Guide to Traffic Management Part 10
Transport Control – Types of Devices

Austroads

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Austroads

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Guide to Traffic Management Part 10: Transport Control – Types of Devices

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Abstract

The 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, town planning and road safety.

Part 10: Transport Control – Types of Devices is concerned with the tools that are required for traffic management and traffic control within a network. It covers the various control devices used to regulate and guide traffic, including signs, traffic signals, pavement markings, delineators, and traffic islands. Other devices and technologies that convey information and guidance to road users while they are active in traffic are also included.

Part 10 provides guidance on the design and use of particular traffic control devices that are applied to achieve or implement traffic management and control measures. It provides advice on the functions, suitability and correct use of devices to create a more efficient and safer road traffic environment for all users in permanent or temporary situations.

Keywords

Traffic control, traffic control devices, traffic management, traffic sign, traffic signal, signal timing, pavement marking, rumble strip, variable message sign, delineation, marker post, traffic island, local area traffic management, construction site

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Edition 3.0 of the Guide has been updated with a new name and introduction to better reflect the content. Additional changes include:

- Section 2 was added using existing content to provide definitions and functions of traffic control devices.
- Section 3 was added using existing content to provide standards and road rules relating to transport control devices.
- Tram lane and tramway line markings were added into Section 8.3.8.

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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:

- Transport for NSW
- Department of Transport 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
- Department of Infrastructure, Transport, Regional Development and Communications
- Australian Local Government Association
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1. Introduction

1.1 Purpose

The purpose of the *Austroads Guide to Traffic Management Part 10 (Transport Control – Types of Devices)* is to provide guidance on the types of transport control devices (signals, signs, pavement markings and islands) available for the operational management of roads. This part is focussed on devices as opposed to the operation of transport control devices which is covered in Part 9.

Part 10 covers the devices that are suitable for use under different road corridor conditions to create a safer road environment for all users in temporary or permanent situations. Part 10 aims to provide a means to ensure uniformity in transport control and management, as it is essential that the devices allow road corridor users to react at different locations in a timely and similar manner.

The aim of this Guide is to encourage harmonisation of practice throughout Australia and New Zealand.

1.2 Intended User

The intended users of Part 10 are those who are responsible for, or interested in the principles behind, the day-to-day management of roads and need an understanding of the transport control devices (signs, pavement markings and islands) that may be used in the management of road corridors.

The devices used will depend on the transport management objectives for the area and will usually require a range of devices including signals, signs, road markings and traffic islands. This part describes the control and communication devices, their functions and suitability as well as their applications in achieving the desired outcomes for transport management.

1.3 How to Use

This part provides an overview of the types of devices used in transport control. They will get an appreciation of the types of devices needed to operate road corridors to achieve movement and place and network operation objectives. These objectives are outlined in Part 4.

This part should not be read in isolation with respect to understanding the full life cycle of implementing transport engineering treatments. Readers should understand the scope of this part and what is out of scope and when to refer to other parts of the Guide (refer to Table 1.1), other Guides, and documents external to Austroads. At the very least, before reading this part readers should access Part 1 to get an understanding of the *Guide to Traffic Management* and the context in which the guidance is provided.

The series provides guidance for good practice. Practices that differ from the Guide should be based on sound engineering judgement and be approved by the relevant road agency.

Within this part some key terms are used. Outlined below are the terms along with an explanation on the context that they should be view in:

- Road: Road refers to the road corridor. That is, the space between property boundaries located either side of the road and includes footpaths. This part provides guidance on the management of all travel modes permitted to travel within the road corridor.
- Traffic: While the term 'traffic' may be closely identified with vehicle traffic, it can also refer to any mode of traffic that may be used within the road corridor. This includes vehicle, freight, pedestrian, bicycle, bus and tram traffic etc. Therefore, traffic has the same meaning as transport in the context of this part. Where traffic is mentioned on its own and without identification of its type, it should be viewed as capturing all modes. Where it is specifically identified (e.g. bicycle traffic) it should be viewed in this form.
- Transport: Transport has the same meaning as traffic as it refers to any mode of transport that may be used within the road corridor. This includes general vehicles, freight, pedestrians, bicycles, buses and trams etc.

1.4 Scope

The *Austroads Guide to Traffic Management* series comprises 13 parts as outlined in Table 1.1. Part 10 is an 'operational road corridor management' document and provides an outline of the devices available to road agencies to manage the road corridor. This is done through providing an overview of:

- principles and application of transport control devices
- signage and marking schemes needed to manage the road corridor network in a holistic way
- types of signs (both static and electronic) available and guidance on their use and management
- electronic signs and guidance on their use and management but not going into the operation of the variable message signs (VMS)
- types of pavement markings and guidance on their use and management
- use of guide posts and delineators
- traffic signals and guidance on their use and management but not going into the operation of the signals
- traffic islands and guidance on their use and management
- current and emerging devices that utilise direct communication with equipped vehicles and may be used for transport control purposes.

Part 10 should be read in conjunction with the Australian and New Zealand standards and the respective road rules. The standards specify essential requirements for the design, installation and practical application of the devices.

Part 10 is restricted to addressing the devices (signs and markings) that are required for transport management and control within a network. It provides guidance on the design and use of the devices that are applied and as described in Part 4, Part 5, Part 6 and Part 9 and outlined in Table 1.1.

When applying the guidance, practitioners should also consider emerging technologies and how these may impact on transport control devices in the future. For example, traffic controllers may be integrated with Bluetooth readers and other broadcast technologies, and VMS may be integrated with connected technologies to broadcast messages to the vehicle. While it may be difficult to predict how prolific these technologies will be in the future, it is considered important that agencies plan for them now and implement technology that is potentially expandable in the future and can be retrofitted with technologies as they emerge.

In addition, the *National ITS Architecture* (Austroads 2014e and 2014f) will increasingly provide guidance on the development and deployment of interoperable ITS solutions, particularly information flows between field devices (infrastructure), management centres and Cooperative Intelligent Transport System (C-ITS) technologies.

In the context of other Guides (i.e. *Guide to Road Design* and *Guide to Road Safety*), this part is restricted to transport management advice, and refers only briefly to issues more appropriately addressed in the other Guides. It is difficult to discuss many aspects of transport management without reference to road corridor design and/or safety issues, and in this part any such reference is brief and is supported by the *Guide to Road Design* and the *Guide to Road Safety*. Road corridor safety is treated as an overarching value in this part and should be considered at every step with respect to transport management. In addition, parts of this Guide may refer to the Australian Standard AS 1742 *Manual of Uniform Traffic Control Devices* (MUTCD) (see references for details of its parts). In New Zealand the equivalent source is the *Traffic Control Devices Manual* (TCD Manual). Readers should be aware of these where applicable.

It is noted that jurisdictions may have variations to practices outlined in this part. These are typically contained in supplements along with other complementary material. Readers should refer to such supplements to best understand jurisdictional practice.

Table 1.1: Parts of the Guide to Traffic Management

Part	Title	Type	Content
Part 1	Introduction to the Guide to Traffic Management	Theory and background	Part 1 provides background material to the Austroads *Guide to Traffic Management* through: • an introduction to the discipline of transport management • an outline of the Guide.
Part 2	Traffic Theory Concepts	Theory and background	Part 2 provides an outline of traffic theory concepts through: • an overview of the basic traffic variables and relationships and the random nature of traffic behaviour • an overview of queuing and gap acceptance theory • an overview of vehicle interactions in moving traffic and the principles underlying managed motorways.
Part 3	Transport Study and Analysis Methods	Theory and background	Part 3 provides details of the methods used for transport studies and analysis through: • describing an overall systems approach to transport studies, including statistical and sampling issues • presenting an overview of the concepts of capacity, level of service and degree of saturation and the factors which affect them • providing information and guidance on capacity analysis as applied to uninterrupted flow facilities, interrupted flow facilities and intersections, respectively.
Part 4	Network Management Strategies	Strategic	Part 4 provides an outline of the broad strategies for managing road corridor networks for the various road corridor users through: • an overview of what is network management • describing the 'movement and place' concept for road corridor management and the movement and place considerations for network types based on the user group (e.g. rural networks, bicycle networks, heavy vehicle networks and others) • an overview of the network operation planning process to be applied in road corridor management.
Part 5	Link Management	Operational road corridor management	Part 5 provides an outline of road corridor link management through: • an overview of network strategies that influence road corridor link management (this is also discussed in Part 4) • principles of access management • guidance on road corridor space allocation for general use and for specific road corridor user types • guidance on lane management principles • guidance on speed limit setting.
Part 6	Intersections, Interchanges and Crossings Management	Operational road corridor management	Part 6 provides an outline of road corridor intersection management through an overview of: • the type of intersections and guidance on how to select the appropriate intersection • roundabouts including guidance on their use, performance, road corridor space allocation and lane management, functional design and signalised roundabouts • signalised intersections including guidance on functional layout, road corridor space allocation and lane management • unsignalised intersections including transport controls, intersection capacity and flow and transport control devices • road interchanges including planning and route considerations, road corridor space allocation, interchange forms, and basic lane numbers and lane balance • rail crossings including types of protection, grade separated and at-grade crossings, path crossings, lighting and selection of treatments • pedestrian and cyclist crossings including mid-block crossings, bicycle treatment at intersections and intersections of paths.

Part	Title	Type	Content
Part 7	Activity Centre Transport Management	Operational road corridor management	Part 7 provides an outline of road corridor management within activity centres through an overview of: • principles and objectives of road corridor management in activity centres • techniques for transport management in activity centres • examples and typical issues associated with various types of activity centres.
Part 8	Local Street Management	Operational road corridor management	Part 8 provides an outline of how to manage local streets through the implementation of LATM. This is done through guidance on design considerations and an overview of: • the principles behind LATM • the LATM planning process and the steps to be taken • the objective decision process for LATM • considerations such as community participation and information, legal aspects and duty of care • types of LATM devices and guidance to aid selection.
Part 9	Transport Control Systems – Strategies and Operations	Operational road corridor management	Part 9 provides an outline of how to operate dynamic transport control systems through an overview of: • objectives and principles of transport operations • traffic operation services, measures and tools • systems and procedures for - operating traffic management centres - maintaining road corridor serviceability and safety through dynamic operations - operating signals, lane management systems, variable speed limits and other ITS for transport control - operating a smart motorway • performance indicators for operating arterial roads.
Part 10	Transport Control – Types of Devices	Operational road corridor management	Part 10 provides an outline of the transport control devices available to road agencies to manage the road corridor through an overview of: • principles and application of transport control devices • signage and marking schemes needed to manage the road corridor network in a holistic way • types of signs (both static and electronic) available and guidance on their use and management • electronic signs and guidance on their use and management but not going into the operation of the variable message signs (VMS) • types of pavement markings and guidance on their use and management • use of guide posts and delineators • traffic signals and guidance on their use and management but not going into the operation of the signals • traffic islands and guidance on their use and management • current and emerging devices that utilise direct communication with equipped vehicles and may be used for transport control purposes.

Part	Title	Type	Content
Part 11	Parking Management Techniques	Operational road corridor management	Part 11 provides guidance on parking management through an overview of: • principles of parking management • factors which influence parking demand • factors which impact on the supply of parking • parking policy framework • impacts of parking on the environment • key elements to consider in the management of off-street parking • key elements to consider in the management of on-street parking • issues impacting rural parking • considerations for park-and-ride facilities • devices used in the management and control of parking (e.g. signs and pavement markings) • duty of care and risk management required for parking management.
Part 12	Integrated Transport Assessments for Developments	Theory and background	Part 12 provides guidance on how to identify and assess the potential impacts of land developments on road corridor management through an overview of: • traffic impacts of developments and the need to assess them • how transport impact assessments fit into the overall planning regime • key considerations that need to be made to enable developments to function from a transport perspective • traffic impact assessments including how to conduct them • some of the other assessments beyond transport flow considerations that should be addressed (e.g. road corridor safety, infrastructure and pavement, and environmental).
Part 13	Safe System Approach to Transport Management	Theory and background	Part 13 provides guidance on how the Safe System philosophy links in with the other Guides through an overview of: • concepts required to achieve a safe road corridor • human factors and the need to consider these in the design and management of roads to achieve a Safe System • concepts behind road corridor safety engineering • key elements to be managed or applied in safety engineering of the road corridor.

1.5 Out of Scope

The subjects that are out of scope in this part are as follows:

- It does not discuss how to operate devices, including how to operate dynamic transport control devices such as signals, overhead lane control signals, VMS and other traveller information systems, congestion management and incident management tools. This is discussed in Part 9.
- It does not go into detailed guidance on specific treatments, as this is left to users' judgement.
- It does not include transport management guidance applicable to the road corridor beyond the traffic control devices seen by road corridor users to convey control and guidance information. For this, readers are referred to other parts as outlined in Table 1.1.
- It does not discuss design aspects; these are referred to in the *Guide to Road Design.*
- Road corridor safety is captured in the guidance covered throughout this Guide series. Further information on safety is provided in Part 13 and the *Guide to Road Safety*.
- Part 10 does not discuss details regarding the look and design of the traffic control devices used in the management of the road corridor. For this, readers should refer to the Australian Standard AS 1742 *Manual of Uniform Traffic Control Devices* (MUTCD) (see references for details of its parts). In New Zealand the equivalent source is the *Traffic Control Devices Manual* (TCD Manual).

2. Traffic Control and Communication Devices and the Safe System

The Safe System is an approach to road safety that is the basis of strategies and action plans to reduce road trauma in Australia and New Zealand. Ultimately the aim is to eliminate deaths and serious injuries resulting from crashes on the road network.

The Safe System approach is based on the following principles:

- People make mistakes – some crashes are unavoidable despite a focus on preventative measures.
- Our bodies are vulnerable – There are limits to the amount of force our bodies can tolerate before we are injured. In a Safe System, when a crash occurs the forces are managed so that they do not lead to death or serious injury.
- Road safety is a shared responsibility – This includes those involved in the planning, design and management of the road system, is addition to all road users.

As the name suggests, the Safe System is a systems approach which recognises that the components are interrelated and must work together to achieve the desired goals. The four elements or pillars of a Safe System are:

- **Safe roads and roadsides** – Roads should be designed, operated and maintained so that they are predictable, self-explaining and encourage safe travel speeds. When a crash occurs, they should be forgiving to ensure that the likelihood of death or serious injury is minimised.
- **Safe speeds** – Operating speeds should be managed so that crash likelihood is low and, in the event of a crash, the impact forces are within human tolerances.
- **Safe vehicles** – Vehicles should incorporate design features and technology that minimise the likelihood of crashes and protect road users (including pedestrians and cyclists) when crashes do occur. In the past this technology has generally focused on minimising injury to vehicle occupants (seat belts, air bags, etc) but in the future is likely to encompass more driver assistance features that help to prevent crashes from occurring.
- **Safe road users** – All users should be alert, comply with road rules and engage in safe behaviour. They are supported through education, information, enforcement of road rules, training and licensing.

Traffic control devices are essential elements of a safe road environment. They regulate traffic (including pedestrian and bicycle traffic) and warn, inform and guide road users. They also play a significant role in promoting safe speeds through physical measures (e.g. raised pavements, including speed humps), speed limit signage and advisory speed signs.

Cooperative intelligent transport systems (C-ITS) have significant potential to improve vehicle safety through emerging technologies that will enable information to be exchanged between vehicles (V2V), between vehicles and roadside infrastructure (V2I) and between roadside infrastructure and vehicles (I2V).

All traffic control and communication devices have a critical role in relation to road user behaviour and the safety of road users. To this end, it is essential that the design and use of traffic control and communication devices takes into consideration road user factors to ensure that road users are able to correctly interpret the information that is being presented and respond in an appropriate and timely manner.

3. Standards and Road Rules relating to Transport Control Devices

3.1 Australian/New Zealand Standards

The Guide provides guiding principles on when to use different traffic control and communication devices. Practitioners should also refer to the Australian and New Zealand Standards for specifications for the design of the traffic control devices (e.g. sign legend design, pavement marking etc.).

The most relevant Australian Standard for traffic control devices is AS 1742 *Manual of Uniform Traffic Control Devices*. AS 1742 takes account of recommendations on symbols given in the *United Nations Convention on Road Signs and Signals*. It comprises the following 14 parts (Part 8 has been withdrawn):

1. AS 1742.1 General Introduction and Index of Signs
2. AS 1742.2 Traffic Control Devices for General Use
3. AS 1742.3[1] Traffic Control Devices for Works on Roads
4. AS 1742.4 Speed Controls
5. AS 1742.5 Street Name and Community Facility Name Signs
6. AS 1742.6 Tourist and Services Signs
7. AS 1742.7 Railway Crossings
8. AS 1742.8 (Withdrawn)
9. AS 1742.9[2] Bicycle Facilities
10. AS 1742.10 Pedestrian Control and Protection
11. AS 1742.11 Parking Controls
12. AS 1742.12 Bus, Transit, Tram and Truck Lanes
13. AS 1742.13 Local Area Traffic Management
14. AS 1742.14 Traffic Signals
15. AS 1742.15 Direction Signs, Information Signs and Route Numbering.

AS 1742 is supported by two other standards, one covering sign face layouts and their manufacture, and one defining standard alphabets, namely:

1. AS 1743 Road Signs: Specifications
2. AS 1744 Standard Alphabets for Road Signs.

In New Zealand, requirements for traffic control devices are set out in the NZ *Traffic Control Devices Manual* (NZ Transport Agency 2008), and in the *Manual of Traffic Signs and Markings (MOTSAM)*, particularly:

1. *Part 1* *Traffic Signs* (NZ Transport Agency 2010a)
2. *Part 2* *Markings* (NZ Transport Agency 2010b).

Throughout this document, where reference is made to AS 1742, practitioners in New Zealand should also refer to the relevant section in *MOTSAM*. It is noted however that *MOTSAM* is progressively being replaced by the NZ *Traffic Control Devices Manual*.

1 AS 1742.3 is currently being updated.
2 AS 1742.9 is currently being updated.

In addition, practitioners engaged in traffic engineering and traffic management should be aware of other standards and specifications that relate to traffic control devices. These are outlined in Table 3.2 .

Table 3.1: Other standards and specifications that relate to traffic control devices

Standard no.	Standard title
AS/NZS 1428.4.1	Design for access and mobility: means to assist the orientation of people with vision impairment: tactile ground surface indicators.
AS/NZS 1906	Retroreflective materials and devices for road traffic control purposes. • AS/NZS 1906.1 Retroreflective sheeting. • AS/NZS 1906.2 Retroreflective devices (non-pavement application). • AS/NZ 1906.3 Raised pavement markers (retroreflective and non-reflective). • AS/NZS 1906.4 High visibility materials for safety garments.
AS/NZS 2009	Glass beads for pavement-marking materials.
AS 2144	Traffic signal lanterns.
AS 2342*	Development, testing and implementation of information and safety symbols and symbolic signs (is also relevant to sign face design).
AS 2700	Colour standards for general purposes.
AS/NZS 2890	Parking facilities: • AS/NZS 2890.1 Off-street car parking. • AS/NZS 2890.2 Off-street commercial vehicle facilities. • AS/NZS 2890.5 On-street parking. • AS/NZS 2890.6 Off-street parking for people with disabilities.
AS 2979	Traffic signal mast arms.
AS 4049	Paints and related materials: pavement marking materials: • AS 4049.1 Solvent-borne paint: for use with surface applied glass beads. • AS 4049.2 Thermoplastic pavement marking materials: for use with surface applied glass beads. • AS 4049.3 Water-borne paint: for use with surface applied glass beads. • AS 4049.4 High performance pavement marking systems.
AS 4191	Portable traffic signal systems.

**AS 2342 is proposed to be withdrawn. Once withdrawn it is proposed that AS 1743 will cover the subject matter.*

3.2 Road Rules and Traffic Control Devices

The Australian Road Rules 2012 provide a template that has resulted in a high degree of uniformity of road law throughout Australia. While most road rules are the same throughout Australia there are some differences between jurisdictions and practitioners should seek advice on variations that apply to their particular jurisdiction.

As the road rules are communicated to drivers through traffic control devices comprising signs and pavement markings, Schedule 2 of the Australian Road Rules illustrates standard and commonly used regulatory signs that relate to many of the rules. Schedule 3 illustrates ‘other permitted traffic signs’. These are alternative signs to those shown in Schedule 2 and are allowed to be retained pending replacement. They are not included in AS 1742.

In New Zealand road rules are set out in the Land Transport Rules, specifically the Land Transport (Road User) Rule 2004 and the Land Transport Rule: Traffic Control Devices 2004. These provide rules for compliance with regard to signs, markings and other devices. Details of traffic signs and their use are given in MOTSAM: Part 1: Traffic Signs[3].

3 It is noted that *MOTSAM* is progressively being replaced by the NZ *Traffic Control Devices Manual*.

4. Principles and Application

4.1 Uniformity

4.1.1 Importance

Uniformity means treating similar traffic situations in the same way. Standard traffic control devices help drivers assess an unfamiliar situation. The uniform design and application of traffic control devices therefore reduces the time a motorist needs to recognise and understand the message and to choose an appropriate course of action. Ideally, the meaning of the message or symbol should be immediately apparent to drivers so that their attention will be distracted for as little time as possible from other necessary decision-making.

Uniformity is essential to law enforcement and for traffic safety. Non-uniformity causes disrespect for the law and can often create potentially dangerous traffic situations. Standardisation of traffic control devices also reduces costs associated with their manufacture, installation, maintenance and administration.

The use of standard traffic control devices does not in itself constitute uniformity. To use a standard traffic control device contrary to the intended application is equally as wrong as using a non-standard device where a standard device is applicable.

4.1.2 Areas of Desirable Uniformity

Areas of desirable uniformity include:

- Design: Uniformity in design includes the selection of the appropriate sign shape, colour, size, legend or symbol, and reflectorisation or illumination (if the sign has significance at night).
- Application: It is essential that devices are located in a uniform fashion to allow road users to react at different locations in a timely and similar manner to the same device or group of devices. To use a device in a manner inconsistent with its use elsewhere is confusing and creates a potentially hazardous situation.
- Location: Uniform location helps drivers to notice the device and interpret the situation appropriately.

4.2 Factors Affecting Performance

The failure of a traffic control device to fulfil its function may result from a number of factors discussed in Sections 4.2.1 to 4.2.7.

4.2.1 Inappropriate Use

Appropriate engineering studies should be carried out before a decision is taken to install a device. While practical trials of devices in unusual situations may be worthwhile, they should be based on sound principles and be closely monitored to evaluate the effects. Inappropriate use of traffic devices, including the use of non-standard devices, can lead to disrespect and lack of observance by road users. Incorrect placement of standard devices (e.g. too close to hazards or other traffic control devices or too remote to be effective) can lead to the devices being missed or ignored.

4.2.2 Maintenance

Traffic control devices are important features of the road/traffic environment and require regular inspection and maintenance to ensure their effectiveness in all operating conditions. A sign that appears in reasonable condition by day may be deficient under night-time conditions due to aging or inappropriate repairs to the sign face. Such deficiencies may only be detected through an inspection at night. A lack of maintenance can lead to disrespect for a device and an ultimate reduction in safety.

The maintenance issue that is most prevalent with respect to the effectiveness of signs is the trimming of trees and other vegetation. Road agencies should ensure that maintenance contractors and workers regularly trim vegetation so that drivers are able to see and read road signs from an appropriate distance.

4.2.3 Environmental Factors

Where particular adverse environmental conditions such as fog, dust, or smoke are known to occur, special compensatory measures may be needed to ensure the effectiveness of the device (e.g. the use of raised pavement markers to supplement painted markings, or reduced spacing of guide posts and delineators).

4.2.4 Site Conditions

Factors such as grade, sight distance and landscaping may have a significant effect on the size and position of various devices.

4.2.5 Road User Factors

Driver expectation, familiarity and knowledge about the devices and vehicle limitations are important considerations in achieving consistent driver behaviour and responses to various traffic control devices. Devices conveying the wrong message or more messages than a driver can readily assimilate, can also lead to them being misinterpreted or missed.

4.2.6 Design of Road or Facility

The installation of traffic control devices will rarely be effective in alleviating problems that are essentially due to deficiencies in geometric layout. Road safety audits (Austroads 2019a) are recommended throughout the development of projects to ensure that designs are effective, and that appropriate use is made of traffic control devices for each road or facility.

4.2.7 Redundant Signs

A related issue is the failure to remove signs when they are no longer appropriate, or at times when they do not apply. For example, a slippery when wet sign should be removed after a road surface has been treated to raise skid resistance to an acceptable level, and temporary roadworks signs (e.g. speed limit signs and signs relating to workers on the road) should be removed during periods when they do not apply.

4.3 Signs and Markings

4.3.1 General Principles

The use of signs and markings within the road environment should be consistent with the principles of a Safe System approach (refer to discussion in Section 2). Providing a safer road environment involves application of road design and traffic management principles with a clear safety focus.

Signs and road markings are often used to address inadequate design. For example, when an operational or safety problem arises on a road network there is often a tendency for road managers to look to signs or pavement markings as an immediate and cost-effective treatment. In some instances, these devices can be part of the problem on the road system and therefore their use in some cases may not be in line with the Safe System approach. The Safe System approach places an obligation on road agencies to consider design options that will contribute to the elimination of deaths and serious injuries. The Safe System Assessment Framework (Austroads 2016b) provides a methodology to assess project options to determine the extent to which they align with Safe System objectives.

The following principles provide for the proper and efficient use of devices (Freeman 1996) in accordance with the Safe System approach:

- External pressures for installation of a particular device should not absolve traffic engineers from determining and recommending a more effective solution to a problem.
- Signs or markings can seldom be used to solve problems caused by poor and confusing road geometry.
- Like situations should be treated in a like manner, and standard devices should always be used unless it can be clearly demonstrated that they do not fit the case.
- All devices should be properly maintained and replaced when worn out, particularly reflective devices.
- Devices should be installed according to guides and warrants. However, a device should not necessarily be installed simply because a guide or warrant is met.
- Excessive use of signs should be avoided as this can cause visual clutter, and driver confusion or information overload. The following questions should always be asked:
  - Are certain signs really needed?
  - Do they serve any practical function?
  - Can they be read and acted upon by a driver?
  - Can an excessive number of signs be replaced by a smaller number of larger signs that are more rationally designed and located?
  - Is a particular type of sign being used so often for purposes of lesser importance that its value in solving more serious problems is degraded?
- Signs need to be of an adequate size and properly located so that drivers can read and act the message.
- Signs and devices should provide for adequate advance warning of hazards or decision points, not forgetting that the hazard or decision point itself needs to be adequately delineated.
- Complexity in the design of word messages and symbols should be avoided. Symbols that have not been tested in accordance with AS 2342 should not be used. Symbols should not have excessive detail, as this will often operate against their effectiveness.
- The limitations on a driver's ability to see and/or read messages conveyed by pavement markings under certain geometric road conditions (e.g. around curves, on crest vertical curves) should be recognised.
- Total reliance on pavement markings to guide or control drivers at locations of special hazard should be avoided (e.g. hazard markers may also be required to delineate an obstruction or road narrowing).
- Structures supporting signs should not be potential roadside hazards in themselves. Frangible[4] supports should be provided, or the structure shielded using an approved safety barrier.

4 Frangible supports are those designed to collapse on impact. The severity of potential injuries to the occupants of an impacting vehicle is reduced, compared to those that could occur if the supports was unyielding. Practitioners should refer to their own jurisdiction guidance on frangible posts in addition to the Austroads Guide to Road Design Parts 6 and 6B, and the Guide to Road Safety Part 9. Examples of jurisdictional guidance on frangible posts is outlined in Commentary 1.

[see Commentary 1]

4.3.2 Considerations for Older Road Users and People with Disabilities

The road design and traffic management needs of older drivers using Australian roads have been the subject of research (Fildes et al. 2001). As people age, they experience decreasing physical and mental capabilities and become more susceptible to injury and shock. Human functions subject to deterioration due to ageing include:

- visual acuity
- attention capacity
- reaction time
- contrast sensitivity.

In relation to traffic management, people with disabilities must have equitable access to all transport services and therefore be considered in the development of all transport and traffic management proposals and treatments. Guidance devices serve to warn people with limited or no sight, and those with other disabilities, of obstacles, and to direct their movements accordingly through various cues. Guidance devices and their cues typically fall into three groups:

1. Audible cues – these range from audio-tactile devices at a pedestrian crossing to public address systems.
2. Visual cues – these include maps, signs, lighting, visually contrasting surfaces and guide lines.
3. Physical cues – these include audio-tactile devices at pedestrian crossings, surface texture changes (tactile ground surface indicators), guide strips, kerbs and other surface-level changes.

Information relating to the design of facilities for persons with a disability is contained in the *Guide to Road Design* (Austroads 2009–19), and other Parts of the *Guide to Traffic Management*, particularly *Parts 6* and *11* (Austroads 2020d and 2020g).

Information is also available in the following Australian/New Zealand Standards:

- AS/NZS 1428.4 Design for Access and Mobility: Tactile Ground Surface Indicators
- AS/NZS 2890.6 Parking Facilities: Off-street Parking for People with Disabilities
- Manual of Traffic Signs and Markings (MOTSAM) Part 1: Traffic Signs (NZ Transport Agency 2010a)
- Manual of Traffic Signs and Markings (MOTSAM) Part 2: Markings (NZ Transport Agency 2010b).

4.4 Alignment with the National ITS Architecture

The Standing Council on Transport and Infrastructure's (now Transport Infrastructure Council) *Policy Framework for ITS in Australia* (Standing Council on Transport and Infrastructure 2012) identifies the need for a National ITS Architecture (NIA). Further information can be found at Austroads' National ITS Architecture webpage (Austroads 2016a).

Key benefits of a NIA include greater efficiency in the development and use of interoperable ITS technologies through leveraging current and future investments in ITS. Using the NIA will also help transport designers and operators understand the operational requirements and information flows that will help inform the selection and application of those technologies.

Therefore, while today's solutions become tomorrow's legacies they should remain interoperable with tomorrow's solutions.

5. Signing and Marking Schemes

Signs and markings constitute the most fundamental way to communicate with road users. Effective and efficient communication supports the Safe System by contributing to safe roads, safe speeds and safe road users. To achieve this, it is essential that signing and marking schemes are prepared with users in mind. Consistency, clarity, simplicity and relevance aid decision making, avoid unnecessary distraction, minimise response times and reduce stress on drivers.

While the use of standard signs and markings is preferred because they are familiar, innovation is encouraged. Where a novel or unconventional treatment is being considered, the cognitive workload placed on users may be increased. In such cases designers should seek an understanding of how users may respond, including advice from human factors experts as necessary.

In addition to the need for signs and markings to be clear and legible to users, there is also a requirement to ensure the same for the emerging driver assist technologies that are being developed. The requirements of these systems are still not well understood and practitioners are advised to follow current standards and guidance for the time being. However, as driver assist and automated driving technologies advance and become more commonplace, it is possible that sign and marking standards will need to change in the future to accommodate vehicles that can read the road. The need for signs and markings to be consistent is likely to become especially important in the future to minimize the chance of a vehicle interpreting the environment incorrectly and making an error.

Signing and marking schemes are an important component of many traffic management plans. While signs and markings are often installed individually for a specific purpose, they are also often part of an overall signing and marking scheme or traffic management scheme for an area. Designers have to ensure not only that the correct device is used for a particular purpose, but also that the devices relate logically to each other and do not provide information that may confuse road users. Where a number of different instructions must be conveyed to drivers, the spacing of devices is important to ensure that drivers have sufficient time to comprehend and respond to the messages. In some cases, information has to be prioritised and the scheme designed accordingly.

5.1 Need for Signing and Marking Schemes

The preparation of a signing and marking scheme is required as part of any:

- review of all signs along a route or throughout an area or a specific type of sign (e.g. direction, speed limit, tourist)
- project involving at least one major intersection or other design aspects which result in a complex situation (e.g. closely spaced intersections)
- motorway construction project
- traffic management scheme, not necessarily involving new construction
- temporary signing at a construction site involving complex traffic management and/or staging
- planning for special events that affect road traffic.

Signing and marking schemes are necessary to ensure that:

- overall proposals are logical and consistent in the way information is presented to motorists
- there is coordination with other devices and features (e.g. traffic signals, street lighting)
- there is consistency with line and pavement markings, and the geometric design of the road or intersection

- a logical progression through the system exists for all road users (pedestrians, bicyclists, disabled persons and drivers)
- they conform to the national or state signing strategy or convention (e.g. destination and tourist signs).

The preparation of signing and marking schemes should be included as an activity in project construction programs with adequate provision made for the time to:

- prepare the scheme
- audit the scheme at an early stage, to reduce the likelihood of errors or deficiencies in the system and overall project cost
- seek necessary agreements (e.g. from local council) and approvals
- design and manufacture any special sign structures
- manufacture, deliver and install all signs, structures, posts and fittings.

5.2 Principles for Preparation of Schemes

The following procedure should be used to prepare a signing and marking scheme associated with a major construction project:

- Prepare a preliminary scheme with signs and markings accurately located with either a facsimile or draft sketch of the sign faces shown adjacent to their locations. Proposed information should be depicted on guidance and information signs.
- Forward copies of the draft scheme to the client and other interested parties for initial comment.
- Produce the scheme in its final form and obtain appropriate approvals.
- Prepare sign face designs for all unique signs.
- Design sign structures or over-bridge sign mounting brackets, and prepare sign and post schedules.

On small, standard, or uncomplicated jobs, a final design may be prepared without the requirement of drafts being circulated. An independent check of final designs should normally be undertaken.

Signage scheme design drawings should be undertaken in accordance with the requirements of the road jurisdiction in which they apply.

5.3 Complex and Closely Spaced Intersections

Acute intersection angles and roads that curve through intersections create further complexity in the arrangement of signs and markings, both on the approaches to and within intersections. For example, raised pavement markers may be necessary to define lanes in wide intersections where roads change direction within the intersection or curve through it.

Where bicycle or bus lanes pass through complex intersections it may be desirable in some instances to use coloured pavement surfacing for these lanes in order to provide better delineation and definition of priority. While coloured pavement may be extended through unsignalised intersections with minor roads for this purpose, it might not be desirable or necessary to do so through major signalised intersections. Use of coloured pavements is covered in Section 8.6 .

Closely spaced arterial road intersections can create some confusion for motorists and difficulty for designers, particularly with respect to the location and effectiveness of advance direction signs. In these circumstances it is usually desirable to provide diagrammatic signs; however, this type of sign is usually quite large and space is usually at a premium in urban situations. Designers should consider the use of overhead signs as a solution to this problem, even though they are expensive.

Another problem that results from closely spaced intersections is the ‘see through effect’, whereby drivers fail to stop at the red signal at the first intersection because they are concentrating on the second intersection. This problem may be addressed by the provision of the *prepare to stop* warning signs with flashing lights (as illustrated in AS 1742.2) or by providing larger aspects on the first set of signals. The situation can also be improved by using louvres and long visors to focus the visibility of the far lanterns to specific drivers in the field of view.

5.4 Traffic Management Plans

Traffic management plans are the means by which a traffic management strategy for a particular area is implemented. The area concerned may be an inner city area involving arterial roads and local roads, a local area subject to particular controls (e.g. speed, traffic infiltration, access by large trucks) or a large shopping centre car park.

The traffic control devices used will depend on the traffic management objectives for the area and will usually require a range of devices including signs, road markings and traffic islands. Controls such as restrictions on parking and entry, turn bans or lower speed limits may be introduced.

Within an area there may be a need for traffic control devices to relate to various road user groups and facilities. The preparation of a traffic management plan showing all necessary devices will ensure that a coherent scheme is developed where various signs relate logically to each other and are not contradictory, clutter is minimised, and sign location and use of sign supports are optimised.

5.5 Route Plans for Direction Signs

5.5.1 General

Direction signs are provided to advise road users about the direction and distances to destinations on the route they are following. They provide information in advance of, at and beyond intersections to reassure road users that they are travelling along the correct route. Direction signs are therefore an important aspect of signing and marking schemes as they assist in the safe, orderly and efficient movement of traffic.

The development of schemes for direction signs along new or existing routes, or throughout road networks, requires the use of a procedure to ensure that information on the signs is accurate, coherent and consistent. The procedure for determining direction signing requirements at all intersections along a major route, either metropolitan or rural, may be facilitated by the preparation of:

- a route overview plan
- intersection direction sign layouts
- a plan of reassurance direction signs and stand-alone route number signs.

The signing scheme designer should apply this procedure to achieve consistency in the use of destinations and route numbers, and to identify the level of treatment required at each intersection according to the requirements of the local jurisdiction guidelines.

Prior to developing an overview plan for an existing route, it will normally be necessary to determine the details and condition of all signs that exist along the route. Some signs may be relatively new and able to be incorporated into the new scheme, while others may be damaged or aged well beyond the warranty period for the sign face material, or require relocation. Further discussion is given in Commentary 2.

[see Commentary 2]

On less complex routes (e.g. short lengths of lower standard routes where only a few signs are needed) the required information may be provided on one plan. Alternative presentation methods to those illustrated in Section 5.5.2 are acceptable provided that the necessary information is documented.

5.5.2 Route Overview Plans

Overview plans provide a pictorial record of basic information required to design and provide effective direction signs along a route or throughout a road network. They can be prepared as either:

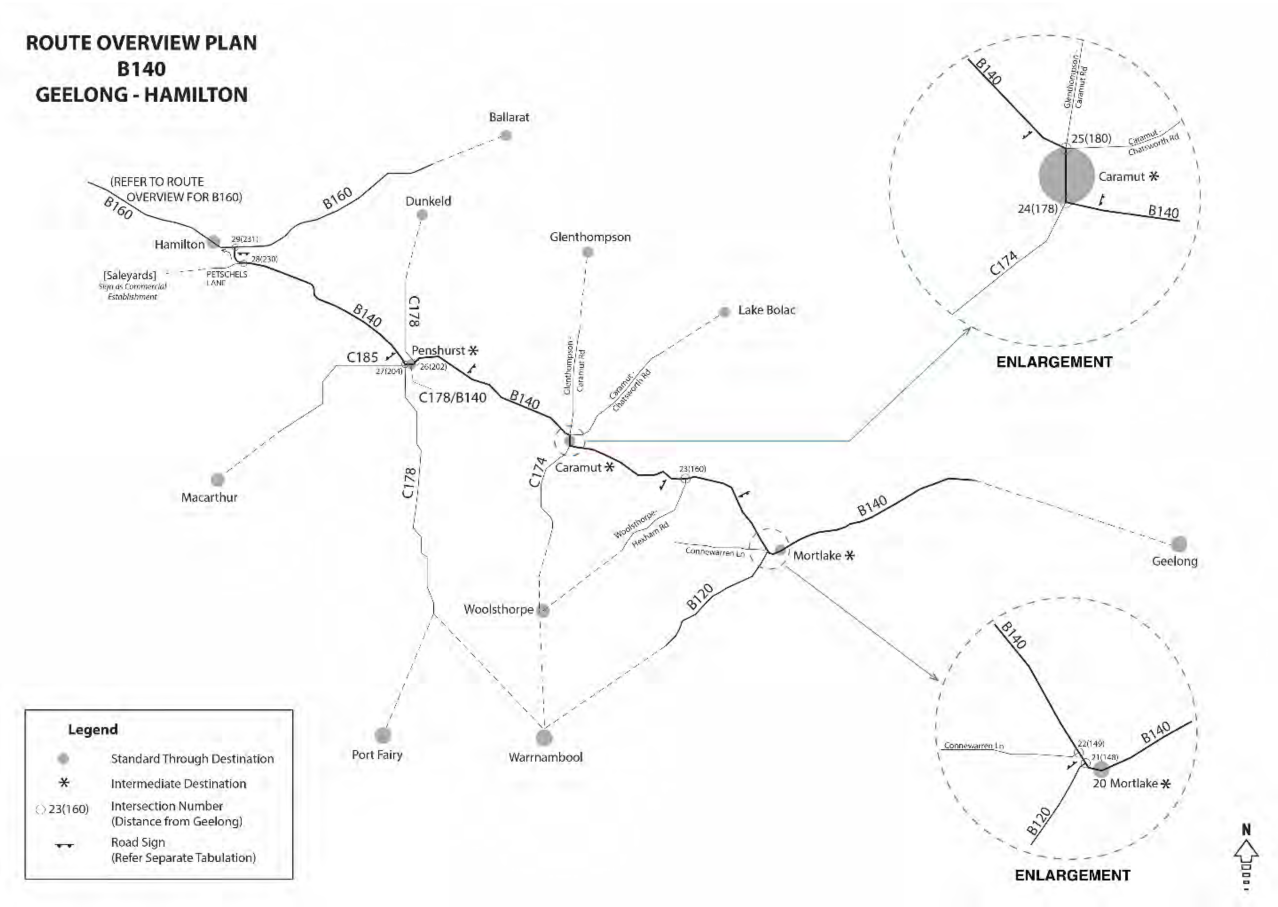
- the first step in upgrading direction signing on an existing route or new road
- a reference plan for the treatment of individual intersections, which require new or replacement signing prior to a comprehensive upgrading of the whole route.

Features of a typical route overview plan (Figure 5.1) include:

- A strip map to describe the entire route, including its length and the start and end chainages. It is not necessary that the route be drawn to scale.
- A number for each intersection indicating the route number or road name for every significant intersecting road along the route (e.g. intersections with M, A, B and C roads) and the kilometres from the datum.
- The through destinations along the route and all intermediate destinations, to assist in labelling reassurance signs. Destinations for all intersecting roads should be recorded.
- The location (distance from the datum) of all reassurance direction signs and stand-alone route number signs placed in accordance with relevant guidelines, ensuring that the maximum prescribed spacing between signs is not exceeded.

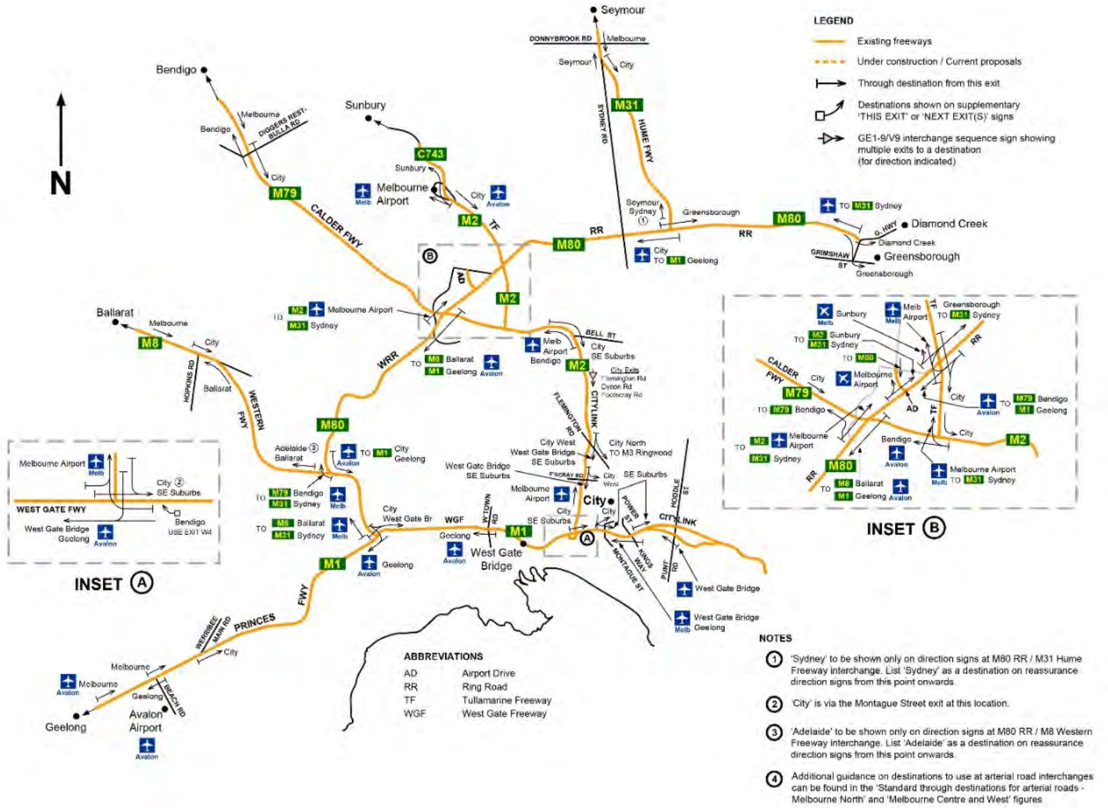
Destination maps for the jurisdiction should be used to determine the names of destinations to be shown on direction signs. Typical maps of destinations are shown in Figure 5.2 and Figure 5.3.

Figure 5.1: Typical route overview plan



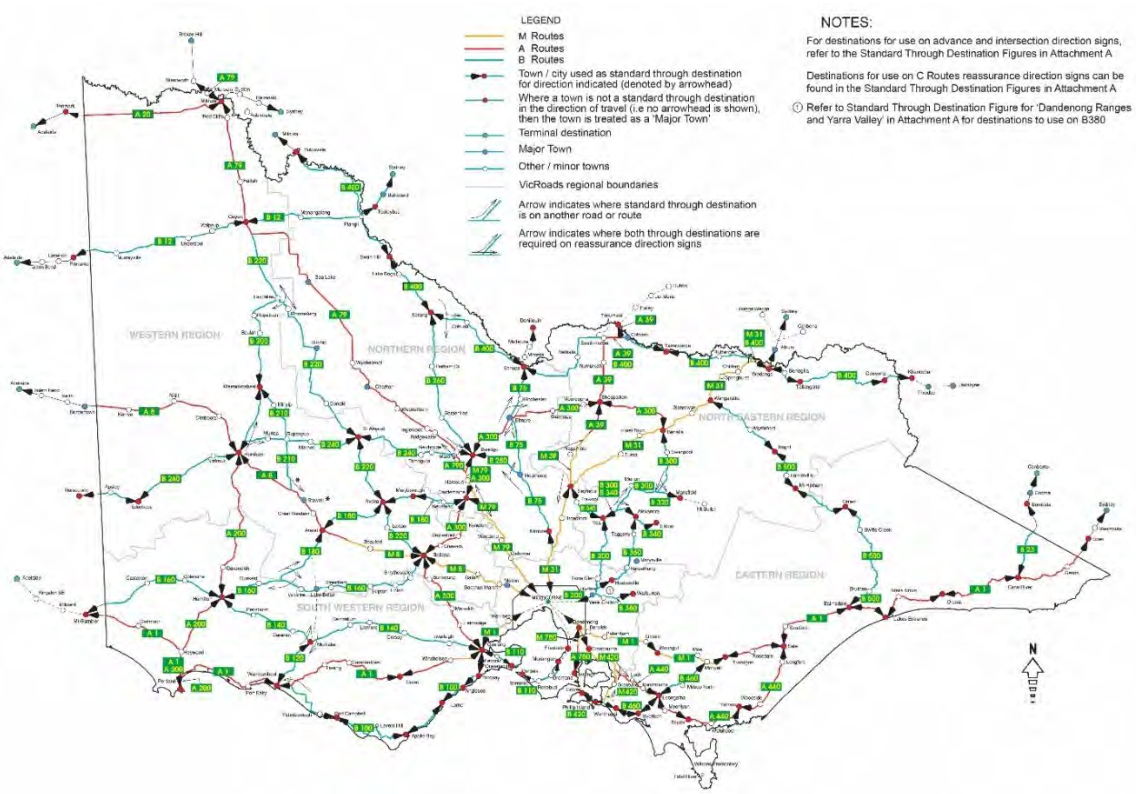
Source: VicRoads (personal communication 2016).

Figure 5.2: Destinations for signs on motorways in Melbourne



Source: VicRoads (personal communication 2016).

Figure 5.3: Destinations for rural M, A and B routes in Victoria



Source: VicRoads (personal communication 2016).

5.5.3 Intersection Direction Sign Layouts

The route overview plan is the basis for the information that will appear on intersection direction sign plans. It is often desirable to prepare a draft concept plan showing intersection direction sign details that can be used to produce working drawings for production of the signs.

These layouts enable the designer to determine the general types of direction signs required based on the road classification, and to document the legend, legend size and material class required for each sign. If required, the approximate size and location of each sign may also be recorded. Typical intersection direction sign layouts are provided in AS 1742.15. Figure 5.4 shows a draft plan for a typical route comprised of several intersections.

A draft of the intersection direction sign layout plan (Figure 5.4) should be produced as the basis for the development of more detailed intersection signing schemes in accordance with AS 1742.15. This information can then be used to guide the production of working drawings for the manufacture of the signs.

5.5.4 Reassurance Direction Signs Plan

The purpose of this plan (Figure 5.5) is to ensure that reassurance direction signs and stand-alone route markers are provided in a consistent and adequate manner along routes. The plan also enables the designer to confirm that all relevant destinations and distances are correct with respect to the relevant datum, and hence in relation to each other. This simple check is achieved by recording the kilometre distance against each sign location. A key element of reassurance direction signage is to keep reassuring the driver of the destination until it is reached.

5.6 Route Planning and Directional and Wayfinding Signage for Bicyclists

The active transport and recreational needs of communities are efficiently served by the development of regional and local networks of interconnected cycling routes linking major trip origins to destinations. The planning of these networks is undertaken by government agencies and local governments as part of regional and municipal bicycle plans.

Directional signs provide wayfinding and informational guidance for bicyclists across these bicycle networks.

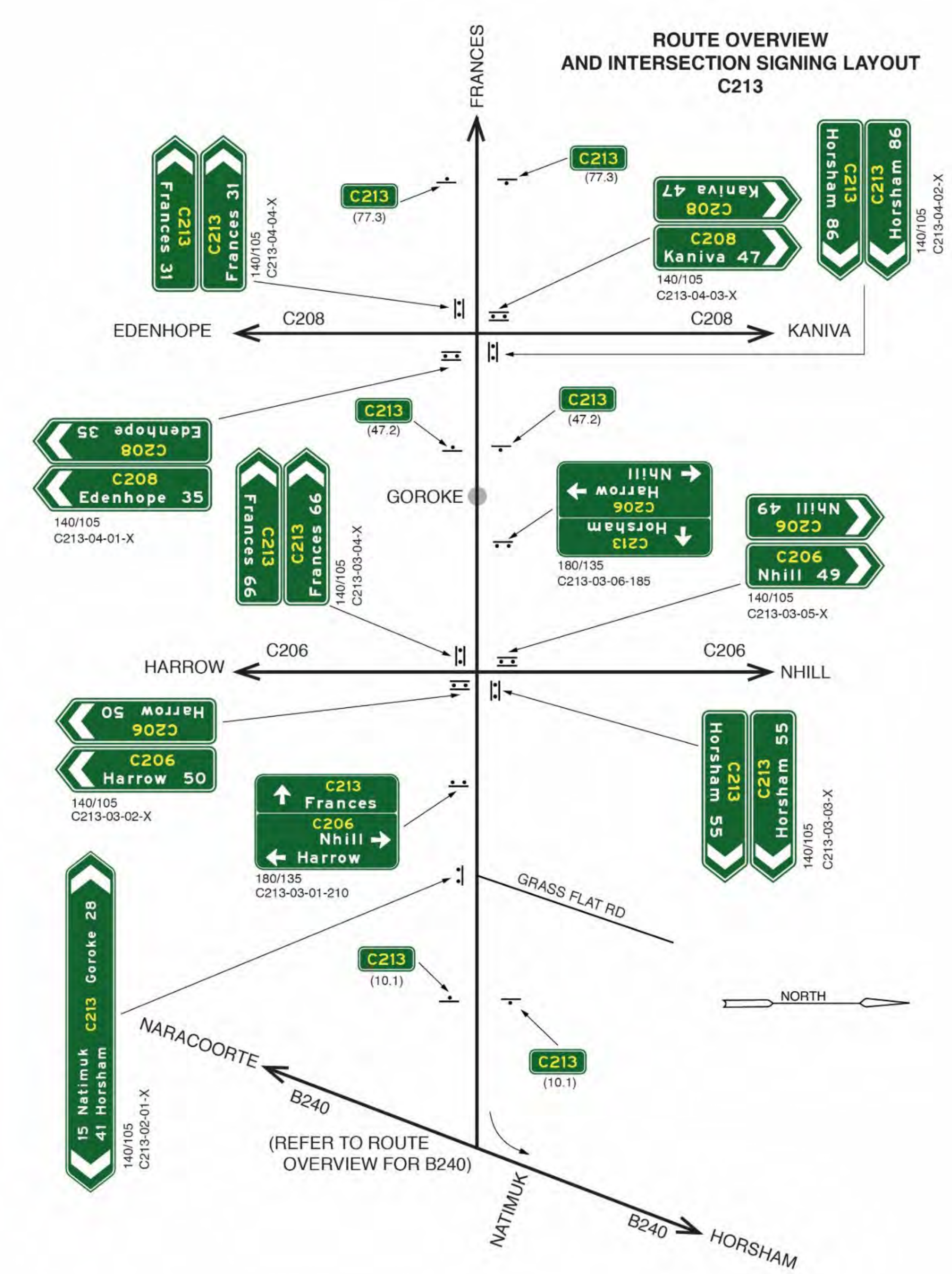
When developing wayfinding signage for bicycles, road designers, engineers and transport planners should aim to provide high quality, professional and consistent directional signs. Ideally these should be consistent with bicycle wayfinding signage in cycle networks across Australian and New Zealand cities and towns to enable riders to use the networks to their full potential and make quick and accurate route choices.

When developing bicycle wayfinding signage consideration needs to be given to:

- focal point mapping, destinations and decision points that are signposted
- route hierarchy and the types of signs appropriate for each type of route in the cycle network
- facility naming, route numbering and branding
- location and mounting of signs
- special sign situations such as marked detour routes, tourist destinations and routes through complex intersections
- other users of the road network and their signage requirements in order to avoid signage overload and signage confusion.

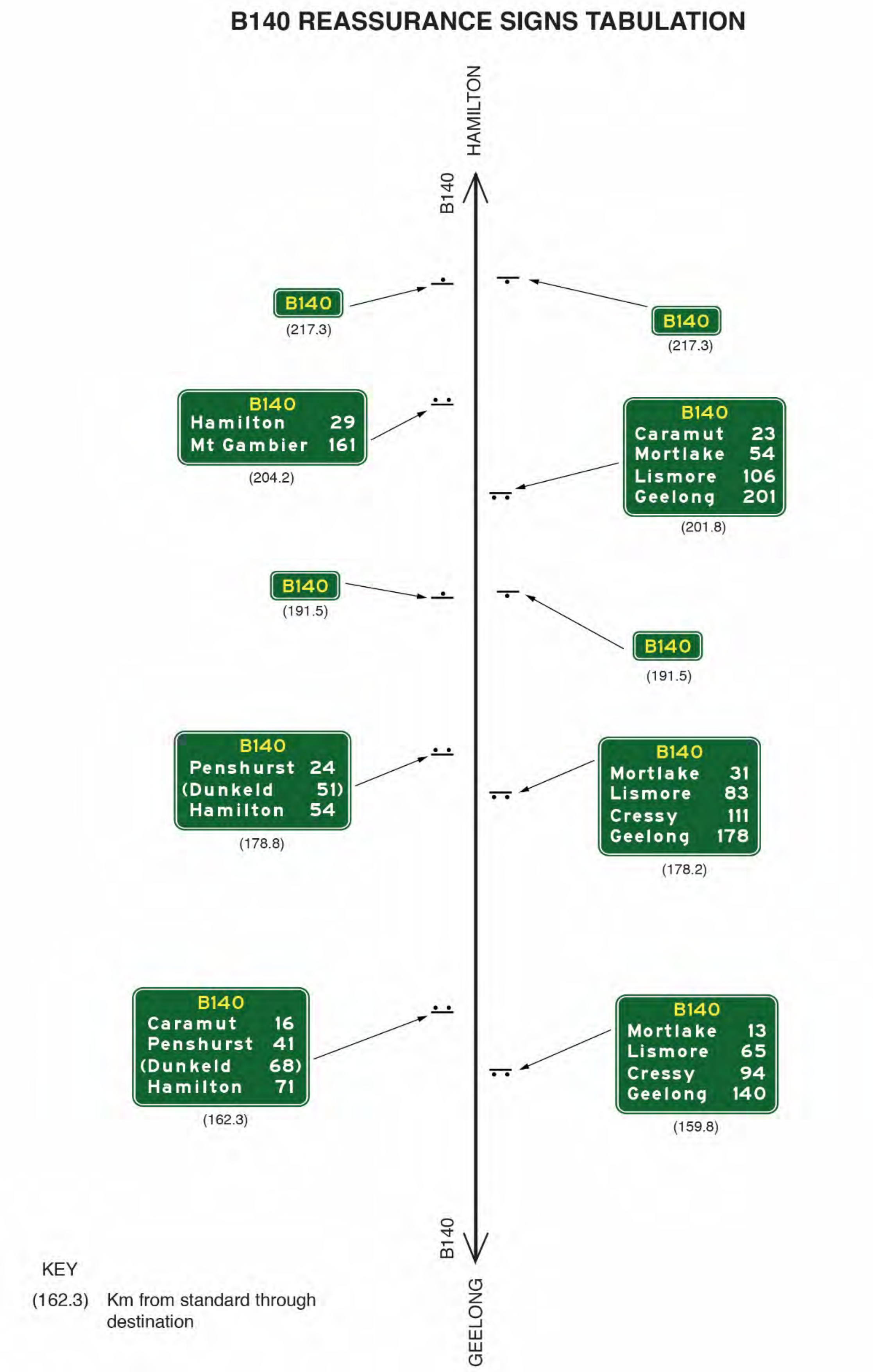
Appendix A provides further guidance on bicycle wayfinding including signage design, cycle route types, developing a directional sign plan, signing complex intersections, sign installation, sign maintenance and alternative sign design. Further detailed guidance is provided in Appendix B of Austroads (2015d).

Figure 5.4: Example of draft intersection direction sign layout



Source: VicRoads (personal communication 2016).

Figure 5.5: Example of a reassurance direction sign plan



Source: VicRoads (personal communication 2016).

5.7 Wayfinding for Pedestrians

With the exception of door to door travel by a private vehicle, many trips undertaken have an element of walking. In areas such as CBDs, shopping centres, sporting complexes etc. where many visitors have undertaken at least the last part of their journey by foot, or are navigating the area by foot, there is a need for pedestrian wayfinding particular from major origins such as public transport hubs. The purpose of the pedestrian wayfinding is to:

- help people orientate themselves and easily find their way to their destinations
- give people confidence to stray from the main tourist routes and explore more of the area
- help people to move easily between transport modes
- encourage the use of sustainable modes of transport.

Some key principles and guidelines to consider when implementing pedestrian wayfinding signage are outlined in Table 5.1.

Table 5.1: Key principles and guidelines to consider when implementing pedestrian wayfinding signage

Principles	Guidelines
1. Focus on the users: users need signage that is coherent and reliable 2. Reduce clutter: have fewer but better positioned signs in the streets 3. Disclose information progressively: the user should be given enough information to achieve the next stage of their journey, but not so much detail that they become confused 4. Create connectivity: by linking one location to the next through signing, visitors can move freely and confidently from one place to another and from one transport mode to another 5. Be consistent: signage should carry consistent, predictable and reliable information 6. Use resources efficiently: work with other agencies to deliver and maintain improved signage.	1. Design signs to aid users, not promote providers 2. Keep it simple 3. Provide users with a hierarchy of destinations 4. Sign via key access routes 5. Help visitors explore 6. Only sign within a walking distance 7. Continue signing to destination 8. Don't sign the obvious 9. Don't sign to destinations behind the reader 10. Sign to closer destinations ahead of those further away 11. Sign to high priority destinations ahead of low priority destinations 12. Sign to suburbs and precincts where this is more concise 13. Avoid signing to destinations within another signed destination 14. Avoid signing diagonally across a road grid 15. Sign across intersections where needed 16. Direct visitors via safe/preferred routes.

5.8 Route Audits

The general purpose of the audit is to ensure that route signs are legible and meet the needs of all intended road user groups, including older drivers. More specifically, the purpose is to:

- ensure that the route has been signed in accordance with the route overview plan
- discover any gaps that may exist in the implemented signing scheme.

The auditor must be a person who has experience with the guidelines that apply to signing schemes, and has had little or no involvement in the route that is to be audited. An independent auditor is more likely to identify gaps or improvements along a particular route than an auditor who has had involvement with the signing scheme design or is otherwise familiar with the route.

If available, copies of the following information will assist in an audit:

- inventory report
- route overview, intersection layout plans and plan of reassurance direction signs
- sign face designs.

The procedure for conducting an audit is to firstly become familiar with the route to be audited by studying the overview and intersection layout plans, and then to travel the route and establish whether:

- the correct signs have been erected as detailed in the overview
- the signs match the sign face designs
- the appropriate type of sign is used in each situation
- sign locations are appropriate
- legends on signs are correct
- sign face materials are appropriate
- signs are obscured, or likely to be, by objects or vegetation
- there are any gaps in the signing scheme.

As part of the audit process, photographs should be taken of signs along the route for further reference. A suggested checklist to facilitate audits is shown in Figure 5.6 .

An audit is used by the responsible manager to determine those aspects of route signing that should be corrected, taking existing and future budgets into account.

Figure 5.6: Example of a checklist for route audits

Checklist for Route Audits

After reviewing the route, answer the following questions (YES/NO)

1. Have the correct signs been erected as per the overview? YES/NO
   If no, please describe ....
   ....
2. Do the signs match the sign face design? YES?NO
   If no, please describe ....
   ....
3. Are the sign types appropriate? YES/NO
   If no, please describe ....
   ....
4. Are the locations of the signs appropriate? YES?NO
   If no, please describe ....
   ....
5. Are the legends chosen for the signs appropriate? YES/NO
   If no, please describe ....
   ....
6. Are the sign face materials chosen for the signs appropriate? YES?NO
   If no, please describe ....
   ....
7. Are the signs appropriately constructed? YES/NO
   If no, please describe ....
   ....
8. Are there any gaps in the signing scheme? YES/NO
   If no, please describe ....
   ....

When YES can be answered for questions 1, 2, 3, 4, 5, 6 and 7 and NO for question 8.

Auditor
Signature:..
Name: ....
Date: ....

Operations Manager
Signature:..
Name: ....

Date:

Source: Based on VicRoads (2001).

5.9 Schemes for Parking Signs on Roads

The *Guide to Traffic Management Part 11* (Austroads 2020g) provides information on parking policy, surveys and guidelines for on-street and off-street parking. This includes guidance on the size of parking bays, but designers should be aware that council planning schemes often provide for different dimensions for parking spaces.

The design and use of parking control signs is covered in detail in AS 1742.11. This standard provides detailed information on:

- types of parking signs
- the layout of the faces of parking signs, priority and arrangement of panels
- permissible forms of information presented on the sign face
- sizes of legends and symbols
- orientation of parking signs at the edge of the road (i.e. not parallel to the kerb)
- longitudinal placement and spacing between signs
- mounting heights
- the need for reflectorisation or illumination of the sign.

Parking fines are an emotive issue within the community and it is therefore essential for traffic engineering practitioners to ensure that parking control signs are designed and installed in accordance with the standards, so that the messages on various panels are clear and not contradictory, and the physical and temporal limits of restrictions are clear.

In designing area parking control schemes under the road rules, a sufficient number of intermediate signs should be provided within the area to give visitors reasonable advice on the restrictions that apply.

Strategies for parking schemes along a road, a route or throughout an area should desirably provide for:

- short, medium and long-term parking depending on the nature of abutting land use
- loading zones to suit different types of delivery vehicles
- special zones for buses, taxis and other uses
- disabled persons parking spaces
- adherence to statutory limits (unless the nature of the road permits a lesser distance that does not compromise sight distances from side streets)
- no stopping areas on the approaches to intersections, commensurate with operational and capacity requirements
- clearways and tow-away zones to overlay parking restrictions that apply to other periods.

Depending on the nature of the parking area, the following Australian/New Zealand Standards may also be relevant:

- AS/NZS 2890.1 Parking facilities: off-street car parking
- AS/NZS 2890.2 Parking facilities: off-street commercial vehicle facilities
- AS/NZS 2890.5 Parking facilities: on-street car parking.

5.10 Signs and Markings for Local Area Traffic Management

Local area traffic management is covered in detail in the *Guide to Traffic Management Part 8* (Austroads 2020e). AS 1742.13 also provides information on types of devices, the application of signs and markings to the devices and an illustration of the standard signs and pavement markings.

A particular issue in local areas is the damage sustained by signs on small traffic islands (e.g. *keep left* signs on splitter islands at roundabouts and other intersections). These signs are often not critical and may be omitted provided that the island outline is clearly visible under all conditions.

5.11 Signs and Markings for Roadworks and Temporary Situations

Signs are used at roadworks to warn road users of temporary hazardous conditions which, if not attended to, may create a danger to traffic or place road workers at risk from passing traffic.

Standard signs and the principles to be followed in their use are given in AS 1742.3 (which is currently being updated with an expected completion date of 2017) and in the New Zealand *Code of Practice for Temporary Traffic Management*, CoPTTM (NZ Transport Agency 2012). While the setting out and removal of signs at roadwork sites should be undertaken in accordance with the standards, supplementary guidance is provided below.

The philosophy is that road users should be given a general warning in advance of works activity and then be positively guided through, around or past the worksite in an appropriate and safe manner by means of specified delineation devices.

Prior planning of the procedure to be used for works on the road should minimise interference to traffic. Proper provision for the measurement of traffic should always be made and sometimes it will be necessary to inform the public of a traffic diversion, including dates and times (perhaps using variable message signs as described in Section 7). Roadworks and openings in the road surface should at all times be effectively fenced and shielded.

On complex construction works, where traffic routes are often relocated for different stages of the work, a series of traffic management plans should be prepared to cater for each stage. The services of a suitably qualified traffic engineer may be necessary in such cases.

At sites affected by roadworks or major events, the information on permanent regulatory, warning, guide, or community information signs may also be affected. It is imperative that the information provided to drivers on permanent and temporary signs does not conflict. For example, if a side street leading to a community centre is being closed and traffic detoured, it is important that direction signs to the centre are amended to conform to the temporary arrangement. This may involve relocation, removal, covering, or temporary alteration of permanent signs.

Traffic control signs and devices at roadwork sites should be installed in the following order:

- warning and regulatory signs in the advance warning area
- all intermediate warning and regulatory signs and devices required in advance of the taper or start of the work area
- all delineating devices required to form the taper including the illuminated flashing arrow sign at the end of the taper where required
- delineation of the work area or a side track
- all other required warning and regulatory signs including termination and end of temporary speed zone signs.

Once the signs are erected personnel involved in the installation of traffic control signs and devices at roadwork sites should:

- inspect the work zone by performing a drive-through inspection and document the observations and correct any deficiencies
- observe motorists driving through the work zone to look for trends in motorist difficulty in manoeuvring through the work zone.

A work vehicle with a flashing arrow or flashing lights must be utilised during the installation of the signs and devices, and positioned between the workers and approaching traffic during the placement of traffic control devices. The work vehicle must travel in the direction of normal traffic flow. Signs and devices that are erected before they are required should be covered so the sign message cannot be seen by road users and the cover removed immediately prior to the commencement of work.

Traffic control signs and devices should be removed in the reverse order as they were erected, starting from the work area and moving out towards the approaches. The delineating devices such as cones and bollards should be removed by positioning a work vehicle between the workers and the approaching traffic and slowly reversing along the closed roadway allowing workers to remove the traffic control devices. Placing an 'advance warning vehicle' between the workers and the approaching traffic should be considered when removing barrier boards from lane closures.

At sites where it is difficult to install and remove traffic control signs and devices due to traffic conditions, traffic volume, shoulder width or road alignment, alternative traffic management plans must be developed to complement the general principles of the installation, and removal of these signs and devices should be given consideration to maintain worker safety.

In some situations, vehicles may be required to move in a forward direction and signs and devices removed in the same order as they were installed. In this situation, care needs to be taken to ensure the safety of workers and approaching road users.

Special consideration is required for the installation and removal of detour routes with the following steps recommended:

- Step 1: install the last sign that vehicles will see (that is the sign at the end of the detour).
- Step 2: install the remaining signs working back towards the beginning of the detour. This procedure allows vehicles to detour only after all the signs are in place.

Alternatively, the signs can be placed one by one and covered until ready for use, where they are uncovered in the above sequence. Works supervisors should drive the detour route to ensure it is suitable for the expected traffic volume and type of vehicles to be detoured. Removal should be undertaken in the following steps:

- Step 1: remove the sign at the beginning of the detour route.
- Step 2: remove all other signs in the direction of the flow of traffic.

5.11.1 Pedestrian Facilities at Roadworks and Building Construction Sites

Roadworks and building construction sites often interfere with the free movement of pedestrians, causing them to be diverted from their usual path, and even onto the carriageway.

Safe practices relating to building and construction sites are generally covered in workplace, health and safety Acts or Regulations and these must be followed. For roadworks, AS 1742.3 and associated variations adopted by states and territories should also be referred to.

Obstructions on the footway (including construction materials and plant) must be well guarded by continuous barriers, with the addition of lamps by night. Where pedestrians are diverted onto the carriageway, the temporary route should be defined clearly to both drivers and pedestrians by continuous barriers. People with sight impairments require solid barriers at a low level for detection; accordingly, free-standing handrails with a rigid bar close to the walkway should be provided. Such solid barriers should be placed at least 1.0 m from the works where practical. All barriers should be free of projections or appendages which could be hazards to pedestrians. Flexible barriers such as those provided by chains, ropes or plastic strips are less favoured as they provide no support should someone fall into them and people with sight impairments find them difficult to detect. Where a temporary footway is provided, its surface must be of an adequate standard and free from loose materials.

Where pedestrians are diverted across the carriageway, adequate provision must be made for the resulting pedestrian flows. Use may be made of a nearby set of traffic signals through appropriate signs or, in some cases, temporary signals (i.e. non-permanent installations which may be installed in a drum or other temporary structure and incorporate pedestrian traffic signal elements – e.g. push button – as opposed to being permanently installed or erected on a portable installation such as a small trailer). It should be recognised, however, that many people will be reluctant to cross or not realise the need to cross the road to avoid temporary works; any pedestrian diversion should be well designed and appropriately signed and marked to improve the confidence of pedestrians to use it.

The types of barriers and protection used at temporary work sites will depend on the length of time that they are needed. At roadwork sites which disrupt pedestrians for only a few hours, a limited amount of protection will be needed. At a construction site for a multi-storey building, the protection may be required for several months and in this case, the temporary pedestrian footpaths provided should be made to basically the same standard as a permanent footpath.

