs may be:

- permanent
- applicable by day of the week or time of day
- temporary to cater for changed road conditions
- applied on a seasonal basis where unusual demand occurs (e.g. coastal towns, alpine resorts)
- applicable to specific classes of vehicle or classes of driver through inscriptions on signs or through driver licensing or vehicle licensing regulations.

Variable speed limits may be needed at schools and other locations where there are traffic conditions requiring changes to the appropriate prevailing speed limit. In such cases, variable signing is required.

In Australia, the requirements for signs for speed management (regulatory and advisory), the placement of signs, pavement markings and calculation of advisory speeds are provided in AS 1742 *Manual of Uniform Traffic Control Devices*. For New Zealand, reference should be made to the Land Transport Rule: Setting of Speed Limits 2003.

6.5 Speed Limits and Speed Zones

A speed limit is defined as the maximum speed at which a vehicle is legally allowed to travel on a section of road. A *speed zone* is defined as the length of road or a network of roads (i.e. area) within which a single speed limit applies. Types of signposted speed limits in Australia and New Zealand include those shown in Table 6.2 and these are used to establish speed zones within default speed limit areas. Refer to Commentary 20 for further discussion on speed zones.

Commentary 20

Table 6.2: Types of signposted speed limits

Types of limit	Comment
Linear speed limit	• Applied to a length of road by appropriate speed limit signing. • Includes transition or buffer speed limits.
Shared road space speed limit (shared zone)	• Applied to an area or length of road shared by both vehicles and pedestrians. • Pedestrians have priority. • Must be supported by an appropriate design (refer to the *AGTM Part 8* (Austroads 2016c).
Area speed limit	• Applied to a network of roads within a defined area with appropriate speed limit signing at each entry to and exit from the area. • May be applied to residential or commercial areas.
Time-based speed limit	• Typically applied to: – school zones – roadwork speed limits – pedestrian activity area speed limits (e.g. strip shopping centres) – seasonal speed limits (often in tourist destinations where high pedestrian and vehicle volumes occur for holiday periods that may have a duration of weeks or months) – respond to changes in traffic conditions (e.g. peak and off-peak conditions).
Variable speed limit	• Illuminated speed limit signs that can be operated automatically to change the speed limit at different times of the day or in response to different traffic and road environments (e.g. school zones, strip shopping centres etc.) or weather conditions. • May be applied to roads where there is high pedestrian activity and potential for significant conflict between pedestrians and motor vehicles. In such areas conflict can be influenced by the presence of parked vehicles, buses, trams, trucks and cyclists. • Used on some urban motorways and expressways to improve safety and capacity during times of high traffic demand.

Types of limit	Comment
Variable speed limit (continued)	• Can be installed for several purposes including (Austroads 2009b): – speed management for safety – speed management for peak traffic flow and congestion/queuing (minor benefit) – speed control for adverse weather conditions – planned and unplanned incident management – tunnel and bridge speed management – periodic activity such as operating a heavy vehicle inspection station – reversible lanes or tidal-flow management – speed management for school zones, strip shopping centres, and high pedestrian activity areas – speed management for roadworks. • National standards (for example AS 1742.4-2008) and the following principles should be applied in changing the limit on variable speed limit signs: – no sign shall change so frequently that a driver sees more than one speed limit change at a single site, except in the case of an emergency (e.g. extreme weather or traffic incident) – a speed limit buffer shall be provided where there is a total reduction in the speed limit of at least 30 km/h – in emergency situations, the variable speed limit sign group immediately upstream of the incident site can be set to the safest speed limit. The variable speed limit (VSL) sign groups further upstream of the first sign group can be gradually reduced to this value in increments of between 10 and 30 km/h as buffer speed signs. The downstream variable speed limit sign groups immediately after the incident can be set back to the normal maximum speed limit (e.g. 100 km/h). Further guidance on variable speed limits and electronic speed limit signs can be found in other Guides as follows: • *AGTM Part 9* (Austroads 2019b) for guidance on the use of variable speed limits • *Guide to Smart Motorways* (Austroads 2016d) for guidance on the use of variable speed as part of lane use management systems on smart motorways • *AGTM Part 10* (Austroads 2019c) for general guidance on when electronic speed limit signs may be used on a motorway and on arterial roads in addition to guidance on sign size, brightness and the annulus requirements.
Heavy vehicle speed limit	• Regulations stipulate maximum limits for heavy vehicles which may be reduced and signposted on sections of road with steep downgrades or substandard horizontal alignment including bridges.

6.5.1 Differential Speed Limits

Differential speed limits apply in Australia and New Zealand. In the Australian Road Rules the maximum speed limit is 100 km/h for a bus with a gross vehicle mass over five tonnes, or for another vehicle with a gross vehicle mass over 12 tonnes, even if the posted speed limit is higher.

Individual jurisdictions may extend this limit to other heavy vehicles and drivers. For example:

- In NSW the maximum speed limit of 100 km/h applies to vehicles more than 4.5 tonnes. Also in New Zealand, a maximum speed limit of 90 km/h applies to vehicles more than 3.5 tonnes and vehicles displaying a school bus sign with a mass of over 2 tonnes (NZ Transport Agency 2014).
- In Western Australia the maximum speed limit of 100 km/h applies to learner drivers.
- Where there is a specific road rule for the maximum speed limit, it applies to the entire jurisdiction and therefore no special speed limit sign is used for the differential speed limit.

Some jurisdictions may have additional requirements. For example, they may apply differential speed limits to heavy vehicles on some specific sections of road for reasons such as road conditions (sharp bends, steep descents and winding roads).

Practitioners should apply NOP principles when considering differential speed limits, either in a trial or full implementation to fully assess the level-of-service trade-offs.

6.6 Application of Speed Limits

6.6.1 Legal Basis

Speed zones must be signed in accordance with the requirements of the applicable regulations for the zone to be enforceable. Details are contained in the Australian Road Rules (Part 3), AS 1742.4-2008 and for New Zealand in the Land Transport Rule: Setting of Speed Limits 2003 and *Traffic Control Devices Manual* (NZ Transport Agency 2008a).

Where the speed limit exceeds the maximum safe speed of travel at an isolated location, suitable warning signs, supplemented by advisory speed signs, should be used to advise drivers of the need to reduce speed.

6.6.2 Establishing Speed Limits

The review and setting of speed limits should be undertaken using NOP which takes into consideration the function and role of the road, the types of users and their needs, and Safe System principles.

Practitioners should refer to Table 6.3 which provides an overview of the general steps that should be taken when reviewing or setting a speed limit. In addition to this guidance, practitioners should refer to the speed zoning guidelines of the relevant jurisdiction.

Computer-based systems such as the XLIMITS suite of applications are available as tools to provide guidance on speed limit assessment. XLIMITS can be set up to reflect the jurisdiction's policy for speed setting by providing a decision tree. Jurisdictions may need to adjust their version of XLIMITS to include broader considerations such as NOP outputs, as outlined above, and Safe System principles which recognise the need to reduce crash risk. Table 6.4 and Table 6.5 are not be prescriptive, but rather provide guidance on when a reduced speed limit should be considered for various road categories and functions based on known crash risks, road use and users, road features and speeds. In addition, the usual speed limit assessments through a road safety audit should be undertaken.

It is noted that the traditional methods of assessing and reviewing speed limits based on the 85th percentile speed are no longer supported (refer to the *AGRS Part 3* (Austroads 2008b) but it is recognised that travel speed surveys can provide the practitioner with useful information in assessing current operating performance. Where travel speeds are found to be markedly higher than assessed speed limits then it may be necessary to consider implementing engineering measures designed to constrain speeds. In the Safe System approach, the focus is shifted more towards setting speeds based on crash risk to minimise harm to road users.

Where there are economically important roads that may have an unreasonable crash risk or demonstrated poor performance there may be a strong case for investment to bring them up to the required standard to support existing or higher travel speeds. In that sense, there is a need to 'engineer up' the road as outlined in the *Speed Management Guide* (NZ Transport Agency 2016).

Table 6.3: General process for setting and reviewing speed limits

Suggested steps	Comments
Identify the need	• Typical circumstances that lead to a review of speed limits include: – a default speed limit is no longer applicable to a road (excluding unsealed roads outside a built-up area which may be excluded from default speed limits subject to the relevant policies in each jurisdiction) – existing safety issues cannot be addressed by engineering solutions – the speed limit no longer aligns with the speed environment (changes in conditions or need for rationalisation) – community requests or other inquiries have prompted a review of a speed limit – existing speed zone lengths are less than the required minimum length – operational safety is unsatisfactory including for specific vehicles such as motorcycles and/or trucks – introduction of a new mode/road user into the road environment (e.g. light rail) – significant change in demand from a specific road user (e.g. new development that increases pedestrian activity).
Traffic surveys	• Establish traffic mix (heavy vehicles, vulnerable road users). • Undertake travel speed surveys, including mean and 85th speed distributions. • Measure traffic volumes. • Identify traffic patterns.
Calculate crash rates	• Calculate fatal and serious injury crashes per 100 million vehicle kilometres travelled (VKT). • Calculate crashes per kilometre (section limits and length, crash data and traffic volumes are required).
Estimate crash risk	• In addition to calculating crash rates, estimate the potential risk of a crash at a site due to issues with the road and/or roadside environment based on site inspections, and determine if a reduction in speed is warranted.
Conduct site inspection	• Visit the road lengths and intersections, document the data and observations as indicated in Table 6.4 and Table 6.5 for road lengths, or Section 6.6.3 for intersections.
Review all data and propose the preferred speed limit	• Refer to typical speed limits on roads of different categories and functions and reduce the speed limits at higher-risk lengths of these roads (Table 6.4 and Table 6.5). For reduced speed limits at higher-risk intersections refer to Section 6.6.3. • Develop the preferred speed limit. • Define start and end points (consider zone lengths).
Stakeholder consultation	• Report and discuss the proposed speed limit with stakeholders (e.g. state/local government, police, the agency with authority for formal approval of speed limit changes).
Conduct second site investigation	• Review information gathered from the initial site inspection. • Review sign locations – check sight distances, conflicting obstacles, and vegetation growth. • Consider if engineering measures are required.
Approval/authorisation	• Refer to local legislation for procedures for installation and removal of speed limit signs. • Seek formal approval from the authorised agency, document the process.
Inform stakeholders	• Inform key stakeholders and public of any changes in speed zoning.
Post-installation check	• Check sign installation. • Document any additional work required.

Note: New Zealand has a speed management tool as provided in Durdin et al. (2016).

Table 6.4: Urban roads – risk-based selection of speed limits for different road categories and functions

Road category/function and proposed speed limit (km/h)		Consider the corresponding speed for the respective category of road when any of the following severe crash risks are present[1]			
		Severe crash rate/ 100 million VKT	**Road use and users**	**Road features**	**Speeds[7]**
Shared zones (fully built-up areas)	10	–	–	Confined car park with high turnover	–
Car parks	20	–	–	Access aisle and car parks with medium turnover	–
Recreational areas/parks/reserves, large car parks	30[13]	–	–	Large car parks and driveways with low turnover	–
Urban local access and collector roads (fully and partially built-up areas)	50[15]	–	Industrial areas, or other areas where pedestrians or cyclists are unlikely to be present.	–	–
	40	Pedestrian and cyclist severe crash rates are high[2]	Residential, commercial and educational areas	–	Mean speed is well below the existing speed limit[8] due to traffic calming or geometric design of the road leading to high speed variation
	30[13]	Pedestrian and cyclist severe crash rates are very high[2]	–	–	–
Urban arterial roads – undivided (fully and partially built-up areas)	60	• Industrial areas, or other areas where pedestrians or cyclists are unlikely to be present; and • Either, no direct property access, or a flush median to separate opposing traffic flows and to provide protection for right turning vehicles.			
	50	–	Default speed limit for urban areas	–	–
	40	Pedestrian and cyclist severe crash rates are high[2]	Pedestrians or cyclists present in high numbers[2], especially in commercial areas and business districts[3] School zone[3][14]	Rural town centres with commercial land use	Mean speed is well below the existing speed limit[8] due to congestion[3], competing road uses[3][4], traffic calming or geometric design leading to high speed variation
	30[13][14]	Pedestrian and cyclist severe crash rates are very high[2]	–	–	–

Road category/function and proposed speed limit (km/h)		Consider the corresponding speed for the respective category of road when any of the following severe crash risks are present(1)			
		Severe crash rate/ 100 million VKT	Road use and users	Road features	Speeds(7)
Urban arterials – divided (fully and partially built-up areas)	80	–	–	–	–
	70(10)	–	–	2–4 standard access points per 100 m (includes intersections)(6) Consistent and frequent presence of unprotected roadside hazards within 1.5 m of the traffic (e.g. trees/poles spaced closer than every 10 m, or continuous(11)) No protection for left or right-turning vehicles Generally curving or winding road alignment (e.g. > 4 higher-risk curves per km (5)(12))	Mean speed is well below the existing speed limit(8) due to congestion(3) and competing road uses(3)(4) leading to high speed variation
	60	Severe crash rate is high(2)	Pedestrians or cyclists are present in high numbers(2), especially in commercial areas and business districts On-road parking is permitted and occurs frequently along the route	> 4 standard access points per 100 m (includes intersections)(6). More than two of the road feature risk factors for 70 km/h	Mean speed is well below the existing speed limit(8) due to congestion(3) and competing road uses(3)(4) leading to high speed variation
	40	–	School frontage(3)(14) Pedestrians or cyclists are present in high numbers(2) and on both sides of the divided road with major generators and attractors (commercial areas and business districts) of pedestrian activity on both sides of the road resulting in a high number of pedestrians crossing the road	–	–

Road category/function and proposed speed limit (km/h)		Consider the corresponding speed for the respective category of road when any of the following severe crash risks are present(1)			
		Severe crash rate/ 100 million VKT	Road use and users	Road features	Speeds(7)
Urban motorways (generally in fully and partially built-up areas)	100	–	–	–	–
	80	Severe crash rate is high(2)	High one-way AADT, e.g. over approximately 88 000 vpd per carriageway(9)	Sight distance consistently restricted Closely spaced interchanges where entry ramps and exit ramps are in close proximity, and there is frequent and conflicting merging and diverging activity	Mean speed is well below the existing speed limit(8) due to congestion(3) leading to high speed variation

1 Any one of the points is sufficient to trigger consideration of a lower speed limit, unless specified otherwise.
2 High or very high when compared with a state/regional average for the given road type. The values could be developed and maintained by each jurisdiction.
3 Lower speed limit may be applied part-time during high-activity times.
4 Competing road uses would include such factors as frequent manoeuvres, e.g. deliveries, access/egress, public transport activity and high-turnover parking.
5 Higher-risk curves may be considered those with a radius ≤ 600 m, or advisory speed significantly lower than the speed limit. There was no specific evidence of this risk factor for urban divided roads and the suggested value should be reviewed in the future.
6 Appendix C provides the method and weightings used in assessment of access and intersection density.
7 In many jurisdictions, mean speeds are close to the speed limit, subject to the effectiveness of the general deterrent of speed limit enforcement. Enforcement and other speed management techniques should be considered where mean speeds are substantially above the speed limit.
8 Mean speed may be already low in response to road engineering and operational factors (e.g. 10 km/h below the speed limit). In such cases, the speed limit may result in high speed variation, and/or provide an unreasonable target speed for some drivers. Reduction of the speed limit on the basis of low observed mean speed should be considered carefully.
9 High traffic volumes can result in high exposure to other risk factors and in higher severe crash numbers, unless crash risk is reduced in other ways (e.g. upgrade of road stereotype, or reduced access).
10 Some road agencies have been through a process of rationalising the speed limits, e.g. focussing on removal of 70 km/h and 90 km/h limits. This idea was generally adopted in these model guidelines. This exception was made as 70 km/h is a well-recognised reduced speed limit on lower quality divided urban arterials. If required by jurisdictional speed zoning policy, the roads meeting criteria for 70 km/h may be speed-limited to 60 km/h.
11 There was no research identified on what frequency of roadside hazards constitutes a substantially higher risk of severe crashes on urban arterials. The value was provided as an example. It was derived from road network observations and project team consensus. It should be reviewed when more robust research becomes available.
12 Previous Austroads research showed that casualty crash risk increases significantly when curves are combined with steep grade (typically > 8%). If this is a relatively frequent occurrence for the road length under review, then a further reduction in speed limit may be considered, if practicable.
13 The use of 30 km/h should be in line with the role and function of the road, accomplished through community engagement, to highlight and confirm the need for the reduced speed limit.
14 South Australia is currently using 25 km/h for school zones however the speed limit is based on the presence of children rather than time of day.
15 As part of New Zealand's self-explaining regime, as described in NZ Transport Agency (2016), areas where the speed limit is higher than is safe and appropriate as deemed by the assessment tables in the Speed Management Guide, the speed limit may be reduced where there is a particularly high risk and/or where the users are already travelling at a lower speed such as 40 km/h (e.g. urban local access roads which are currently signposted at 50 km/h would generally have their speed limit reduced to 40 km/h over time)

Source: Adapted from Austroads (2014b).

Table 6.5: Rural roads – risk-based selection of speed limits for different road categories and functions

Road category and function, upper speed limit (km/h)		Consider the corresponding speed for the respective category of road when any of the following severe crash risks are present(1)			
		Severe crash rate/100 million VKT	Road use and users	Road features	Speeds(9)
Rural residential roads (partially built-up areas)(5)	60	–	–	–	–
	40	–	School frontage(3)(13)	–	Mean speed is well below the existing speed limit(8) due to traffic calming or geometric design of the road leading to high speed variation
Rural roads – undivided (arterial and local; farmland, undeveloped, sparsely built-up areas)	100	–	–	–	–
	80	Severe crash rate is high, provided minimum AADT is exceeded(4)	High AADT(10), e.g. over approximately 12 000 vpd	At least two of: • lane width ≤ 3.0 m • ≤ 0.5 m sealed shoulders and effective unsealed shoulders < 1 m • ≤ 2 m clear zone, or 2–4 m clear zone with high density/continuous roadside hazards • generally curving and/or undulating road alignment (e.g. 2–4 higher-risk curves per km (6)(11)) • 1–2 standard access points per 100 m (includes intersections)(7) A rural hamlet/settlement	Mean speed is well below the existing speed limit(8) due to geometric design of the road
	60	–	–	As per 80 km/h, but in addition: • generally winding and/or hilly road alignment (e.g. > 4 higher-risk curves per km(6)) • > 2 standard access points per 100 m (includes intersections)(7)	Mean speed is well below the existing speed limit(9) due to geometric design of the road

Road category and function, upper speed limit (km/h)		Consider the corresponding speed for the respective category of road when any of the following severe crash risks are present[1]			
		Severe crash rate/100 million VKT	Road use and users	Road features	Speeds[9]
Rural arterial roads – divided (farmland, undeveloped, sparsely built-up areas)	100	–	–	–	–
	80	Severe crash rate is high[2]	–	At least two of: • ≤ 0.5 m sealed shoulders and effective unsealed shoulders < 1 m • ≤ 2 m clear zones, or 2–4 m clear zone with high density/continuous roadside hazards • generally curving and/or undulating road alignment (e.g. 2–4 higher-risk curves per km [6][11]) • 1–2 standard access points per 100 m (includes intersections)[7] • sight distance consistently restricted A rural hamlet/settlement	–
Rural unsealed roads (no permanent seal or narrow seal ≤ 5 m wide; farmland, undeveloped, sparsely built-up areas)	100[14]	–	–	–	–
	60	Severe crash rate is high[2]	–	A rural hamlet/settlement	–
Rural motorways (farmland, undeveloped, sparsely built-up areas and major roads in remote areas)	110	–	–	–	–
	100	High severe crash rate[2]	High one-way average annual daily traffic (AADT)(10), e.g. over approximately > 12 000 vpd per carriageway	Sections with at-grade intersections less than 1 km apart[12] Direct access > 2 standard access points per km Clear zones < 4 m	–

Road category and function, upper speed limit (km/h)		Consider the corresponding speed for the respective category of road when any of the following severe crash risks are present(1)			
		Severe crash rate/100 million VKT	Road use and users	Road features	Speeds(9)
Rural motorways (farmland, undeveloped, sparsely built-up areas and major roads in remote areas) (continued)	80	–	–	Sight distance is consistently restricted Adverse horizontal and/or vertical alignment AND consistent clear zone < 4 m A rural hamlet/settlement	–

1 Any one of the conditions is sufficient to trigger a lower speed limit, unless specified otherwise.
2 High when compared with a state/regional average for the given road type. The values could be developed and maintained by each jurisdiction.
3 Lower speed limit may be applied part-time during high-activity times.
4 The minimum AADT should be determined for each jurisdiction. Crash rates per 100 million VKT are typically high on low-volume roads but may be based on very few crashes (e.g. up to ~1000 vpd for rural undivided roads). The model guidelines are not intended to result in mass speed limit reductions on lower-order roads which carry low traffic volumes. A high crash rate at a typical AADT for a given road stereotype would indicate a significantly increased individual and collective risk.
5 Refers to local roads that have partially built-up residential development, typically 2–4 standard driveways per 100 m. The abutting land holdings should be in excess of 0.4 hectare.
6 Higher-risk curves may be considered those with a radius ≤ 600 m, or advisory speed significantly lower than the speed limit.
7 Appendix C provides the method and weightings used in assessment of access and intersection density.
8 In many jurisdictions mean speeds are close to the speed limit, subject to the effectiveness of the general deterrent of speed limit enforcement. Enforcement and other speed management techniques should be considered where mean speeds are substantially above the speed limit.
9 Mean speeds may be already low in response to road engineering and operational factors (e.g. 10 km/h below the speed limit). In such cases, the speed limit may provide an unreasonable target speed for some drivers. No robust research evidence was available on the role of speed variation or speed targeting on crash risk on rural roads. Reduction of the speed limit on the basis of low observed mean speed should be considered carefully.
10 High traffic volumes can result in high exposure to other risk factors and in higher severe crash numbers, unless crash risk is reduced in other ways (e.g. upgrade of road stereotype, or reduced access).
11 Previous Austroads research showed that casualty crash risk increases significantly when frequent curves are combined with steep grade (typically > 8%). If this is a relatively frequent occurrence for the road length under review, then a further reduction in speed limit may be considered, if practicable.
12 On rural motorways, at-grade intersection refers to a highway standard design (or less) and does not include interchanges or other on/off ramps. Ramps are to be counted as access points.
13 South Australia is currently using 25 km/h for school zone however the speed limit is based on the presence of children rather than time of day.
14 As part of New Zealand's self-explaining regime, as described in NZ Transport Agency (2016), roads which have a low economic function, carry little traffic, but are still high risk at the posted speed limit of 100 km/h would generally have their speed limit reduced to 80 km/h or less over time (e.g. rural unsealed roads which are currently signposted at 100 km/h which are high risk at that speed limit and/or where users generally travel at 80 km/h or less).

