Austroads

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Guidance and Readability Criteria for Traffic Sign Recognition Systems Reading Electronic Signs

Guidance and Readability Criteria for Traffic Sign Recognition Systems Reading Electronic Signs

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Abstract

This report proposes electronic sign readability criteria for use by jurisdictions in the design and testing of electronic signs. It considers the requirements of traffic sign recognition systems in current vehicles and those soon to enter the market.

It follows work undertaken in 2018 that identified that that leadership was required on readability criteria for electronic signs as it impacts a range of electronic assets including motorway and school zone Variable Speed Limit signs (VSLS), Lane Use Management Signs (LUMS) and Variable Message Signs (VMS).

The 2020 study found that emerging technologies and updates to standards in progress go some way to mitigating the issues previously observed. A coordinated drive is still needed across all road agencies to deliver harmonisation of the on-road assets and the standards used to test and validate these.

Keywords

Traffic sign, electronic traffic sign, readability, vehicle technology, autonomous vehicles

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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
- New Zealand Transport Agency.

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Summary

Traffic sign recognition systems are a key system used in automated driving and advanced driver assistance applications and have continued to evolve as OEMs work towards Autonomous Vehicles (AV). These systems are currently used to warn drivers when they exceed speed limits and, in the case of automated driving vehicles, to control speed of the vehicle in conjunction with other speed inputs.

A lack of consistency in the deployment of traffic signs in Australia, their size, angle, positioning and varied designs, can lead to them being unreadable by TSR systems.

The purpose of the project was to investigate the readability criteria that are suitable for consideration and adoption by the jurisdictions, along with the cost and feasibility of their implementation. This project assessed and proposes electronic sign readability criteria that are suitable for consideration and adoption by the jurisdictions in their electronic sign design and test specifications in light of requirements from current and near-future market in-vehicle traffic sign recognition systems.

Key Findings

The Australian Standards Road Traffic Signals Committee (LG006), having discussed Traffic Sign Recognition systems during the recent revisions to AS 4852.1, AS 4852.2 and AS 5156, has addressed some of the TSR readability issues with a series of new requirements. Consultation also indicated New Zealand are in the process of revising specifications for electronic signage which address some of the identified factors for recognition.

A common issue identified by OEMs which appears to have the greatest impact on the readability of electronic signs by TSR systems is LED flicker. Image artefacts may be caused by objects with changing or flickering illumination in an image frame and may include missing parts of an object, edge colour artefacts, and object distortion (Silsby, 2015). Flicker can not only be variable across different sign types (manufacturer, or design), but also be out of sequence across different sections of the signs (Austroads, 2018).

Other additional causes for artefacts include multiplexed displays. Artefacts affecting the performance of camera-based traffic sign detection may require a form of flicker mitigation to compensate. The widespread use of LEDs for automotive and traffic lighting in applications such as front and rear LED lights and electronic traffic signs has driven the development of LED flicker mitigation (LFM) capability within cameras sensors, ensuring pulsed light sources do not appear to flicker.

Recent developments in CMOS image sensors include LED Flicker Mitigation (LFM) while maintaining high dynamic range (HDR) output, limiting the appearance of flicker from LED lighting. There is currently no consensus within the automotive imaging industry as to what level of mitigation is required and there are currently no standards for LED flicker metrics and measurement procedures. This is being addressed as part of the IEEE P2020 Working Group on automotive image quality standards (Deegan, 2018).

Recommendations

It is not intended that road agencies immediately begin implementing changes to on-road assets to support Traffic Sign Recognition systems. As with any other change in standards, a transition process is required during which road agencies will begin to implement these changes in a manner which is determined by their priorities and resources.

However, it should be noted that some road agencies have already begun to implement some of the recommendations of the report. The discretion of each road agency is required to develop a program for implementation and funding for these changes to occur. It is most likely that this will be done under existing maintenance programs.

Jurisdictions were approached to provide detail on assets and renewal plans, unfortunately the level of detail disclosed by jurisdictions and stakeholders does not allow a detailed assessment of the current costs and efforts at this stage. The potential enhancements that may be deployed are variable and subject to a scalable implementation to increase compatibility with TSR systems. This could range from simple firmware updates in assets to more complex replacements of hardware. The cost of implementing these enhancements would vary from a million to tens of millions of dollars depending on the manufacturer, model and number of devices deployed by each jurisdiction.

It is anticipated that the next steps will be to:

- revise road agency specifications to align with updated AS 4852.1, AS 4852.2 and AS 5156
- harmonise testing and certification with standards for Automotive Vision Systems being developed by the IEEE P2020 Working Group
- consider incremental retrofit of existing assets where feasible or deemed necessary as part of renewal plans.