6. Traffic Signs

Effective traffic signs are an important part of traffic management systems, and are a fundamental requirement for the safe and efficient use of roads. A key concept of a Safe System, is self-explaining roads (i.e. roads that are predictable and designed to elicit road user behaviours, including speed, that are appropriate and safe for the intended function and use of the road). A self-explaining road should only require a minimum amount of signing: limited to that which is essential for the regulation and guidance of road users. Ideally, no warning signs would be required.

Traffic signs are used to communicate a variety of information to road users and this is achieved through a combination of visual effects involving a message displayed on a distinctive signboard shape, background colour and brightness. The message may be in words, numerals, symbols, diagrams or a combination of these components. This section deals with static signs that are generally formed by applying a retroreflective sign face material to a signboard, usually a thin plate of aluminium. Electronic signs including variable message signs are discussed in Section 7.

Effective and efficient communication with drivers and other road users will enhance road user safety. The objective is to minimise the cognitive workload (particularly in complex situations), avoid distraction and minimise processing and response times. To achieve this, signs must be:

- Legible
- Positioned appropriately (both longitudinally and laterally)
- Consistent (with other signs and the road environment)
- Concise
- Relevant

These requirements are discussed in more detail throughout this section.

Standard sign shapes and colours, and typical usage of various types of signs, are discussed in AS 1742. A comprehensive index of current standard signs is contained in AS 1742.1. In New Zealand the basic references are the Land Transport Rules and *MOTSAM*. Where possible, New Zealand adopts Australian policies for the use of signs, however there may be some differences with respect to size, shape and colour.

To assist effective traffic control and road safety, it is essential that signs are used in accordance with standard practice. The application of individual signs is not given in this Guide and advice should be sought in AS 1742 and in jurisdictional guidelines.

Used appropriately, road signs can be a very cost-effective means of managing traffic. AS 1742.2 and other Guides outline general principles that enable signs, markings and devices to achieve the purposes for which they are designed and installed. However, it is incumbent on traffic engineers and designers to consider carefully the application of signs, and combinations of signs, in any given situation, rather than simply following basic guidance. Regardless of whether guidelines and warrants are met, designers should assess the need for a new (standard) sign and consider whether:

- drivers will be overloaded with excessive information at the site
- drivers are likely to notice, appreciate and act on the message
- existing devices are needed or should be removed or relocated
- the problem or situation can be reasonably addressed by erecting a sign
- alteration to the road layout is necessary.

6.1 Development of New Signs

At times, to address a recurring problem, road agencies identify a need for a new sign because no suitable sign appears in the list of standard signs. The development of a new sign should only proceed after assessment of the underlying problem and consideration of options that might align more closely with Safe System objectives. Application of the Safe System Assessment Framework (Austroads, 2016b) can be used to assess alignment with the Safe System.

The principles for designing and testing effective traffic signs (Donald 1995) are:

- Any new traffic signs should be designed and tested according to the relevant Australian Standards (e.g. AS 1742 *Parts 1* and *2*, AS 1743, AS 1744 and AS 2342).
- There must be valid reasons provided before any new traffic sign is developed.
- It is important to maintain consistent signing methods to assist drivers in their driving task.
- The issue of mandatory versus prohibitory messages must be considered on a case-by-case basis. Although no universal prescription can be made, the simpler option is generally best.
- Symbolic signs are preferable where an effective symbol can be developed, due to increased legibility distance. However, complex messages are more effectively conveyed by text signs.
- The use of abstract symbols should be kept to a minimum and, when used, they should have a text component as well.
- The use of highly stylised pictorial symbols should be avoided, as drivers often do not comprehend them in the way the sign designer envisages. As it is difficult to predict in advance what form of symbolic sign will be well understood by users, it is preferable to develop a number of signs (for testing) which vary in their image content.
- It is important to test a number of attributes (e.g. legibility distance, comprehension, etc.) when considering the effectiveness of signs.
- Testing should be carried out with a group of subjects that is broadly representative of the driving population.
- It is important to consider whether testing should be carried out in situ or in isolation.
- When testing traffic signs, open-ended questions are preferable, with the tester recording word for word any unusual answers not already shown coded on the interviewer's answer sheet.
- It is important to avoid introducing a new sign only because it had the best performance in the testing phase. It may be the case that no sign performs well enough to be implemented.
- The process of how new signs are to be introduced, including the extent and form of user education, always needs to be considered and managed carefully.

6.2 Types of Signs

Road signs are provided to regulate, warn, guide and inform road users, or to manage traffic at roadworks or in other temporary situations. The signs and their use are standardised so that drivers are presented with signs and messages that are applied uniformly in similar situations. AS 1742.1 provides a useful index of the most common road signs, a summary of standard sign numbers, sizes, shapes and colours, and cross-references to the relevant Parts of AS 1742 for each sign.

The standards also provide a range of signs relating to particular road user groups including bicyclists, pedestrians, people with a disability, buses, trams and trucks.

6.2.1 Regulatory Signs

Purpose

The purpose of regulatory signs is to inform motorists of statutory requirements, for example, priority at intersections, speed limits, prohibition of vehicle movements at intersections, and control of standing or parking of vehicles. As regulatory signs communicate statutory requirements to the road user, they must be sited and maintained so as to give the driver, or other applicable road user, every opportunity to obey the law or instruction.

Regulatory signs derive their legal status from traffic regulations within the relevant jurisdiction and are generally based on the national road rules (Australian Road Rules 2012 or New Zealand Land Transport Rules). Schedules within these documents provide illustrations of regulatory signs that relate to the rules.

Some regulations may apply to a considerable length of road and repeater signs may be required at specified distances as a reminder to drivers using the route or to inform drivers joining the route. This is particularly necessary in the case of speed restriction signs. However, unnecessary signs should be avoided if the situation can be adequately catered for by the road rules.

Location

The location of regulatory signs varies with the purpose of the sign. Some can be placed well before the point where action is required while others are required to be erected at the point where the traffic law or regulation applies.

Situations where *stop, give-way* or *roundabout* signs should be erected on both sides of the approach lanes facing approaching traffic include:

- wide one-way carriageways
- approaches to multi-lane roundabouts
- situations where a sign located on the left would not be conspicuous to approaching drivers (e.g. because of excessive lateral displacement or vegetation) in which case a sign may also be located on a splitter island in the centre of the road.

The use of a *stop sign* or a *give-way* sign is dependent on the available sight lines on the relevant approach. It is important that *stop* signs are installed only where they meet warrants, as inappropriate use of *stop* signs can cause disrespect for the sign and the law requiring drivers to stop (refer to AS 1742.2 for warrants).

The location of other types of regulatory signs varies and guidance is provided in the relevant parts of AS 1742. For example, speed restriction signs are generally erected on both sides of carriageways on divided arterial roads. Regulatory signs may be located on the right side of carriageways if that location provides a better result for drivers (e.g. restricted use of the right lane for some special purpose such as a transit lane). In addition, if a sign relates to a particular lane it may be preferable to locate the sign above the lane.

6.2.2 Warning Signs

Purpose

Warning signs are used to alert drivers to hazardous or potentially hazardous conditions that may not be apparent or discernible owing to road geometry or environmental conditions. Warning signs advise the driver and other road users of conditions that require caution and possibly a reduction in speed for their own safety and that of other drivers, pedestrians and bicyclists. They may also be used as an advance warning of another traffic control device (e.g. pedestrian crossing, *stop* sign, and traffic signals) where visibility of the device is severely restricted.

Warning signs are generally diamond shaped and have a black legend, symbol, and border on a yellow background.

It is important that warning signs be used only where the potential hazard is not obvious to an approaching driver, as improper use leads to reduced effectiveness of warning signs generally.

Location

A warning sign should generally be erected on the left side of the carriageway and be positioned so that it will convey its message effectively without restricting lateral clearance or sight distance. If considered necessary, the sign or a duplicate sign may be erected on the right side of the carriageway. Situations requiring a duplicate sign may include:

- one-way carriageways, either as part of a one-way system or divided road
- roads where an important sign on the left may be frequently obscured by large vehicles (e.g. two-way multi-lane roads, overtaking lanes)
- two-way two-lane roads to form a gateway treatment where a high level of visual impact is required.

Warning signs should be placed at a point where legibility is achieved in sufficient time for the driver to respond to the warning. This time includes that required to read the sign, react to it, and safely decelerate to an appropriate speed or stop. If a greater legibility distance or improved visual impact is required, a larger sign with correspondingly larger symbols or legend should be used. Advice on the longitudinal location of warning signs for various standard treatments is given in AS 1742.2.

In some instances, it may be necessary to install warning signs fitted with advance warning signals (Section 10.5.1).

6.2.3 Guide Signs

Purpose

Guide signs are used to guide motorists by providing information on the direction and/or distance to destinations on the route to be followed or along other roads that intersect the route. They also give directions to roadside services such as rest areas, camping facilities, parking areas and tourist facilities. AS 1742 adopts the following system of naming guide signs:

- advance direction (AS 1742.15)
- intersection direction (AS 1742.15)
- finger boards (AS 1742.15)
- reassurance direction (AS 1742.15)
- motorway guide (AS 1742.15)
- street name (AS 1742.5)
- community facility name (AS 1742.5)
- services (AS 1742.6)
- tourist (AS 1742.6)
- route markers (AS 1742.15)
- kilometre posts (AS 1742.2).

Advance direction signs allow drivers time to select a route prior to entering an intersection. Intersection direction signs (position signs) are used to confirm the route to be taken out of an intersection, while reassurance direction signs are located beyond the intersection to reassure drivers that the correct choice has been made, and to provide distances to destinations along the route. All three types of direction sign are normally used on important roads, and advance direction and reassurance direction signs are often not provided on roads of lesser importance.

The design of guide signs needs careful consideration as they must be sufficiently legible and large enough for drivers to read them from vehicles moving at high speed, often in high-volume, multi-lane situations where lane changing, merging and weaving may be involved. Their distinctive feature is that they incorporate directional information such as route numbers, destinations, traffic instructions (e.g. *left lane, exit 1 km)* and directional arrows or lane arrows. The information must be placed in a defined sequence to guide the motorist approaching each intersection or motorway exit. They are often large and are generally located at standard distances from intersections or motorway exits.

Route numbering supplements direction signing as an additional aid to navigation by assigning numbers to roads that have significance as through routes. The principles and design of route numbering are fully described in AS 1742.15. It is most important that route numbers be displayed repeatedly and frequently so that drivers will be reassured that they are following the desired route. In several jurisdictions route numbering is changing from a system based on numbers within shields to an alpha-numeric system. For the purposes of route numbering, the new system classifies a route according to the function it performs. Routes are designated A, B, or C depending on the functional hierarchy, A being the most important arterial roads. An M designation may be substituted for the A route classification for urban and rural motorways. B and C arterial routes are therefore arterial routes of lesser importance. Not all jurisdictions use C routes. A unique number is provided for each road within each designation.

Location

The principles relating to the location of guide signs include:

- Advance direction signs should be located far enough in advance of an intersection so that drivers have enough time to read the sign, react to the sign and safely respond (e.g. decelerate, change lanes or stop).
- Intersection direction signs should be located to provide clear direction to the turning point and path to be taken by drivers.
- Reassurance direction signs should be located at a sufficient distance beyond intersections to enable drivers time to deal with potential conflicts and tasks associated with the intersection, and to comprehend the information on the sign.
- All guide signs should be located so that they do not impede the sight distances required for all traffic movements within intersections, and do not obscure pedestrians using intersections.

AS 1742.15 advises that guide signs should not normally be erected in medians unless:

- they have special relevance to traffic travelling in the right lane
- in special cases a sign is required to supplement a similar sign on the left
- they are unable to be mounted on the left (e.g. urban situations with roadside development and a wide median).

It may also be acceptable to erect guide signs in medians where the median width is sufficient enough to not require protection of the sign or where suitable protection can be provided.

Guide signs may be located in traffic islands provided that they do not impede pedestrian movements or interfere with a driver’s sight lines.

6.2.4 Other Signs and Markings

Other signs and markings include chevron alignment markers and diagonal chevron markings.

Chevron alignment markers

Chevron alignment markers should be used to augment the delineation of substandard curves wherever an engineering assessment indicates that other prescribed or recommended delineation by means of pavement markings and post delineators is insufficient to delineate the curve adequately. Chevron alignment markers should not be used unless these other devices are also in place. AS 1742.2 provides details and standards in relation to the use of chevron alignment markers. They should be reserved exclusively for curve delineation, and should not be used for the delineation of islands or other obstructions, or for any other purpose.

Diagonal and chevron markings

Wide diagonal or chevron markings may be applied to areas of pavement that are not intended for use by moving vehicles. They define splayed island approaches to obstructions, sealed shoulders, painted islands and medians and areas separating exit ramps from the motorway carriageway. They are also used to indicate escape areas, if required.

Diagonal markings are used when all traffic must pass to one side of the marking. Chevron markings are used when traffic may pass to either side of the marking. These include markings on splayed approaches, diagonal markings on shoulders and flush islands and medians.

AS 1742.2 provides details and standards for the use of the above markings.

In New Zealand these markings are used for similar purposes but where wide diagonal lines are marked as part of right-turn bays and flush medians the areas are permitted to be used by turning drivers only.

6.3 Design of Sign Faces

6.3.1 General

AS 1743 is intended to be used for the design and manufacture of standard road signs that generally fall into two broad categories, namely:

- signs for which a complete graphic design is preset or substantially preset (e.g. regulatory and warning signs)
- signs where varying information within a standardised style requires each sign to be ‘made to measure’ (e.g. direction, services and tourist signs).

In addition, there is an occasional need for a new standard sign, or a sign that is unique to a particular site or situation, to be designed. In such cases the principles and design guidelines contained in all relevant standards are to be applied.

Signs must be designed to be conspicuous and easily read by approaching drivers. Conspicuity refers to the ease with which a sign is first noticed and detected. It depends on the sign’s luminance, contrast ratio, size, and its location relative to a driver’s line of sight. In addition to a sign being visible and detectable, the sign message must also be legible; that is, sufficient detail within the sign must be visible at a given distance and in a given time period. A driver must also be able to comprehend the intended meaning of the message.

Signs can be literal (e.g. *keep left*) or symbolic. Symbolic signs have become more important as their use has increased. They increase conspicuity and legibility due to the use of larger sign elements and have the potential for overcoming problems associated with illiterate drivers, or drivers not familiar with the local language. More detail in a symbol may allow the sign to be better understood, but greater detail also reduces the legibility distance.

The legend used on road signs in Australia and New Zealand must be in the English language. Information on signs is not to be duplicated in another language, as it is not practicable to accede to all such requests from the community. The replication of information in multiple languages would lead to confusing and ineffective signs that have excessive information. Notwithstanding this restriction, jurisdictions may display Australian aboriginal names, or Maori names in New Zealand, instead of the English name for destinations, places or other geographic features. Proposed names may need to be subjected to a specific approval process within jurisdictions.

6.3.2 Numbering of Signs

AS 1742.1 and AS 1743 provide a numbering system for road signs that enables ease of identification for practitioners and also facilitates the correct ordering and supply of signs, particularly those with preset graphics. Practitioners in New Zealand should refer to *MOTSAM*.

6.3.3 Colour of Signs

The use of various colours must comply with those specified in AS 1742.1 and AS 1743. Except for the distinctive shape of some critical regulatory signs (e.g. octagonal *stop* signs) and warning signs (diamond shape), colour is the most important characteristic that enables early driver recognition of signs. It is most important that the colour of road signs complies with Australian Standards. The standard colours for non-reflective road signs are given in AS 2700. The colours of retroreflective sign face material must conform to the requirements specified in AS/NZS 1906.1.

Some road agencies have installed signs that extend the use of colour beyond that prescribed in AS/NZS 1906.1. This often involves the use of red, green or yellow as a backing board to improve the conspicuity of the sign against its locational background, usually at hazardous or potentially hazardous sites. An example is shown in Figure 6.1. Some road agencies such as NZTA do not permit red backgrounds or backing boards as they are reserved for specific signs such as the *Wrong Way* signs at motorway off-ramps or for the railway level crossing signs at high-risk railway level crossings. Practitioners should refer to their own jurisdiction’s signage guidelines before considering the use of colour for backing boards.

Figure 6.1: Red background used to emphasise a potential hazard

Fluorescent colours

Australasian road agencies use fluorescent sheeting material to improve the conspicuity of particular signs that are considered critical for road safety for vulnerable groups (e.g. fluorescent yellow-green is used for warning signs relating to pedestrians and pedestrian crossings).

In some cases contrasting fluorescent material may be used as a target board or border to further improve the conspicuity of warning or important guide signs, or as a legend on particular types of sign; however, such use requires the specific approval of the relevant road agency.

The use of fluorescent colours has now been uniformly adopted and is specified in AS 1742.1 for the following uses:

- Fluorescent orange – used as a background colour for roadwork signs that relate to people working on the road, for children crossing flags and the hand stop banner for use at a children's crossing.
- Fluorescent yellow – used as a background colour in lieu of yellow for roadwork signs, route numbers on direction signs and other specified hazard signs.
- Fluorescent yellow-green – used in lieu of yellow as a background colour for regulatory and warning signs for the protection of pedestrians.

Further advice on the use of fluorescent colours is given in Section 6.4.1.

6.3.4 Standard Signs (Pre-set Graphics)

These signs include the standard signs listed in AS 1742.1 that are also shown in other parts of AS 1742. Standard drawings for these signs are provided in AS 1743. The designs in AS 1743 can be used to manually produce a drawing of the required size sign, or electronic files of the signs can be obtained from Standards Australia. This may be necessary where specific inscriptions are allowed under the Australian Road Rules or site-specific information (e.g. limits and times on parking signs) needs to be added. However, many of these signs are manufactured using computer aided design tools.

6.3.5 'Made-to-measure' Signs

General

These signs are generally those direction signs that have site-specific information on them, usually route numbers, destinations and road names. Each sign is separately drafted in accordance with the principles provided in AS 1743, usually using a computer program. The signs include large guide signs used for major arterial intersections and motorways. The design of the signs can be challenging in order to develop a sign face design that meets basic design rules (e.g. information not excessive), provides coherent guidance and results in an efficient use of space.

Examples of each numbered sign type are shown in the AS 1743 drawings. The model layout shown for the selected sign function, together with any specific layout requirements or restrictions shown on the drawing should be followed as closely as possible. However, complex road layouts and geometry will necessitate that designers carefully consider the information provided on signs to ensure consistency with the road and linemarkings, and other signs provided in advance of or beyond the sign being designed. Complex situations may require a series of signs to convey the necessary information to drivers.

Design principles

The rules and model drawings in AS 1743 should be used as a basis for the design of sign faces for made-to-measure (or special) signs. Individual drawings are necessary for the production of these signs and the drawings must show all critical information and dimensions necessary for manufacture.

An example of a sign face design for a direction sign is shown in Figure 6.2 . It should be noted that design and drawing details may vary between states and territories.

Designers should be aware that even when all the design rules are obeyed, a sign may not look well balanced and adjustments may have to be made to sign elements such as spacings and arrow types to achieve a satisfactory appearance. The following points should be noted when arranging information on a sign face:

- Cramping of the legend is to be avoided.
- Large areas of blank sign face should be avoided, particularly blank areas that are not symmetrical across the sign face, unless a directional enhancement is being sought.
- If there are two lists side by side (e.g. on a reassurance sign), the left list should be left justified and the right list should be right justified.
- Destinations on reassurance signs should be listed in the order that they would be reached by a driver along the route.
- Elements such as arrows and symbols may sometimes have to be larger than the accompanying principal legend would normally require (e.g. where the element relates to several lines of legend).

The amount of legend on guide signs must be limited so that they can be read during the brief time drivers can divert their attention from the driving task. The principal legend on motorway guide signs should be limited to three lines on roadside signs and two lines on overhead signs. The principal legend does not include symbols, exit instructions, and cardinal directions, which can make up other lines within reasonable limits. Examples are provided in AS 1742.15.

Figure 6.2: An example of a drawing for a made-to-measure intersection direction sign (G2-1)

Source: VicRoads (personal communication 2016).

The information on direction signs may be displayed as words and/or symbols as in 'stack' type direction signs, or in diagrammatic form. The latter is commonly used at roundabouts, closely spaced intersections or motorway exits, or other sites where the provision of a diagrammatic representation of the intersection layout may be an advantage. Diagrammatic type signs generally have shorter reading time and are more easily interpreted than stack type signs, but usually require larger signboards.

6.3.6 Standard Alphabets for Road Signs

Practitioners should refer to AS 1744 for the standard alphabet to be used on road signs. The purpose of the standard alphabet as defined by AS 1744 is to establish uniformity in the forms and dimensions of letters, numerals and symbol characters. AS 1744 specifies the forms and sizes of letters, numerals and text symbols along with the spacing between them. These alphabets are intended specifically but not exclusively for use with the standard road signs in AS 1743.

6.3.7 Letter Size and Legibility

The various parts of AS 1742 list the sizes of standard signs (e.g. regulatory or warning signs) that are available. The size of the sign is determined by the size of the legend and symbols that, in turn, may be determined by the:

- legibility requirements for a particular traffic speed environment
- width of road and lateral offset to the sign
- ability to accommodate a sign at constrained or difficult urban sites.

The variety of legends used on direction signs generally precludes the adoption of standard sign sizes. The size adopted will depend on the letter height selected, the number of words in the legend, symbols used, and the general arrangement. AS 1742.15 provides a tabular guide to the minimum legend sizes required for various types of direction signs on non-motorway roads and for motorway signs. However, it is recommended that relevant road agency guidelines be consulted as they may specify letter heights for particular situations or types of road that vary from Australian Standards noting that the level of retroreflectivity, letter series and letter height all have a significant effect on legibility.

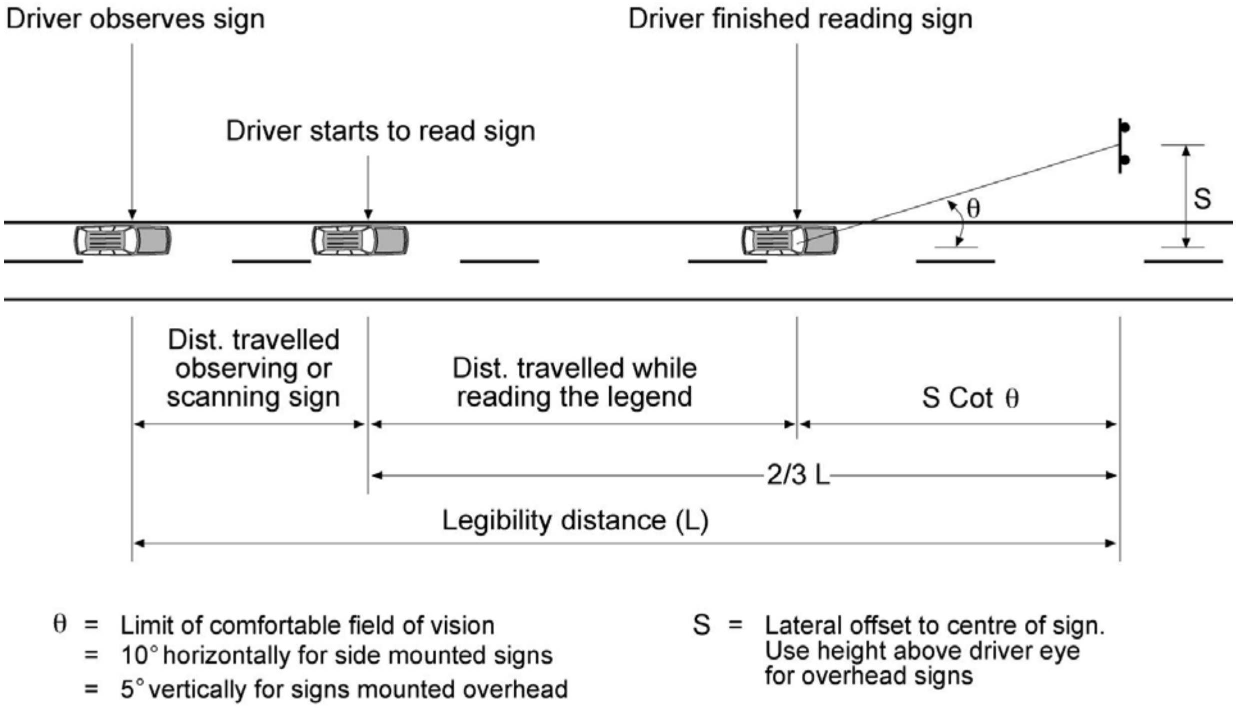
At locations where the background and surroundings to the sign have a large amount of material that would make the sign difficult to see (e.g. urban areas with illuminated advertising signs, shop fronts or other lights) a larger legend and sign may be used at the discretion of the designer. In addition, larger signs are required where they are located overhead or on high-speed roads.

It is sometimes necessary to establish the legibility distance of a legend from first principles. Instances that require this may include:

- the design of a completely new sign
- demonstration that a particular sign is located a sufficient distance from a hazard.

The procedure for determining the legibility distance required of a traffic sign can be represented diagrammatically as shown in Table 6.3. This arrangement assumes that the driver does not start to read the information on the sign until sometime after the letters first become legible. This is generally considered to be at a distance equivalent of two-thirds of the legibility distance from the sign.

Figure 6.3: Sign legibility distance



The distance travelled while reading the legend or while locating a place name on a sign is dependent on the form of the legend (e.g. words in vertical stack or diagrammatic arrangement) and the number of words to be read. Research at Melbourne University (Jacobs & Cole 1978) indicates that:

- the time taken by average observers to correctly read a sign involving two to eight words is given by:

$$t = 0.32N - 0.21 \text{ seconds} \qquad 1$$

where

N = the number of words on the sign

- the time taken to locate a place name (seven letters) on a sign comprised of a vertical stack of up to eight words (as in a reassurance direction sign) is given by:

$$t = 0.25N \text{ seconds} \qquad 2$$

where

N = the number of words on the sign

The research indicates little practical difference in the above two values of *t* for signs containing up to five words (a generally accepted practical limit for most signs). Thus, for most general purposes the time taken to read a sign (of up to five words) may be taken as given in Equation 2

The distance travelled while reading the sign is therefore given by:

$$tv = 0.25Nv \qquad 3$$

where

v = the speed in metres per second

It is generally accepted that the normal range of lateral vision should be limited to 10° horizontally and 5° vertically. This minimises the driver's head and eye movement from the travel path ahead. Thus, as a driver approaches a sign, the reading of the legend should be completed before the centre of the sign subtends these angles at the driver's eye. These angles give values of cot θ (in Figure 6.3) of 5.7 and 11.4 for angles of 10° and 5° respectively.

Using the above relationships and values, Figure 6.3 shows that the total legibility distance of a sign is given by:

$$\frac{2}{3}L = 0.25Nv + S\,cot\,\theta \text{ and therefore}$$

$$L = 0.105NV + 8.55S \text{ for side} - \text{mounted sign, and} \qquad 4$$

$$L = 0.105NV + 17.1S \text{ for a sign mounted overhead} \qquad 5$$

where

L	=	legibility distance required (metres)
N	=	number of words on the sign (for two to five words)
v	=	travel speed of vehicles approaching the sign in m/s
V	=	travel speed of vehicles approaching the sign in km/h. V is usually taken as 60 km/h for urban areas, 70 km/h for semi-urban areas and 80–100 km/h for rural areas
S	=	lateral or vertical displacement of the centre of the sign from the centre of the traffic lane, or above the driver eye height, for side or overhead-mounted signs respectively

The legibility distances for letters of the standard sign alphabets detailed in AS 1744 have been determined for the average observer with normal (or corrected) vision as shown in Table 6.1. Thus, the required letter height H (in mm) for words on a side (laterally) mounted advance direction sign (modified E series) is given by:

$$H = \frac{0.105NV + 8.55S}{0.75} \text{ and therefore}$$

$$H = 0.14NV + 11.4S \qquad 6$$

where

N	=	number of words on the sign
V	=	travel speed in km/h
S	=	lateral offset of the sign (measured from the centre of the sign to the centre of the traffic lane)

This is the initial capital letter height and the lower-case letters are always 75% of the height of the initial capital letter. Equation 6 relates to the modified E series alphabet due to the 0.75 divisor.

It should be noted that the modified E series alphabet, which is specifically used for lower-case lettering on direction signs, has a stroke width of one-fifth of the letter height and the legibility of the lower-case words is the same as that of the initial capital letter (for further details refer to AS 1744).

Table 6.1: Legibility distance of letters

Alphabet series	Legibility distance (m) per mm of capital letter height
C	0.5
D	0.6
E	0.65
Modified E (and lower-case)	0.75

The required letter height for other letter series and sign situations may be determined from Equation 6 by applying the following adjustment factors to the formula:

- For other letter series, increase H by 7% for Series E, 25% for Series D, and 50% for Series C.
- To compensate for adverse visual effects of urban areas, where advertising signs, building lights etc. reduce the conspicuity of traffic signs and drivers are often involved in complex traffic situations, increase H by 50%.
- For signs mounted overhead (i.e. where the driver's comfortable field of observation is limited to 5° vertically), the factor S in the formula must be multiplied by 2.
- Where an overhead sign is mounted at the roadside, more than 3 m from the edge of the pavement, it may be necessary to calculate the equivalent lateral distance SEL from the formula:

$$S_{EL} = [(S_L)^2 + 4(S_V)^2]^{0.5} \qquad 7$$

where

S_L = lateral offset of the sign from driver's path

S_V = vertical height of the centre of the sign above the driver's eye

The distance S_{EL} is then used in place of S in Equation 6 for H for laterally placed signs.

Further to the above guidance, Appendix B outlines guidance used by Main Roads Western Australia (MRWA) to determine the sight distance to direction sign. Practitioners may consider this guidance for application within their jurisdictions.

6.3.8 Arrows and Symbols

Arrows

Arrows are used on many direction signs to indicate directions to a destination or to indicate lanes which should be used for particular traffic movements. Direction arrows and associated legend on stack type advance direction signs are arranged in the following order, from top to bottom of a sign:

- vertically upwards for directions ahead
- angled 45° upward left or right
- horizontal left or right.

Within this order, destinations are arranged in order of increasing distances down the sign, and with direction arrows arranged so that on successive lines on the sign they are placed on alternate sides of the sign. Arrows angled upward at 45° are used on motorway exit signs to emphasise the diverging layout of motorway exit ramps. Where arrows are used to designate lane usage they should point vertically (or near vertically) downward over the required lane. However, where electronic signs are used for lane closure purposes during incident management, the arrows should be inclined at 45° away from the lane that is closed in order to indicate the need for drivers to change lanes (Section 7.6.2).

The identification and direction of arterial roads that have significance as through routes can be achieved by displaying the route number and direction of the route. Route numbers or markers in the case of tourist drives (AS 1742.6) should be located in a standard position on sign faces in relation to direction arrows and destination names.

The design and layout of arrows, chevrons and borders on traffic signs are important and AS 1743 provides details.

Symbols

The use of symbols on signs to convey all or part of a message may reduce reading time and extend legibility distance, provided that the symbol is properly designed, is simple in form, and its message is readily interpreted. Common standard symbols, such as the arrow and junction diagram, have legibility distances two to three times that of a word legend occupying comparable signboard space.

The introduction of new symbols is governed by the requirements of AS 1743, which specifies procedures for determining the need for a symbol, its design, and testing for recognition and interpretation. In general, no new symbols will be introduced for road signs, either for standard or non-standard signs, unless they have been subjected to and meet the relevant requirements of AS 1743 procedures. Notwithstanding this, some road agencies may adopt unique logos to define tourist experiences of importance (e.g. Explorers Way in South Australia and Northern Territory). These tourist initiatives are developed in partnership between road and tourism agencies and are supported by a substantial tourism program that assists in recognition of the symbol.

6.4 Sign Materials and Illumination

It is essential that road signs are able to be read under all conditions including darkness or inclement weather. This attribute depends not only on the size and design of the legend, but also on the nature of the material used for the sign face. Road sign faces are therefore usually constructed from retroreflective sheetings that render them highly visible at night. In special circumstances a sign may have internal or external lighting.

Retroreflectivity is of no benefit in the daytime or when signs are floodlit. However, in some jurisdictions all signs are required to be retroreflective. Non-retroreflective fluorescent colours have been used for backgrounds to make important signs more conspicuous in situations where sign messages are only required during daylight hours (e.g. certain signs at roadworks and children's crossings).

It is also most important that road signs have the structural integrity to perform satisfactorily throughout their design life and must therefore be constructed in accordance with road agency specifications. Road signs generally have an aluminium substrate or zinc/aluminium coated steel substrate, to which retroreflective sheeting is usually applied. These signs generally fall into one of the following categories:

- Flat sheet, permanent or temporary signs – unbraced
  - this category comprises small signs (such as standard regulatory or warning signs) but excludes any sign that has a width to height ratio in excess of 2.5 to 1 as these must be braced.
- Flat sheet, permanent or temporary signs – braced
  - this category comprises all flat sheet signs larger than unbraced signs.
- Folded box edge temporary signs
- Extruded aluminium section signs
  - this category comprises fingerboards, road/street name signs and the like made from extruded aluminium sections.

Extrude signs where sections are dovetailed together to form a sign that presents all of the necessary information are suited to situations where, over a period of time, some of the information is expected to change (e.g. tourist signs where new attractions are opened in an area or an attraction ceases to operate). In such cases a section can be simply added or removed from the sign.

Unbraced signs are bolted directly to post brackets. Braced signs have transverse stiffeners (i.e. at right angles to posts) that accommodate the post bracket fittings. The number of stiffening braces required depends on the height of the sign and the wind forces that are experienced in the area.

The size and shape proportions of signs in the Australian Standards that have preset graphics have been selected, as far as practicable, so as to achieve an economical cut from sign face sheeting and substrate material 1200 mm wide. It is strongly recommended that the same principle be applied to made-to-measure signs so that joints in both the substrate and sheeting are minimised.

Each road agency has a specification that covers detailed requirements for the manufacture of road signs, such as structural requirements and good practice for the joining of sign substrates and sign face sheeting. Supervisors of works or contracts should ensure that signs erected on roads meet the requirements of the road agency.

6.4.1 Retroreflective Materials

General

All signs that are intended to convey their message during the night need to be reflectorised (or if possible illuminated – refer below) so that they display their colours and shape and are as legible by night as they would be by day.

The ability of road signs to perform at night (without floodlighting) is dependent on the retroreflective properties of the sign face material. Retroreflection occurs when light directed from vehicle headlights onto a sign face material is directed back to the light source, enabling the reflective object to be seen by an observer located near to the light source. This enables drivers to see both the colour of the materials and read the legend, provided that adequate contrast is provided between the legend and the background. For adequate legibility, the luminance contrast ratio (luminance of legend divided by luminance of sign background) must comply with AS/NZS 1906.1. The value varies depending on the background colour and site conditions.

Reflectorisation of road signs is achieved by using retroreflective material for all parts of a sign (legend, border and background) except those parts that are black.

The effectiveness of reflective signs may be reduced by glare. This may be a surface reflection from a high-intensity streetlight or from the sun, or it may be glare from the excessive brightness of a high-class retroreflective material lit only by the vehicle headlights. Highly retroreflective backgrounds can make a legend on any sign unreadable, and on large signs the background should always be of a lesser brightness than the legend. High-class retroreflective materials with a glossy surface can suffer from surface reflections if care is not taken in their siting and orientation with respect to street lights and vehicle headlights.

In practice effective road signs are assured through proper location, adequate design such as sufficient size of sign and legend, and the use of proven sign face materials. The need for site-specific calculations is very rare but commercial computer software packages are available when the need arises.

All road signs should be reflectorised using materials conforming to AS/NZS 1906.1 and guidelines issued by the road agency. The latter sources are important as product approval and use by road agencies may precede their inclusion in Australian Standards due to a natural lag in the process of developing standards. Road agencies generally publish a list of approved sign face materials.

Classes of sign face material

AS/NZS 1906.1 specifies the performance requirements for retroreflective sheeting used in the manufacture of road signs and related traffic control devices. Practitioners should refer to AS/NZS 1906.1 along with road agency specifications for the class of retroreflective sheeting that should be used for road signs within their jurisdiction.

Non-reflective material

Non-reflective material is not used extensively. It is used for signs that apply only during daylight hours (excluding dawn and twilight times) or signs that are illuminated between dusk and dawn.

Black is the only non-reflective colour in general use. For example, it is used for legends on yellow or white background materials for warning signs and regulatory signs respectively. Before use, non-reflective materials (including fluorescent materials), paints, films or other surface coatings should be suitably evaluated for function, durability and compatibility with other materials used in the sign manufacture.

Luminous intensity reduction

It should be noted that the luminous intensity reduces with aging of sign face material and the manufacturers' guarantees are related to a specified percentage of the luminous intensity of new material being maintained at the end of the guarantee period. The performance degradation of road signs is discussed further in Section 6.6.3 in relation to maintenance.

It should be noted, however, that some material suppliers will not support their warranties if non-suitable paints or films are applied by sign manufacturers. Road agencies rarely have the capability of evaluating material of this type prior to installation and therefore require the manufacturers to provide the necessary quality assurance and warranty.

6.4.2 Illumination

Historically, illumination of overhead signs on urban motorways has been generally considered necessary. However, with recent developments in signage material this has enabled more overhead signs to be effective without external illumination, and this has resulted in significant savings through the reduction in capital and maintenance costs associated with sign lighting. Illumination is now only required where:

- ambient light or background clutter detracts from sign prominence or legibility
- there are other illuminated signs (traffic or other signs) in proximity or within the field of view
- where there is a strong background light level behind the sign (e.g. emerging from a tunnel and a sign is located at the portal facing into the tunnel).

Overhead signs on motorways and other roads are not normally illuminated unless there is a background of street lighting, advertising billboards or other extraneous lighting of such a high level that it detracts from the prominence or legibility of the sign.

Where there is any doubt as to whether illumination will be required at a later time, provision should be made in the sign structure, including 600 mm additional vertical clearance, for future installation of lamps.

Signs are always illuminated from below the lower edge using either strip or point-source lamps. Where external illumination is provided, it is important that it be as uniform as practicable over the sign face to avoid bright spots that may obscure part of the legend.

Ordinary street or highway lighting does not meet the requirements for sign illumination.

Internally illuminated road signs are not common in Australia and New Zealand. However, they may be used for exit direction signs in tunnels, and in such cases it is important to ensure adequate size and internal contrast. The limited headroom available in tunnels constrains the size of these signs and it is therefore important to consider signage in the early stages of a project when the locations of other utilities are not fixed. Internal illumination of signs may be achieved by a light within or behind the sign face illuminating the main message or symbol, or the sign background, or both, through a translucent material.

6.5 Location and Placement of Signs

6.5.1 General

An important requirement of a road sign is its visual impact or conspicuity. A satisfactory outcome is normally achieved through proper location and size of signs. The location and placement of signs involves consideration of:

- longitudinal placement
- lateral placement including clearances
- vertical clearances
- road layout, environment and topography
- orientation of the sign face relative to drivers.

A sign location will generally be satisfactory if the sign is placed within the driver's comfortable field of vision (10° either side of centre in the horizontal plane and 5° upward in the vertical plane) and has adequate legibility distance.

AS 1742.2 provides general advice on the location and placement of signs, and other parts of the standard provide information relating to specific types of sign (e.g. AS 1742.11 for parking control signs).

It is also important to establish whether a sign will perform satisfactorily if it is mounted on posts beside the road, or whether it should be mounted above the road on a cantilever, gantry or other structure.

Guide signs and other important signs (e.g. *left lane ends 300 m*) on rural arterial roads and rural motorways are usually side-mounted. Important rural interchanges that have heavy entering and exiting traffic movements, or more complex movements (e.g. semi-direct ramps or loop ramps) often are provided with overhead signs. Overhead signs are also often provided on arterial roads at the access points to motorways.

Side-mounted guide signs are satisfactory for most situations on urban arterial roads. However, overhead signs are often necessary on urban arterial roads that have a very high volume of large trucks that impede sight distance to the side-mounted signs for other drivers. They are also provided where it is impracticable to achieve satisfactory performance from a side-mounted sign (e.g. footway or median too narrow, verandas present, or obscuration by a structure or vegetation).

Because of the high volumes of general traffic and trucks on urban motorways, guide signs and other important signs are generally mounted overhead.

6.5.2 Longitudinal Placement

A road sign must be located at a position along the road where it can be related to the road feature to which it refers, and if necessary, far enough in advance of that feature to ensure that all drivers will see the sign, read it, and make a decision before reaching a point where they must act.

The distance required for a driver to see and read a sign is described in Section 6.3.7. The distance beyond the sign required for drivers to make a decision and act is related to travel speed and the nature of the action to be taken. For example, in the case of a *stop* sign a driver should quickly comprehend the sign and then have the required intersection approach sight distance to bring the vehicle to a stop (*Guide to Traffic Management Part 6* (Austroads 2020d) and *Guide to Road Design Part 4* (Austroads 2017b). On the other hand, a driver on an urban motorway may require relatively large distances in which to read and comprehend a direction sign, and subsequently undertake any necessary lane change or weaving manoeuvres.

In complex situations it is often necessary to place a number of signs along the road so that decisions and actions are taken progressively leading up to the final action. Motorway exit signs are an example of this approach, for which the standard arrangement is summarised in Table 6.2 .

In some situations, such as closely spaced intersections or interchanges, it may not be possible to accommodate the requisite 'normal' direction signs in the distance available and a large diagrammatic sign of the intersecting roads or motorway exits may be necessary. A common example of progressive signs on arterial roads is where a left lane ends and drivers are warned of the distance to the end of the lane, and finally instructed to merge right.

Table 6.2: Typical direction sign treatments at motorway interchange exits

Motorway location	Application	Signs and mounting required		
		1st advance sign	2nd advance sign	Exit direction sign
Rural	Normal application	Side-mounted at 2 km	Side-mounted at 1 km	Side-mounted at exit taper
Urban	Single-lane exit	Cantilever mounted at 1 km	Cantilever mounted at 500 m	Gantry
All locations	Two-lane exit	Cantilever mounted at 1 km	Gantry mounted at 500 m (generally start of auxiliary lane)	Gantry
All locations	Successive exits spaced at 1.2 km or less	For closely spaced motorway exits, refer to AS 1742.15		

Note: At low-volume exit ramps in the urban area (AADT< 3000) on motorways that carry a low volume of trucks, consideration may be given to side-mounted signs. This case will normally occur only on 4 lane outer urban motorways.

Source: Based on VicRoads (2001).

On urban roads the longitudinal placement of signs may be dictated by the presence of physical features such as minor intersections, driveways or shop verandas. In addition, road alignment (horizontal or vertical) may require a sign to be placed further in advance of a feature than would be the case if adequate sight lines were available.

In general, and for situations that do not have complications, the following may be used as a guide:

- For signs which give advance warning of a hazard or of a single specific action required of a driver (i.e. not involving a complex decision), the distances given for warning signs in Table 6.3 are appropriate. Within the ranges given in the table, the longitudinal location is varied according to approach speed, and to the manoeuvre likely to be required (e.g. a possible stop condition will require longer advance warning than a condition requiring minimal speed change). The range also permits some flexibility in selecting a prominent site for the sign. Further details and examples are given in AS 1742.2.
- For signs which require a simple decision to be made (e.g. a navigational decision arising from an advance direction sign), the distances in Table 6.3 may be sufficient in restricted choice situations, say where only one other route choice is available. For each additional choice or element of complexity in the decision, as a guide, the distance should be increased by the equivalent of about one second of travel time.

- For signs requiring complex decisions, such as services or tourist facility signs, a distance equivalent to about 12 seconds of travel time is normally used.

These distances may be reduced appropriately where a larger than normal sign, with increased legibility distance, is used.

The maximum distance at which any advance sign is located before a hazard or decision point should not generally exceed the equivalent of about 15 seconds of travel time, unless it is accompanied by a second advance sign. The secondary advance sign should have the same message and be located not more than about 15 seconds in advance of the hazard or decision point. In such cases a distance plate is added to the first sign, or a distance is included on the sign (e.g. motorway advance direction signs).

Table 6.3: Longitudinal location of warning signs

Road environment	A (m)			B (m)
	Must or may need to stop	Significant speed reduction required	No, low or moderate speed reduction required	
V_{85}: < 75 km/h	80–120	60–80	40–60	50
V_{85}: 75–90 km/h	120–180	80–120	60–80	60
V_{85}: > 90 km/h	180–250	120–180	80–120	70

Notes:
V_{85} = 85th percentile approach speed measured 1.5 to 2 times A in advance of hazard.
A = distance from sign to hazard (or nearest sign to hazard where there are two or more signs).
B = minimum distance between successive signs where there are two or more.

Source: AS 1742.2.

In terms of the effective presentation of information to drivers, there should not be more than one sign of a particular type on each post, except where one sign supplements another (e.g. advisory speed plates with curve warning signs) or where route or directional signs must be grouped. However, designers should be mindful of the hazard that additional poles present for motorcyclists and should seek opportunities to minimise the number of poles. Where it becomes necessary to convey two or more different messages at the one location on separate signs and supports, they should be located a minimum of 0.6 V_{85} metres apart (where V_{85} is the 85th percentile speed in km/h).

Examples showing the longitudinal location of signing arrangements are provided in figures throughout various parts of AS 1742.

6.5.3 Lateral Placement and Height

AS 1742.2 provides general guidance on minimum and maximum clearances between the edge of a traffic lane and the edge of the sign nearest the road, and on the vertical clearances required to overhead signs. Designers should also consult road agency guidelines as practices may vary among jurisdictions.

Signs are normally erected on the left side of the road but, if considered necessary, a supplementary sign may be placed on the right side to ensure that drivers who have their view of a critical sign obscured (on the left side) obscured are given every chance to read the message.

Lateral placement

A sign should be located laterally so that it:

- is as near as practicable to the edge of the carriageway consistent with minimum clearances to ensure that vehicles do not strike the sign (e.g. overhang from large turning vehicle, overhang from high vehicle on crossfall)
- meets road safety requirements (e.g. frangible supports, located beyond the clear zone or behind safety barrier)
- does not limit sight distance for drivers entering from a side road (e.g. truck drivers as they have a higher eye height than passenger vehicle drivers)
- is not an obstruction to road users, including pedestrians and bicyclists.

Guidelines for clearances to signs are illustrated in AS 1742.2 and may vary between jurisdictions. However, the following approach can be taken as a general guide to acceptable lateral offset and vertical clearance.

On unkerbed roads the nearest edge of a sign should be at least 600 mm clear of the road shoulder but should not be less than 2 m nor more than 5 m from the edge of the travelled way. On kerbed roads the edge of the sign should not be less than 300 mm or generally more than 1 m from the kerb face. Where signs are more than 5 m from the edge of the travelled way, an oversize sign may be needed to compensate for the loss of legibility and visual impact.

In rural areas and urban areas not frequented by pedestrians, the bottom edge of the sign should normally be not less than 1.5 m above the road pavement. In urban areas, to prevent obstruction to pedestrians and interference from parked vehicles, the clearance to the bottom edge of the sign should be not less than 2.0 m over verges or not less than 2.5 m over pathways. For signs erected above the roadway the clearance to the bottom edge should generally be not less than 5.3 m, but in certain locations, such as above parking lanes, consideration may be given to reducing this to 4.7 m.

Height

Where warranted (refer to AS 1742.2), signs may be located overhead on cantilevers or gantries that have sufficient vertical and lateral clearances from the running lanes so that they will not create a hazard to road users. Support structures should be located beyond the clear zone or be shielded by a suitable safety barrier. It is also most important that sign supports are not placed so as to obstruct footways, bicycle paths, shared paths or property accesses.

Gantries and cantilever supports are most commonly used on motorways but also on the normal arterial road system. When used on arterial roads the sign supports are located in accordance with the requirements in AS 1742.2.

Gantry-mounted signs may also be beneficial:

- where different restrictions over individual lanes are required to be displayed
- when side-mounted signs would be obscured for a significant proportion of a driver’s reading time
- at traffic junctions where the number of lanes reduces after the junction
- where junctions are closely spaced
- on elevated roads where it is not possible to erect side-mounted signs
- in other locations where mounting signs on the left-hand side of the road is deemed to create difficult or hazardous situations for drivers.

Gantries should be located so that signs are not obscured by bridges over roads, including motorways. The location and spacing of gantries may also be affected by local restrictions in verge or median widths. Where the location is suitable, and it is practicable, signs should preferably be mounted on the over-bridge.

6.5.4 Road Layout, Environment and Topography

The nature of the road layout, surrounding environment and topography can affect both the longitudinal and lateral placement of signs.

The presence of vegetation in either urban or rural environments that is worthy of retention may require that a sign is placed in advance of the vegetation or closer to the road than preferred. On roads that have avenues of closely spaced mature trees with substantial canopies, it is often difficult to find suitable locations for advance intersection direction signs and intersection direction signs. In some cases cantilevered supports are required to obtain satisfactory sight lines to signs.

In urban areas, particularly commercial environments, the location and/or effectiveness of signs can also be adversely affected by:

- the road design, intersection layout or presence of other infrastructure that might impede visibility of the sign (e.g. bridge over road)
- the presence of a confusing or distracting background that may include advertising signs, shop fronts, building facades or other features or activities
- verandas that prevent provision of advance direction signs
- the location of street lighting and public utility poles
- bus or tram stops and associated infrastructure
- side streets and driveways
- public utility services (water, gas, electricity) that prevent the provision of foundations for larger sign supports.

In rural, and some urban situations, topography can result in a road passing over a fill embankment or watercourse, or through a cutting that precludes the use of side-mounted signs. A similar situation arises in the case of elevated structures, tunnels or roads flanked by large retaining (or noise) walls in urban areas.

Similarly, an intersection layout (particularly complex layouts) may not be conducive to the provision of effective signs due to constraints on location (e.g. verandas over footpaths, traffic islands too small, intersections closely spaced).

The background to a sign affects its visual impact and this may differ by day and by night. The effects of sunset and sunrise on the sign, or on the driver's view of the sign, may also be factors to consider. In urban areas the effects of street lighting, advertising signs, and shop awnings may also influence the visual impact of a traffic sign.

6.5.5 Orientation of Signs

As a general principle, for the safety and convenience of road users, all signs should be orientated to face the road users for whom the message is intended. Specific examples to be noted are:

- Parking signs should be placed at an angle of 30° (plus or minus 10°) to the edge of the road (refer to AS 1742.11) to face approaching drivers and should not be placed parallel to the road.
- At median openings within intersections, *keep left* signs should be angled to face right turners from the side roads (rather than to directly face through traffic on the major road) to reduce the chance of drivers turning into the wrong carriageway.

Signs that relate to traffic approaching along a road should be erected at right angles to the direction of travel but rotated away from the driver's line of sight to reduce headlight reflection at night from the sign surface. Normally a rotation of about 5° is used. This requirement is illustrated in AS 1742.2 for both a straight alignment and a horizontal curve to the left. In the latter case the sign is orientated relative to a 200 m chord across the curve.

6.5.6 Collocation with Electronic Signs

Collocation of a lane use management system (LUMS) (LUMS comprises an electronic speed limit (ESL) and lane control signal (LCS) display – refer to Section 10.5.11), variable message signs (VMS) and/or direction signs (DS) has been widely practised overseas and in Australia and New Zealand. While triple collocation of LUMS, VMS and DS has been practised overseas, it is still relatively new to the Australian driving community. While there is no clear evidence showing that triple collocation gives rise to riskier behaviour, this proposition should be viewed with caution. Section 7.5.4 provides guidance on the collocation of LUMS, VMS and/or DS.

6.5.7 Location and Placement of Signs for Pedestrians

Signs should be placed within the normal field of vision of those for whom they apply. For a standing person, signs should be placed less than 10° above or below eye level; for a seated person, signs within 15° of eye level are acceptable. Signs mounted between 900 mm and 1.5 m from ground level provide the most appropriate compromise between the requirements of seated and standing people. However, it needs to be recognised that signs mounted at this height are more prone to vandalism and where this is prevalent a higher mounting height may be desirable.

Signs are most easily read if they directly face the direction of travel; however, signs should be placed so that they do not constitute hazards to pedestrian movement. Signs placed within 30° horizontally of the direction of travel can usually be read without requiring head movement. The sign should also be clear of pedestrians so that its placement does not adversely impact on the safe movement of pedestrians.

6.6 Maintenance

Proper maintenance is essential if signs are to remain effective and command the attention and respect of motorists and other road users for the full warranted life of the sign.

6.6.1 Performance Degradation

The materials used for traffic signs have retroreflective properties that enable them to perform adequately during the night as well as the day. However, all materials will degrade with time and there will come a point at which the external (between the sign and its background environment) and internal (between the legend and sign background material) contrasts of the sign will no longer be sufficient to enable the information to be read. The sign will then be ineffective. Invariably this will happen to the night-time performance first.

Degradation of the sign can be due to environmental factors such as:

- ultraviolet radiation
- sign location such as industrial environments which may have the greatest adverse effect on the sign, followed by coastal and then residential environments
- amount of dirt accumulation
- weathering due to variations between day and night temperatures.

Sign degradation impacts on the retroreflectivity of traffic signs. It is important that road agencies monitor the performance of signs and replace them when they are no longer reasonably readable in all conditions.

6.6.2 Inspection

All signs and devices require regular inspection (day and night) to ensure that:

- they have not become obscured or partly obscured by tree growth or tall grass, or by man-made obstructions such as poles, traffic signals, etc. installed since the sign was erected
- each sign or device is in good physical condition and does not require replacement due to age or damage, or repair of bullet holes or other damage

- each sign is performing the function and conveying the message that was originally required both by day and at night under vehicle headlights or other lighting
- the function of the sign or the message to the road user is still relevant, and there is not a need for an updated sign or device
- signs and devices are being cleaned by maintenance crews sufficiently often
- supporting structures are in sound condition and fittings are secure
- signs are oriented correctly to face the appropriate traffic stream
- outdated signs are removed or replaced.

6.6.3 Routine Maintenance

For maximum performance, signs should be kept clean and free from dirt, road tar, oil, bituminous material and mulch. Primarily this means cleaning the surface of the reflective sheeting as this is the essential element affecting performance of a sign. In some jurisdictions graffiti-resistant treatments are used for signs in areas where vandalism is a problem. Special care should be taken when cleaning signs to ensure that the integrity of the sign (including its retroreflective properties) is not damaged.

6.6.4 Repair of Damaged Signs

As a general rule, and depending on the extent of damage, signs with reflective backgrounds which are older than about six years should be replaced rather than repaired, since the difference in reflectivity between the old sign material and a new patch will produce an unsightly appearance. Signs less than six years old should only be repaired where it can be done without affecting the sign’s integrity or warranty.

7. Electronic Signs

Electronic signs are being increasingly used to manage traffic, improve road efficiency and enhance safety. They are used primarily where the information to be provided to road users changes with time. Electronic signs are an integral component of motorway management systems, variable speed limit zones, incident and event management schemes, warning systems at high crash risk sites, worksite traffic management and delivery of road user information. From the Safe System perspective, electronic signs contribute to safe roads, safe speeds and safe road user objectives. Incident management systems that utilise electronic signs also can be used to facilitate emergency vehicle access to crashes involving injury to roads users. This application supports post-crash response by emergency services, which is often recognised as the fifth pillar of the Safe System.

As with static signs, effective and efficient communication with drivers and other road users will elicit the desired response and enhance safety. The objective is to minimise the cognitive workload (particularly in complex situations), avoid distraction and minimise processing and response times. To achieve this, electronic signs must be:

- Legible
- Positioned appropriately (both longitudinally and laterally)
- Consistent (with other signs and the road environment)
- Concise
- Relevant.

Electronic signs are located either over or adjacent to the roadway, and can be used as regulatory, warning, guide and information signs. They can be implemented as permanent (fixed) or portable (typically trailer-mounted) signs. The National ITS Architecture will increasingly assist ascertaining the operational requirements and information flows to help inform the use of electronic signs.

7.1 Variable Message Signs

Variable message signs (VMS) and changeable message signs (CMS) display electronically generated messages that can be changed to display predefined or free text information, figures and symbols as follows:

- VMS are able to provide unlimited variable information. The display types currently used include fibre optic, light emitting diodes (LEDs), reflective flip pixel displays, internally illuminated displays and in some cases a combination. The display may be one large complete matrix or one that comprises a series of matrices arranged in rows and columns.
- CMS are able to provide variable information from a limited number of fixed displays. Generally, they are made to resemble static roadside signs with up to three different displays. They are also available in forms using LED or fibre optic technology to display different symbols and messages.

Manual operation relies primarily on a pre-prepared set of generic messages; free text may also be used. Semi-automatic operation utilises vehicle detectors or closed-circuit television (CCTV) cameras that may be linked to alarms to provide warning of an incident and to recommend specific messages for implementation by a traffic management centre operator.

Fully automated systems require the integration of incident detection systems with message selection and deployment for the management of incidents, congestion and impact of adverse weather conditions.

7.1.1 General Principles

The general principles in AS 1742.2 that apply to standard retroreflective signs also apply to the provision of VMS and CMS. The effectiveness of any road sign depends on three factors – conspicuity, legibility, and comprehension.

The factors involved in the design of effective road sign faces described in Section 6.3 also apply to VMS. Like static signs, VMS must be conspicuous and easily read at normal operating speeds.

There is no single formula to produce VMS that are easily comprehended. Simplicity, clarity, and meeting the needs of motorists are important factors. Guidance for achieving effective VMS in terms of conspicuity, legibility and comprehension is given in this section.

7.1.2 Applications

VMS are widely used to provide road users with information about road and traffic conditions. They have the ability to display a large number of individual messages for the purpose of directing, informing, warning or guiding road users. VMS may be used as individual signs to address a particular issue, or as part of a system to manage traffic along a road or within an area. A common systemic use is for the management of traffic during incidents on high-volume urban motorways or on the arterial road network. VMS may be permanent, or temporary signs mounted on a trailer or vehicle to meet a short-term requirement.

VMS are used for a broad range of applications relating to incidents, traffic congestion and management, and road safety, including but not limited to:

- incident management at a site or along a route, usually a motorway, to inform drivers of an incident and action required; this may include traffic diversion through the use of ‘condition’ and ‘closed’ signs on an adjacent arterial
- warnings about traffic or road conditions downstream of the sign
- warning of situations that have the potential to be a road safety problem
- provision of information on future planned events
- control of traffic during roadworks, maintenance or major events
- guidance of drivers seeking parking areas
- travel time information
- height detection devices
- weather conditions (e.g. wind, fog, snow, ice)
- advisory speed, trailer mounted
- speedometer check
- approaches to signalised intersections that have severe sight distance restrictions due to horizontal or vertical curvature
- approaches to rural intersections that have a safety problem.

Figure 7.1 shows an example of a cantilever-mounted VMS with a typical message relating to changed traffic conditions ahead on a major arterial route.

VMS therefore enable direct and timely communication with road users to provide an extensive range of important information. However, this flexibility is accompanied by a responsibility to provide consistent information in a standard format, and to use the devices only for appropriate purposes.

Current practice in VMS implementation is well developed in several countries (e.g. Highways Agency 2016a and 2016b, Paniati 2004). Guidance for application in Australia and New Zealand is provided in this section.

Figure 7.1: Cantilever-mounted VMS displaying a typical message

7.2 Sign Faces

7.2.1 General Characteristics

Sign dimensions

The dimensions of a VMS are dependent on its location, as higher speeds require larger character sizes in order to provide suitable legibility distance. The character size and number of characters and lines will dictate the overall dimensions of the VMS along with whether it displays a pictogram or not. A guide for overhead and side-mounted signs for various lateral offsets from the carriageway is provided in Section 7.2.2. Guidance on the impact of the VMS dimensions due to the use of pictograms is provided in Section 7.3.1.

The generally higher speeds in rural areas and on urban motorways require larger characters and hence larger VMS than for arterial roads in urban areas. Rural roads tend to have more spacious road reserves that can accommodate the larger signs. In determining the size, consideration must be given to the visual impact on an area, particularly when used on urban arterial roads, although in some rural situations interference with views can also be a consideration. In urban situations the sign size and location may often be constrained by lack of space or the existence of other infrastructure.

Matrix characteristics

A permanent VMS should be capable of displaying a maximum of four lines of text with each line able to display a maximum of 18 characters. For higher speed roads (e.g. with operational speeds greater than 80 km/h) it may be desirable to limit the display to three lines of text. It may also be preferred if the message can be displayed on one frame but no more than two.

To ensure clarity of the message adequate spacing between the characters and the lines must be provided. The matrix characteristics and spacing between characters and lines of the VMS should be undertaken in accordance with AS 1742, AS 1744 and AS 4852.1.

Fonts

Fonts used in VMS should be undertaken in accordance with AS 1742, AS 1743 and AS 1744. As outlined in Section 6.3.6, AS 1744 provides the standard alphabet to be used.

Colour and contrast ratio

The colour of the pixels used for VMS legends should be either white or yellow as they provide the greatest legibility against the otherwise black background of the sign. In general, static road signage does not use multi-colours (e.g. instruction signs use black on white, warning signs use black on yellow). Colour in a VMS should be consistent with practice in static road signage with colours for the legend such as white or yellow. There may be justification to use other colours, where it is undertaken for a purpose such as:

- To represent traffic conditions (e.g. green for light, red for heavy) – refer to Section 7.6.2.
- Where it is part of a recognised symbol used on the VMS and/or where in some circumstances the VMS is displaying a regulatory symbol, where another colour is part of the regulatory sign (e.g. red annulus of a regulatory speed symbol and not advance warning of a speed sign), although it is noted that VMS are not normally used to display regulatory signs. For a regulatory sign to be enforceable, its depiction on the VMS must closely resemble the static sign in the road rules, even though colours may be reversed.

If road agencies wish to use multi-colours in VMS messages beyond the guidance outlined above, it is recommended that:

- When implementing multi-colour VMS a study should be undertaken either through a trial or in simulations to obtain an understanding of how effectively the messages will be understood by drivers.
- In order to increase the effectiveness of the multi-coloured VMS across the driving population, usage should be consistent across the jurisdiction. In particular the use of colour on VMS should be consistent along the entire corridor.
- As some colours may be seen easier during the day than at night, consideration should be given to the time and duration of the intended VMS message.
- As a proportion of the population is colour blind, consideration should be given to the readability of the message by that group.

In daytime the luminance of both the message and background is important. A contrast ratio, which is a measure of the luminance of the VMS message display divided by the luminance of the background of the sign face, of between 8 and 12 provides optimum legibility.

Luminance ratio levels are set so that the presence of external sources of light will not cause a lowering of the contrast of the message such that it becomes ineffective. If the VMS has a variable luminance setting, then the luminance ratio requirement should be met first and then the minimum levels of luminance must be met at that luminance level or greater. Test procedures are available for the measurement of luminance ratio.

At night some method of automatic dimming is required, as the levels of luminance necessary for effective daytime operation will cause far too much glare for drivers at night. It is therefore appropriate to specify different levels of luminance for different ambient light conditions.

External and internal illumination

Although VMS can utilise a variety of technologies, the current best practice is to use light emitting diodes (LEDs) to display messages and symbols.

Borders

Practice varies for the provision of borders. Generally, they are not considered necessary; however, some road agencies may wish to increase the conspicuity (or target value) of VMS by providing a 50 mm wide retroreflective tape around the perimeter of the front cover of the VMS.

7.2.2 Legibility

Legibility distance is primarily dictated by the size of characters, the type of alphabet and whether upper or lower-case letters are used. Other factors include obstructions and observation angle. The sign legibility distances for a VMS are the same as those described in Section 6.3.7 for normal retroreflective signs, comprising the cumulative distances travelled whilst:

- observing or scanning the sign
- reading the sign
- no longer being able to read the sign (i.e. too close, angle too great).

VMS can generally be regarded as satisfactory within viewing angles of 10° horizontally and 5° vertically as described in Section 6.3.7. Specifications for VMS should provide an adequate luminance ratio to ensure that the signs can be read at these angles.

In order to determine the legibility distance required for VMS, practitioners may utilise the legibility distance formula contained in Section 6.3.7 making allowance for the number of frames, time the frame is displayed, viewing angle and offset.

In addition to guidance outlined in Section 6.3.7, Appendix B provides guidance used by MRWA to determine the sight distance to direction sign. The guidance contained in Appendix B is also relevant to electronic signs and therefore practitioners may consider this guidance for application within their jurisdictions.

For permanent VMS, the legibility distance should allow for the maximum practical message length (taken as eight words per frame). For mobile VMS, the formula should be used for shorter messages if necessary.

For horizontally offset signs, the minimum likely offset distance (at 60 km/h) comprises 3 m for the driver's position in a single approach lane, a clearance/footpath width of 1.75 m and a half-sign width of 1.25 m, giving a total offset of 6 m.

For a four-lane motorway, there may be 3 m for the driver's position, two full lanes (11.1 m), 3 m shoulder, a clearance of up to 1 m behind the barrier and a 3 m half sign width, giving a total offset of about 21 m.

7.3 VMS Messages

7.3.1 Types of Messages and Symbols

Where a VMS can be used to provide a variety of messages composed of words it is necessary to establish priorities for the display of the different types of messages. Messages related to safety or traffic flow at a particular site should take precedence over those providing less critical information. For example, the following is a suggested descending order of priority based on road safety and traffic flow considerations:

- current traffic incident or event (i.e. road closures and hazard warning which may include hazards associated with incidents such as a crash, severe weather events such as floods or current roadworks)
- severe congestion
- planned (future) roadwork
- weather-related conditions that could impact on safety such as heavy rain, fog
- parking guidance
- planned (future) special events.

In some scenarios (such as in managed motorways and where the travel time technology is available) it may be appropriate to display travel time/motorway conditions if conditions are such that one of the aforementioned message types is not required. For arterial road applications, filler or standby messages, which may only be displayed if considered useful and appropriate by the jurisdiction may be used as default messages. Campaign/promotion messages (e.g. road safety messages, community benefit messages and general transportation messages) can fall into this category.

In addition to the above:

- It is noted that road agency VMS installations should not be used for commercial advertising under any circumstances.
- For VMS messages, it is important that the highest priority message be displayed and therefore ongoing monitoring of conditions and incidents is required (if a low priority message is displayed when a higher priority message should be, this may bring the VMS into disrepute).

Pictorial messages and symbols

Pictograms in conjunction with text enable the VMS to display more information on the one frame and/or reduce the amount of text required. This can enable messages to be displayed on one frame as the pictogram can display the cause of an event or problem while the text conveys the action to be taken. An example of a VMS display utilising pictograms in conjunction with text is shown in Figure 7.2 .

Figure 7.2: Example of a pictogram and text-based VMS

Source: Austroads (2015c).

Pictograms used for VMS applications are dependent on the capability of the sign, the operational characteristics of the motorway and the messages which the road agencies wish to convey. As a result, VMS need to be designed with the size of the pictogram content in mind. With the latest VMS technology, the preference now is for one integrated hardware panel that can display either pictogram or text of both as opposed to a separate panel to display the pictogram or text separately.

Table 7.1 provides examples of pictograms that are used by some road agencies. Practitioners can use these pictograms within their own jurisdiction, however they should ensure that other pictograms for the same purpose are not already specified and that any pictogram is consistent with use across the jurisdiction. Where jurisdictions do not specify pictograms, practitioners are encouraged to use those depicted in Table 7.1. Further pictograms may be developed based on the characteristics of the road environment. However, they should be readily recognised and understood by drivers and therefore may need to be subject to comprehension testing in accordance with AS 1743. In addition, where symbols are specified in AS 1742 for the same purpose and/or are outlined in the Australian Road Rules, the symbols should be utilised in order to maintain consistency.

7.3.2 Abbreviations

Use of abbreviations should generally be limited to those that are highly recognised, independent of their context or are adequately understood when used with ‘prompt’ words (e.g. prep for prepare if it precedes to stop).

A list of recommended abbreviations and standard abbreviations that rely on a prompt word is provided in Appendix C.

Time-related information

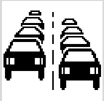
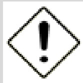
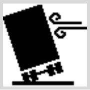
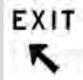
It is essential that time-related information shown on VMS be accurate and current if the system is to be credible to users. To achieve this will require high quality data gathering, usually automatic. The types of time-related information that can be considered for use on VMS include:

- travel time on highways
- delays on highways
- time saved on alternative routes
- delay avoidance on alternative routes.

Driver information systems that provide travel time information on motorways are in use in many places. Data is collected automatically through tagged vehicles or pavement loops and suitably calibrated algorithms. These systems aim to reduce delay and driver frustration and make better use of the available road capacity. They are generally considered to have some influence on a driver’s choice of route.

Similarly, information on delays on highways and time saved on alternative routes requires a sophisticated data collection and analysis system and procedure. Displays of time saved on alternative routes could lead to a concentration of diverted traffic on one route, even when it may be desirable to spread the load between the alternative routes. This application would only be appropriate in a highly monitored network.

Table 7.1: Examples of pictograms for various purposes

Description	Example symbol/s	Description	Example symbol/s
Roadworks		Emergency vehicle	
Incident		Cycling event	
Congestion	 Preferred or  Alternative(1)	Running event	 (3)
Breakdown		General use	 (4)
Wind		Used in conjunction with LUMS where permissible	 (5)
Traffic controller	 (2)	Exit	
Flooding			

1 *VicRoads and MRWA have outlined that their preference is to use the alternative pictogram for congestion.*
2 *The traffic controller pictogram is considered not applicable for use on motorways.*
3 *VicRoads and MRWA may use an alternative pictogram to this. Practitioners in these jurisdictions should refer to jurisdictional guidelines.*
4 *To be used for general hazards where a more specific pictogram for the hazard is not available. When this is used the event type should be stipulated as the first line of the VMS.*
5 *Not all LUMS will permit the use of the 40 km/h ahead pictogram.*

Source: Based on TMR, MRWA and VicRoads (personal communication 2016).

7.4 Message Content and Format

It is important that messages on VMS are easily read and comprehended. The minimum requirement is that all messages should include a problem statement and an action statement. Where necessary, messages may also include location, effect and attention statements. These statements are described below and a list of typical problem, location, effect, attention and action statements is provided in Appendix D. The statements are combined to provide appropriate messages that are applied consistently across road networks. Appendix E provides a list of recommended generic messages.

7.4.1 Problem Statements

Problem statements define the type of incident that will affect traffic conditions. Such incidents could include accidents, roadworks, traffic congestion, environmental conditions and hazards on the road. Examples of problem statements include *accident, congestion, roadwork* and *traffic signals.*

7.4.2 Location Statements

These statements describe the location of the incident to which the VMS message refers. The location may be described in terms of the distance to the incident, place names, road/street names, suburbs, route numbers, exit numbers/names, road infrastructure and landmarks. The location description used will depend on circumstances. In general, road names are preferred to route numbers.