Source: Adapted from Austroads (2014b).

6.6.3 Localised Speed Limit Reductions at Higher-risk Intersections

As outlined in Section 6.6.2 variable speed limit reductions based on the detection of a vehicle at the side road of an intersection have been effective in rural locations. In urban locations where intersections are more closely spaced and traffic volumes higher such approaches may not be viable and permanent speed reductions may need to be considered to address safety.

Model National Guidelines for Setting Speed Limits at High-risk Locations (Austroads 2014b) indicates that safety at intersections that have design and operational deficiencies should be preferably managed through engineering treatments, including intelligent transport system solutions. Where there are urban roads with frequent intersections, a reduction in the speed limit should be applied along the entire relevant road section.

Austroads (2014b) stipulates that a reduction in speed limits at intersections could be considered as a temporary treatment along major road approaches where the following criteria are met:

- located on outer-metropolitan, semi-rural and rural arterials
- have high volumes of traffic
- have high speed limits (> 80 km/h)
- are at-grade, sign or signal controlled
- experienced at least one of the following
  - significant increase in crashes due to growth in traffic volumes
  - permanent increase in complexity of traffic movements
  - permanent change in the surrounding road environment over a period of time (e.g. increased direct access)
  - current function of the intersection exceeds its original rural function, but an upgrade would not be cost-effective in the short- to medium-term.

Localised reduction of speeds at rural at-grade rail crossings may be also considered.

A reduced speed limit should be treated as temporary until funds can be made available to upgrade the intersection to match its current or desired future function. Safety and operational performance of an intersection with a reduced speed limit should be periodically monitored (e.g. annually).

Generally, it is expected that the speed limit at intersection approaches would be returned to the higher limit some distance past the intersection. If a lower speed limit already applies past the intersection, an effort should be made to create a continuous speed zone. This approach will lessen the impact of localised speed limit reductions or the frequency of changes.

Side-road approaches can be considered for speed limit reduction only in cases where their priority is comparable to that of the major road. The road agency responsible for the minor road may use other engineering means to reduce approach speeds on minor-road approaches to the intersection.

6.6.4 Supporting Active Travel, Shared Spaces and Activity Centres Through Speed Limits

As outlined earlier and in the *AGTM Part 4* (Austroads 2016b), roads provide both movement and place functions. In addition, roads serve a variety of users which include pedestrians and cyclists. They may be undertaking their whole trip by walking and/or cycling or after having used one or more of the alternative modes.

In some areas of the road network such as activity centres, the presence of pedestrians and cyclists will be significant; in areas where it is not significant the road agency may wish to encourage it. In other parts of the road network it may be in the interests of the road agency to discourage walking and/or cycling and in these situations provide suitable alternatives.

Where pedestrians and cyclists are present or where the road agency wishes to encourage these modes, speed limits may need to be reduced as outlined in Table 6.4 in line with the Safe System approach.

To support active travel, shared spaces and activity centres, measures beyond just a reduction in speed should be considered. This is to improve the level of service, therefore facilitating and encouraging cycling and walking. As outlined in Section 1.2, accessibility-based NOP and the LOS framework outlined in the *AGTM Part 4* (Austroads 2016b) provide a framework for practitioners to understand the level of service and therefore the trade-offs in LOS that engineering treatments will have on the LOS for private motorists, transit users, pedestrians, cyclists and freight operators, across their five needs of mobility, safety, access, information and amenity. The LOS framework is consistent with the Safe System framework. The Austroads *AGTM Part 4* (Austroads 2016b) provides further information on this.

The *Guide to Traffic Management Part 7: Traffic Management in Activity Centres* (Austroads 2019a) and the *AGTM Part 8* (Austroads 2016c) provide guidance on measures that can be used to manage traffic in activity centres and shared spaces including strategies to manage speed, vehicle and pedestrian movements, and bicycle movements and when to separate and combine various users in a shared space environment.

6.6.5 Minimum Speed Zone Length

Table 6.6 indicates the minimum lengths of speed zones derived from the model national guidelines (Austroads 2014b) and Australian Standards. The typical lengths are recommended for situations where a route or a road section has sufficient risk factors to warrant a speed limit reduction. This practice is recommended to reduce the frequency of speed limit changes.

The localised speed limit reductions should be considered at:

- school zones
- pedestrian/cyclist activity zones (e.g. shopping strips)
- local residential areas
- rural hamlets and where default speed limits apply, through rural towns
- higher-risk intersections on outer-urban and semi-rural arterials based on the factors listed in Section 6.6.3
- at-grade rail crossings.

The reasons for lower localised speed limits over short lengths should be communicated to road users to maximise their credibility. When there are several localised speed limit reductions next to each other (e.g. several school zones and shopping strips along one route), consideration should be given to consolidation of these into one continuous speed zone.

Table 6.6: Minimum lengths of speed zones

Speed limit (km/h)	Proposed minimum length of speed zone (Austroads 2014b) (km)		Minimum length of speed zone (AS 1742.4-2008) (km)
	Typical	Localised	
≤ 40	0.4	0.4[(1)]	0.4
40 school zone only	n.a.	n.a.	0.2
50 (default urban)	0.5	n.a.	n.a.
60	1.0	n.a.	0.6
70	2.0	n.a.	0.7
80	2.0	0.8	0.8
90	n.a.	n.a.	0.9
100 (default rural)	3.0	n.a.	2.0
110	10.0	n.a.	10.0
Speed limit buffer: any speed	n.a.	n.a.	0.3[(2)]

1 *Lower minimum speed zone lengths may be specified for specific applications such as school zones or pedestrian activity zones to suit local conditions, but should be no less than 200 m (absolute minimum).*
2 *Subject to maximum length of 0.4 km.*

Source: Adapted from Austroads (2014b) and AS 1742.4-2008.

6.7 Signing of Speed Limits

6.7.1 Introduction

The standards for the design of the face of speed limit signs, their size and placement are provided in AS 1742.4-2008 and AS 1743-2018. With respect to the electronic speed limit sign size, brightness and annulus requirements, practitioners should refer to guidance outlined in AS 5156-2010, the *AGTM Part 10* (Austroads 2019c) in addition to Appendix B of AS 1742.4-2008. For New Zealand, guidance is provided in the New Zealand Land Transport Rule: Setting of Speed Limits 2003.

Road agencies should ensure that all speed limit signs are clearly visible to drivers approaching them. Essentially, they should be:

- of an appropriate size
- located both longitudinally and laterally to provide maximum visibility
- placed so that vegetation will not obscure them in future, and utilities, other signs and structures do not obscure them
- well maintained.

6.7.2 Types of Signs

The signs may be static and display the same information continuously or they may be designed to enable a speed limit to be changed to suit conditions that apply at various times. The information displayed may be changed mechanically, electrically or manually (e.g. signs that fold). Electronic variable speed limit signs that may be changed automatically by a controller or from a traffic control centre are in common use. The type of sign used depends on the application and on cost.

6.7.3 Use of Electronic Speed Limit Signs in School Zones and High Pedestrian Activity Areas

At school zones and some selected locations where there is high pedestrian activity (such as a strip shopping centre) road agencies may implement reduced speed limits. Except for school zones where the speed is generally reduced uniformly across a jurisdiction, speed reductions are generally based on a risk assessment (refer to Section 6.6.2 for further guidance).

The speed limit may be reduced on a permanent basis or be time based, where the time of application reflects the change in environment and therefore risk. For example, school speed zones generally apply during the time when the students are arriving or departing. At locations such as strip shopping centres, reduced speed limits apply when pedestrian activity is high (i.e. the reduced speed limit may only apply during business operating hours).

Where the speed limit is time based, and the times of application are generally consistent and well known (e.g. school zones) this can be conveyed using a static sign (refer to AS 1742.4-2008). Alternatively, to increase the conspicuity of the sign, or where the times may alter, ESL signs are being used. These signs are illuminated and comply with the format and colours specified in road rules and are capable of being changed by electronic means. As there are increased cost and maintenance implications their use is generally limited to areas where there are high speeds or large traffic volumes and/or where the reduced speed zone times may alter.

Outlined below is a list of road environments where the use of electronic speed limit signs at school zones or other high pedestrian activity areas may be considered. The road environments are listed in order of priority and are for use of the signs at school zones on the main school frontage road, where the school has direct access to the road or carriageway. Alternatively, the road environments may apply to roads which pass through a high pedestrian activity area (e.g. major strip shopping centre or activity precinct). The guidance may vary from jurisdictional guidance and therefore practitioners should check state and territory supplements to determine the requirements that apply (Main Roads Western Australia 2014):

- four-lane single carriageway – 70 km/h speed limit or greater
- four-lane single carriageway – 60 km/h speed limit
- two-lane single carriageway – 70 km/h speed limit or greater
- two-lane single carriageway – 60 km/h speed limit
- four-lane carriageway with median strip or pedestrian refuge island – 70 km/h speed limit or greater
- four-lane carriageway with median strip or pedestrian refuge island – 60 km/h speed limit
- two-lane carriageway with median strip or pedestrian refuge island – 70 km/h speed limit or greater
- two-lane carriageway with median strip or pedestrian refuge island – 60 km/h speed limit
- 50 km/h distributor roads
- 50 km/h local access roads.

Sites that can be given a higher priority include those which have one or more of the following:

- a history of pedestrian casualty crashes
- existing vehicle speed data provided by the police service, local government authority etc. which demonstrates that the operating speed (85th percentile) is 10 km/h or greater than the posted speed over the full 1.5-hour school zone period
- a school zone is located on a designated restricted access vehicle route, and/or a designated heavy vehicle route.

6.7.4 Location of Signs

Signs must be used at all speed limit changes in accordance with the relevant standards. They should be positioned so that drivers have a timely view of the signs and the road scene, and are not likely to be distracted by other signs or roadside development.

At intersections, signs are not required for traffic entering a road if the default urban or rural speed limit applies. Drivers entering a road to which a non-default speed limit applies are advised of the applicable speed limit through repeater signs at significant intersections and other appropriate locations (Section 6.7.5). Drivers entering a higher-order road from a side road will need to have signs indicating the speed limit on the higher-order road, if it is not the default, otherwise a speed differential between drivers will occur. A large speed differential creates safety issues. Conversely, if a lower speed limit than the default applies, adequate signage at each joining road will need to be shown, otherwise enforcement will not be possible.

Area speed zones are only enforceable if they are correctly signed. Speed limit area signs must be placed to face traffic on each road entering the area. The signs should be positioned a sufficient distance from any intersection to be readily seen by drivers after they have turned from the intersecting road. In addition, end speed limit area signs must be placed to face traffic on each road leaving the area. The signs should be placed at the same location as the entry signs, but facing the opposite direction. Normal speed limit signs may be required to indicate the limit on the road immediately outside the area speed zone.

6.7.5 Speed Limit Repeater Signing

In addition to providing signs to mark the beginning and end of a speed zone it is essential to reassure drivers of the speed limit that applies along a road. One way of achieving this is by using repeater signs that:

- remind drivers of the limit, particularly just beyond the beginning of a zone
- advise drivers turning into the road at a significant intersection of the limit that applies
- advise drivers of the limit where it may appear to them to be inconsistent with general expectations.

Repeater signs are generally not required in speed zones where the default urban speed limit would apply. This is unless the roadside development alters markedly and there is no deviation from the urban default speed limit, or where there is a demonstrated or perceived safety problem.

6.7.6 Conflict with Other Signs

Prior to the installation of speed limit signs, an inventory of existing signing should be undertaken to ensure that it does not conflict with or detract from other road signing. Care should be taken to ensure that advisory speed signs are not greater than the posted speed limit and there is an appropriate distance between regulatory and advisory signs.

6.8 Physical Speed Management Devices

Physical devices may be used to achieve a speed environment that is compatible with the road activity (e.g. concentrated roadside activities, high number of vulnerable road users) and often require alteration of the road geometry to change the perspective of drivers to one of a slower speed environment. Some of the treatments available are listed in Table 6.7.

Table 6.7: Speed control treatments

Treatment	Comment
Perimeter (threshold) treatments	• Used where it is desired to inform drivers they are entering a slow-speed environment. • Involve treatments such as road narrowing, surface changes, traffic islands, and devices to create horizontal or vertical displacement of vehicles, accompanied by signage.
Speed constraining treatments	• Make excessive speed physically uncomfortable. • Include vertical displacement devices such as road humps, speed cushions, rumble strips. • Include horizontal displacement devices such as roundabouts, slow points.
Perception treatments	• May influence the driver's perception of the speed environment. • May involve urban design to create a low-speed environment. • Trees and shrubs may be used to change the streetscape. • Road markings may be used to complement treatments. • Are less effective than physical devices.

Where speed limits of 40 km/h or less are applied to local streets they should generally be supported by physical design features or local area traffic management (LATM) devices. The way the safety objective is achieved along residential streets is comprehensively provided in the *AGTM Part 8* (Austroads 2016c). The Guide describes LATM as a 'tool for traffic calming' and details the processes and designs that can be applied.

The management of traffic in business areas (e.g. activity centres) is covered in the *Guide to Traffic Management Part 7: Traffic Management in Activity Centres* (Austroads 2019a).

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Appendix A Urban Engineering Treatments

This appendix provides information on engineering treatments that can be used to achieve Safe System speeds on urban arterial roads. The content is based on *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice* (Austroads 2016e). The treatments are separated into urban arterial intersections (Appendix A.1) and urban arterial mid-blocks (Appendix A.2).

A.1 Urban Arterial Intersections

Table A 1 to Table A 14 provide information on treatments at urban arterial intersections.

Table A 1: Vehicle activated signs

Engineering treatment		Vehicle activated signs (VAS)
Description		Vehicle activated signs are electronic roadside warning signs, often solar powered, which are triggered by road users when they exceed a pre-determined speed trigger. At all other times the sign is blank. Once triggered, the sign displays the pertinent hazard ahead, and may include a message to slow down or a travel speed. This alerts drivers to the presence of the intersection with the aim being that they increase their alertness and reduce their speed to negotiate the intersection safely. The findings are based on rural applications due to limited information on urban applications.
Effectiveness	Speed reduction	• 5 km/h reduction in 85th percentile speed and 2 km/h reduction in mean speed. • Overall reductions in mean speeds and the proportion of vehicles exceeding the speed limit. • Sustained reductions in the percentage of vehicles exceeding the speed limit compared with static signs.
	Crash reduction	• Unknown (as a guide, VAS for rural intersections have shown a 70% reduction in crashes).
	Road user effects (delays, congestion, consistency of travel time)	• Unknown.
Implementation issues		• Determining the safe speed (trigger speed) at which the sign will be activated. • Vandalism has been noted as an issue, however, this is mainly on rural roads. • Overuse of the treatment may increase familiarity, and therefore reduce effectiveness. • Sign placement to ensure that the line of sight from the sign to the vehicle is clear so that the radar works effectively, and the sign is clearly visible. • The placement of VAS should allow adequate time and distance for drivers to adjust their speed appropriately. • Signs can present a hazard to errant vehicles, and therefore should be sited appropriately and in some cases consideration may need to be given to the use of a frangible-base pole. • Sign design and configuration should be consistent so as reduce driver confusion.
Cost		Medium.
Treatment life		5–10 years.
Applicability		• Signs should only be applied where there is a crash problem related to inappropriate speed not adequately addressed by static signs. • Also applied in work zones, school zones and at curves.

Source: Based on Austroads (2016e).

Table A 2: Roundabout

Engineering treatment		Roundabout
Description		Roundabouts are circular central islands, around which (in Australia and NZ) traffic circulates in a clockwise direction, which are used where T or X intersections may not be appropriate. Entry to the roundabout is controlled by way of signs and markings, with all entering traffic required to give way to the right and to traffic on the circulating roadway. However, in certain circumstances roundabouts are signalised, either partly or wholly and either at peak times only or all the time. Other roundabout types include turbo (Table A 4) and mini roundabouts. Mini roundabouts are not typically applied on high-volume roads.
Effectiveness	Speed reduction	• 10 km/h reduction in 85th percentile speed.
	Crash reduction	• 75% reduction.
	Road user effects (delays, congestion, consistency of travel time)	• General/overall reduction in delays and emissions. • Minimises delay during off-peak periods (when considered against a conventional intersection). • Fewer conflict points and improved angles of conflict in comparison with conventional intersections, contributing to a reduction in the incidence and severity of crashes. • More time for drivers to react to potential dangers. • Priority is simple and consistent on all approaches (give way to right and to circulating traffic). • Since most road users travel at similar speeds through roundabouts, crash severity can be reduced compared to some traditionally controlled intersections. • The visibility of the intersection is increased.
Implementation issues		• Good design (including deflection) is required to reduce vehicle speeds on the approach to the roundabout. Additional signs may also be used to provide advance warning. • Loss of parking and limited road reserves are concerns on arterial roads. • If traffic flows are unequal on approaches, additional features may be needed. • Can increase the risk for vulnerable road users, e.g. increased crash risk for cyclists. Pedestrian crossing facilities needed in some circumstances. • Need to be able to accommodate the turning circle of emergency services vehicles and large goods vehicles. • Must consider angle of deflection and distribution of lanes (exclusive left or right-turn lanes) in design. • Concerns with roundabout installations in close proximity to signals. • Increased crash rates and difficulty determining vehicle turning movements at 3-lane roundabouts.
Cost		High.
Treatment life		20 years+.
Applicability		• Requires a larger area of land than traditional intersection. • A large number of circulating and approach lanes, traffic volumes and the presence of pedestrians and cyclists affect the safety and operation of roundabouts. • Appropriate when the peak circulating flow plus entry flow is moderate (i.e. up to approximately 2000 to 3000 veh/h for two-lane roundabout), but this is dependent on design and traffic conditions (see Austroads 2017e). • Consider using advisory speeds on the approaches to reduce speeds and speed variability.