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1. Introduction

1.1 Context

In 2018, the Austroads project *Implications of Traffic Sign Recognition for Road Operators* (CAV6056) found that electronic signs could not be consistently read by Traffic Sign Recognition (TSR) systems. TSR technology is a key component used in automated driving systems (ADS) and advanced driver assistance systems (ADAS). These systems currently warn drivers when they exceed speed limits and in the case of automated vehicles, to control the speed of the vehicle in conjunction with other speed inputs[1]. Along with recommendations within other Austroads reports (Austroads, 2018) and Vehicle OEMs, further investigation was proposed to identify the readability of Variable Speed Limit Signs (VSLS) and provide changes to Australian and New Zealand Standards for road traffic signage.

Traffic sign recognition systems are a key system used in automated driving and advanced driver assistance applications and have continued to evolve as OEMs work towards Autonomous Vehicles (AV). These systems are currently used to warn drivers when they exceed speed limits and, in the case of automated driving vehicles, to control speed of the vehicle in conjunction with other speed inputs.

To note, from 1 January 2018, the Australasian New Car Assessment Program (ANCAP) safety rating process expanded to additional areas of assessment, including active safety features such as Autonomous Emergency Braking (AEB), Lane Support Systems (LSS) and Speed Assistance Systems (SAS). Major OEMs are now compelled to include TSR technology in their models in order to achieve a 5-star rating. A key system used in automated driving and Advanced Driver Assistance Systems (ADAS) is TSR.

1.2 Purpose

The purpose of the project was to investigate the readability criteria that are suitable for consideration and adoption by the jurisdictions, along with the cost and feasibility of their implementation. This project assessed and proposes electronic sign readability criteria that are suitable for consideration and adoption by the jurisdictions in their electronic sign design and test specifications in light of requirements from current and near-future market in-vehicle traffic sign recognition systems.

1.3 Scope of the Project

The scope of this project involved identifying the latest available information on the development of Traffic Sign Recognition (TSR) systems and issues with readability of electronic signs, analysing the current Australian and New Zealand Standards of relevance, and engaging with road agencies to understand their current practices and to develop actions resolving any identified gaps.

The project explored:

- existing global TSR implementations
- electronic signage (technologies, specifications, requirements, information relating to existing assets)
- adapting these findings to the local market
- ensuring a clear and practical output is available for use by stakeholders.

[1] Standard map/navigation technologies, 'HD' ADAS mapping technologies which include lane geometry and road objects, and connected devices (either vehicles or infrastructure) providing road and traffic information

The focus of the project was to investigate the readability criteria suitable for consideration and adoption by the jurisdictions, along with the cost and feasibility of their implementation. The key objectives were to:

- undertake a review of current national and international best-practice approaches relating to TSR technologies
- undertake a review of current national and international approaches relating to electronic sign design and test specifications
- research new and emerging techniques and technologies both national and international that support TSR readability with electronic signs
- lead the facilitation between road members to consolidate the findings of the reviews and work with the members to understand the pathways needed to commonly agreed criteria
- consult with external stakeholders such as sign suppliers and suppliers of machine vision systems to further understand the challenges that are being reported and the desirable changes to address these
- document and test readability criteria, and asses the costs and ease of incorporation by road members
- work with the road agency members to establish the base criterion across all members along with desirable criteria which may not necessarily be readily achieved by all member states.

Within the scope of this project, the technologies that are considered include, electronic signs that apply across all roadway levels, in permanent or temporary configuration, including but not limited to considerations of motorways and school zones as previously identified as most critical by the vehicle industry. These include:

- Lane Use Management Signs (LUMS)
- electronic speed limit signs
- variable message signs – considering both text and pictogram displays
- changeable message signs – considering both text and pictogram displays.

Additionally, the project includes within its scope, sign performance criteria including (but not limited to):

- size
- height
- approach angle
- sign’s power source
- contrast and adaptability to ambient light
- refresh rates, including pixel scanning method.