Sometimes it will be necessary to refine the location description by the use of modifiers. Recommended location modifiers include *after*, *near, ahead, at, next, left, right* and *centre*. In many cases the word *ahead* is a statement of the obvious and may be omitted where it would add to the number of frames required for the message.

When distances are displayed on VMS they should not be too far from the location, as drivers may forget the message displayed before reaching the destination. A distance of five kilometres may generally be regarded as the maximum value.

7.4.3 Effect Statements

Effect statements describe the state of the road or the effect the incident will have on traffic operations. A delay statement is one specific type of effect statement. This can be displayed as *major delays, minor delays*, [number] *mins delay* or [number] *hrs delay*. Alternatively, the statement may be displayed as *delays expected*. Other examples of effects statements are *heavy traffic* and *slow traffic.*

The quantified statement should only be used where reliable information is available and can be regularly updated. Delays of up to about 10 or 15 minutes are considered minor in urban and rural environments respectively.

7.4.4 Attention Statements

These statements are designed to gain the attention of a particular group of motorists rather than the normal case of directing messages at all motorists. The attention statement identifies the target audience to whom the action statement is directed, for example *buses, trucks, high vehicles* and *local traffic*.

7.4.5 Action Statements

Action statements describe what is required of the driver if the VMS message is to be effective and it is therefore an essential element if some action by motorists is required. Typical examples of action statements are *reduce speed, use next exit* and *prepare to stop*.

It should be noted that some action statements are not explicit, but require drivers to make decisions. Where the capacity of a road is reduced but traffic can still use it, a signed detour may not be appropriate. In such cases, drivers can be advised either to *consider alternative routes* or *find alternative routes*.

7.4.6 Message Load and Exposure Times

The message load is expressed in ‘units of information’. Studies have shown that an eight-word message is approaching the maximum processing limit for drivers. In addition, no more than two units of information should be shown per line of VMS message.

A unit of information provides an answer to a question that a driver may pose. For example, ‘accident’ is a one-word unit of information (a problem statement), ‘at Queen Street’ is regarded as a two-word unit (a location statement) and ‘use next exit’ is a three-word unit (an action statement). A unit of information may contain one to four words and a word would normally have two to eight characters. Some location names may be longer than eight characters but message design should exclude any other words longer than eight characters.

Dudek et al. (2000) has indicated that:

- No more than three units of information in total should be displayed when all three units must be recalled by drivers.
- Four units of information may be displayed on a VMS when one of the units is minor and does not have to be remembered by drivers in order to take appropriate action.
- An eight-word message (about four-to-eight characters per word), excluding prepositions such as ‘to’, for’ and ‘at’ is about the maximum that drivers travelling at high speeds can process.
- A unit of information may be displayed on more than one line on the sign, but a sign line should not contain more than two units of information.
- A minimum exposure time of one second per short word (four-to-eight characters) or two seconds per unit of information, whichever is the largest.

7.4.7 Number of Frames and Display Changes

While two-frame messages are acceptable, every effort should be made to limit a message to a single-frame display. The design legibility distance does not allow most drivers to read a three-frame message and these should therefore be avoided wherever possible. It is recommended that filler or standby messages be limited to a single frame.

Messages should not roll across the frame, scroll down the frame or flash. Changes of display should be made by completely blanking out the current frame and introducing the new frame as a complete display. Transition effects should not be used.

Where a message is contained in two consecutive frames, an interval of 0.5 seconds duration is recommended between the last frame and the repeated first frame. Where a message is to be changed, a blank display of at least two seconds should be used between the end of one message and the start of a different message.

7.4.8 Time and Date Information

Time and date information may be required for VMS messages providing advance advice of special events or roadwork that will affect future traffic operations. One week is normally considered to be an appropriate advance notice period.

Information may also be provided on when an event or incident is expected to end. This element will contain time duration, days of the week, day periods, time of day, time periods, dates and/or date periods. Time duration in minutes should be shown in five or ten-minute time increments.

Dates and date periods are not comprehended nearly as well by drivers as days of the week. They should therefore only be used for major occurrences and when the dates involved are at least a week into the future.

Recommended presentations of time and date information are included in Appendix D.

7.4.9 Message Compatibility and Credibility

VMS messages (including defining locations on VMS such as place names or road names) must be fully compatible with static signs, particularly direction signs. VMS should complement the existing static signs rather than simply duplicating them.

Where incident management through detection or closed circuit television (CCTV) cameras is in place, this should be integrated with the VMS system as much as possible. In particular, downstream cameras and/or incident detection should support VMS wherever possible.

Accurate VMS messages are vital if they are to be credible to drivers and achieve high levels of driver confidence and compliance. Credibility can be substantially aided by:

- Ensuring that the message is relevant and accurate. Unless the accuracy of incoming information can be verified, the use of a more general message may be appropriate.
- Using CCTV, where available, to verify the type and extent of an incident (problem), the return to normal operation, and hence the need to remove or change the message.
- Exercising restraint in the use of filler messages, especially in situations where an incident has occurred where display of a general road safety message for example would be irrelevant.
- Avoiding the use of ambiguous or long messages.

VMS should be monitored and maintained to ensure that letters and words within messages are complete. Faulty pixels that remove sections of the characters or unnecessarily activate other sections of the frame adversely affect the integrity of the signs.

7.5 Location and Spacing

All VMS/CMS should be placed so they are clearly legible to all road users and do not compete with other traffic signs, traffic control devices or roadside furniture. VMS should not be placed in locations where they will be partially hidden by any roadside objects, furniture or vegetation.

In addition, VMS must be positioned so that road users have time to respond to the messages provided, and therefore should be positioned an adequate distance in advance of major decision points. On motorways major decision points occur at exit ramps as these are most likely to be used for diversions, although in some instances median crossings are constructed for this purpose.

The locations of VMS for motorway management systems will depend on the extent of the system that is required to meet traffic management objectives, and the cost that a road agency is prepared to incur to meet the requirements for a particular site.

7.5.1 Longitudinal Placement

In general, VMS should be placed longitudinally in accordance with the principles for location of static signs (Section 6.5.1). The location of VMS will depend on the objective and extent of the application, the nature of the site and the ability to obtain a suitable site in relation to other signs and structures.

VMS should not generally be placed within an interchange area or in close proximity to an on-ramp where merging, frequent braking or weaving movements are common. The VMS location should also take account of the need for drivers to respond to other important static signs in the area.

On urban arterial roads where traffic diversion is necessary or recommended, it is desirable that the VMS be located 400 to 700 m in advance of the diversion point. On high-speed rural roads and motorways a greater distance will normally be necessary (e.g. 900 to 1200 m of the decision point).

As a general rule, it is recommended that the first VMS to display a message for an incident should be not more than 5 km upstream of a minor incident (not involving a lane blockage/closure) and not more than 8 km upstream of an incident that involves substantial delays because of a lane blockage/closure. Signs more remote than this should not display messages related to the incident. These maximum distances may relate to rural roads and some parts of urban motorway networks, but are unlikely to relate to typical urban arterial road networks. There may be exceptions on motorway systems where greater advance notice using VMS is warranted, but this should only be done if it is possible to provide an effective message to encourage diversion via suitable exits to alternative routes.

7.5.2 Lateral Placement and Height

The lateral placement of VMS should comply with that required for static signs (Section 6.5.3). In addition to this guidance the systematic deployment of VMS as part of a motorway management system usually requires that all VMS are located on gantries, cantilevers or other overhead structures, as overhead signs are the most effective way of conveying essential information to motorists.

Typically, gantries, or other overhead structure that spans the carriageway (e.g. bridge) should be used:

- where lane use management system (LUMS) signs are used (LUMS comprise an electronic speed limit (ESL) and lane control signal (LCS) display – refer to Section 10.5.11) are used:
  - in this case where LUMS are utilised it is acceptable (although not necessarily preferred) to also install VMS on the same gantry (refer to Section 7.5.4 for further discussion on collocation with other signs)
  - alternatively, VMS may be installed on any structure (separate gantry, cantilevered or other overhead structure) subject to it meeting the legibility requirements, with consideration given to obscuration due to a high percentage of heavy vehicles.
- on motorway carriageways that have four or more lanes.

On the approaches to exit ramps it is particularly important that the normal static advance exit and exit position signs are coordinated with any VMS, LUMS and other signs/signals provided for traffic diversion or other purposes. AS 1742.2 illustrates typical arrangements and spacings for static motorway exit signs within which the VMS must be accommodated.

Further to the above, it is preferred to separate large VMS containing incident messages and lane control from gantries that support the static direction signs. This is discussed further in Section 7.5.4.

Following a decision on the nature and extent of the motorway management system required, designers should:

1. Determine static directional sign locations (highest priority) – as per guidance in AS 1742.2.
2. Determine LUMS and ESL sign locations within the direction sign layout. The typical design sequence for LUMS and ESL sign placement is as follows:
   a. relative to interchanges
   b. within mid-blocks segments.
3. Determine VMS locations.
4. Determine other static sign locations.

Ideally, successive VMS should not be located within 1000 m of one another; however, if required, closer spacing can be used.

7.5.3 VMS Orientation

Generally, VMS can be comfortably read when they are within 10° off-centre horizontally and 5° vertically of a driver's line of sight (i.e. signs should not be located at 90° to the roadway). Sign placement should be checked so that horizontal or vertical curves do not result in the sign being outside this range.

7.5.4 Collocation with Other Signs

Although some standards and guidelines do not permit collocation of sign information, these have been overtaken by current practice.

Dual collocation of LUMS with VMS or dual collocation of LUMS with direction signs (DS) is a practical arrangement which is widely practised overseas and in Australia and New Zealand.

While triple collocation of LUMS, VMS and directional signs is practised internationally such as along UK motorways, triple collocation is an emerging concept in Australia and New Zealand that is being discussed by some road agencies.

Austroads (2015c) investigated the potential impact of collocating LUMS, VMS and/or DS through surveys and simulation. The study confirmed that dual collocation of LUMS with VMS or dual collocation of LUMS with DS appears to present no difficulties to drivers.

With triple collocation of signs, the study found that although drivers were generally able to cope with the information displayed they usually did not like the complicated signs. As a result, it is recommended that the signs should be used only in situations where other arrangements for displaying essential sign information are impractical. Further, drivers' behaviour and reactions to the signs should be monitored closely in the period following any installation.

Given the above findings, the following guidelines should apply to the collocation of electronic signage:

- no collocation: preferred
- dual collocation of LUMS with VMS or dual collocation of LUMS with DS: acceptable
- triple collocation (i.e. collocating with a static sign and LUMS): not preferred but acceptable to trial if constraints require it and limitations are applied to the display of the VMS and static sign (see below for further guidance).

Although not preferred, where triple collocation is being considered the following guidelines should apply:

- VMS messages should be limited to one frame and no more than three lines at one word per line (e.g. *roadworks ahead* or *heavy delays ahead*) unless the message is used to convey estimated travel time.
- Use of travel time messages in triple collocation scenarios is still being explored and it is felt by many that their use in triple collocation is the most complicated message permitted. Due to the potential to overload drivers, especially drivers not familiar with the area, the number of destinations displayed should be limited. The number would be best determined based on an assessment of the complexity of the road environment. For more complex road environments, it may be appropriate to limit the number of destination to one, while for less complex road environment, two or three destinations may be acceptable.
- VMS colour should not be used unless to indicate the congestion level.
- Use of pictograms in the VMS should be avoided in order to keep the message simple.
- Road agencies should design the scope and evaluation methods of any field trial of triple collocation of signs with extra caution and with driver behaviour closely monitored after the installation.

7.6 Applications of VMS

7.6.1 General

The systematic deployment of VMS has mainly been as part of motorway management systems that employ a range of advanced techniques to allow road agencies to monitor and control motorway networks by regulating traffic flows, speeds and movements across the network. However, it is expected that similar systems will in time be used to improve the management of surface arterial road networks.

Motorway management systems and their underlying traffic management strategies rely on VMS and other electronic signs and signals to provide the interface with road users. Electronic devices are used in a systematic way and may regulate, warn or advise drivers in response to changing traffic, environmental, or other road conditions. Such systems can satisfy the dual objectives of improving traffic efficiency and road safety, thus contributing to safe mobility.

The extent of the signing and technology used in a particular system will vary depending on the objective that the road agency has for the system. While incident management capability is a primary attribute of most systems, the level of signing used can vary considerably. Also, consideration of the system requirements for particular sections of motorway may lead to variation in the combination of signs provided.

VMS have been applied to a range of situations including:

- driver information
- ramp control
- lane closures (directing vehicles into appropriate lanes when incidents occur)
- motorway closures
- lane allocation for specific vehicle types (e.g. heavy-vehicle lane or no trucks in certain lanes)
- special event management
- adverse weather conditions (including fog)
- sight distance limitations
- signing and delineation in tunnels
- reversible roads.

The increasing use of variable speed limits as a traffic management tool has been facilitated by the development of VMS technology. Section 7.7 covers this topic in more detail.

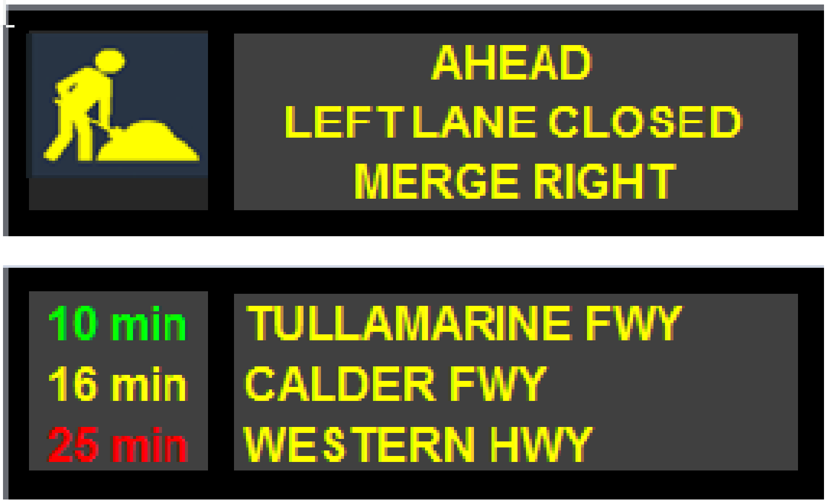
7.6.2 Driver Information Signs

Incident management systems rely on the ability to relay processed information about road conditions (including incidents) in a concise manner to road users. This is in order to encourage drivers to detour around incidents and so avoid the further build-up of congestion in the area of the incident and to allow responders to better respond to incidents. VMS should aim to provide warning and/or safety-critical messages (e.g. *accident ahead*) along with incident/event messages. Latest best practice is for the VMS to provide this in alternating form on the one VMS.

A key factor in providing effective signs is to present relevant information to the motorist in a clear and simple way. In addition to VMS installations, driver information systems utilise other signs that also form part of the incident management system.

Estimated travel time can be conveyed to drivers through multipurpose VMS as shown in Figure 7.3 . This allows for the one VMS to display travel time information during standard operating conditions, but also enables the same VMS to display information about a major event such as a lane closure. Typically, the travel time is displayed in minutes and may be undertaken in colour or accompanied by a colour display in order to represent the level of congestion, that being red (heavy), yellow (medium) or green (light).

Figure 7.3: Example of travel time information being displayed on a multipurpose VMS which may also display incident messages



Dedicated trip information signs may also be used on a road to which the information applies. These signs inform motorists of the travel time to key exits. Typically, the sections that are labelled on the sign are static, while the journey time is dynamic and displayed through the use of an LED display (Figure 7.4).

Figure 7.4: Trip information sign

Trip condition signs (Figure 7.5) may provide information relating to travel time and congestion on an intersecting route. They are positioned prior to the interchanges that enable access to that route. They may display either an estimation of the travel time from the interchange to a major interchange on the intersecting route or information on the trip conditions along the route (e.g. light, medium or heavy). The conditions may be displayed in colours indicating the level of congestion.

Figure 7.5: Trip condition sign

For both the travel time and trip condition VMS, the preference now (unlike that shown in older versions of the signs that are still in use as shown in Figure 7.4 and Figure 7.5) is for the VMS to display the destinations in sequential order with the nearest destination at the top of the sign and the furthermost destination at the bottom. The travel time numbers to various destinations are the total travel time from the location of the sign to the destination and therefore should always be increasing from the top of the sign to the bottom (Figure 7.6).

Arterial road VMS providing advance motorway condition information are placed at strategic locations on arterial roads that ‘feed’ the motorway. The latest best practice is for these signs to be a full VMS matrix, as shown in Figure 7.6, and for them to display the name of the motorway and travel time to key destinations. Colour coding may also be used in order to give an indication of the level of congestion.

Figure 7.6: Example of an arterial road VMS providing advance motorway condition information

The signs may also comprise a normal retroreflective intersection direction sign (as shown in Figure 7.7) with an LED/VMS panel indicating the level of congestion for the various segments of the motorway. On seeing these signs drivers can decide whether to use the motorway or an alternative arterial route.

Figure 7.7: Motorway condition sign

Electronic ramp control signs are located in a highly visible location just prior to the entrance ramp of a motorway. They are VMS installations that display a variety of simple messages about use of the motorway. They indicate if the motorway is closed, and control access by displaying messages such as *motorway closed* and *no left turn*. Where ramp metering signals are used (refer to Section 10.6), the same VMS installed at the entrance to the on-ramp can be used to display the motorway access control. Where ramp metering signals are not installed, VMS will need to be installed to display the control. Figure 7.8 shows an example of the various displays of the electronic ramp control signs. The primary purpose of their use is to be able to close or limit access to a motorway at the particular on-ramp where the signs are installed in the event of a major incident so as to prevent excessive congestion and therefore reduce the time taken to clear traffic and return to normal operating conditions.

Figure 7.8: Example of electronic ramp control sign messages

7.6.3 Lane Control Signals/Signs

Lane control signs on motorways may be used in response to incidents in order to:

- close a lane or lanes on a carriageway and guide traffic past an incident
- close a carriageway beyond a motorway exit and divert traffic from the motorway during severe incidents or significant maintenance operations.

Section 10.5.11 outlines the various symbols and their usage for overhead lane control.

On high-volume motorways the safe and effective closure of lanes or a carriageway should take place through the display of signs on a number of successive gantries.

Further information on lane control signals is given in Section 10.5.11 and their use in lane management systems is described in Austroads (2020f).

7.6.4 Weather Warning Systems

Weather warning systems may be used on motorways and non-motorway arterial roads (usually rural highways) where a range of conditions related to weather have an adverse effect on road safety through their impact on a driver's performance or the road surface.

Common conditions include:

- heavy precipitation
- flooding or high probability of flooding
- fog
- ice and/or snow
- freezing pavement
- high wind speed and direction
- smoke (primarily due to wildfires).

Use should be limited to scenarios where the weather event will have an adverse effect on safety and requires drivers to change their normal driving behaviour for that particular section of road (i.e. where weather conditions require drivers to decrease their speed to maintain safety). The warning may also be accompanied by an ESL that legally requires drivers to reduce speed.

7.6.5 Reversible Lanes

Reversible lane arrangements (known as tidal flow in some jurisdictions) occur where the directional use of a lane is reversed to provide additional capacity in the peak traffic direction. For example, a six-lane undivided road may be operated as three lanes each way during off-peak periods, and be changed to four lanes for the peak direction and two lanes for the counter-peak direction during peak periods.

In order to achieve a satisfactory level of safety, reversible lanes are managed by overhead lane signals, the permitted use of lanes being designated by arrow signals, and prohibitions on use designated by a red cross over the appropriate lanes.

Reversible flow lanes are most common on arterial roads in Australia and New Zealand but can be utilised on motorways provided that satisfactory traffic management and median crossings are developed. Examples of gantry signals for reversible lane operation are shown in Figure 7.9 . Such treatments have provided improved levels of service and capacity at relatively low cost.

A critical aspect of reversible lane treatments is the signing and delineation at the ends of the arrangements where they transition to normal operation. Signs to advise drivers of the ‘off-centre’ operation and the times to which it applies are provided in advance of the treatment. It is difficult to achieve a clear lane marking arrangement within the terminal areas of the treatment, but pavement lights have been used successfully for this purpose (Section 8.5.7).

7.6.6 Incident Management

Use of permanent VMS for incident management or driver information systems in Australia and New Zealand has been confined to motorways. However, it is expected that as the use of intelligent transport system (ITS) technology increases within vehicles and traffic management systems, adequate data and system capability to provide incident management and driver information systems on non-motorway arterial road networks will become available. The deployment of VMS more broadly throughout the arterial road system may raise issues regarding the extent of their use, location and size.

The minimum spacings indicated in Figure 7.5 are also considered appropriate for urban arterial roads. For these roads the key decision points are major intersections with other arterial roads that have a high potential to be used for traffic diversion. VMS used for this purpose should desirably be positioned 400–700 m prior to the diversion.

An important function of incident detection and managements systems is to provide rapid access by emergency services to critical incidents. The World Health Organisation (2016) recognises post-crash response as the fifth pillar of the Safe System. Early treatment of vehicle occupants or road workers injured in crashes ensures that the severity of injuries is minimised and increases the chances of survival.

7.6.7 Over-height Systems

Height detection systems are installed to detect vehicles that are too high to pass under low structures, often old railway overpasses of arterial roads where the bridge will usually have a low clearance. These systems are associated with routes that carry a substantial number of trucks.

A laser-beam detector may be used to detect vehicles that are too high. Typically, once a detection occurs the system activates flashing lights mounted on a height advisory sign or activates a VMS where it is appropriate to provide more information on the action required of the truck driver. CB radio break-in as discussed in Section 12.2.1 may also be used as a supplementary form of warning communication.

These systems inform truck drivers not to proceed along the current route and may provide appropriate direction to alternative routes. The provision of height detection systems reduces damage to important structures and minimises community costs.

Figure 7.9: Overhead signals for lane reversal

Note: In this scenario the middle lane is reversible with the direction of allowable travel indicated by the changeable lane control signal. Here the lane is closed to traffic moving away from the camera.

7.6.8 Speed Indicator Systems

These are systems whereby vehicle speeds are detected (using laser speed-detection equipment, for example) and displayed on an electronic sign (Figure 7.10) mounted beside or over the road.

The primary purpose of the system is:

- to make drivers aware of their speed, particularly those travelling above the speed limit, and encourage them to reduce their speed
- to enable drivers to gauge the accuracy of their speedometer.

With the use of speed cameras for enforcement and a reduction in speeding infringement tolerances in some jurisdictions, the system can provide an important service to drivers.

Displayed speed readings are generally within 1 to 2 km/h of the actual speed, and the maximum speed displayed is usually limited in order to discourage irresponsible speeding behaviour at the site.

Figure 7.10: Speed indicator system on a motorway

7.6.9 Vehicle Activated Intersection and Road Geometry Signs

Vehicle activated intersection and road geometry signs can be effective in warning drivers of hazardous intersections or curves. They may be applied to:

- a signalised intersection on the outskirts of a city or town where drivers are failing to adjust from the high-speed rural environment to the urban environment, evidenced by an unacceptably high number of crashes
- an unsignalised intersection that has an unacceptable crash history and funds are not yet available for permanent treatment
- a vertical crest curve on the approach to traffic signals where insufficient sight distance exists to the intersection or to the back of a stationary queue of vehicles
- a sharp horizontal curve that has a history of run-off-road crashes (Kathmann & Cannon 2001).
- the main road approaches to low volume rural intersections where traffic approaching on the side road activates a reduced speed limit on the main road.

The above examples illustrate applications of VMS signs to influence driver behaviour to encourage safer road use and safe speeds.

Vehicle activated warning signs may also be targeted at specific vehicle types, for example, where heavy vehicles can be susceptible to rollovers on horizontal curves if driven at excessive speed as shown in Figure 7.11 .

Figure 7.11: Vehicle activated warning sign for trucks

Source: Bennett (2007).

Standard static road signs (including warning signs) will often be provided in these situations, with the vehicle activated sign being in the form of a VMS or CMS to alert drivers to particular conditions or to emphasise the condition to which the static signs relate. It is important that VMS used for this purpose are appropriately integrated with necessary static signs or located with adequate separation from the static signs (Section 6.5.2).

The signs used to address the signalised intersection problem usually comprise a traffic signal warning sign and a *prepare to stop* panel with in-built or attached flashing yellow lights in accordance with AS 1742.14 (Figure 10.35). The lights are activated at the appropriate time by the signal controller.

Hazardous unsignalised intersections and those with a sight distance problem may be provided with an electronic sign that alternately flashes *too fast* and *slow down* when vehicles are detected approaching at a higher than desirable speed. These signs may be accompanied by an electronic speed limit sign to emphasise the limit that applies (Figure 7.12).

Vehicle activated signs in the form of either VMS or CMS may also be used to control the speed of vehicles approaching relatively sharp horizontal curves (Figure 7.13).

Figure 7.12: Example of VMS at an intersection on a divided rural arterial road

Illuminated speed limit sign.
TOO FAST – SLOW DOWN in background

VMS: TOO FAST – SLOW DOWN

Figure 7.13: Examples of vehicle activated signs on an approach to a curve in the form of a CMS and VMS application

CMS example

VMS examples

Austroads (2014a) explored various treatments for reducing speeds on rural roads. This included vehicle activated signs on the approach to intersections and curves. Key findings including description, benefits, implementation issues and treatment life are outlined in Figure 7.2 .

Table 7.2: Key findings on vehicle activated signs on the approach to intersections and curves

Sign type	Vehicle-activated signs – intersections	Vehicle-activated signs – curves
Description	Electronic signs such as VMS or electronic features accompanying a static sign (e.g. conspicuity device in the form of flashing lights) may be 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 VMS may display a message about a hazard, and may include a message to slow down. Alternatively, once triggered the conspicuity devices may become active, drawing attention to the static sign and indicating that the message on the static sign is relevant. Both approaches alert 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.	Electronic signs such as VMS or electronic features accompanying a static sign (e.g. conspicuity device in the form of flashing lights) may be 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 VMS may display a message about a hazard, and may include a message to slow down. Alternatively, once triggered the conspicuity devices may become active, drawing attention to the static sign and indicating that the message on the static sign is relevant. Both approaches alert drivers to the presence of the curve with the aim being that they reduce their speed to negotiate the curve safely.
Quantitative benefits	• Speed reduction: 5 km/h • Crash reduction: 70%	• Speed reduction: 2–6 km/h • Crash reduction: 35% in injury crashes
Qualitative benefits	• Alert motorists to the presence of an intersection • Provide more prominent warning • May be set to alert only motorists who are exceeding a threshold speed • May be set to operate in certain conditions only (e.g. time of day)	• Additional guidance to alert motorists to hazards • Provide information on the direction of the curve
Implementation issues	• Vandalism has been identified as a potential issue, especially in remote rural areas although some suppliers are incorporating vandal-resistant features into their design such as anti-theft measures • 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 • Modern signs utilise LEDs which have long service life and use minimal power allowing them to operate on solar. The signs may also be fitted with a photo-sensor which instantly self-adjusts the LEDs output according to ambient light levels	• Vandalism has been noted as an issue, especially in isolated rural locations although some suppliers are incorporating vandal-resistant features into their design such as anti-theft measures • 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 • Modern signs utilise LEDs which have long service life and use minimal power allowing them to operate on solar. The signs may also be fitted with a photo-sensor which instantly self-adjusts the LEDs output according to ambient light levels
Treatment life	5–10 years	5–10 years

Source: Based on findings from Austroads (2014a).

7.6.10 Public Transport

Buses (and trams) can be equipped with a global positioning system (GPS) unit or other forms of automatic vehicle location technologies to provide real-time location information for fleet management and passenger information. The usual timetable and the real-time arrival information are displayed at a bus stop using variable message panels and can assist in managing passenger expectations.

The real-time bus location information can be made available on the Internet. With wired or wireless Internet and other user-subscribed services through short message service (SMS), a rail passenger can access the arrival time of a scheduled bus when the passenger gets at a station. Hence, the passenger can plan ahead. The bus driver can also have the rail timetable and potentially the driver can delay the departure time from the bus stop within a certain tolerance to catch the rail passengers that seek a mode interchange at the stop. The task of dynamically integrating rail and bus transit services is a challenging one that can benefit from ITS measures.

An example of a sign displaying passenger information at a bus stop is shown in Figure 7.14 . Similar technology can be applied to tram routes. ITS is also used to provide priority for buses and trams on arterial road networks and these initiatives often involve the use of VMS. For example, Figure 7.15 shows a sign used in the dynamic fairway system introduced in Melbourne to clear queues of motor vehicles from the lane in front of trams and thus reduce the delay to tram services.

Figure 7.14: Passenger information sign at a bus stop

Figure 7.15: Dynamic fairway sign in Melbourne

Note: In this example traffic must turn right to clear the tracks for trams to proceed straight ahead.

7.6.11 Parking Guidance

Parking plays an important role in the provision of road transport services. In many cities, there is a mix of on-street and off-street parking facilities. Although the primary purpose of arterial roads is to carry through traffic, on-street parking on arterial roads in off-peak periods is common and motorists are familiar with the disruption it causes to traffic flow.

Off-street parking can also place increased pressure on the road system by drivers searching for parking at popular destinations such as city centres. Congestion from increased traffic circulation has a flow-on effect, inhibiting traffic movements in surrounding areas. Parking guidance systems utilising dynamic signs can be installed on arterial roads and other busy roads leading into central city areas to help improve the flow of traffic and reduce congestion.

Dynamic signing systems for parking are provided to advise motorists at critical locations around a city of the number of spaces that are available in large off-street car parking stations. The information displayed on the signs can be updated manually or automatically. The signs usually advise motorists of the:

- name and remaining capacity of the car park
- location of the car park
- locations of other car parks in surrounding streets.

The VMS allow drivers to make informed decisions in advance on where to park. In areas where several car parks are connected to a parking guidance system, such as in a city centre, car parks can be connected to a central computer via modems. Individual car parks can measure occupancy levels using inductive loops, infrared or video detection technology and update the central computer, which in turn updates the various signs in the area with occupancy levels.

In large cities it is usual to have parking guidance systems provided for different sectors within the city. The sectors may be given a name or a colour coding so that drivers can easily relate signs and information to the correct sector.

The planning, design and implementation of a parking guidance system requires a number of measures to be considered:

- a parking area master plan for the particular city should be used as the basis for identifying the grouping of parking areas to be included in various sectors, both those existing and those likely to be established within a short to medium term
- the definition of the sectors will provide the basis for the signing scheme by establishing the location of signs required to provide advance information relating to each sector, and to provide guidance of vehicles from the vicinity of a full parking area to an unfilled parking area
- the means of defining a sector, by name or by colour
- the type of message textural or pictogram.

The sign should contain only that information required to direct drivers to the parking stations. Extraneous information should not be allowed. The sign should therefore contain:

- the names of the parking areas or sector
- arrows to indicate the direction to be taken
- the status of the parking area (pictogram or number of spaces).

The convention for the arrangement of arrows on the sign face must match any corresponding static signing and comply with AS 1742.2 for direction signs, as follows:

- a left-turn arrow is to the left of the legend
- a right-turn arrow is to the right of the legend
- an arrow for a straight-ahead movement can be to the left or right of the legend, and in such a way as to avoid arrows being directly above or below each other.

A typical parking guidance sign is shown in Figure 7.16 .

Figure 7.16: Parking guidance sign

Further advice on electronic parking guidance systems is given in Austroads (2020g).

7.7 Electronic Speed Limit Signs

Electronic speed limit (ESL) signs are illuminated signs that comply with the format and colours specified for speed limit signs in road rules, and are capable of being changed by electronic means. An example of an ESL in use is shown in Figure 7.17. A distinct advantage of the ESL is that allows for the speed limit to be variable, based on a variety of specified conditions. The amount of variability could be as simple as on or off (i.e. when on the speed limit as displayed is applicable, when off the default speed limit for that section of road would apply).

Requirements for ESL signs are set out in AS 1742.4. They may be used with a general VMS, but it is not considered good practice to incorporate speed limit signs into a single display including other message signs.

Figure 7.17: Electronic speed limit sign in use

The potential benefits of variable speed limits include reduced numbers of crashes, reduced crash severity, improved traffic flow, a lower probability of incidents and, in some cases, reduced delays. ESL may also be considered for installation in situations characterised by:

- a history of high crash rates related to high traffic speeds and high traffic volumes during identifiable times
- large variations in vehicle speeds (e.g. sudden stopping)
- periods of high risk of conflict with unprotected road users
- significant traffic congestion and queuing
- a history of dangerous driving conditions during adverse weather or road conditions.

In order to enforce variable speed limits, it is essential that records are kept of the times when various speed limits are in operation.

7.7.1 Motorways

ESL signs may be used on motorways to impose a lower speed limit and improve safety and capacity. Use of ESL and in particular LUMS (comprising an electronic speed limit (ESL) and lane control signal (LCS) display) relies on the development of a business case to demonstrate the enhanced safety and efficiency outcomes relative to the investment in infrastructure (which can be significant depending on the length of route). Key considerations for the use of LUMS for any project include:

- requirements for increased capacity due to excessive demand and flow breakdown, including comparison of options for use of the emergency lane (full or part-time) compared with conventional road widening.
- requirements for improved incident management (i.e. the need to divert traffic from the incident lane and improve access for emergency vehicles) above the existing capability for the route.
- requirements to improve safety as a result of inclement traffic conditions such as during congestion and bad weather; LUMS and ESL systems should only be installed on sections that experience recurrent conditions, and therefore installation is likely to deliver significant benefits over the system lifecycle.
- requirements for enhanced environmental conditions (i.e. air quality and noise) in response to government policy directives.

In Australia and New Zealand, variable speed limits are applied to all lanes in the one direction of travel for a single carriageway as illustrated in Figure 7.18.

Variable speed limits may be activated automatically or manually through a traffic management centre. The ESL signs may be mounted on posts besides the motorway or placed overhead on gantries or existing structures. Generally, it is considered that side-mounted signs, installed in pairs, are satisfactory for carriageways with three or less lanes and that overhead mounting is desirable for carriageways that have four or more lanes. For motorways that comprise three lanes and carry a high percentage of trucks, overhead mounting is considered desirable as the high percentage of trucks can impede sight lines to side-mounted signs for vehicles in the middle lane.

Austroads (2020f) provides further advice on the operational aspects of using ESL on motorways.

Figure 7.18: ESL above each lane of the carriageway to indicate the limit

7.7.2 Arterial and Local Roads

ESL signs are also used on arterial roads at locations where excessive vehicle speeds contribute to unacceptable safety risks, but full-time lower limits are inappropriate because of the time-based nature of a particular safety issue. This may occur at regular times (e.g. morning peak) or irregular times (e.g. during adverse weather conditions, major traffic incidents). The signs are now increasingly being used in some jurisdictions for shopping centre precincts or school zones on arterial or local roads.

ESL signs may be used on arterial roads in the following situations:

- in conjunction with a school zone
- through strip shopping and commercial centres, and entertainment precincts that have high pedestrian activity across the road
- in areas subject to extreme environmental conditions (e.g. icy roads, windy conditions)
- on the approaches to at-grade intersections that have a safety problem where speed is a factor, typically on the fringe of urban areas (e.g. intersections on major duplicated highways pending conversion to full motorway standard)
- at times when high volumes and high speeds result in an unacceptable crash rate
- at roadwork locations
- to address any other traffic safety issues where speed is a key contributing factor.

In order to increase conspicuity, particularly when a reduction in speed is implemented, the inner sections of the red annulus of the speed limit display may be flashed. In order to comply with speed signage conventions, the outside section of the red annulus should remain steady (i.e. illuminated and non-flashing). This is outlined further in Section 7.7.3.

7.7.3 ESL Sign Size, Brightness and Annulus Requirement

Outlined below are recommendations for the ESL sign size, brightness and flashing requirements. They are a result of consensus being achieved amongst Australian and New Zealand road agencies as outlined in Austroads (2015b).

Sign size requirement

It is recommended that road agencies adopt the static sign size (and design) as outlined in AS 1742.4 and AS 1743. When ESL are designed for specific applications, the size requirements as shown in Table 7.3 must also be considered.

Table 7.3: Proposed ESL size requirements

Location	Size
School/shopping zones	Size B[(1)]
Tunnels	Size B, though Size A can be used where size constraints prohibit use of Size B
Managed motorways	Size C
Other	Size C on other high-speed roads Size B for all other cases

1 *The minimum size of enhanced school zone signs (i.e. when flashing annulus and flashing conspicuity devices are incorporated with static speed limit signs for school zones) could be Size A.*

Source: Based on AS 1742.4 and AS 1743.

Sign brightness requirement

The design of ESL signs should meet the requirements of AS 5156 with suitable/sufficient conspicuity.

Based on consultations with road agency practitioners, there may be a flaring effect issue with illuminated numerals for the signs, particularly for smaller sized signs. The intensity of the illumination will affect the level of flaring experienced and thus the illumination should be adjusted based on the lighting conditions, especially during daylight hours. However, this may be difficult to control due to the different lighting conditions throughout the day. Despite the smaller size regularly used in road tunnels, flaring should not be an issue due to the more controlled lighting environment.

Sign annulus flashing requirement

When displaying the normal speed limit, all pixel rings of the annulus must be illuminated. When displaying other than the default speed limit, the outermost ring of the red annulus must be illuminated and non-flashing to satisfy the regulatory status of the sign, with all other inner rings flashing.

7.8 Portable/Temporary VMS

Portable VMS are trailer-mounted signs that should only be used when they are necessary to improve traffic management relating to an incident or major event. They generally should not be used for the display of commercial advertising messages.

Portable VMS are used for traffic management purposes in the following circumstances:

- at road construction and maintenance sites
- in the areas surrounding major events
- for incident management where permanent VMS are not available or are inoperative, or where the spacing of permanent VMS is unable to give adequate warning of a major incident
- to encourage lower speeds in local streets.

Portable VMS are generally used at roadwork sites or in association with major events to:

- pre-warn motorists of road construction or maintenance activities, or events that may cause delay during some future period
- advise motorists of likely delays and suitable alternative routes during the duration of the works or event.

This information enables motorists to plan their trips so that they may use other routes and do not contribute to congestion or other problems in the area.

The use of traffic control devices for works on roads is covered in AS 1742.3. The standard includes vehicle-mounted flashing arrow signs and requirements for messages relating to roadworks. It is also important that VMS at roadwork sites complement the signing arrangements provided in standards.

Local government authorities often use trailer-mounted speed signs to inform motorists if they are travelling in excess of the posted speed limit. This is a similar use to the permanent speed indicator signs described in Section 7.6.8, but has the advantage of portability to enable a broad coverage of the local road network.

These temporary speed signs can be effectively used when positioned on local or collector/distributor roads if when there has been a permanent change to the speed limit. This helps motorists to adapt to the change. Where portable VMS are used to convey messages about measured speeds it is important to ensure that the devices are set up precisely to achieve a satisfactory level of accuracy.

The following conditions apply to the deployment of portable VMS:

- drivers are required to do something in response to the message (e.g. change travel speed or lane, divert or be aware of a change in current or future traffic or road conditions)
- static signs that can effectively convey the required message are not readily available
- information can be confirmed from a reliable source
- traffic conditions are monitored so that the VMS can be removed or the message changed as soon as necessary.

The principles for legibility, location, and sign and message design apply to both permanent and portable VMS. However, the following aspects require consideration in using and locating portable signs:

- Adequate reading distance should be available, allowing for any obstructions.
- The lateral placement should be such that the sign is easily read.
- Where practicable, they should be placed on the verge behind any existing shoulder.
- They must not be placed on bicycle lanes or on shared footpaths.

- Where possible, they should be placed outside of the clear zone corresponding to the prevailing traffic speed.
- The signs should be located clear of any roadside furniture, side streets and driveways, so that required visibility to permanent signs and sight distances for entering drivers are not compromised.
- They should be placed at least 300 m from the nearest permanent VMS.
- When placed on footways adequate horizontal and vertical clearance should be provided for pedestrians, including persons in wheelchairs.
- They should not be placed on both sides of a carriageway at the same location if separate signs are needed for each side of the road (e.g. different messages or visibility problems).
- Signs should be turned 3 to 5° away from the perpendicular to the edge of the carriageway to reduce glare.
- If use is intermittent throughout the duration of an incident or event, the sign should be turned away from drivers when it is not being used for messages.
- The sign trailer should be anchored to prevent it being moved under wind loading or by vandals.

Various message statements for use on VMS at roadwork sites are included in Appendix D.

Further to the above conditions, it is important, particularly where used on major arterials heavily monitored and controlled by the road agency's traffic management centre (TMC) that the temporary VMS is integrated with the TMC operation. The level of integration should be sufficient to enable TMC operators to understand, in real time, what messages are displayed on the VMS so that operators can use this knowledge, in addition to knowledge of the traffic flow (e.g. through CCTV footage), to understand current traffic conditions and therefore implement appropriate traffic management strategies. This can include advising motorists upstream of certain conditions in a manner that is consistent with messages displayed on the VMS located at the roadwork site. This may not always be possible when knowledge of what message is displayed on the VMS is unknown.

8. Pavement Markings

8.1 General

Pavement markings are all the lines, symbols, patterns, messages, numerals, or other devices set in the pavement or applied or attached to the pavement or kerb to regulate, warn or guide traffic. They are a very effective way of providing guidance for motorists and other road users (e.g. bicyclists, public transport users) as the markings are generally within the driver's field of view. They may act as a supplement to other traffic control devices but often they are the only effective way to convey regulations and warnings to drivers.

Pavement markings, along with signs, represent the most fundamental way to communicate with road users. Effective and efficient communication supports the Safe System by contributing to safe roads, safe speeds and safe road users. Some pavement markings are also critical to the effectiveness of emerging technologies, such as lane keeping assist, which contribute to safer vehicles.

All road users are highly dependent upon markings for their guidance and safety. Markings have many functions, including separating traffic streams travelling in either the same or opposing directions, defining the priority at conflict points (including pedestrians priority), providing warning to drivers who might drift from the traffic lane (audio-tactile edge and centre line markings) and warning of hazards.

Markings are highly standardised, which aids comprehension, reduces reaction time and maximises the likelihood of appropriate road user response and behaviour. Whilst innovation with markings is encouraged, care must be exercised when considering novel or unconventional uses. It is important to understand how drivers might respond to new types of markings and consider possible unintended consequences before they are actually trialled on the road. Advice from human factor experts may be helpful. Confusing, complex or misleading markings will compromise road user safety.

The highly standardised nature of road markings is likely to become especially important in the future as increasing numbers of vehicles are able to read the road in some way.

8.1.1 Use of Markings

Markings are often used in conjunction with each other to provide a traffic treatment for any given situation. For example, raised retroreflective pavement markers (RRPMs) are often installed adjacent to painted lines or traffic islands.

Signs that are used to regulate or warn drivers are often accompanied by road markings. While it is not always possible, the most effective road designs ensure that drivers are able to see road markings (i.e. not only the signs) and have sufficient time to respond and take appropriate action (e.g. to merge or stop). The provision of satisfactory sight distances should ensure that this requirement is met.

AS 1742 provides examples of the use of pavement markings for different situations and treatments. Standard patterns for various types of lines and their widths are described. However, practice in respect to the width of lines varies and therefore reference should be made to individual jurisdictional guidelines.

While many of the general principles described here apply equally in New Zealand, some of the markings differ, as do meanings assigned to markings used in both Australia and New Zealand. Practitioners in New Zealand should refer to the Land Transport Rules and to *MOTSAM Part 2: Markings* (NZ Transport Agency 2010a).

Practitioners should have knowledge of their jurisdiction's road markings to ensure that use is consistent with the road rules.

8.1.2 Limitations of Markings

Whilst pavement markings are essential for effective traffic management, practitioners involved in the management and design of roads need to be aware that they may have the following limitations:

- Markings are subject to traffic wear and require programmed maintenance to ensure their effectiveness.
- They can be partly or wholly ineffective on wet roads at night, or when dust or snow is present.
- Dark and wet conditions can enhance poorly blacked out or erased markings, which can mislead or confuse drivers. Special care, therefore, needs be taken when removing superfluous markings.
- They can cause skidding problems if materials are not carefully selected or the size of painted areas is not kept to the minimum.
- The visibility of markings can be greatly affected by crest vertical curves (particularly transverse markings).
- They may be obscured by other vehicles.
- Markings cannot be relied upon to give long-range delineation of the alignment of a road under all conditions.
- Transverse and word/symbol markings need to be greatly elongated to be seen, read and understood by drivers and off-line viewing of elongated markings may cause the message to be so distorted as to be illegible.
- They cannot be used on unsealed roads.

Despite these limitations their advantage under favourable conditions is that they convey information to drivers, often continuously (e.g. as longitudinal lines), without diverting drivers' attention from the roadway, and can be used to clearly define the status of certain areas of pavement for road users. A strong visual contrast between the pavement and the pavement markings is a primary requirement.

8.2 Colour and Reflectorisation

8.2.1 Colour

White is used for most Australian and New Zealand road markings and should be used unless otherwise specified.

Yellow may be used for parking lines either adjacent to the edge of the road to prohibit stopping, or for special bays (e.g. loading zones) to indicate areas that are not for use by the general motorist. In Victoria yellow markings are also used in conjunction with road rules to restrict other vehicles from entering tram-only areas, and from delaying trams on other parts of tram routes. They are also used in Victoria and New South Wales to improve contrast for longitudinal markings above the snow-line in alpine ski resort areas. On a light-coloured pavement, black may be used as a background to the white stripes of a broken line to improve the contrast, although this does not establish black as a standard colour. In New Zealand, yellow is used for no-passing lines.

The use of other colours for linemarking should not be encouraged as most other colours have inferior contrast, particularly at night, dusk or dawn. An exception is the use of blue markings for parking facilities for people with a disability (AS 1742.11) as the benefit of a distinctive colour in discouraging non-compliant use is considered to be more important than lack of contrast in this low-speed situation.

Where the use of a particular area of pavement needs to be highlighted to address traffic management or safety issues associated with its special use (e.g. bicycle lanes, bus lanes, pedestrian crossings), the lane or area may be provided with a surfacing of a standard colour to clearly define its purpose (Section 8.6).

The colour of RRPMs is described in Section 8.7.

8.2.2 Reflectorisation

All longitudinal lines, diagonal markings and chevrons having application at night must be reflectorised. Glass beads used in pavement marking materials must comply with AS/NZS 2009.

Raised pavement markers provided for delineation purposes must have retroreflective properties in accordance with AS/NZ 1906.3.

8.3 Linemarking Materials

Pavement markings in Australia and New Zealand comprise water-borne paint, solvent-borne paint, or long-life materials.

Water-borne paint is generally used for linemarking and road marking in rural areas. When used, consideration of the timing of resealing works and traffic volumes should be taken into account, as the use of long-life materials may prove more economical. Water-borne paint may be favoured as it:

- provides better retention of the larger glass beads, which results in improved night visibility and safety in wet conditions
- is more environmentally friendly
- is non-flammable and therefore safer to use.

Solvent-borne paint is sometimes used for an initial application on chip seal surfaces as an alternative to water-borne paint.

Long-life materials are most suitable for use in metropolitan areas or major rural cities on heavily trafficked routes, unless resurfacing is proposed within three years. Although more expensive than water-borne paint, long-life material is more cost-effective on these heavily trafficked routes due to its life span being two to five times longer. The use of these materials for edge lining, as traffic island outlines or approach markings has the further advantage that the lines can be profiled in a way which provides a tactile and audible warning when traversed by vehicle tyres. This category includes thermoplastic, cold-applied plastic material, and pliant polymer tapes.

Specifications for the above materials and for raised pavement markers are generally in conformity with the relevant Australia Standards, as outlined in Table 8.1 .

Table 8.1: Australian Standards which refer to materials for raised pavement markers

Standard no.	Standard title
AS/NZ 1906.3	Raised Pavement Markers (Retroreflective and Non-reflective)
AS/NZS 2009	Glass Beads for Pavement-marking Materials
AS 2700	Colour Standards for General Purposes
AS 4049	Paints and Related Materials: Pavement-marking Materials • AS 4049.1: Solvent-borne Paint: for use with Surface Applied Glass Beads • AS 4049.2: Thermoplastic Pavement Marking Materials: for use with Surface Applied Glass Beads • AS 4049.3: Waterborne Paint: for use with Surface Applied Glass Beads.

8.3.1 Types of Longitudinal Lines

Longitudinal lines are used for the purpose of delineating the traffic path and for regulating traffic movements. They can be classified into the following line types:

- dividing
- barrier
- lane
- transition
- continuity
- edge
- special (e.g. bicycle lane, bus lane, fairway lanes in Victoria).

AS 1742.2 provides information on standard patterns and widths of most of these lines, AS 1742.9 and AS 1742.12 cover markings for special lanes, and AS 1742.15 covers those relating to motorways. As some patterns and widths for particular treatments may vary between jurisdictions, local guidelines should be consulted.

As a general guide, dividing and barrier lines (if overtaking is to be prohibited) are warranted on two-lane sealed pavements (including bridges) that are 5.5 m or more wide if the annual average daily traffic (AADT) volume is in excess of:

- 300 vehicles on rural roads
- 2500 vehicles on urban roads.

Irrespective of these volume warrants, continuous or isolated sections of separation or barrier lines may be desirable where special conditions apply, such as:

- frequent horizontal and/or vertical curves
- sub-standard curves
- areas subject to fog
- approaches to a major road
- sections where the crash record indicates a need
- continuity of marking on an arterial road
- heavy volume of night or tourist traffic
- approaches to pedestrian crossings.

Warrants for the provision of barrier lines and the extent of their provision are covered in AS 1742.2.

8.3.2 Dividing Lines

Dividing lines are used to separate the portions of the roadway to be used by opposing streams of traffic. They are usually placed at the centre of two-way carriageways although they may be offset from the centre depending on directional traffic flows, traffic management (e.g. overtaking lanes) and parking requirements.

Dividing lines are broken, the standard pattern being a 3 m painted stripe and a 9 m gap. This pattern is also used for part-time bus and transit lanes where the lane is used as a general traffic lane at other times. However, where the special part-time lane is used for parking or another use at other times, a 9 m stripe and 3 m gap are used.

8.3.3 Barrier Lines

Barrier lines are a particular form of dividing line described in the Australian Road Rules (ARRs) that prohibit vehicles from using the opposing traffic lane(s). The most common usage, and the only option available in New Zealand, is to create no-overtaking zones on two-lane two-way roads where the sight distance ahead is restricted to the extent that the majority of drivers could not overtake safely. The restriction may apply to one or both directions of travel. Table 8.2 summarises the legal significance of barrier lines under the ARRs.

Table 8.2: Legal significance of barrier lines

Type of barrier line	Legal significance in Australian Road Rules
Two parallel continuous lines (double two-way barrier line)	• Must not be crossed to overtake from either direction • Must not be crossed to enter or leave the road (e.g. to access property or the verge of the road)*
Two parallel lines, one continuous and the other broken (double one-way barrier line)	• Must not be crossed to overtake from the travel direction immediately adjacent to the continuous line • May be crossed from both directions to enter or leave property or some other part of the road reservation
Single barrier line	• Must not be crossed to overtake from either direction* • May be crossed from both directions to enter or leave property or some other part of the road reservation

** Does not apply in WA and New Zealand.*

Note: Rules may differ across jurisdictions.

In New Zealand, yellow no-passing lines may be marked on two-lane two-way roads where sight distances are inadequate (primarily vertical curves). Yellow no-passing lines are mandated on three-lane sections of road without a solid median (e.g. where there is a passing lane in one direction) and are encouraged on four-lane (or more) roads. The main difference between the New Zealand no-passing line and the Australian barrier line is that in New Zealand drivers are not precluded from turning across them.

If safe intersection sight distance is not available for drivers entering or leaving the road from a property, it may be desirable to provide a double two-way barrier line rather than a single barrier line to prohibit crossing (Austroads 2020d). Note, however, that this is not valid in New Zealand.

Appropriate gaps should be left in double two-way barrier lines where it is necessary for drivers to enter, leave or cross the road. These gaps should not be provided where such crossing is undesirable, despite the fact that drivers may wish to cross. If the demand for gaps would destroy the integrity of a barrier line, and access to adjacent properties is to be permitted, a single continuous barrier line may be substituted.

Where the barrier linemarking does not allow right-turn property access as per the local road rules, replacement with an alternative barrier line that allows access should be considered.

Double two-way barrier lines

Where overtaking is to be prohibited, a double two-way barrier line should be used (rather than a single barrier line on rural roads). They are visually dominant and well understood by drivers who generally have a sound understanding of their legal obligations for this marking.

Double two-way barrier lines are required where it is necessary to prohibit drivers from driving to the right of a dividing line in the following cases:

- Where, on account of overtaking sight distance restrictions, a no-overtaking zone is warranted. AS 1742.2 provides detailed information on how to set the limits of double two-way barrier lines on two-lane two-way roads. The minimum overtaking sight distance (line of sight shown in AS 1742.2) must be based on the guaranteed visual unobstructed view within the road reserve.
- To mark the dividing line between the overtaking lane and the opposing trafficable lane. If visibility is sufficient, a double one-way barrier line may be used in some circumstances.
- On the approach to medians, median islands or other central carriageway obstructions at which all traffic must pass to the left. A single barrier line may be acceptable.
- Outlines and approaches at some painted median islands. Note that the single unbroken lines may be used in urban situations to enable vehicles to legally pass over the island, thus improving the length for deceleration, allowing traffic to queue over the painted chevron in peak hours, and enabling access to property.
- To mark the dividing line on the approaches to traffic signals and *stop* and *give-way* controlled intersections on undivided roads. A single barrier line may be acceptable.
- Approaches to railway level crossings (refer to AS 1742.7). A one-way barrier line is also acceptable.
- Elsewhere where consideration of safety or traffic control requires that all traffic must keep to the left of a dividing line. The desirable minimum length of the line is given in AS 1742.2.

Double two-way barrier lines must not be used in the following cases:

- for part-time requirements, e.g. on the approach to a school crossing
- on narrow bridges having less than 5.5 m between kerbs or vertical obstructions (AS 1742.2).

Double one-way barrier lines

A double one-way barrier line is used where it may be appropriate to use a dividing line (allow overtaking) for one direction of travel, but it is not suitable for use for the other direction.

Where there are access points adjacent to the road, the double one-way barrier line (not allow overtaking) may be problematic, as it permits driver's to cross the continuous line on either side to enter or leave the road unless restricted by local road rules. This may apply where sight distance is not adequate for:

- stationary motorists to select gaps in oncoming traffic and turn into properties adjacent to the road (gap acceptance sight distance)
- following vehicles to either stop when they identify the presence of the stationary vehicle (stopping sight distance) or decelerate and pass to the left of the stationary vehicle (manoeuvre sight distance).

If there is not sufficient sight distance to address both of these situations then consideration should be given to restricting access to left-in, left-out only and install a double two-way barrier line to prohibit vehicles crossing the centre of the road in order to enter or exit the driveway. Alternatively, if the sight distance is poor in both directions, consideration should be given to having the driveway relocated.

Single barrier lines

Single barrier lines may be appropriate in the following situations:

- On multi-lane urban two-way carriageways where lane lines are marked.
- Urban locations where a barrier line is required, but a double line is not practical because of the frequency of driveways.

- On long lengths of winding road in hilly or mountainous terrain where speeds are relatively low and which would otherwise require double two-way barrier lines. A single line may be more visually acceptable in this environment and does not consume as much width as a double line.
- At isolated curves and crests on narrow rural roads not meeting the dividing line width guideline, but where barrier lines would be warranted on sight distance criteria, and shoulders are of an adequate standard.
- Where the demand for gaps in a double line for property access would otherwise destroy the integrity of the double barrier line.
- To delineate curves, crests and islands on otherwise unmarked narrow residential and collector streets, where parking is not to be allowed adjacent to the dividing line (due to the ARRs requirement to maintain 3 m clear road width between parked vehicles and the barrier line).
- On the centreline of undivided approaches to traffic signals, or stop, give-way or roundabout holding lines.

8.3.4 Lane Lines

Lane lines should be used on all carriageways where sufficient width for two or more lanes of traffic moving in the one direction is provided. Urban two-way carriageways with a continuous width of 12.5 m (i.e. four-lane undivided arterial roads) or greater should be lane lined, or may be marked with parking lanes where appropriate.

If vehicles are permitted to change from one lane to another, the line must be a single broken line in the appropriate standard pattern. In some circumstances it may be desirable to prohibit lane changing (e.g. close to an important intersection, or in an auxiliary lane at a two-lane motorway exit) and in these situations lane lines are usually marked as an unbroken line.

Continuous lane lines 80 to 100 mm wide are used in the following situations:

- approaches to traffic signals, and stop/give-way and roundabout holding lines; the length of these lines may vary depending on road geometry; however, 20 to 30 m is a desirable length to assist in warning drivers of the presence of an intersection
- as the line between a through lane and an acceleration, deceleration or a turning lane on roads other than motorways; a continuity line is used to extend the lane line along the tapers
- to delineate an exclusive bicycle or parking lane
- to define full-time and part-time public transport lanes
- to define turn lanes at traffic signals
- where it is desired to prohibit lane changing while improving lane delineation through sharp curves, over crests or through other changes in the alignment of lanes.

Continuous lane lines 150 mm wide are used in the following situations:

- to define full-time special purpose lanes such as bus and transit lanes on arterial roads
- on motorways, as the line between the exit ‘trap’ lane and through/optional exit lane, and between the through lane and the ‘added lane’ on two-lane entry ramps.

It is to be noted that continuous lane lines for bus lanes are only appropriate if lane changing is prohibited; that is, where vehicles are not permitted to enter the bus lane to turn left, and buses are not permitted to leave the bus lane.

Where off-centre operation involving reversible flow in the centre lane(s) is implemented, the lane lines may temporarily operate as separation lines and a bold, broken line pattern or continuous lines may be used to discourage lane changing. The linemarking at the terminals of these facilities requires special consideration.

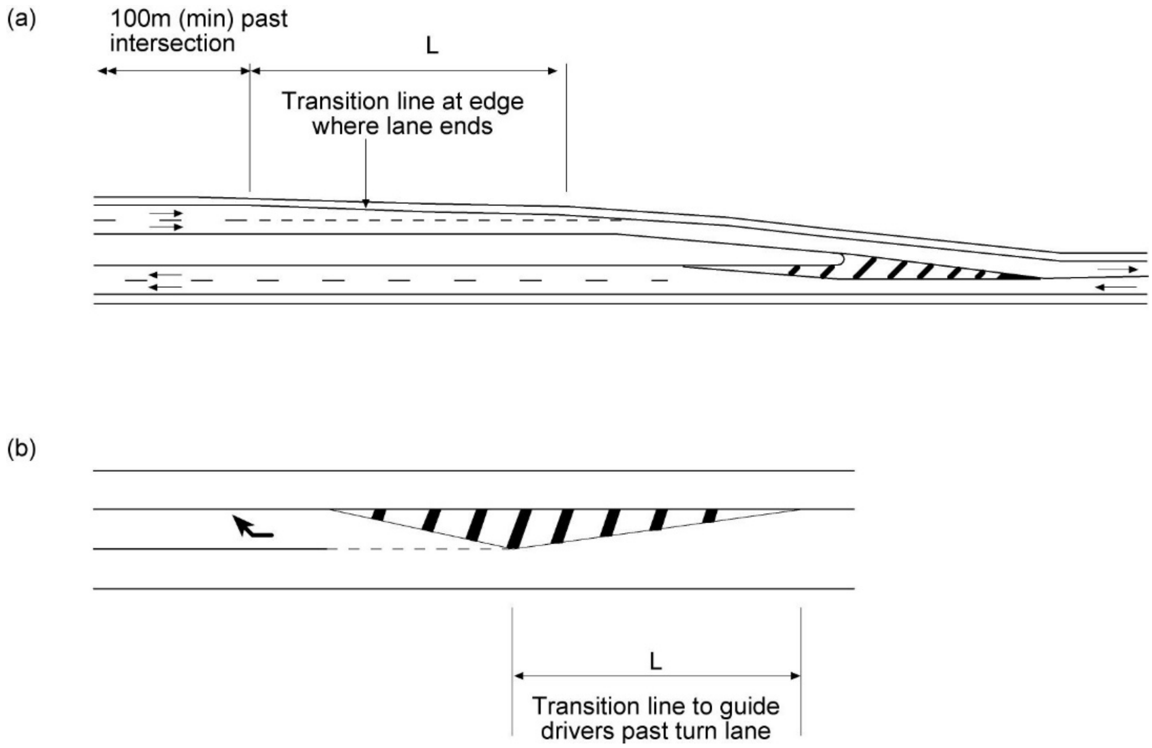
8.3.5 Transition Lines

'Transition line' is a general term given to a specific application of other types of longitudinal lines. It may apply to those parts of an edge line or island outline that are used to deflect vehicles laterally at points where:

- the width of the carriageway changes to a greater or lesser number of lanes (except in New Zealand where it applies to the former case only)
- traffic has to negotiate median traffic islands, safety zones, or obstructions on the road.

Figure 8.1 shows a situation where transition lines are used to guide drivers through a lane reduction, an alignment involving a lateral shift, and also past a median nose. Transition lines are usually marked as single, unbroken lines; however, where they are used in advance of a median island separating opposing directions of traffic flow, a double barrier line may be used. They should extend over the full length of any constructed transition zone, the length of which will depend to a large extent on prevailing traffic speeds and the vertical and horizontal alignment of the roadway.

Figure 8.1: Examples of transition lines



Notes:

Preferred transition from divided to undivided road.
L is length of merge.
Transition lines used along edge of road to guide drivers through lane reduction, alignment, and past the median nose.

The following is a guide to the length of transition lines approaching traffic islands or other obstructions in the roadway where the length of the constructed width of the transition is not obvious:

L = 0.30 VW for diverging or minor changes

L = 0.50 VW for merging areas

where

L = length of transition (m)
V = 85th percentile speed (km/h)
W = lateral shift (m)

However, the minimum length of the transition line should be 60 m in rural areas and 30 m in urban areas. Transition lines should generally be the same width as edge lines or outline markings depending on the location. Where traffic volumes are high, or the merge area is on a significant grade, the transition length may need to be recalculated.

8.3.6 Continuity Lines

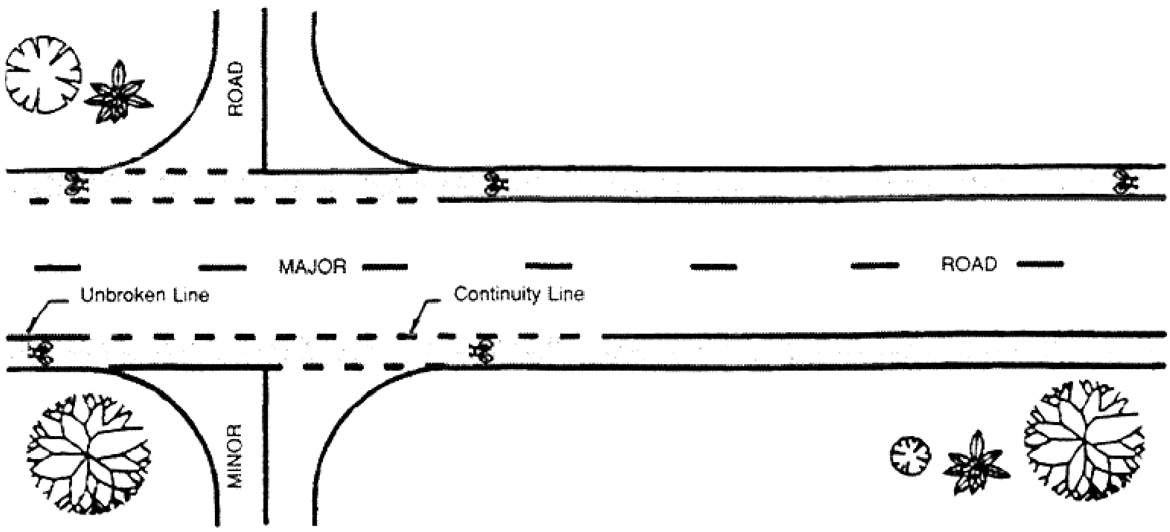
A continuity line is a broken line which may be used to indicate the edge of that portion of a carriageway assigned to through traffic, and where it is intended that the line be crossed by traffic turning at an intersection, or entering or leaving an auxiliary lane at its start or finish. The standard pattern is a 1 m line and a 3 m gap.

Continuity lines are used at a merge associated with lane reductions that require a positive lane change manoeuvre from the terminating lane to the adjacent lane. Where a general merge manoeuvre is required, the continuity line is omitted, and drivers are expected to merge in turn in accordance with the road rules. AS 1742.2 sets out the signing and marking requirements for lane reduction and merge situations.

Continuity lines may be used:

- where an added lane treatment ends
- where a lane reduction occurs beyond a signalised intersection; the preferred treatment is to install a continuity line in association with signing, but in some cases this may not be practicable due to geometric or road cross-section constraints
- where a lane reduction occurs at the end of an overtaking-lane section
- across the entry point to right and left-turn lanes
- across the entry and exit points to and from motorway ramps
- at the entry and exit points of slow-vehicle turnouts
- where a bicycle lane is marked to continue through an unsignalised intersection (Figure 8.2), to continue across the entry point of an auxiliary lane or a merge at the end of an auxiliary lane
- to define short sections of two-way median turn lanes, and across local street openings where two-way median turn lanes are installed.

Figure 8.2: Marking of bicycle lane with continuity line through minor intersection



8.3.7 Edge Lines

Edge lines provide a continuous guide for drivers by delineating the edge of the travelled way. They are marked to make driving safer and more comfortable, particularly at night.

Generally, edge lines are provided on:

- motorways (urban and rural) and on other rural arterial roads where the shoulder is partly or fully sealed
- urban arterial roads where street lighting is of a low standard and extra delineation at the kerb line is required
- rural roads where the AADT is greater than or equal to 2500 vehicles per day (VPD)
- rural roads in high rainfall areas (greater than 1000 mm per annum) or where the road is subject to fog or wet days for significant periods and the AADT is greater than or equal to 1000 VPD
- rural roads where the heavy vehicle AADT is greater than 300 VPD.

Edge lines are used to:

- supplement the delineation provided by lane or separation lines on two-way pavements greater than or equal to 6.8 m that have unsealed shoulders; in special circumstances (e.g. where poor alignment exists, or in fog prone areas) edge lines may be provided for pavements between 5.5 and 6.8 m
- define the edge of the general traffic lane where bicycle lanes or sealed shoulders are provided on wide pavements
- delineate the left side of the pavement on the approaches to and across bridges when the width of the bridge is less than the full formation width
- delineate the right side of each carriageway of duplicated roads where the median is not kerbed
- improve delineation adjacent to median kerbs provided that the resulting lane width is not less than 3 m.

Gaps should be left in edge lines at all intersections with minor roads that have no controlled intersection markings, such as unsealed roads. A standard continuity line may be placed across the gap if delineation is required, or to continue a bicycle lane through the intersection in accordance with the Australian Road Rules (ARRs). Where stop or give-way intersection markings are provided, they are not necessarily placed in line with the edge lines.

Where unsealed shoulders about the pavement, edge lines should be located at a sufficient clearance inside the pavement edge (e.g. 150 mm to the edge of the line) to ensure that edge wear does not diminish or destroy the integrity of the line.

Yellow edge lines

A continuous yellow edge line is a regulatory line that can be used to ban parking as an alternative to *no stopping* signs in accordance with the ARRs. The relevant road rule applies to yellow edge lines marked adjacent to kerbs, or at the edge of traffic lanes where it can be used to ban parking on shoulders.

Audio-tactile line marking

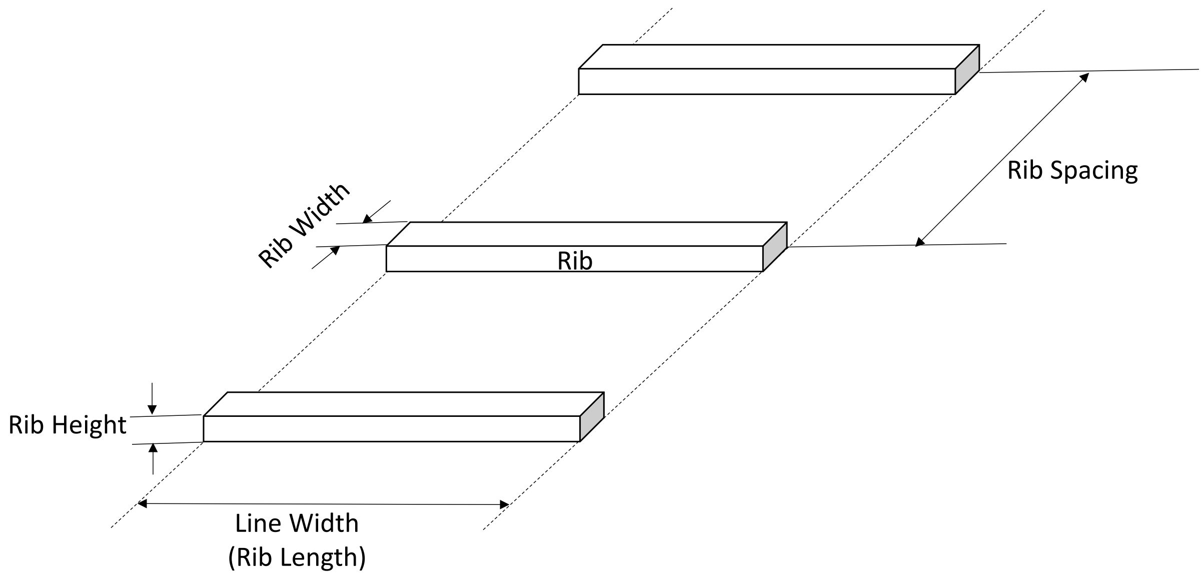
Audio-tactile line marking (ATLM) is generally associated with edge lines as a road-based measure to reduce fatigue-related crashes by minimising run-off-the-road crashes and therefore primarily used in rural areas.

In general, ATLM is used to provide a noise (audio) and vibratory (tactile) warning to drivers starting to stray due to fatigue or fog, although another significant benefit is its superior wet weather delineation. Drivers also tend to focus on the edge line for guidance when traffic is approaching from the opposite direction at night to avoid being dazzled by headlights.

ATLM is created by installing a line of small projections or depressions in the road surface although depressions are not recommended for general use. An example of the characteristics of a discontinuous ATLM is shown in Figure 8.3 , while Figure 8.4 shows a treatment on a motorway.

Projections are created by fixing small, raised objects of non-compressible material to the road surface – most commonly either extruded thermoplastic ribs or plastic raised pavement markers.

Figure 8.3: Example of a discontinuous thermoplastic audio-tactile edge line



Note: The dimensions of the audio-tactile edge line, including line width, rib spacing, rib height and rib width may vary between jurisdictions.