Source: Based on Austroads (2016e)

Table A 3: Signalised roundabout

Engineering treatment		Signalised roundabout
Description		Signalising roundabouts involves the use of partial or full signalisation. This is mainly implemented at roundabouts with significant growth in traffic flow, unbalanced flows and high circulating speed. Partially signalised roundabouts have part-time metering that only operates during peak periods, and normal roundabout priority is used at all other times. Fully signalised roundabouts have signals at all approaches which operate at all times. Note: Treatment refers to both signalising an existing roundabout and new installation.
Effectiveness	Speed reduction	• Unknown.
	Crash reduction	• 28% reduction in all crashes compared to non-signalised roundabouts.
	Road user effects (delays, congestion, consistency of travel time)	• Reductions in traffic delay during peak periods for fully signalised and partially signalised roundabouts. • Provides pedestrian crossing facilities. • Improves cyclist safety. • Increases in traffic delay at fully signalised roundabouts in the off-peak periods. • Prioritises different legs, creating more balanced flows and regulating traffic patterns.
Implementation issues		• Requires clear line/lane marking for circulating vehicles. • The placement of signals should be clear to avoid confusion with neighbouring signals and also provide adequate sight distance and angling for vehicle controllers. • Need to optimise cycle time length to reduce queuing. • The choice of full or partial signalisation depends on site-specific conditions. Where partial signalisation is adopted, additional signage at operating times is required to reduce confusion about the difference between metered and signalised roundabouts. • Need to consider whether to partially or fully signalise intersection, or use advanced signal greens for cyclists.
Cost		High.
Treatment life		20 years+.
Applicability		• Generally applied at high-capacity and high-speed intersections on high-order arterial roads. • Can also be applied at existing congested roundabouts with unbalanced flows.

Source: Based on Austroads (2016e).

Table A 4: Turbo roundabout

Engineering treatment		Turbo roundabout
Description		These are multilane roundabouts where vehicles are required to enter in specific lanes depending on which exit they wish to take. Raised linemarkings can be used to further discourage lane changing and lower speeds. This style of roundabout requires some vehicles to give way to two lanes when entering the roundabout.
Effectiveness	Speed reduction	• Slower mean and 85th percentile speeds.
	Crash reduction	• Up to 70% reduction in crashes.
	Road user effects (delays, congestion, consistency of travel time)	• 25–35% higher capacity than conventional two-lane roundabouts. • Reduction in the number of conflicts due to elimination of weaving.
Implementation issues		• Requires clear line/lane marking for circulating vehicles. • May be difficult in managing longer vehicles around the roundabout. • Possible drainage issues at separator islands. • Requires additional signage on roundabout approaches.
Cost		High.
Treatment life		20 years+.
Applicability		• Generally applied at high-capacity and high-speed intersections on high-order arterial roads, with traffic volumes of up to 35 000 vehicles per day. • Should not be used on high cyclist volume roads. If applied on these roads, cyclist lanes should be considered to eliminate the crash risk.

Source: Based on Austroads (2016e).

Table A 5: Raised intersections

Engineering treatment		Raised intersections
Description		Raised intersections (also known as platform intersections, raised junctions or plateaus) are a speed management device, typically with the aim of reducing the speed of vehicles to 50 km/h or less. The entire intersection can be raised, with the pavement surface sometimes flush with the adjoining footpath. Alternatively, raised sections can be placed in advance of the intersection (sometimes referred to as raised stop bars) to achieve a similar effect. Raised intersections can be painted or paved in a manner such that they serve to further increase driver awareness of the intersection. The results include outcomes from an evaluation conducted through Austroads (2016e). Further research may be undertaken in the future.
Effectiveness	Speed reduction	• 3 km/h reduction in mean speed. • 8 km/h reduction in 85th percentile speed.
	Crash reduction	• 40% reduction in casualty crashes.
	Road user effects (delays, congestion, consistency of travel time)	• 'Downgrading' of functionality of road – e.g. urban arterial potentially becomes a lesser road. • Inconvenience and delay to buses and emergency vehicles. • Increased noise levels. • Pedestrians confusing ramp markings for crossing facilities.
Implementation issues		• Increased height and a steeper ramp gradient lead to a greater level of speed reduction. Austroads classifies a 1:30 gradient as bus friendly. However, this grade may result in less speed reduction for other vehicles. • Need to consider the impact on drainage. • Require appropriate delineation. • Traffic volume, composition and geometry should be taken into considerations when determining the suitability of this treatment. • Confusion of priorities may occur; therefore, proper pedestrian crossings should be designed with raised intersections.
Cost		Medium to high.
Treatment life		20 years+.
Applicability		• Recommendation that raised intersections and raised stop bars are not utilised on roads with posted speed limits of above 60 km/h. • Should not be used where there is limited or restricted sight distance.

Source: Based on Austroads (2016e).

Table A 6: Horizontal deflection

Engineering treatment		Horizontal deflection
Description		Horizontal deflection treatments often involve the installation of kerb extensions, medians and/or pedestrian refuge islands at intersection approaches. This combination of treatments can be used to slow vehicles to a Safe System compliant intersection speed, as well as to facilitate shorter and safer pedestrian crossings. Additionally, a similar approach involves installing splitter islands at intersections, generally on the approach to give-way or stop-controlled intersections. The splitter island slows and directs traffic, and separates opposing traffic streams. Splitter islands can also serve as pedestrian refuge islands if required. This treatment is often applied at roundabouts, but it is also used on minor intersection approaches.
Effectiveness	Speed reduction	• Up to 5 km/h.
	Crash reduction	• 30% reduction in pedestrian crashes. • 35% reduction in crashes for splitter islands. • 15% reduction in crashes for a mountable median. • 25% reduction in crashes for a non-mountable median.
	Road user effects (delays, congestion, consistency of travel time)	• Evidence from literature indicates volume reductions. • Improves access, crossing and pedestrian visibility. • Reduces vehicle-to-vehicle and vehicle-to-pedestrian conflict points. • Little/minimal effect on emergency vehicle access.
Implementation issues		• There is little known research on the use of horizontal deflection to slow vehicles at non-roundabouts. This is an area where further study is required to determine accurate crash and speed reductions. • Can cause lane-keeping issues through intersections due to lack of delineation. • Deflection is generally achieved through narrowing and can cause lane reductions for cyclists and lane-keeping issues for heavy vehicles (especially in turning movements). • Some concern about deflecting vehicles into oncoming traffic, pedestrians or cyclists. • Concerns on whether deflection is a forgiving treatment, especially to those exceeding the speed limit. • Deflection is generally used in combination with other treatment types.
Cost		Medium.
Treatment life		10 years+.
Applicability		• Often applied at roundabouts, but it is also used on minor intersection approaches. • Not suitable for bus routes and high commercial vehicle volumes.

Source: Based on Austroads (2016e).

Table A 7: Perceptual countermeasures

Engineering treatment		Perceptual countermeasures
Description		The treatments are used to alter a driver's perception of the environment. Can be used to make drivers think they are going faster than they are, or that the road narrows. Both cause the driver to slow on approach to the intersection. In addition, the treatments are likely to raise awareness of the presence of the intersection. This type of treatment is quite common in the UK, particularly on the approach to roundabouts. There was limited research and application of perceptual countermeasures on urban arterial roads and consequently the findings on rural roads are provided as an indicative measure of effectiveness.
Effectiveness	Speed reduction	• 13 km/h reduction in 85th percentile speed from perceptual narrowing. • 11 km/h reduction in 85th percentile speed from lane narrowing through buildings, parked cars etc. • Up to 8 km/h reduction in 85th percentile speed from markings that give the appearance of travelling faster on the approach to an intersection.
	Crash reduction	• 60% on roundabout approach.
	Road user effects (delays, congestion, consistency of travel time)	• Increased awareness of intersection.
Implementation issues		• Overuse of the treatments can lead to them losing their effect and drivers not responding to the same extent. • Careful consideration on placement of the treatment needs to be undertaken to ensure that drivers have enough time to brake safely before the intersection after encountering the treatment. • Additional linemarking may have a negative effect on skid resistance, particularly for motorcyclists. • Tends to draw the eyes down towards the linemarking and away from focus on the road. • Additional noise that the markings create can be an issue for urban or residential environments. • There could be confusion about priorities between pedestrians and vehicles at crossing points. • Need for on-going maintenance where trafficked.
Cost		Low.
Treatment life		1–5 years.
Applicability		• Should not be placed too far in advance of an intersection. • Line spacing and width should be consistent.

Source: Based on Austroads (2016e).

Table A 8: Traverse rumble strips

Engineering treatment		Transverse rumble strips
Description		Transverse rumble strips are small raised lines across the width of the lane that are designed to produce an audio-tactile effect that alerts drivers to an upcoming intersection. They are often used where there are stopping sight distance restrictions, high approach speeds, or a history of stop violations. As with perceptual countermeasures, the findings are based on rural road environments due to limited information on the effectiveness and application on urban arterial roads.
Effectiveness	Speed reduction	• Up to 5 km/h reduction in speed.
	Crash reduction	• 30% reduction in fatal and serious injuries (FSI) crashes. • 20% reduction in casualty crashes.
	Road user effects (delays, congestion, consistency of travel time)	• Increased awareness of the intersection. • More time to react to other vehicles on the intersection.
Implementation issues		• Need to be placed so that the driver has enough time to slow down before the intersection and stop if necessary. • Signs are also required to indicate the reason(s) to slow down. • Significant maintenance costs due to cracking at the interface with the pavement. • The profile for the rumble strips needs to be suitable so as not to present a hazard to motorcyclists. • Noise issues in urban and residential areas.
Cost		Low.
Treatment life		1–5 years.
Applicability		• Rumble strips are noisy and should not be used near residential areas, with peri-urban and industrial areas more ideal. However, if driven over at higher speeds the noise and vibratory effects are less severe.

Source: Based on Austroads (2016e).

Table A 9: Reduce excessive sight distance

Engineering treatment		**Reduce excessive sight distance**
Description		Adequate sight distance is essential to provide drivers with enough reaction and manoeuvring time to adapt to the road features and to other road users. This involves improving the triangle sight distance at intersections, enhancing visibility for all road users at the intersection and, in some cases, reducing excess sight distance. Although at first seemingly counter-intuitive, reducing excess sight distance at certain locations can also be effective in improving safety, particularly at roundabouts. Examples tend to involve the use of screens or hedges to reduce the view available of traffic approaching the intersection from other directions. This prevents drivers from taking risks (including increasing their speed) by anticipating gaps that might not still be present when the traffic approaches the intersection. It also forces them to slow down in case they need to stop at the intersection. Note that the minimum sight distance is still required at these locations. This treatment is relatively untested in Australia or New Zealand and so detailed assessment should be undertaken at any potential sites before this treatment is used. Following installation, close monitoring should also be undertaken.
Effectiveness	Speed reduction	• Up to 20 km/h reduction in 85th percentile speed at roundabouts.
	Crash reduction	• Up to 40% for reductions in excess sight distances at roundabouts.
	Road user effects (delays, congestion, consistency of travel time)	• Unknown.
Implementation issues		• Should allow sufficient sight distance for the driver or vehicle controller to make a sound judgement. • Potential safety risks because of reduced visibility and the legal implications if any crashes were to happen as a result. • Concerns about what effect this would have on vulnerable road users. • Necessary to maintain the minimum sight distance required, but ‘excess’ sight distance could be removed.
Cost		Low.
Treatment life		5–10 years.
Applicability		• Best locations are lower speed/local environments; however, treatment use is site specific.

Source: Based on Austroads (2016e).

Table A 10: Lower speed limits

Engineering treatment		Lower speed limits
Description		Involves lowering the mandatory (posted) speed limit on the approach to an intersection. This is typically used in combination with other treatments (for example, enhanced signage) and is rarely used as a sole method of speed reduction. No evidence was identified indicating a reduction in speed or crashes from reductions in speed limits using static signs alone; however, when used in combination with other treatments it appears that this treatment has promise. The effect also depends on the magnitude of the speed limit change. For more information on lowering speeds refer to Section **Error! Reference source not found.** and Section 6.6.3.
Effectiveness	Speed reduction	• Unknown.
	Crash reduction	• Unknown.
	Road user effects (delays, congestion, consistency of travel time)	• Minimal increases in travel time likely. • Mainly effective where there is a transition from high to low-speed environment.
Implementation issues		• Risk of merging or conflicting with other road signs at intersections.
Cost		Low.
Treatment life		10years+.
Applicability		• Typically needs to be combined with other treatments to help ensure compliance.

Source: Based on Austroads (2016e).

Table A 11: Variable speed limits (VSL)

Engineering treatment		**Variable speed limits (VSL)**
Description		VSL signs are dynamic or adjustable road signs displaying variable statutory speed limits depending on prevailing traffic, weather and road conditions. They are a form of intelligent transport system (ITS) technology with the simplest informing drivers of designated speed limits along roadways. The VSL system utilises information about prevailing road environment conditions such as traffic speed, traffic volume and weather, road surface conditions and/or approaching traffic to determine appropriate speed limits. The findings are based on rural roads as there was limited research on urban arterial applications of VSL.
Effectiveness	Speed reduction	• Up to 17 km/h reduction in 85th percentile speed.
	Crash reduction	• 8% reduction.
	Road user effects (delays, congestion, consistency of travel time)	• Improved traffic flow.
Implementation issues		• The signpost presents a hazard to errant vehicles and frangible posts should be used where possible. • A power supply is needed, which is particularly an issue in remote rural areas, although solar powered signs are now available. • The speed limit should not change too frequently as this might cause confusion. • Enforcement is needed to encourage/promote compliance.
Cost		Low to medium.
Treatment life		5–10 years.
Applicability		• Also, applied where there are variable traffic conditions and traffic mix, e.g. in high pedestrian activity areas where there is potential for conflict between pedestrians and vehicles.

Source: Based on Austroads (2016e).

Table A 12: Lane narrowing

Engineering treatment		Lane narrowing
Description		Lane narrowing at intersections is usually achieved with kerb extensions, solid or painted medians and wider shoulders. This encourages motorists to slow down to navigate through the narrower section at a more appropriate speed. Additionally, perceptual countermeasures may also act to produce a perceived narrowing of lanes on approach to intersections. Kerb extensions limit the use of kerbside turning lanes, so lane narrowing is generally not recommended for high-capacity roads, or where there is a significant volume of buses, heavy vehicles or cyclists.
Effectiveness	Speed reduction	• 7 km/h reduction in 85th percentile speed.
	Crash reduction	• Up to 30% reduction.
	Road user effects (delays, congestion, consistency of travel time)	• Improved pedestrian safety due to reduced crossing distances.
Implementation issues		• Ensure consistency in application to avoid driver confusion. • Adequate lane width is needed for emergency and heavy vehicles to navigate. • Introduces issues for cyclist movements. • Can potentially reduce road capacity, therefore application should be carefully considered.
Cost		Low.
Treatment life		15 years.
Applicability		• Narrowing the road at intersections is a treatment generally reserved for residential streets, as a narrow road design can negatively impact on heavy vehicles, transit vehicles and bicycles, although a narrower road can create space for wider footpaths, kerbside parking or central medians.

Source: Based on Austroads (2016e).

Table A 13: Signals: green wave

Engineering treatment		Signals: green wave
Description		Localised green wave or linked signals refer to coordinating adjacent traffic signals or linking several signals at intersections along a route segment on major urban arterial road such that a vehicle travelling at a recommended speed will be rewarded with consecutive green lights. This is likely to reduce travel time, speed variability and emissions. The approach is used to manage traffic, but is sometimes assumed to be an effective method for reducing speeds. No evidence was identified relating to speed reduction or safety benefits from this treatment.
Effectiveness	Speed reduction	• Unknown.
	Crash reduction	• Unknown.
	Road user effects (delays, congestion, consistency of travel time)	• Reduced braking and stopping, in turn reducing the likelihood of rear-end crashes. • Reduction in pollution and emissions (10–40% reduction). • Reduced wear and tear on vehicles due to smoother traffic flow. • 10–20% reduction in travel time. • Increases in noise levels in-between intersections.
Implementation issues		• Coordination usually results in increased delay for vehicles entering the coordinated system. It can also be costly if major signal controller or communications hardware upgrades are necessary. The time taken to design the coordination scheme and program the signal controllers can vary. • May pose issues when vehicles need to drive at 50 km/h or more as it may result in vehicles increasing their speed to get on to the green wave. • Speed guidance may be required as road users may not know what speed to travel at to get the green wave. • Operation of traffic signals should be reviewed every two to three years.
Cost		Low.
Treatment life		1–5 years.
Applicability		• Works best in unsaturated traffic conditions.

Source: Based on Austroads (2016e).

Table A 14: Signals: dwell-on-red

Engineering treatment		Signals: dwell-on-red
Description		The dwell-on-red (or rest-on-red) treatment involves programming an additional phase into signalised intersections and pedestrian crossings so that an all-red phase is displayed when there is no traffic or pedestrian demand. The signals only switch to green when a vehicle or pedestrian activates the change, either through vehicle detection, or through manual activation by pedestrians at a crossing point. The treatment is applied in high night-time pedestrian activity centres, including those where pedestrians are likely to be alcohol affected. The overall aim of rest-on-red signals is to reduce vehicle speeds and bring down the proportion of vehicles travelling at a speed that threatens severe pedestrian injury. The results include outcomes from an evaluation conducted through Austroads (2016e). Further research may be undertaken in the future.
Effectiveness	Speed reduction	• Up to 11 km/h.
	Crash reduction	• Up to 45% reduction.
	Road user effects (delays, congestion, consistency of travel time)	• Possible vehicle delay, however, this is in off-peak conditions.
Implementation issues		• Treatment effectiveness depends on traffic flow, implementation should therefore take traffic flow during operating times into consideration. • Local knowledge of high alcohol times should be applied.
Cost		Low.
Treatment life		1–5 years.
Applicability		• This treatment has typically been applied on arterial roads where there is likely to be high volumes of alcohol-affected pedestrians, and is only activated late at night and into the early morning.

Source: Based on Austroads (2016e).

A.2 Urban Arterial Mid-blocks

Table A 15 to Table A 27 provide information on treatments at urban arterial mid-blocks.

Table A 15: Humps/platforms

Engineering treatment		Humps/platforms
Description		Humps/platforms refer to vertical deflection treatments used to control speed, with various forms of speed humps available for different road types. Speed humps are around 100 mm high and 3–4 m wide and are generally recommended for use on local roads. Speed tables and platforms consist of an approach transition of approximately 1.8 m, rising to a height of 70–100 mm above the road surface, with a flat section of around 3–6 m in between. The exact length and grade of entrance and exit ramps and the length of the table will differ depending on the function of the road. The results include outcomes from an evaluation conducted through Austroads (2016e). Further research may be undertaken in the future.
Effectiveness	Speed reduction	• Up to 25 km/h reduction in 85th percentile speed. • 25 km/h reduction in mean speed. • 5–15% reduction in 85th percentile speeds at Seminole humps (e.g. flat top speed hump) and 11–18% at Watts humps (e.g. rounded speed hump).
	Crash reduction	• 40% reduction in serious injury and minor injury crashes.
	Road user effects (delays, congestion, consistency of travel time)	• Increase in vehicle delay and travel time. • Increase in emissions.
Implementation issues		• At higher speeds, aggressive humps/platforms can cause significant driver discomfort and damage to some vehicles. Milder ramp profiles of 1:12 used on roads ≤ 60 km/h and 1:30 or 1:35 on 70 km/h roads. • There also needs to be consideration for heavy and emergency response vehicles. • Through traffic and overall traffic volumes, and traffic mix should be considered before application. • Adequate provision of drainage should be considered. • Should be applied with associated advance warning signs. • Priority issue – pedestrians interpreting raised platform as pedestrian crossing. • Inconsistency in design (colour/texture etc.) across the road network may affect user perception. • Potential noise concerns.
Cost		Medium.
Treatment life		10 years+.
Applicability		• Suitable for lower-tier arterial roads with limited emergency and heavy vehicle volumes. • Typically applied in environments of up to 60 km/h.

Source: Based on Austroads (2016e).

Table A 16: Vehicle activated signs (VAS)

Engineering treatment		Vehicle activated signs (VAS)
Description		The main types of VAS implemented at mid-block segments are hazard warning (e.g. curve warning) and speed advisory signs. They are mainly installed in locations with known/identified speeding problems or speed-related crash history or in instances where the use of standard static speed and warning signs has not been effective in lowering travelling speeds or altering driver behaviour. The findings are based on rural applications.
Effectiveness	Speed reduction	• 10 km/h reduction in 85th percentile speed.
	Crash reduction	• Unknown (as a guide, VAS for rural mid-blocks have shown a 35% reduction in casualty crashes).
	Road user effects (delays, congestion, consistency of travel time)	• Increase driver awareness of surrounding environment.
Implementation issues		• Vandalism has been noted as an issue, especially in isolated rural locations. • Overuse of the treatment may reduce its novelty value, and therefore effectiveness. • The line of sight from the sign to the vehicle should be clear so that the radar detection works effectively, and the sign is clearly visible. • There may be power supply issues in rural areas, although solar-powered devices are now available. • As the sign presents a hazard to errant vehicles, it should be frangible. • Consistency across the road network is required.
Cost		Medium.
Treatment life		5–10 years.
Applicability		• Generally applied at hazardous locations or when entering a mixed traffic zone, e.g. school zones, work zones or strip shopping centres. • Can be applied at isolated hazard locations e.g. curves.

Source: Based on Austroads (2016e).

Table A 17: Wombat crossing (raised pedestrian crossing)

Engineering treatment		Wombat crossing (raised pedestrian crossing)
Description		Raised pedestrian crossings, typically termed wombat crossings in Australia, have a similar profile and speed reduction effect as flat-top speed humps but they differ in that they give priority to pedestrians rather than motorists. Wombat crossings consist of a raised platform with a marked pedestrian crossing on top, with a central refuge and kerb blisters if space permits. The raised crossing serves the purpose of slowing vehicles, as for a speed hump or platform, but also increases the visibility of pedestrians due to the increased height. The results include outcomes from an evaluation conducted through Austroads (2016e). Further research may be undertaken in the future.
Effectiveness	Speed reduction	• Up to 9 km/h reduction in 85th percentile speed. • Up to 8 km/h reduction in mean speed.
	Crash reduction	• 40% reduction in casualty crashes. • 30% reduction in serious and minor injury crashes. • 45% reduction in vehicle-pedestrian crashes.
	Road user effects (delays, congestion, consistency of travel time)	• Increased response time for emergency vehicles, increases in noise levels, drainage problems.
Implementation issues		• Wombat crossings have similar dimensions to road platforms, with more gradual ramps and longer flat sections recommended on bus and bicycle routes. • Ongoing maintenance required for the trafficked area. • Drainage needs to be considered during platform installation. • Need to be highly visible to drivers – this can be achieved by using lighting treatments or contrasting pavement designs. • Less priority concerns/confusion than humps/platforms, provided adequate crossing signs are consistently installed.
Cost		Medium to high.
Treatment life		10 years+.
Applicability		• Suitable for high pedestrian volume locations e.g. strip shopping centres, school zones and in low-speed sections of arterial roads. • Usage has historically been on local/lower category roads; however, the treatment shows promise on arterial roads. • Generally, not applied on multilane roads as the higher crossing distance might present a crash risk for pedestrians and cause vehicle delay.

Source: Based on Austroads (2016e).

Table A 18: Road diet (median turning lanes)

Engineering treatment		**Road diet (median turning lanes)**
Description		Road diets have been extensively used in the USA and involve converting a four-lane road (two each way) into a road with only one lane in each direction, and a two-way right-turn lane in the centre. A road diet can also provide enough space to install a bicycle lane or on-street parking. The results include outcomes from an evaluation conducted through Austroads (2016e). Further research may be undertaken in the future.
Effectiveness	Speed reduction	• 4 km/h reduction in 85th percentile speed. • 5 km/h reduction in mean speed.
	Crash reduction	• 35% reduction in casualty crashes.
	Road user effects (delays, congestion, consistency of travel time)	• Minimal increases in travel time. • Reduces turning movement conflicts. • Reduces crossing distance for pedestrians. • Possible reallocation of road space to transit, cyclists and or emergency vehicles. • Reduces speed differentials.
Implementation issues		• Installation of median turning lanes should not impede traffic flow or create operation problems. • A clear understanding of the turning volumes and movements at the treatment site is required. • Can reduce road capacity and vehicle volumes.
Cost		Low to medium.
Treatment life		1–5 years.
Applicability		• Typically applied to high traffic volume four-lane undivided arterials with a high volume of vehicles sharing the inside lane for higher-speed through movements and right-turns. • Suitable for roads with traffic volumes of up to 20 000 vehicles per day.

Source: Based on Austroads (2016e).

Table A 19: Pedestrian refuge island

Engineering treatment		Pedestrian refuge island
Description		A pedestrian refuge island is a raised median island in the middle of the road with at-grade space provided for pedestrians to wait until a gap in traffic allows them to complete crossing the road. It also acts as a median island that can narrow the travel path and have a speed reduction effect. Refuges effectively allow pedestrians to cross two narrow one-way streets rather than attempt to cross one wide two-way street. Refuges are particularly beneficial to elderly pedestrians and those with impaired mobility who may otherwise find it difficult to cross a street in one movement.
Effectiveness	Speed reduction	• Potential for speed reduction due to lane narrowing, however, no statistics available.
	Crash reduction	• 25% reduction in casualty crashes. • 45% reduction in pedestrian crashes.
	Road user effects (delays, congestion, consistency of travel time)	• Provides pedestrian crossing facility, encouraging walking. • Reduces pedestrian exposure to traffic by splitting crossing distances and pedestrian crossing points. • Reduces pedestrian waiting time.
Implementation issues		• Clear delineation and lighting required to ensure the refuge is clearly visible to approaching traffic. • Placement of the refuge should also allow for or take into consideration other road space needs at the location, e.g. the presence of cyclists might mean provision of additional space. • Turning movements from driveways and intersections need to be carefully evaluated when considering the location of a refuge. • Islands should be designed to cater for pedestrians with visual and mobility impairment. • Refer to local standards and guides for treatment implementation, e.g. AS 1742.10-2009.
Cost		Low to medium.
Treatment life		20 years+.
Applicability		• Used where there is a high concentration of pedestrians and where it is difficult to cross the full roadway in one stage. • Speed reductions are dependent on how much the traffic lane is narrowed. • Also used in locations where pedestrian movements are distributed over a length of road, rather than centralised, e.g. strip shopping centres. • Suitable for low-volume arterial roads and strip shopping centres. • Applied where there is sufficient room for vehicles to pass.

Source: Based on Austroads (2016e).

Table A 20: Medians

Engineering treatment		Medians
Description		A median reduces speeds through the installation of a raised or painted (flush) median treatment. This involves the physical separation between opposing traffic streams, increasing the distance and the recovery area in case of a driver error. In some cases, safety barrier systems can also be employed to prevent vehicle encroachment into opposing traffic lanes. Provision of a physical median is usually associated with a major road upgrade or a duplication of carriageways while flush medians are a low-cost alternative.
Effectiveness	Speed reduction	• Mixed results.
	Crash reduction	• 15% reduction in casualty crashes for flush/painted median. • 46% reduction in casualty crashes for raised median.
	Road user effects (delays, congestion, consistency of travel time)	• Likely to restrict right-turns in or out of side roads and properties. • May require design of median breaks and turning lanes. • Potential to increase efficiency through improved traffic flow.
Implementation issues		• The use of medians varies depending on available space and surrounding land use. This determines the extent and type of median solution applied. Community acceptance of the medians that restrict turning movements may be an issue. Regular gaps may need to be provided, along with sheltered turning lanes. • Regular and on-going maintenance is required. The maintenance costs vary by median type. • Drainage should be taken into consideration before median installation. • Concern that vehicles may try to overtake using flush medians. • Questionable whether speeds are reduced.
Cost		Medium to high.
Treatment life		1–5 years for flush median. 10 years+ for raised median.
Applicability		▪ Very narrow medians often cannot accommodate signs, traffic signal hardware, or provide staging for pedestrians. ▪ Speed reductions are dependent on how much the traffic lane is narrowed. ▪ Providing adequate roadside lighting for a narrow median may be an issue if the carriageways are wide.

Source: Based on Austroads (2016e).

Table A 21: Gateway treatments

Engineering treatment		Gateway treatments
Description		Gateway treatments (also referred to as entry treatments or thresholds) are used to delineate transitions from higher-speed to lower-speed environments, or mark a change from a major to a residential road. This is achieved using raised pavements, speed signs, coloured pavements and different pavement types. There was no available literature on the effectiveness of gateway treatments on urban roads. Consequently, the findings on rural roads are provided as an indicative measure.
Effectiveness	Speed reduction	• Up to 25 km/h in 85th percentile speed. • Up to 15 km/h in mean speed.
	Crash reduction	• 25% reduction in casualty crashes. • 35% reduction if pinch point used. • 40% reduction in FSI crashes if pinch point is used.
	Road user effects (delays, congestion, consistency of travel time)	• Raised awareness of a change in road environment.
Implementation issues		• Needs to be located at the point where development commences to be most effective. • Should be backed up by changes in the environment (e.g. use of painted medians) after the threshold to maintain the speed reductions. • Introduction of street furniture may introduce hazards for errant vehicles. • Care should be taken so that the gateway does not have a negative effect on skid resistance, presenting an additional risk, particularly for motorcyclists. • There may be maintenance issues associated with this treatment.
Cost		Low to medium.
Treatment life		5–20 years depending on selected features.
Applicability		• Suitable for transition zones or where there are clear changes in traffic conditions and speed environment (e.g. entry to a shopping strip).

Source: Based on Austroads (2016e).

Table A 22: Traverse rumble strips

Engineering treatment		Transverse rumble strips
Description		Transverse rumble strips are audio-tactile strips that extend across the travel lane to alert drivers to unusual or changing traffic conditions. They can be placed at mid-block locations to warn drivers of an upcoming curve or hazard, especially where the advised speed at the curve is significantly different to the speed limit. The strips work due to the unpleasant feeling they produce through vibrations and wheel noise, and can be used at decreasing intervals to give drivers a sensation of speeding up. The findings are for rural applications.
Effectiveness	Speed reduction	• Unknown.
	Crash reduction	• 34% reduction in all crashes. • 36% reduction in serious and minor injury crashes. • 25% reduction in FSI crashes.
	Road user effects (delays, congestion, consistency of travel time)	• Motorcyclist and cyclist vehicle control concerns.
Implementation issues		• Ongoing maintenance required as treatment loses effectiveness in trafficked areas. • Noise can be an issue in built-up areas.
Cost		Low.
Treatment life		1–5 years.
Applicability		• Transverse rumble strips are noisy when driven over, so are more suited to low-speed environments where the noise is less severe e.g. industrial sites, urban fringes or rural roads away from residential/built up areas.

Source: Based on Austroads (2016e).

Table A 23: Shared spaces/naked roads

Engineering treatment		Shared spaces/naked roads
Description		Shared spaces, otherwise known as 'naked roads', are an urban design concept where the priority for users is shifted from vehicles towards pedestrians and cyclists. This shared use encourages better public spaces for the community. While shared spaces can be achieved in different ways, the general concept involves removing conventional road management systems such as traffic signals and signs, kerbs, barriers and linemarkings. Shared spaces are related but different to shared zones which typically do not involve the removal of this infrastructure.
Effectiveness	Speed reduction	• There are mixed results for this treatment, although some studies show up to a 13 km/h reduction in mean and 85th percentile speed.
	Crash reduction	• There are mixed results for this treatment with some studies showing safety improvements, while others report increases in risk, particularly for vulnerable roads users. Some studies show a 49% reduction in casualty crashes.
	Road user effects (delays, congestion, consistency of travel time)	• 20% increase in pedestrian usage. • Increased risk for vulnerable road users (pedestrians and cyclists); additionally, evidence of safety concerns for vision and hearing-impaired pedestrians. • The low speed environment results in less severe crash outcomes.
Implementation issues		• Shared space applications depend on the area-specific traffic and spatial problems. • They require substantial re-design of road and pedestrian space to create a distinct environment. • There could be confusion with who has priority. • This treatment can present some problems for the visually and hearing impaired.
Cost		Medium to high.
Treatment life		10 years+.
Applicability		• Shared space is typically applied in high pedestrian volume areas, including strip shopping centres. • Not considered possible for roads with traffic volumes of more than 15 000 vehicles per day.

Source: Based on Austroads (2016e).

Table A 24: Lower speed limits

Engineering treatment		Lower speed limits
Description		Involves lowering the posted speed limits using static signs towards Safe System levels. This is a widely applied speed management measure aimed at producing lower vehicle speeds, and crash and injury severity reductions. Surrounding land use, traffic mix, volumes, overall road function and the road safety record should be considered before speed limit changes are applied.
Effectiveness	Speed reduction	• 3–4 km/h reductions in mean speed (short term), in the long run, mean speed reverts to the speed limit reduction. • 6 km/h reduction in 85th percentile speed.
	Crash reduction	• 25% reduction in casualty crashes.
	Road user effects (delays, congestion, consistency of travel time)	• Reduced vehicle vibrations, noise and emissions. • Increase in traffic flow reducing congestion and delays. • Reduction in vehicle operating costs.
Implementation issues		• Speed limit reviews should be implemented as part of a wider speed management or zoning plan, taking into consideration the road function and recommended speed limit, surrounding land use, traffic mix, road alignment and crash history and record. Jurisdictional speed zoning/management guidelines and AS 1742.4-2008 provide detailed instructions on the process. • Speed limit changes should be part of a combined strategy such as traffic calming or driver perception changes designed to reduce the speeds of vehicles. • Consider intersecting local roads. • Repeater signs, advance warning signs and enforcement should also be implemented to increase compliance.
Cost		Low.
Treatment life		10 years+.
Applicability		• Should be applied as an area or zone-wide measure. • There may be a need to alter the speed environment to increase compliance.

Source: Based on Austroads (2016e).

Table A 25: Variable speed limits (VSL)

Engineering treatment		**Variable speed limits (VSL)**
Description		VSL are dynamic road signs displaying variable enforceable speed limits depending on prevailing traffic, weather and road conditions. There are three main types of VSL: speed harmonisation, speed buffering and speed reduction. Speed harmonisation VSL reduce speed differentiation between vehicles and lanes; speed buffering VSL produce gradual reduced speed zones and are mainly applied in cases of downstream congestion; speed reduction VSL reduce or lower speeds to match prevailing conditions (weather, road and traffic, e.g. congestion).
Effectiveness	Speed reduction	• Unknown, but evidence of overall reductions in speed. • Increase compliance with prevailing speed limits.
	Crash reduction	• 8% reduction in casualty crashes.
	Road user effects (delays, congestion, consistency of travel time)	• Increase driver awareness of changing traffic and road conditions. • Used for congestion management, improving travel speeds in congested conditions. • Can create smoother and more regular flows.
Implementation issues		• Sign placement and visibility are crucial in the effectiveness of VSL in speed management. The threshold speed and traffic volume should be carefully considered to consider local/location-specific conditions. • Enforcement and consistent signage are required for compliance. • Treatment ideal for high pedestrian activity areas, shopping strips and school areas.
Cost		Low.
Treatment life		10 years+.
Applicability		• VSL are applied on any arterial road, regardless of traffic volumes. Their adaptability to prevailing conditions makes them applicable in school and work zones as well.

Source: Based on Austroads (2016e).

Table A 26: Variable message signs (VMS)

Engineering treatment		**Variable message signs (VMS)**
Description		VMS are traffic control devices used for traffic management and to warn drivers of prevailing conditions and display dynamic safety messages e.g. congestion and delay messages, road closures or crashes. There are three main types of VMS, permanent and enhanced permanent, mobile and vehicle-mounted. VMS can be automated or manually controlled and are mainly implemented on motorways, highways and major arterial roads.
Effectiveness	Speed reduction	• 1–2 km/h reduction in mean speed.
	Crash reduction	• 10% reduction in injury crashes.
	Road user effects (delays, congestion, consistency of travel time)	• Increased driver awareness of prevailing conditions and hazards. • Traffic condition VMS reduce emissions and travel time.
Implementation issues		• Need to consider sign placement and visibility e.g. adequate roadside space and clearance. • Use of gantries may be required on wide carriageways. • Vandalism may be an issue. • Signposts are a roadside hazard; therefore, they may require shielding. • Should be positioned an adequate distance from the hazard to allow road users sufficient response time and distance.
Cost		Low to medium.
Treatment life		5–10 years.
Applicability		• Applicable where static signage is deemed inadequate or corridor-specific information is needed. They are also applied in school and work zones. • The message should also be legible without interfering with the driving task. • The messages should be short and clearly legible.

Source: Based on Austroads (2016e).

Table A 27: Repeater signs

Engineering treatment		Repeater signs
Description		Repeater signs, static in nature, can be placed several hundred metres apart to remind drivers of the speed limit, especially on roads where the posted speed limit is not immediately apparent by the appearance of the road. Repeater signs aim to reduce the number of drivers inadvertently exceeding the speed limit.
Effectiveness	Speed reduction	• Up to 3.6 km/h reduction in mean speed.
	Crash reduction	• Unknown.
	Road user effects (delays, congestion, consistency of travel time)	• Better traffic flow can improve the efficiency of traffic signals, and create larger gaps in traffic for pedestrians to cross the street. • Repeater signs can ensure compliance/driver awareness, as it is sometimes easy to miss a speed zone change sign.
Implementation issues		• May increase clutter and add to roadside hazards. • Placement and spacing of repeater signs determined by AS 1742.2-2009. • Signs need to be visible to be effective.
Cost		Low.
Treatment life		5–10 years.
Applicability		• The sign size and spacing depend on the speed environment and the associated speed limit changes.

Source: Based on Austroads (2016e).

Appendix B Rural Engineering Treatments

This appendix provides information on engineering treatments that can be used to achieve Safe System speeds on rural roads. The content is based on *Methods for Reducing Speeds on Rural Roads – Compendium of Good Practice* (Austroads 2014a). The treatments are separated into rural curves (Appendix B.1), rural intersections (Appendix B.2), level crossing treatments (Appendix B.3), transition zones (Appendix B.4) and rural routes and mid-blocks (Appendix B.5).

B.1 Rural Curves

Table B 1 to Table B 9 provide information on treatments at rural curves.