Source: Based on Department of Planning, Transport and Infrastructure (2009).

Audio-tactile linemarking should be considered where there is a recorded history of fatigue-related crashes and may be considered on roads prone to fog. Fatigue-prone areas are generally well known to local authorities, emergency services and jurisdictions, and may be verified by an analysis of a state or territory crash database. Network road safety audits may also identify potential locations. They are generally within a particular distance range from city or town centres on long and fairly straight roads. Fatigue-related crashes predominantly involve single vehicles but not always (e.g. some head-on crashes).

Figure 8.4: Audio-tactile edge lines on a motorway

In a review of various studies into the effectiveness of ATLM in reducing crashes, Austroads (2012) found that the average reduction in casualty crashes as a result of edge lines was approximately 20% and centrelines was approximately 15%.

It is noted that in Australia and New Zealand ATLM centrelines are not as widely used as edge lines but are starting to become more widely adopted as a measure to address head-on crashes.

ATLM should not be installed:

- unless the structural integrity of the surface, base and sub-base is sufficient to prevent cracks developing between the carriageway and the shoulder
- where substantial portions of the road (say more than 25%) are likely to require resurfacing within three years of installation.

The preferred minimum cross-section width of a sealed roadway for the use of ATLM is 9.0 m comprising two 3.5 m lanes and two 1.0 m sealed shoulders. However, ATLM can be used where the total sealed pavement width is an absolute minimum of 7.0 m (the edge line should have a clear distance of 150 mm to the edge of the bitumen) provided that:

- the section of road has a history of fatigue-related road crashes and would benefit from the application of ATLM
- the shoulder can be maintained in a condition that will guarantee the integrity of the line and savings associated with crash reductions outweigh the additional cost incurred due to reduced lifespan of the ATLM.

The minimum continuous length of ATLM that should be applied to a road is one kilometre.

It is desirable that ATLM should not be installed within 500 m of a residential building (where practicable) with a minimum of 200 m, unless appropriate noise barriers are installed or unless the frequency and severity of fatigue-related crashes in the area are such that a continuous treatment is considered essential on safety grounds.

ATLM should be discontinued across locations subject to constant wear from traffic braking and turning. Typical locations are intersections and access points to commercial developments, service stations and rest stops.

8.3.8 Special Lane Lines

Special lane lines apply to the provision of transit, bus, truck and bicycle lanes. AS 1742.12 provides guidance for the marking and treatment of transit, bus and truck lanes, while AS 1742.9 provides information on bicycle lanes.

Full-time transit, bus and truck lanes are provided with a 100 to 150 mm wide continuous white lane line to separate the facility from general traffic lanes. Under the ARRs vehicles that are allowed to use the special lane may move across the lane line. For part-time lanes an 80 to 150 mm wide broken line is used with a:

- 3 m stripe and 9 m gap if the lane is a general traffic lane at other times
- 9 m stripe and 3 m gap if the lane is used for parking or some other special use at other times.

Tram Lanes (or fairways as they were once known) came into existence in Melbourne in 1983 to give some priority to trams. There are two types of Tram Lanes with either a solid or dashed yellow line, which both operate under the premise of general traffic not delaying trams (Austroads 2017c). Tramways, on the other hand, have a double solid line and are not to be entered by general traffic. Special lane lines may be used to provide full-time or part-time tram lanes, or to restrict motor vehicles from delaying trams on routes along four-lane undivided roads. Depending on the application, the lines are continuous or broken yellow lines (AS 1742.12). In Victoria, these lines are referred to as fairway lines. Tram lanes and tramway line marking is shown in Figure 6.5.

In practice in a congested road network, Tram Lanes often fail to give adequate priority. There are a couple of practical reasons for this, as follows (Austroads 2017c):

- It is often difficult to predict that one will be delaying a tram when moving into a Tram Lane, particularly when drivers are sitting in a long traffic queue.
- Opportunities to move out of the way of trams are often limited with long queues or parked vehicles in adjacent lanes discouraging or prohibiting this behaviour.

To ensure absolute priority VicRoads has a strong preference for physical separation and uses the double yellow line marking (of the Tramway) only by exception. It states that separation kerbs shall be used for all tramways except where approval is given by the VicRoads Director – Network Policy & Standards for use of double continuous yellow lines (Vicroads, 2015).

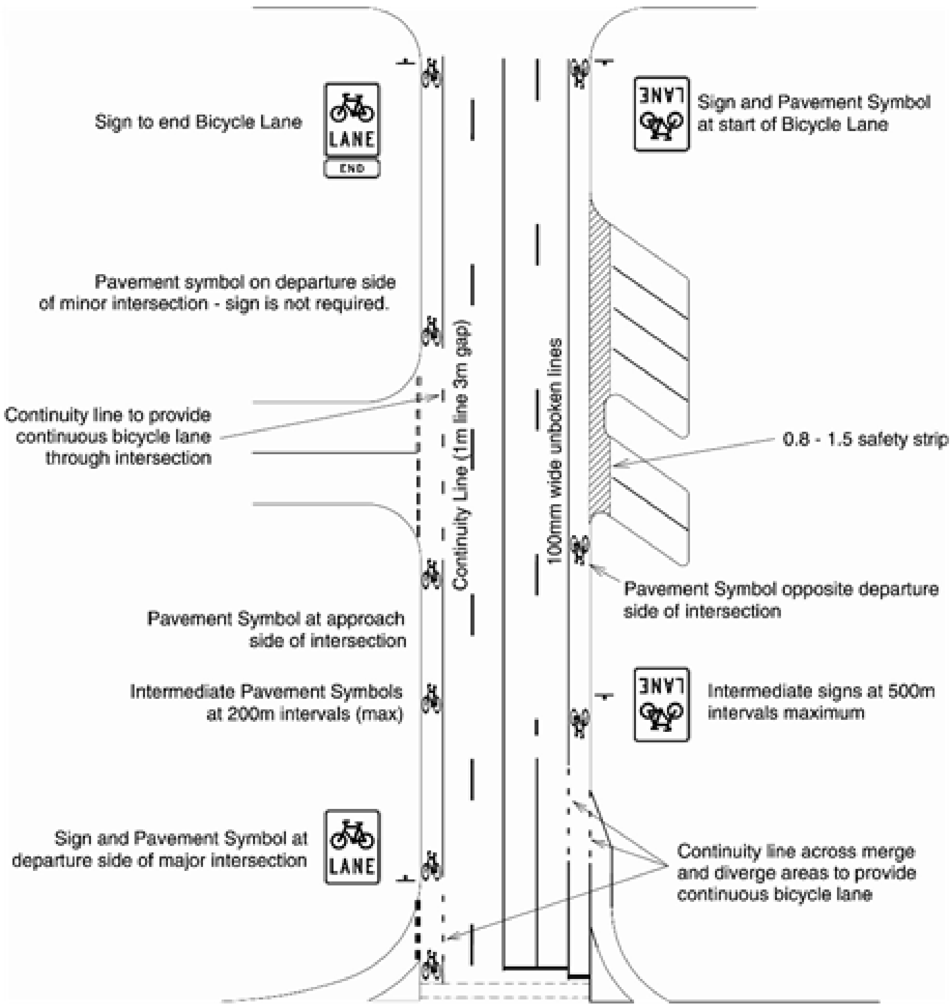
Bicycle lanes are generally separated from general traffic by a 100 mm wide continuous white line. In areas where bicycles and motor vehicles cross or intersect, continuity lines are used to define the bicycle lane. Figure 8.6 provides an illustration of a bicycle lane treatment for a road that shows the marking treatment through an unsignalised intersection, on the approach to a signalised intersection including a ‘head-start’ treatment, and adjacent to angle parking. Further information is provided in Austroads (2020d), AS 1742.9 and relevant jurisdictional guidelines.

Figure 8.5: Tram Lane and Tramway Line Marking

Patterns and Dimensions	Usage
6m 6m yellow 100mm wide	Lane in which vehicles are not to delay trams
yellow 100mm wide	Full-Time or Part-Time Tram Lane
1m 3m gap 1m (Yellow) 200 wide	Continuity Line for start of Part-Time Tram Lines
yellow 100mm wide yellow 100mm wide 100mm wide gap	Tramways

Source: VicRoads (2015).

Figure 8.6: Example of bicycle-lane markings



Source: VicRoads (2001).

8.4 Transverse Lines

Transverse lines can be classified into three types:

- stop lines
- holding lines (give way)
- pedestrian crossing markings.

8.4.1 Stop Lines

A stop line is an unbroken line marked transversely across the general traffic lanes and special lanes at traffic signals, stop signs, and at children's crossings. The stop line is 300 mm wide; 450 mm is preferred, but where the 85th percentile speed on the approach is 80 km/h or more the width should be increased to 600 mm. The stop line indicates the point behind which vehicles must stop.

Where stop or give-way line markings are provided at an unsignalised intersection in conjunction with *stop* or *give-way* signs, the line is continued as a broken line across the right-hand side of the carriageway. The broken line is always narrower than the line on the left-hand side of the carriageway. The dimensions of the broken section of the stop line are a 150 mm wide line comprising 600 mm long segments with 600 mm gaps. The treatment of stop lines and give-way lines at kerbed intersection is shown in Figure 8.7. Where it is necessary to locate the stop line in advance of the intersecting carriageway because of visibility restrictions, the needs of pedestrians, or clearance to stopped vehicles for traffic turning at the intersecting roadway, the broken line is continued across the road.

The treatment of give-way lines at intersections on roads that are unkerbed and have shoulders is illustrated in Figure 8.8.

Stop lines are also provided for bicycle lanes. Where no head-start area is provided, the normal stop line provided for motor vehicles needs to extend across the bicycle lane. Typical arrangements for setting out a stop line as part of a head-start area are discussed further in Austroads (2020d) and AS 1742.9.

Stop lines should generally be at right angles to the road centreline on the approach. At highly skewed intersections it may be appropriate to stagger the stop lines in each traffic lane. At railway level crossings stop lines may be painted parallel to the rail tracks (AS 1742.7).

8.4.2 Give-way Lines

A give-way line is at least 300 mm wide consisting of line segments 600 mm long separated by 600 mm gaps marked across an intersection approach controlled by a *give-way* or *roundabout* sign.

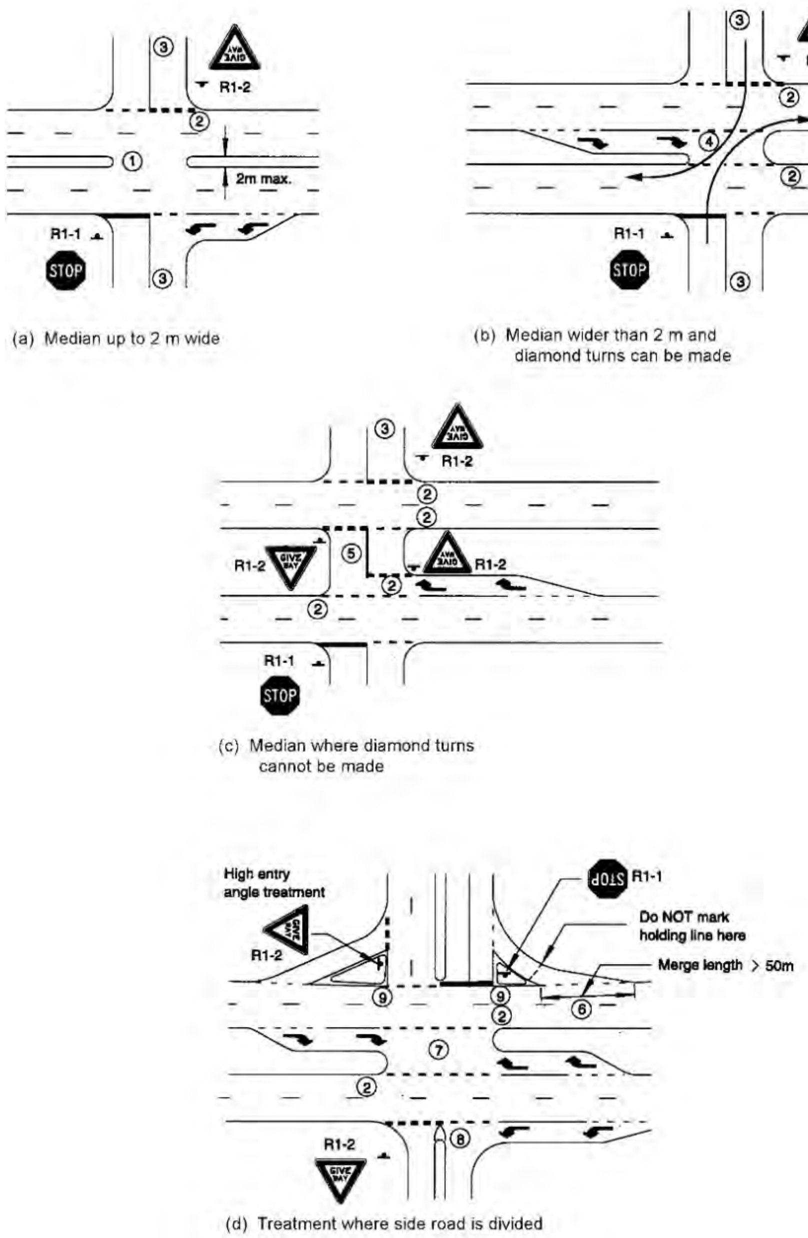
Give-way lines indicate the safe position at which a stationary vehicle giving right of way should stand. It is continued across the right-hand side of the carriageway at half the width of the line used across the approach lanes. Where it is necessary to locate the holding line in advance of the through carriageway because of the needs of pedestrians or clearance from traffic, the broken line is continued across the road. The treatment of holding lines at intersections that have kerbs is illustrated in Figure 8.7 whereas the treatment at unkerbed intersections is shown in Figure 8.8 (also refer to AS 1742.2).

A holding line may also be used at railway level crossings that are controlled by a *give-way* sign and crossings that have no regulatory control devices to indicate the safe position for a vehicle to stop.

8.4.3 Limit Lines

In New Zealand, single continuous transverse lines, known as 'limit lines' are used for *stop* and *give-way* signs, roundabouts, railway level crossings and in advance of pedestrian crossings. Where *stop* signs are installed (intersections and railway level crossings) the pavement markings are yellow.

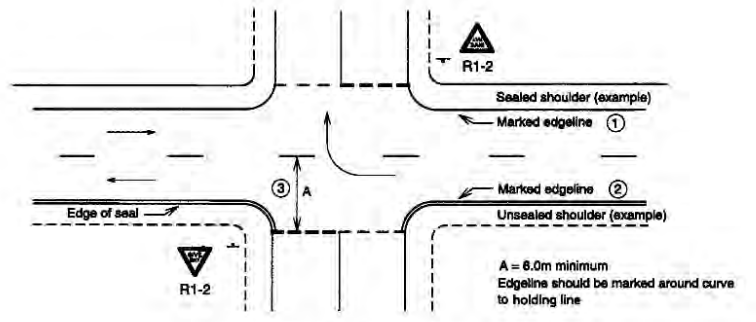
Figure 8.7: Typical stop line and give-way line treatments at kerbed intersections



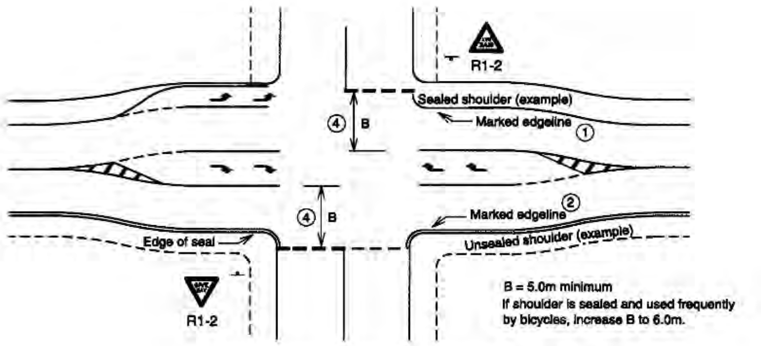
1 *Long openings may require pavement delineation, especially if on a curve or crest. Use standard continuity lines on the prolongation of each median kerb in such cases.*
2 *The leading edge of the broken give-way line at a median opening (i.e. edge nearer the major road) is aligned with the face of kerb. An exception to this is where a painted edge line is installed along the median; in such cases the markings at median openings are a prolongation of the edge line.*
3 *A side road centreline is provided if the remainder of the side street has a separation line marked, or if the width between kerbs, or seal width measured 10 m back from stop/holding line, is 6 m or more. The line may be extended beyond 30 m if the approach is curved, or on a crest, or if there is some other unusual geometric feature. However, where less than 3 m clear distance will result between the line and a parked car, parking is illegal under the ARRs and this should be considered in the arrangement adopted.*
4 *There must be sufficient clearance for opposing right turners to pass when simultaneously following a diamond turn pattern.*
5 *The central line in the median opening is an unbroken line, preferably 150 mm in width.*
6 *Apply relevant road agency guidelines.*
7 *Median treatment as in Examples a, b or c as appropriate.*
8 *Approach island or median nose set back. A 100 mm wide outline between end of stop/holding line and island/median nose may be marked to enhance delineation.*
9 *Controlled intersection markings are a prolongation of the painted island outline.*

Source: VicRoads (2001).

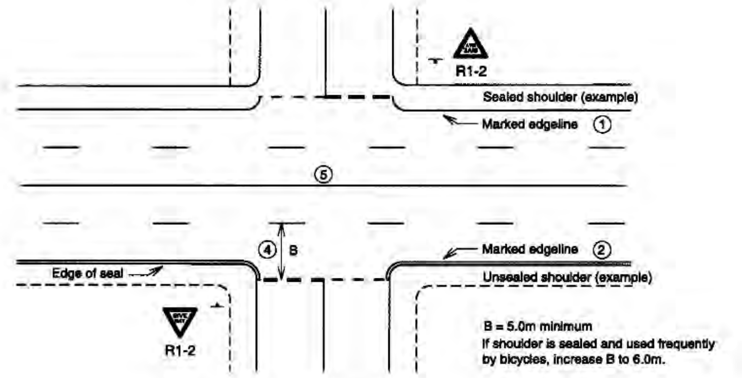
Figure 8.8: Typical give-way lines on roads that have shoulders



(a) Two-lane two-way major road



(b) Right turn lane marked on major road



(c) Multi-lane major road

1 *Where an edge line is provided, it may continue around the corner to the stop or give-way marking.*
2 *An edge line may or may not be marked adjacent to an unsealed shoulder.*
3 *At crossroads where right turns are made in the direction of the arrow, distance 'A' should be at least 6 m to permit a through vehicle to pass a right turning vehicle without risk of colliding with a vehicle waiting at the holding line. In the case of a T-intersection, adopt 5 m (This note applies only where pavement is unkerbed).*
4 *The holding line should be set back sufficiently to achieve a balance between clearance to the major road traffic lane, sight distance, and the crossing distance for vehicles leaving the side road. Some jurisdictions have specific requirements regarding the position of the holding line.*
5 *A median may exist in this situation.*

Note: These arrangements are applicable where there is no central island on the minor road, and also apply to T-junctions.

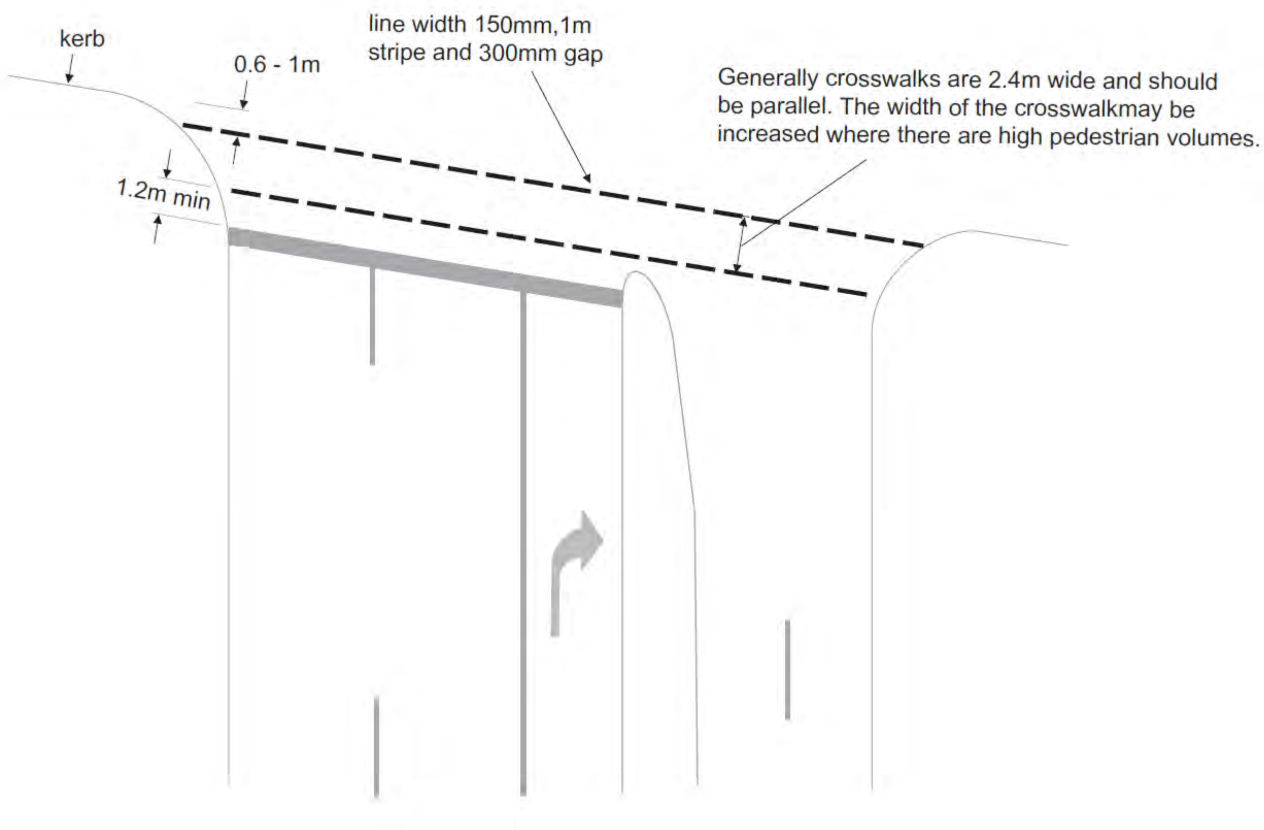
Source: VicRoads (2001).

8.4.4 Pedestrian Crossing Markings

Under the ARRs, markings to assist pedestrians to cross the road are defined as a 'marked foot crossing', a 'pedestrian crossing' or a 'children's crossing'. Details of these are outlined below with further details in Austroads (2017a) and Austroads (2008–17).

Marked foot crossings (Figure 8.9) are provided at traffic signals and are defined by two parallel broken lines on the road surface extending from one side of the road to the other. They may be provided at intersection signals or at mid-block pedestrian operated signals. The lines across the road are generally placed in the order of 2.4 m apart, but no less than 2 m, are 150 to 300 mm in width, with 1 m line segments and 300 mm gaps.

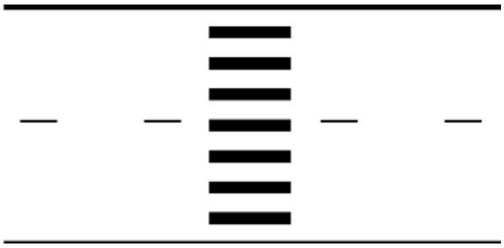
Figure 8.9: Marked foot crossing line markings at a signalised intersection



Source: Department of Planning, Transport and Infrastructure (2015).

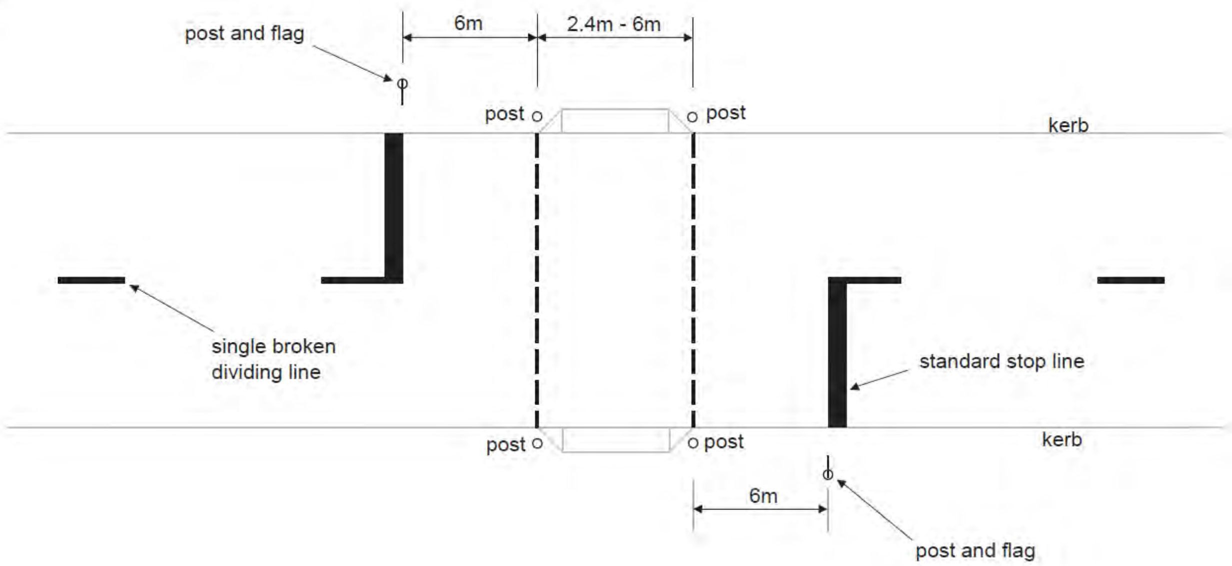
Pedestrian (zebra) crossings (Figure 8.10) consist of a series of longitudinal bars 600 mm wide and generally not less than 3.5 m long. The bars are placed parallel to the road centreline with gaps of 600 mm. The crossing is usually at right angles to the road centreline, but it may be angled (at a suggested maximum angle of 30° to a perpendicular line to the kerb) where local circumstances require.

Figure 8.10: Pedestrian (zebra) crossing line markings



Children's crossing markings (Figure 8.11) consist of a pair of parallel broken lines (1 m line segments and 300 mm gaps) 150 mm wide across the road. The crossings are also defined by flags, signs, posts or flashing lights depending on the type, and stop lines in advance of the crossing lines. A substantial distance (e.g. 6 m) is usually provided between the crossing lines and the associated stop lines to provide greater clearance between stopping vehicles and young pedestrians.

Figure 8.11: Example of children's crossing line markings – this one accompanied by post and flag



Source: Department of Planning, Transport and Infrastructure (2015).

8.5 Other Markings

8.5.1 Turn Lines

Broken (as opposed to solid) turn lines of 100 mm thickness and 600 mm stripe with 600 mm gaps may be used within a signalised intersection, particularly in complex intersections, to guide traffic along the most desirable turning path. Further guidance on the use of turn lines at intersections is outlined in Section 10.7.1. They are predominantly used for right-turning movements and normally required when one or more of the following conditions apply:

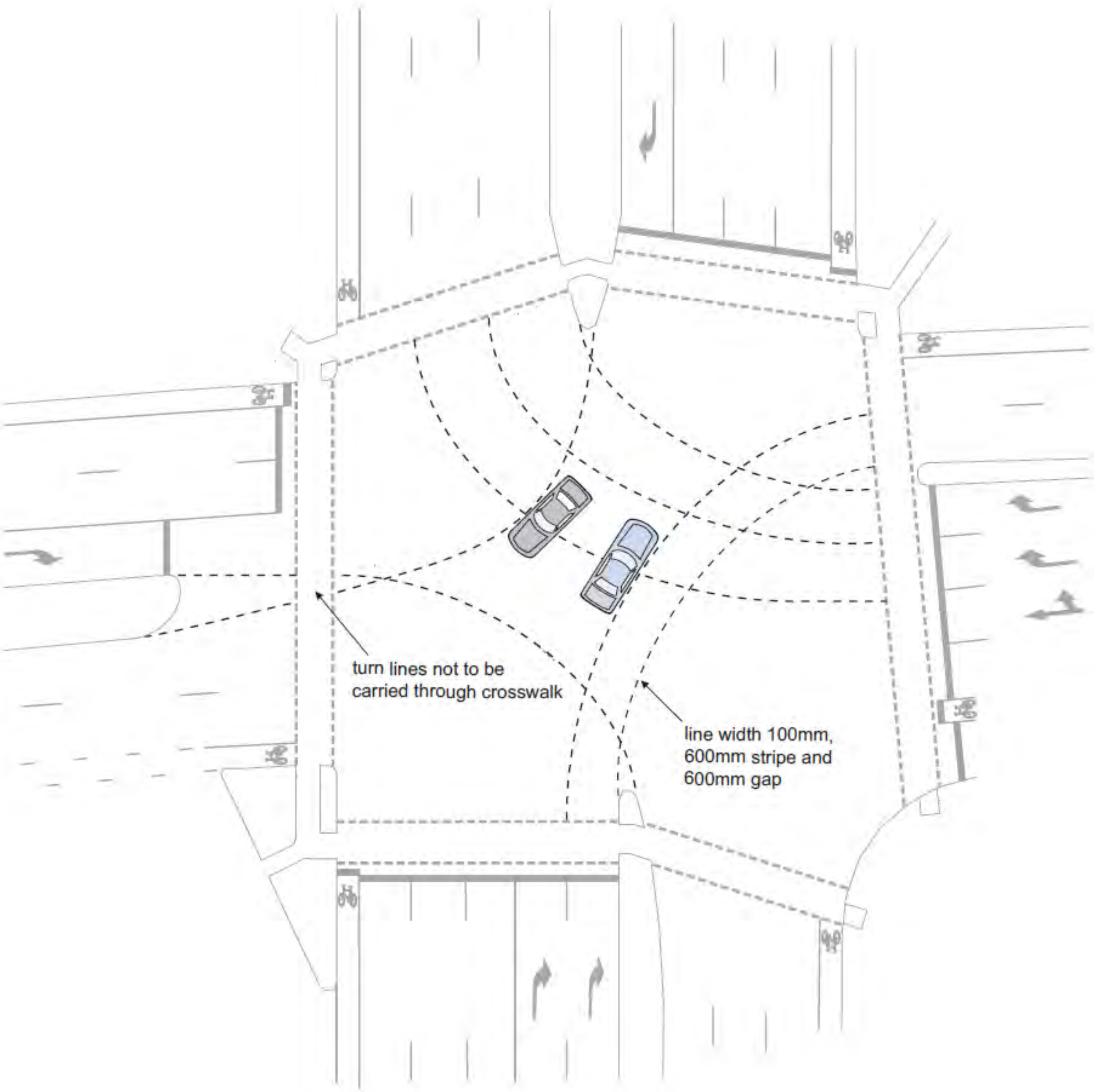
- undivided approaches on opposite sides of an intersection have separation lines offset by more than 3 m
- the intersection is on a summit vertical curve and right-turning drivers could be unsure of the required travel path through the intersection

- the right-turn movement is from two or three lanes turning in the same direction
- one or more of the approaches is sharply angled or the intersection is on a skew
- the divided-road carriageway width on two or more approaches exceeds 10.5 m
- any other feature makes the turning path difficult to follow.

In some instances, where multiple left-turn lanes exist (e.g. where a motorway off-ramp joins a divided arterial road) turning lines may be required to assist vehicles turning three or four abreast.

At cross intersections, clearance to meet the swept path requirements must be provided for opposing right-turn vehicles. When a driver of a right-turning vehicle filtering through an intersection has difficulty in determining where to stop, which may be due to the curvature of the road and/or vehicles making a right turn from the opposite direction, a 300 mm wide holding line may be marked to indicate where to wait prior to completing the turn. An example of the use of turn lines is shown in Figure 8.12.

Figure 8.12: An example of the use of turning lines at an intersection



Source: Department of Planning, Transport and Infrastructure (2015).

8.5.2 Diagonal and Chevron Markings

Wide diagonal or chevron markings may be applied to areas of pavement that are not intended for use by moving vehicles, for example, painted islands and medians, the approaches to islands or obstructions, and in emergency stopping lanes to discourage use by through traffic. Details of the markings are covered in AS 1742.2.

In New Zealand, flush medians and approaches to right-turn bays (which utilise diagonal markings) may be used by turning vehicles.

8.5.3 Off-road Path Markings

Dividing lines and barrier lines on shared paths or bicycle paths should be marked in accordance with AS 1742.9.

8.5.4 Yellow Box Markings

Yellow box markings have been trialled at signalised intersections in Melbourne, Sydney and Perth.

Yellow box markings are used to delineate locations on the road where motorists should not stop at any time but particularly during congested conditions such as:

- in the middle of intersections
- at mid-block locations which provide access to critical locations (for example, at fire stations or ambulance access to and from hospital grounds), although some jurisdictions may prefer to use 'keep clear' pavement markings (refer to Section 10.7.4)
- at railway level crossings.

It is important when considering yellow box markings that their effectiveness is enhanced with education and enforcement accompanying their use.

As vehicles being trapped in a queue on a railway level crossing can have disastrous consequences, delineation of the conflict area between trains and vehicles using the yellow box marking can assist drivers to stop their vehicles clear of the tracks. This encourages a reduction in the number of vehicles stopping on the railway tracks and therefore reduces the number of vehicles at risk. Their use at railway level crossings is covered in AS 1742.7.

It is recommended that yellow box markings should only be installed at railway level crossings where:

- Traffic queues extend across the rail tracks on a regular basis as a result of a downstream constraint (e.g. a signalised intersection). The constraint should be subject to an engineering assessment to determine if it can be removed or improved to reduce or eliminate the queuing.
- An engineering evaluation of the site has been carried out to maximise the effectiveness of such markings (e.g. the downstream limits of the markings should be visible to the driver of a passenger vehicle at the stop line of the rail crossing).

Use of the yellow box markings for situations other than railway level crossings, such as those noted earlier, is at the discretion of the road agency.

8.5.5 Messages on Pavements

Words, numerals, and symbols may be marked on pavements in accordance with AS 1742.2 to provide guidance, warning, or regulatory messages to drivers. For example, the words *keep clear* are often used as an alternative to yellow box markings (Section 8.5.4).

They should be elongated in the direction of traffic movement so that they may be legible at the maximum distance. Legibility distance is increased by enlarging the length of characters. There is, however, a diminishing rate of benefit obtainable with increasing length.

Words, letters and numerals

Where traffic travels at minimum headways a pavement message should be limited, where practicable, to one line. On high-speed roads a separation of four times the character height should be used, and the message should be arranged so as to read sequentially (i.e. with the first word nearest to the driver).

For low-speed urban situations the separation between lines may be from one-half to one times the character height, in which case the message should be arranged to read from top to bottom (i.e. with the first word farthest from the driver).

Permissible word messages and dimensions of letters and numerals used on the road pavement are specified in AS 1742.2.

Arrows

Arrows are used where necessary to ensure correct lane usage at approaches to intersections and other control points. Arrows should be used in preference to words to designate turning lanes. Pavement arrows are elongated similar to letters or numerals in order to increase their recognition distance (AS 1742.2).

If any lane on the approach to an intersection is to be designated by means of arrows, where practicable at least three arrows should be placed in that lane to increase the probability of recognition. A spacing of 15 to 30 m should be used between repeater arrows according to the size of the arrow, larger arrows being used for high-speed roads.

At intersections where queues of vehicles are likely to occur (e.g. at traffic signals) pavement arrows should commence a sufficient distance in advance of the intersection to ensure that waiting vehicles do not obscure the arrows, wherever this is practicable.

The permissible combinations of pavement arrows and their design details are shown in AS 1742.2.

Parking and loading areas

Pavement markings are used in business areas to designate sections of road for use as public parking spaces, bus stops, loading zones, and taxi stands. Markings may also be used to indicate no-standing and parking restrictions.

AS 1742.11 provides information on road markings associated with parking and parking restrictions, and Austroads (2020g) covers typical dimensions and layouts for parking spaces.

8.5.6 Roundabout Markings

Pavement markings at, and on the approach to roundabouts are provided to guide and control drivers (and when appropriate, bicyclists) through the intersection. Austroads (2020d), *MOTSAM Part 2* and AS 1742.2 provide guidance on the provision of markings related to roundabouts.

8.5.7 Kerb Markings

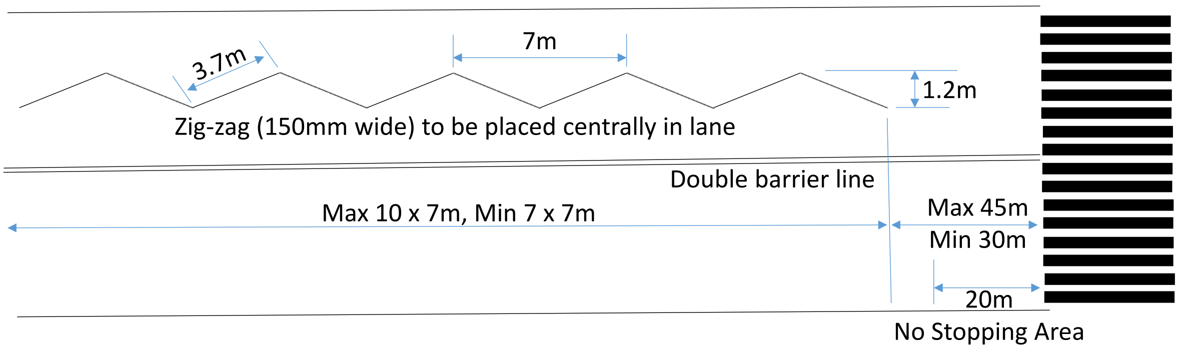
Kerbs of medians and traffic islands may be painted and reflectorised if added visibility is required. Reflectorised markers may also be used on kerbs as they may be more durable than paint.

8.5.8 Zig-zag Markings

Zig-zag road markings may be used in some jurisdictions in order to increase driver awareness of an approaching feature such as a pedestrian (zebra) crossing and school zones (e.g. acts as a gateway feature). The markings should only be used selectively where sight distance may be poor and where features such as pedestrian crossings are unable to be relocated.

As the use of the markings and their design differs between road agencies, practitioners should refer to jurisdictional guidelines before implementation to conform if their use is permitted and to also confirm the layout of the zig-zag pattern. An example of a zig-zag marking used on the approach to a pedestrian crossing is shown in Figure 8.13.

Figure 8.13: Example of zig-zag road marking on the approach to a pedestrian (zebra) crossing



Source: Based on Roads and Traffic Authority (2012).

8.6 Use of Coloured Pavements

Guidance on road space allocation for different road users (e.g. public transport, bicycles) is provided in Austroads (2020c). Lane recognition (e.g. bus lane, bicycle lane) may be enhanced by using coloured pavement surfaces and to improve compliance. The surfacing is relatively expensive, and guidelines for its use vary among jurisdictions. The practice adopted in several jurisdictions is shown in Table 8.3 .

Table 8.3: Pavement colours for special-use facilities

Facility	Colour	Suggested AS colour
Bus lane	Red (1)	Signal red R13
Bicycle lane	Green	Emerald green G13
Pedestrian crossing	Yellow	Golden yellow Y14
LATM (e.g. thresholds, platforms)	Terracotta	Terracotta R52

1 *In WA, terracotta-coloured asphalt is used for bus lanes.*

Source: AS 2700.

In New Zealand, bus lanes are green and cycle lanes are also generally green, although one local authority uses red.

Although AS 1742.12 recommends the use of particular pavement marking to designate part-time and full-time special lanes, some road agencies are choosing to provide coloured surfacing throughout the entire area of some bus and bicycle lanes in order to provide enhanced recognition by motorists and to improve compliance.

The use of green surfacing for bicycle lanes by some agencies may be limited to areas where bicyclists experience considerable stress, such as:

- areas where the paths of motor vehicles and bicycles cross or weave, typically on the approaches and departures of intersections at the tapers to left-turn lanes and added lanes (diverge and merge areas)
- within particularly complex intersections, or very wide intersections, where enhanced delineation of the bicycle lane is essential.

Austroads (2011) noted that the provision of coloured cycle lanes of good width leading from the transition to the advanced limit lines of signalised intersections improves bicyclist perceptions of safety to a greater extent than the improvement in actual crash risk. As such facilities improve bicyclists' perceptions, their use encourages more to ride.

Yellow pavement material may be used where it is desirable to reinforce pedestrian priority and encourage drivers to give way to pedestrians by highlighting pedestrian areas such as marked foot crossings at pedestrian operated signals. If the road surface is coloured yellow there would be poor colour contrast with any pedestrian (zebra) markings, so yellow pavement colouring should not be used in such cases.

8.7 Raised Pavement Markers

8.7.1 Types

Raised pavement markers are used to augment marked lines on the road surface. The most common types of raised pavement markers are:

- raised retroreflective pavement markers (RRPMs)
- non-retroreflective pavement markers (NRPMs).

AS 1742.2 provides details of patterns to be used for placement of markers on the road surface.

RRPMs and NRPMs are generally constructed of plastic in the form of domes approximately 100 mm in diameter or trapezoidal prisms about 100 mm wide. RRPMs contain a retroreflector that provides delineation under vehicle headlights at night, whereas NRPMs are used in situations where night-time delineation is not necessary or could cause confusion.

RRPMs and NRPMs used on roads must comply with the requirements of AS/NZ 1906.3.

8.7.2 Raised Retroreflective Pavement Markers

RRPMs are used to augment painted lines, stripes and chevrons when it is necessary to improve their visual properties. They are intended to be trafficable when placed within a painted island or median strip. They are not obscured at night under wet conditions as the retroreflective panels sit above the surface and are more prominent than reflectorised painted markings. In addition, they provide an audible and tactile signal when traversed by vehicle wheels.

Generally, where they augment painted lines, reflective markers are used to ensure adequate alignment and lane delineation at night and during inclement weather. RRPMs are used in various colours as follows, in accordance with AS 1742.2:

- white is used to augment lane lines and markings at painted traffic islands
- yellow is used to augment dividing lines (including barrier lines) and, where appropriate, markings at painted traffic islands, and on the right-hand edge lines of one-way carriageways
- red is used where appropriate to augment left-hand edge lines of two-way and one-way carriageways

- blue is used in some jurisdictions to mark the location of fire hydrants; a single marker is placed near the road centreline opposite the position of the hydrant
- in some jurisdictions green is used on left edge lines at motorway exits, and to mark culverts or drains in New Zealand.

RRPMs can be either one-way or two-way markers, meaning that they are retroreflective for either only one direction of approach, or for both directions. One-way markers are therefore used to delineate lane lines and traffic islands and two-way markers are used for dividing and barrier lines.

RRPMs are used to delineate all types of longitudinal lines, including the outlines of traffic islands.

8.7.3 Non-retroreflective Pavement Markers

Where used, NRPMs should always be white. Their use should normally be restricted to the definition of traffic lanes across signalised intersections where the travel lane through the intersection would otherwise be poorly defined because:

- the intersection is wide or highly skewed
- the through lanes change direction within the intersection area
- lanes on opposite sides of the intersection are offset by half a lane width or greater
- drivers are required to steer a curved course through the intersection, particularly where tangent points are close to the intersection.

The placement of NRPMs within an intersection to guide non-turning traffic should be considered where it is apparent that such traffic would have difficulty in finding the correct lane on the departure side. The treatment should only be considered for wide signalised intersections on multi-lane roads. They may be considered for unsignalised intersections in special cases.

The application of NRPMs is also illustrated in AS 1742.2. Where applied, the treatment is completed for all through lanes on all legs, even if the problem only exists for a proportion of the intersection, or one intersecting road only. Markers are generally not positioned within the area bounded by turning lanes, unless confusing or inaccurate guidance would result (e.g. where a curved path is to be followed). Regular maintenance of NRPMs will reduce the possibility of confusing patterns occurring due to an excessive number of missing markers.

NRPMs may also be used in off-road parking areas to outline parking spaces (Austroads 2020g).

8.7.4 Guidelines for Use

Requirements for the provision of raised pavement markers may vary between jurisdictions and be based on the function of the road, traffic volumes and other specific considerations. As a guide, they may be used to augment painted separation and barrier markings on:

- rural roads when AADT exceeds 1000
- urban roads when AADT exceeds 10 000
- on multi-lane roads.

In addition, consideration in the provision of raised pavement markers should be given to:

- roads that have a crash problem that could be addressed through improved delineation (e.g. run-off-road crashes)
- areas subject to poor environmental conditions such as excessive rain or fog
- roads that are poorly lit

- locations that have sharp curves (horizontal or vertical) that may not be expected by approaching drivers
- roads that have special requirements (e.g. remote areas, high percentage of heavy vehicles).

AS 1742.2 provides guidance on the spacing between markers to be used for dividing, barrier and lane lines, and for the outline of traffic islands.

8.7.5 Illuminated and Other Pavement Markers

Internally illuminated pavement markers (IIPMs) are self-illuminating pavement markers which may be used in some jurisdictions as an alternative device to RRPMs.

The light source is commonly a high intensity LED (light emitting diode) display with various proprietary products being based on solar power, induced power or a hard-wired power supply. As they are used as an alternative to RRPMs, they should operate in a steading state when in operation (i.e. not operate in flashing mode).

Their use as an alternative should only be considered after an engineering assessment, and only after a conclusion is reached that linemarking to an appropriate standard and RRPMs would not provide the required delineation. As part of any engineering assessment, consideration should be given to ongoing maintenance issues, including replacement due to vandalism or theft.

When used, IIPMs are to be in accordance with the requirements for RRPMs, including colour and configuration requirements (as outlined in Section 6.7.3). Besides providing an alternative to RRPMs, IIPMs may also potentially be used to provide delineation on a part-time basis, for example delineation of merge tapers at the commencement of part-time lanes and as lane controls such as contra-flow and tidal-flow treatments to supplement overhead signals. However, any such use should be subject to an engineering assessment and subject to permitted jurisdictional practice. Therefore, practitioners should refer to jurisdictional guidelines when considering their use.

Various products are available that will respond or self-activate in response to environmental or other predetermined conditions such as:

- Failing light: illuminates when ambient light levels fall below a pre-set level.
- Moisture: various products are available that illuminate whenever fog, rain or mist is present.
- Ice: illuminates at temperatures low enough to allow the formation of ice on the road surface.

IIPMs are available as either surface-mounted models (similar to NRPM), RRPMs, or flush (inset) mounted.

With respect to their ongoing operation it is noted that solar-powered markers have the advantage that costly wiring is not necessary, but to be effective they must also be robust enough to withstand normal traffic and the novelty of them may lead to sites being vandalised. Induced power may be delivered to markers via a cable placed in a saw cut along the line of the markers. As there are no direct connections, damaged markers can be replaced without maintenance being required for power connection. Hard-wired systems are usually very robust but require the provision and maintenance of direct electrical connections to each marker. They have the advantage that a communication link can be made available between markers enabling various effects to be implemented at the discretion of the road agency.

Glass spherical markers

Retroreflective markers generally comprise a strong plastic shell housing a retroreflector. RRPMs are available in other robust materials and designs that may not be able to be tested under AS/NZ 1906.3. The performance and suitability of such devices should be determined through tests and/or field studies. One example is a glass dome type RRPM that reflects light from all directions. These devices have an advantage in situations where it may be difficult to orientate other approved devices for satisfactory performance (e.g. on very sharp curves, around the periphery of the central island of a roundabout). Such devices may be relatively expensive and may only be suitable where they can be embedded into the road surface (i.e. asphalt or concrete). A similar product is available that is designed to be embedded into the face of concrete kerbs.

8.8 Rumble Strips

8.8.1 Types and Application

The most common forms of transverse rumble strip construction are:

1. raised bars
2. grooved bars
3. corrugated Portland cement concrete
4. concrete with widely spaced corrugations
5. overlays with exposed coarse aggregate
6. raised pavement markers
7. textured thermoplastic strip.

The first four types of strip entail a pattern or cluster of parallel bars or grooves spaced relatively close to one another and oriented in a transverse direction across the carriageway. The first, second and fifth types are reported to be the most commonly used in practice. The last two are commonly used in Australia for longitudinal delineation (to delineate lanes or the edge of the road).

Rumble strips formed from grooves in hot asphalt, or by grinding grooves in existing pavement, are generally not favoured as they lead to soil and debris being collected in the grooves causing a reduction in tactile performance. This treatment is therefore not recommended for general use and is not suitable for thin stone chip seals.

Austroads (2012) reviewed studies into the effectiveness of rumble strips. Five studies identified crash reductions with the installation of transverse rumble strips. In addition, many studies concentrated on speed reduction associated with this treatment. The conclusion from the review was that the studies demonstrated, at a low confidence level, an average crash reduction of 25%.

8.8.2 Use of Rumble Strips

Rumble strips are not recommended for extensive use throughout the road network. In light of the research and potential adverse effects:

- They should only be used as an alerting device to address a road safety problem where other conventional measures such as signing and road markings have proven to be ineffective, and the site is unlikely to attract funding for a permanent solution (e.g. changes to geometric layout) in the foreseeable future.
- They should not be used as a traffic management device for the control of speeds.

It is recommended that installations of rumble strips should be accompanied by signing to convey the nature of the potential hazard, and hence communicate the reason for the installation to drivers.

Austroads (2014a) identified the use of traverse rumble strips on the approach to curves, rural intersections and level crossings as one method of reducing speed on rural roads. Some of the implementation issues associated with their use include:

- Rumble strips are noisy and should not be used near residential areas (e.g. not within 150 m of residential areas). However, if driven over at higher speeds the noise and vibratory effects are less severe. It is noted that resin-based treatments may be acceptable for use in low-speed local streets abutting residential property, especially where a crash problem (e.g. sharp curve) is being addressed.
- They need to be placed so that the driver has enough time to slow down before the curve, intersection and/or level crossing.
- Signs are also required to indicate the reason(s) to slow down.
- There are maintenance issues.
- There may be issues with skid resistance (particularly for motorcyclists).
- There has been evidence of driving on the wrong side of the road in order to avoid the rumble strips placed on the approach-side only.

As traverse rumble strips can be installed in various formations with no current harmonisation across Australia and New Zealand, further guidance on their implementation is not provided in the Guide. Commentary 3 presents some guidance on implementation based on Department of Transport and Main Roads (2015).

[see Commentary 3]

8.8.3 Tactile Ground Surface Indicators

AS 1428.4 provides guidance for the provision of TGSIs as part of traffic management treatments.

In New Zealand, practitioners should refer to NZ Transport Agency (2015) for guidance on facilities for blind and vision-impaired pedestrians.

8.8.4 Emerging Areas – Perceptual Countermeasures

Perceptual countermeasures are treatments which are used to alter a driver’s perception of speed, or of the road environment (e.g. making the road appear narrower, or to make a curve appear more severe). The aim is that by altering the perception of the speed, the driver will slow down to match the perceived conditions.

The use of these markings is being explored for by road agencies with some providing their own advice and guidelines. Practitioners should therefore refer to road agencies for guidance.

Figure 8.14 provides three examples of such markings.

Figure 8.14: Examples of perceptual pavement markings

Name	Description	Image
Peripheral traverse lines	Peripheral traverse lines on the approach to an intersection are used to encourage drivers to decelerate more rapidly than they usually would through altering their perception. In some cases, 'dragon teeth' (as discussed below) may be used instead of peripheral traverse lines.	
Dragon teeth	Dragon's teeth are a painted series of triangular road markings placed in pairs on each side of a lane or road. In Roads and Maritime Services they are being used to further increase the visibility of school zones for motorists and provide a constant reinforcement to slow down to 40 km/h around schools as shown in the adjacent image. In VicRoads they are being trialled to create the perception of the road narrowing, through increasing the size of the dragon teeth, and therefore encouraging drivers to slow down. VicRoads is trialling their use along a section of road that has a significant crash history.	As used by Roads and Maritime Services at school zones  *Source: Roads and Maritime Services (2015).* As trialled by VicRoads to address a safety issue along a section of road with a significant crash history 
Lane narrowing	A solid or painted median, possibly incorporating profiled edge lines, to create narrower lanes on the approach to an intersection or on the approach to or passing through a hazardous area is used to encourage motorists to slow down in order to safely navigate through the narrower section. The image shows lane narrowing being used with traverse rumble strips.	

9. Guide Posts and Delineators

Guide posts with reflectorised delineators are placed in series in pairs on both sides of the road formation to indicate to road users the alignment of the roadway ahead, especially at horizontal and vertical curves. Properly installed and maintained retroreflective delineators provide effective long-range delineation for night driving and can be an advantage in fog prone areas. Guide posts with delineators may also be used to alert drivers approaching an intersection. Retroreflective delineators are generally mounted on white posts, with red delineators used on the left side of the carriageway and white delineators on the right. AS 1742.2 provides standards for the provision and installation of guide posts.

Details of the type, placement and fixing of delineators may vary across jurisdictions. Guide posts should be constructed so that when struck by a vehicle, they do not constitute a safety hazard.

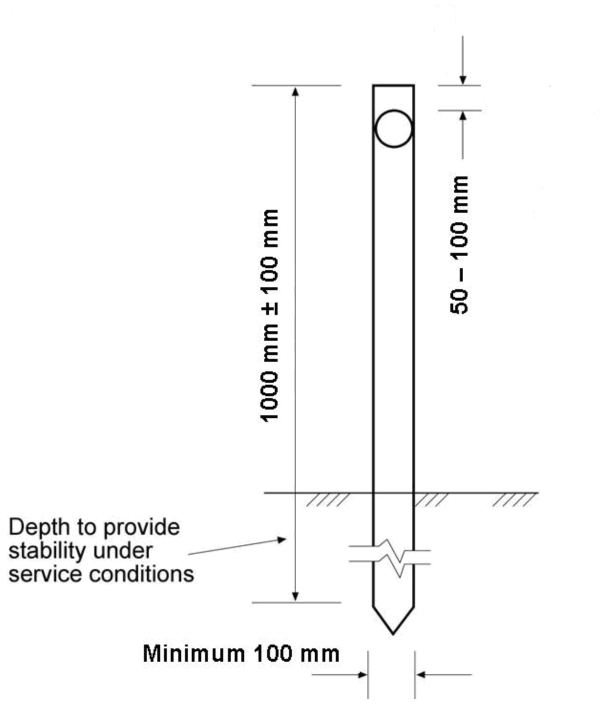
9.1 Features of Guide Posts

As specified in AS 1742.2, guide posts typically have a height of 1 m above the shoulder edge with a display face width of 100 mm facing the traffic. However, if posts of this height obstruct visibility, as may be the case on the inside of a curve on a crest, shorter posts should be used. The post must be white, and generally it is white for the full height.

A number of different post types are currently in use including rigid and flexible types which may be constructed of materials such as timber, plastic, rubber and sheet steel. However, in line with Safe System principles, current best practice is to use flexible, lightweight, plastic guide posts that flex when hit. Use of such flexible guide posts significantly reduces the risk of the post becoming a hazardous projectile if struck by a vehicle.

A typical guide post is illustrated in Figure 9.1 .

Figure 9.1: A typical guide post



To maintain visual uniformity, the type of guide post and delineator, and the lateral and longitudinal placement should be consistent along road sections. The delineator type should also be consistent over a minimum length of road (e.g. 2 km). More detail is provided in Section 9.3.

9.2 Location and Spacing

The location and spacing of guide posts is described in AS 1742.2 for a range of situations. Appropriate spacing is important to enable a driver to determine confidently the direction of the route ahead. This is achieved by ensuring that on straight roads at least two pairs of guide posts and delineators are always visible to the driver, and on curves delineators provide smooth indication of the road alignment.

Wherever practicable, guide posts should be placed at a uniform distance from the pavement edge. On unkerbed roads, they should be erected at the outside edge of the shoulder of the roadway. For kerbed carriageways, they should desirably be set back 1 m from the face of the kerb.

9.3 Delineators

Delineators are small retroreflectors or panels of retroreflective material which may be used separately or be attached to guide posts or safety barriers as effective aids for night driving. AS/NZS 1906.2 specifies the standard required for delineators for aspects such as photometric properties (e.g. retroreflectivity), physical integrity and durability.

While Figure 9.1 depicts a circular reflector as the delineator, rectangular strips of retroreflective material are primarily being used for new installations. Delineators made up of vinyl retroreflective sheeting are less susceptible to impact damage when the guide post is hit, and are therefore recommended for use on flexible posts. Further, use of retroreflective vinyl sheeting pose less risk of delineators being dislodged and becoming missiles in the event of the guide post being struck.

9.4 Colour of Guide Post and Delineators

The colour of the guide posts is white. However, in some scenarios such as where snow may occur, orange guide posts may be used.

As outlined in AS 1742.2, the following colours should be used for delineators:

- White: for posts facing oncoming vehicles on the right side of two-way roads.
- Yellow: for posts facing oncoming vehicles on the right side of one-way roads (including divided roads).
- Red: for posts facing oncoming vehicles on the left side of the road.

9.5 Snow Poles

Where snow is more common and to significant depth, snow poles may be used in place of guide posts.

Snow poles are a special form of guide post used to mark the edge of the road formation when hidden by snow, for the benefit of both normal traffic and snow-clearing plant. Details for their design and installation are provided in AS 1742.2.

10. Traffic Signals

Traffic signals are the most common form of traffic control at major intersections on urban road networks. They may be situated at an isolated site, or be part of a complex system of signal coordination.

While intersection signals have generally been found to improve the safety performance of intersections, they are not generally accepted as a Safe System treatment (Austroads, 2015h). For most movements at an intersection, the installation of traffic signals changes the task for road users from gap acceptance to signal compliance. The latter is less prone to error and the workload and skills required to negotiate a signalised intersection are less than those at an equivalent unsignalised, stop or give way controlled intersection. Hence, intersection signals contribute to safer roads and safer road users. However, signalised intersections are not typically forgiving when road user error results in a crash. The most common FSI crashes at signalised intersections are opposing turning (right turn against), adjacent directions (side impact), pedestrian and same direction (rear end and side swipes) (Austroads, 2017a). Austroads (2015h and 2020d) present a number of treatments and alternative designs aimed at improving the alignment of signalised intersections with Safe System objectives.

This section provides details of signal displays, signal face layouts, display sequences, location of signals and associated road signs and markings. Austroads (2020d) provides guidance on traffic management aspects of signalised intersections while the broader operation of traffic signal systems is covered in Austroads (2020f).

In designing a new or remodelled traffic signal installation, care should be taken to ensure that new signs and markings associated with the signals are consistent with all existing traffic control devices on all approaches to the intersection.

10.1 Types of Displays and their Meanings

A signal aspect is a single optical system on a signal face capable of being illuminated at a given time. A *signal display* is an aspect that is illuminated.

Signal faces are made up of a number of signal aspects, generally in one or two columns. Their nature is described in AS 1742.14. The design and recommended sizes of signal aspects, including shapes of symbols, are given in AS 2144.

Vehicle aspects must be red, yellow or green. Pedestrian aspects must be red or green. Bicycle aspects for two-aspect lanterns must be red or green, and for three-aspect lanterns must be red, yellow or green. Special vehicle aspects for trams, buses or emergency vehicles must be white.

Signal aspects currently in use are illustrated in Figure 10.1 but they are not used in all jurisdictions.

10.1.1 Circular Aspects

Circular aspects (disks) are used as a first preference. They are the easiest to comprehend and have the greatest visual range.

Circular aspects control all traffic approaching or waiting at the stop line associated with the aspects if they are the only ones in the signal face. At an intersection, a circular green display permits left-turning and right-turning traffic to filter (accept gaps in a pedestrian movement or oncoming traffic) unless prohibited by other controls.

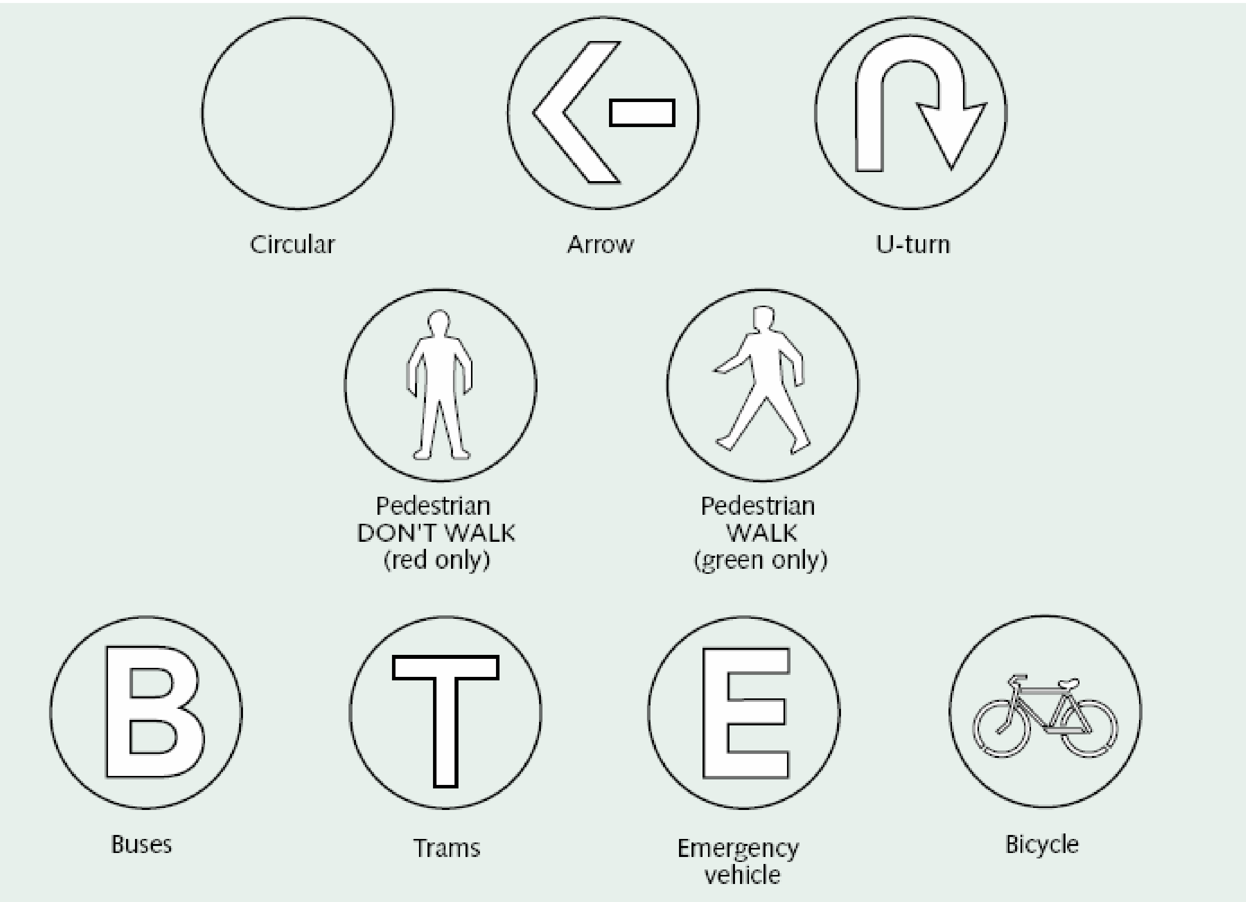
10.1.2 Arrow Aspects

Arrow aspects are used to control particular movements at traffic signal installations including U-turn movements as shown in Figure 10.1 . Arrow aspect orientations to be used are shown in Figure 10.2.

Directional arrow displays supplement or cancel the intent of any circular displays with which they are associated. Although not commonly used due to the emergence of LED displays, arrows can be displayed by means of masks obscuring part of the lens. Where masks are used so that the greater part of the lens is obscured, the visual range of the lantern is reduced. For this reason, straight-through arrows (used to control the faster movements) should preferably not be used in red or yellow aspects; they should only be used in green aspects when absolutely necessary.

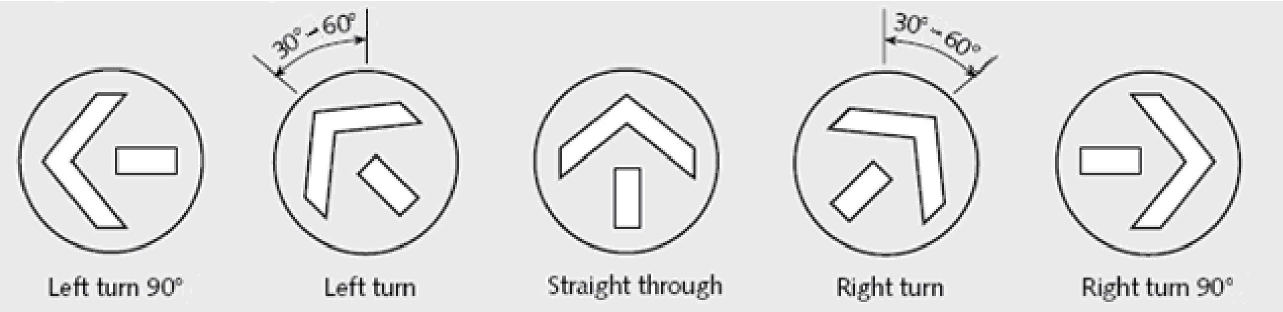
Where all traffic on an approach must turn left (and/or right), and there is no conflict with a pedestrian or other traffic movement, extra guidance may be given by replacing green circular aspects with arrows. Downward pointing arrow aspects should not be used with intersection control signals. Their use is confined to overhead lane control signals.

Figure 10.1: Signal aspects currently in use



Note: U-turn and E aspects are not permitted in some jurisdictions.

Figure 10.2: Arrow aspect orientations



10.1.3 Pedestrian Aspects

The don't walk aspect is a red standing human figure, and the walk aspect is a green walking figure as shown in Figure 10.1.

10.1.4 Bicycle Aspects

Where regulations permit, bicycle aspects can be used in a similar way to those for pedestrian aspects to control bicyclists crossing the road, or in a similar way to vehicle aspects to control on-road bicyclists at an intersection. The symbol for bicycle aspects is shown in Figure 10.1.

Two aspects, red and green, are used for road crossings (except in New Zealand). Three aspects – red, yellow and green – are used at road intersections with exclusive bicycle lanes, or at intersections of a road and exclusive bicycle path.

10.1.5 Special Vehicle Aspects

Special vehicle aspects are used to control bus, tram and emergency vehicle movements at traffic signals as regulations permit. The symbols for special vehicle aspects are shown in Figure 10.1 .

The white T or B, and in some jurisdictions, the E aspects are used to indicate that trams, buses or emergency vehicles may proceed.

White arrows are also used occasionally to indicate that drivers of special vehicles may proceed in the direction of the arrow.

10.1.6 Combination of Aspects

Pedestrian aspects must not be combined with vehicle aspects in the same signal face. Circular and arrow aspects may be combined as detailed later in the section. Circular or arrow aspects can also be combined with special vehicle aspects. Some jurisdictions are trialling a combination of bicycle and pedestrian aspects.

10.2 Signal Face Layouts

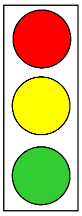
10.2.1 Vehicle Signal Face Layouts

This section discusses general requirements for vehicle signal face layouts. Sections 10.2.2 and 10.2.3 discuss signal face layouts with right-turn and left-turn arrow aspects. The sequence of vehicle signal displays is discussed in Section 10.3.

Basic signal face layouts

Aspects are arranged in columns with the red aspect upper-most, the yellow aspect central and the green aspect at the bottom. The basic three-aspect signal face consists of red, yellow and green circular aspects in a single column as shown in Figure 10.3 . This is the normal minimum permissible signal face layout. In special traffic situations, two-aspect signal faces may be used. Single-aspect signals are not permitted (except for overhead lane control signals).

Figure 10.3: Basic three-aspect signal face layout



Multi-column signal face layouts

Multi-column signal faces can contain four, five, or six aspects. Generally, these face layouts have an arrow aspect column adjacent to the basic three-aspect column. Six-aspect face layouts, as shown in Figure 10.4, are used to control left-turn or right-turn movements independently of the through movement on the same approach.

Multi-column signal faces must comply with the following:

- aspects of the same shape and orientation are located in the same column
- left-turn arrow aspects are located to the left of the circular aspects, and right-turn arrow aspects are located to the right of the circular aspects
- columns containing only a yellow aspect are not permitted
- columns containing only red and green aspects are not permitted.

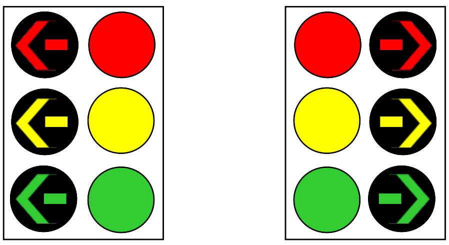
In addition to the above and except in the case of a four-aspect single column display as detailed below:

- aspects of the same colour are located on the same horizontal level
- no column contains more than three aspects
- only one aspect of each colour is permitted in each column
- at one time not more than one aspect is illuminated in each column.

The use of three columns in a display is not recommended as they are difficult to comprehend and are not catered for in standard mountings. Therefore, where possible, they should be split into separate two-column displays mounted on different posts or mast arms.

Multi-column display sequences are discussed in Section 10.3.2.

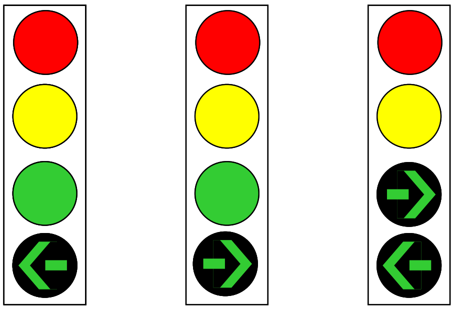
Figure 10.4: Six-aspect multi-column signal face layouts



Four-aspect single-column signal face layouts

A single column of four aspects can be used consisting of red and yellow circular aspects and two green aspects (circular and arrow, or two arrows) as shown in Figure 10.5. This is not permitted for overhead-mounted signals. Four-aspect columns should not be used in multi-column displays.