Table B 1: Advance curve warning signs – curves

Engineering treatment		Advance curve warning signs – curves
Description		The signs are placed on the approach to a curve to alert drivers to a change in the horizontal alignment of the road. Often an advisory speed sign is also installed underneath. The signs alert drivers to the presence and alignment of the curve (e.g. left curve, right curve, reverse curve etc.) giving additional information to safely negotiate the curve. Aside from the standard warning sign, a number of different sign configurations have been employed to raise awareness at particularly problematic locations. Measures include the use of larger than standard sized signs, brightly coloured backing boards, and flashing lights.
Benefits	Speed reduction	• Unknown.
	Crash reduction	• 25% reduction in casualty crashes (i.e. all crash types, and all fatalities and injuries).
	Other	• Reduced risk of run-off-road crashes. • Reduced risk of head-on crashes.
Implementation issues		• Careful consideration is needed as to the correct placement of the signs, including the distance from the curve, ensuring the visibility and conspicuity of the sign, taking into account operating speed and road layout. • Signs present a hazard to errant vehicles and consideration should be given to using flexible signposts. • Overuse of the signs can lead to driver complacency thus reducing their effectiveness, so should only be used where the curve is unexpected, where the operating speed is a good deal less than the regulatory speed limit (e.g. 10 km/h is used in several jurisdictions), or there are other risk factors. • A route-based approach should be taken to the installation of curve warning signs. • Where applicable, the sign needs to show additional hazards, such as intersections on the curve.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 2: Chevron alignment markers – curves

Engineering treatment		Chevron alignment markers – curves
Description		Chevron alignment markers (CAMs) are individual or grouped chevron signs, placed on the outside of a curve to help indicate the presence and severity of the curve. This assists the driver in positioning the vehicle to negotiate the curve safely. As the driver traverses the curve, the delineation device also provides a continuous feature for positive guidance. This treatment tends to affect driver speeds on a horizontal curve, which is particularly important because excessive speed is a significant factor in crashes at horizontal curves.
Benefits	Speed reduction	• 2 and 3.5 km/h for chevrons with fully retroreflective posts.
	Crash reduction	• 30% reduction in casualty crashes.
	Other	• Improved delineation at curves. • Advance driver cues of a curve ahead. • An indication of the curvature (the tighter the curve, the closer the spacing).
Implementation issues		• Need to be positioned carefully so that drivers will have at least two in view at all times, until the curve has straightened out to a point where they are not required. • Potential hazard to errant vehicles. Design of signposts to minimise damage and injury is an important consideration when selecting this treatment. • The misuse or overuse of these signs could potentially reduce their effectiveness in critical road sections.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 3: Advisory speed signs – curves

Engineering treatment		Advisory speed signs – curves
Description		Advisory speed signs are plates, usually attached under a curve warning sign, which display the appropriate speed to be able to negotiate the curve comfortably. The treatment also indicates the severity of the curve, with a lower speed indicating a more severe curve. Reducing speeds on the road sections preceding horizontal curves is particularly important because excessive speed is a significant factor in crashes at curves.
Benefits	Speed reduction	• Unknown.
	Crash reduction	• 40% reduction in casualty crashes.
	Other	• Provide advance warning of approaching curve. • Indicate the severity of the curve. • Low installation cost. • Convey a simple clear meaning to the motorist.
Implementation issues		• Signs must be used in a consistent and credible manner to ensure compliance by motorists. If drivers think the speed is too low they may drive at a higher speed than they would have done without the sign present. • Advisory speed signs are not recommended on unsealed roads due to rapidly changing conditions. • The signs should be placed so they can be seen in time for the driver to brake before the curve. • Care must be taken not to place the signs where they can be seen at the same time as a mandatory speed limit sign. • Signs present a hazard to errant vehicles and consideration should be given to using flexible signposts.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 4: Vehicle activated signs – curves

Engineering treatment		Vehicle-activated signs – curves
Description		The electronic signs are only activated by the presence of a vehicle, and in some cases only if the vehicle is travelling above a threshold speed limit. Once triggered, the sign displays the hazard, and may include a message to slow down. This alerts the driver to the presence of the curve with the aim being that they reduce their speed to negotiate the curve safely.
Benefits	Speed reduction	• 2–6 km/h.
	Crash reduction	• 35% in injury crashes.
	Other	• Additional guidance to alert motorists to hazards. • Provide information on the direction of the curve.
Implementation issues		• Vandalism has been noted as an issue, especially in isolated rural locations. • Overuse of the treatment may reduce their novelty value, and therefore their effectiveness. • The line of sight from the sign to the vehicle should be clear so that the radar works effectively, and the sign is clearly visible. • There may be power supply issues in rural areas, although solar-powered devices are now available. • As the sign presents a hazard to errant vehicles, it should be frangible.
Cost		Medium.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 5: Other delineation devices – curves

Engineering treatment		Other delineation devices – curves
Description		Alternative delineation devices to chevron alignment markers are available. These are: • guide posts • linemarking • pavement markers. They provide additional guidance to the driver to improve safe negotiation, but may also have some effect on motorists' speed.
Benefits	Speed reduction	• Unclear – some studies show an increase in speed.
	Crash reduction	• Guide posts: 5%. • Edge line marking: 10%. • Centrelinemarking: 20%. • Pavement markers: 5%.
	Other	• Clearer delineation. • Improved path definition. • Alert driver to presence of curve.
Implementation issues		• Road markings have been shown to increase speeds in some rural settings. There are maintenance costs associated with these treatments.
Cost		Low.
Treatment life		1–5 years.

Source: Based on Austroads (2014c).

Table B 6: Traverse rumble strips – curves

Engineering treatment		Transverse rumble strips – curves
Description		Rumble strips are lines or sections of profiled road markings placed across the carriageway to cause noise and vibration in the vehicle to alert the driver to the presence of a hazard. They have been used to a limited extent in advance of rural curves.
Benefits	Speed reduction	• 5 km/h.
	Crash reduction	• Unknown.
	Other	• Increased awareness of curve.
Implementation issues		• Rumble strips are noisy and should not be used near residential areas. However, if driven over at higher speeds the noise and vibratory effects are less severe. • Need to be placed so that the driver has enough time to slow down before the curve. Excessive braking on the curve would be dangerous. • There are maintenance issues with such markings. • There may be issues with skid resistance (particularly for motorcyclists) when using these markings.
Cost		Low.
Treatment life		1–5 years.

Source: Based on Austroads (2014c).

Table B 7: Perceptual countermeasures – curves

Engineering treatment		Perceptual countermeasures – curves
Description		Perceptual countermeasures are treatments which are used to alter drivers' perception of their speed, or of the road environment (e.g. making the road appear to narrow, or to make a curve appear more severe). By altering the drivers' perception, it is intended that the driver will slow down to match the perceived conditions rather than the actual ones. Perceptual countermeasures at curves include altering the spacing and height of guide posts on the outside edge of the curve to make the curve appear more severe, or by using road markings to give the impression that lanes are narrower, or that the curve is more severe.
Benefits	Speed reduction	• 5–10 km/h.
	Crash reduction	• Unknown.
	Other	• Improved lane positioning.
Implementation issues		• The results in terms of speed reduction have been mixed for this treatment. Some studies have shown decreases in speed of up to 10 km/h, although speed reductions of 5 km/h are more typical. Other studies have found no benefit. • There may be maintenance issues with this type of treatment. • Caution should be used when placing markings on the road surface, as these may decrease surface friction.
Cost		Low to medium.
Treatment life		1–5 years.

Source: Based on Austroads (2014c).

Table B 8: Route-based curve treatments – curves

Engineering treatment		Route-based curve treatments – curves
Description		Route-based treatments are a method of ensuring consistency of signing of curves along a section of road. Each curve is classified based on risk factors, such as design speed, tangent speed, sight distances etc. Once the risk of the curve has been identified, signs and markings for that curve are installed according to this risk category. The higher the risk category the more treatments are installed. These include advance curve warning signs, guide posts, chevron markers and profiled road markings.
Benefits	Speed reduction	• Unknown.
	Crash reduction	• Unknown.
	Other	• Alert driver to presence of curves based on risk. • Consistent with the self-explaining roads concept.
Implementation issues		• Must be consistent to avoid confusion and maintain driver confidence and compliance. • An assessment process is required to determine risk category.
Cost		Low to medium.
Treatment life		Up to 10 years.

Source: Based on Austroads (2014c).

Table B 9: Slow markings – curves

Engineering treatment		Slow markings – curves
Description		The word slow is painted on the road on the approach to a curve, giving drivers additional advance warning of the hazard, and a clear indication of what they are required to do.
Benefits	Speed reduction	• 5%.
	Crash reduction	• Unknown.
	Other	
Implementation issues		• There is very limited research on this topic. • Road markings can be hard to read in certain conditions. • Skid resistance may be decreased when using road markings.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

B.2 Rural Intersections

Table B 10 to Table B 19 provide information on treatments at rural intersections.

Table B 10: Advance warning signs – intersections

Engineering treatment		Advance warning signs – intersections
Description		Warning signs are often used in advance of intersections to alert motorists to the possibility of an increased level of risk. It is expected that such signs will raise the attention level of motorists, and it is also possible that motorists will slow to a safer speed in some circumstances. Aside from the standard warning signs, several different sign configurations have been employed to raise awareness at particularly problematic locations. Measures include the use of larger than standard sized signs, brightly coloured backing boards, and flashing lights.
Benefits	Speed reduction	• Unknown, but it is known that the presence of an intersection tends to lower speeds, so there is likely to be some reduction.
	Crash reduction	• 30%.
	Other	• Alert motorists to the presence of the intersection.
Implementation issues		• Signs present a hazard to errant vehicles and consideration should be given to using flexible posts. • Different sign configurations (e.g. larger than standard signs) could be considered at particularly problematic locations.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 11: Vehicle activated signs – intersections

Engineering treatment		Vehicle activated signs – intersections
Description		The electronic signs are only activated by the presence of a vehicle, and in some cases only if the vehicle is travelling above a threshold speed limit. Once triggered, the sign displays the hazard, and may include a message to slow down. This alerts drivers to the presence of the intersection with the aim being that they increase their alertness and reduce speed to negotiate the intersection safely.
Benefits	Speed reduction	• 5 km/h.
	Crash reduction	• 70%.
	Other	• Alert motorists to the presence of the intersection. • Provide more prominent warning. • May be set to only alert motorists who are exceeding a threshold speed. • May be set to operate in certain conditions only (e.g. time of day).
Implementation issues		• Vandalism has been identified as a potential issue, especially in remote rural areas. • There may be power supply issues in rural areas, although solar-powered devices are now available. • As the sign presents a hazard to errant vehicles, it should be frangible.
Cost		Medium.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 12: Roundabouts – intersections

Engineering treatment		Roundabouts – intersections
Description		Roundabouts are circular central islands, around which traffic circulates in a clockwise direction, which are used at intersections. Entry to the roundabout is controlled by way of signs and markings, with all entering traffic required to give way to traffic on the circulating roadway. However, in certain circumstances roundabouts are signalised, either partly or wholly and either at peak times only or all the time.
Benefits	Speed reduction	• 4 km/h (30 m in advance of intersection).
	Crash reduction	• 70%.
	Other	• Fewer conflict points and improved angles of conflict in comparison with conventional intersections. • More time for drivers to react to potential dangers. • Priority is simple and consistent on all approaches (give way to circulating traffic). • Since most road users travel at similar speeds through roundabouts, crash severity can be reduced compared to some traditionally controlled intersections. • The visibility of the intersection is increased. • Can improve traffic flow.
Implementation issues		• Good design (including deflection) is required to reduce vehicle speeds on the approach to the roundabout. Additional signs may also be used to provide advance warning. • If traffic flows are unequal on approaches, additional features may be needed. • Can increase the risk of bicycle crashes. • Need to be able to accommodate the turning circle of emergency services vehicles and large goods vehicles. • Provision for pedestrians is needed, although this may be less of an issue on most rural roads. • A larger area of land is needed than for a traditional intersection.
Cost		High.
Treatment life		20 years+.

Source: Based on Austroads (2014c).

Table B 13: Perceptual countermeasures – intersections

Engineering treatment		Perceptual countermeasures – intersections
Description		The treatments are used to alter a driver's perception of the environment. Can be used to make drivers think they are going faster than they are, or that the road narrows. Both cause the driver to slow on approach to the intersection. In addition, the treatments are likely to raise awareness of the presence of the intersection. This type of treatment is quite common in the UK, particularly on the approach to roundabouts.
Benefits	Speed reduction	• 4 km/h from perceptual narrowing. • Up to 8 km/h from markings that give the appearance of travelling faster on the approach to an intersection.
	Crash reduction	• 60% on approach to roundabouts.
	Other	• Increased awareness of intersection.
Implementation issues		• Overuse of the treatments can lead to them losing their effect and drivers not responding to the same extent. • Careful consideration on placement of the treatment needs to be undertaken to ensure that drivers have enough time to brake safely before the intersection after encountering the treatment. • Additional linemarking may have a negative effect on skid resistance, particularly for motorcyclists.
Cost		Low.
Treatment life		1–5 years.

Source: Based on Austroads (2014c).

Table B 14: Traverse rumble strips – intersections

Engineering treatment		Transverse rumble strips – intersections
Description		Rumble strips are lines or sections of profiled road markings placed across the carriageway to cause noise and vibration in the vehicle to alert the driver to the presence of a hazard. They can be placed equidistantly or spaced at decreasing intervals to shorten the time between vibrations.
Benefits	Speed reduction	• 5 km/h (200 m in advance of the intersection).
	Crash reduction	• 20% fatal and injury crashes. • 30% fatal and serious injury crashes.
	Other	• Increased awareness of the intersection. • More time to react to other vehicles on the intersection.
Implementation issues		• Rumble strips are noisy and should not be used near residential areas. However, if driven over at higher speeds the noise and vibratory effects are less severe. • Need to be placed so that the driver has enough time to slow down before the intersection and stop if necessary. • Signs are also required to indicate the reason(s) to slow down. • The profile for the rumble strips needs to be suitable so as not to present a hazard to motorcyclists.
Cost		Low.
Treatment life		1–5 years.

Source: Based on Austroads (2014c).

Table B 15: Reductions in sight distance – intersections

Engineering treatment		Reduction in sight distance – intersections
Description		Screens or hedges are used to reduce the view available of traffic approaching the intersection from other directions. This prevents drivers from taking risks by anticipating gaps that might not still be present when the traffic approaches the intersection. It also forces them to slow down in case they need to stop at the intersection. Note that minimum sight distance is still required at these locations. This treatment is relatively untested in Australia or New Zealand and so detailed assessment should be undertaken at any potential sites before this treatment is used. Following installation, close monitoring should also be undertaken.
Benefits	Speed reduction	• Up to 18 km/h.
	Crash reduction	• 40%.
	Other	
Implementation issues		• Screens need to be placed carefully so that adequate sight distances are maintained close to the intersection so that drivers can see oncoming traffic. • Additional signs may be needed to warn drivers of the presence of the intersection. • Erection of a screen presents an additional hazard and should be flexible or shielded. • This treatment shows potential, but has not been widely trialled in Australia or New Zealand. The treatment should therefore only be used after a detailed site assessment, and following installation the site should be carefully monitored.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 16: Reduction in speed limits – intersections

Engineering treatment		Reduction in speed limits – intersections
Description		The treatment involves the lowering of the mandatory speed limit on the approach to the intersection. This is typically used in combination with other treatments (for example, enhanced signing) and is rarely used as a sole method of speed reduction. No evidence was identified indicating a reduction in speed or crashes from reductions in speed limits alone; however, when used in combination with other treatments it appears that this treatment has promise.
Benefits	Speed reduction	• Unknown.
	Crash reduction	• Unknown.
	Other	
Implementation issues		• Enforcement is needed to ensure compliance.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 17: Variable speed limit – intersections

Engineering treatment		Variable speed limit – intersections
Description		Variable message signs are used to signal changes in the speed limit, when traffic volumes or environmental conditions make it necessary. These can be mandatory or advisory speed limits. Some systems respond when vehicles approach the intersection from a side road.
Benefits	Speed reduction	• Dependent on limits; 17 km/h when reduced from 90 km/h to 70 km/h.
	Crash reduction	• Unknown.
	Other	• Improved traffic flow.
Implementation issues		• The signpost presents a hazard to errant vehicles and flexible posts should be used where possible. • A power supply is needed, which is particularly an issue in remote rural areas, although solar-powered signs are now available. • Enforcement is needed to ensure compliance.
Cost		Low to medium.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 18: Lane narrowing – intersections

Engineering treatment		Lane narrowing – intersections
Description		Solid or painted medians, possibly incorporating profiled edge lines, are used to create narrower lanes on the approach to an intersection. This encourages motorists to slow down to safely navigate through the narrower section. Perceptual countermeasures may also act to produce a perceived narrowing of lanes on approach to intersections.
Benefits	Speed reduction	• 5 km/h.
	Crash reduction	• 30% all crashes. • 20% fatal and injury crashes.
	Other	
Implementation issues		• Need to ensure consistency in application in local areas to avoid driver confusion. • Lanes need to be wide enough for emergency vehicles and other larger trucks to navigate.
Cost		Low to medium (dependent on method used).
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 19: Increasing the prominence of the intersection – intersections

Engineering treatment		Increasing the prominence of the intersection – intersections
Description		This treatment increases the visibility of an intersection by painting the road surface, or using coloured pavement. The theory behind the treatment is that people do slow for an intersection, so if they become aware of it earlier they will slow earlier and reach a lower speed upon reaching the intersection itself. So far, the treatment has only been tested in a simulator and not in an on-road environment.
Benefits	Speed reduction	• 10 km/h (based on simulation).
	Crash reduction	• Unknown.
	Other	• Increases awareness of the intersection.
Implementation issues		• As this is an untested treatment care would need to be taken when first implementing, and careful monitoring should be undertaken. • Care should be taken so that the treatment does not have a negative effect on skid resistance, as this would present an additional risk, particularly for motorcyclists. • It is important that the priority remain clear to motorists through appropriate linemarking and signage. • There may be maintenance issues associated with this treatment.
Cost		Low.
Treatment life		1–5 years.

Source: Based on Austroads (2014c).

B.3 Level Crossing Treatments

Table B 20 and Table B 21 provide information on treatments at level crossings.

Table B 20: Rumble strips – railway level crossing

Engineering treatment		Rumble strips – railway level crossing
Description		Rumble strips are lines or sections of profiled road markings placed across the carriageway to cause noise and vibration in the vehicle to alert the driver to the presence of a hazard. This treatment can be used in advance of curves or intersections, including at rail level crossings.
Benefits	Speed reduction	• 5 km/h.
	Crash reduction	• Unknown.
	Other	• Increase awareness of the hazard.
Implementation issues		• Signs need to be installed to inform motorists of the reason(s) to slow down. • This treatment can be noisy – though this is less of an issue with railway lines in rural areas. • The profile used needs to be suitable to not present a hazard to motorcyclists. • A small number of drivers were filmed driving around the rumble strips and onto the wrong side of the road during one trial.
Cost		Low.
Treatment life		1–5 years.

Source: Based on Austroads (2014c).

Table B 21: Speed signage – railway level crossing

Engineering treatment		Speed signage – railway level crossing
Description		This measure involves mandatory speed limit reductions on the approach to level crossings using static speed limit signs. This approach has been trialled overseas and more recently in Australia.
Benefits	Speed reduction	• 7–12 km/h.
	Crash reduction	• Unknown.
	Other	• Increase awareness of the presence of the level crossing.
Implementation issues		• Requires enforcement to have full effect, which is problematic in very remote locations.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

B.4 Transition Zones

Table B 22 to Table B 26 provide information on treatments at transition zones.

Table B 22: Advance warning – transition zones

Engineering treatment		Advance warning – transition zones
Description		An advisory sign (e.g. 60 ahead) is used in advance of a speed limit change to alert motorists of the impending change. A review of this treatment (from a 100 km/h to a 60 km/h zone) identified that the treatment was not effective at slowing speeds to 60 km/h at the speed transition point, but was more effective than the 60 km/h sign alone.
Benefits	Speed reduction	• Minor.
	Crash reduction	• Unknown.
	Other	
Implementation issues		• Should be considered instead of buffer zones, as this treatment is as effective, but does not have the same enforcement implications.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 23: Buffer zones – transition zones

Engineering treatment		Buffer zones – transition zones
Description		A staged reduction in the speed limit, usually on the approach to a village or other built-up area, is used. For example, it could involve a drop in the speed limit for 100 km/h to 80 km/h then shortly after to 60 km/h. Implemented through use of static speed limit signs.
Benefits	Speed reduction	• Minor.
	Crash reduction	• Unknown.
	Other	
Implementation issues		• Enforcement is needed to ensure compliance which is problematic over a small area. • This treatment is no more effective than using advance warning signs (which do not require enforcement).
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 24: Count-down signs – transition zones

Engineering treatment		Count-down signs – transition zones
Description		A series of static signs is used with a decreasing number of diagonal marks until a new speed limit comes into force. They are similar to those used on the approach to motorway exit slip roads in the UK.
Benefits	Speed reduction	• No significant change.
	Crash reduction	• Unknown.
	Other	• Increase awareness of the change in conditions ahead.
Implementation issues		• The signpost presents a hazard to errant vehicles, and flexible posts should be used where possible. • May cause confusion as to when the speed limit changes.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 25: Rural thresholds – transition zones

Engineering treatment		Rural thresholds – transition zones
Description		This measure uses a combination or treatments to slow traffic down and to create a visual difference on entering a village or other built-up area. There is usually a combination of signs (either static or active), road markings and road narrowing. Threshold treatments work significantly better when a pinch point (some form of perceived or actual road narrowing) is used.
Benefits	Speed reduction	• Up to 25 km/h.
	Crash reduction	• 25% overall reduction (fatal and injury). • 35% overall if pinch point used. • 40% reduction in fatal and serious injury when a pinch point is used.
	Other	• Raised awareness of a change in road environment.
Implementation issues		• The treatment needs to be located at the point where development commences to be most effective. • The treatment may need to be backed up by changes in the environment (e.g. use of painted medians) after the threshold to maintain the speed reductions. • May introduce hazards for errant vehicles. • Care should be taken so that the treatment does not have a negative effect on skid resistance, as this would present an additional risk, particularly for motorcyclists. • There may be maintenance issues associated with this treatment.
Cost		Low to medium (depending on treatments used).
Treatment life		5–20 years (depending on treatments used).

Source: Based on Austroads (2014c).

Table B 26: Vehicle-activated traffic signals – transition zones

Engineering treatment		Vehicle-activated traffic signals – transition zones
Description		Vehicle-activated traffic signals are used on the approach to some small towns in Portugal and Spain on the secondary interurban road network. If motorists exceed the speed limit on approach to the town, the signals turn to red, thereby delaying motorists. It is reported that authorities are 'happy' with the use of this device, but that there are no evaluations as to their effectiveness.
Benefits	Speed reduction	• Unknown.
	Crash reduction	• Unknown.
	Other	
Implementation issues		• If used at isolated locations (e.g. away from intersections or pedestrian crossing points), their credibility might be questioned.
Cost		Medium.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

B.5 Rural Routes and Mid-blocks

Table B 27 to Table B 29 provide information on treatments on rural routes and at mid-blocks.

Table B 27: Speed limits – rural routes and mid-blocks

Engineering treatment		Speed limits – rural routes and mid-blocks
Description		Lower speed limits in rural areas have historically been set in locations where there are increases in roadside development. Recently, trials in Australia and New Zealand have set lower speeds based on risk, including roads with adverse horizontal alignment. There have been mixed results for this treatment.
Benefits	Speed reduction	• 0–4 km/h (individual sites vary to a much greater extent).
	Crash reduction	• Unknown.
	Other	• Raised awareness of a change in road environment.
Implementation issues		• Compliance levels often decrease. • Public consultation and education is typically required. • Higher benefits are possible when coupled with road narrowing.
Cost		Low.
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 28: Road narrowing – rural routes and mid-blocks

Engineering treatment		Road narrowing – rural routes and mid-blocks
Description		This measure involves either physical narrowing of the road by using extended kerbs or raised medians, or narrowing by use of road markings and wide, painted medians. In some overseas cases a low-volume two-lane road is converted to a one-lane road, by removing the centre line and providing broken edge lines.
Benefits	Speed reduction	• Up to 5 km/h.
	Crash reduction	• Unknown.
	Other	• Reduction in vehicles drifting from the lane, resulting in reductions in head-on and run-off-road crashes.
Implementation issues		• Perceptual measures (including painted medians) have the advantage that they typically do not introduce a roadside hazard, whereas physical measures can. • In several cases this treatment has been installed but not evaluated so outcomes may be unreliable. • Higher benefits are possible when coupled with lower speed limits.
Cost		Low to medium (depending on extent).
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Table B 29: Weather-activated signs – rural routes and mid-blocks

Engineering treatment		**Weather-activated signs – rural routes and mid-blocks**
Description		Weather-activated signs include electronic speed limit signs and dynamic message signs to inform the driver of the adverse weather conditions. They also include static signs, warning motorists of potentially adverse conditions, or changes in the speed limit when adverse weather conditions are present such as fog, rain, wind, snow and ice.
Benefits	Speed reduction	• Up to 15 km/h.
	Crash reduction	• Unknown.
	Other	• Less variance in speed. • Greater spacing between vehicles.
Implementation issues		• A power supply or solar panels are required which may increase costs in more remote areas. • Vandalism may be an issue, especially in isolated rural locations. • As the sign presents a hazard to errant vehicles, it should be frangible.
Cost		Low to medium (depending on extent).
Treatment life		5–10 years.

Source: Based on Austroads (2014c).

Appendix C Access and Intersection Density Assessment

The following methodology was applied in Austroads (2014b) to calculate the average number of standard vehicle accesses per 100 metres based on driveways, business access points, minor and major intersections. This method has been applied consistently in VLimits 2.0, QLD-SLR and WALIMITS 3.0.

The total number of accesses is counted on both sides of the road for the full length of the section being reviewed. Crossroads are counted once on each side of the road. Each type of access is weighted as per Table C 1 to convert it to equivalent standard driveways. The total is summed and divided by the road section length in kilometres x 0.1.

Table C 1: Access and intersection weighting

Access category	Weighting
Residences, small commercial establishments, small public buildings and other units that generate light and/or occasional activity.	1
Average commercial establishment, local schools, caravan parks, light industries, public buildings and units generating activity, which is either: • continuously light • moderate at certain times, such as commuting hours • substantial at infrequent intervals.	2
Heavy industry, schools, shopping centres and other units generating continuous moderate activity or substantial activity at certain regular times.	3
Large shopping centres and other units generating substantial and continuous activity. Some large industries, which are tourist attractions or for some other reason generate substantial traffic volumes, would be included in this activity.	4
Unsignalised intersecting roads of substantially lesser importance than the road being assessed, or intersecting roads where side traffic and turning movements have little effect on the traffic flow pattern of the road being considered.	1
Unsignalised intersecting roads of lesser importance than the road being assessed but where the side-road traffic and turning movements are such that the intersection has an appreciable effect on the traffic flow pattern of the road being considered.	2
Unsignalised intersecting roads of comparable or greater significance than the road being assessed. Intersections that have a pronounced effect on the traffic flow pattern of the road being considered.	3
Roundabouts, signalised intersecting roads and any at-grade rail crossings.	3

Source: Austroads (2014b).

Generally, only active access points are included, i.e. those which show signs of current use. Disused or duplicated access points in rural or urban fringe areas should not be included in the calculations. In areas where rapid development is occurring, known access points to the land parcels about to be developed may be included in the calculations.

It should also be noted that:

- Abutting development on service roads is not considered and therefore only the points of access to the through traffic lanes are counted.
- Crossroads are counted only once on each side of the road being assessed
  - stem of a T or Y-intersection – 1 access point
  - cross-intersection – 2 access points
  - any multi-leg intersection – 2 access points.

- Grade-separated intersections may be ignored; however, each ramp on or off the assessed road should be counted.
- If the assessed road section begins or terminates as a stem of a T-intersection, the intersection should not be counted.
- For divided roads, the presence of the median can be ignored while calculating the number of accesses.

Commentary 1

Compilation of Australian and overseas experience (Austroads 2000) has affirmed that increased frequency of access to rural and urban arterials, and other high-speed routes, will inevitably lead to increases in crashes. Table C1 1 provides a summary of the effect on crash rates of different levels of access.

Table C1 1: Compilation of experience – access related to crashes

On rural roads	• As a rule of thumb, there are 10 crashes(1) per 100 mvkm(2) of travel per access point. • Typically, the comparative crash rates for no access control: partial control: high level of control will be roughly in the ratios 100:60:40. That is, there could be two to three times the number of crashes if there is no access control. • On four-lane rural roads, each private access adds 2–3% to the crash rate, and much more at higher degrees of road curvature. • Each commercial access point per kilometre can add 5–10% to the crash rate at low access frequencies (perhaps 10–15 crashes/100 mvkm for each access point). • An access point on a four-lane rural highway can be up to 10 times more hazardous without a median than with one.
On urban arterials	• Allowing direct access and frequent minor junctions can increase the casualty crash rate by 30% on divided roads and 70% on undivided roads. • Each non-commercial access point adds 1–2% to the crash rate on low-access four-lane roads, and 2–3% on two-lane roads. • Going from zero to 10 commercial access points per km on two-lane urban roads can add about 80% to the crash rate. Going from 0 to 20 access points per km can double or treble the rate. • On four-lane roads, each extra commercial access point can add 5–10 crashes/100 mvkm above 10 access points per km. • Urban arterials without medians have a 30–40% higher crash rate than divided sections.

1 *Crashes means all reported crashes, including damage only.*
2 *mvkm denotes million vehicle kilometres.*

Source: Austroads (2000).

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Commentary 2

An integrated approach to planning and arterial road development, including access management, should:

- regulate interruptions to traffic flow to a degree consistent with the transport functions of the road, thus creating safer traffic conditions, smoother traffic flow, and increased capacity
- ensure that appropriate and compatible land uses are located next to traffic routes, and that adequate access is provided for them, to minimise risk and inconvenience to road users and people requiring access to adjacent land
- reduce road user costs, and external costs imposed on the wider community by road use
- facilitate safe pedestrian and bicycle movements to all types of development
- maximise access to road-based public transport
- enhance rather than diminish the amenity of sites adjoining traffic routes.

In broader community planning terms, inadequate attention to access management can lead to a reduction in abutting property values, sub-optimal economic activity and reduction in the viability of private investment in abutting property.

An integrated approach in which access requirements are clearly specified for road types provides benefits to both road agencies and developers as proposals can be efficiently planned and implemented.

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Commentary 3

Access management objectives are concerned with achieving an appropriate balance between the safety and efficiency of the road, and convenient and safe access to abutting property. In this regard, many aspects of road design and road safety relate directly to access management, for example:

- Motorway and expressway interchanges, at-grade intersections and driveways should be designed in accordance with the objectives and principles described in the *Guide to Road Design Part 4: Intersections and Crossings: General* (Austroads 2017g).
- It is important that all driveways to adjacent land
  - can accommodate turning movements by the appropriate design vehicle (e.g. B-doubles, road trains)
  - have culvert end walls and associated open drains that can be safely traversed by vehicles that run off the road (refer to the *AGRD Part 6* (Austroads 2010)).
- Access situations that require detailed traffic investigation and design of access requirements include:
  - location of service centres within or close to motorway and expressway interchanges
  - proposed developments that generate and/or attract significant traffic volumes and are situated adjacent to intersections, and may lead to proposed driveways in close proximity to the intersection
  - major shopping centre developments or extensions that not only affect traffic operations on adjacent roads but may have an impact on arterial roads some distance from the centre.
- There are several specific design techniques that can be utilised locally to assist in the provision of good access management and design along arterial roads. They are generally aimed at minimising and managing the conflict points that exist along a route. Techniques include:
  - Service roads: Where road reservations are wide enough, service roads may be provided on divided roads to consolidate access from abutting properties and minimise interruption to traffic flow. They may also be used on undivided highways approaching rural towns but provision should be made for vehicles turning right into the service roads. Service roads should be divided from the main carriageway.
  - Medians: The provision of raised medians with indented right-turn lanes at key intersections is a most effective way of regulating access and reducing crashes. Raised medians are installed as roads are divided but may also be provided locally to address issues relating to traffic conflict (including pedestrians) and safety.
  - Relatively narrow painted (or flush) medians and two-way right-turn lanes (Australia only, not permitted in New Zealand) have also been used successfully to remove conflicts associated with access (for all vehicle types accessing abutting property) and to improve safety for pedestrians crossing roads.
  - Intersection spacing: Increasing the distance between intersections generally improves traffic flow on major arterial roads, reduces congestion and improves air quality. Where traffic flow requirements are suited, roundabouts may be used at key intersections along a road to provide safe and efficient access.
  - Driveway spacing: Fewer driveways spaced further apart result in more orderly and safer access movements. During the planning process opportunities should be sought to consolidate accesses to properties.
  - Safe turning lanes: Indented left and right-turn lanes improve traffic flow and safety by removing conflict between turning and following vehicles.

The location and design of an access driveway may be dictated by the nature of vehicles accessing abutting land. For example, it may be preferable to locate an access for heavy vehicles at a site rather than have them U-turn or use unsuitable alternative routes through local roads.

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Commentary 4

Urban arterial roads include motorways, expressways, divided roads and undivided roads.

Urban motorways and expressways have access controlled by statutory or planning regulations and, because of the high traffic volume and speed, access is permitted only through interchanges.

Most existing non-motorway and non-expressway urban arterial roads often have direct access from driveways and local roads and hence improved access arrangements that reduce the disruption to traffic flow can only be achieved as abutting land is consolidated and/or redeveloped, or through traffic management techniques (e.g. turn bans). However, a greater degree of access control can be achieved on new divided roads in outer urban areas through the provision of service roads and/or medians, or by arranging subdivision developments to provide internal road systems which avoid direct driveway and local road access to the arterial roads. In such cases direct access between the properties and the arterial road may need to be prohibited by planning regulations and/or by the provision of vegetation or landscaping treatments, or other physical barriers. These treatments may also help in screening the development from the view of drivers and provide scope for the provision of paths. While access may be restricted for motor vehicles it is necessary to provide well located connections between the abutting land and arterial road so that pedestrians and cyclists can conveniently access public transport, the arterial road and associated paths and crossings.

Where new arterial roads are planned in developing urban areas, the provision of full or partial control of access through statutory or planning provisions is desirable. This should include the designation and protection of land for the appropriate forms of intersection treatment including roundabouts and grade separation where appropriate.

As described in Section 2.1.2 of the Guide, the concept of access management categories may be implemented to better manage the progressive development and redevelopment of properties abutting arterial roads. This concept would involve developing several categories relating to various degrees of access control and assigning a category to each road or section of road. The categories would range from full access control (i.e. motorways and expressways), to limited access control to virtually no access control.

Figure C4 1 and Figure C4 2 illustrate practical examples of access management for cases where access is ‘restricted’ and ‘limited’ respectively. The former example is an expressway where access is restricted to signalised intersections whereas the latter allows mid-block access points. These examples relate to access management categories. The spacing of intersections and intersection layouts may vary depending on local requirements.

It is important to note that the examples shown in Figure C4 1 and Figure C4 2 are intended to illustrate only the traffic design features of the access management. They are not intended to suggest any treatment of the right-of-way boundary with respect to planning issues such as pedestrian and bicycle access, orientation of buildings and landscaped areas.

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Figure C4 1: Restricted access to an urban arterial road

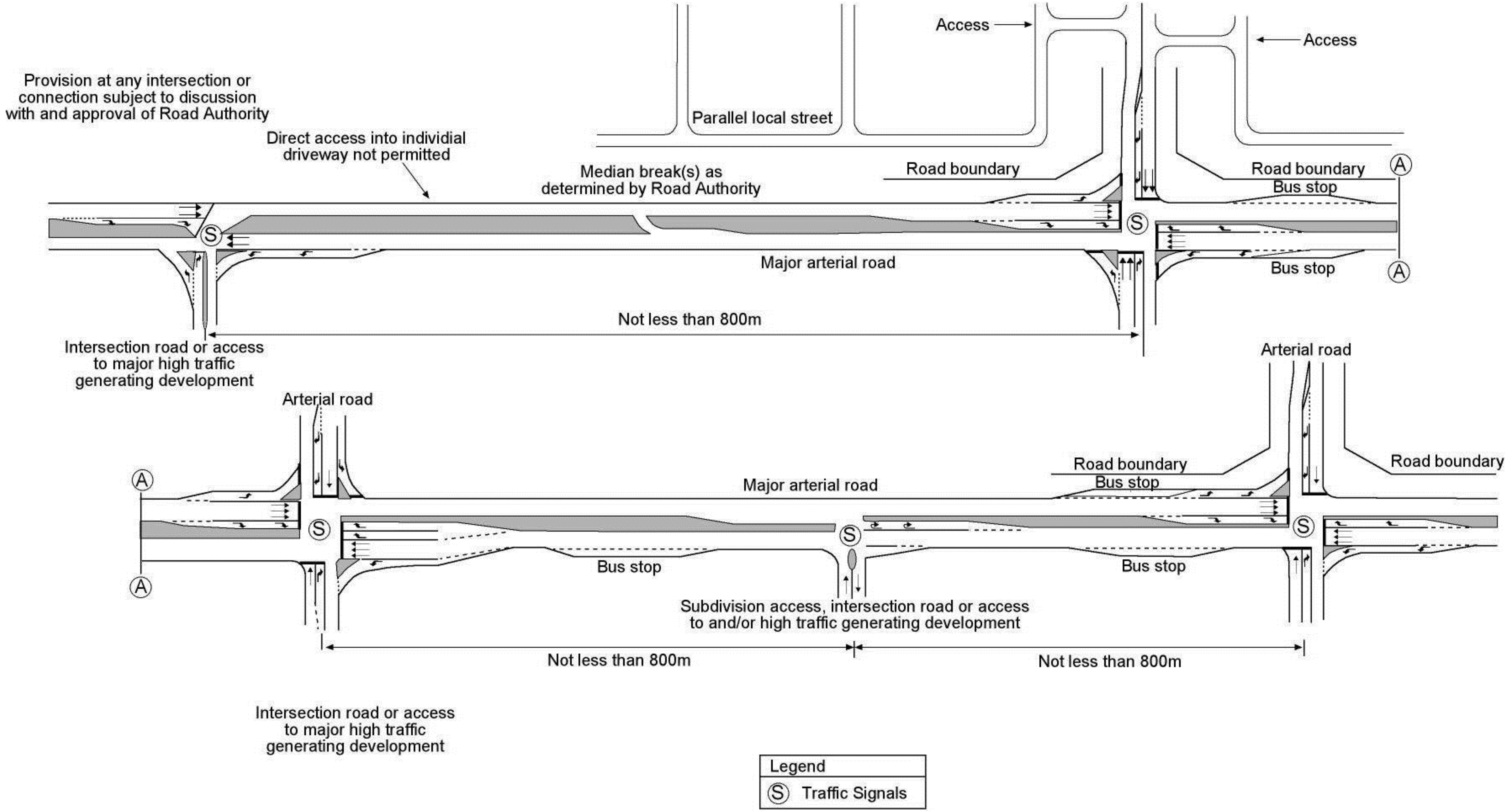
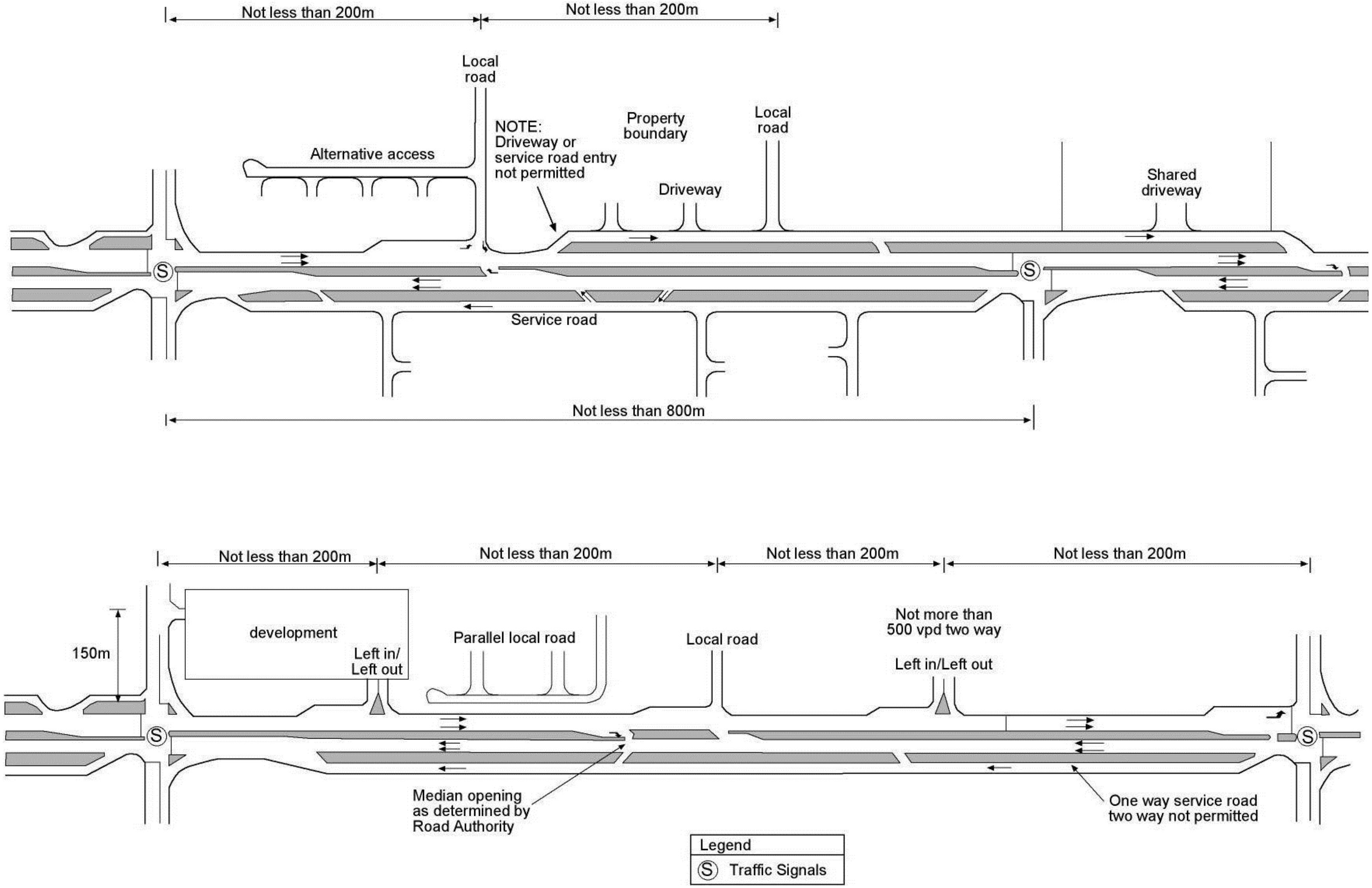


Figure C4 2: Limited access to an urban arterial road



Commentary 5

Roads in rural areas are usually either restricted access roads or roads where general access is permitted with controls applying to the location and design of access points. Restricted access roads are generally of motorway and expressway standard and have no driveway or minor road connections. They may be accessed only through interchanges or, in some cases, at-grade intersections. On other rural roads access to property is provided at infrequent farm driveways or other types of entries, or minor and major at-grade intersections.