Figure 10.5: Four-aspect single-column signal face layouts

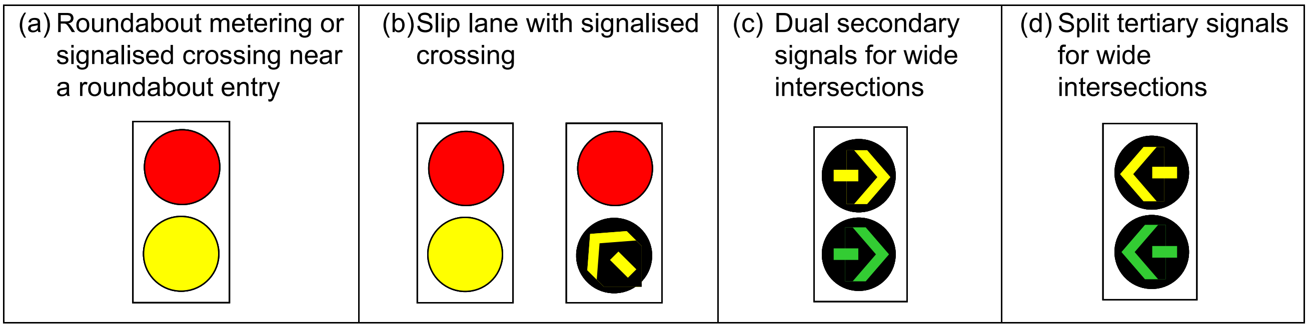


Two-aspect signal face layouts

Where regulations permit, two-aspect signal face layouts (Figure 10.6) are used in the following circumstances (also see ramp metering signals in Section 10.6, and metering signals at sign-controlled intersections in Section 10.5.7):

- As roundabout metering signals (Section), or at signalised crossings near a roundabout entry, comprising red and yellow circular aspects (Figure 10.6 (a)). In this case, a green circle is not used in order to avoid conflict with the requirement to give way at the roundabout.
- To stop traffic at a signalised crossing on a left-turn slip lane where traffic may continue to filter after the pedestrian phase has finished, comprising red and yellow circular or arrow aspects (Figure 10.6 (b)). In this case, a green circle or green arrow is not used in order to avoid conflict with the requirement to give way to other traffic at the slip lane give-way line.
- As yellow and green arrow aspects on the far-right side of a divided road (dual secondary signal as shown in Figure 10.6 (b)) to reassure right-turn traffic in a wide intersection that it may proceed (Figure 10.6 (c)).
- As 'split tertiary' signals comprising yellow and green arrows, which are used where the road that left turners are turning into has a median or island (Figure 10.6 (d)) (refer to Section 10.4.3).

Figure 10.6: Two-aspect signal face layouts



10.2.2 Face Layouts with Right-turn Arrow Aspects

Six-aspect signal face layouts with right-turn arrow aspects

A six-aspect signal face layout with red, yellow and green arrow aspects can be used to independently control right-turn movements (Figure 10.4).

The green right-turn arrow should be displayed only when no conflicting traffic movements (vehicle or pedestrian) are permitted.

The yellow right-turn arrow is always displayed following the green arrow display.

The red right-turn arrow should be displayed following the yellow arrow display when the right-turn movement or a conflicting movement (vehicle or pedestrian) must be protected. Vehicle movements include special vehicles such as tram, bus, or train.

Full signal control simplifies the decision making process for drivers turning right as they are not required to find a suitable gap in the opposing traffic stream and do not have to give way to pedestrians crossing the road into which they are entering. This method of control is considered to provide moderate to high alignment with the Safe System for right turns at signalised intersections (Austroads, 2017a). Full control of right turns is therefore preferred ahead of phasing options that permit filtering.

Five-aspect signal face layouts with right-turn arrow aspects

Right-turn yellow and green arrow aspects

A five-aspect signal face layout with yellow and green arrow aspects (Figure 10.7) may be used in lieu of a six-aspect face layout when:

- the right-turn movement may filter at all times when the circular aspect is green (hence no need for red arrow)
- there is no conflicting pedestrian movement or special movement which requires protection from the right-turning vehicle.

Right-turn yellow and red arrow aspects

A five-aspect signal layout with yellow and red arrow aspects (Figure 10.8) is rarely needed (and is not permitted in some jurisdictions). It may be used to terminate a right-turn filter movement during the circular green display to avoid blockage of the intersection during a nearby tram, bus or train movement.

Figure 10.7: Five-aspect signal face layout with yellow and green right-turn arrow aspects

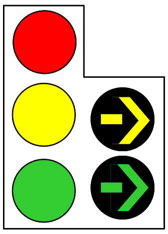
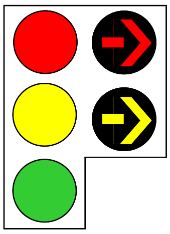


Figure 10.8: Five-aspect signal face layout with red and yellow right-turn aspects



Four-aspect signal face layouts with right-turn arrow aspects

Single right-turn green arrow aspect

A four-aspect signal layout with single green arrow aspect (Figure 10.9) may be used only when the right-turn green arrow display is always terminated simultaneously with the circular green display, i.e. when the circular yellow display is introduced.

Single right-turn red arrow aspect

A four-aspect signal layout with single red arrow aspect (Figure 10.10) may be used only when its use is restricted to the sequence discussed in Section 10.3.3.

This signal face layout is used infrequently. It may be used to delay a filter right-turn movement for the protection of pedestrians or special vehicles.

Figure 10.9: Four-aspect signal face layouts with single right-turn green arrow aspect

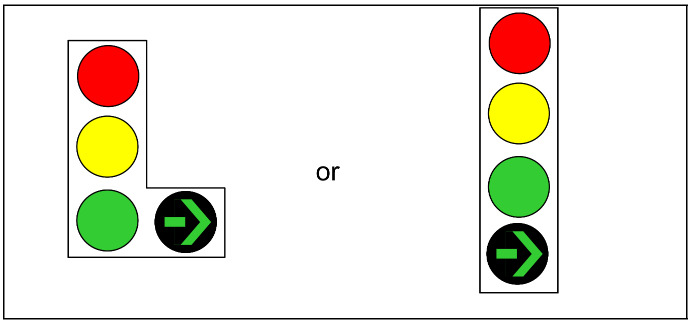
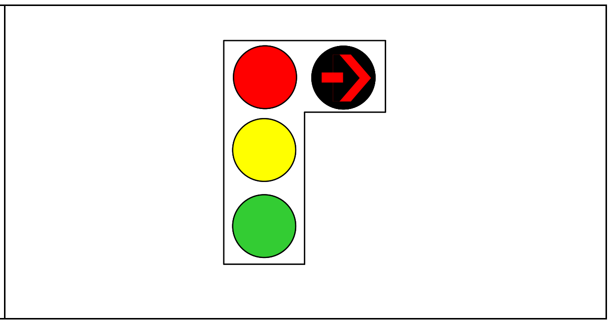


Figure 10.10: Four-aspect signal face layout with single right-turn red arrow aspect



10.2.3 Face Layouts with Left-turn Arrow Aspects

Six-aspect signal face layouts with left-turn arrow aspects

A six-aspect signal face layout with red, yellow and green arrow aspects can be used to independently control left-turn movements (Figure 10.4).

The green left-turn arrow should be displayed only when no conflicting traffic movements (vehicle or pedestrian) are permitted.

The red left-turn arrow should be displayed following the yellow arrow display when the left-turn movement or a conflicting movement (vehicle or pedestrian) must be protected. Vehicle movements include special vehicles such as tram, bus, or train.

The column of left-turn aspects should be blacked out when the left-turn movement may filter through a parallel walk or other traffic movement (i.e. when only the circular green is displayed).

Five-aspect signal face layouts with left-turn arrow aspects

Left-turn yellow and green arrow aspects

When it is not required to protect conflicting movements during the display of the circular green, the red left-turn arrow aspect may be omitted from the six-aspect face layout, forming the five-aspect signal face layout shown in Figure 10.11. The left-turn green arrow should be displayed only when no conflicting traffic movements are permitted.

Left-turn yellow and red arrow aspects

The yellow and red arrow aspects alone (Figure 10.12) should be provided when the left-turn movement may be stopped during the circular green display but the requirements for a left-turn green arrow in Figure 10.11 are not met. This occurs infrequently but may be required to stop left-turn traffic for trains or trams.

For left-turn traffic, a green period must be assured when the circular green aspect is displayed alone.

Figure 10.11: Five-aspect signal face layout with yellow and green left-turn arrow aspects

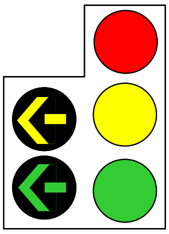
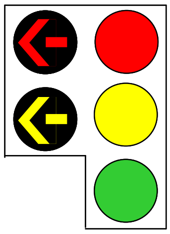


Figure 10.12: Five-aspect signal face layout with red and yellow left-turn arrow aspects



Four-aspect signal face layouts with left-turn arrow aspects

Single left-turn green arrow aspect

A four-aspect signal layout with single green arrow aspect (Figure 10.13) may be used only when the left-turn green arrow display is always terminated simultaneously with the circular green display (i.e. when the circular yellow display is introduced).

Single left-turn red arrow aspect

A four-aspect signal layout with single red arrow aspect (Figure 10.14) may be used only when its use is restricted to the sequence discussed in Section 10.3.4.

This display is used infrequently. It may be used to delay a filter left-turn movement for the protection of pedestrians or special vehicles, in which case the red arrow should be switched off at the earliest practicable time (e.g. at the end of the walk period).

Figure 10.13: Four-aspect signal face layout with single left-turn green arrow aspect

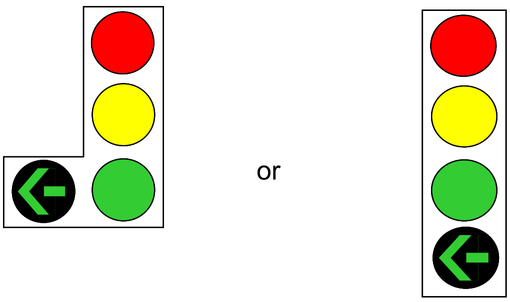
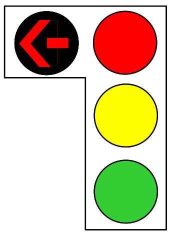


Figure 10.14: Four-aspect signal face layout with single left-turn red arrow aspect



10.2.4 Permitted Layouts

Refer to Figure 10.6 for permissible two-aspect signal face layouts. Single-aspect layouts are not permitted except in rare circumstances.

Figure 10.15 summarises the preferred three to six-aspect signal face layouts for normal vehicles including the more common layouts discussed in Sections 10.2.1 to 10.2.3.

Figure 10.16 shows examples of signal face layouts that are permitted, but not preferred. Any other layouts are not permitted.

Figure 10.15: Permitted signal face layouts

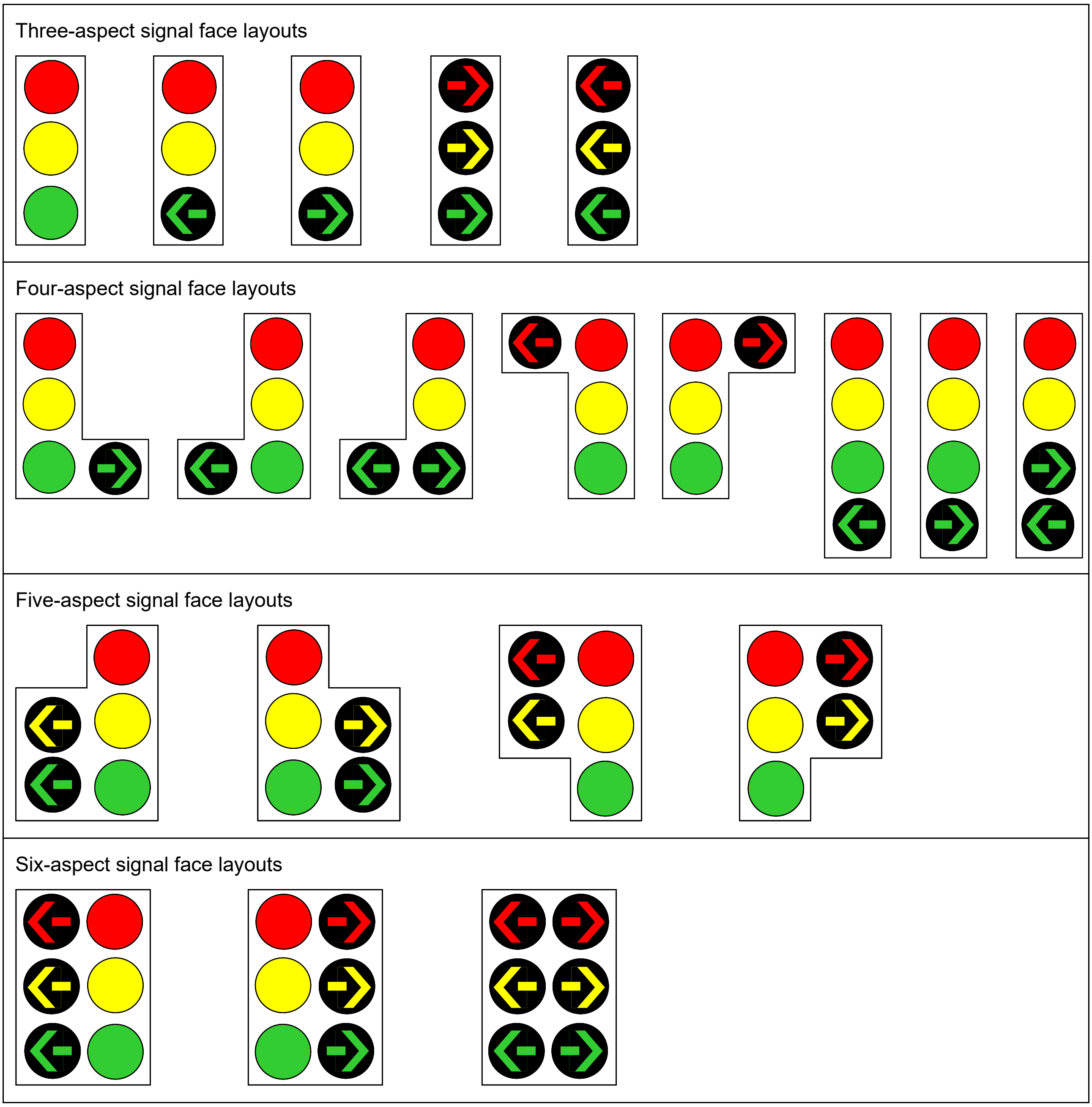
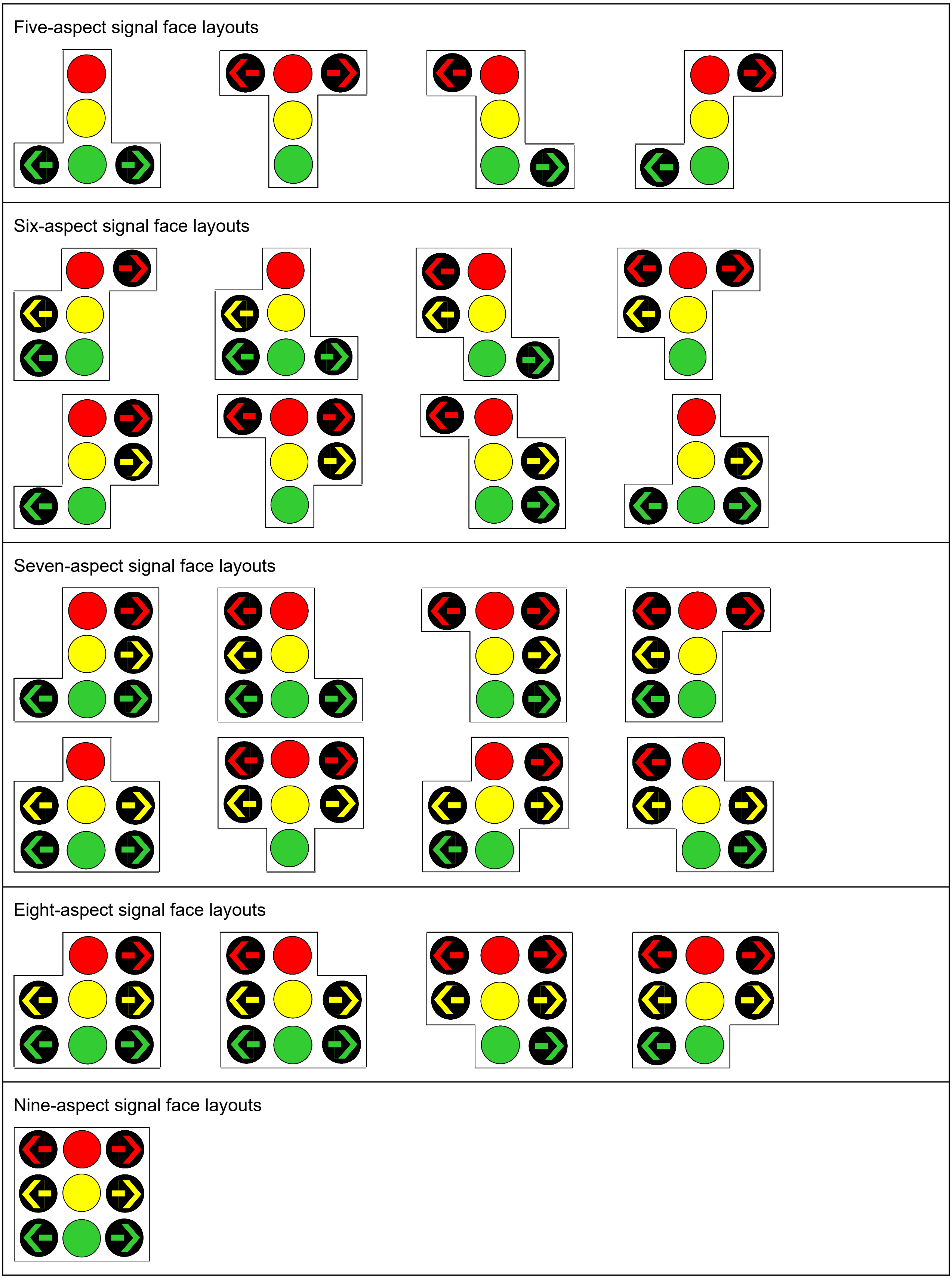


Figure 10.16: Signal face layouts that are permitted but should be avoided if possible



10.3 Display Sequences

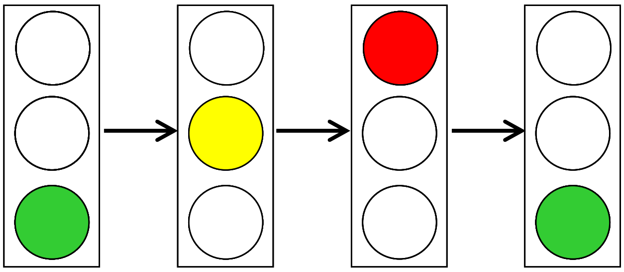
10.3.1 Basic Sequence

The basic sequence of vehicle displays within a signal face must be green to yellow to red to green as shown in Figure 10.17 It applies to three-aspect circular, arrow or symbolic arrangements, and four-aspect arrangements with a green arrow where both greens must terminate at the same time (Figure 10.15).

The exceptions are:

- midblock pelican crossings where the sequence for vehicle movements must be green to yellow to red to flashing yellow to green
- multi-column arrangements without a three-aspect symbolic column, or a single symbolic aspect where the sequence may include an 'off' condition.

Figure 10.17: Basic display sequence for three-aspect signals



10.3.2 Sequences with Arrow Aspects

Guidance on the basic sequence of displays with arrow aspects is as follows:

- Where it is desirable to allow for filter movements to take place, the off condition of a column of arrow aspects may be used.
- Any green display must always be followed by a yellow display applicable to that movement, although not necessarily in the same column. The yellow should be displayed for a duration sufficient for termination of that movement.
- A red display must be preceded by its associated yellow display where present, or a circular yellow display.

Some jurisdictions may permit a flashing yellow arrow to be used in certain circumstances. Therefore, practitioners should consult their jurisdictional guidelines for permitted uses that may utilise the flashing arrow and for guidance on how and when this may be used in sequence with the other signal aspects.

10.3.3 Right-turn Sequences

In addition to the examples of right-turn display sequences for six-aspect arrangements shown inFigure 10.18 , examples of display sequences to initiate and terminate arrow-controlled right-turn movements are illustrated in Figure 10.19 and Figure 10.20 respectively.

Figure 10.21 shows a special display sequence using a four-aspect arrangement with a single right-turn red arrow aspect as discussed in Section 10.2.2. This figure shows initiation and termination of a filter right-turn movement.

In some jurisdictions, five or six-aspect signals may be used to operate a partially controlled right turn and a partially controlled turn with red arrow drop-out. Figure 10.22 and Figure 10.23 show an example of this, where it is undertaken utilising five and six-aspect signals respectively.

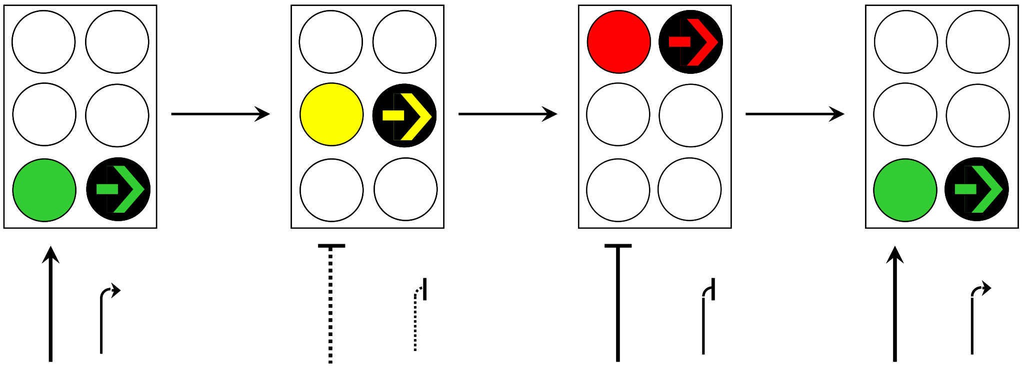
10.3.4 Left-turn Sequences

Display sequences to initiate and terminate arrow-controlled left-turn movements are illustrated in Figure 10.24 and Figure 10.25 respectively.

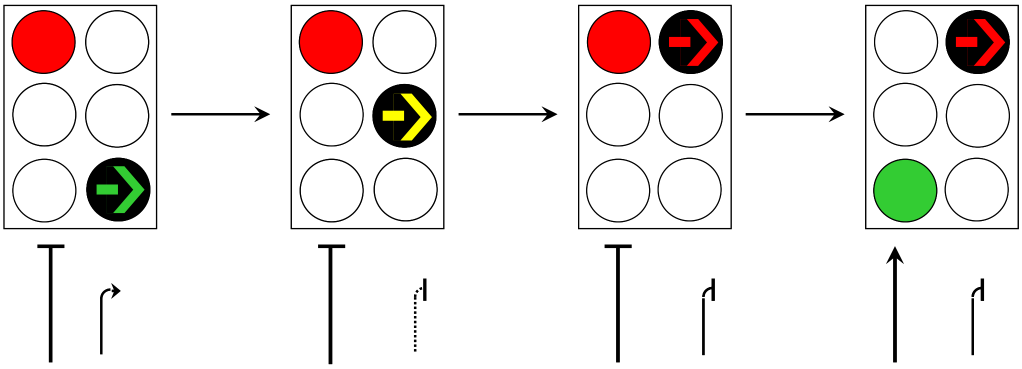
Figure 10.26 shows a special display sequence using a four-aspect arrangement with a single left-turn red arrow aspect as discussed in Section 10.2.3. This figure shows initiation and termination of a filter left-turn movement.

Figure 10.18: Examples of fully-controlled right-turn display sequences for six-aspect arrangements

Right-turn arrow displays change simultaneously with circular displays: right-turn and through movement initiated and terminated at the same time



Right-turn arrow and circular displays change at different times: terminating the right-turn movement and initiating the through movement



Right-turn arrow and circular displays change at different times: terminating the through movement and initiating the right-turn movement

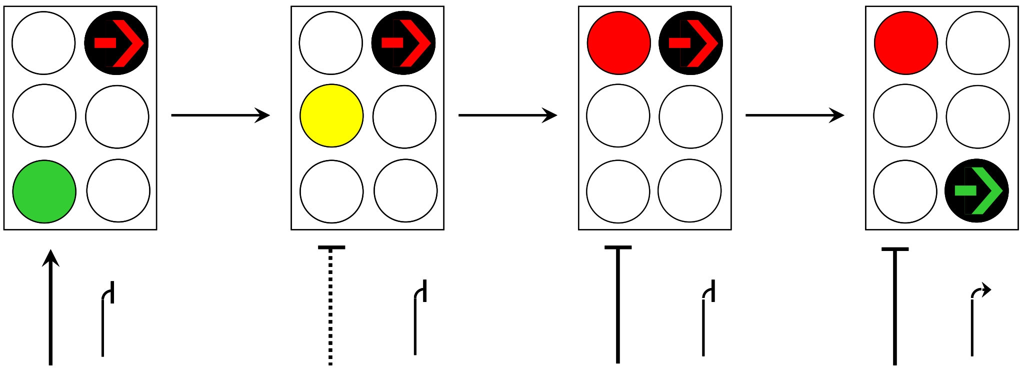


Figure 10.19: Examples of display sequences to initiate an arrow-controlled right-turn movement

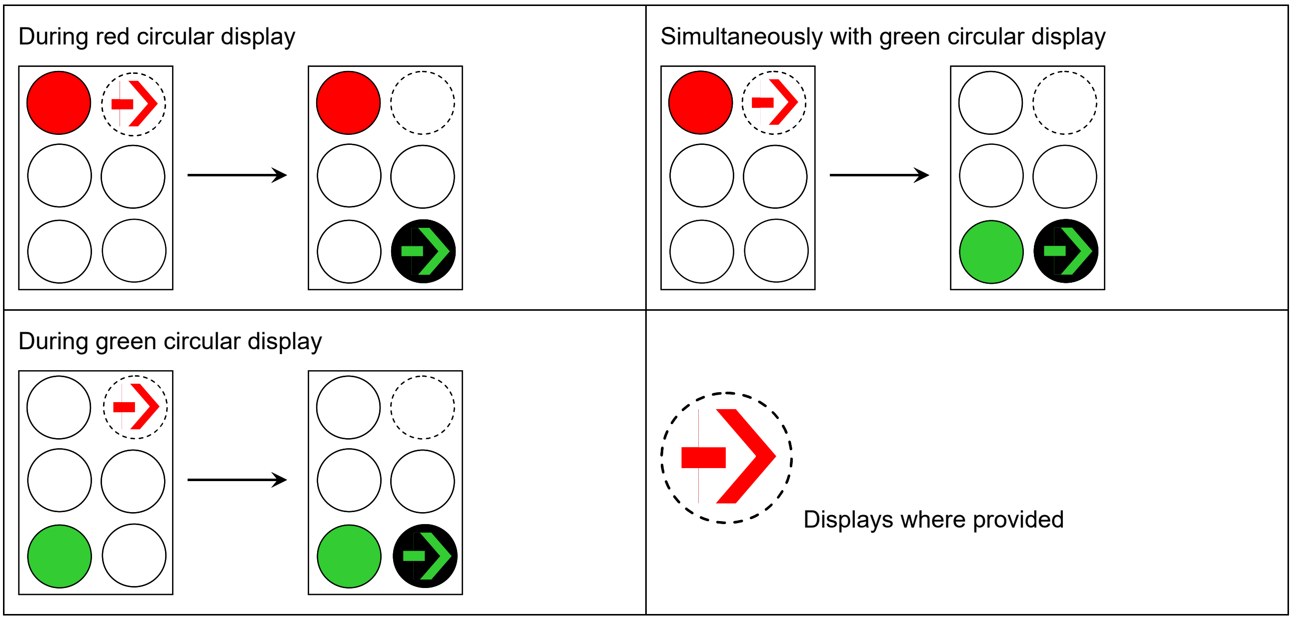


Figure 10.20: Examples of display sequences to terminate an arrow-controlled right-turn movement

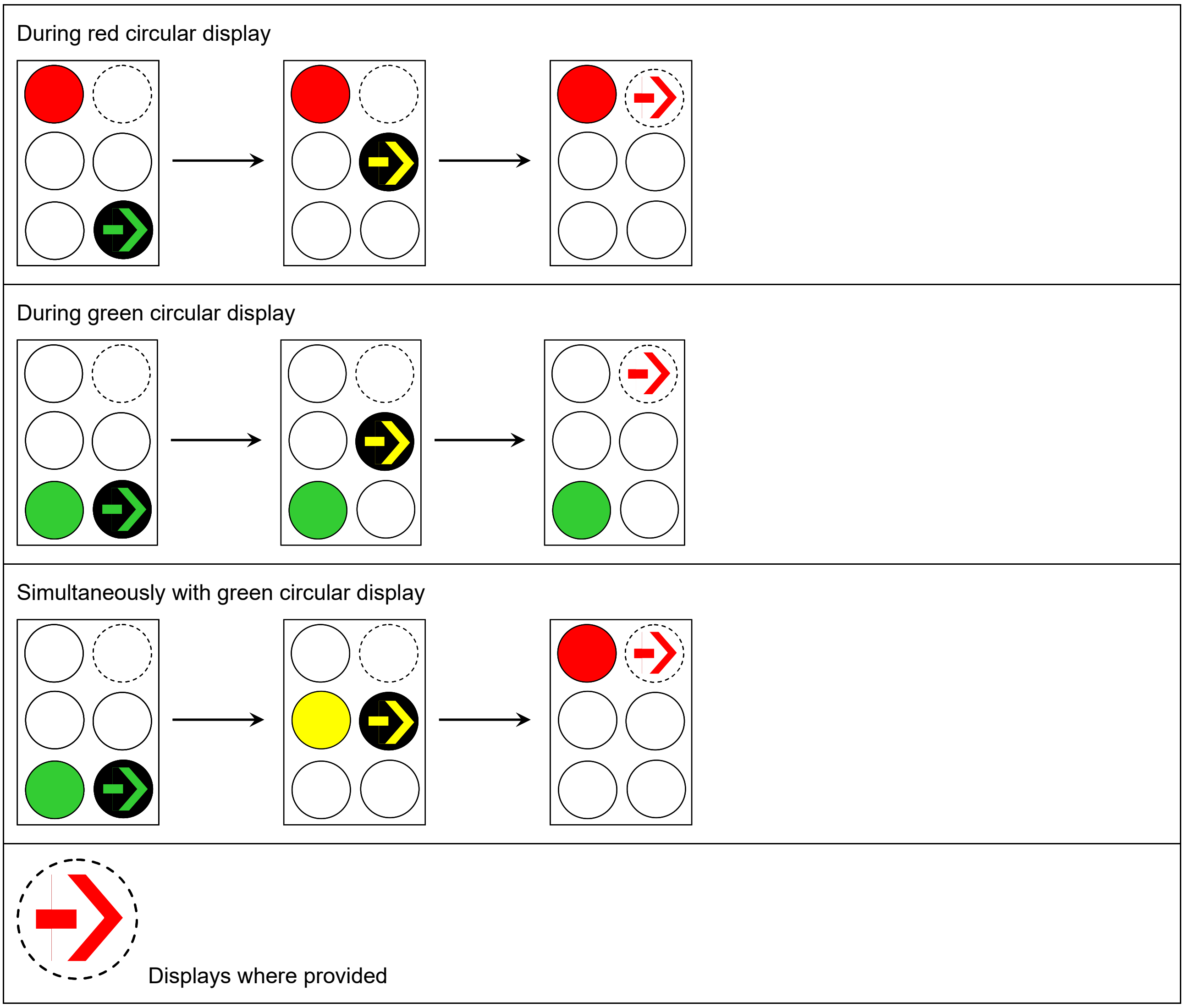


Figure 10.21: Display sequences for four-aspect arrangement with single red right-turn arrow aspect for the protection of pedestrians or special vehicles

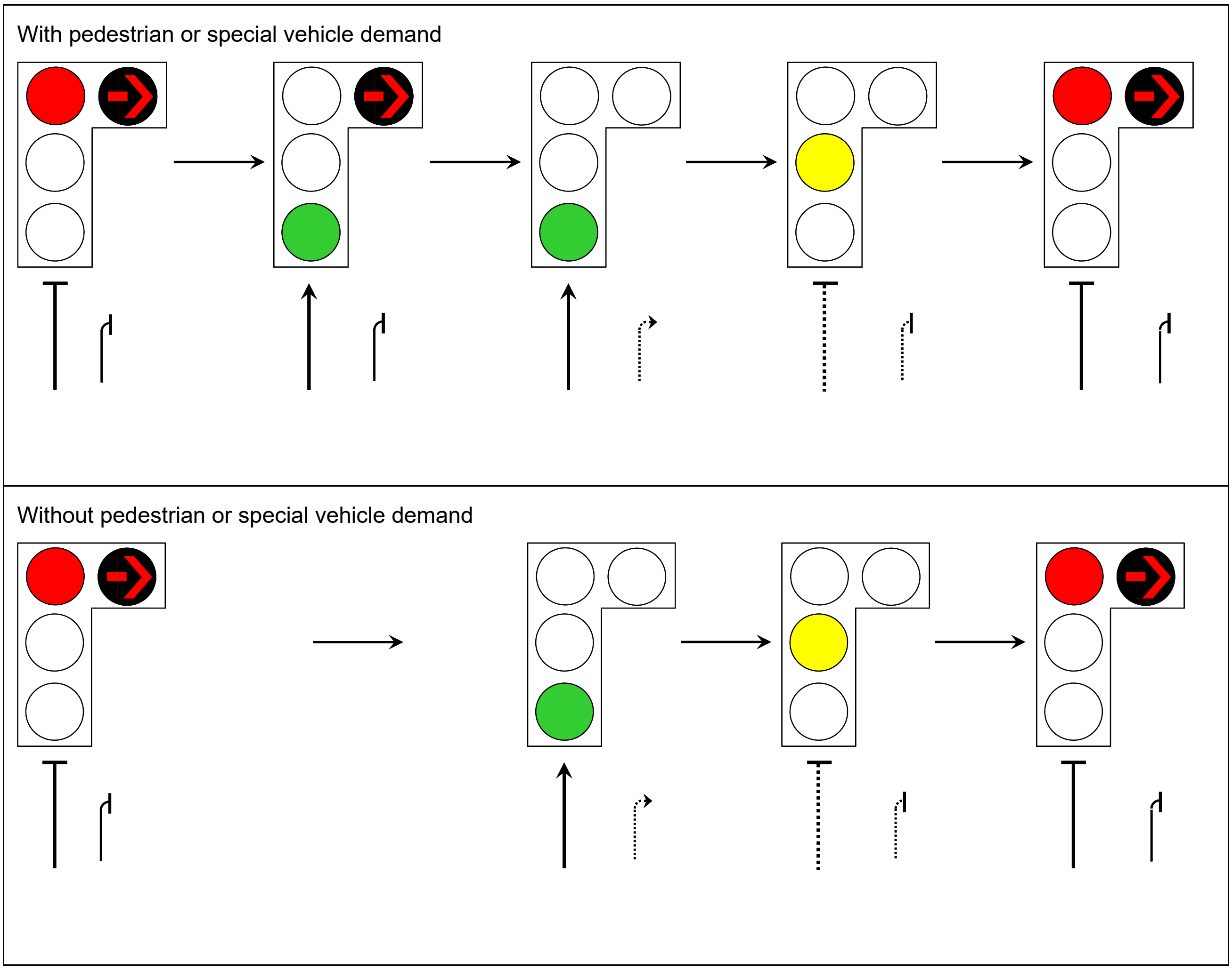


Figure 10.22: Partially controlled right turn

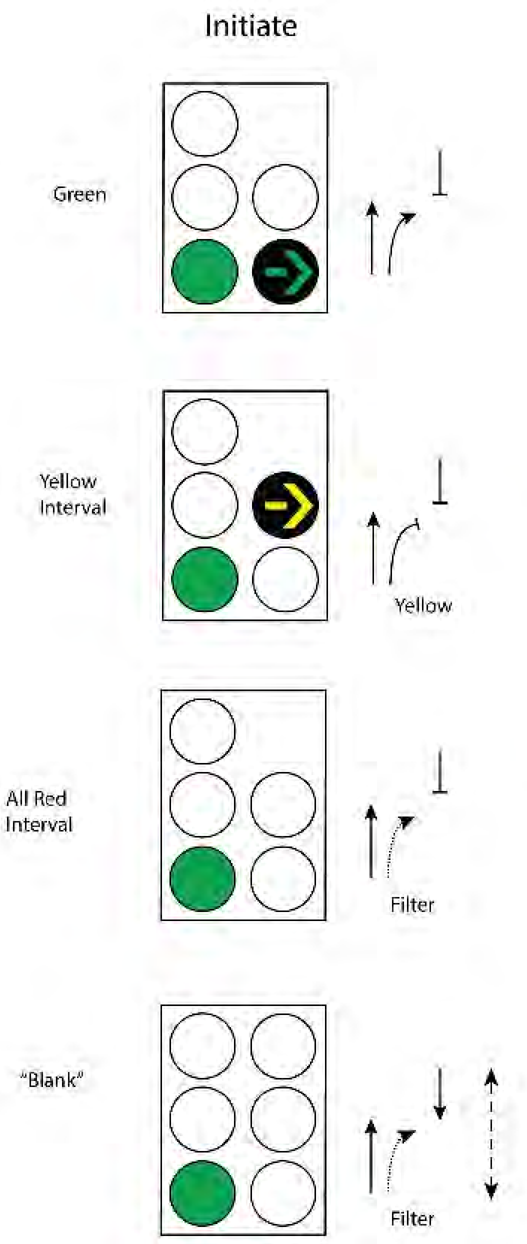


Figure 10.23: Partially controlled turn with red arrow drop-out

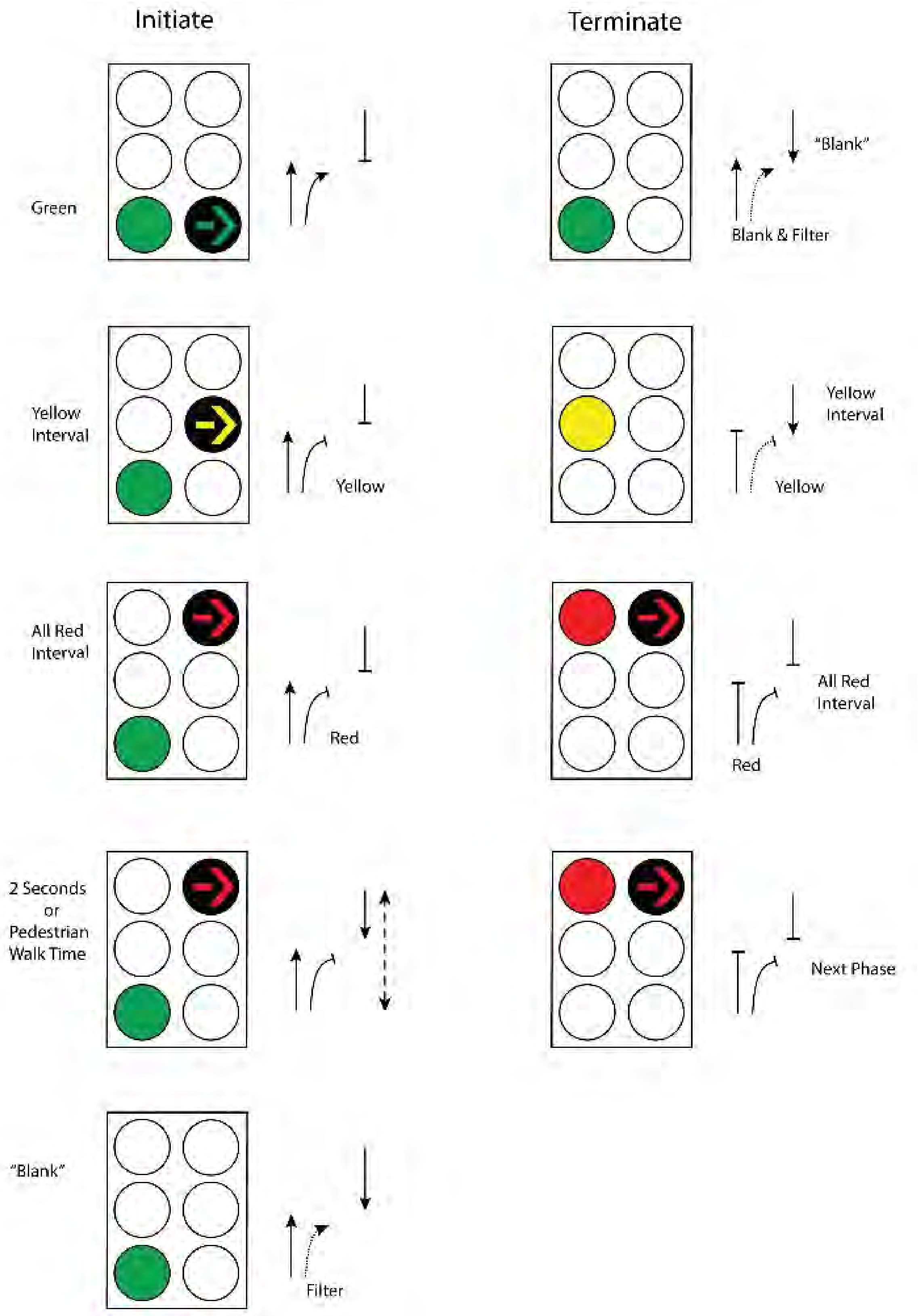


Figure 10.24: Examples of display sequences to initiate an arrow-controlled left-turn movement

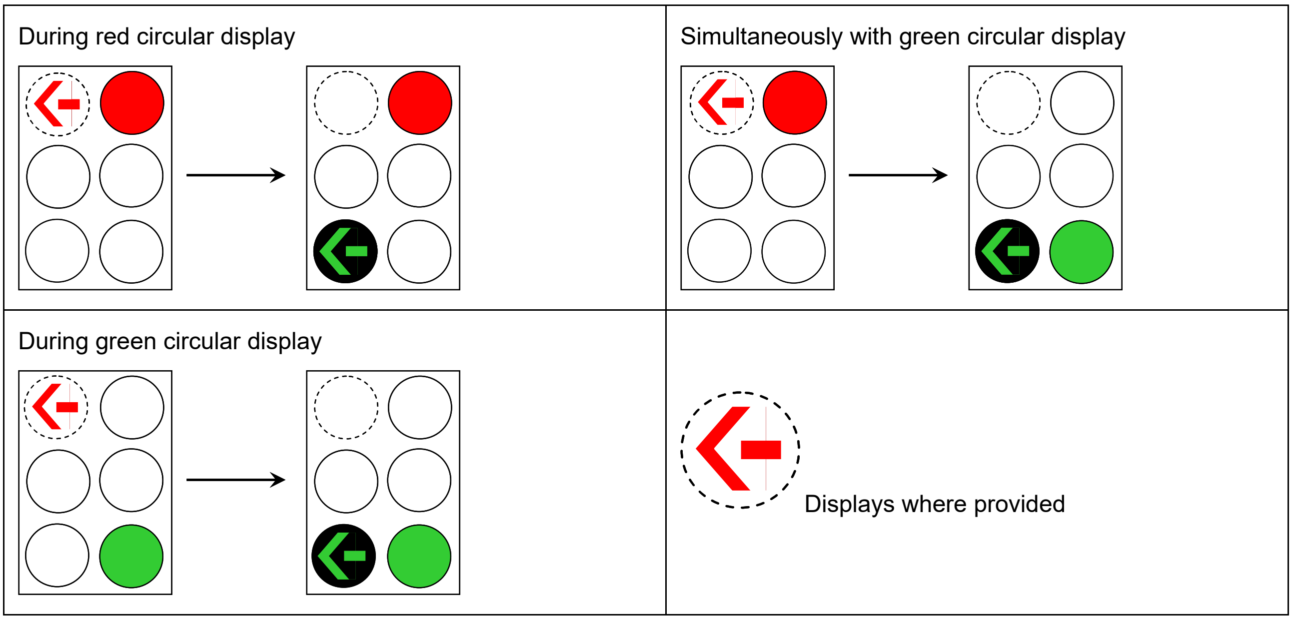


Figure 10.25: Examples of display sequences to terminate an arrow-controlled left-turn movement

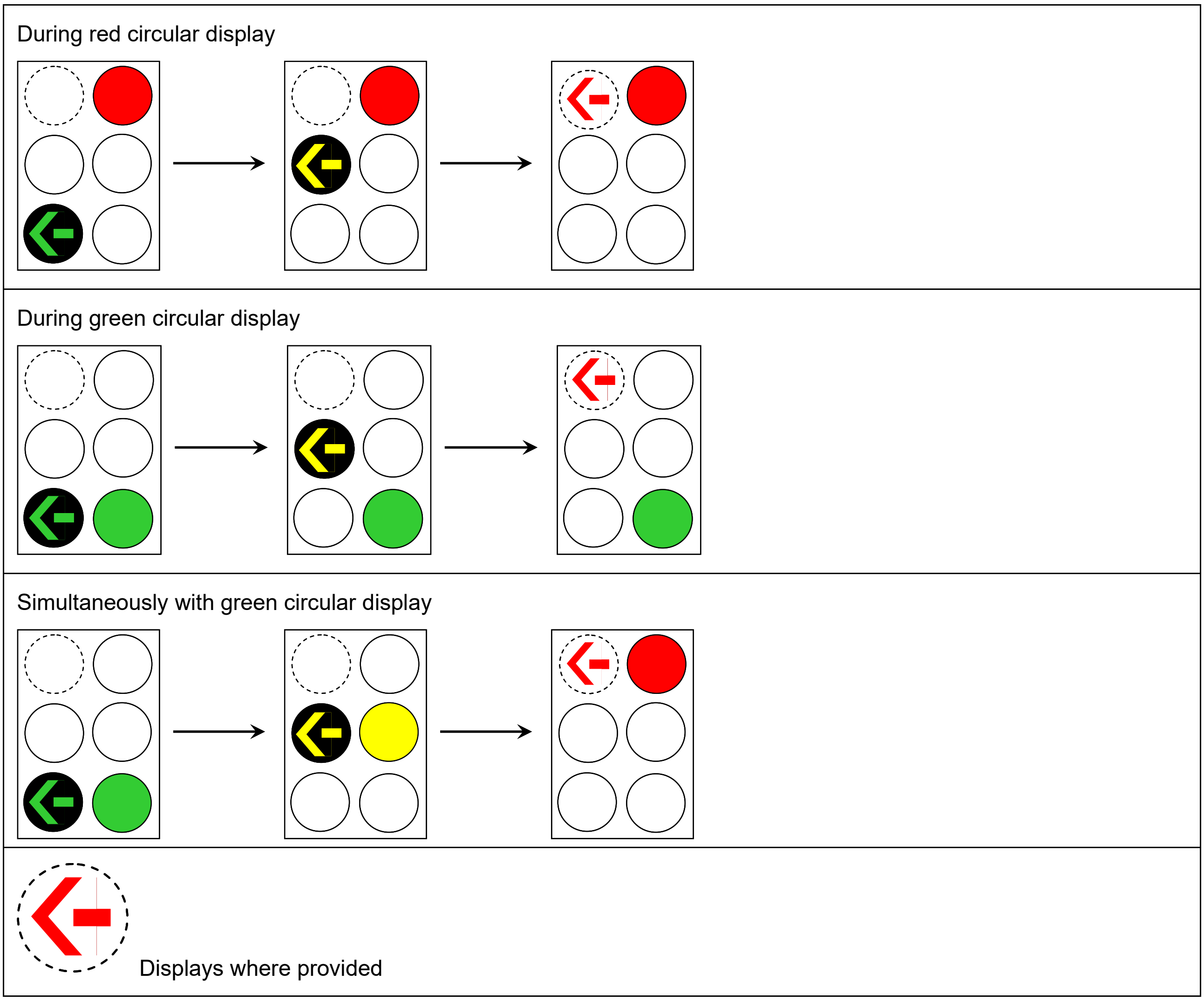
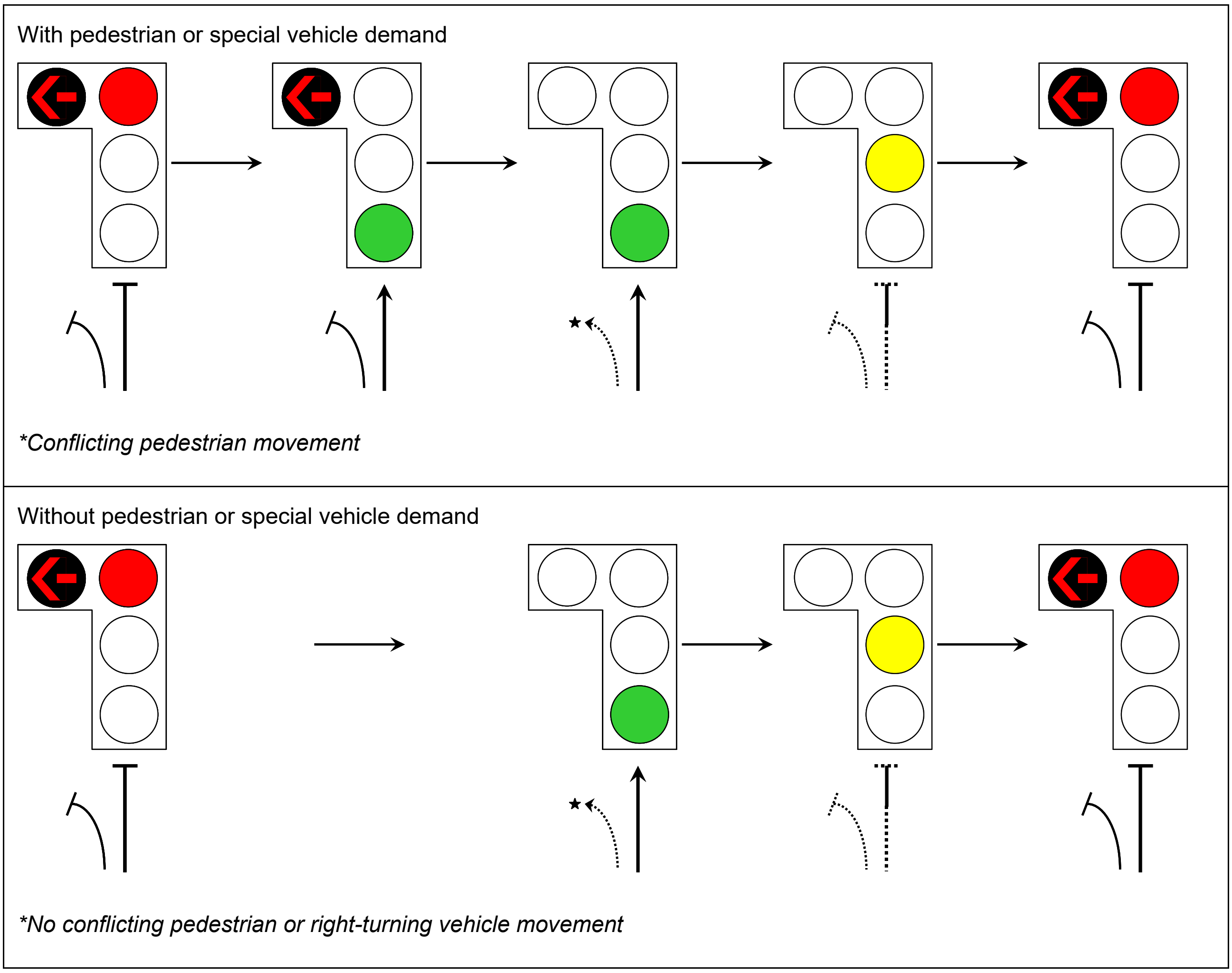


Figure 10.26: Display sequences for four-aspect arrangement with single red left-turn arrow aspect for the protection of pedestrians or special vehicles



10.3.5 Sequences for Two-aspect Columns

The sequence requirements for two-aspect vehicle signals (where used as regulations permit) are as follows:

- at roundabout metering signals: off to yellow to red to off
- at far right secondary signals: off to green to yellow to off
- at left-turn slip lanes with signalised crossings: off to yellow to red to off.

For pedestrian and bicycle signalised crossings, see Sections 10.3.6 and 10.3.7.

10.3.6 Pedestrian Signals

Practitioners should also refer to AS 1742.14 for further guidance on pedestrian signal lanterns and push buttons, and to Austroads (2020f) for further guidance on signal phasing for pedestrians. However, the following details are noted.

Signal face layout

A pedestrian signal face layout consists of a red pedestrian aspect mounted above a green pedestrian aspect as shown in Figure 10.1. Pedestrian aspects must never be incorporated with vehicle aspects in a common signal face.

Basic sequence

The basic sequence for pedestrian displays is steady red to green to flashing red to steady red.

In some jurisdictions, the red pedestrian signal is extinguished until the pedestrian demand is registered. In this case, the sequence for pedestrian displays is off to steady red (on pedestrian demand) to green to flashing red to steady red (for a short period, e.g. two seconds) to off.

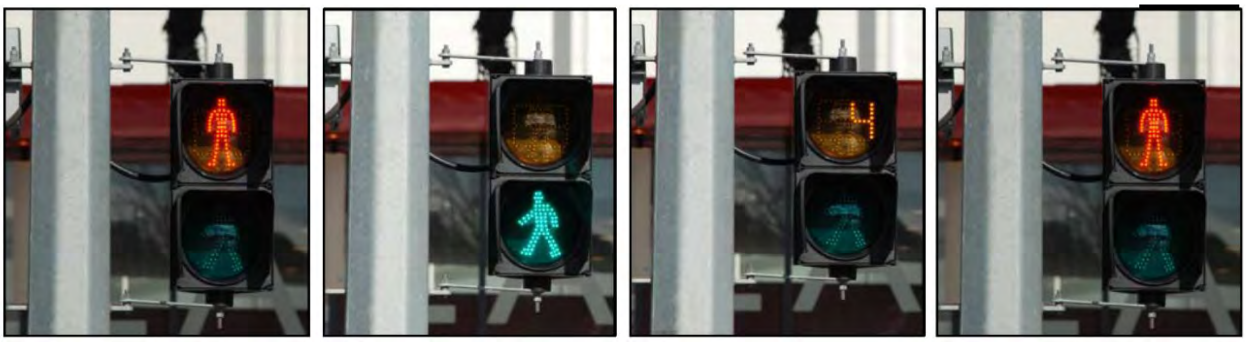
Procedure without pedestrian displays

When pedestrian signal aspects are not provided or are not operating at an intersection, pedestrians may be controlled by the circular vehicle displays (subject to legislation).

Pedestrian countdown timers

The flashing red pedestrian symbol may be directly replaced with a yellow countdown timer display (within the same aspect) indicating the number of seconds left (stopping at 1) before a steady red standing pedestrian is displayed. Figure 10.1 provides an example of how the pedestrian countdown timer would be incorporated into the pedestrian signal sequence. The green pedestrian symbol and solid red pedestrian symbol would be unchanged. Various jurisdictions are exploring the use of pedestrian countdown timers. Following successful trials, jurisdictions are developing guidelines for their use. As it is still a relatively new application for some jurisdiction, practitioners should refer to jurisdictional guidelines.

Figure 10.27: Pedestrian traffic signal sequence incorporating the pedestrian countdown timer



Source: Department of Planning, Transport and Infrastructure (2013).

10.3.7 Bicycle Signals

Practitioners should also refer to Section 10.5.5 and AS 1742.14 for further guidance on bicycle signals at signalised crossings. However, the following details are noted.

Signal face layout

Where permitted by legislation, a bicycle signal face layout consists of a red bicycle aspect mounted above a green bicycle aspect as shown in Figure 10.1. These two-aspect bicycle lanterns must never be incorporated with vehicle aspects in a common signal face.

Three-aspect bicycle signals (red, yellow and green bicycle aspects) can also be used to separately control bicycle movements.

Basic sequence

The basic sequence for bicycle displays with a two-aspect arrangement is steady red to green to flashing red to steady red. The sequence for bicycle displays with a three-aspect arrangement is green to yellow to red to green.

Procedure without bicycle displays

When bicycle signals are not provided at signalised intersections, bicycles on the roadway are controlled by the vehicle signals.

10.3.8 Special Vehicle Signals

Signal face layout

Where permitted by legislation, a special vehicle signal face layout consists of a single column of red and yellow aspects and a white special vehicle aspect (B for buses, T for trams, or E for emergency vehicles) that provides control of special vehicle movements (Figure 10.1).

In some cases, it may be necessary for special-purpose aspects to be mounted and aimed separately from vehicle or pedestrian displays.

Single white aspects are also used to control special vehicle movements.

Special vehicle sequence

The sequence for special vehicle displays is red to white to yellow to red. Where white special vehicle lanterns are displayed as single aspect units, the sequence is off to white to off.

A single white aspect does not fully control a special vehicle movement (i.e. its absence does not compel a special vehicle to stop).

10.3.9 Signal Start-up and Failure Displays

Signal display on failure

When the intersection cannot be controlled with the normal vehicle displays due to equipment malfunction or maintenance activities, the display recommended is flashing yellow at a rate of 1 hertz with equal ‘on’ and ‘off’ times. It indicates that the drivers should proceed through the intersection with caution using non-signalised intersection road rules.

For this reason, flashing yellow should not be used as a regular, routine mode of operating intersection signals under any condition other than when the traffic signal is malfunctioning or during maintenance activities.

Signal display on start-up

When initiating operation of a signal-controlled intersection the following sequence of displays is recommended:

- display flashing yellow on all approaches for a minimum of 10 seconds
- display steady red on all approaches for 3 seconds minimum
- display green aspects to the first (usually preselected) movements to proceed
- introduce a cyclic display of all phases and movements
- proceed with normal operation.

10.4 Location of Signal Faces

This section discusses location of signal equipment within the area of the intersection, including location of pedestrian the signal faces. Signal faces should be located in accordance with the specifications in AS 1742.14.

10.4.1 Designation of Signal Faces

Based on AS 1742.14, the designation of signal faces in relation to their location for a given approach is outlined below, and shown in Figure 10.28 .

- Primary signal faces:

  Located on the left-hand side, adjacent to the stop line or other point where traffic is required to stop. An additional primary signal may be installed on the right-hand side on a median or dividing island. Their principal function is to warn approaching traffic of the state of the signals, and to stop traffic at the correct position, noting that, in the absence of a stop line, traffic is legally required to stop before passing the primary signal.

- Secondary signal faces:

  Located to the right side of the roadway, beyond the point where traffic is required to stop (e.g. on the far side of an intersection, in a position readily visible to traffic stopped at the stop line). Their principal function is to indicate to traffic that is stopped, the start of a running phase.

- Tertiary signal faces:

  Located to the left side of the roadway beyond the point where traffic is required to stop. Their principal function is to back-up the secondary signals.

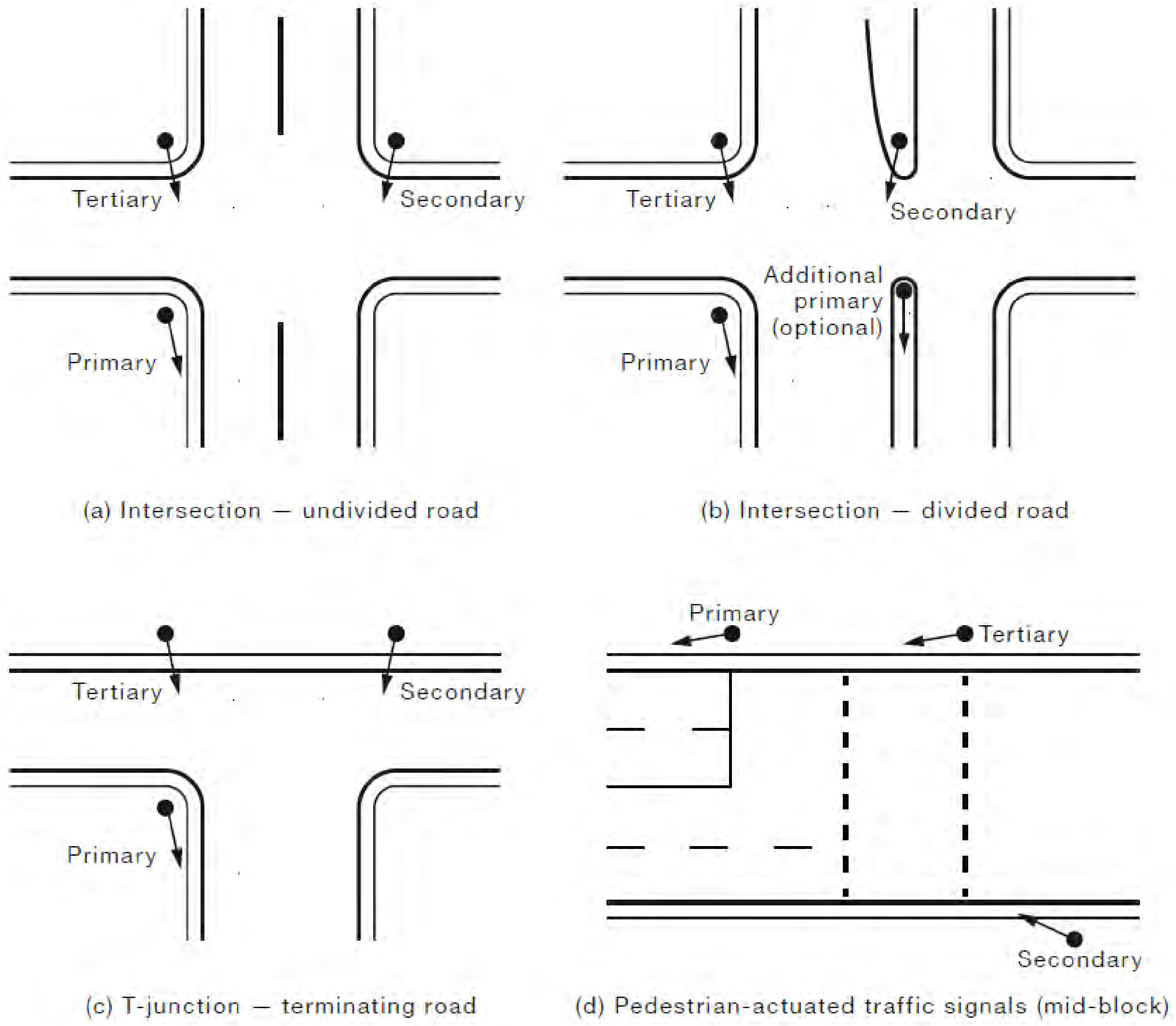
In addition to the above signal faces, overhead signal faces should be used in the following situations:

- where the stopping sight distance to the post-mounted display is inadequate (e.g. because of vertical or horizontal alignment, awnings, poles, trees or similar sight obstructions)
- where the roadway is too wide for kerb-mounted lanterns to fall within the driver's line of sight.

Regardless of the above requirements, overhead signals may be omitted if there is a likelihood that they could appear to apply to an adjacent upstream signalised intersection.

The minimum signal layout for an undivided, divided and T-junction intersection along with a pedestrian-actuated traffic signal is shown in Figure 10.28.

Figure 10.28: Designation of signal faces



10.4.2 Signal Face Functions

A design must provide for the following signal face functions for each approach as relevant:

- Warning display: to alert the approaching drivers to the presence of traffic signal control.
- Stopping display: to inform approaching drivers sufficiently in advance of the stop line that they are required to stop.
- Starting display: to inform drivers stopped at the stop line when they may proceed.
- Manoeuvring display: to inform drivers about to enter the intersection, or within the intersection, of any priority or restriction allocated to them.

Each signal face can provide more than one function as detailed in Table 10.1 . A signal face does not adequately provide the function if two or more lanes of traffic separate approaching vehicles and the signal face.

Table 10.1: Signal face functions

Location of signal face	Main functions performed			
	Warning	Stopping	Starting	Manoeuvring
Primary	Yes	Yes	No	No
Secondary	‡	‡	Yes	Yes
Tertiary	‡	‡	Yes	Yes
Dual primary	Yes	Yes	No	No
Overhead primary	Yes	Yes	No	No
Overhead secondary	‡	‡	Yes	‡
Overhead tertiary	‡	‡	Yes	‡

‡ *These functions may also be provided depending on site geometry, topography and other conditions.*

10.4.3 Signal Face Site Requirements

Recommended minimum number of signal faces

The minimum number of signal faces for a given approach is three, with the exception of special applications and facilities (Section10.5). An approach with a primary, secondary and tertiary signal face satisfactorily provides for all essential signal face functions while still providing a limited degree of safety in case of individual lamp failure.

The minimum number of signal faces for each left-turn movement is two. They should be located in the primary and tertiary locations. Where the road that left-turning vehicles are turning into has a median or island, the tertiary signal face may be located on that median or island if a suitable post is provided ('split tertiary' arrangement). Signal faces for a channelised left-turn carriageway are covered in Section 10.4.4

The minimum number of signal faces for each right-turn movement is two. They should be located as follows:

- on a divided road with medians of sufficient width, in the dual primary and secondary locations
- otherwise, preferably in the overhead primary and secondary locations
- as a last choice, in the primary and secondary locations.

Furthermore, if both the secondary and overhead secondary are provided, right-turn aspects should be placed on both. On a divided road where there are two or more lanes turning right, consideration should be given to installing a right-turn signal face in the dual (far-right) secondary location.

At intersections where geometry, physical features, approach widths or other factors restrict the functions provided by only three signal faces, additional signal faces may be necessary, for example at multiple-leg intersections or where the controlled area is exceptionally large or complex. Excessive numbers of signal faces add to the visual clutter at the intersection and to intersection operating costs. The provision of additional signal faces that are not warranted may become confusing.

Dual primary signal faces

A dual primary signal face is normally provided when there is a median island of sufficient width, and:

- there are two or more approach lanes
- there are right-turn arrow aspects.

Overhead signal faces

Overhead signal warrants

Overhead signal faces mounted on mast arms have been shown to reduce the incidence of adjacent direction crashes at signalised intersections. They improve conspicuity of the signals and reduce the likelihood of red light running (Durdin et al, 2016). They are required in the following situations:

- where the stopping sight distance to the post-mounted signal face is inadequate, e.g. because of vertical or horizontal alignment, awnings, poles, trees or similar sight obstructions
- where the roadway is too wide for kerb-mounted signal faces to fall within the driver's line of sight.

Care should be exercised with the use of mast arm mounted signals where there are closely spaced signalised intersections as drivers may be misled regarding which intersection the overhead signal applies to.

Overhead signal location

The primary signal face location is preferred for overhead signal faces Table 10.1() because it provides:

- the greatest sight distance from the stop line
- warning and stopping functions when dual primary signal faces are warranted but cannot be provided.

Provided adequate sight distance is available, an overhead secondary signal face may be used instead of an overhead primary signal face where additional starting and/or manoeuvring functions are required (e.g. if secondary median signal faces are not available or for additional right-turn arrow aspects when dual primary signal faces are not available).

Where two overhead signal faces are required for each approach, primary and secondary signal faces for opposite approaches are often mounted on the same mast arm to reduce costs.

Provided adequate sight distance is available, an overhead tertiary signal face may be used instead of an overhead primary signal face when additional starting or manoeuvring functions are required (e.g. for additional signal faces incorporating left-turn arrows).

Provided signal face functional requirements are met (Section10.4.2), economy in the use of mast arms can be achieved by mounting more than one signal face on a mast arm (e.g. on crossroad intersections, a primary signal face for one approach and a tertiary signal face for the approach from the right).

Unless obstructions such as power lines are present, the mast arm outreach selected should ideally locate the signal face above the second lane from the kerb.

Where obstructions are present and inadequate sight distance is the main reason for providing an overhead signal face, the signal face should be located:

- as near as possible to the ideal location
- so that necessary safety clearance from the obstruction is maintained.

Pedestrian signal faces

The following requirements apply for signalised crossings at intersections and mid-block locations (also see *Mid-block signalised crossings* in Section10.4.4):

- A pedestrian signal face must be provided at each end of a signalised crossing. It should be located within 1 m of the projection of the crosswalk lines and aimed at the opposite end of the crossing.
- If the crossing width exceeds 10 m, two pedestrian signal faces should be provided at each end of the crossing.
- If the crossing distance exceeds 25 m, supplementary pedestrian signal faces should be installed on a median island where practicable.
- The pedestrian signal face should be located, and if necessary screened, to ensure that it is obvious which crossing is controlled by the signal face.
- Where a crossing is staged as two separate movements, each stage must be signalised as a separate crossing.

In accordance with AS 1742.14 the push buttons should be orientated so that they are perpendicular to the crossing with the arrow legend orientated horizontally.

10.4.4 Positioning of Signal Equipment

The conspicuity of traffic signals is influenced by a combination of factors such as signal colour, intensity, size, background luminance and exposure time, as well as the location of the signal in the driver's visual field.

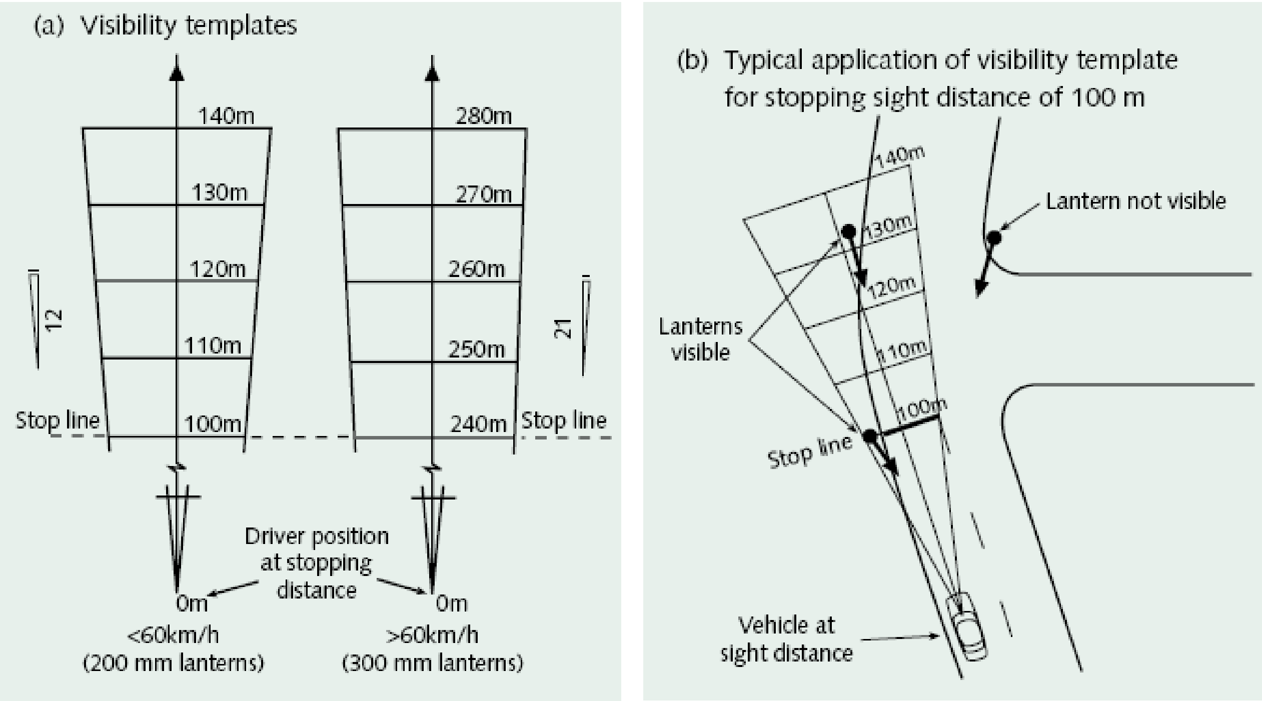
Figure 10.29 (a) provides examples of the driver lantern visibility templates that may be used for signal layout design plans to determine if lanterns are located sufficiently close to the driver's line of sight. The templates shown in Figure 10.29 (a) are for 200 and 300 mm lanterns. Figure 10.29 (b) illustrates a typical application of a visibility template.

The number of signal posts should be minimised for safety and aesthetic reasons (e.g. pedestrian and vehicle signals can be mounted on a common post, or vehicle signals for different approaches can be mounted on a common post).

The recommended positions for signal posts and mast arms are detailed below. It is important that these positions satisfy the requirements of the Commonwealth *Disability Discrimination Act 1992* and AS/NZS 1428.4.

Mast arms are rigid structures and they should only be located where the probability of impact by vehicles is low (AS 2979).

Figure 10.29: Signal face visibility templates



Lateral post positions

Kerbside posts and mast arms should be positioned nominally 1 m from the kerb face, but not closer than 0.6 m.

Median posts should be located centrally in the median, or on wide medians the post should not be located more than 2 m from the relevant kerb face.

Longitudinal post positions

Cross-road intersections (Figure 10.30 and Figure 10.31)

- Primary signal faces:

  Posts for primary and dual primary signal faces should be placed between the projection of the adjacent stop line and up to a distance of 3 m downstream. They should not be placed upstream of the adjacent stop line (except as provided for in Section 10.4.8) or on the departure side of a signalised crossing. Posts should be placed not less than 1.2 m from an island nose.

- Secondary signal faces:

  Secondary signal faces are usually placed on the primary post (or dual primary post if there is a median) of the opposite approach.

- Tertiary signal faces:

  Posts for tertiary signal faces are preferably placed on the projection of the building alignment, or at the tangent point of the curve where large radius curves are used, or a minimum of 2 m from the corner and 1 m from adjacent edges of the triangular island formed by a separate left-turn lane.

Separate controlled lanes within an intersection

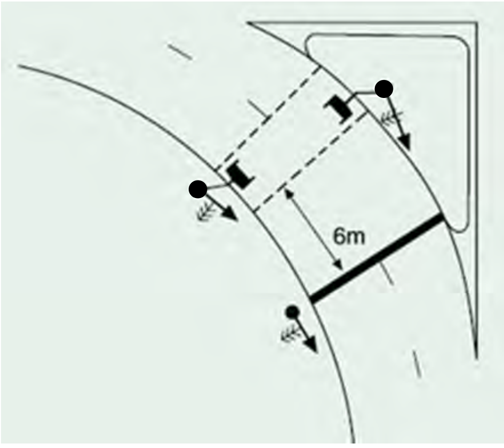
- Primary signal faces:

  Posts for primary and dual primary signal faces are located as described above except that one of these posts should be located at least 6 m beyond the stop line to provide a starting signal (Figure 10.30).

- Secondary and tertiary signal faces:

  Posts for these signal faces are located as shown in Figure 10.3 to provide starting and/or manoeuvring functions. The provision of both secondary and tertiary signal faces may not always be required. Where there is a separate departure lane and secondary and tertiary signal faces are provided, the posts should be placed either side of the separate departure lane to reduce the likelihood of driver error and incorrect manoeuvres (Figure 10.31).

Figure 10.30: Signal face location for channelised left-turn control



Legend

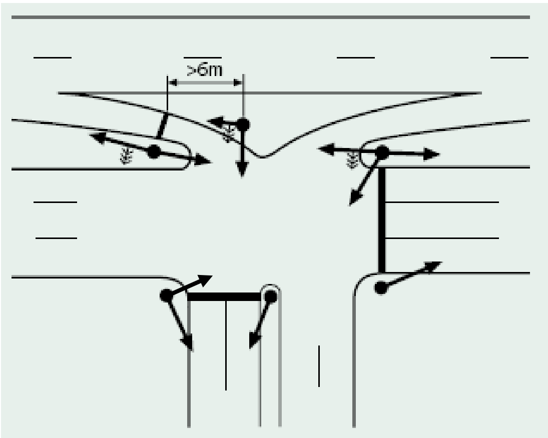
= Pedestrian signal

= Pole

= Traffic signal

Note: Pedestrian push button and arrow legend are not shown.

Figure 10.31: Signal face location for channelised right-turn treatment (seagull)



T-intersections

- Primary signal faces:

  Posts for primary signal faces are located as described above.

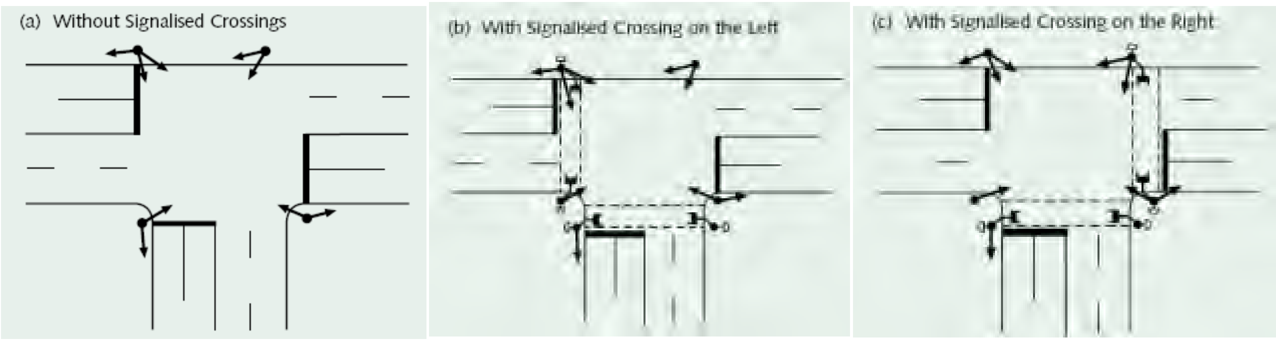
- Secondary signal faces:

  Posts for secondary signal faces at the head of the T are located as described above, but posts for the stem of the T are located to the right of the projection of the centreline but closer to the line of sight of the approaching motorist (as shown in Figure 10.32(a)). The preferred location of the signalised crossing is to the left of the stem as shown in Figure 10.32(b). Figure 10.32(c) shows the relocation of posts for secondary and tertiary signal faces to allow a common post to be used with a pedestrian signal face.

- Tertiary signal faces:

  Posts for tertiary signal faces are located generally as described above, except that some adjustment is normally made to allow the common post to be shared with the secondary signal face for the stem of the T.

Figure 10.32: T-intersection signal location



Mid-block signalised crossings

- Primary signal faces:

  Posts for these signal faces are located as described above.

- Secondary signal faces:

  For undivided carriageways, these signal faces are mounted with the primary signal face of the opposite approach on a common post. For divided carriageways, secondary signal faces are mounted with the pedestrian signal face on a common post located on the projection of the crosswalk line.

- Tertiary signal faces:

  For both divided and undivided carriageways, these signal faces are mounted with the pedestrian signal face on a common post located on the projection of the departure side crosswalk line.

- Overhead signal faces:

  If overhead signal faces are provided, the tertiary signal faces may be omitted.

Figure 10.33 shows examples of typical pedestrian mid-block crossings as used by VicRoads. The examples demonstrate the principles outlined above.

10.4.5 Collision Risk Reduction

Poles at the intersection of major roads have the highest risk of being involved in a crash. The layout of signal infrastructure should therefore be undertaken in line with Safe System principles.

Not only do poles pose a crash risk and influence the severity, crashes involving poles supporting traffic signal equipment contribute substantially to maintenance costs and signal outages.

In order to minimise the collision risk, intersection design should aim to:

- minimise the number of poles by using joint-use poles
- use frangible solutions where possible
- increase the offset of poles to as far from the trafficable lane as possible.

10.4.6 Lantern Mounting Heights

Practitioners should refer to AS 1742.14 for guidance on lantern mounting height. However, in summary, for lanterns located on the road verge, the lantern height as measured from pavement level to the top of the lantern assembly should be as follows:

- For vehicle lanterns the mounting height should be 4 m.
- For pedestrian lanterns the mounting height should be 3 m.

The minimum height clearance from the path to the bottom of the target board should be 2 m when located above a footpath and 2.4 m when located above a bicycle path.

For overhead lanterns located above the roadway, a minimum clearance between the road level and the bottom of the target board should be at least 5.4 m or an extra 0.1 m above the required height clearance for the road, where the height clearance is above 5.3 m. Additional clearance beyond the minimum may result in the lantern being located too far above the driver's line of sight.

Greater clearances may be required for over-dimensional-load routes. For example, VicRoads requires a minimum clearance of 6 m for overhead lanterns used for ramp metering on motorways. Practitioners should refer to the minimum height clearance for routes within their jurisdiction and use this in addition to the guidelines provided when determining the height of overhead lanterns.

Figure 10.34 shows a typical signal mounting arrangement as used by VicRoads that meets the above requirements.

10.4.7 Clearances from Power Lines

Minimum clearances from overhead power lines to any signal equipment are specified by the electricity authorities. The required clearances vary depending on line voltage, line insulation and local electricity authority practices, therefore the authority should be consulted if equipment is to be located near power lines.

10.4.8 Lantern Aiming

The visual range of each lantern is determined by its position, photometric performance and orientation. Table 10.2 shows the coverage provided by a lantern for various aiming distances.

Table 10.3 lists the recommended aiming distances from the stop line towards the centre of the approach lanes for stopping and for warning functions.

Starting signals should be aimed at a point 3 m from the stop line at the centre of the approach.

Manoeuvring signals should be aimed at the centre of the stop line.

A lantern should not be required to be seen from closer than 8 m.

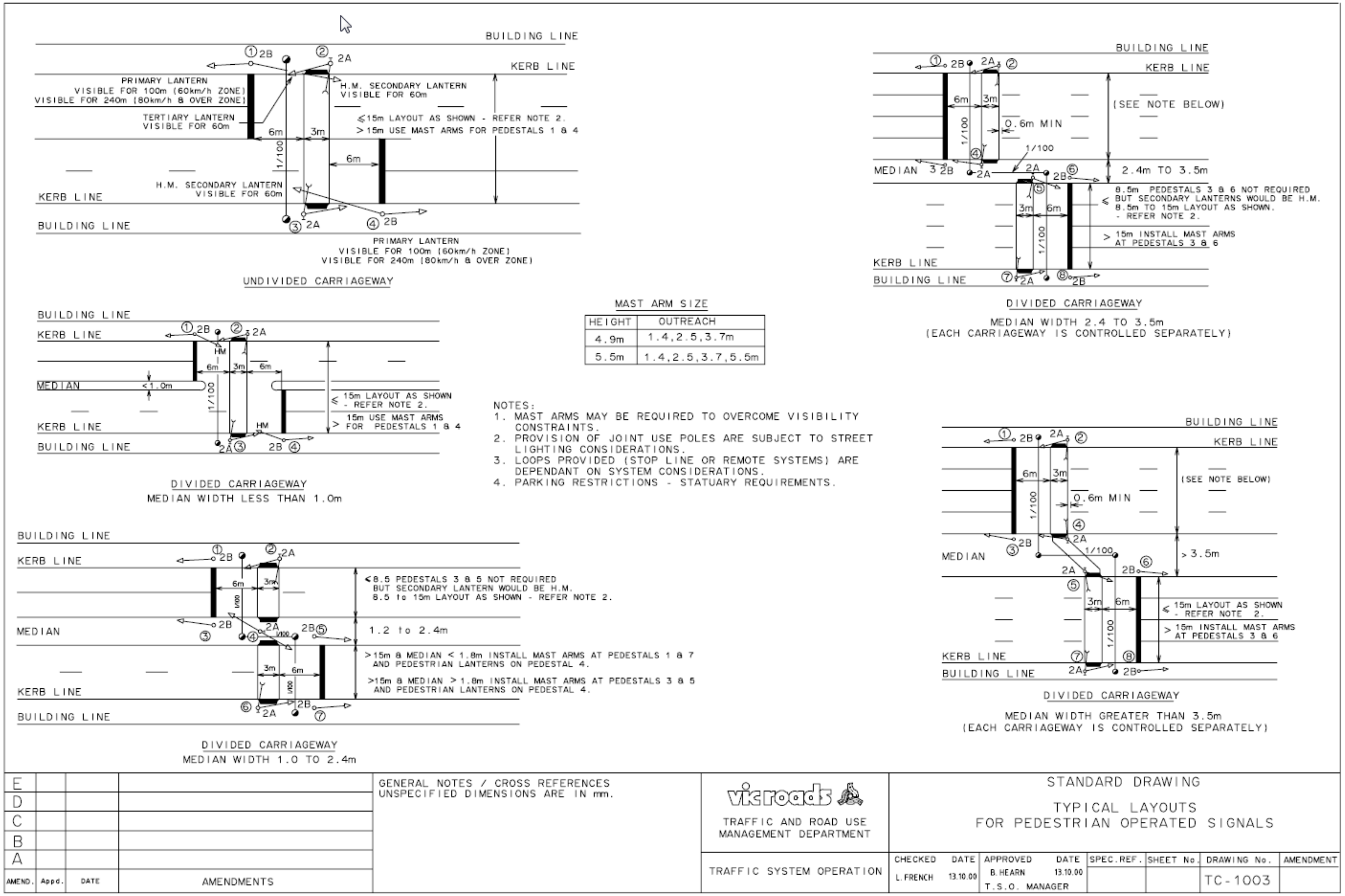
Table 10.2: Visual coverage of lanterns

Aiming distance (metres from lantern)	Visual coverage	
	Ground mounted	Overhead
	(metres from lantern)	
40	10–70	–
60	20–95	–
80	40–120	50–110
100	55–145	65–140
120	75–170	–
130	–	90–170
140	–	105–195
150	–	125–225

Table 10.3: Recommended aiming distances

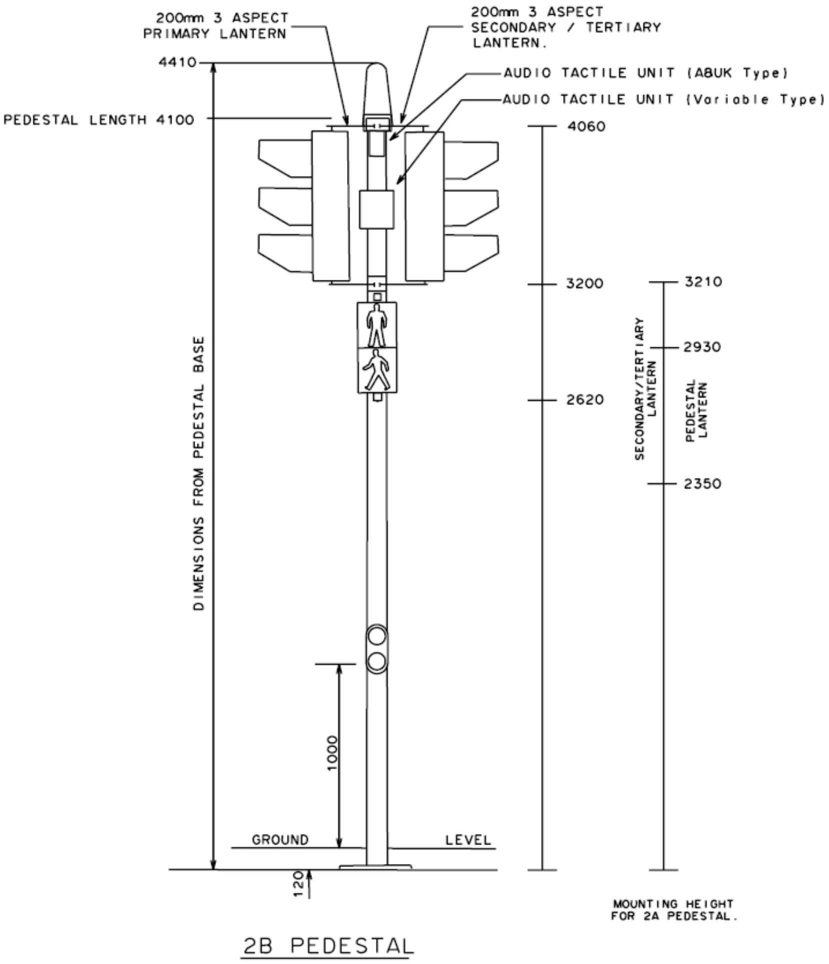
Approach speed (km/h)	Stopping	Warning
	(metres from stop line)	
40	40	80
50	60	100
60	80	130
70	100	150
80	120	170

Figure 10.33: Typical layouts for mid-block pedestrian operated signals as used by VicRoads



Source: VicRoads (personal communication 2016).

Figure 10.34: A typical signal mounting arrangement as used by VicRoads



Source: VicRoads (personal communication 2016).

10.4.9 Unusual Geometry or Site Features

Alternative positions and/or additional lanterns may be provided where fixed obstructions (such as poles, trees, awnings, underground services and background interference including illuminated advertising signs) or intersection approach geometry are such that standard positions and numbers of lanterns are not adequate to carry out the required functions. These are illustrated in the following examples:

- Where the warning or stopping function of primary (or dual primary) lanterns is adversely affected on left-hand curve approaches, an additional lantern should be provided on the right-hand side of the road.
- Where it is not practicable to screen a lantern effectively from traffic for which the signal display is not intended, that lantern should be relocated or omitted.
- Where it is necessary to prevent a lantern from being seen by traffic at an upstream stop line, tilting of the lantern or other measures to limit the field of view can provide effective solutions. Some agencies tilt only the green face display as the confusion normally only occurs when green is displayed.
- Where a railway line is in close proximity to a signal installation, lantern screening and aiming arrangements must ensure that signals do not constitute a source of confusion to train drivers (Section 10.5.2).
- Where a low bridge over an approach road obstructs visibility of the lanterns, an advance warning may be used (as described in Section 10.5.1). When the bridge is adjacent to the intersection, an additional primary signal may be placed in advance of the bridge, not more than 10 m from the stop line.

10.4.10 Other Street Furniture

To reduce street furniture clutter, suitably located existing utility poles may be used for the mounting of lanterns, provided that agreement to do so can be obtained from the utility authority. A minimum 1 m clearance should be provided from lanterns to other separate street furniture items.

Where possible, streetlights and lanterns should be located on one common post or structure under a joint-use arrangement with the local electricity authority. The use of common posts for mounting guide signs and signal hardware is encouraged (Section 10.8.1).

10.4.11 Visors

Visors are used to modify the angular visual coverage of the lantern (e.g. to hide the lantern from the view of drivers on other approaches) and/or to shield the lantern optical system from incident light that may produce sun-phantom illumination. The following procedures should be noted:

- Table 10.4 details the angle at which the signal is totally cut-off from view for various visors.
- Cutaway visors are used to provide additional visibility on the cutaway side and standard cut-off on the other side.
- Where no restriction of angular coverage is required an open visor should be used to shield the lantern from incident light.
- Closed visors are normally used on secondary and tertiary lanterns. The shorter closed visor should be used unless additional angular cut-off is essential. The longer visors are also more difficult to protect from damage.

10.4.12 Louvres

Louvres are used when visors are unable to provide the necessary visual cut-off. Their use should be minimised because louvres reduce the efficiency of the optical system and produce reflected images that are visible under low ambient lighting. The following procedures should be noted:

- Louvres should not be used in association with symbolic aspects.
- Horizontal louvres are used to:
  - minimise sun-phantom illuminations where visors have been proved to be ineffective
  - restrict the signal display coverage along the approach.
- Vertical louvres are used to:
  - produce the required signal display where the cut-off provided by visors is inadequate (typically at skewed intersections)
  - restrict the visibility of the signal display to a certain lane or lanes of the approach
  - shield the lantern from the view of train drivers or other persons in the vicinity of an intersection when it is desired that they should not be able to see the lantern.

Table 10.4: Cut-off angles for visors

Lantern size (mm)	Visor type as per AS 2144	Length (mm)	Angle for total cut off of signal indication
200	Open type A	200	No restriction
200	Closed type B	200	90°
200	Closed type B	300	67°
200	Cutaway type C	300	Open side 32° on closed side
300	Open type A	300	No restriction
300	Closed type B	300	90°
300	Closed type B	400	74°
300	Cutaway type C	400	Open side 37° on closed side

10.5 Special Uses

This section presents information on functional and operational aspects of special traffic signal applications and facilities. For further information, refer to AS 1742.2 and AS 1742.14.

10.5.1 Advance Warning Signals

Advance warning signals are an active warning device consisting of a warning sign with alternating flashing yellow lights. Alternative formats for advance warning signals are shown in Figure 10.35(note: the two alternatives shown on the right-hand side of the diagram are not permitted in New Zealand, where *MOTSAM* sign PW-64 should be used). An image of an advance warning signal in use is shown in Figure 10.36

The advance warning device is cabled to the traffic controller and timed as a separate signal group. The yellow lights should flash alternately, one being off while the other is on, at a frequency of 1 Hz.

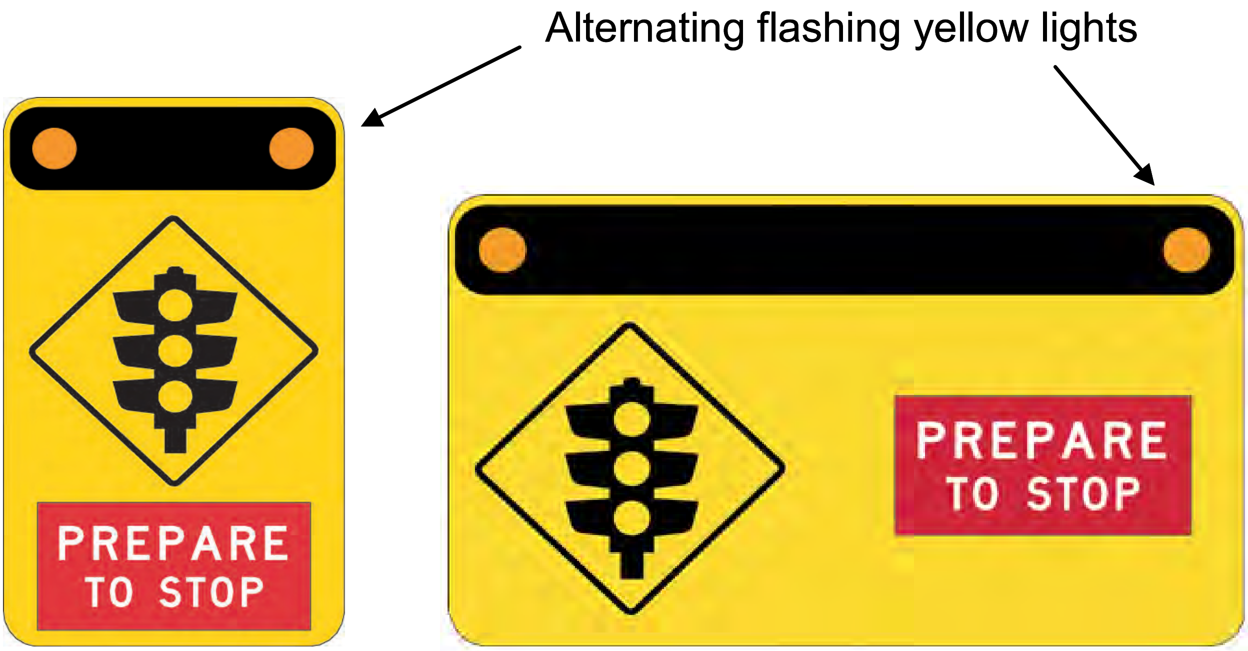
There are four main purposes for the use of an active advance warning device (rather than a passive device):

- On arterial roads with a high proportion of heavy or long combination vehicles, where there is a high risk of frequent infringement of signals and a high risk of rear-end and cross crashes due to the inability to stop in time for the red display e.g. due to high approach speeds or significant downhill grade, the warning device should be located approximately at the stopping sight distance from the stop line of the intersection, on the approach side of the intersection (AS 1742.14).
- As outlined in Austroads (2020f) the flashing yellow lights are started a fixed time in advance of the yellow interval when the main through-traffic phase is terminating at the intersection, using the early cut-off period timer. The flashing lights may be terminated at the onset of the next green display for the main through-traffic phase, or earlier at the start of the red display.
- A traffic signal installation that is obscured from the view of approaching traffic such that there is a high risk of collision with the rear end of traffic queued at the signals: the warning device should be located at not less than the stopping distance in advance of the probable end of the queue.

  The yellow lights will need to flash beyond the start of the green display when the sight distance to the back of the queue for the through movement is a problem. The back of the queue will not begin to move until some seconds after the green signal is displayed. This time can be calculated as the 95th percentile queue value (in vehicles) multiplied by the queue departure response time. Akçelik, Besley and Roper (1999) reported a typical queue departure response time of 1.15 s per vehicle in the queue observed at intersections in Melbourne and Sydney.

  The assembly is generally erected on the left of the approach. However, if it cannot be seen in this position due to restricted sight distance caused by horizontal left-hand curvature, the assembly should be erected on the right of the approach. The assembly may also be mounted overhead if the sight distance to a side-mounted sign is restricted by vertical road curvature.
- A situation where the signal being approached is almost always green. Drivers who regularly approach the signal would have a low expectation of encountering a red signal.

Figure 10.35: Alternative formats for advance warning signals



Note: These signs are not permitted in New Zealand, where MOTSAM sign PW-64 should be used.

Figure 10.36: Advance warning signal signs in use

10.5.2 Railway Level Crossings

Proximity to level crossing

If a road signal installation is located in close proximity to a railway level crossing such that there is a probability that a vehicle queue generated by the road signals will extend across the rail tracks, special provision should be made to force the road signals to a phase that will clear the queue before the arrival of the train.

The signal requirements should be determined in consultation with the railway authority.

Use of yellow box pavement markings and fixed or variable message signs such as *keep tracks clear* may be effective in preventing vehicles queuing over rail crossings.

Some examples and guidelines for good practice have been documented by the ITE Technical Committee (ITE 2006) while guidance on traffic management at railway level crossings is given in Austroads (2020d).

Linking requirements

If linking with the railway level crossing is justified, track switches should be provided by the railway authority to enable the special queue-clearing sequence to be initiated before the flashing red signals commence to operate.

The road signal sequence should be arranged so that after the queue-clearing phase has terminated, no phases or turning movements can be introduced for traffic needing to cross the rail tracks until the train has cleared. The railway track switches should provide an indication when the train has cleared the level crossing. In the case of a rail crossing provided with manually operated gates, no special provision is generally required. When the level crossing opens to road traffic, the normal phase sequence is restored and some compensation can be given to the waiting traffic.

Provision of additional storage may be necessary for vehicles that cannot be released while the railway crossing is closed.

Railway level crossings within the intersection

It may be possible to include the railway level crossing within the conflict area. In this situation the train movement will need to be treated as a priority phase. The flashing red railway display should be provided as part of the control.

Conflicting railway and road signals

Special precautions may need to be taken to shield any green roadway display from traffic approaching or stopped by a flashing red railway display. Similarly, roadway displays should be shielded from the view of train drivers.

10.5.3 Emergency Vehicle Facilities

As outlined in AS 1742.14, signals for mid-block access points to or from emergency service facilities may be provided by using three-aspect signal faces in a similar manner to an intersection.

However, where there are concerns that the green aspect is displayed for very long periods due to the infrequent operation of the signals, the following alternative signals may be used:

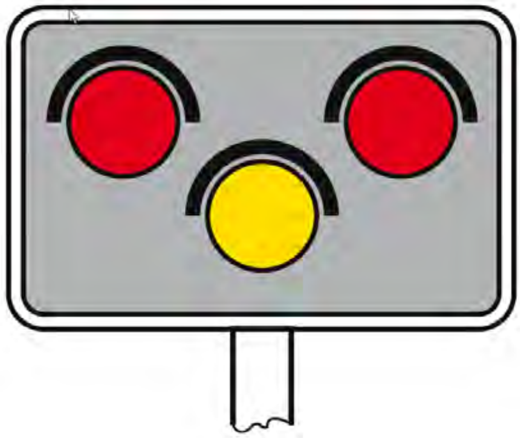
- Two-aspect signals:

  The signal faces must contain red and yellow signal aspects only. Operation of the signals comprises a display of aspects in the sequence off to yellow to red to off where the yellow may be either steady or flashing. The sign *stop here on red signal* is provided on the primary signal post if a stop line is not marked.

- Flashing red signals:

  The signal face containing flashing signals comprises a single steady yellow signal surmounted by twin alternate flashing red signals in the configuration shown in Figure 10.37. Operation of the signals comprises a display of aspects in the sequence off to yellow to flashing red to off. The yellow signal may be displayed for longer than the normal yellow period. Signs may be displayed at or near the signals indicating to road users that they must stop when the lights are flashing.

Figure 10.37: A flashing red signal face which may be used at emergency vehicle facilities



Note: Jurisdictions may use two-aspect signals or even conventional signals as an alternative to the flashing red signal face as shown.

Source: AS 1742.14.

The layout of signals for emergency vehicle facilities should be in accordance with the typical signal layout used for the non-terminating road of a standard signalised T-intersection as discussed In Section 10.4. That is, the signal layout should comprise three signal faces (a primary, secondary and tertiary) for both approaches of the road in which the emergency vehicle entry point is located.

10.5.4 Public Transport Priority

Special public transport priority treatments at signalised intersections, such as special signal phases for buses and trams, are used as a travel-demand management measure to encourage the use of public transport.

Signal aspects and display sequences for buses and trams are described in Sections 10.1.5 and 10.3.8.

Operational arrangements for providing active public transport signal priority are set out in Austroads (2020f).

Bus priority

A three-aspect column is used to control a bus phase. A bus lane must be designated a bus-only lane for at least 100 m on the approach to the stop line. This is necessary to legally deny vehicles other than public buses access to that length of lane. Otherwise, a vehicle could block the bus movement when a white B is displayed. Other vehicles can legally enter a bus lane up to 100 m before turning or leaving the road. Signs and pavement markings can be used to designate a length of bus-only lane. The lane adjacent to the bus-only lane must be marked with left-turn and through arrows if it is a shared lane, or left-turn arrows only if it is an exclusive left-turn lane. This is essential to legally allow other vehicles to turn left across the bus-only lane.

A single white B aspect must be one of at least a four-aspect signal face. It is used to provide a priority start at the beginning of the phase in which other vehicles moving in the same direction as the buses operate. A single white B aspect is needed only when the buses and vehicles in the adjacent lane merge on the departure. A priority start is not necessary if the bus lane continues on the departure. Conflicting movements between buses and other vehicles must be denied or non-existent. The only exception is a merge conflict on the departure.

It is important to remember that any vehicle classified as a public bus may use a bus or bus-only lane; the lane will not be used exclusively by buses on a registered route at all times. For example, if a registered bus route continued left at a signalised intersection, buses on that route would only turn left. However, other public buses in the bus-only lane could proceed straight ahead or turn right when a white B is displayed. This must be considered before using B aspects to control buses.

Tram priority

Tram priority is controlled differently from bus priority. Unlike buses, tram direction is controlled by tracks either located in the centre lanes of a shared roadway or clear of the trafficked lanes in a centrally located tram reserve.

A three-aspect column is used to control tram movements in their own right of way to eliminate conflicts between trams and other vehicles and to provide tram-only phases.

A single-aspect white T and five-aspect signal faces as shown in Figure 10.1 and Section 10.2.2 are used to provide priority for trams on shared roads. The five-aspect signal face is used in conjunction with a tram-actuated leading right-turn phase to clear queued vehicles between the tram and the stop line. The single-aspect white T is used with tram-only phases, where trams are on a unique route. Where trams use alternative routes, white arrows are used to indicate the turning direction.

10.5.5 Bicycle Facilities

Where bicycles use signals to cross a road via an off-road facility, bicycle facilities are combined with pedestrian facilities at signalised intersections and mid-block signalised crossings. Signal sequences for bicycle and pedestrian signals are described in Section 10.3.7. Signal face site requirements and positioning of signal equipment for pedestrian signals are discussed in Section 10.4.3 and Section 10.4.4.

Bicycles may be controlled by two-aspect red and green bicycle signal faces, or three-aspect red, yellow and green bicycle signal faces (Section 10.3.7). The type of bicycle path (e.g. exclusive, shared) is a factor in the selection of two-aspect or three-aspect signal faces.

A bicycle rider is required to dismount[5] when crossing a road from a footpath, bicycle path, shared path or separated path whether traffic signals are installed or not. However, where bicycle lanterns are installed, a rider facing a bicycle signal may negotiate the intersection or mid-block location without dismounting.

Where bicycles use on-road facilities, it is recommended that, at intersections, a stop line for bicycles is placed 2 m downstream of the normal stop line so that left-turning motor vehicle drivers, in particular bus and truck drivers, will be aware of bicycles waiting for a green signal. If vehicles cannot turn left, there is no need for this treatment.

Detailed information on traffic control devices for bicycle facilities is provided in AS 1742.9.

10.5.6 Roundabout Metering Signals

Roundabout metering signals may be used where excessive queuing and delays are observed on one or more legs of a roundabout due to heavy circulating flow rates, especially in the case of strongly directional origin-destination movements. In this case, a dominant approach stream constitutes the major proportion of traffic in the circulating stream that causes a significant reduction in the capacity of the approach that has to give way to the circulating stream. These signals are usually employed on a part-time basis since they may be required only when heavy demand conditions occur during peak periods.

5 In Queensland, cyclists are not required to dismount when crossing pedestrian crossings, crosswalks and children's crossings.

Two-aspect yellow and red signals are used for roundabout metering as shown in Figure 10.6 (a). The sequence of aspect display is off to yellow to red to off. When metering is not required neither aspect is displayed.

Figure 10.38 shows the use of metering signals at a roundabout. The signalised approach is referred to as the ‘metered approach’ and the approach with the queue detector as the ‘controlling approach’.

When the queue on the controlling approach extends back to the queue detector, the signals on the metered approach operate so as to create a gap in the circulating flow. This helps the controlling approach traffic to enter the roundabout. When the red display is terminated on the metered approach, the roundabout reverts to normal operation.

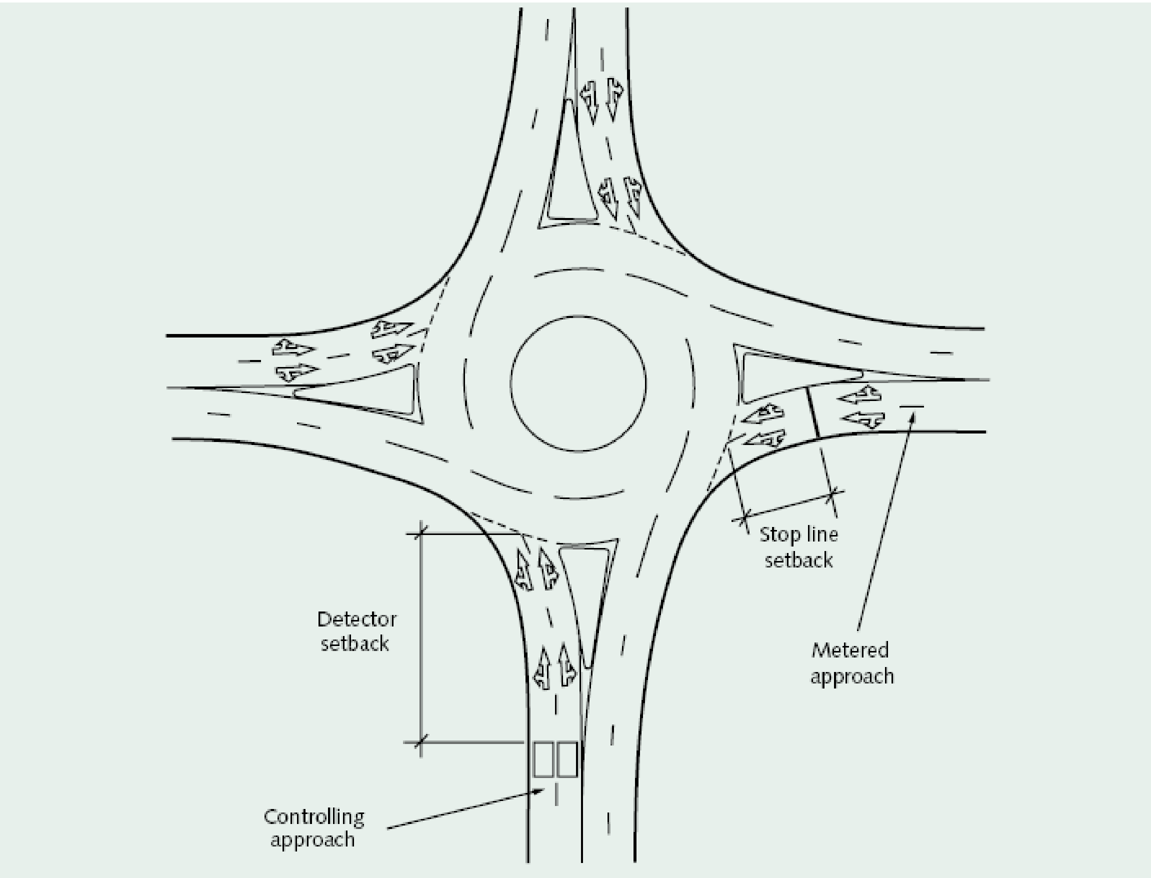
The introduction and duration of the red signal on the metered approach is determined by the controlling approach traffic. The duration of the blank signal is determined according to a minimum blank time requirement, or extended by the metered approach traffic if vehicle detectors are used on that approach.

A minimum of two signal faces, one primary and one tertiary, must be installed. A regulatory sign *stop here on red signal* must be fixed to any signal post erected adjacent to the stop line, as drivers do not expect to stop at the advance stop line location. Stop lines must be located not less than 3 m in advance of the approach holding line but preferably should be positioned approximately 20 m from the holding line. Queue detector setback distance on the controlling approach is usually in the range 50 to 120 m.

Various site-specific methods may also be used to meter traffic (e.g. using an existing upstream mid-block signalised crossing on the metered approach).

In some cases, it may be necessary to supplement the traffic signals with explanatory fixed or variable message signposting. Where sight restrictions exist, advance warning signals should be considered.

Figure 10.38: Roundabout metering signals



10.5.7 Metering Signals at Sign-controlled Intersections

The use of metering signals at intersections controlled by *give-way* or *stop* signs is an unusual application, and can only be applied where local traffic regulations permit. The system is similar in operation to roundabout metering signals (Section 10.5.6). However, it is only recommended for local urban collector roads where the posted speed limit is 60 km/h or below.

The objective of the system is to reduce excessive delays experienced by sign-controlled movements that have difficulty in finding adequate gaps in priority traffic streams. As an alternative to full signalisation, the metering signals are employed on a part-time basis at sites where they are required only during peak demand periods.

This arrangement consists of two-aspect yellow and red signals (Figure 10.6 (a)) for metering the major road traffic, and a queue detector for vehicles waiting on the sign-controlled approach. The sequence of aspect display is off to yellow to red to off.

When metering is not required, metering signals facing the major road traffic are in off state (blank display). When the queue detector on the approach subject to sign control detects vehicles waiting, the metering signals display yellow and then red. When the red display is terminated on the major road, the intersection reverts to normal operation. In one jurisdiction, two-aspect yellow and green displays are used on the sign-controlled approach. In this case, the display sequence is off to green to yellow to off.

A regulatory *stop here on red signal* sign is used at the major road stop line as in the case of roundabout metering signals.

10.5.8 Special Intersection Treatments

Seagull T-intersections

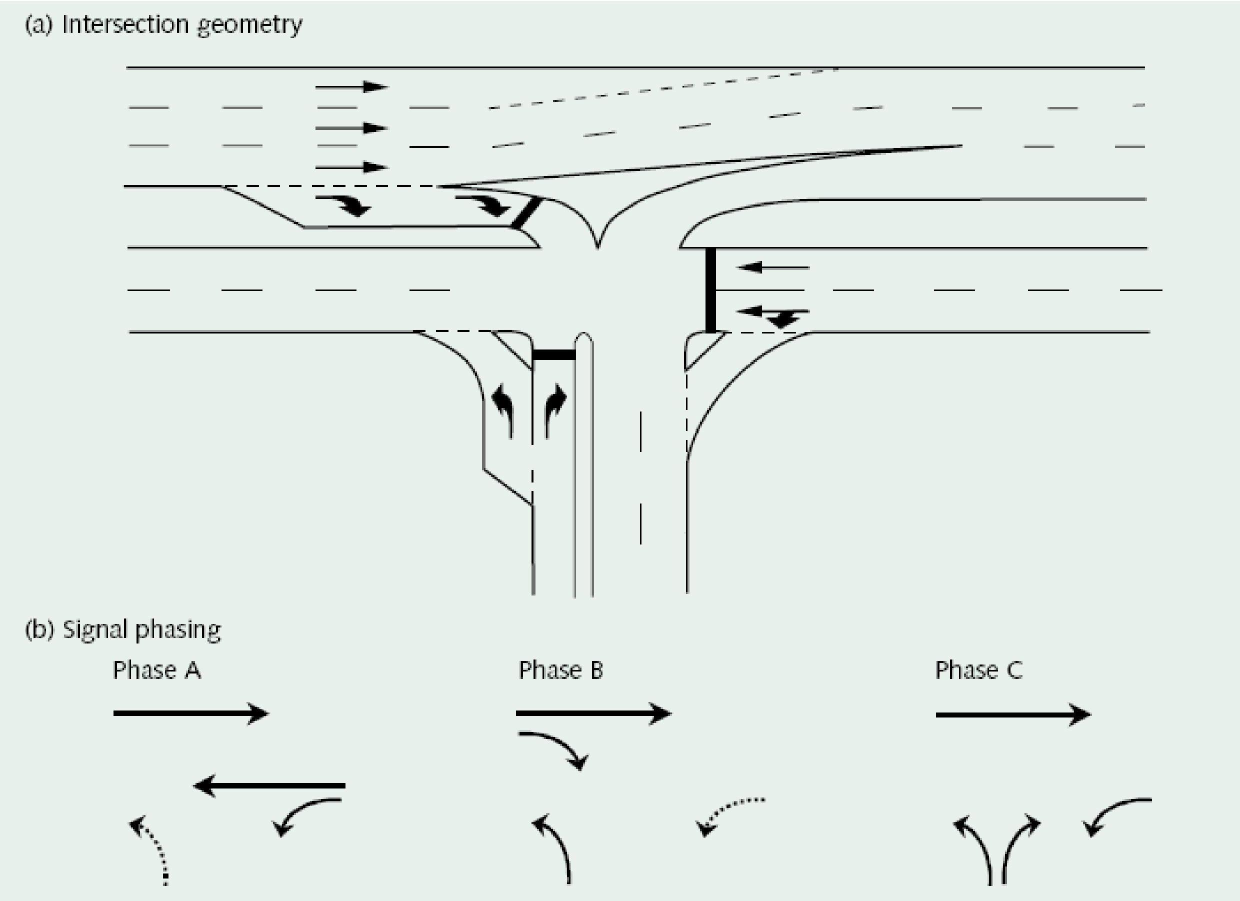
The purpose of a 'seagull' treatment of a signalised T-intersection is to avoid stopping through vehicles on the major road, approaching from the left of the T-intersection stem as shown in Figure 10.39 (a). This through movement is not signal controlled and operates continuously as shown in Figure 10.39 (b). However, this movement could be signalised in order to make provision for pedestrians crossing. When there is pedestrian demand, the through movement would be stopped when the side-road movement operates (e.g. in Phase C in Figure 10.39 (b)).

Generally, traffic signals should be installed on seagull intersections only where right-turn vehicles from the stem of the T-intersection do not have to merge with through traffic on the departure and weave across through traffic to turn left just beyond the signals. Any merging by these right-turn vehicles can result in rear-end collisions.

If traffic has to merge on the departure, the safest option is for through traffic in the left-most lane to merge to its right. This means providing right-turn vehicles from the stem of the T-intersection with their own lane or lanes on the departure as shown in Figure 10.39 (a).

A capacity and performance evaluation should be carried out to determine if the seagull operation is more efficient than other intersection design options. This should account for lane under-utilisation on the major approach road from the left of the T-intersection that is likely to be caused by this treatment.

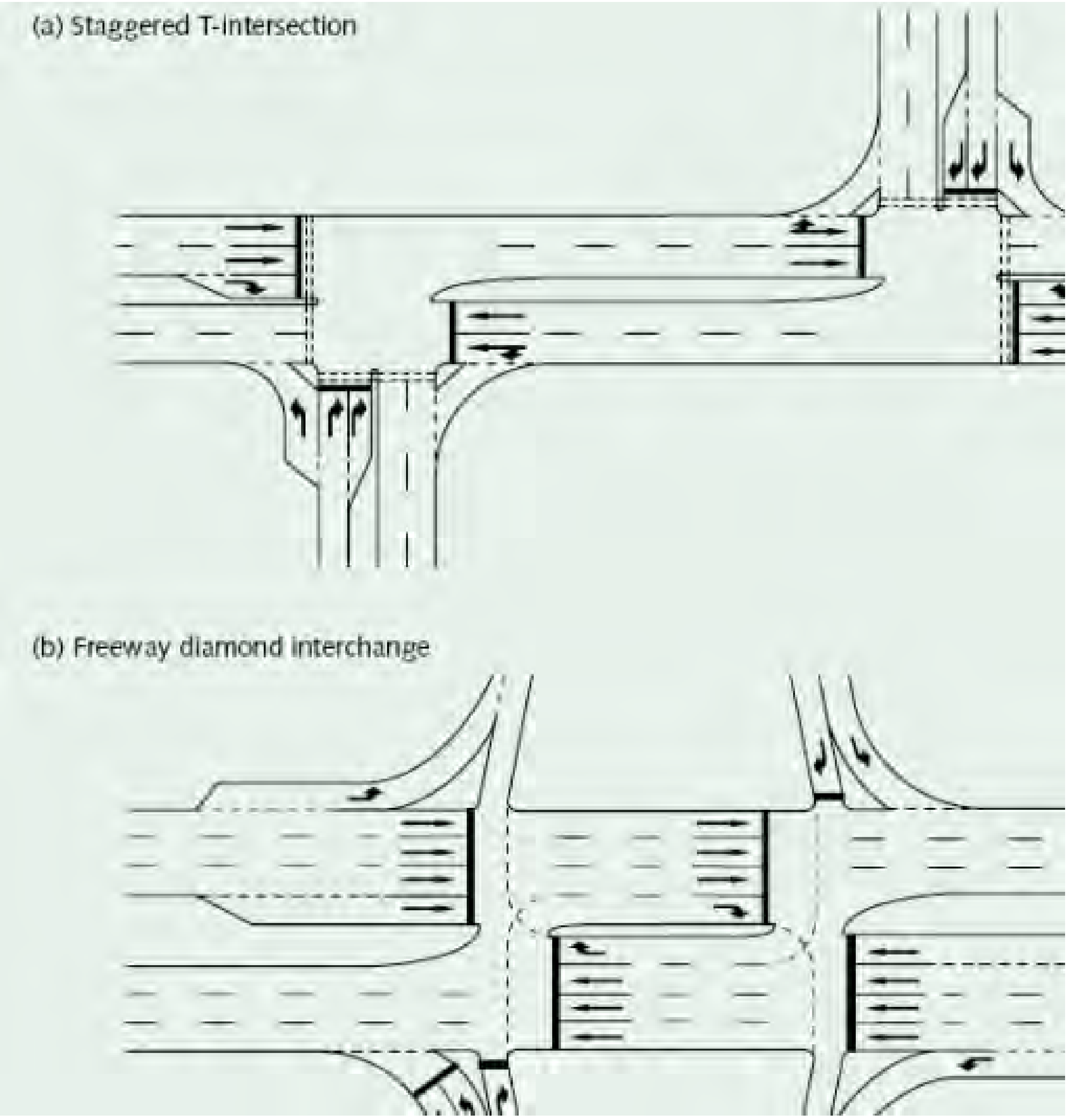
Figure 10.39:T-intersection geometry and signal phasing



10.5.9 Paired Intersections

‘Paired intersection’ is a term used for two closely spaced intersections with limited queuing space between the two intersections (internal approaches). Typical examples are staggered T-intersections and motorway diamond interchanges as shown in Figure 10.40 (a) and (b). Intersections with a wide median have similar characteristics.

Figure 10.40: Examples of staggered T-intersection and motorway diamond interchange



Paired intersections are regulated either by a single traffic signal controller using built-in offset arrangements achieved through special phasing arrangements, or by two separate signal controllers that are linked under a signal coordination system.

With paired intersections, care should be taken to avoid the potential 'see through' problem (i.e. downstream green signals being seen by motorists stopped at the upstream stop line).

Severe unequal lane utilisation may be observed due to heavy origin-destination flows in paired intersection systems (e.g. 'dog-leg' movements at staggered T-intersections). This should be taken into account in designing geometry and signal phasing for paired intersections.

Management of queuing in internal approaches of a paired intersection system is important to avoid blockage of upstream signals by through and turning vehicles queued in internal approach lanes. Early cut-off and early-start phasing arrangements, simultaneous offsets and shorter signal cycle times are useful methods for this purpose.

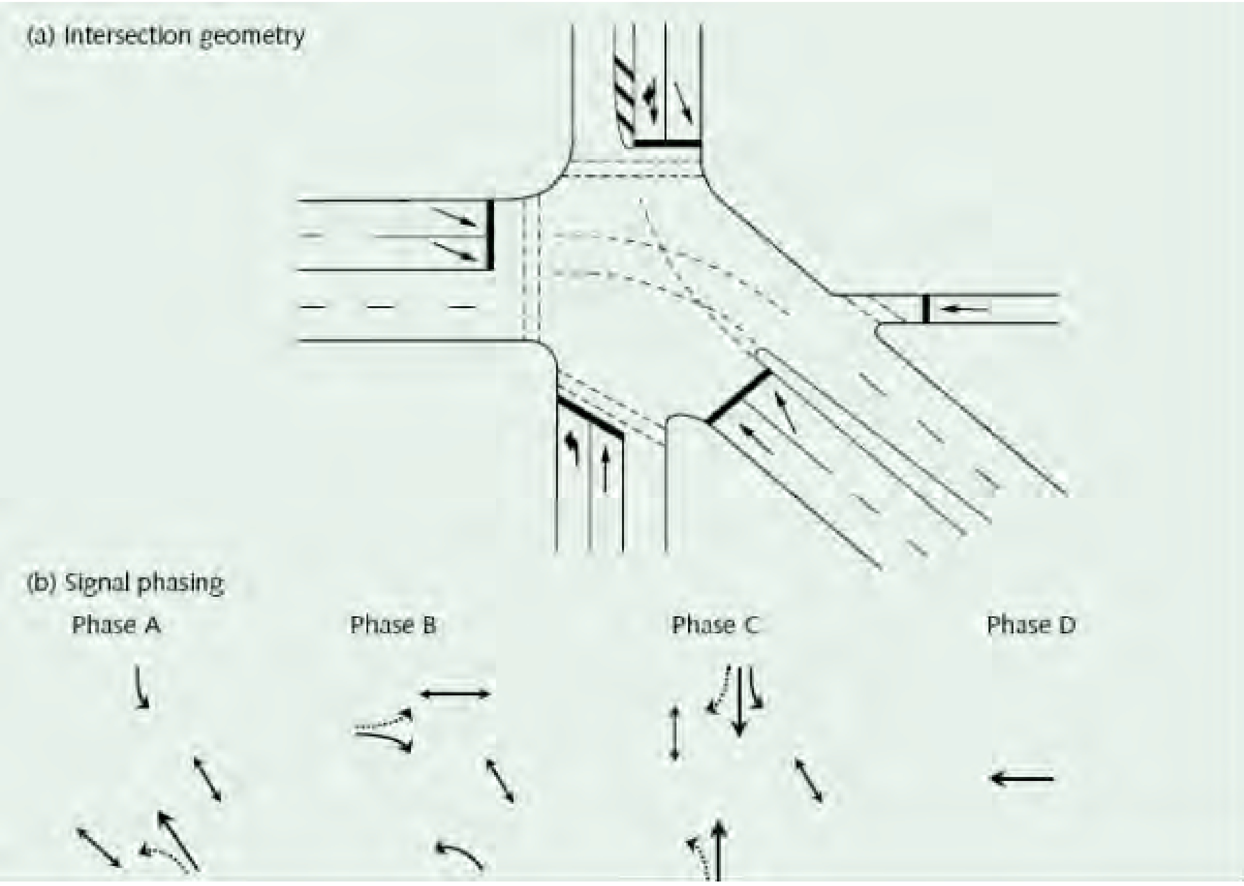
It is important to ensure that adequate queue storage spaces are provided for vehicles turning right from internal approaches to the motorway entry ramps.

10.5.10 Intersections with More than Four Legs

At intersections with more than four legs, potentially, there are more than four origin-destination movements from each approach road. The design of lane arrangements and signal phasings for such intersections is a significantly more complex task. Where allowed, U-turn movements will also need to be considered in the design (refer to AS 1742.14). Generally, these complex intersections would be treated on a site-specific basis.

An example of a five-way intersection geometry and phasing arrangement is shown in Figure 10.41.

Figure 10.41: Example of an intersection with more than four legs



The complexity of signal design for such intersections depends on the number of conflicting vehicle movements. The main aim is to minimise the number of phases as much as possible by eliminating some of the conflicting movements. This may mean banning some movements by using regulatory signs, introducing one-way approach and one-way exit conditions, or introducing partial or total road closure. Where movements are banned, alternative routes should be available and may need to be signposted as such. In Figure 10.41, the east leg is a one-way approach, and the right-turn movement from the west leg to the south leg is banned.

Pavement markings should reflect the physical direction of travel as appropriate as shown in Figure 10.41. This consideration also applies to three-way and four-way intersections where legs intersect at other than 90° angles (e.g. Y-junctions).

Signalised crossings may require special attention, depending on the vehicle movements permitted in the same phase, to ensure that there are no safety problems. The inclusion of signal-controlled bus, bicycle, or tram lanes can further complicate the signal phasing for this type of intersection. Where possible these special vehicles should be controlled by normal vehicular displays.

For intersections where legs intersect at other than 90° angles, care needs to be taken to avoid the potential see-through problem, by ensuring that the green signals on one leg are not seen by drivers on an adjacent leg.

10.5.11 Overhead Lane Control Signals

Overhead lane control signals may be used to control a reversible-flow lane as part of a peak-period tidal flow scheme, or to control lane usage at a toll station or a similar facility. When used to control the use of lanes in a managed motorway system (including controlling the speed of the lane and whether the lane is trafficable or not) the signals are referred to as lane use management system (LUMS) signs.

Table 10.5 outlines various overhead lane control signals that are used to control the traffic flow operation of the lane.

Where a lane control signal aspect display is not required to change since the traffic is always allowed to use the lane in the same direction, it may be replaced by a fixed sign, subject to various conditions, including:

- The lane arrow must be a downward pointing white arrow on a black background or black arrow on a white background.
- The lane cross must be red on a white background.
- The minimum signboard size must be 600 x 600 mm.
- On each set of signals across a roadway, signals over lanes immediately to the left or right of reversible lanes must be signal aspects and not sign alternatives.
- Sign alternatives must be as conspicuous as the signal displays. The white portion of the sign must comprise retroreflective material, and external illumination must be considered for this purpose.

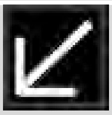
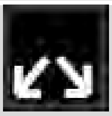
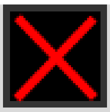
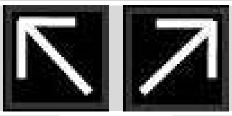
Further information on the use of lane control signals in motorway LUMS is given in Austroads (2020f). Figure 10.42 shows an example of LUMS in action, directing vehicles out of the left lane and then later closing the lane to traffic.

Figure 10.42: Example of LUMS in action

Upcoming lane closure. Merge right.

Lane closure.

Table 10.5: Signal face layouts with arrow and cross aspects for overhead lane controls

Symbol	Description
	Lane open and speed limit Used to indicate that a lane is open for traffic and to indicate the speed limit. While this treatment is primarily used on the open road, some jurisdictions are considering extending this practice to tunnel and reversible lane applications in order to maintain consistency with the use of overhead lane control in the jurisdiction.
	Lane open Used where the speed limit is designated through speed limit signage placed to the side of the carriageway. Primarily used for reversible lane and tunnel applications. Refer to the point above. A green downward arrow may be used instead of a white arrow in tunnel-only applications to indicate an open lane provided there is no visual conflict with arrows on intersection signals. It is noted that NZTA currently permits the use of green downward arrows to indicate that a lane is available, but may consider permitting the use of white downward arrows. NZ practitioners should refer to NZTA guidelines available at the time when considering their use.
	Merge left Used on the approach to a lane closure.
	Merge right Used on the approach to a lane closure.
	Merge left or right Used on the approach to a lane closure.
	Lane closed (steady) Used at the closed lane.[1]
	Exit lanes - As defined in AS 1742.14 [2] Used at designated exit lanes to indicate that drivers in that lane need to exit at the next exit ramp on the left or right.
	Exit lanes - As used in managed motorways throughout Australia [2] Used at designated exit lanes to indicate that drivers in that lane need to exit at the next exit ramp on the left or right.
	Designated right-turning lane Used to indicate that a driver may only use this lane to turn right and that right turns are permitted from both directions.

1 *A flashing red cross may be used in some jurisdictions on the approach to a lane closure to indicate that the lane ahead is closed and for drivers to leave the lane immediately. Where used, it should be supported by the jurisdiction's version of the Australian Road Rules.*

2 *The set used may depend on the capability of the lantern display.*

10.5.12 Single-lane Operation and Portable Signals

Single-lane operation

Single-lane operation by means of traffic signals may be applied:

- as a permanent arrangement at a single-lane bridge or other road constriction that is too narrow for two-way traffic (e.g. repair works that will continue for a long time), and where the combination of the length of single-lane section, traffic volume and inter-visibility between approaches does not permit the safe use of a *give-way* or *stop* sign control or alternatively an uncontrolled operation
- as a temporary arrangement using portable traffic signals or temporary fixed traffic signals at roadworks or bridgeworks where the above conditions apply.

For permanent and temporary fixed traffic signals, signal faces comprise a single column with three circle aspects. A primary signal face must be installed on each approach. Both secondary and tertiary signal faces are recommended for each approach in case of lamp failure. The minimum requirement is two signal faces for each approach. The secondary and tertiary signal faces are installed 6 to 10 m beyond the primary signal face. A regulatory sign *stop here on red signal* is erected adjacent to the stop line.

The general treatment for single-lane operation is to use two phases where one phase controls each direction of traffic. This requires very long intergreen times to allow one movement to clear the conflict area before the other movement can be started. This causes long delays that could lead to driver frustration. This cannot be avoided in heavy traffic situations, but delays can be reduced in low traffic situations by adding an all-red phase. The controller will normally wait in the all-red phase until one of the other two phases is demanded. That phase can then be introduced immediately with minimum delay to the motorist. The phase is extended and terminated as usual.

Where guard fence is used on the single-lane bridge approaches, it should be extended if necessary to protect the traffic signal posts and controller.

Portable signals

Portable traffic signals are intended primarily for short-term application of single-lane operation. If conditions are to continue unchanged for longer than two or three months, consideration should be given to the installation of temporary fixed, rather than portable, traffic signals. Decisions regarding this can be made on safety and economic grounds.

Portable traffic signals comprise a single column with three circle aspects, and are usually trailer mounted or in tripod format. One signal face is required to control each direction of travel. This is located at (or 6 m downstream of) the stop line or stopping position on each approach. A regulatory sign *stop here on red signal* is also erected adjacent to the stop line.

Requirements for the design, construction and performance of portable traffic signal systems are specified in AS 4191. Location and operation of portable traffic signals is described in AS 1742.3.

10.5.13 Left Turn on Red

In some jurisdictions a left turn on red (LTOR) movement is permitted under certain circumstances. In such cases a *left turn on red permitted after stopping* sign allows vehicles on the signed signalised intersection approach to turn left when facing a red circle display, subject to having first stopped at the stop line on that approach, then proceeding only if it is safe to do so. Location of the LTOR sign is discussed in Section 10.8.2.

LTOR may be used as a delay reduction measure, subject to any jurisdictional regulations and the criteria described in AS 1742.14 to ensure the safety of pedestrians, bicyclists and motorists. Due to concerns related to drivers not stopping before turning and to issues regarding the safety of pedestrians, some jurisdictions do not permit the use of LTOR while others may impose additional conditions and restrictions to those outlined in Section 7.5.1 of AS 1742.14. LTOR may be considered for use where the left-turn movement is controlled by circular aspects only.

In addition to the conditions for use specified in AS 1742.14, LTOR is not permitted on any approach where the movement would conflict with a bus or tram movement proceeding on a white display.

The vehicle detectors in the left lane where LTOR is used will need to be set up to ensure that a vehicle having turned from the lane during the red period does not unnecessarily initiate a phase change.

Slip lanes should not be provided with LTOR signs as other road rules apply to this situation.

10.6 Ramp Metering Signals

Ramp metering systems control the flow of traffic entering a motorway via access ramps in order to prevent the breakdown of flow on the motorway and hence preserve its ultimate capacity, and minimise delay and travel time. Ramp metering may also be applied to similar situations on ramps leading onto roads other than motorways. Metering signals may be used on a part-time basis.

Further details on ramp metering operations are given in Austroads (2020f).

Three-aspect red, yellow and green signals are used for ramp metering. The sequence of aspect display is as per a standard three-aspect traffic signal (a short cycle e.g. a few seconds depending on the magnitude of the metering as determined by the metering control algorithm) of red to green to yellow to red. When metering is not required all aspects are turned off.

A typical ramp metering signal layout for an entry ramp with two metered lanes is shown in Figure 10.43. It shows RC1 signs used to warn motorist on the approach to a ramp that ramp signals are present and currently in operation. The additional RC2 signs may be used in conjunction with a W3-3 signal warning sign where the sight distance is poor or where deemed appropriate. Typical entry freeway ramp signals for two lanes metered plus metered priority lane and for two lanes metered plus freeflow priority lane are shown in Figure 10.44 and Figure 10.45 respectively.

The signals are driven by a ramp metering controller that permits one vehicle to enter the motorway each time the green signal is displayed. In the case of ramps where traffic queues in two lanes at the metering signal, a 'dual release' system displays green signals to each queue simultaneously. Different acceleration rates of neighbouring vehicles enable the vehicles to progress along the acceleration lane at different rates.

Signal faces should be located to the side of the ramp and overhead. The distance from the associated stop line to the entrance ramp nose must be sufficient to allow a vehicle stopped at the signals to accelerate to motorway speed before merging with the traffic stream. Adequate provision for queuing at the signals should also be made, including provision for possible queuing back beyond the ramp.

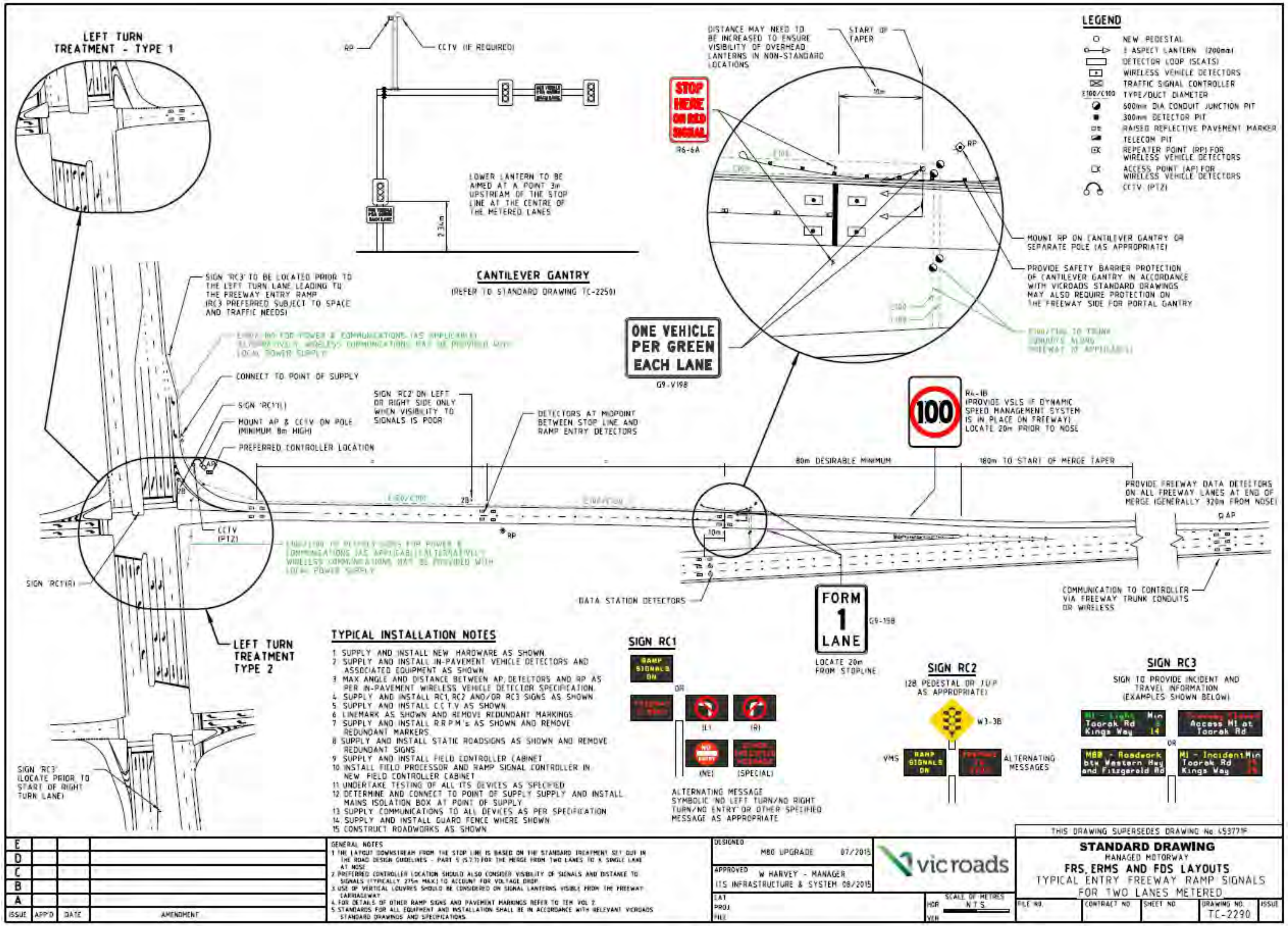
As shown in Figure 10.43 , the signals at the on-ramp should be accompanied by VMS which indicate that the ramp signals are on (ramp signals on message) and that drivers should be prepared to stop (prepare to stop message) when the ramp signals are operating.

Motorways that operate at or near capacity for significant periods of the day are suitable for the deployment of ramp metering systems. For motorist acceptance and compliance, the system must operate efficiently and not appear to unnecessarily delay ramp traffic.

Many ramp metering systems are operated in conjunction with motorway management systems7F6. In this case, ramp metering controllers are connected to a central computer that processes data from vehicle detectors on the motorway and ramps, and computes appropriate ramp flow rates.

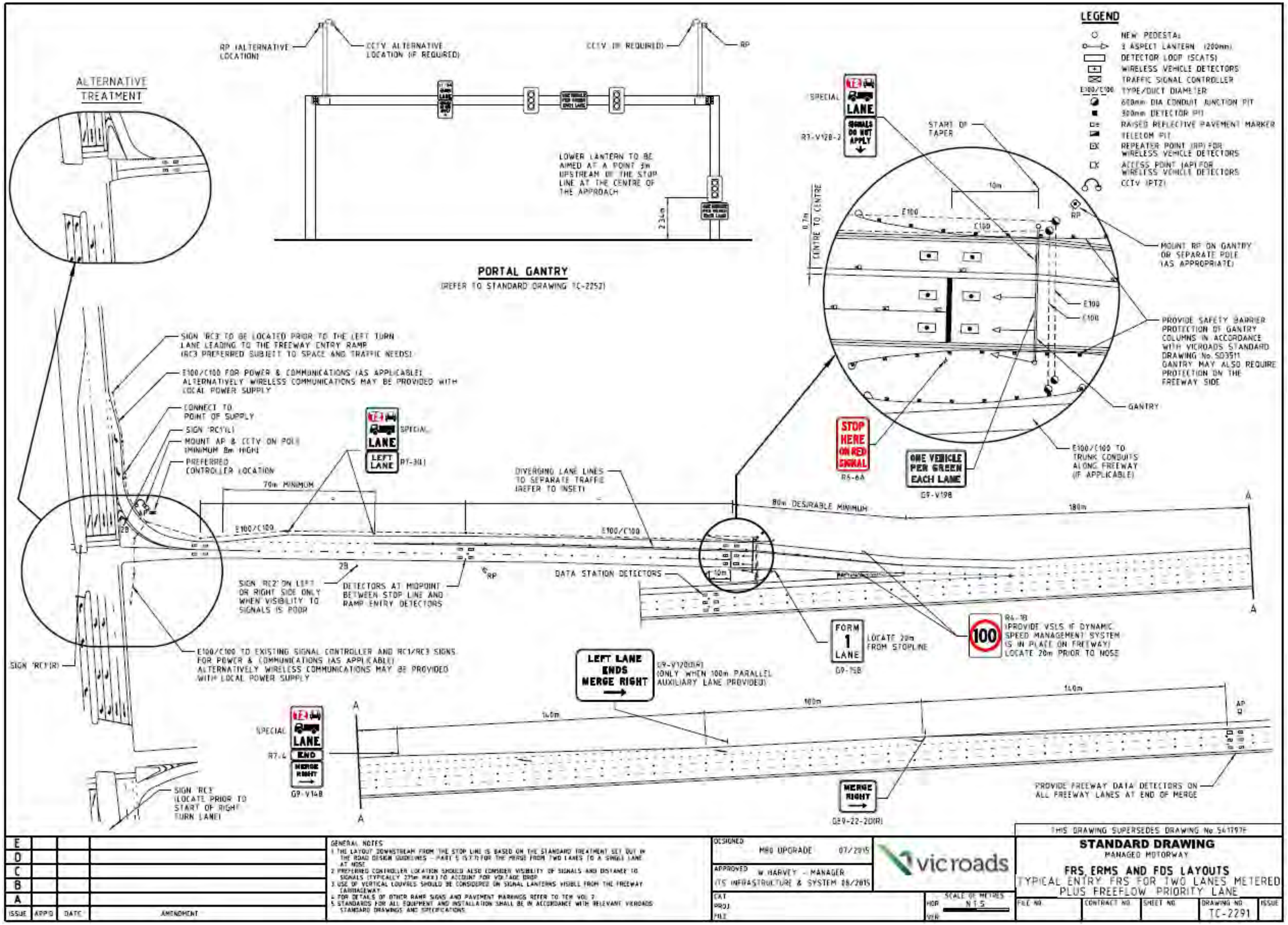
6 Other terms may be used by road agencies to refer to a motorway management system such as motorway control system, freeway management system or freeway control system.