Access management is often not an issue on rural arterial roads except:

- at locations where sight distance is limited by the horizontal or vertical geometry of the road or by roadside features
- on the approaches to cities and towns, where ribbon development may extend outwards from the town
- where a large or popular tourist attraction or recreational development is constructed adjacent to the road
- where laden heavy vehicles must enter high-speed traffic on rural highways (e.g. extractive industries)
- within small villages.

Access management strategies for rural and urban arterials must account for the future development of the road (e.g. duplication, conversion to a motorway or expressway) and put in place controls to ensure that future access requirements can be properly managed.

Access to rural motorways and expressways should desirably be provided only at interchanges, however, the need to maintain acceptable access to some properties may require some existing points of access to rural motorways and expressways to remain until alternative access can be arranged. This is particularly relevant to situations where an existing road is converted to motorway or expressway standard, and access to low-volume side roads or driveways needs to remain for a period of time. In some cases access may be permitted to minor roads through the provision of unsignalised at-grade intersections pending the construction of interchanges and frontage roads at some future time.

On specific routes or sections of a route it may be necessary, however, to exercise an intermediate level of control. Typical examples include rural roads on the approaches to towns and cities, and roads that form a short but important link between two population centres. In these cases it may be appropriate to provide service roads or allow access only at a limited number of intersections.

The typical treatment applied at important driveways and intersections on two-lane two-way rural roads is to provide auxiliary lanes for left and right-turning movements, details of which are provided in the *Guide to Road Design Part 4: Intersections and Crossings: General* (Austroads 2017g).

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Commentary 6

The efficient transport of people and goods in cities and across the road network generally is essential if the economic and social needs of society are to be met.

The modes of transport which play important roles in satisfying these needs include heavy vehicles, bicycles, trains, trams, buses, taxis, motorcycles and private motor cars. Most trips also start and finish as pedestrians, and trips that encourage more walking lead to healthier communities.

While the private motor car is the favoured mode (by the community at large) for most trips in cities, there is an increasing realisation in communities that it is not possible or desirable to provide sufficient road space to completely meet the growing demand for travel by private motor car. Consequently, many state and local highway and road agencies are planning and implementing measures which are aimed at achieving an acceptable balance between the transport and communication needs of communities and the need to maintain or enhance the amenity of residential areas, towns and cities.

New roads, particularly motorways and expressways, can form a physical barrier within communities and interfere with social interactions. The same can be true of existing arterial roads that are wide and have a significant volume of traffic that may travel at relatively high speeds. While crossing points are provided where adequate demand exists, the severance can lead to:

- trip diversion and suppression
- poor accessibility
- restricted personal mobility.

These effects can be a substantial disadvantage to pedestrians and cyclists, and indirectly result in psychological, cultural and social severance for some people.

Ultimately it will require the application of an integrated approach to the management of available road space to ensure that the necessary balance of road user and community needs is met. These needs can vary widely and, in some cases, they may be incompatible and unable to share the same road space. This will require careful consideration being given to the appropriateness of selected measures having regard for the allocation of limited space within road reservations for various competing uses.

The selection of the most appropriate traffic management measures will depend on several factors, including the road function, local road environment, adjacent land use activities and the broader land use–transport system considerations to meet the economic and social expectations of road user groups or the local community.

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Commentary 7

Pedestrian fencing might be appropriate in the following circumstances (note that pedestrian fences also provide useful guidance for vision-impaired pedestrians):

- areas of heavily concentrated and vulnerable pedestrian traffic (e.g. near exits from schools or sporting facilities)
- at locations where there has been a history of crashes involving pedestrians crossing at inappropriate locations
- to control pedestrian movements on higher-speed arterial roads with consistent and substantial pedestrian presence, particularly where alignment discontinuities and speed differentials have been noted.

The visibility as well as the physical layout of the fence, are very important and should be major factors in deciding whether pedestrian fences should be installed.

Attention should be given to the height and placement of the fence, and to the material used in its construction, to minimise the potential sight obstruction between drivers and pedestrians about to cross the road. Improper installation or rehabilitation of pedestrian fences can effectively negate any potential increase in pedestrian protection and can also increase the severity of vehicle accidents.

Fencing with rigid horizontal railing, installed near roads, can be a hazard to occupants of errant vehicles. The horizontal rails can easily become detached and spear into the driving compartment.

As fencing can potentially be a roadside hazard to errant vehicles and can also impact the streetscape and amenity, it is recommended that alternative measures be considered to reduce the risk to pedestrians prior to erecting fencing. Such measures may include, but are not limited to:

- speed limit reduction
- traffic calming
- relocation of a pedestrian crossing to better fit pedestrian desire lines

- installation of a new pedestrian crossing at a desired location
- installation of kerb upstands/separators (where turning movements by large vehicles take them close to the footpath)
- installation of bollards
- footpath improvements and widening.

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Commentary 8

An overtaking lane may be defined as any form of lane added in one or both directions of travel to increase overtaking opportunities. They may be located in level or rolling terrain or on sustained grades, and an overtaking lane is defined to include climbing or descending lanes on grades, and short four-lane road sections up to about 5 km in length. The provision of overtaking lanes may be justified on operational or safety grounds.

US studies have reported statistically significant crash reductions of 25% over the length of the added lane, for overtaking lane sections in level and rolling terrain (Harwood & Hoban 1987). No crash problems were found for turning movements, taper areas, or permitting overtaking in the opposing direction where adequate sight distance was available.

It is usual to adopt a strategic approach to the provision of overtaking lanes throughout the whole length of a highway, using computer analysis packages, such as the Traffic and Rural Roads (TRARR) model (developed by ARRB Group) to determine the most effective number and length of overtaking lanes and their general location. Alternatively, simplified mathematical models, graphical methods or tabular frameworks can be applied.

Guidance on the design and evaluation of overtaking lanes is given in the *AGRD Part 3* (Austroads 2016a).

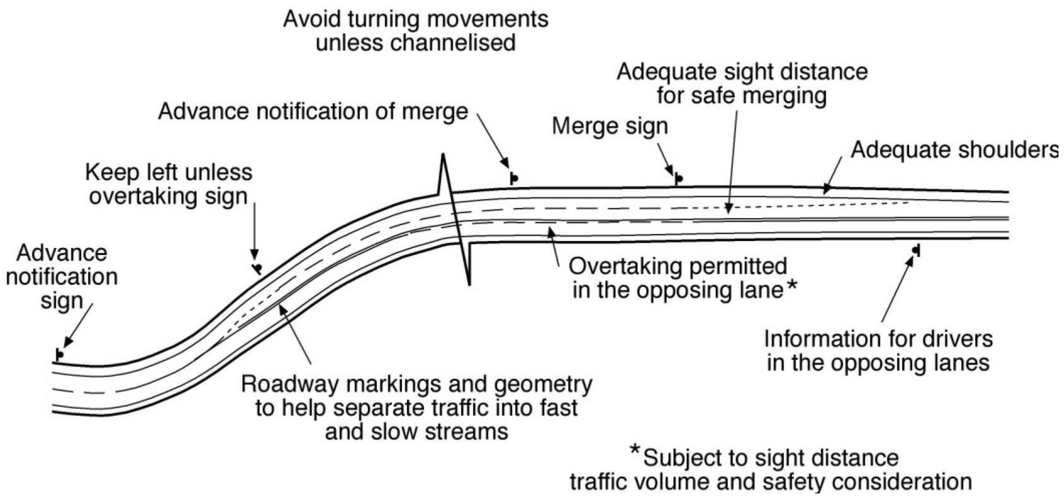
The following points should also be considered:

- It is generally more cost-effective to provide several short overtaking lanes at regular spacing rather than a few long ones which exceed the recommended lengths.
- Sight distance is important at both merge and diverge tapers. At the merge, a lack of clear visibility of the actual merge point can lead to conflicting behaviour, with slow vehicles merging too soon and faster vehicles attempting one more pass. Adequate visibility reduces driver uncertainty and maximises use of the available overtaking lane. At the diverge, good visibility provides an opportunity for the following drivers to move up and prepare to overtake as soon as the added lane is available, again maximising the use of the extra lane.
- Location is often chosen to minimise construction costs, while avoiding intersections and busy roadsides and to provide adequate sight distance at each end. A further consideration is that locations should appear logical to the driver. In some cases, an overtaking lane on a long straight can encourage slower drivers to speed up, thus reducing its effectiveness. At the other extreme, low-speed curves (below the standard of adjacent road sections) are not suitable for overtaking, and should be avoided. Overtaking lanes should also not be located immediately upstream of low-speed curves. The choice between a location on a grade and a level location will depend on the severity of the grade, relative construction costs, and whether the overtaking problem is localised or continuous over a long road section. Also, environmental constraints (e.g. inability to remove trees) may influence the location of overtaking lanes.
- It is important to have a strategy for the staged introduction of overtaking lanes along important rural arterial roads. The objective may be to provide overtaking opportunities every 5 km in the long term. In the first instance, a spacing of 10, 15 or 20 km (Austroads 2016a) may be appropriate, depending on existing overtaking opportunities and other factors. As traffic grows, intermediate overtaking lanes can be provided between the initial installations until the objective of a 5 km spacing is realised.

- The minimum lengths indicated in Austroads (2016a) provide for the majority of movements as single overtakings, but may not allow many multiple overtakings, or overtakings between vehicles with only a small difference in speed. Minimum lengths are generally only appropriate for lower operating speeds or constrained situations.
- Overtaking lanes may be extended up to the normal maximum length to allow start and termination points to fit in with the terrain. However, since bunches of vehicles generally break up in the first section of the overtaking lane, the additional length is not as well utilised.
- The sight distance to the termination of the overtaking lane is based on the distance for the vehicle in the fast lane to complete or abandon the overtaking manoeuvre. Terminations should not be located on left-hand curves.
- Judgement needs to be exercised in relation to the definition of 'slow vehicles'. While in practice all heavy vehicles, buses and cars towing trailers may be classed as slow vehicles, this may not represent the true situation in every case. For example, on level road sections some heavy vehicles and buses can travel as fast as many cars, while on particularly scenic routes some car drivers may choose to travel slowly and may need to be counted as slow vehicles.
- If conditions allow, series of overtaking lanes should be generally of the same length.

Figure C8 1 illustrates good practice to manage traffic at overtaking lanes.

Figure C8 1: Overtaking lane design practice



Note: Signs and dashed line at merge area not used in New Zealand.

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Commentary 9

A clearway is a length of road defined by signs at each end and along which the standing of vehicles is prohibited by control signs and no-stopping signs, the latter generally near intersections.

The standard signing arrangements to be adopted for clearways is provided in AS 1742.11-2016 *Parking Controls* or NZ Transport Agency (2008a). Generally, clearways and parking restrictions operate during the peak traffic hours for a direction, to provide an increase in the peak direction capacity. In New Zealand, special vehicle lanes are effectively clearways and do not require additional signing.

The times of operation of clearway restrictions should be uniform over as large an area as possible, but should also take account of the fact that sometimes the time of the peak period moves progressively with the traffic towards or away from the centre of a large city. The duration of the clearway restrictions should not be less than one hour. Usually the duration is two to four hours, but on primary arterials there may be a need to implement clearways over extended periods up to 24 hours along critical routes.

On critical routes through inner city areas, where parking infringements can have an extremely adverse effect on traffic flow and capacity, the clearway signs may be supplemented with tow-away signs that enable offending vehicles to be removed from the roadway.

Where a full clearway is not warranted, owing to the short length over which the need applies, restrictions may be imposed on parking or stopping of vehicles to maximise the through-traffic capacity. This is typically applied on many arterial roads near important intersections and through-road shopping areas during peak periods.

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Commentary 10

The turning envelope of a long wheelbase bus (e.g. a tag-axle coach) can be extremely large and care should be taken to ensure the swept path does not encroach on pedestrian areas and cycle paths. The types of LATM devices that can affect the operation of buses are:

- Bus boarders: Kerbside parking (often illegal) causes consistent problems for bus operation and can lead to significant cumulative delays, especially in busy central business districts and suburban town strips. A device for alleviating this problem is the construction of a bus 'boarder' or 'reverse embayment' where the kerb is built out into the roadway. General traffic is required to stop behind a bus that is loading/unloading passengers.
- Bus stop relocation: Locating new bus stops adjacent to traffic calming devices, and at sites immediately before intersections, especially in conjunction with selective vehicle detection priority measures, can assist in minimising delays for buses.
- Road humps: Road humps have a detrimental effect on bus passenger comfort. Overuse of road humps on a route will impact on route times and discourage public transport use.
- Speed cushions: Speed cushions can permit buses to straddle the cushion and maintain reasonable speeds while causing cars to slow. Parking should be prohibited near a speed cushion so that buses can position themselves correctly when straddling.
- Slow points: A series of slow or pinch points can cause significant delays for buses. Where used, slow points should be coordinated with bus stops to minimise delays. To maintain both passenger and bus safety, it is recommended that the following design of slow points should not be used on roads with bus routes:
  - one-lane, two-way slow points (parallel or angled)
  - one-lane, angled and double-angled slow points.
- two-lane, parallel, and angled slow points are the preferred forms of slow points for use on roads with bus routes. The following minimum widths are recommended for buses:
- parallel slow point – minimum road width 7 m
- angled slow point – minimum of 5 m per traffic lane – not preferred on bus routes.
- T-intersection deviation*:* The design at T-intersections should allow for bus turning movements. Recommended widths are discussed in the *AGTM Part 8* (Austroads 2016c) and the *AGRD Part 3* (Austroads 2016a).
- Splitter islands at intersections: Designs should allow for bus turning movements. A frequent problem on bus routes is the failure to provide adequate clearance and road space for buses to complete their turns. This is particularly problematic for buses entering a road with a splitter island for left or right-turns. It is essential that the bus overhang be confined to the roadway and be clear of the kerb and splitter island.

Recommended road and lane widths are discussed in Austroads (2016c) and Austroads (2016a).

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Commentary 11

Exclusive bicycle lanes are often used to provide a safe environment for cyclists, a satisfactory level of service, and positive connectivity of a cycling route. The provision of a painted line between the motor vehicle lane and the bicycle lane together with bicycle logos at frequent intervals has several advantages as it:

- clearly defines the road space provided for use by each mode
- results in motor vehicles generally not blocking the progress of cyclists where traffic queues exist
- provides lateral separation and improved safety when motor vehicles in the adjacent lane are moving
- creates an awareness in the minds of motorists that a cyclist may be present (at times when few cyclists are using the lane).

A sealed shoulder with a continuous edge line and bicycle pavement markings, where shoulders are already present on a carriageway, can have the same effect as an exclusive bicycle lane without legally requiring the cyclist to travel in the sealed shoulder. Parking regulations need to be applied separately if parking is an issue, unlike exclusive bicycle lanes which create parking and stopping restrictions.

The ability of cyclists to move freely and safely along arterial roads in cities and towns is a key factor in promoting cycling in general and commuting by bicycle. Like motorists, commuter cyclists desire to travel safely, quickly and conveniently to and from their work places. Provision of additional space in a wide kerbside lane, while appreciated by cyclists, can lead to increased conflict and impedance of cyclists. Well delineated exclusive bicycle lanes largely address these potential issues.

The provision of bicycle lanes also leads to cyclists generally travelling in a single file and legitimises the presence of cyclists on the road (in the minds of motorists) which should lead to greater acceptance.

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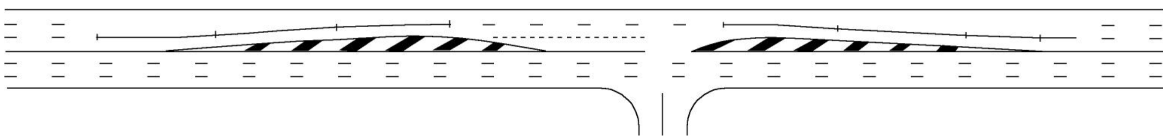
Commentary 12

An S-lane (Figure C12 1) is an indented right-turn lane created by terminating the kerbside lane of a three-lane one-way road to create the space to deviate the other two lanes to the left, leaving space for an indented turn bay. It is accompanied by a full-time no-stopping restriction along the adjacent kerb. It may be implemented where there is insufficient space in the median to accommodate a turn bay, and where narrowing the through lanes to create space for a turn bay is not feasible.

Figure C12 1: Example of an S-lane



Advantages of S-lanes include:

- Capacity increase. Where the kerbside lane along the road in question is used for parking, two lanes of capacity are maintained past an intersection where otherwise traffic waiting to turn right would block the median-side lane, parking would take up the kerbside lane, and at times only a single lane would remain available for through traffic. Consistent availability of two through lanes is achieved.
- Reduced delays. New South Wales experience shows that substantial performance improvement in terms of reduced delay can be achieved when six-lane arterial roads without indented turn bays are systematically treated to either restrict the turn (by turn prohibition or median gap closure) or to provide an S-lane at minor junctions.
- Modest reductions in crash rates occur through reduced exposure of right-turning vehicles to rear-end collisions by through traffic.