Figure 10.43: Typical entry freeway ramp signals for two lanes metered



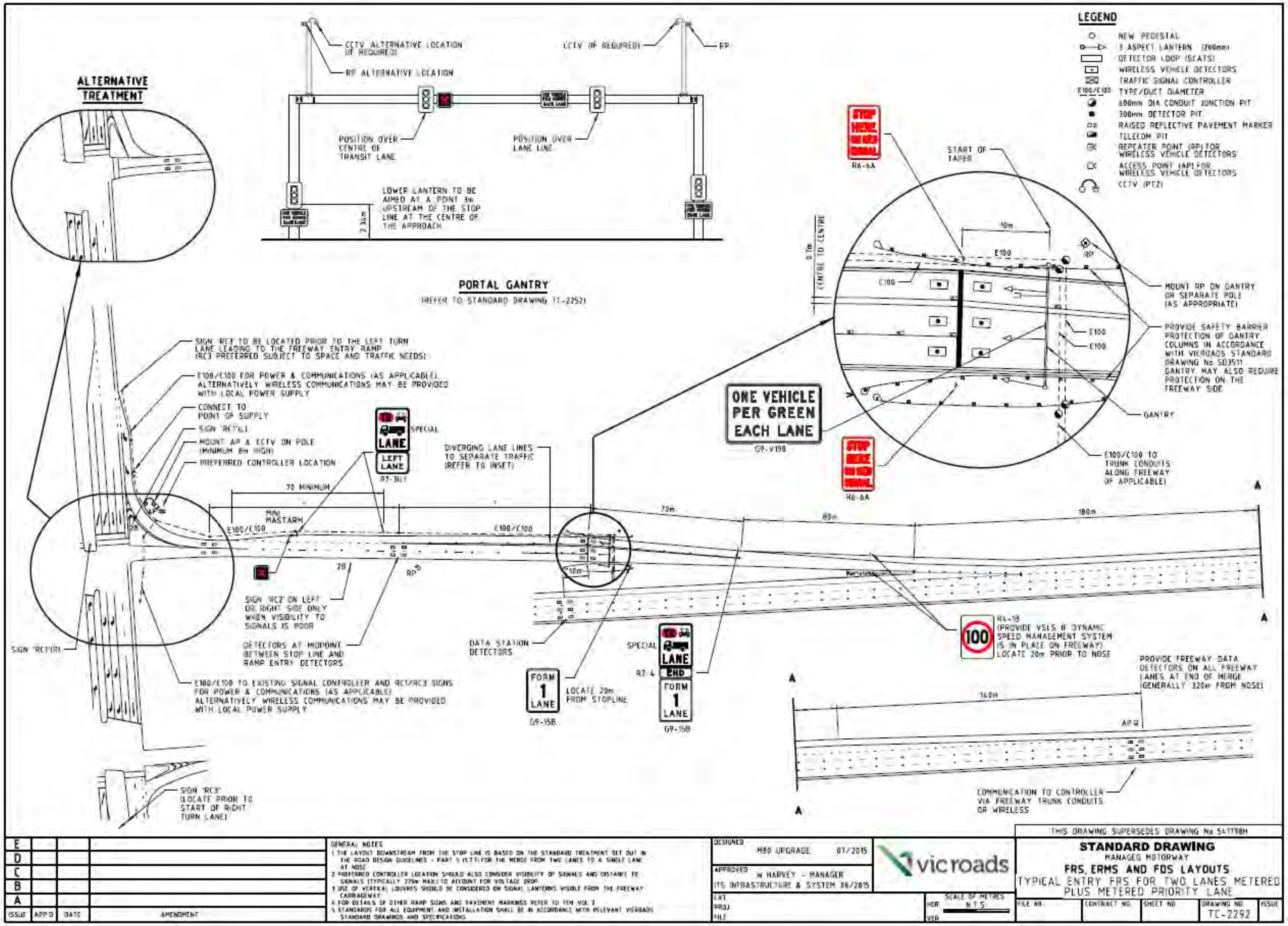
Source: VicRoads (personal communication 2016).

Figure 10.44: Typical entry freeway ramp signals for two lanes metered plus metered priority lane



Source: VicRoads (personal communication 2016).

Figure 10.45: Typical freeway ramp signal for two lanes metered plus freeflow priority lane



Source: VicRoads (personal communication 2016).

10.7 Pavement Markings at Signals

This section provides information on pavement markings used at signalised intersections. It contains additional and supplementary data to that contained in AS 1742.2, AS 1742.14 and Austroads (2020d). In New Zealand, reference should be made to *MOTSAM*[7] *Part 2*.

Pavement markings at traffic signals are often obscured by general traffic. Therefore, they must be properly maintained for the effective and safe operation of signals.

10.7.1 Longitudinal Lines

Dividing lines

Unbroken dividing lines are marked on the road to separate opposing traffic movements on the approaches to signalised intersections and mid-block signalised crossings on undivided roads.

An unbroken dividing line may be a single unbroken line or a parallel pair of unbroken lines. Both types of dividing lines prevent overtaking. A single unbroken line may be crossed to enter or leave the road, but a parallel pair of unbroken lines may not be crossed to enter or leave the road unless a local jurisdiction road rule permits.

Normally, dividing lines should be provided for a minimum of 30 m on the approach to the stop line. This length may be extended if road conditions on an intersection approach require it.

Lane lines

On the immediate approaches to traffic signals, the use of lane lines is essential where the approach width will accommodate two or more traffic streams. Lane lines are generally broken lines but must be unbroken where lane changing is to be prohibited on the approach.

Turn lines

Turn lines are used to provide guidance for two or more traffic streams turning in the same direction. Turn lines are not used for single turning movements unless in their absence, opposing right turns would be in danger of colliding, or the turning path to the departure is not obvious under all conditions.

Where opposing right-turn movements operate in the same phase, care must be taken with positioning turn lines so that sufficient swept width is provided for each vehicle and a sufficient gap is left between opposing turning traffic. The use of Austroads turning path templates can assist with positioning and determining the radii of turn lines (Austroads 2013). It is suggested that a gap of 1.2 to 2.0 m is provided between the overhang lines of the Austroads templates. At major urban intersections with double right-turn lanes from opposite directions, it is necessary to select the design vehicles for the turns (e.g. car and semi-trailer from both directions).

Turn lines should not be carried through pedestrian crosswalks.

10.7.2 Transverse Lines

Stop lines

Stop lines indicate to drivers the point behind which vehicles must stop when required (e.g. during the red interval). Where approach speeds are 80 km/h or above, lines 600 mm wide are preferred, elsewhere lines 450 mm wide are preferred, although 300 mm lines may be used.

7 It is noted that *MOTSAM* is progressively being replaced by the NZ *Traffic Control Devices Manual*.

In accordance with AS 1742.14, the stop lines should generally be located as follows:

- so as to minimise inter-green times and clearance times
- no less than 3 m from conflicting vehicle movements (or 4.4 m if a future pedestrian crosswalk is anticipated)
- adjacent to or not more than 3 m in advance of a primary signal post
- clear of the swept path of vehicles (especially articulated vehicles) turning from other approaches
- 1.2 m minimum from parallel pedestrian crosswalks at intersections (measured from the outside edge of the pedestrian crosswalk to the centre of the stop line)
- 6.0 m minimum from signalised mid-block pedestrian crossings (measured from the outside edge of the pedestrian crosswalk to the centre of the stop line)
- at a minimum of 6 m (desirable 10 m) in advance of the secondary or tertiary signal face for that approach
- at an angle of between 70° and 110° to the direction of travel.

Where bicycle head-start storage is provided, the location of the stop line should be in accordance with AS 1742.9.

Pedestrian crosswalk lines

The signalised crossing should be at least 2.4 m wide and delineated by two parallel 150 mm wide broken lines with 1 m line segments and 300 mm gaps.

The pedestrian crosswalk lines must be accompanied by a stop line of 450 mm width (preferred) located on the approach side of the road to the crosswalk lines and located at least 1.2 m in advance of the pedestrian crosswalk lines.

As outlined in AS 1742.14 this width may be increased by up to 10 m when there are heavy pedestrian volumes but consideration should be given to signal timings and time for vehicles to clear the width at the designated speed of the road environment. The line nearest the centre of the intersection should be not less than 0.6 m (desirably 1.0 m) clear of the cross-street kerbline projection. For scramble crossings (Section 10.8.2) the lines nearest the centre of the intersection are removed, and in some jurisdictions, diagonal lines connecting opposite corners of the controlled area are used.

Signalised crossings should generally follow the shortest route across the carriageway, or be angled at no more than 20° to the pedestrian's shortest route.

Pedestrian (zebra) crossings defined by parallel white stripes on the road surface and two *walking legs* signs are not used within the controlled area of signalised intersections. However, some jurisdictions use marked pedestrian crossings at unsignalised slip lanes at signalised intersections.

10.7.3 Painted Medians and Islands

Painted areas may be linemarked to prevent or permit vehicles to cross the area:

- A single broken outline will permit vehicles to cross the median or island to overtake vehicles, enter an abutting property, or enter the road from an abutting property.
- A single unbroken outline will prevent overtaking, but enable a vehicle to cross the median or island to enter a turn bay, enter an abutting property, or enter the road from an abutting property.
- Double unbroken outlines will prevent overtaking, turning to access an abutting property, entering the road from an abutting property, or crossing the painted area to enter a turn bay.

Traffic signal posts must not be placed in the painted areas, and should always be located behind raised kerbing.

10.7.4 Pavement Messages and Symbols

The use of pavement messages and symbols should be minimised in advance of signalised intersections. They may be hazardous if placed in the path of braking traffic. Where advance warning of signals is required, signs should be used in lieu of pavement messages.

The *keep clear* marking may be used at minor unsignalised intersections and access roads where entering or exiting traffic may be impeded by queues from a nearby signalised intersection.

Pavement arrows in a lane are provided to indicate the direction in which a driver is legally obliged to travel through the intersection from that lane. They should only be used where necessary so that skidding problems for motorcycles are minimised. They should not be used to indicate a turn where the turn is restricted during certain hours of the day.

10.7.5 Raised Pavement Markers

These devices may be used to augment painted lines at traffic signals where it is considered necessary to improve night or wet-weather visibility, or to indicate paths that would otherwise be confusing.

Reflective markers are often used on intersection approaches whereas non-reflective markers may be used to delineate lanes that change direction through the intersection (e.g. curves and misalignment between approach and departure lanes).

Raised pavement markers are discussed in greater detail in Section 8.7.

10.8 Signs Used with Traffic Signals

This section refers to traffic signs that are associated with traffic signal installations.

Unless otherwise specified in this section, all signs should be designed and located in accordance with AS 1742. Refer to AS 1742.1 for a general index of signs and AS 1742.2 for treatment at intersections. Sign numbers given in this section refer to those based on these standards. In New Zealand, reference should be made to *MOTSAM Part 1*.

10.8.1 General Requirements

Erection

At signalised intersections, signs must not be located where they obscure signal displays or limit the sight distance to conflicting or merging traffic. Sight distance is important in the event of signal failure.

To reduce the number of posts at a signalised intersection, it may be possible to mount small signs on signal posts provided the posts are suitably located and the signs do not interfere with signal operation or maintenance.

Periodic signs

It is often necessary to prohibit certain movements or classes of vehicles in order to maximise intersection throughput in peak traffic demand periods. At signalised intersections, this may be achieved by:

- the use of regulatory signs together with supplementary plates showing the times of operation; this type of prohibition applies regardless of traffic variations (e.g. 4.00 to 6.00 pm, Monday to Friday)
- the use of changeable message signs that are displayed only when the restriction applies; the display may be achieved by internal illumination or by mechanical rotation or shutters.

The restriction can be imposed as required in association with an area traffic control plan and in combination with a suitable signal display. The installation and maintenance costs are higher than fixed signs. Operational safety in the breakdown mode should be ensured.

Illuminated signs

Internally illuminated, fibre optic and LED signs are used at signalised intersections. These signs can comprise an illuminated white legend (e.g. *no right turn* on a black background), or a symbolic sign (e.g. a no right turn symbol).

Illuminated signs may apply continuously or at certain limited times during the day. They may flash continuously or for that part of the signal cycle when emphasis is required.

10.8.2 Signs at Signal Installations

Parking signs

Signs controlling or prohibiting parking or stopping are used extensively in the vicinity of signalised intersections in order to improve intersection capacity and to reinforce statutory no-stopping requirements associated with traffic signals (see R5 series signs in AS 1742.11).

Stop here on red signal/arrow signs

The *stop here on red signal* and *stop here on red arrow* signs (R6-6 and R6-14 shown in Figure 10.46) are not intended for routine use at signalised intersections. Uses are generally limited to the following:

- to define a stopping point which is different from the location of the primary signal, and where the stopping point cannot be adequately defined by a stop line
- in situations where traffic turning with a green signal is required to stop at a red signal in the cross street (e.g. internal approaches of staggered T-intersections) or within a wide median opening where right-turn traffic filtering through an opposing stream is not safe
- as a reinforcement in situations where signals might be unexpected such as at temporary signals.

Figure 10.46: Stop here on red signal (R6-6) and stop here on red arrow (R6-14) signs

Give-way to pedestrians sign

The give-way to pedestrians sign (R2-10 shown in Figure 10.47) is used at signalised intersections under the following circumstances:

- Turning vehicles are observed not to give way to pedestrians using a signalised crossing. This may occur with filter right-turn movements through a parallel pedestrian movement where the signalised crossing distance is long. In this case, the right-turn movement may become established before a pedestrian enters the conflict zone, particularly from the same side of the road that the right turn commences.
- Turning traffic experiences an unexpected conflict with a signalised pedestrian movement. This can occur where the signalised crossing is located a short distance down the street being entered. In this situation, turning-vehicle drivers may assume there is no crossing and may become unaware of pedestrians.

The sign should only be used in the above circumstances. Indiscriminate use would reduce the effectiveness of the sign and the traffic regulation that requires drivers to give way to pedestrians crossing the road that the drivers are entering.

Generally, this sign is erected on the same traffic signal posts as the signal faces which control the movement.

Internally illuminated or fibre optic *give-way to pedestrians* signs that are activated by pedestrian demand may be used for greater conspicuity.

Figure 10.47: Give-way to pedestrians (R2-10) sign

Pedestrian scramble-crossing sign

The *pedestrians may cross diagonally* (or pedestrian scramble-crossing) sign allows pedestrians to cross the road diagonally at signalised intersections where an exclusive pedestrian phase is used (sign R3-5 for use on the left hand side of the crossing is shown in Figure 10.48).

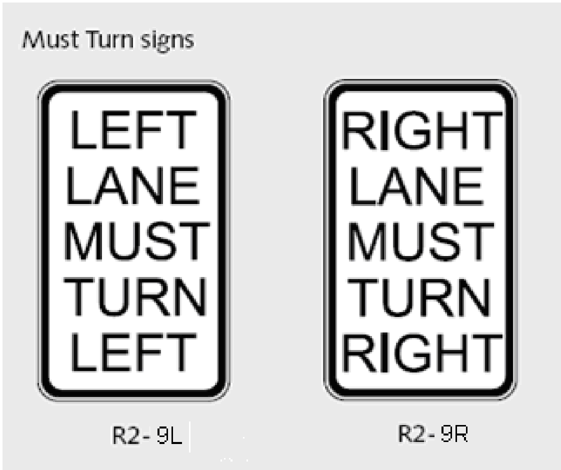
During the scramble-crossing phase, all pedestrian movements including diagonal movements operate simultaneously within the marked limits of the crossing. Scramble-crossing phases must operate full time. They should be installed only where there is demonstrated need for pedestrians to cross diagonally and there are delay reductions to vehicles and pedestrians.

Figure 10.48: Pedestrian scramble-crossing (R3-5) sign for use on the left hand side of the crossing

Signs to control turning movements

Signs to control turning movements consist of *turn ban* signs and *must turn* signs (Figure 10.49). These signs must always be consistent with signal arrow displays and/or pavement arrow markings. Generally, these signs are erected on the same traffic signal posts as the signal faces which control the movement.

Figure 10.49: Signs to control turning movements at signalised intersections

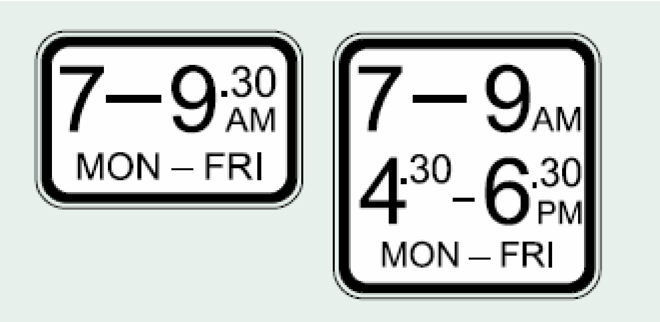


Turn ban signs

No left turn (R2-6L), *no right turn* (R2-6R), and *no turns* (R2-7) signs are used to ban turning movements.

Turn bans can be full-time or part-time (limiting their operation to certain times of day). For part-time turn bans, signs R2-6L and R2-6R are used with a time-of-operation supplementary plate (R9-1) showing the times the turn is banned as shown in Figure 10.50 .

Figure 10.50: Supplementary time-of-operation plates for part-time turn bans (R9-1)



No left turn or *no right turn* may be controlled by internally illuminated signs as an alternative to R2-6L and R2-6R signs.

Special vehicles may be excepted from the turn ban if necessary. Further supplementary plates for buses (R9-2), bicycles (R9-3) or authorised vehicles (R9-4) can be used for this purpose (Figure 10.51).

Figure 10.51: Supplementary plates excepting special vehicles from turn bans

Must turn signs

Left lane must turn left (R2-9L) and *right lane must turn right* (R2-9R) signs are used where a mid-block through lane becomes an exclusive turn lane at the intersection.

This lane arrangement practice should be discouraged and avoided if possible as it can lead to lane-change crashes.

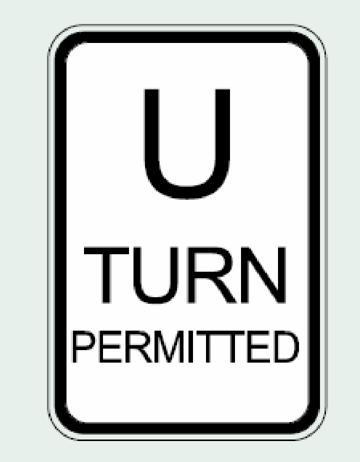
U-turn permitted sign

Some road jurisdictions' road rules prohibit U-turns at signalised intersections. Where prohibited signs must be erected to allow U-turns, where it is considered safe to do so. In these scenarios the *U-turn permitted* sign is used (Figure 10.52). As a general rule the sign should only be used on intersection approaches with medians and preferably with right-turn auxiliary lanes. U-turns should only be permitted where:

- geometry is sufficient to allow the U-turn to be made in one manoeuvre by vehicles of the type likely to make the turn
- there are no more than two opposing through lanes of traffic (may not apply where a fully controlled right-turn phase is provided)
- there is adequate visibility of approaching vehicles (may not apply where a fully controlled right-turn phase is provided)
- there would be no danger to pedestrians
- there is no left-turn green arrow control in the road to the right.

Supplementary plates such as *light vehicles only* can be used with the *U-turn permitted* sign in order to advise of site restrictions such as limited turning radii.

Figure 10.52: U-turn permitted (R2-15) sign

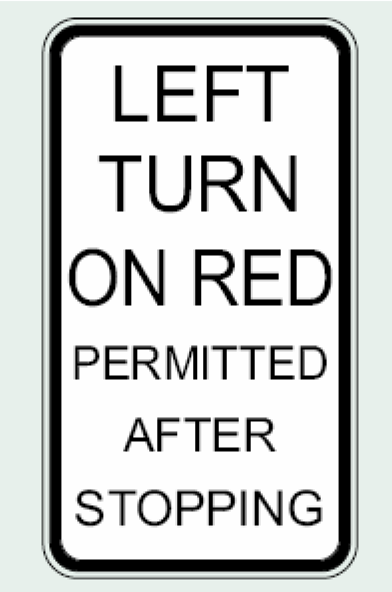


Left turn on red permitted after stopping sign

The left turn on red permitted after stopping sign (R2-20) is used to allow vehicles on any approach where this sign is displayed, to turn left through a red circle display after first stopping at the stop line, provided it is safe to do so (Figure 10.53). See Section 10.5.13 for more detailed advice on LTOR.

This sign is mounted below the primary signal face. A supplementary sign should also be mounted below the tertiary signal face if drivers have difficulty seeing the sign at the primary signal position when stopped at the stop line.

Figure 10.53: Left turn on red permitted after stopping (R2-20) sign

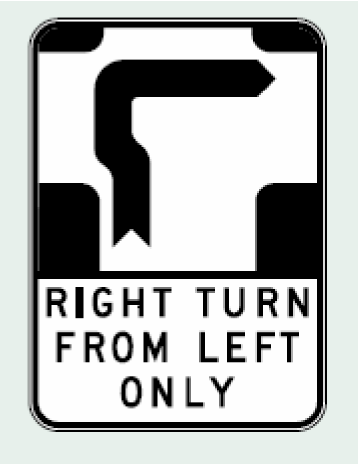


Hook turn sign

The *right turn from left only* sign (Figure 10.54) is used at an intersection controlled by traffic signals where right-turning drivers are required to make a hook turn. This manoeuvre consists of entering the intersection from the far-left side of the approach road, moving forward while keeping to the left of the intersection and clear of any vehicle crossing the intersection, waiting in that position until the traffic lights on the road to the right change to green, and then turning into that road.

This sign must be located in such a position that it is clearly seen by drivers approaching the intersection (e.g. overhead location).

Figure 10.54: Hook turn sign

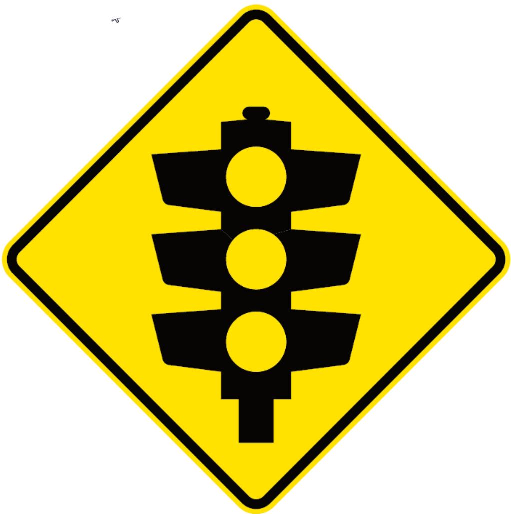


Warning signs

The symbolic *signals ahead* sign W3-3 (Figure 10.55) is required where:

- the sight distance to the signal stop line or to the back of the stationary queue at the signals is less than the stopping sight distance (e.g. 115 m for a speed of 80 km/h)
- the signals are located in an unexpected position (e.g. temporary signals in a rural area)
- high approach speeds may lead to frequent infringement of the signals or to crashes (especially when coupled with a large downhill grade).

Figure 10.55: Traffic signals ahead (W3-3) sign



This sign is usually used at the first set of signals encountered when approaching from a rural speed zone of 80 km/h or more. In some instances, duplication of the sign on the opposite side of the road may be warranted.

A *prepare to stop* supplementary plate W8-27 (Figure 10.35) should also be considered in order to reinforce the *signals ahead* sign. Under circumstances where this is considered to be inadequate, flashing yellow signals should be used to attract special attention to these signs (Figure 10.35). AS 1742.2 gives stopping sight distance values for various design speeds.

Other signs

Other signs used at signalised intersections include *form 1 lane* (G9-15), *form 2 lanes* (G9-16), *no hook turn by bicycles* (R2-22), and symbolic *walking legs* sign for marked pedestrian crossings on slip lanes (R3-1).

In addition, jurisdictions may use a sign or method to obscure some or all signal faces for each approach to a signalised intersection. This may be undertaken prior to the commissioning of a new set of signals. Different jurisdictions may use different methods and signs to obscure traffic signals, and practitioners should refer to jurisdictional guidance when considering approaches to obscure traffic signal faces.

11. Traffic Islands

The function of traffic islands, their classification and layout and geometric design including guidelines on usage, size, shape and other factors are described in Austroads (2020d). The use of traffic islands at roundabouts is covered in Austroads (2017b and 2020d). Detailed definitions are given Austroads (2015d).

Traffic islands are an integral component of geometric design. Their functions include traffic control and guidance, separation of conflicting traffic movements and segregation and / or refuge for vulnerable road users. Traffic islands are an essential element of safe roads and roadside under the Safe System.

Care needs to be exercised when designing traffic islands to ensure that they are not hazardous, particularly for motorcyclists and bicyclists. They must be clearly visible in all conditions, which means that they need to be delineated by appropriate signs and markings and/or be well illuminated.

The following guidance is limited to traffic islands created by the use of devices such as pavement markings, coloured or textured surface treatments and safety bars or rumble strips applied to the surface of the road.

It is important in designing traffic islands and medians to ensure that they are large enough to accommodate the number of pedestrians that might seek refuge on them during staged crossing of the road. They should also adequately cater for aged and disabled pedestrians.

An outer separator is a raised longitudinal island between a through-traffic carriageway and a service road that provides access to abutting properties. Its primary purpose is to separate through traffic from local traffic and other frontage activities, leading to a more efficient arterial road and safer access. It is important that the design of outer separator openings ensures that drivers leaving the main carriageway do not unduly interfere with following traffic flow, that they enter the service road at a safe speed, and that drivers entering the main carriageway from the service road have adequate sight distance. Flush or painted outer separators are not recommended, and should not be used with two-way service roads.

Medians separate traffic flowing in opposite directions. Islands may separate traffic flowing in the same direction or in opposite directions. Medians and islands can be raised, depressed or defined by markings or contrasting material on the pavement. It should be kept in mind that medians without barriers only provide partial protection against head-on collisions. Median barriers are recognised as a key component of Safe System compliant infrastructure, particularly on high speed roads.

Further information on the use of traffic islands, medians and outer separators in traffic management on arterial roads, including guidelines on width requirements to cater for various purposes, is given in Austroads (2020c).

11.1 Flush Medians and Islands

Medians defined in paint, contrasting surface material, or as a depressed design have the same degree of legal control as raised installations (i.e. they should not be crossed by traffic). Provided drivers do not cross a double line they may drive over a marked traffic island in order to enter a right-turn lane or to queue on the island. In New Zealand legal requirements related to painted medians are different from those in Australia. Practitioners should refer to the Australian Road Rules or New Zealand Land Transport Rules to understand the legal implications of medians, dividing strips and traffic islands.

Painted medians and islands do not have the same degree of physical control or conspicuity as raised installations, particularly when the surface is wet or under poor light conditions. Therefore, raised medians and islands are generally preferred.

Islands at intersections should be designed to suit turning paths of design vehicles and maintain continuity of the major road through the intersection.

There are many situations where it is desirable to provide some form of traffic channelisation at relatively low cost, without significantly affecting surface drainage, or without entirely prohibiting the possible encroachment into or traversing of these areas by vehicles. This may be achieved by the use of flush or painted median or island treatments. The interior may be either sealed with a contrasting coloured aggregate and/or consist of diagonal or chevron markings. Flush devices may be better defined by outlining areas of pavement with painted lines and raised pavement markers. These treatments may be used:

- where the resultant width between kerbs would be too narrow for a raised median
- on approaches to a raised or depressed median.

The treatments may also be used where an intersection is unlit. It is noted, however, that raised channelising islands at unlit rural intersections can operate satisfactorily provided there is appropriate delineation and offsets to the nose of the island, with a painted chevron on the approach. This may be preferable to large areas of flush island.

Minimum dimensions for painted medians and islands are provided in Austroads (2020d).

Typical uses of flush islands include:

- small islands in urban areas
- islands to shelter turn lanes
- channelising islands at rural intersections where operating speeds are high, or road lighting is absent or inadequate
- narrow medians
- narrow lane separators.

In general, the use of these islands anticipates occasional traversing by some vehicles. They should therefore be kept free of signs, poles or other road furniture items, except that in certain circumstances special-purpose light, fully flexible, delineating posts or cones may be used to increase the general visibility and delineation of the traffic island. This should only be done in well-lit low-speed areas.

Painted medians may be used as a road surface treatment aimed at addressing excessive vehicle speeds. Introducing a painted median may reduce instances of speeding through decreasing the available lane width for drivers to negotiate (particularly if the lane width is reduced below 3 m), while still allowing a recovery zone.

11.1.1 Pedestrians and Flushed Medians and Islands

Typical pedestrian behaviour is to use a direct route between two points, even at increased risk. Kerbed or raised medians can help reduce the risk for pedestrians as they provide a refuge area. Where flush medians and islands (or wide centreline treatments) are used in a location where pedestrians may cross, then refuge islands at intervals should be used to create adequate separation of traffic and refuge space for pedestrians.

11.1.2 Wide Centreline Treatments

Wide centrelines are a type of flush median treatment, also known as the narrow painted median strip treatment (Figure 11.1).

Figure 11.1: Wide centreline treatment example

Source: ARRB Group.

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.

A New Zealand study of 15 trial locations (MWH 2013) reached the following conclusions:

- The treatments decreased the injury crash rate, the fatal and serious crash rate, and the death and serious injury crash rate with the greatest reductions being in the death and serious injury crash rate which approximately halved.
- The treatments on highways with over 14 000 vpd provided large reductions (> 66%) in head-on injury crashes, although some sites also had audio-tactile linemarking (ATLM) installed. It was noted that sites without ATLM had little difference in the crash rate between pre and post-treatments. This suggests that ATLM should also be considered when installing wide centreline treatments particularly at large-volume sites.
- The treatments resulted in a reduction in run-off-road crashes with sites with ATLM showing the biggest reductions.

While wide centreline treatments with ATLM have proven safety benefits, they do not eliminate the risk of head-on crashes. Austroads (2016b) classifies wide centreline treatments as a supporting Safe System treatment for head-on crashes with compatibility with future implementation of Safe System options, rather than a primary treatment.

Wide centreline treatments could be considered for use on high-speed roads (i.e. > 90 km/h) as well as other 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, such as wire rope barrier or adding an additional lane are not practical or cost-effective. Unlike the provision of a physical obstruction, such as a wire rope barrier (as shown in Figure 11.2), wide centrelines may be designed to permit drivers to cross into the opposing travel lane to perform overtaking manoeuvres, through the use of broken, wide centreline markings. 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:

- Incident history and crash risk: The treatment should be used where there is a high risk of head-on or run-off-road type incidents 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 may require additional protection.
- Services: With the widening of the road, there may be a need to relocate services.

Practitioners should refer to the *Guide to Road Design Part 3: Geometric Design* (Austroads 2016c) and to jurisdiction guidance on the use of the application.

Figure 11.2: Wide centreline treatment with wire rope barrier installed

11.2 Flush Islands with Pavement Bars

An alternative to raised traffic islands may be developed using applied bars or closely spaced raised pavement markers within a flush island. Pavement bars are raised blocks that may be used to augment painted islands and painted median strips to discourage but not prohibit traffic movements across them. These devices should only be used where the island is defined with painted or other applied surface markings (thermoplastic or other long-life pavement marking materials).

Islands with pavement bars may be applied to the surface of normal road pavement at relatively low cost and have little or no effect on surface drainage. They provide somewhat better visibility to motorists than do pavement markings alone, particularly in wet conditions and, where raised pavement bars are used, the jolting effect is a significant deterrent to vehicle encroachment.

The size and shape of pavement bars need to be carefully designed so that they do not cause a hazard to motorcyclists and bicyclists. Typically, the height should not be greater than 30 mm and they should be spaced at a distance greater than the normal wheelbase of motorcycles (approximately 2.0 m). The bars are usually fixed to the surface of the road with adhesive and may be painted with white or yellow reflective paint. They should only be used on straight road sections, never on curves because of the hazard they may pose to motorcyclists.

Where motorcycle and bicycle traffic is significant, or where serious vehicle encroachment over a flush or painted traffic island is a persistent problem, it may be preferable to use close-spaced raised pavement markers or to install a conventional kerbed raised-island treatment.

Commercially manufactured low profile pavement bars are currently available in yellow or white plastic.

The use of bars in islands may be an advantage:

- as an approach treatment to a median and/or other central obstruction
- in place of a narrow median
- where raised islands cannot be accommodated due to limited road width
- where because of the absence of street lighting or restricted pavement width, raised islands are undesirable and painted islands are not considered effective
- to form islands that over-dimensional vehicles can traverse.

Some typical arrangements are illustrated in AS 1742.2. Pavement bars should not be installed as a centreline treatment on two-way carriageways less than 6.8 m in width. Installations of the bars should be outlined with pavement markings. If the installation is in the form of a median separating opposing directions of traffic, the outline markings may consist of barrier lines.

11.3 Moveable Medians, Islands and Barriers

Medians and islands that can be moved remotely from a traffic management centre have been used in some circumstances by jurisdictions. They are installed where a particular area of pavement has to be used by different traffic streams at different times of the day, and it is imperative to physically separate the streams. Figure 11.3 shows an example of an island that is anchored at one end and is moved by an electro-mechanical system so that the island nose can be shifted laterally by a lane width.

These islands may also be provided in other situations, such as medians, where the median lane provided for traffic from one direction is dedicated to through or turning traffic from the other direction at certain times of the day.

Moveable medians and islands (i.e. by remote control) are particularly suitable for high traffic volume situations where it would be disruptive and potentially hazardous for employees if a physical barrier had to be placed manually.

Figure 11.3: Island that can be moved remotely from a traffic management centre

Movable lane barriers provide a physical barrier and protection where reversal of traffic flow in one or more lanes is implemented to cater for peak traffic demands (tidal flow). They are usually provided at the ends of the treatment where there is a higher probability of head-on crashes. This system provides physical separation and reduces the severity of crashes experienced by other reversible-lane methods (such as overhead lane signals) in collisions between vehicles travelling in opposite directions.

On high-speed facilities, tidal flow may be managed by the use of a moveable safety barrier, such as the system adopted for the Auckland Harbour Bridge. Concrete barriers are used to provide a relatively solid barrier. A specially designed vehicle is used to transfer sections of the barrier to cater for traffic demands. Deflection of the barrier upon impact is minimised and can be quickly reinstated by the transfer vehicle.

12. Communication Devices

12.1 General

Guidance on traveller information systems commonly used in Australia and New Zealand is provided in Austroads (2020f). It focuses particularly on systems directed at the provision of information to road users as part of the traffic operation functions of road agencies. The general purpose in providing road user information is to influence traveller activities in one or more of the following ways, aimed at more efficient and safer use of the road network:

- transport mode choice
- route choice
- time-of-travel choice
- driving behaviour

Communication devices in the context of traffic control and management may be defined as those that convey information or guidance directly to road users while they are actively involved in traffic. Their primary purpose is to influence road user behaviour in order to improve traffic efficiency and safety.

In addition to the basic devices of signs, signals, markings and delineators, communications which may be considered under this definition include audio messages by radio and mobile phone, and digital transmissions via mobile phone, internet and global positioning technologies. In addition, there is a variety of emerging driver assistance technologies that have potential to deliver much safer vehicles. For applications that require a response by drivers, it is vital that the human-machine interface is well designed to maximise effectiveness and ensure that drivers are not overloaded or distracted.

Individual driver behaviours can impact on the efficient and safe operation of a road. For example, driver decisions relating to the choice of traffic lane, the frequency of lane changing, merging, and travel speed can potentially affect route capacity and safety. Provision of additional information and guidance directly to drivers about the following matters can assist in managing the traffic stream:

- lane availability ahead (because of incidents, roadworks or congestion)
- advisory or optimum travel speeds
- likely delays
- suggested alternative routes

As discussed in this chapter ITS technologies and applications are constantly changing. The NIA Framework (NIAF) associated with the NIA provides a consistent approach to accommodating these changes and will maximise interoperability between the existing and emerging ITS technologies and applications.

The primary focus of the NIAF approach (and hence NIA) is to help transport designers and operators understand the operational requirements and information flows that will help inform the selection and use of ITS technologies and applications, particularly as cooperative and autonomous systems begin to proliferate.

Effective communication with road users, regardless of the delivery method, will ensure that response times are minimised, behaviours are appropriate and road user safety (a key pillar of the Safe System) is enhanced. To achieve this, information must be delivered in a way that is:

- clear and concise
- lacks complexity
- does not detract from critical driving tasks
- timely.

12.2 Technologies and Applications

Substantial advances have been made in traffic control and management through developments in radio, internet, mobile phone, and global positioning system (GPS) technologies. Applications include but are not limited to the following areas:

- traffic surveillance
- network management and operations
- traveller information systems (external or in-vehicle)
- incident management
- vehicle-to-vehicle communication systems
- vehicle-road infrastructure interaction
- work zone traffic management
- fleet management

These technologies may be adapted to provide information and guidance to road users to encourage appropriate responses for improved traffic efficiency and safety.

Information on route and traffic conditions can be communicated to motorists en-route via devices including static road signs, travel-time signs and variable message signs. When conditions change as a result of incidents, unplanned events or abnormal congestion then additional dynamic, prescriptive and predictive information is required.

Current technologies allow such information to be conveyed via:

- in-vehicle audio systems such as radio broadcasts, hands-free mobile phones or automated annunciation systems (for public transport)
- in-vehicle audio/graphic systems such as navigation aids based on GPS technology
- personal devices such as portable digital assistants (PDAs), pagers, mobile phones (for pedestrians as well as drivers)

Information may be presented to motorists within a specific radius, or in particular locations such as tunnels. The information can be sourced in part from automated systems monitoring traffic, road and weather conditions.

Further details of such information and communication systems, and their use in traffic network operations, is given in Austroads (2020f).

12.2.1 Radio Rebroadcast and CB Radio Break-in

Radio rebroadcast and CB radio break-in technology can be used to communicate audible messages over the vehicle's own radio or CB radio.

As both technologies involve the use of radio communications, Australian practitioners should consult the Australian Communication Media Authority (ACMA) and New Zealand practitioners should consult the Radio Spectrum Management (RSM) with respect to conditions of their use. In particular there may be specific conditions for the use of radio rebroadcast which involves the transmission of information over a frequency where the person transmitting was not the approved licence holder of the frequency.

General information about the use of both technologies is provided.

Radio rebroadcast

Radio rebroadcast technology may be used where messages may need to be conveyed to all vehicles within the transmission area that have their radios turned on. The technology is able to override the normal radio broadcast and relay a traffic-related message to the driver. Most applications of radio rebroadcast technology are to communicate safety messages about the use of road tunnels (e.g. messages associated with a change in traffic operation such as a reduced speed limit). Guidance on its use is provided in the *Guide to Road Tunnels Part 2: Planning, Design and Commissioning* (Austroads 2019b) and the *Guide to Road Tunnels Part 3: Operation and Maintenance* (Austroads 2018). While prepared in the context of road tunnels, the guidance outlined in Austroads (2018 and 2019b) is also applicable to non-tunnel applications.

In addition to the guidance provided in Austroads (2018 and 2015c), radio rebroadcasts with customised traffic-related messages are only suitable for applications where potentially all vehicles need to hear the message, as the message will be broadcast on all radios within the transmission area. For this reason, use of the technology needs to be carefully considered as road agencies would want to avoid backlash from drivers who may not need to hear the message or from users of radios not used in the road environment but still within the transmission area. Use is generally limited to tunnels and to the broadcasting of safety-related message as the receivers of the message can be controlled and the content of the message is relevant.

CB radio break-in

CB radio break-in can be used to broadcast pre-recorded alert messages over UHF-CB radio. As heavy vehicles are the main users of CB radio on roads, use of the technology is generally limited to applications targeting heavy vehicles. The broadcast can be undertaken on any one or multiple channels but in Australia broadcasts are generally undertaken on the channels used for trucking (i.e. 29 or 40). Applications could be for general alerts to trucks about roadworks and the need for trucks to adhere to roadwork traffic controls (i.e. speed, stop/go etc.), however use could also extend to over-height warnings and/or railway level crossings depending on the trigger. For example, for over-height warnings the trigger would be to detect the truck and whether it is over height; for level crossings the trigger would be to detect an approaching truck and when the level crossing becomes active, or to detect when a train is present. Obviously the messages are only broadcast in the cabin of the truck when the CB radio is on and tuned to the correct channel. It should be treated as a support tool to standard signage and/or communication devices. Further, any CB radio within range of the transmission will broadcast the message into the cabin of the truck, so care should be taken with the content and the aerial and power used in order to limit the transmission range.

12.2.2 Emerging Technologies

Various in-vehicle technologies are emerging that may potentially impact on how drivers and more specifically vehicles equipped with the emerging technology receive information. This can include connected technologies such as cooperative intelligent transport systems (C-ITS) which will enable real-time information to be exchanged between vehicles (V2V), between vehicles and roadside infrastructure (V2I) and between roadside infrastructure and vehicles (I2V). The information will pertain to the road environment and may enable benefits to be achieved from both a road user’s and road operator’s perspective. The various benefits can be categorised into safety, productivity and environmental benefits.

When implementing new traffic control devices, particularly electronic devices such as VMS and traffic signals, consideration should be given to how these technologies will need to be interoperable with emerging connected technologies such as C-ITS. This includes how the emerging technology will be interoperable with the electronic device at the following four levels:

1. Technical level: This includes the hardware/software of systems and platforms that enable machine-to-machine communication to take place (i.e. the technical ability to wirelessly connect).
2. Syntactical level: This addresses the agreed data formats of communication so that the machine-to-machine communication can be processed and understood by each machine.
3. Semantic level: This refers to the meaning and interpretation of the content of the communication being exchanged. Without this interoperability, messages communicated between machines may be misunderstood and therefore the machine may not be able to use the message to achieve the objective of it being sent.
4. Organisational level: This encompasses the ability of an organisation to exchange data across systems, which will require a level of consistency in business processes (and architecture). Success will be dependent on the level of technical, syntactical and semantic interoperability achieved.

Austroads (2014b) discusses how interoperability can be achieved between C-ITS and ESL, traffic signals and traveller information systems (including VMS). Practitioners should refer to this source when installing these devices.

In addition to technologies such as C-ITS, vehicle technologies are also emerging that obtain information by reading the road and roadside infrastructure and consideration needs to be given to how these technologies will be able to read signs and linemarking when they emerge. There is a need for traffic control devices to be implemented where possible in a standardised manner with international practice to enable the emerging technologies that may be developed internationally to be activated and function locally.

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Appendix A Route Planning and Directional and Wayfinding Signage for Bicyclists

A.1 Introduction

The active transport and recreational needs of communities are efficiently served by the development of regional and local networks of interconnected cycling routes linking major trip origins to destinations. The planning of these networks is undertaken by government agencies and local governments as part of regional and municipal bike plans.

Directional signs provide wayfinding and informational guidance for bicyclists across these cycle networks. These guidelines deal only with directional signs for cycling routes (both on- and off-road) within a cycling network. They do not cover the many other aspects of cycling network signs and markings, such as regulatory and warning signs, linemarking, regulatory pavement symbols and behaviour signs for which there are separate guidelines (Table A 1).

Table A 1: Reference documents for cycle network signs

Contents	References
Regulatory, warning, advisory and directional signs. Linemarking and pavement symbols	Australian Standard AS 1742.9 Manual of Uniform Traffic Control Devices Part 9: Bicycle Facilities NZ Traffic Control Devices Manual Part 2: Direction, Service and General Guidance Signs (NZ Transport Agency 2011)
Design, layout and dimensioning of individual directional signs	Australian Standard AS 1743 Road Signs: Specifications
Detailed directional sign planning, installation guidance and resources	Austroads *Bicycle Wayfinding* Publication No. AP-R492-15, Austroads (2015a) Queensland Transport and Main Roads, *A Guide to Signing Cycle Networks* Department of Transport and Main Roads (2009) (available for download from the TMR website: www.tmr.qld.gov.au) Main Roads Western Australia guidance on *Bicycle Direction Signs* (Main Roads Western Australia 2007–16) outlined in three parts: • Part A: Policy Statement • Part B: Application and Approval Guidelines • Part C: Technical Guidelines

These guidelines are designed to assist road designers, engineers and transport planners to provide high quality, professional and consistent directional signs for cycle networks across Australian and New Zealand cities and towns. Directional signs enable riders to use cycle networks to their full potential and make quick and accurate route choices.

The guidelines provide guidance and advice on the following issues:

- planning a directional sign system (focal point mapping, destination and decision points)
- route hierarchy and the types of signs appropriate for each type of route in the cycle network
- facility naming, route numbering and route branding
- location and mounting of signs
- special sign situations such as marked detour routes, tourist destinations and routes through complex intersections.

The purpose of the signs is to provide wayfinding and directional assistance for bicyclists using routes which comprise a wide range of facilities, some of which may be shared with motorists or pedestrians. Directional signs have no regulatory purpose or intent and do not imply an exclusive use by bicyclists of paths shared with pedestrians or streets shared with drivers. In practice, care should always be taken to ensure that directional signs are fully supported by regulatory signs relevant to the street/path facilities that comprise the cycle route.

In the interests of uniformity, local governments and private sector large-scale landowners are encouraged to apply these guidelines when installing directional signs for cycling route facilities on streets, roads and paths under their control. To assist cycle network providers with the implementation of the guidelines, the Queensland Transport and Main Roads resource manual, *A Guide to Signing Cycle Networks* (Department of Transport and Main Roads 2009), is recommended. This publication contains additional information and advice on the practical aspects and processes involved in the installation of cycle network directional sign systems.

A.1.1 Application of the Guidelines

The guidelines are intended to supplement guidance on directional signs for cycling networks described in Section 5 of Australian Standard AS 1742 *Part 9: Bicycle Facilities*, Australian Standard AS 1743 *Road Signs: Specifications* and the *NZ Traffic Control Devices Manual Part 2: Direction, Service and General Guide Signs* (TCDM-2) (NZ Transport Agency 2011). The guidelines replace directional sign guidance previously provided in Austroads Guides and are intended to provide uniform guidance for Australian and New Zealand jurisdictions. In each jurisdiction, additional guideline supplements may apply and practitioners should consult them to determine the most appropriate sign implementation.

A.1.2 Signing Routes with and without Cycle Infrastructure

Cyclists are legally defined as vehicles and can use public roads unless specifically prohibited for operational safety reasons (e.g. urban motorways). The lack of cycling infrastructure along a route, such as cycle-lane markings, regulatory and warning signs and bicycle pavement symbols, does not necessarily mean that the route is unsuitable for cycling.

It is noted that bicyclists have differing levels of competency and sensitivity to traffic. Experienced bicyclists will often prefer unmarked, wide, kerb-side traffic lanes to marked cycling/car parking lanes due to their close proximity to opening car doors. Others (such as children, new adult riders and the elderly) may prefer to avoid trafficked roads altogether and ride off-road.

Fitting a route with a system of directional signs provides all bicyclists with important wayfinding information which helps them to more effectively use their bicycles for a wide range of local and regional trips. Without these signs it is difficult for them to take full advantage of the road system and to use their bicycles as an efficient means of transport.

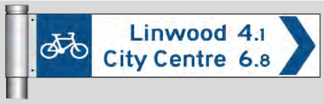
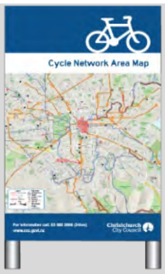
On routes where off-road cycling facilities are provided, the needs of on-road bicyclists are always considered. This may often mean the installation of additional signs at junctions or turning points to address the separate cycling travel paths of each group.

A.2 Sign Designs

There are eight types of cycle directional signs and a set of directional pavement indicators used on cycle networks. Each route type has its own family of signs consisting of some or all of these sign types. Pavement markings can be used on all route types for wayfinding guidance.

The various types of bicycle wayfinding signs as detailed in Austroads (2015a) are outlined in Table A 2. Included is the type, description and example of each of these sign types.

Table A 2: Bicycle wayfinding sign types

Bicycle wayfinding sign type	Description	Example
Fingerboards	Fingerboards are double-sided direction signs used at intersections and route turnings to show the way to destinations further along the route. When fingerboards are located at junctions with other routes they also show distances to the destinations shown on the sign. Fingerboards are used to mark all route types.	
Direction indication signs	Direction indication signs are used in place of fingerboards where that type of sign cannot be used due to siting/mounting or legibility issues. Direction indication signs can show destinations only (at turning points) or destinations and distances (at junctions with other routes). Direction indication signs are used on veloways and primary routes.	
Advance direction signs	Advance direction signs are used to indicate the destination choices in advance of a route junction. They are used on veloways and primary routes at junctions with other veloways or primary routes. They can be used on veloways or primary routes at junctions with local or tourist/recreational routes if those routes are of importance and connect to a major trip attractor relevant to cycle traffic on the primary route.	
Reassurance direction signs	Reassurance direction signs are used following route junctions on veloways and important primary routes to reassure bicyclists that they are following the correct route. These signs also indicate the distances to multiple destinations on the route being followed. They are usually only used on high-speed, limited-access veloways but can be used on important primary routes if reassurance is needed due to complex navigational situations.	
Location signs	Location signs are used at underpasses or bridges over a cycle route to identify cross streets/roads which are not otherwise signed due to the remoteness of the site. Location signs can be used on all types of route.	
Facilities/services signs	Facilities/services signs are simple one-line fingerboards used to indicate nearby facilities and services easily accessible from a route. These signs can be used on all types of route.	
Route markers	Route markers are simple direction arrow signs used to indicate route turns in place of other types of directional signs. Route markers are used on local and tourist/recreational routes to indicate route turnings in between junctions with fingerboards. They are not used on veloways and primary routes. Direction indication or fingerboards should be used on these routes.	
Map signs	Map signs are used on veloways and primary routes to provide additional wayfinding information to bicyclists such as other routes and destinations within an area covered by a network map.	

Bicycle wayfinding sign type	Description	Example
Project signs	Project signs are used on cycle facilities to provide information about new/changed cycleway and shared path infrastructure projects. Project signs are usually erected following the announcement of a project and can remain in position for up to two years after completion to highlight the public investment in the new infrastructure. Project signs should meet the following objectives: • communication of critical project information • identification of the funding authority • delivery date. Project signs may additionally list the following: • future planned infrastructure details • funding scheme (if applicable) • cycle network infrastructure funding agency additional involvement.	

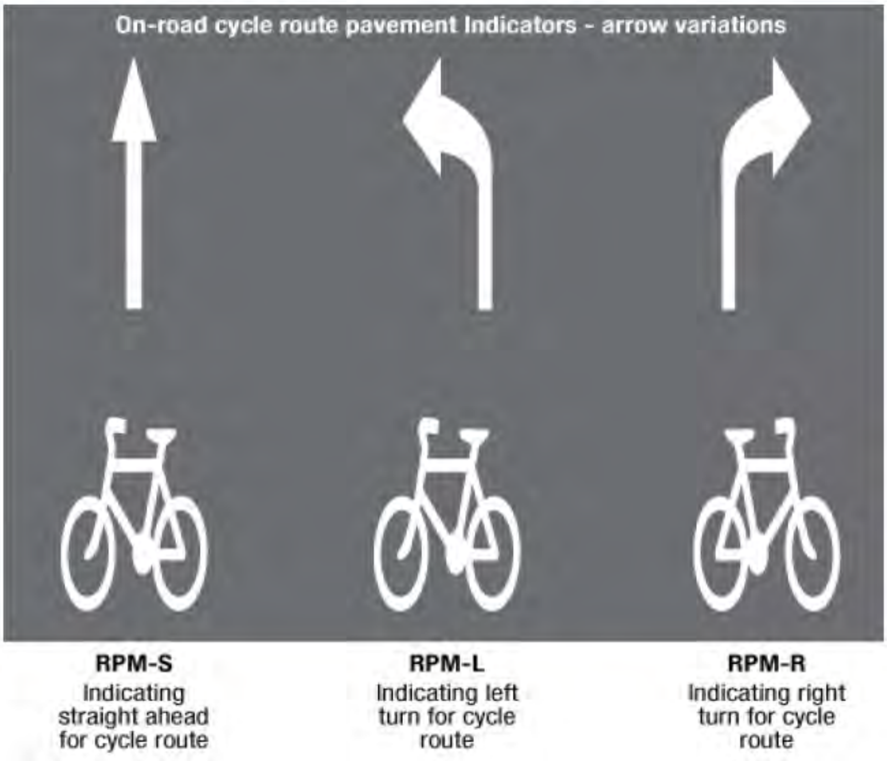
Note: Practitioners are advised to refer to the most up-to-date standards and/or guidelines when considering using the signs.

Source: Austroads (2015a).

A.3 Directional Pavement Markings

Route directional pavement markings (Figure A 1) indicate on-road route turns to warn cyclists of on- to off-road transitions which may be difficult to see from a distance or at speed. Directional pavement markings are a useful aid to navigation and provide an important supporting role to signs. The pavement markings can be used on all types of route as an aid to navigation.

Figure A 1: Directional pavement marking example



A.4 Cycle Route Types

Cycle networks consist of five distinct route types: veloways, primary, local, tourist/recreational and long-term detours. Each route type (Table A 3) uses a different combination of sign types appropriate to the needs of the route within the overall network hierarchy. Design details for each sign type, including sign variations and recommended usage, are provided in Austroads (2015a).

Table A 3: Cycle routes and the sign types used on each route type

Sign types	Route types				
	Veloway	**Primary**	**Local**	**Tourist/ recreational**	**Long-term detours**
Route type description	High-speed, limited-access routes usually paralleling major arterial roads or motorways	The main arterial routes of urban cycle transport networks	Shorter routes connecting primary routes to local destinations	Off-road, shared path and tourist/recreation al routes	Long-term detour routes for veloways, primary or tourist/recreation al routes
Fingerboards	Yes, at junctions with other routes and where the route changes direction	Yes, at junctions with other routes and where the route changes direction	Yes, integrated with street signs	Yes	Yes
Direction indication signs	Yes, at junctions with other routes and where the route changes direction	Yes, at junctions with other routes and where the route changes direction	No, use markers instead	No, use markers instead	Yes
Advance direction signs	Yes, before route junctions with veloways or primary routes	Yes, before route junctions	No, use markers instead	No, use markers instead	No
Reassurance signs with distances	Yes, after route junctions with other veloways or primary routes	Only on lengthy remote routes for reassurance	No, use markers instead	No, use markers instead	No
Route markers	No, use direction indication signs	No, use direction indication signs	Yes	Yes	No, use direction indication signs
Route numbering	Yes	Yes	No	Yes	Yes, if route replaced by detour is already numbered
Route branding	Yes	Yes	No	Yes	No
Street signs	Yes, if none exist	Yes, if none exist	Yes, if none exist	Yes, if none exist	Yes, if none exist

A.5 Developing a Directional Sign Plan

The methodology recommended in these guidelines for planning and implementing cycling sign projects is similar to other transport systems such as highway and arterial road signs. A key requirement is that routes are planned and signed within the context of the surrounding regional cycle network. This planning enables routes to be fully signed indicating the full range of destinations available across a region rather than within a narrow corridor.

The following steps for developing a directional sign plan are outlined in the following sections:

- Document the current (and planned) cycle routes (Appendix A.5.1).
- Create (or update) the focal point map for the region (Appendix A.5.2).
- Document any facilities which will need to be named on signs (Appendix A.5.3).
- Document any route numbering which will be required on signs (Appendix A.5.4).
- Document any route branding which will be required on signs (Appendix A.5.5).
- Conduct a pre-sign, risk assessment survey (Appendix A.5.6).
- Document all junctions with other routes (Appendix A.5.7).
- Prepare a sign schedule covering the route (Appendix A.5.8).
- Prepare a sign artwork files for the sign manufacturer (Appendix A.5.9).

A.5.1 Identify Cycle Routes

When considering cycling routes for sign projects, it is essential to differentiate between cycle routes and cycling facilities. Cycle routes are continuous connections which facilitate travel within an area served by the cycling network. Each cycling route can consist of many types of cycling facilities from on-road lanes and separated off-road cycleways within the road corridor to low-traffic-volume local streets with little or no linemarking or explicit cycling facilities.

The lack of defined regulatory cycling facilities and engineering treatments such as bicycle lanes and paths should not prevent the installation of directional signs along a designated route providing that the usual road safety and traffic management practices are followed. A cycle route only has to be assessed as legally rideable for it to be considered for signing.

The planning phase for signing cycle networks and their component routes is only concerned with cycle routes. The type and existence of cycling facilities is a key consideration in the implementation phase of a sign project, as the precise siting of any directional signs should be directly influenced by the facilities.

The first stage in developing a sign plan is to identify all interconnecting cycle routes and the destination names (focal points) used on these routes which should be included on signs. For example, at a junction of two primary routes, the advance direction signs on each approach will list the next focal point for the route being followed and those for each intersecting route. At route junctions, fingerboards for other intersecting routes are usually installed at a later stage when the full sequence of signs is being installed.

A.5.2 Create a Focal Point Map

When planning and designing directional signs for cycling routes utilising a network approach, designers first need to determine the destination and decision points (route junctions) for each route within the network. These details can then be used for single- or multiple-route sign projects. The key tool for the coordinated development of directional sign systems for cycling is the focal point map for a region.

A focal point map is a planning document used by the cycle network's manager to establish the destinations which appear on directional signs for the network. A key aim is to achieve rigid consistency in the use of named destinations so that a coherent system of signs can be developed to enable direct and unambiguous navigation around the cycle network. Only those destinations appearing on the focal point map are used on cycle network signs.

This map is usually maintained by a government authority responsible for the regional cycle network. This could be a centrally located council working in consultation with the road agency and neighbouring councils. As cycle networks are more urban-oriented than the main road network, they may use different focal points to highway/arterial road focal point maps within the same area or region.

The following guidelines apply to focal point mapping methodology for cycle networks. Further details can be found in Austroads (2015a):

- Focal points are significant destinations within a region where routes join, cross or terminate. They are indicated in the focal point map by a solid disc symbol. At complex junctions where routes overlap or cross, small red arrows are sometimes used on the map to clarify the paths for each route. For an urban cycle network, it is recommended that focal points be spaced at approximately 5 km.
- Terminal destinations are focal points where routes terminate. This may lie beyond any junction with another route or where a route terminates by joining another route at a T-junction etc.
- Sub-destinations are important intermediate centres along a route. To keep sign content compact, only one sub-destination is listed with the next focal point destination until the sub-destination is reached.
- In areas where a focal point is needed but is not immediately apparent, the focal point map designer consults with stakeholders to determine the most appropriate destination name to include on route direction signs.

City centre focal points are used in large and complex metropolitan CBDs where many routes converge but do not intersect neatly at a single junction. A city centre focal point is usually defined as a small area encompassing all route junctions with a compact geographical area. Primary routes leading to the city centre are considered to have reached it when they are at the defined boundary even though this may be a distance from the actual geographical centre of the city. The destination wording (used for the particular city centre) should continue to be used on signs between the boundary edge and the geographical centre. It is usual practice to list any destinations on the opposite side of the city centre which that route may connect with and continue onto. This practice further assists with route-finding within a complex area.

A.5.3 Identify any Named Facilities

Veloways, primary and tourist/recreational cycle routes may occasionally use all, or sections of, path facilities which have been named by a local council or government agency. The use of cycle facility names on cycle route signs should be kept to a minimum as it can place heavy demands on available sign space often increasing the physical size of signs and does not necessarily improve wayfinding.

Veloway and primary route signs can include facility name indication as follows:

- Facility name indication is limited to the start and finish of the named facility or at junctions where other primary routes enter the facility.
- The length of a facility name sign or integrated facility name box should not exceed the length of the associated route sign. Lengthy facility names are abbreviated or the facility name shown using the more condensed AS 1744 Series C typeface.
- On veloways and major primary routes, the names of significant intersecting streets/roads (route exit points) may be shown on signs using a similar layout.

A.5.4 Identify any Numbered Routes

In densely populated cities where there are far more route options than in smaller centres, route numbering may make it considerably easier for users to navigate their way around the cycle network. Route numbering may also be appropriate on longer-distance (inter-city) routes as numbered routes can extend across an entire metropolitan or city area.

Adoption of a system of cycle route numbering is sanctioned by the appropriate authorities responsible for the cycle network within a city, region or state. Planning and maintenance of the cycle route numbering system is the additional responsibility of an inter-governmental group or agency/jurisdiction which maintains the focal point map for the cycle network within the city/region. If route numbering is sanctioned, the numbering system is applied consistently on all network directional signs within the region.

There are three levels of numbered routes recommended:

- Alpha-numeric numbered routes (white letter/number on a blue background). These are usually higher-speed, limited-access veloway routes or 'cycling super highways' offering the highest quality level of service and access to urban centres for bicyclists. This type of route uses an alpha-numeric code comprising the letter V (for veloway) followed by the route number in the series. The use of this type of route numbering is limited to a small number of cycle routes within a capital city or between cities within a densely populated region (such as the V1 in Southeast Queensland which links Brisbane to the Gold Coast using the M1 and M3 Motorway corridors).
- Two-digit numbered routes (white numbers on a green background). These routes are the core primary routes for the metropolitan cycling network providing continuous cycle travel between major urban centres.
- Three-digit numbered routes (white numbers on a dark brown background). These routes are major urban or rural tourist/recreational facilities providing a continuous route throughout the region. Examples of this type of route are: lengthy and continuous urban recreational routes, rural rail trails, urban on-road training routes, and long distance rural routes on and off roads.

Veloway, primary and tourist/recreational route signs can include route numbering indication as follows:

- Route numbering can be used on signs and markers.
- Route numbers can be associated with a single destination, a group of destinations or a route.
- Route numbering and route branding are separate systems with potentially overlapping segments.

Examples of route numbering signs are shown in Austroads (2015a).

A.5.5 Identify any Branded Routes

Longer tourist/recreational routes are being developed in many Australian and New Zealand communities. Part of the implementation of these routes, which may often pass through a number of local government areas, is the application of a common branding and promotional identity which often encompasses design elements such as a branding logo, specialist wayfinding and facilities sign designs.

Veloway, primary and tourist/recreational route signs can include route branding indication as follows:

- Logos are the preferred method of branding. Logos use a simplified design and are instantly recognisable.
- Cycle route branding can be integrated into sign designs or installed as a separate sign above or below fingerboards. When an external route branding sign is used with a fingerboard for the same route, the branding sign is mounted above the fingerboard. If an external route branding sign is installed with a fingerboard for an overlapping primary or tourist/recreational route, the external branding sign is fixed below the fingerboard.
- Route numbering always takes precedence over route branding.
- Route branding and route numbering are separate systems with potentially overlapping segments. When branding logos are used on the same destination line as route numbers, the route number indicator is positioned next to the destination name.

Examples of branded routes are shown in Austroads (2015a).

A.5.6 Conduct a Pre-sign Risk Assessment

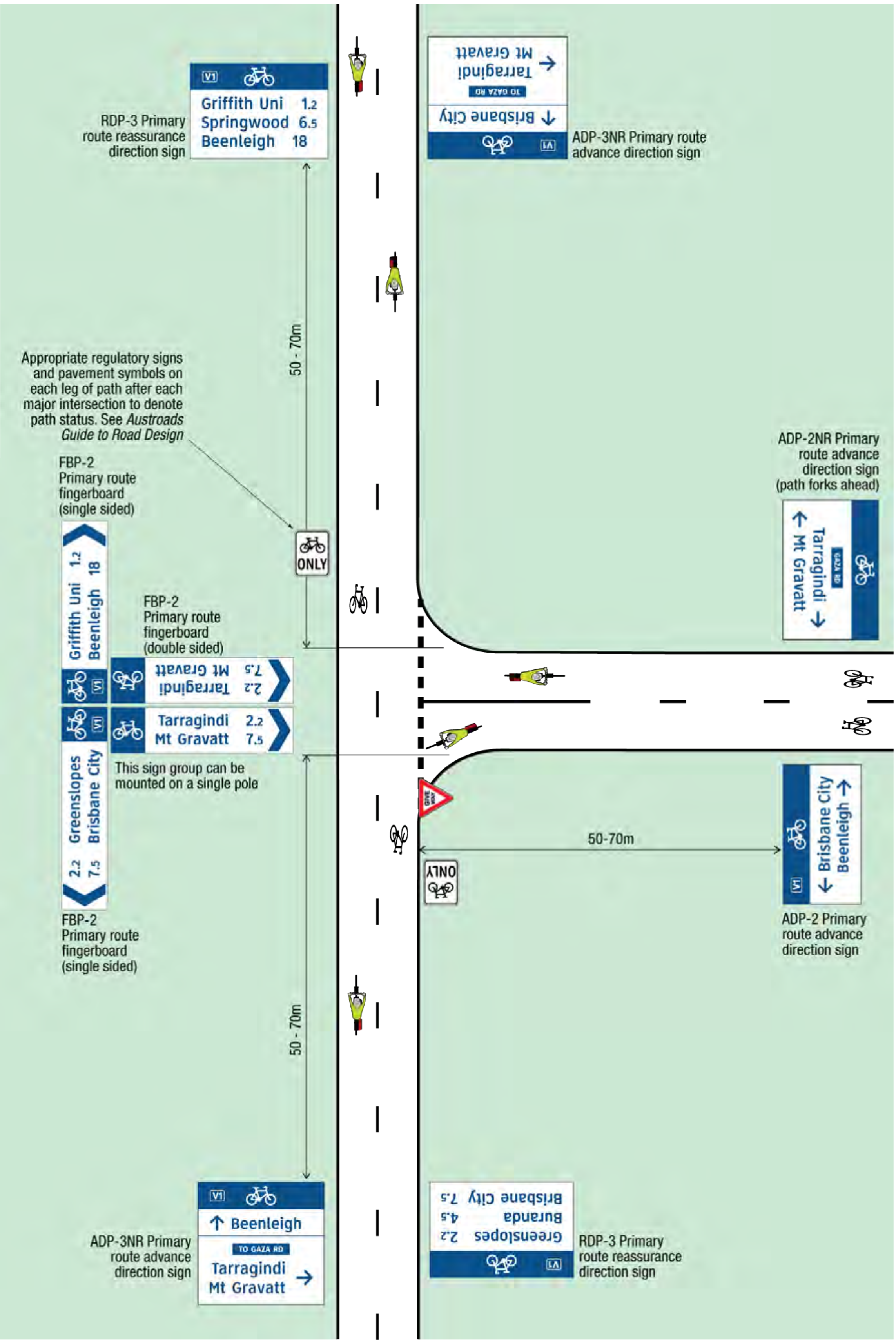
Prior to the installation of directional signs on a cycle route it is recommended that a physical risk assessment of the route is made. This assessment will study the route to determine if it can be legally cycled. The condition of existing cycle facilities on and off road, intersections/crossing points and any critical safety issues will be noted. Where major deficiencies occur in the permanent infrastructure (one-way streets preventing two-way cycle access, off-road sections where cycling is not permitted, continuous medians preventing route turns etc.) remedial action will be recommended and carried out prior to sign installation.

The type and extent of remedial work will usually depend on the structure of the road environment and the availability of any bicycle-specific treatments and infrastructure. Recommendations for pre-sign risk-assessment procedures are provided in the Queensland Transport and Main Roads publication *A Guide to Signing Cycle Networks* Department of Transport and Main Roads (2009) (search title on the TMR website www.tmr.qld.gov.au).

A.5.7 Design Sign Layouts for Route Junctions

Figure A 2 to Figure A 5 show recommended intersection sign layouts for the four route types: veloways, primary, local and tourist/recreational routes. The examples show usage of various bicycle wayfinding signage referred to in the previous sections. Due to the complexity of intersections it may often be advisable to use a graphical presentation for advance direction signs.

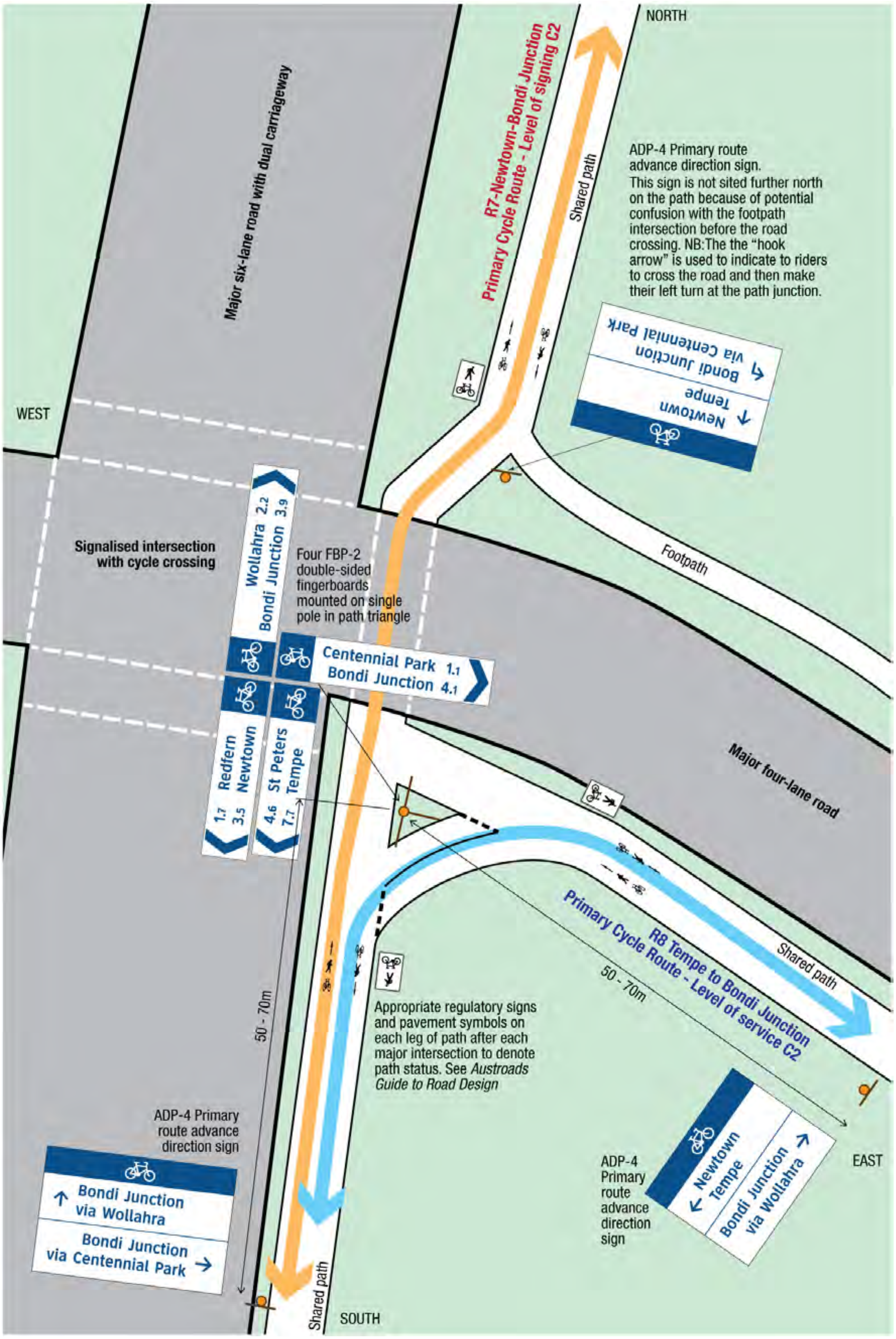
Figure A 2: Typical intersection sign layout for veloways



Note: Practitioners are advised to refer to the most up-to-date standards and/or guidelines when considering using the signs.

Source: Austroads (2015a).

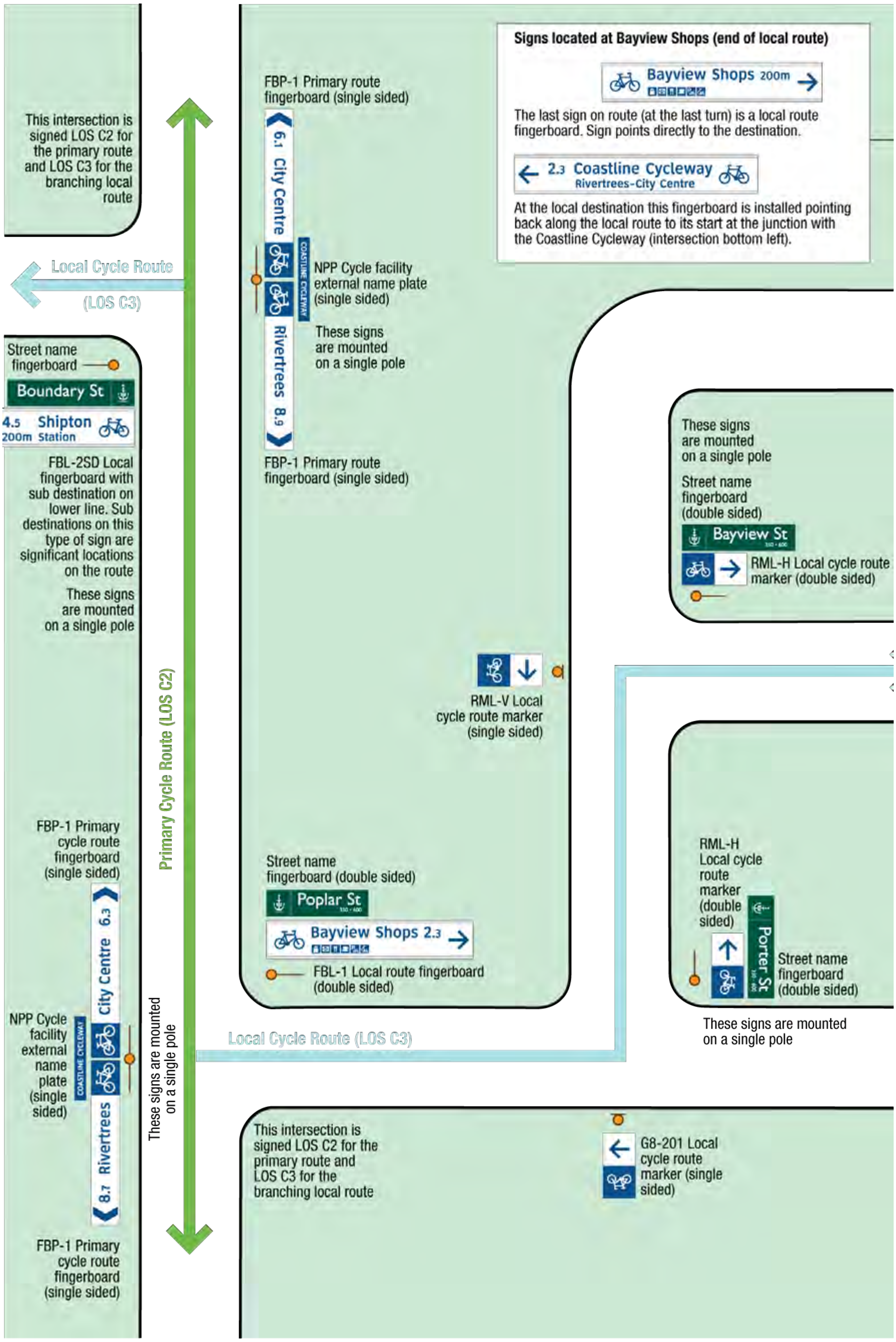
Figure A 3: Typical intersection sign layout for primary cycle routes



Note: Practitioners are advised to refer to the most up-to-date standards and/or guidelines when considering using the signs.

Source: Austroads (2015a).

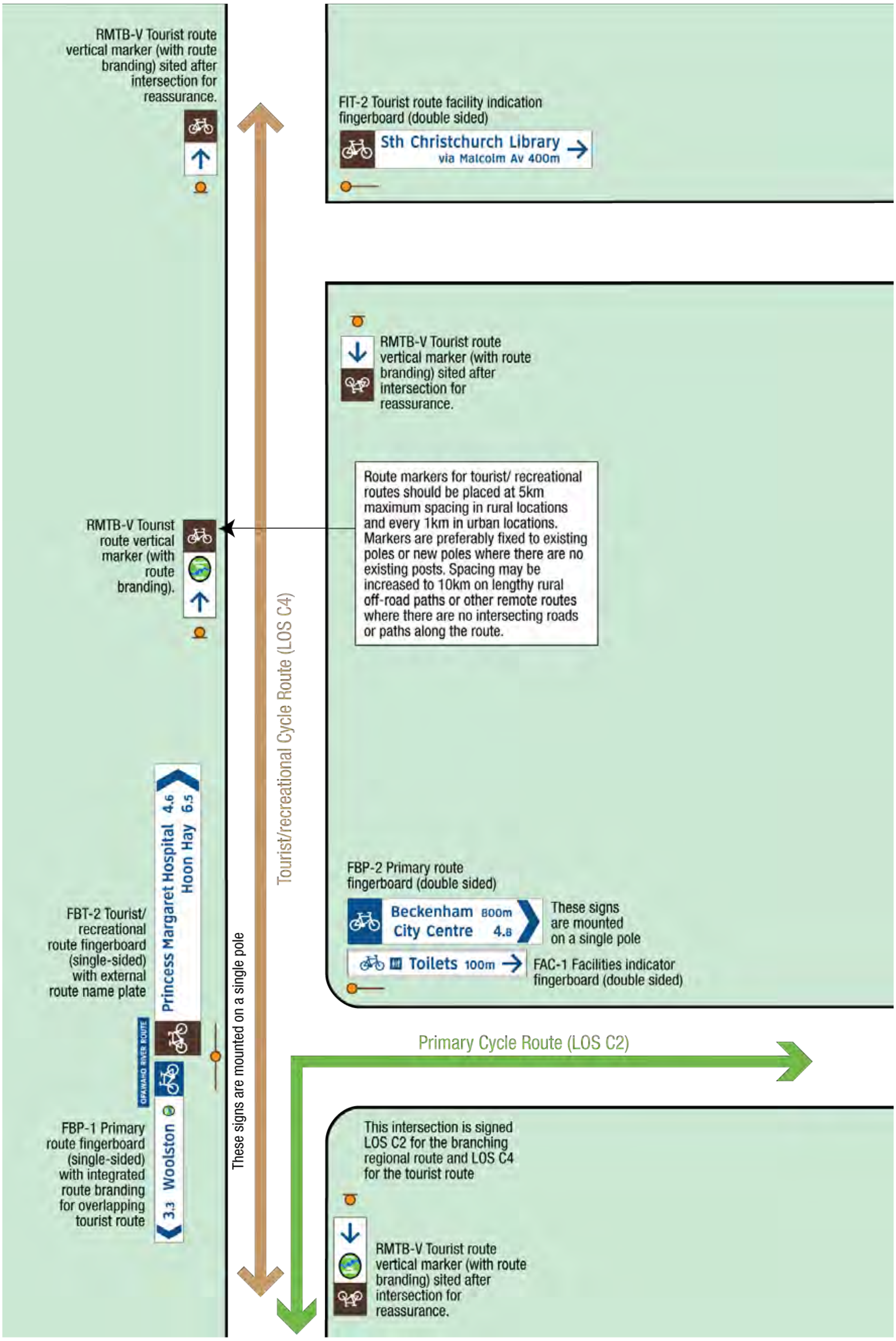
Figure A 4: Typical intersection sign layout for local cycle routes



Note: Practitioners are advised to refer to the most up-to-date standards and/or guidelines when considering using the signs.

Source: Austroads (2015a).

Figure A 5: Typical intersection sign layout for tourist/recreational cycle routes



Note: Practitioners are advised to refer to the most up-to-date standards and/or guidelines when considering using the signs.

Source: Austroads (2015a).

A.5.8 Create Sign Schedules

A sign schedule (detailing the location, type and lettering) is the key reference document used to specify the content and location of all signs in the project. Typical details included in a sign schedule are:

- Contents for all signs in the project (including destinations, distances and direction arrows). To determine which destinations to show on advance direction signs for intersecting routes, refer to the focal point map which lists all destinations applicable for each route.
- Precise location of each sign. It is recommended that marked-up site photos, detailed site maps or diagrams be appended to the sign schedule to ensure an accurate communication with the sign installer for each sign's particular siting requirements.
- Mounting details/requirements (new pole, existing poles, modifications to existing, fixing type etc.).
- New signs found necessary by the site assessment – missing regulatory signs, services and facilities signs, signs indicating connecting paths to the street system, additional signs at junctions for separate on- or off-road facilities and street name signs at junctions and route turns.
- Redundant signs to be removed.
- Additional works required to fully install the signs (minor tree pruning and branch removal where vegetation obscures signs when installed).

A.5.9 Prepare Sign Artwork for Manufacture

The completed route sign schedule can then be used to manufacture the signs. The first stage of this process is to transfer the information in the sign schedule into electronic artwork for each sign. This work is usually undertaken 'in-house' by the sign manufacturer or by an external graphic artist.

It is recommended that the sign project designer/planner recheck all electronic sign layouts for accuracy prior to sign fabrication. Sign layouts should conform to the sign layout templates in Australian Standard AS 1743.

A.6 Signing Complex Intersections

Often it is not possible to indicate a simple path through a road intersection due to the size and location of the roads through the junction and the complexity of the intersection layout. This is particularly an issue when routes transition between on- and off-road facilities at large multi-laned, signalised intersections. Appendix B of Austroads (2015a) provides examples of how to provide bicycle wayfinding through a complex intersection.

A.7 Sign Installation

The manufactured signs can be installed according to the sign schedules and detailed siting instructions provided by the sign system planner/designer. Additional advice and recommendations on sign installation issues are provided below.

A.7.1 Sign Mounting and Clearances

Signs are mounted in full view of bicyclists using the cycle route, and located so that they provide clear, unambiguous directions at critical turning points or junctions. Care is needed to place signs where they can be clearly seen by bicyclists and in a location where their message is not compromised or overwhelmed by proximity to other road signs or structures.

Cycle network signs should be sited so that they do not diminish the effectiveness of, or conflict with, existing road signs and create ambiguity for other road users.

Cycle network signs, like highway signs, are a discrete system designed to guide bicyclists through often complex road environments. Cycle route signs are not included with, or mounted on, main/arterial road directional signs or sign supports. Cycle route directional messages are not included or integrated into main/arterial road signs.

Sign clutter should be minimised by utilising existing sign and street poles where this does not compromise the effectiveness of the direction or host signs. Mounting on existing power poles is permissible provided that the council or road agency has an arrangement with the power utility to sanction this. In urban environments some councils permit the co-use of parking sign poles as a clutter reduction measure.

Signs should be mounted at a clearance height of 2.5 m and preferably no higher than 4.0 m. Sign supports need a minimum of 0.5 m clearance from the cycleway or roadway. Do not mount signs so that they overhang the roadway or interfere with turning vehicles.

Where there is a risk that signs could be rotated by either wind or vandalism, use anti-rotational fittings or fixing screws can be used. This is particularly important on fingerboard signs which indicate travel direction at intersections.

Map and information display signs need to be mounted with sufficient horizontal clearance (1.5 m minimum, 2.0 m preferred) to permit bicyclists and other path users to comfortably view the sign and still provide clearance to other street/path users.

Route markers for tourist/recreational routes on rural routes are placed at 5 km maximum spacing and generally located on existing sign posts or new route marker posts where there are no existing sign posts. Spacing may be increased to 10 km along off-road paths or other remote routes where there are limited or no intersecting roads/paths along the route. In urban environments, markers should be placed on continuous or branded recreational routes at 1 km intervals increasing to 2 km where there are no intermediate junctions.

A.7.2 Sight Distances and Sign Visibility

At cycle route junctions/decision points, directional signs need to be positioned so that bicyclists can safely read the signs and comfortably follow their chosen route. Stopping distance and the sight distance to the intersection are also important in hilly conditions.

When placing advance direction signs it is essential to take into account all local variables such as slope and sight distances. Signs should be located to provide adequate warning of a change of direction depending on the site. Table B.9 in Austroads (2015a) lists recommended mounting distances for advance direction signs.

If two signs indicating separate directions cannot be mounted on the same pole on one corner of an intersection due to site conditions, separate mounting of the signs should be considered. This also applies to mounting signs on existing sign or power poles (where an agreement exists between the road/street/path owning authority and the power supply company) provided that such mounting offers superior sight lines and visibility for the sign(s).

A.7.3 Sign Legibility and Lighting

Direction signs need to be easily readable in either day or night conditions. Signs located in a normal urban environment usually have adequate ambient lighting. If possible, signs should be located under, or adjacent to, overhead lighting.

A.7.4 Sign Stack Mounting Order

At major junctions it is important to place fingerboards in a logical vertical order so that bicyclists can easily follow the signs for a particular route. Generally, fingerboard pairs for a continuous route through a junction are placed together in the vertical sign stack. Ideally fingerboard pairs for the same route are mounted at the same level but this may not be possible due to mounting system limitations. Always consider sign visibility from different approaches for large sign installations when multiple routes pass through junctions.

A.7.5 Integration with Existing Path Signs

Many local governments are implementing wayfinding sign systems to assist people using shared paths and urban greenways. Many of these paths have been developed with unique signs and branding. Cycle network signs installed as an overlay on existing paths (with existing signs) require careful sign placement to ensure the needs of path users and the cycle network are fully accommodated.

Cycle network signs should be kept to a minimum at locations as follows:

- entry to the path where the primary route joins
- path-branching intersections of other primary and local routes
- exit from the path of the primary route.

Existing path signs should provide the necessary destinations, distances, directions to facilities, cross-street/access-path naming and map signs. Off-road paths and path junctions are signed the same as on-road routes. Where no existing path sign system is in place, normal cycle network signs are applied throughout the path.

A.7.6 Post-installation Check and Review

Following installation, the location and sign contents are finally checked on site by the sign system planner/designer. All signs need to point in the right direction and be easily visible to bicyclists riding the route. Signs wrongly installed or containing inaccurate information need to be documented and supplied to the sign installer for rectification.

A.8 Sign Maintenance

Cycle network direction signs can be installed during the implementation phase of a cycleway project or retrofitted as part of a longer-term program for high quality wayfinding and directional sign systems across a cycle network.

The maintenance of cycle route direction signs is usually the responsibility of the government agency, local government or private landowner that owns or operates the road, street or path. It is important that ongoing sign maintenance responsibilities be assigned and carried out, particularly where joint funding and partnership arrangements have installed the signs and infrastructure. Any ongoing maintenance of cycle network infrastructure needs to include the maintenance of the sign system.

A.8.1 Sign Defect Reporting Systems

Asset managers/owners are increasingly interested in accurate reporting systems which allow them to more efficiently maintain infrastructure such as cycling network directional signs.

Internet-based infrastructure defect reporting systems are currently used by a number of Australian and New Zealand councils and government agencies. It is important that these systems be accessible to the bicyclists who regularly use the network to ensure prompt reporting of missing or damaged signs. This type of reporting system is recommended as it encourages network users to report faults which may otherwise take much longer to detect under the asset authority's regular maintenance inspections.

It is essential that asset items relating to cycling signs be added to existing internet-based defect reporting systems as soon as directional signs are installed so that users may make an accurate selection from the reportable faults listed on the system.

A.9 Alternative Sign Design Options

Alternative sign design options include providing travel time and shared route markings. Detailed guidance on these marking is outlined in Appendix B of Austroads (2015a).

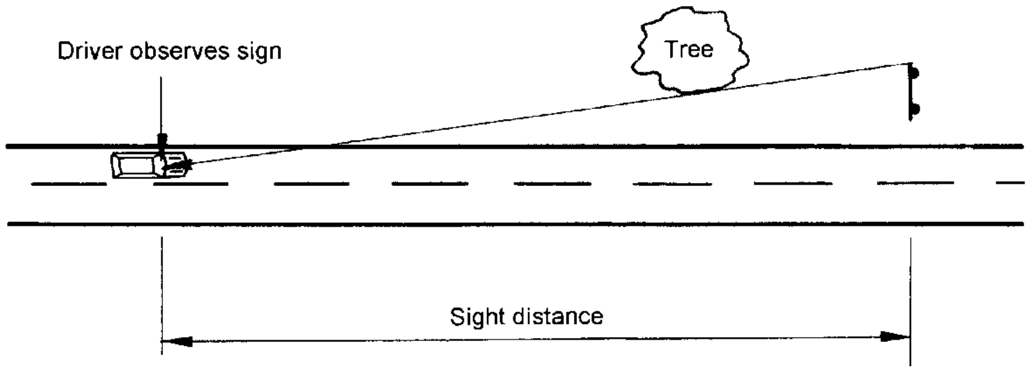
Appendix B Operational Guideline for the Determination of Sight Distances to Direction Signs

This Appendix outlines guidance used by Main Roads Western Australia (2015) to determine the sight distance to direction signs. Practitioners may consider this guidance for application within their jurisdictions.

Vegetation in the road verge can often obscure the visibility of direction signs and other large road signs and must be maintained to ensure that adequate visibility is available. These guidelines have been prepared to determine the extent of pruning or clearing of the vegetation that is necessary to achieve the required sight distances.

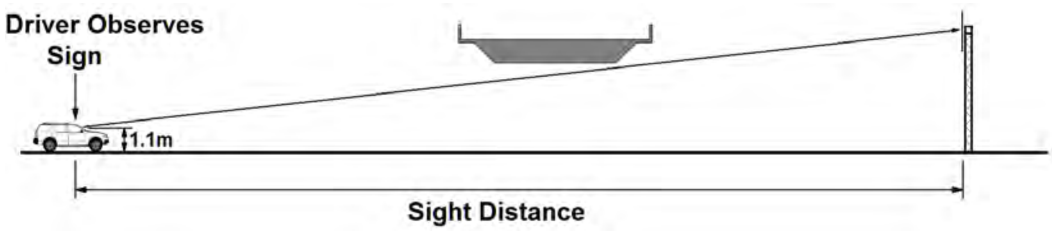
With reference to Figure B 1 and Figure B 2, the sight distance to the direction sign is measured along the road from point at which the whole sign is visible to the driver. For multi-lane roads, the sign is to be viewed from the lane closest to the road verge. It is assumed that the driver's eye height is 1.10 m and that the driver is located in the center of the lane.

Figure B 1: Horizontal Sight Distance Measurement



Source: Main Roads Western Australia (2015).

Figure B 2: Vertical Sight Distance Measurement



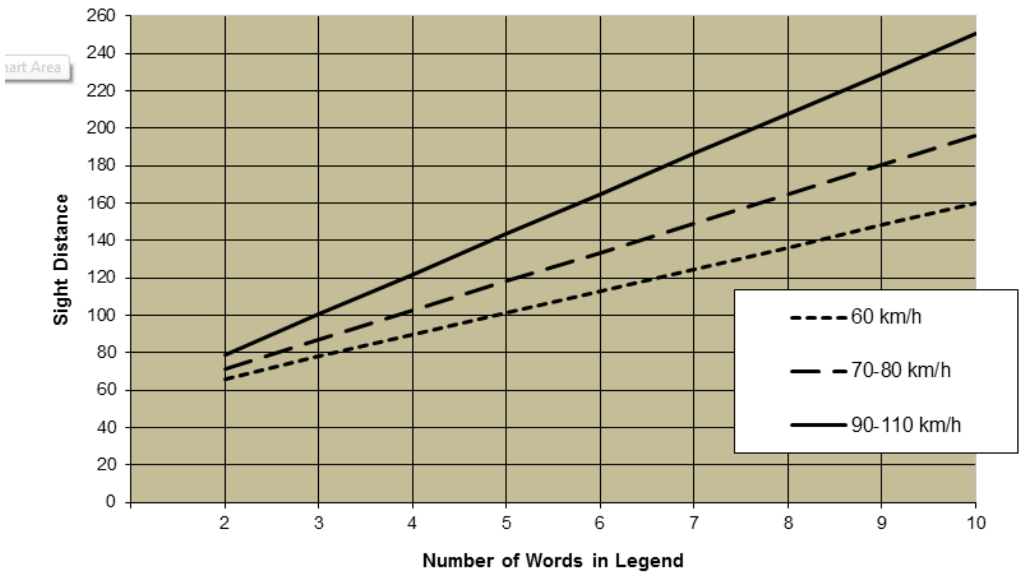
Source: Main Roads Western Australia (2015).

Minimum sight distance requirements can be determined in Figure B 3 and Figure B 4 using the approach speed and the number of words or symbols (excluding arrows) on the sign. The approach speed should be taken as the posted speed limit of the road or the normal operating speed on roads which have not been speed zoned.

The graph in Figure B 3 should be used to determine the desirable minimum sight distance to the sign. If the measured sight distance is less than the minimum sight distance, tree pruning or clearing of low vegetation is required.

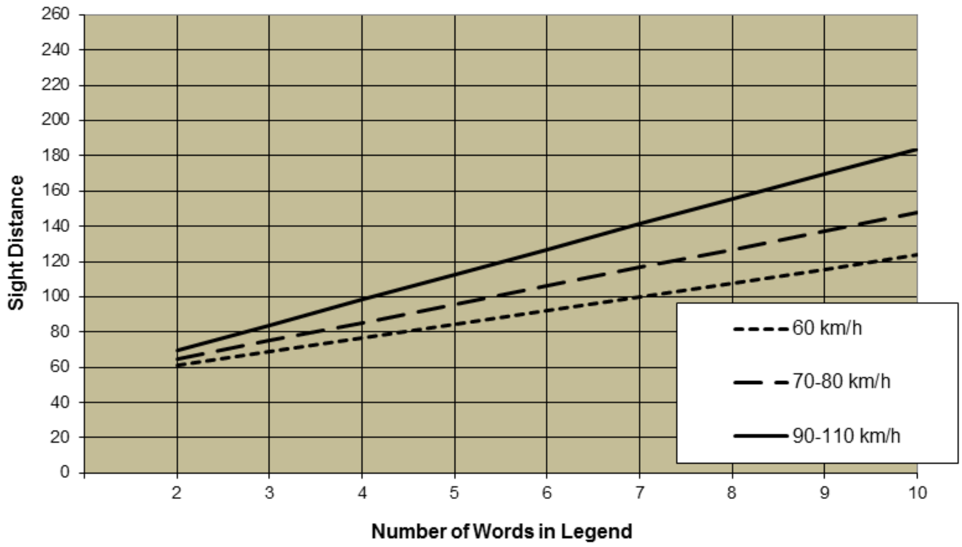
Sight distances given in Figure B 4 should only be used where the sight distance determined from Figure B 3 cannot be achieved without extensive clearing or because the visibility of the sign is obscured by a road embankment. The sign should be relocated if the minimum requirement in Figure B 4 cannot be achieved.

Figure B 3: Desirable Minimum Sight Distance Requirements



Source: Main Roads Western Australia (2015).

Figure B 4: Absolute Minimum Sight Distance Requirements



Source: Main Roads Western Australia (2015).

Appendix C Abbreviations for Use on VMS

C.1 Recommended Abbreviations to Use with VMS

The following is a list of acceptable abbreviations for frequently used words. Abbreviations may be used on VMS messages but where possible should be avoided.

Word	Abbreviation
ALTERNATE	ALT
ACCIDENT	ACDNT
AVENUE	AVE
BOULEVARD	BVD
CANNOT	CAN'T
CENTRE	CNTR
DO NOT	DON'T
EMERGENCY	EMER
ENTRANCE	ENT
ENTER	ENT
EXPRESSWAY	EXPWY
FREEWAY	FWY
INFORMATION	INFO
IT IS	IT'S

Word	Abbreviation
JUNCTION	JCT
LEFT	LFT
MAINTENANCE	MAINT
NORMAL	NORM
PARKING	PKING
ROAD	RD
SERVICE	SERV
SHOULDER	SHLDR
SLIPPERY	SLIP
SPEED	SPD
STREET	ST
TRAFFIC	TRAF
TRAVELLERS	TRVLRS
WILL NOT	WON'T

C.2 Standard VMS Abbreviations Used in Conjunction with Other Words

The following abbreviations are easily understood whenever they appear in conjunction with a word commonly associated with it (prompt word). The prompt word can appear before or after the abbreviated word depending on the meaning. For example, RT is alternatively recognised as either 'right' or 'route' based on the prompt word.

Word	Abbreviation	Prompt word
ACCESS	ACCS	ROAD
AHEAD	AHD	FOG*
BLOCKED	BLKD	LANE*
BRIDGE	BRDG	(NAME)*
CENTRE	CNTR	LANE
CHEMICAL	CHEM	SPILL
CONDITION	COND	TRAFFIC*
CONGESTED	CONG	TRAFFIC
CONSTRUCTION	CONST	AHEAD
EASTBOUND	E-BND	TRAFFIC
ENTRANCE	ENT	FREEWAY*
EXIT	EX, EXT	NEXT*
EXPRESS	EXP	LANE
FRONTAGE	FRNTG	ROAD
HAZARDOUS	HAZ	DRIVING
KILOMETRE	KM	(NUMBER)*
LOCAL	LOC	TRAFFIC
MAJOR	MAJ	ACCIDENT
MINOR	MNR	ACCIDENT
MINUTE(S)	MIN	(NUMBER)*
NORTHBOUND	N-BND	TRAFFIC
OVERSIZED	OVRSZ	LOAD
PAVEMENT	PVMT	WET*
PREPARE	PREP	TO STOP
QUALITY	QLTY	AIR*
RIGHT	RT	KEEP*
ROADWORK	RDWK	AHEAD (DISTANCE)
ROUTE	Rte	BEST*
SOUTHBOUND	S-BND	TRAFFIC
TEMPORARY	TEMP	ROUTE
UPPER, LOWER	UPR, LWR	LEVEL
VEHICLE	VEH	STALLED*
WESTBOUND	W-BND	TRAFFIC

** Indicates prompt word used before abbreviation.*

Appendix D VMS Message Statements

D.1 Recommended VMS Problem Statements

No.	Problem Statement	No.	Problem Statement
1	ANIMALS ON ROAD	16	INCIDENT
2	BREAKDOWN	17	LANE(S) CLOSED
3	BRIDGEWORK	18	LOW LIGHT
4	‘name*’ BRIDGE CLOSED*	19	OIL ON ROAD
5	CHEMICAL SPILL	20	POOR VISIBILITY
6	CONGESTION	21	ROAD CLOSED
7	CRASH	22	ROAD FLOODED
8	DEBRIS ON ROAD	23	ROAD NARROWS
9	DELAYS	24	ROADWORK
10	EXIT ‘number*’ CLOSED	25	SLIPPERY ROAD
11	‘name*’ EXIT CLOSED	26	TRAFFIC HAZARD
12	FIRE	27	TRAFFIC SIGNALS
13	FOG HAZARD	28	TUNNEL CLOSED
14	HAZARD	29	TWO WAY TRAFFIC
15	ICY ROAD		

** Name/number is optional, to be used only when there could be confusion as to which bridge or exit is closed.*

D.2 Recommended VMS Location Statements

Location definers	Position definers
BUS LANE	AHEAD
BUSWAY	AT
CENTRE LANE	BEYOND
EXIT ‘number’	IN
INTRSCT	NEAR
‘landmark’	NEXT
LEFT LANE	
LEFT LANES	
LEFT SHOULDER	
‘location’ EXIT	
‘name’ BRIDGE	
‘name’ DR (DRIVE)	
‘name’ HWY (HIGHWAY)	
‘name’ RD (ROAD)	
‘name’ ST (STREET)	
‘number’ km	
‘number’ m	
OVERPASS	
RIGHT LANE	
RIGHT LANES	
RIGHT SHOULDER	
ROAD	
SERVICE ROAD	
TUNNEL	
UNDERPASS	
‘location’ EXIT	
‘number’ km AHEAD	
‘number’ m AHEAD	

D.3 Recommended VMS Effect Statements

‘location’ CLOSED
EXPECT DELAYS
MAJOR DELAYS
MINOR DELAYS
POLICE CONTROL
TRAFFIC CONTROL
‘number’ min DELAY
‘number’ hrs DELAY

D.4 Recommended VMS Attention Statements

ALL TRAFFIC
BUSES
BICYCLES
CARS
EMERGENCY VEHICLES
HIGH VEHICLE (S)
LOCAL TRAFFIC
THROUGH TRAFFIC
TRUCKS
WIDE LOADS
‘destination’ TRAFFIC

D.5 Recommended VMS Action Statements

DETOUR AHEAD
DO NOT OVERTAKE
MERGE LEFT (with arrows)
MERGE RIGHT (with arrows)
MUST STOP
NO ENTRY
NO EXIT
PREPARE TO STOP
PROCEED WITH CAUTION
REDUCE SPEED
USE ALTERNATE ROUTE
USE EXIT ‘number’
USE ‘name’ EXIT
USE ‘road’ ROAD
USE ‘road’ STREET
‘attention statement’/KEEP LEFT
‘attention statement’/KEEP RIGHT
‘attention statement’/MERGE TO RIGHT LANE
‘attention statement’/MERGE TO LEFT LANE

D.6 Recommended VMS Time and Date Statements

Time duration	‘number’ min ‘number’ hrs ‘number’ DAYS ‘number’ WEEKS
Time of day*	‘number’ AM ‘number’ PM ‘number’ AM – ‘number’ PM
Time period*	
Days of the week	SUN, MON, TUE, WED, THU, FRI, SAT
Day period	MON – FRI
	SAT – SUN
	WEEKEND
Months of year	JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC
Date	‘number’ JAN
Date period	‘number’ JAN – ‘number’ FEB
Miscellaneous	EXPECTED POSSIBLE SOON

** The use of a 24-hour clock should be avoided.*

Appendix E Generic Message Set

	Frame 1			Frame 2		
	Line 1	Line 2	Line 3	Line 1	Line 2	Line 3
1	ACCIDENT	EXPECT DELAYS				
2	ACCIDENT	PROCEED	WITH CAUTION			
3	ACCIDENT	DETOUR AHEAD				
4	ACCIDENT	PREPARE TO STOP				
5	ACCIDENT	MAJOR DELAYS		FIND	ALTERNATE ROUTE	
6	ACCIDENT	MAJOR DELAYS		PROCEED	WITH CAUTION	
7	ACCIDENT	MAJOR DELAYS		PROCEED	WITH CAUTION	
8	ANIMALS ON ROAD	PROCEED	WITH CAUTION			
9	ANIMALS ON ROAD	PREPARE TO STOP				
10	BREAKDOWN	PROCEED	WITH CAUTION			
11	BREAKDOWN	AHEAD		MERGE LEFT		
12	BREAKDOWN	AHEAD		MERGE RIGHT		
13	CHANGED TRAFFIC	CONDITIONS		PROCEED	WITH CAUTION	
14	CHEMICAL SPILL	PROCEED	WITH CAUTION			
15	CHEMICAL SPILL	DETOUR AHEAD				
16	CHEMICAL SPILL	DETOUR AHEAD		FIND	ALTERNATE ROUTE	
17	CONGESTION	AHEAD		EXPECT DELAYS		
18	CONGESTION	AHEAD	MAJOR DELAYS	FIND	ALTERNATE ROUTE	
19	CONGESTION	AHEAD	MAJOR DELAYS	PROCEED	WITH CAUTION	
20	CONGESTION	AHEAD	MINOR DELAYS	PROCEED	WITH CAUTION	
21	DANGER	PROCEED	WITH CAUTION			
22	FLAGMAN	AHEAD		REDUCE SPEED	PREPARE TO STOP	
23	FOG	BEYOND TUNNEL				
24	FOG HAZARD	PROCEED	WITH CAUTION			
25	HAZARD	AHEAD		EXPECT DELAYS		
26	HAZARD	PROCEED	WITH CAUTION			
27	HAZARD	AHEAD		DETOUR AHEAD		
28	HAZARD	MAJOR DELAYS		FIND	ALTERNATE ROUTE	
29	HAZARD	MAJOR DELAYS		PROCEED	WITH CAUTION	
30	HAZARD	MINOR DELAYS		PROCEED	WITH CAUTION	
31	HIGH VEHICLE (S)	MUST STOP				
32	LANE CLOSED	AHEAD		MERGE RIGHT		
33	LANE CLOSED	AHEAD		MERGE LEFT		
34	LANE (S) CLOSED	IN TUNNEL				
35	LOW LIGHT	IN TUNNEL				
36	NO ENTRY	TUNNEL CLOSED				
37	OIL ON ROAD			PROCEED	WITH CAUTION	
38	POLICE CONTROL	AHEAD				
39	POOR VISIBILITY	AHEAD		PROCEED	WITH CAUTION	
40	ROAD CLOSED	AHEAD		PREPARE TO STOP		
41	ROAD CLOSED	AHEAD		FIND	ALTERNATE ROUTE	

	Frame 1			Frame 2		
	Line 1	Line 2	Line 3	Line 1	Line 2	Line 3
42	ROAD CLOSED	DETOUR AHEAD				
43	ROAD FLOODED	AHEAD		FIND	ALTERNATE ROUTE	
44	ROAD FLOODED	AHEAD		PROCEED	WITH CAUTION	
45	ROAD FLOODED	DETOUR AHEAD				
46	ROAD FLOODED	AHEAD		PREPARE TO STOP		
47	ROADWORK	AHEAD		REDUCE SPEED		
48	ROADWORK	AHEAD		EXPECT DELAYS		
49	ROADWORK	DETOUR AHEAD				
50	ROADWORK	AHEAD		PREPARE TO STOP		
51	ROADWORK	AHEAD		MERGE LEFT		
52	ROADWORK	AHEAD		MERGE RIGHT		
53	SMOKE HAZARD	AHEAD		PROCEED	WITH CAUTION	
54	TRAFFIC HAZARD	AHEAD				
55	TRAFFIC HAZARD	IN TUNNEL				
56	TRAFFIC SIGNALS	AHEAD		PREPARE TO STOP		
57	TUNNEL CLOSED	MERGE RIGHT				
58	TWO WAY	TRAFFIC				

Commentary 1

Frangible supports are designed to collapse on impact. The severity of potential injuries to the occupants of an impacting vehicle is reduced, compared to injuries that could occur if the posts were unyielding.

Jurisdictions provide different guidance for frangible posts. Practitioners should refer to the jurisdiction guidance in addition to Austroads *Guide to Road Design Parts 6* and *6B*, and the *Guide to Road Safety Part 9*.

Outlined below are examples of differing jurisdictional guidance for frangible posts.

C1.1 Main Roads Western Australia (MRWA)

MRWA provides the following guidance for frangible post selection (based on grade 350 steel):

- For roads with a speed limit less than 60 km/h the size of the circular hollow section (CHS) post must not be greater than 101.6 CHS 2.6 (the first figure is the diameter while the second figure following CHS is the wall thickness).
- For roads with a speed limit of 60, 70 or 80 km/h the size of the CHS post must not be greater than 76.1 CHS 2.3.
- For roads with a speed limit greater than 80 km/h the size of the CHS post must not be greater than 60.3 CHS 2.9.
- If a three-post installation is to be used the two outer posts must be more than 2.1 m apart.
- The maximum size universal beam (UB) considered frangible when fitted with a breakaway base is the 250 UB 37.
- Signs located in positions where the impact may come from two directions at 90° to one another should not be supported on universal beam posts.
- The minimum clearance height for signs supported on slip base UB posts should be 2.2 m. This clearance is required to enable a vehicle to pass underneath the unsupported portion of a sign, once the post is struck by an errant vehicle, without the sign penetrating the windscreen. For signs located on a batter, this clearance applies to the post closest to the roadway.

C1.2 Department of Planning, Transport and Infrastructure South Australia (DPTI)

DPTI provides the following guidance for post selection based on sign size.

C1.2.1 Small to Medium Size Signs

Small to medium size signs (i.e. general regulatory or warning type) should be supported by steel rectangular hollow section (RHS) supports complying with Table C1 1. Circular hollow sections (CHS) should not be used for small to medium size signs under any circumstances.

Table C1 1: Rectangular hollow section supports

Post length (mm)	Post size width x depth x wall thickness (mm)
≤ 3200	75 x 38 x 3.0 or 80 x 40 x 1.6
> 3200 to ≤ 4200	80 x 40 x 2.5

Source: Department of Planning, Transport and Infrastructure (2016).

C1.2.2 Large Size Signs

Except for overhead signs, steel CHS supports (nominal 100 mm diameter) should be used where non-frangible posts are permitted.

Where frangible posts are required, the posts should be either:

- aluminium CHS complying with Table C1 2
- steel CHS complying with Table C1 2
- proprietary frangible posts if the product is approved by the principal.

The contractor may apply for approval of a proprietary frangible post not included in the approved products list. Any request for approval of a post must include all necessary supporting information and will constitute a 'hold point'.

The contractor acknowledges that for efficiency of maintenance, the principal requires that the number of types of proprietary frangible posts on the road network is kept to a minimum. The principal reserves the right to withhold approval of any proprietary frangible posts at discretion.

Table C1 2: Posts deemed to be frangible

Circular steel posts	
Speed zone (km/h)	**Diameter(1) x wall thickness (mm)**
≤ 80	80 x 3.3
≤ 70	90 x 3.3(2)
≤ 60	80 x 5.0 or 100 x 3.5(2)
≤ 40	125 x 3.5(2)
Circular aluminium posts	
≤ 110	100 x 4.6/5.5

1 *All circular post sizes are shown as nominal bore (inside dimension).*
2 *Indicates the preferred sizes for use on DPTI roads.*

Source: Department of Planning, Transport and Infrastructure (2016).

Further to the above, it is noted that overhead signs must be supported by cantilever, gantry or portal type structures.

C1.3 Roads ACT

Roads ACT provides guidance on what posts are considered frangible, as outlined in Table C1 3.

Table C1 3: Steel posts considered as frangible

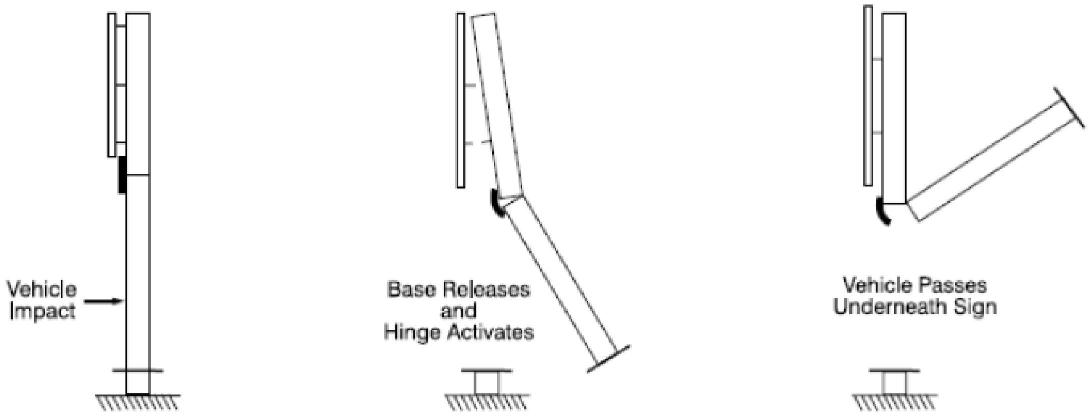
Operating speed (km/h)	Maximum moment (kNm)
< 60	7.90
60 to 80	3.95
> 80	3.01

Source: Roads ACT (personal communication 2016).

If the post requires a greater design moment then a frangible post should be used. Frangible post systems should be approved by the road agency. Roads ACT refers to guidance outlined in the Department of Transport and Main Roads (2001), summarised below:

The function of breakaway supports is to support the sign under normal wind load conditions, yet fail in a relatively safe manner when struck by a vehicle as shown in Figure C1 1.

Figure C1 1: Impact performance



Source: Department of Transport and Main Roads (2001).

Breakaway supports are fabricated using rectangular hollow sections RHS or CHS steel tube with both a slip base plate and a fuse plate hinge (except for single-post signs). Failure occurs when the vehicle impact force overcomes the frictional force between the base plate and tension tearing of the fuse plate weld. Breakaway support details are designed to accommodate the impact from both traffic directions, to cater for use in median strip and gore areas.

The slip base and fuse plate details are not required for small posts, which are considered to be frangible in collisions (refer to Figure C1 2).

Figure C1 2: Small size steel posts considered as frangible

Likely collision speed (km/h)	Post size, nominal bore (NB) (mm)
< 60	100
60 to 80	80
> 80	65

Source: Department of Transport and Main Roads (2001).

Galvanised steel pipe posts up to 65 NB will rarely cause injury to the occupants of cars or heavier vehicles which collide with them. The same applies to low-speed urban type conditions involving steel pipe up to approximately 100 NB (RHS 75 x 50). For RHS, 75 x 50 posts may be considered as frangible.

Consideration should be given to the use of an additional post that may reduce the required post size to within the frangible limits. Increasing the number of posts is not a valid method for resultant post spacing less than 1.5 m, due to the increased likelihood of collision with two posts.

To maximise road safety and minimise cost, the intention should always be to locate signs in ‘low risk’ regions where breakaway posts are not required.

Low risk regions are either:

- outside the clear zone
- behind a guard rail or other barrier device
- at the bottom of a steep embankment or top of a steep cutting.

'High risk' regions are those within the clear zone which are not protected by a barrier device or steep slope.

Breakaway posts should be avoided where secondary incidents involving the impacting vehicle or dislodged pole and sign are significant. This is particularly relevant in urban areas where pedestrians may be struck by falling pieces.

The standard design of large signs, usually situated within the clear zone, incorporates breakaway details in the truss support system.

To achieve satisfactory performance of the breakaway supports, the following criteria should be met:

- The clearance of the sign above the ground should be a minimum of 2.1 m to avoid penetration of an impacting vehicle windscreen.
- Proper functioning of the slip base depends on control of clamping pressure between the base plates produced by bolt tensioning. It is important for the specified bolt torque to be adhered to. The drawings specify shop assembly of slip bases, to minimise the inaccuracies of torque-controlled bolt tensioning. Pre-assembled slip bases will also enable supports to be plumbed prior to pouring concrete footings.
- Large truss supports will often be difficult to erect prior to pouring footings. It is therefore desirable to cast in the stub and then assemble the slip base on site. Special attention must be given to the tensioning on site, with calibrated torque wrenches used and bolt threads kept clean.
- For CHS/RHS posts, the fuse plate hinges have been designed to resist 45% of the post-moment capacity. Signs with panel height greater than 165% of the clearance between the ground and sign produce a bending moment which exceeds the fuse plate hinge capacity. For these signs the post size should be increased to the next section size. The allowable panel height is then twice the clearance.

For truss supports, the fuse plate hinges have been designed to resist 66% of the axial compression capacity of their CHS posts/legs. Signs with panel height greater than 400% of the clearance between the ground and sign, produce an axial force which exceeds the fuse plate hinge capacity. For these signs, the truss size could be increased to the next available size.

C1.4 Department of Transport and Main Roads Queensland (TMR)

The *Design Guide for Roadside Signs* (Department of Transport and Main Roads 2001) as currently referred to by Roads ACT (refer to Commentary C1.3) is considered outdated and is currently under review by the department. At present TMR refers to Table D2 of AS 1742.2.

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Commentary 2

It will normally be necessary to determine the details and condition of signs along the route as part of the development of a route overview plan. An inventory of existing signs should be undertaken to provide a basis for determining the extent to which existing signs can be accommodated in a revised signing scheme.

The information required may be collected or available through a formal asset management system that may be computer based. However, the following items will be useful in collecting data and records should a formal automated system not exist:

- camera (should be able to be manually focused, no permanent flash unit, preferably with variable focal length lens)
- measuring device for use in photographs, can be a survey staff
- tape measure
- distance measuring device to determine longitudinal location of sign
- intersection layout proformas or pad of plain paper to sketch sign layouts at intersections
- strip map
- sign inventory data, where available
- designs for existing signs along the route, where available
- colour/material class swatch samples
- stringline level
- copy of relevant standard drawings for road signs.

The use of a proforma such as the sign inventory form shown in Figure C2 1 is recommended.

A suggested procedure for conducting the inventory is:

- Identify route(s) for which the sign inventory is to be prepared.
- Prepare strip map and associated data for route. Data is to include chainage data, and any existing sign designs for the route.
- Travel the route to pick up sign details:
  - Complete sign inventory using a proforma.
  - Take photographs of signs (or sign assembly as required). Photographs should include a measuring device capable of being used to scale the approximate dimensions of sign and mounting details.
  - Night inspections are also recommended to ensure that the signs' retroreflectivity is adequate.
  - Where a sign is associated with an intersection layout, a sketch plan should be prepared showing the sign location within the intersection. This sketch should be included on, or cross-referenced to, the individual sign details shown on the sign inventory proforma.
  - Obtain sign data from the rear face of the sign (manufacturer's name, material class and date of manufacture). If this data is not available, determine the class of material and complete the details on the form.
  - Record mounting details. To collect details of mounting height, estimate the level of the edge of the traffic lane on the post, and then determine the three components of the mounting height on the respective points on the form. A stringline level may be used to assist in this task.

  - Complete the comment section on the form, noting especially details such as inappropriate location of a sign or sign assembly, conflict with other traffic devices, signs obscured due to trees or other local features, and any other comments that are relevant to the site. If necessary, photographs or sketches may be used to illustrate the comments.
  - Additional photographs (i.e. rear of sign) may be required if sign-mounting arrangements are not standard.
- Assemble inventory sheets (sign inventory proformas) and other data, match photographs, and mount photographs on inventory sheets. Ensure that all data pertaining to a sign is cross-referenced to additional information that may have been collected.

Figure C2 1: Sign inventory form

SIGN INVENTORY FORM:

Photo - film no ____________

Negative number ____________

LOCATION INFORMATION

Route number (major route) ____________

Road name (major road) ____________

Road name (side road) ____________

Side of major road
(left or right, in direction of travel) ____________

Side of minor road
(left or right, in direction of travel ____________

Sketch sign location on reverse side if required.

REGION: ____________

Inspected by ____________

Date ____________

SRRS Reference ____________

SRRS Reference Chainage ____________

Plus or minus ____________

SRRS Chainage to sign ____________

Distance down side road
(from edge of nearest
through lane) ____________

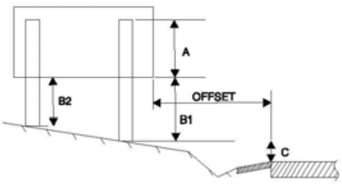
MOUNTING DETAILS

Mounting height (see diagram) A ______ mm

inner post B1 ______ mm

outermost post B2 ______ mm

C ______ mm



Offset from traffic lane
(nearest edge of lane to edge of sign) ____________ mm

Post type and size (circle selection)

Steel (GWI)

Strutted aluminium

Frangible timber

Other (describe)

Size ____________ mm (OD for round)

Number of posts ____________

Spacing ____________ mm

Post condition (circle choice) Can be reused

Not reusable

SIGN INFORMATION

Sign type (include reference number if known, ie. G1-V2)

Size

Height ________ mm

Width ________ mm (including chevron)

Lettering size ________ mm
(Capital Letter of Principal Legend)

Design number (copy attached) ____________

Sign Colour Legend ____________

Background ____________

Sign Face Material (Class)

Legend ____________

Background ____________

Sign condition code (circle choice)

A N1

N2 N3

A - Good Condition
Suitable for overlay
N1 - Sign colours do not match swatch samples
N2 - Sign damaged
N3 - Unacceptable day or night visibility

Designation on rear of sign

____

Source: VicRoads (2001).

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Commentary 3

The following information is based on guidance provided by the Department of Transport and Main Roads (2015) for the implementation of traverse rumble strips.

Rumble strips are to be reserved only for those rare locations where standard signing treatments do not (or are not expected to) provide adequate safety.

Rumble strips are transverse strips in the pavement, either raised above the pavement or grooves formed in the pavement, which give an audible and tactile sensation to the driver of a vehicle passing over them. They are placed so that the increased noise, vibration and occupant discomfort associated with the high speed of travelling over the strips will encourage drivers to reduce the speed of their vehicles.

The creation of rumble strips is achieved either by forming grooves in the pavement (hot asphalt) or grinding the existing pavement, or by the application of a raised tacked-on strip of rough pavement material constructed generally using a spray seal. An alternative to using spray seal is the application of recycled rubber rumple strips with standard module sizes of 1500 mm long, 600 mm wide, and 60 mm high.

Raised strips formed by spray seals are the preferred method for use at approaches to hazards or intersections. For temporary usage, recycled rubber rumble strips should be considered.

Rumble strips can also be used as a countermeasure for driver fatigue. However, the configuration and location need to be carefully considered and designed.

Prior to installing rumble strips, the following signing options should be considered:

- increased level of signing on the approaches by duplicating the recommended signs on both sides of the road
- provision of edge lines
- installation of retroreflective raised pavement markers to supplement separation lines and edge lines
- increased size of the recommended signs (and hazard markers where applicable)
- use of *reduce speed* signs. These should only be used where there is considerable danger to the motorist if this sign is disobeyed.

The above measures may be combined to achieve the desired level of warning. If the highest practicable level of signing still fails to produce a satisfactory result, the installation of rumble strips may be considered in conjunction with a high level of signing.

A high level of signing alone is generally more effective and less expensive than low-level signing with rumble strips.

A risk assessment should be undertaken to document the above considerations.

C3.1 Traverse Rumble Strip Spacing

The spacing of traverse rumble strips that should be used is that of a converging pattern of transverse strips placed so that a decelerating vehicle will strike the strips at a constant time interval of not less than 0.5 second. This requires about 20 strips for deceleration from 100 to 25 km/h.

Accordingly, it is recommended that a pattern of up to 10 strips should be used so that a strip is struck each second while decelerating at a comfortable rate.

Example traverse rumble strip configurations, including spacing, on the approach to an intersection for 100, 80 and 60 km/h approaches are shown in Figure C3 1, Figure C3 2 and Figure C3 3 respectively.

Figure C3 4 provides an example of a traverse rumble strip configuration used in fatigue zones. It is important that fatigue zone rumble strips be accompanied by appropriate fatigue signing, as shown in Figure C3 5.

For use at roadworks and temporary sites, the number and frequency can be reduced as the speed environment is much lower.

C3.2 Traverse Rumble Strip Dimensions

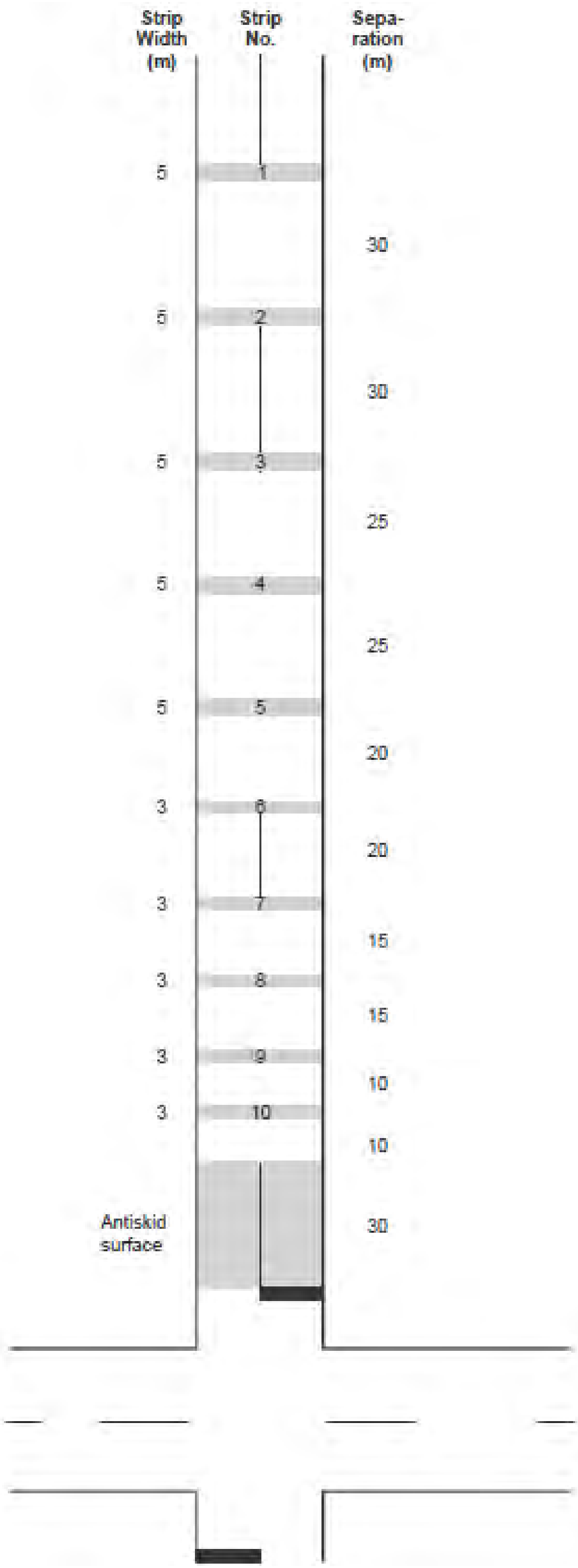
Traverse rumble strips are to be placed across the entire pavement to minimise driver avoidance.

The width of the individual rumble strip should not be less than the average car axle spacing. The recommended widths are shown in Figure C3 1 to Figure C3 4.

The height of strips is generally 10–20 mm and they are usually constructed by a polymer modified binder spray seal on the existing pavement.

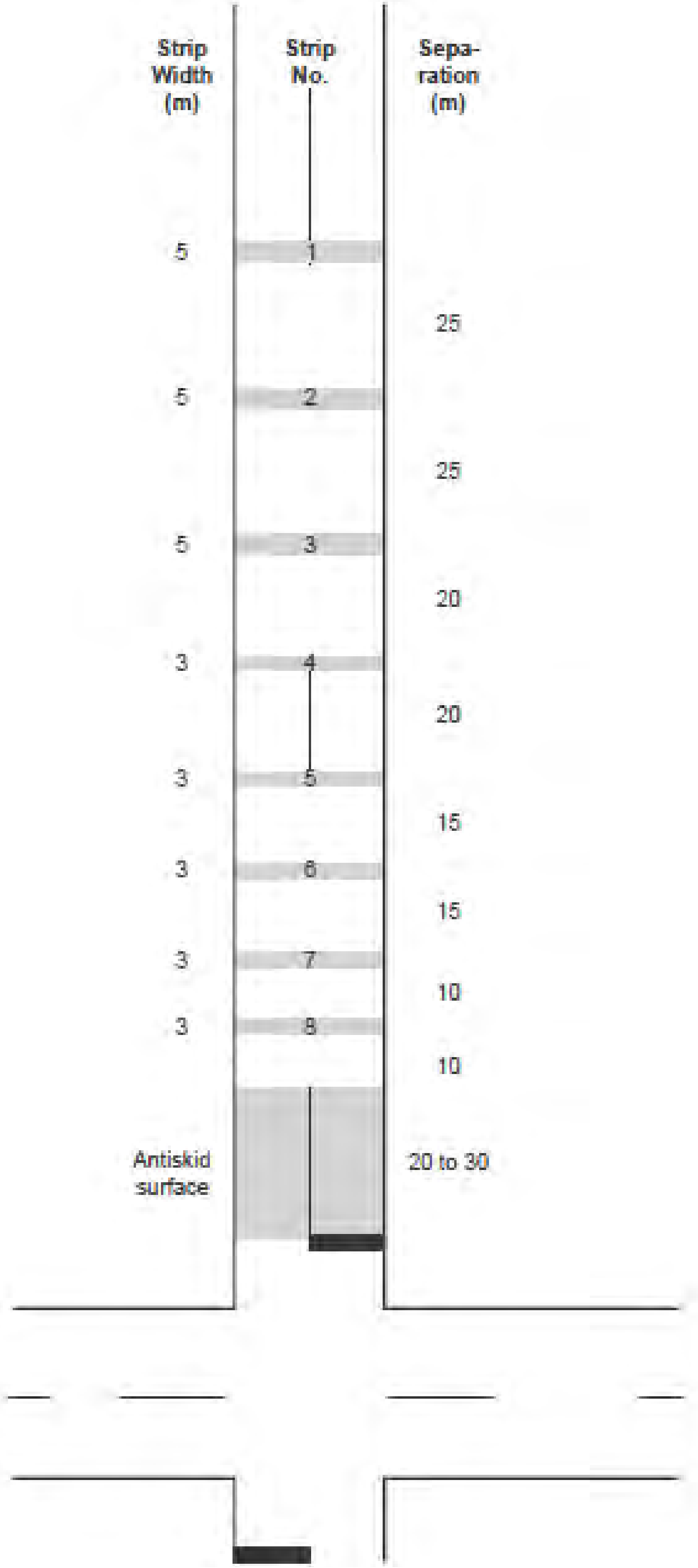
It is recommended that the last 15–30 m prior to the stop or give way line should be continuously treated with the same rough-textured material used for the rumble strips (asphalt or recycled rubber) to provide a rough surface on which to decelerate quickly should braking occur too late.

Figure C3 1: Rumble strip pattern for 100 km/h approach



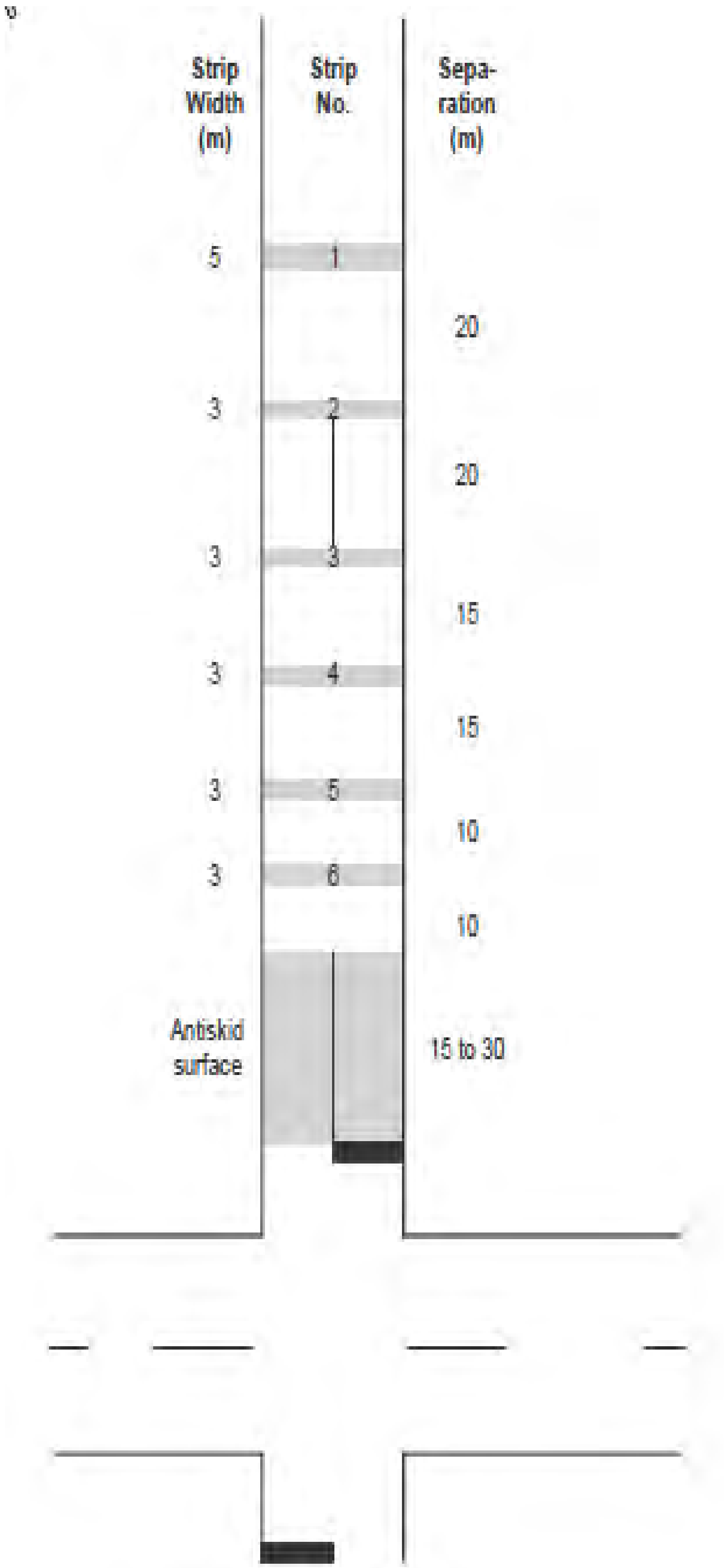
Source: Department of Transport and Main Roads (2015).

Figure C3 2: Rumble strip pattern for 80 km/h approach



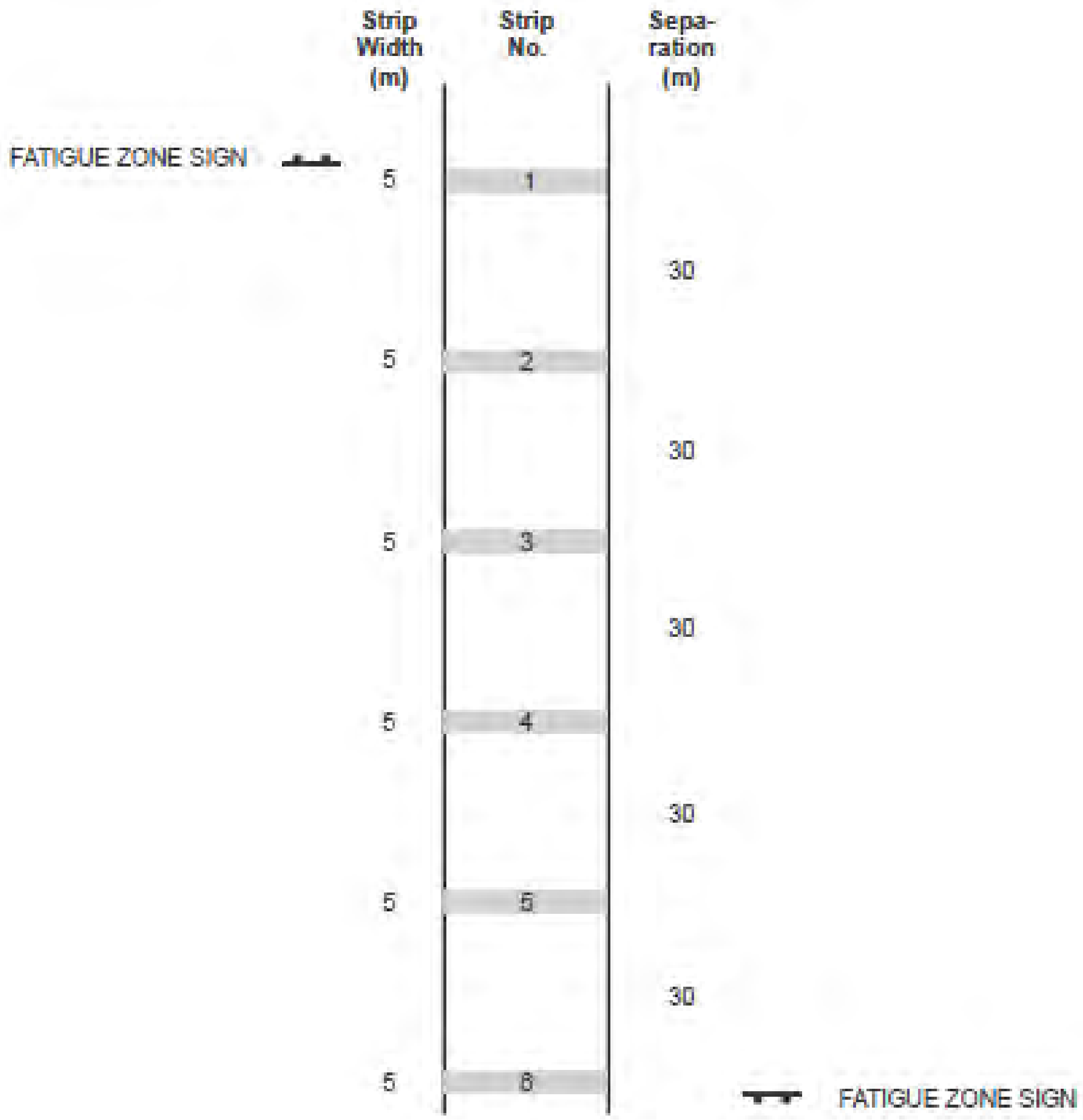
Source: Department of Transport and Main Roads (2015).

Figure C3 3: Rumble strip pattern for 60 km/h approach



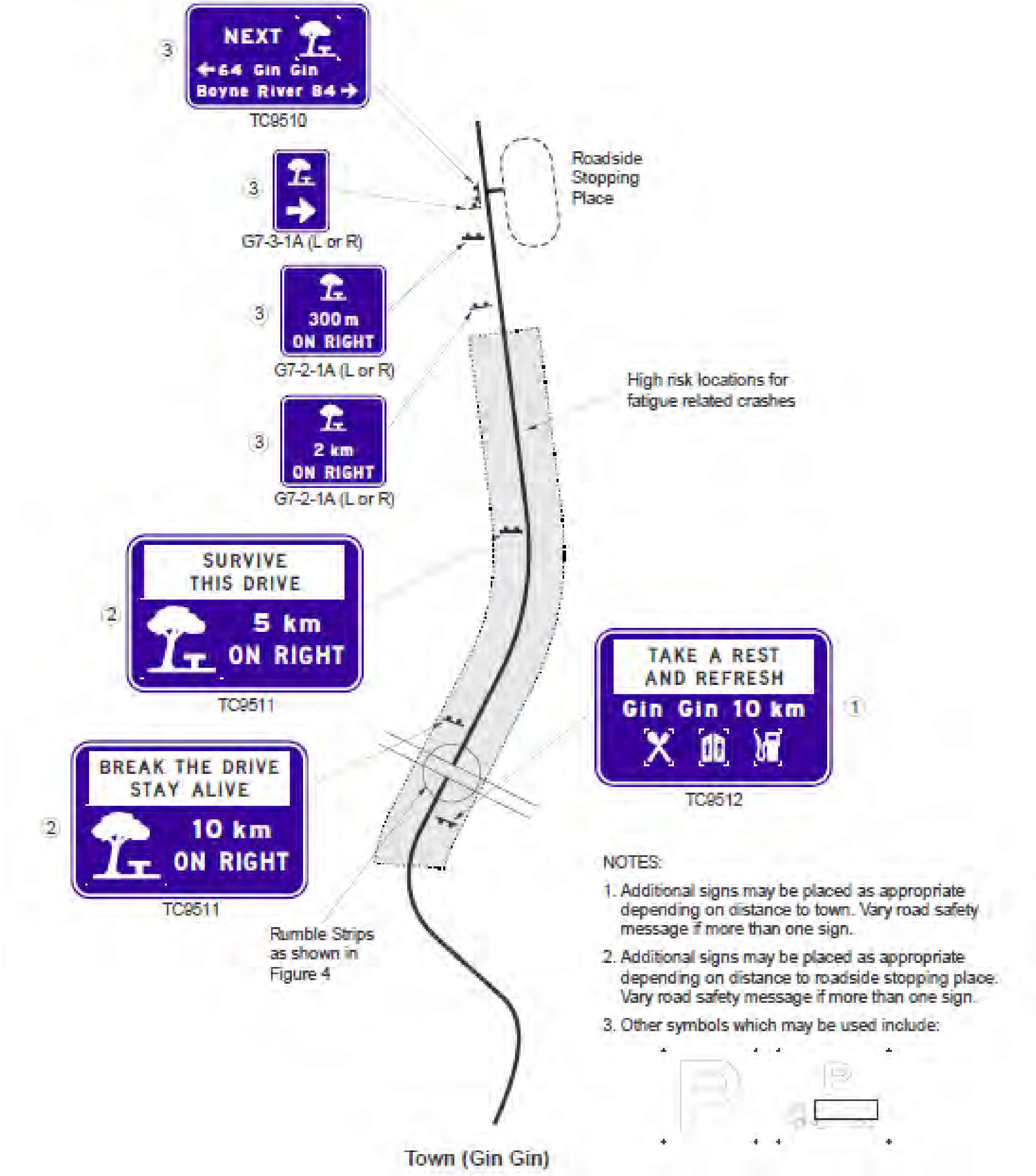
Source: Department of Transport and Main Roads (2015).

Figure C3 4: Rumble strip pattern for a fatigue zone (100 km/h approach)



Source: Department of Transport and Main Roads (2015).

Figure C3 5: Typical layout for signing and rumble strip pattern for a fatigue zone



Source: Department of Transport and Main Roads (2015).

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Austroads' *Guide to Traffic Management* captures contemporary traffic management practice including emerging techniques and technologies, and relevant international experience. It provides valuable guidance to practitioners in managing road traffic efficiently, safely and economically.

Guide to Traffic Management Part 10: Transport Control – Types of Devices provides guidance on the types of transport control devices (signals, signs, pavement markings and islands) available for the operational management of roads. It covers the devices that are suitable for use under different road corridor conditions to create a safer road environment for all users in temporary or permanent situations.

Guide to Traffic Management Part 10

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