Disadvantages of S-lanes include:

- Loss of kerbside parking space. This can be a particularly contentious issue in strip shopping centres.
- Forced merge of the kerbside lane and the adjacent (centre) lane on approach to the intersection in cases where the kerbside lane is a clearway in peak traffic periods. In practice the delays caused by this merge are less than the delays that would otherwise occur behind right-turning vehicles in the median-side lane.

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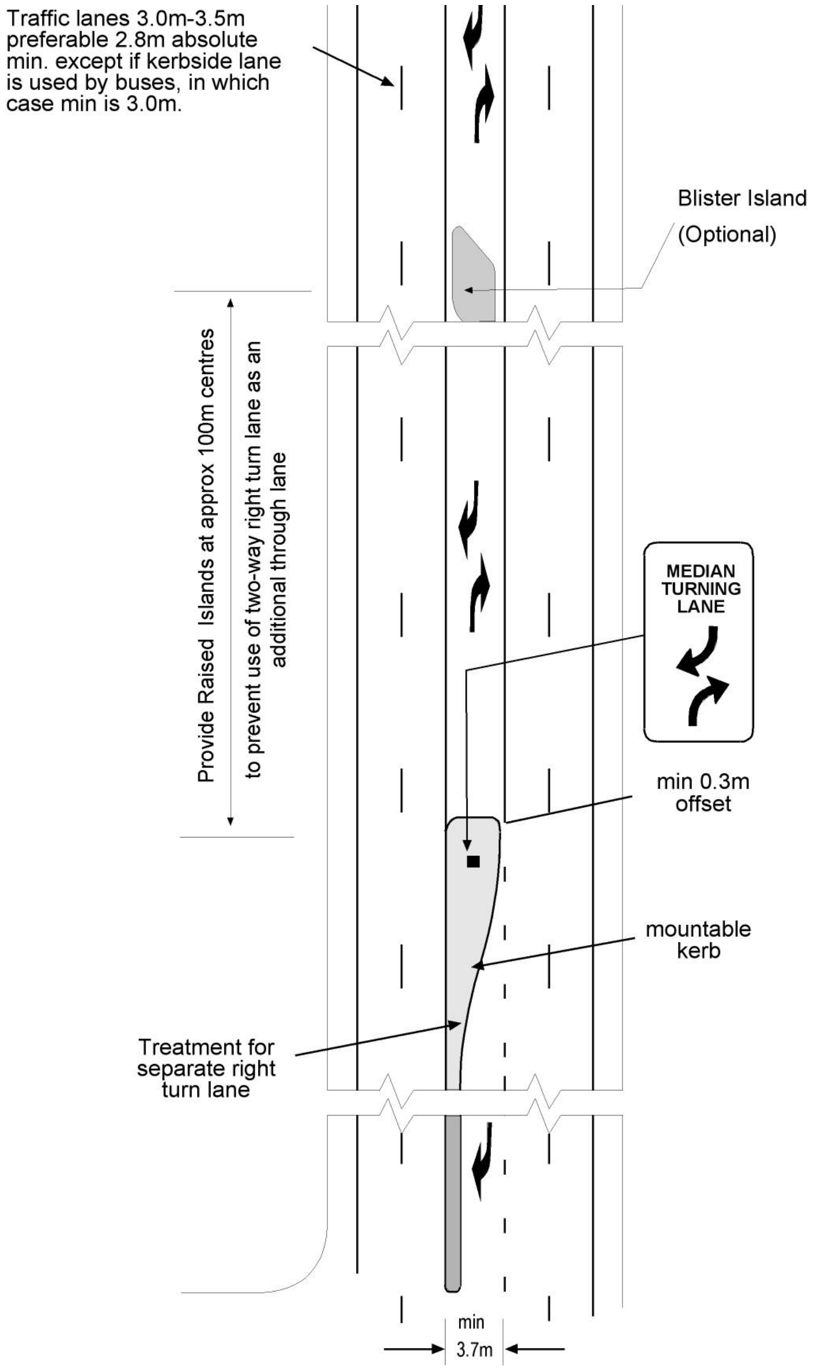
Commentary 13

A two-way right-turn lane is illustrated in Figure C13 1. It should be noted that the treatment is not permitted in New Zealand, however, a flush median may serve a similar purpose.

Figure C13 1: Two-way right-turn lane



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Commentary 14

Possible exceptions to the statement that most lane management actions on urban local roads are intersection-related include the following:

- the provision of mid-block slow points and other LATM devices that, through their channelisation, force vehicles to follow a travel path
- the marking of narrow lanes in existing undivided roads that are about 13 m wide, perhaps in conjunction with parking lanes, bicycle lanes or medians, to create a perception of a narrower road with the objective of reducing speed
- a narrower lane on multi-lane dual-carriageways has the effect of vehicles offsetting one another rather than driving immediately adjacent to each other, which can help reduce side swipes
- the provision of kerbside parking that is restricted to the use of the occupiers of adjacent properties holding appropriate permits
- the provision of on-road heavy vehicle parking or turning space in local roads that serve industrial activities.

Generally, however, the issues involved in such activities are much broader than those confined to the definition of lane management.

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Commentary 15

Sydney's Warringah Freeway is one example of a reversible road providing tidal flow. The section approaching the Sydney Harbour Bridge from the north was designed with four roadways with tidal flow in mind. In the morning peak period three of the roadways serve the peak direction, two of them feeding the Sydney Harbour Bridge (itself operating a tidal flow arrangement), and one feeding the Sydney Harbour Tunnel. In off-peak and afternoon peak periods two of the roadways serve each direction of travel. Tidal flow arrangements are also introduced at other times to meet unusual demands generated by major events or by incidents closing one or more lanes on the Harbour Bridge.

Auckland's Harbour Bridge is another example of tidal flow. The bridge was opened in 1959, with the world's first moveable barrier system installed in 1990. The original machines could move the barriers in 40 minutes, with new machines cutting down that time to 20 minutes. In morning peaks, the barrier is moved from the central position into a 5/3 configuration (five lanes southbound and three lanes northbound), while in the evening peak, the configuration is 3/5 with three lanes southbound and five lanes northbound. Outside of the peaks, there are four lanes in either direction.

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Commentary 16

The primary reason for managing vehicle speeds in an area or on a route is because of the risk and costs drivers can impose on themselves and others by selecting inappropriate travel speeds. This could be due to:

- higher tolerance to risk
- not taking sufficient account of the effects of their choices on other road users
- underestimating the effects of speed on crash probability and severity
- the inability of some drivers to correctly judge the capability of their vehicles or to anticipate road geometry and roadside conditions
- misinterpreting or receiving inappropriate signals from the road and road environment.

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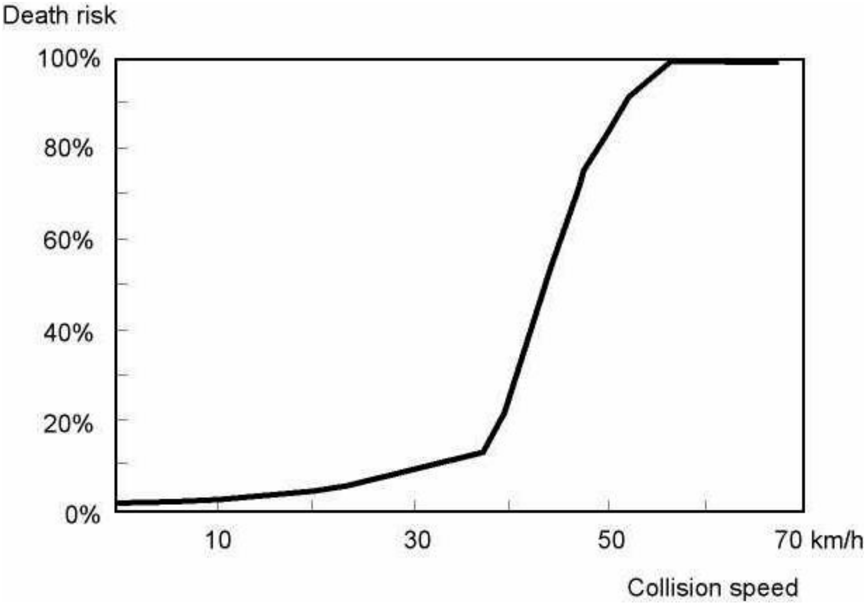
Commentary 17

Studies have indicated that there are strong grounds for containing vehicle speeds to at least the posted speed limit because of the high crash rates at speeds up to 15 km/h above this (refer to the *AGRS Part 3* (Austroads 2008b)).

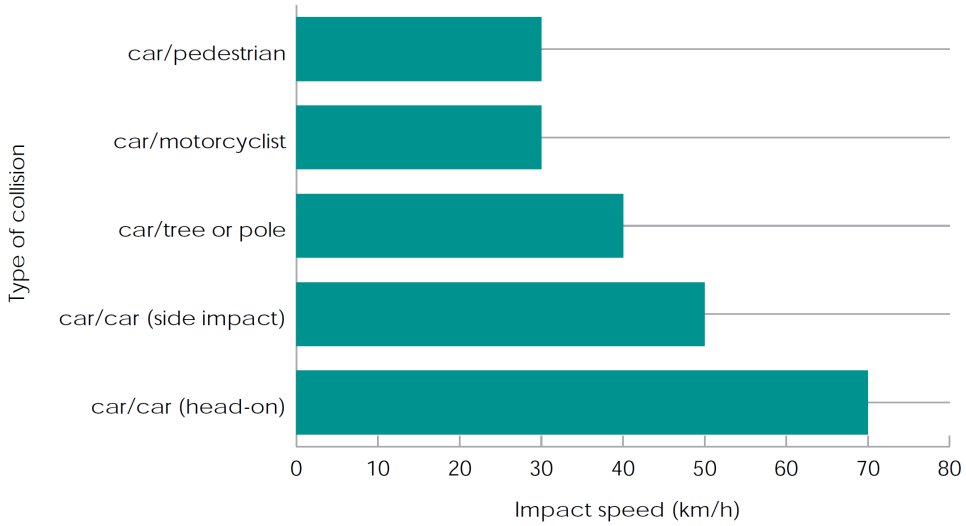
It is generally accepted that the risk of death to pedestrians struck at an impact speed of 40 km/h is about 20% and rises very steeply to 100% at about 55 km/h (Figure C17 1). Survivable impact speeds for different crash scenarios are shown in Figure C17 2. Studies have confirmed the value of reduced speed limits for pedestrian safety in areas of high pedestrian activity and good management of operating speeds in other areas (refer to McLean et al. (1996) and the *AGRS Part 3* (Austroads 2008b)).

Figure C17 1: Relationship between collision speed and probability of death for pedestrians



Source: Corben and Duarte (2000).

Figure C17 2: Survivable impact speeds for different crash scenarios



Source: Australian Transport Council (2011).

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Commentary 18

The following information on in-vehicle treatments is sourced from Appendix B.2 of *Achieving Safe System Speeds on Urban Arterial Roads: Compendium of Good Practice* (Austroads 2016e).

C18.1 Intelligent Speed Adaption

Intelligent speed adaption (ISA) refers to advanced technology which assists drivers in being aware of, and adhering to, the posted speed limits, i.e. the infrastructure provided is supplemented and ultimately becomes more effective. The most widely applied ISA system uses the global position systems (GPS) or satellite navigation technology to compare the local speed limits to the vehicle's travelling speeds, alerting the driver (visual or audible alert) if the speed limit is exceeded. ISA is now included in the European New Car Assessment Program (Euro NCAP) Safety Assist Assessment Protocol (Euro NCAP 2013).

ISA interface types include:

- advisory systems – audio or visual information about the prevailing speed limits
- supportive systems – provide information on prevailing speed limits and warn the driver when the speed limit has been exceeded
- limiting systems – interact with the vehicles (e.g. there is resistance on the accelerator pedal when the driver attempts to exceed the speed limit).

Figure C18 1 summarises the types of ISA and feedback methods.

Figure C18 1: ISA types

Level of support	Type of feedback	Feedback
Advisory – informing	Mostly visual	The speed limit is displayed and the driver is reminded of changes in the speed limit.
Advisory and supportive – warning (voluntary)	Visual/auditory	The system warns the driver when they exceed the posted speed limit at a given location. The driver decides whether to use or ignore this information and to adjust the speed.
Supportive – intervening (voluntary)	Haptic throttle (moderate/low force feedback)	The driver gets a force feedback through the accelerator if they try to exceed the speed limit. If applying sufficient force, it is possible to drive faster than the limit.
Limiting system – automatic control i.e. speed limiter (mandatory)	Haptic throttle (strong force feedback) and dead throttle	The maximum speed of the vehicle is automatically limited to the speed limit in force. Driver's request for speeds beyond the speed limit is simply ignored.

Source: SWOV (2010).

ISA can be implemented as a voluntary or mandatory system. Voluntary ISA compares the travelling speed with the posted speed limit but allows the driver to override the system. Mandatory ISA, on the other hand, exerts full control on the vehicle's speed (Carsten et al. 2006).

In a review of various studies, SWOV (2010) found that the general trend is for ISA to lead to reductions in mean speed, speed variability and speed violations.

The first Australian trial of ISA was conducted as part of the TAC SafeCar Project (Mitsopoulos et al. 2004). Fifteen vehicles in Melbourne were equipped with an advisory ISA system (visual and auditory signals) which became a supportive ISA system (upward accelerator pressure), if warning signals were ignored for more than two seconds. The vehicles were equipped with a following distance warning (FDW) system (to prevent tailgating), a seatbelt reminder, a reverse collision warning system (to prevent collisions while driving backwards), and daytime running lights. A control group consisted of eight drivers, with control vehicles not equipped with ISA or FDW. All 23 drivers travelled at least 16 500 km. The ISA system reduced mean, maximum and 85th percentile speed, and speed variability, in all speed zones. ISA + FDW tended to have better results than ISA used in isolation. ISA + FDW and isolated ISA reduced the percentage of time driven above the speed limit, while not increasing travel times. FDW alone did not significantly affect speed.

ISA fitted to truck fleets in Australia operating on certain routes or in industrial sites was evaluated by Crackel and Toster (2007). A later study by Crackel (2009) was positive about the technology.

More contemporary, larger-scale studies of ISA have since been undertaken in NSW (NSW Centre for Road Safety 2010; Wall et al. 2008, 2010, 2011). It has been found that drivers break the speed limit less often when ISA is activated/installed, but that the effects are not totally permanent if returning to a vehicle not fitted with ISA. Some ISA systems can also be switched off during the driving task and in some cases drivers can increase speed on roads where speed limit data is not available. Notwithstanding, it has been estimated that the use of ISA would have resulted in an 8.4% reduction in fatalities and a 5.9% reduction in injuries in the test area. ISA systems require accurate, up-to-date maps and speed limit data.

In 2014, following the trials, Transport for New South Wales released the Speed Advisor smartphone application which provides free access to accurate speed zone information across the NSW road network. Monash University Accident Research Centre (Young et al. 2013) found that speed alerting ISA devices led to reductions in mean and 85th percentile speeds. There were further reductions in time spent exceeding the speed and returning to the speed limit.

Potential overconfidence (in relying completely on the speed limit indicated by the system without observing real-time traffic circumstances) has been suggested as an issue by Morsink et al. (2007). ISA in its current format does not typically alert motorists to other risks that may require a reduction in speed (for example, a severe curve in the road). As a result, it would be of benefit to examine a variant of ISA that included other risk-based information, including advisory speeds.

C18.2 In-vehicle Warning Systems

Over recent years, several car manufacturers have been fitting crash avoidance and speed management technologies. New technologies are developed every year so only the most common and promising treatments are summarised. Robust information is not yet available on the safety benefits of these systems.

Forward collision avoidance systems provide alerts to the driver if sensors detect that the vehicle is getting too close to the vehicle in front. Advance systems also include autonomous braking and severity reducing features such as tightening seatbelts or adjusting head restraints.

Adaptive cruise control means that the car automatically slows and speeds up depending on the distance to the vehicle in front. Should the vehicle need to slow down considerably, the system will either disengage or continue to slow the vehicle to a complete stop.

Several in-vehicle safety systems utilise GPS technology through devices in the vehicle or with smartphones. This includes curve speed warnings, which involves matching vehicle location and speed to digital maps. If the calculations determine that the speed is unsafe for an approaching curve then a warning is issued to the driver. The same GPS technology can be applied to warn drivers of upcoming black spots, school zones, traffic incidents, roadworks and the location of speed and red-light cameras. These features are also being integrated into some ISA systems, as outlined in Commentary C18.1.

There are several other in-vehicle safety features that do not have a direct impact on vehicle speeds but may help to reduce the number or severity of crashes. These include lane departure warnings, adaptive headlights, side view assist, electronic stability control, emergency brake assist, anti-lock brakes and more.

In-vehicle technologies are emerging such as Cooperative Intelligent Transport Systems (Cooperative ITS) (discussed in the *Cooperative ITS Strategic Plan* (Austroads 2012b)) and automated driving technologies.

Cooperative ITS is being established to enable vehicles to communicate with other vehicles, roadside infrastructure and centres in a standardised manner using a variety of communication media (refer to the *Concept of Operations for C-ITS Core Functions* (Austroads 2015e).

Automated driving technologies in vehicles are also emerging where the technology will take over some or all of the driving task depending on the level. A summary of automated driving levels as specified by the SAE J3016_201609 standard is outlined in Table C18 1.

Table C18 1: Automated driving levels

Level	Feature	Status
0	**No driving automation** All driving tasks are undertaken manually	Currently available with many vehicles being sold meeting SAE level 1. Example technologies include: • lane change assist • park distance control • lane departure warning • front collision warning
1	**Driver assistance** The majority of the driving tasks are manual but some tasks are assisted (e.g. steering, braking)	Currently available with some vehicles being sold meeting SAE level 1. Example technologies include: • adaptive cruise control • park assist (driver controls the brake and accelerator) • adaptive cruise control including stop and go • lane keeping assist
2	**Partial driving automation** Some tasks are automated but hands must remain on the steering wheel	Emerging technology with a few vehicles being sold meeting SAE level 2. Example technologies include: • traffic jam assist • park assistance (driver can be outside the vehicle)
3	**Conditional driving automation** All aspects of driving are automated but the human driver must be ready to take back control when prompted	Technologies to potentially emerge in the near future (e.g. to 2020) with example technologies including: • traffic jam chauffeur • highway chauffeur
4	**High driving automation** All aspects of driving are automated with the driver being able to take back control if needed	Technologies to potentially emerge in the medium future (e.g. to 2025) with example technologies including: • parking garage pilot • highway urban pilot • urban and suburban pilot
5	**Full driving automation** No human interaction required	Technologies to potentially emerge in the distant future (e.g. to 2030) with example technologies including: • fully automated pilot vehicle

Source: Based on Ertrac (2015).

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Commentary 19

The default rural speed limit in Austroads jurisdictions is 100 km/h except Western Australia and the Northern Territory, where it is 110 km/h.

The default urban speed limit is 50 km/h except in the Northern Territory, where it is 60 km/h. Definitions of a built-up area usually are based on either existence of road lighting or a specified minimum density of roadside urban development, or both. In the Northern Territory the limit is applied to municipal local government areas.

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A speed zone is typically used to vary the speed limit where roadside development is such that the default limit is not appropriate for the prevailing road and traffic conditions. Determination of the speed limit should be based on engineering studies and may be higher or lower than any default limit imposed in the surrounding area.

The benefits in varying the speed limit include:

- encourages more uniform and better driving habits
- improves safety by lessening differential speeds, thereby reducing overtaking manoeuvres
- is better observed and more easily enforced.

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Austroads' 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 5: Road Management is concerned with traffic management on sections of road between major intersections. It presents detailed information and guidelines relating to the factors that need to be considered in applying traffic management techniques and treatments to road types that include, freeways/motorways/expressways, urban arterial and local roads, and rural highways and local roads. It considers the needs of all road users including pedestrians, cyclists, motorcyclists, heavy vehicles and public transport. Part 5 provides the guidance under the four key areas of access management, road space allocation, lane management and speed limits.

Guide to Traffic Management Part 5

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