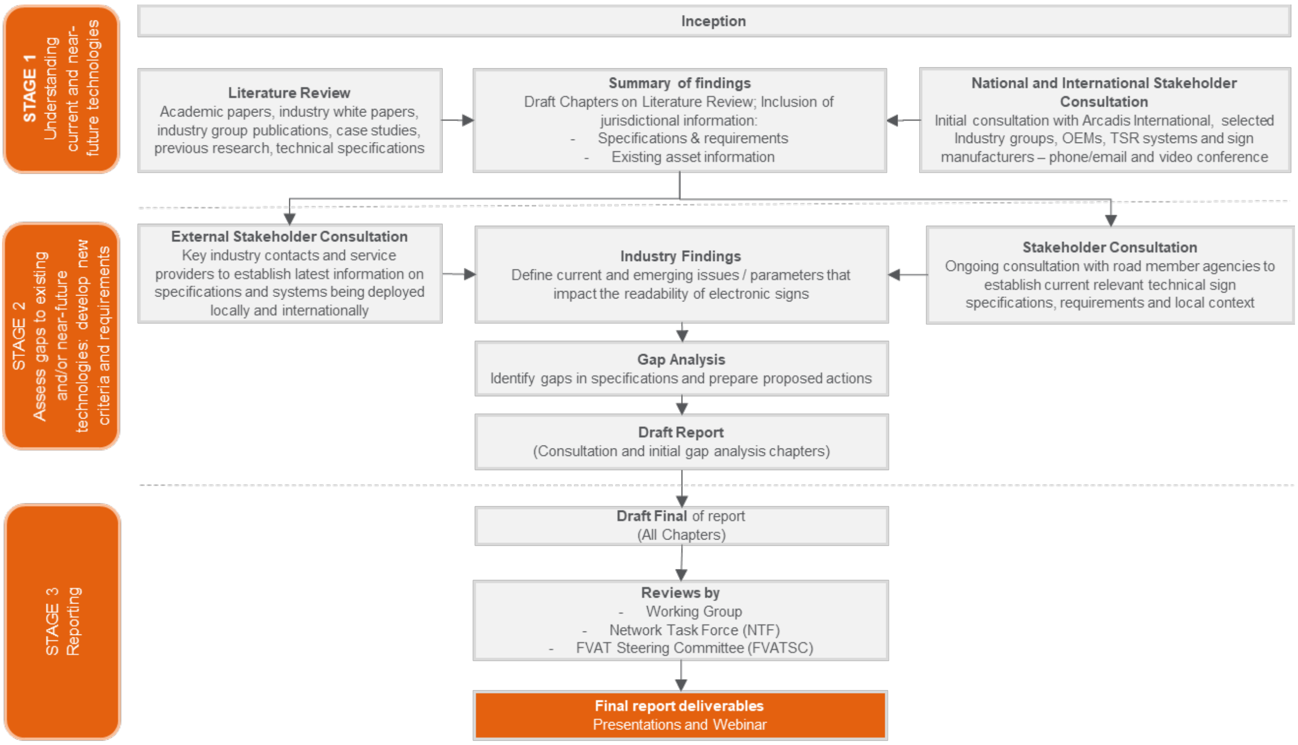
1.4 Methodology

The Project Working Group (PWG) included Austroads’ member agencies and representation from the Future Vehicles and Technology Program[2]. This Group was the key quality review and technical stakeholder subject matter experts throughout the project.

The methodology was focused around three key stages, as shown below, to deliver the outcomes of the study.

[2] https://austroads.com.au/about-austroads/future-vehicles-and-technology

Figure 1.1: Flowchart summarising methodology used



1.4.1 Stage 1: Understanding Current and Near-future Technologies

Consultation took place with the Project Working Group (PWG) members to understand the relevant technical sign specifications, quantity and placement of assets and existing design requirements for electronic signage. This assisted in establishing an understanding of current and near-future electronic sign technologies to ensure the local context and adaption of the literature review findings.

In conjunction with the initial consultation and development of the PWG, a comprehensive literature review of publicly available documents, previous research on the topic and any relevant technical sign specifications or requirements from road agencies in Australia and overseas was undertaken. This included analysis of existing information on electronic signage made available by the various member agencies, such as specifications, requirements and information relating to existing assets and research on the topic of electronic sign readability by in-vehicle TSR systems.

1.4.2 Stage 2: Assess Gaps to Existing Technologies and/or Near-future Technologies: Develop New Criteria and Requirements

Following the consultation within Stage 1 of the project, further engagement with stakeholders was undertaken to determine existing and/or emerging technologies, key issues and additional parameters impacting the readability of electronic signs.

The following areas were considered in these consultations:

- key parameters that impact the readability of electronic signs by TSR systems
- issues which arise out of these parameters
- latest information on the development of TSR systems
- latest information in the development of electronic signs
- impact of these emerging and near-future developments on sign readability.

In this Stage of the analysis, technologies and requirements which can impact readability, including the review process, their ability to affect readability (aiding or hampering) were compared to existing local standards and specifications.

The main objective of the gap analysis was to identify gaps in specifications and recommend a common standard to achieve consistent levels of performance across all Australia jurisdictions and New Zealand.

As in the earlier stages, continued work with Austroads member agencies was undertaken to confirm that:

- Any proposed actions include criteria and requirements for their electronic sign design and test standards and specifications to address the needs of electronic sign readability by TSR systems.
- Criteria and requirements cover aspects relating to the development, design, construction, testing, commissioning, operations and maintenance.
- Criteria and requirements allow vehicle manufacturers and sign suppliers to work to achieve consistent levels of performance of TSR systems.
- Jurisdictions understand and can assess the costs and efforts of implementation.

1.4.3 Stage 3: Consolidated Reporting

Through careful consideration and amendments to address any feedback, the updated documents for each successive Austroads review were prepared. Where required, additional comments and clarifications of the proposed changes were provided via teleconference during the review and approval process. Additionally, quality control procedures ensured that all revisions and edits are tracked and audited prior to release of the documents.

The final full report consists of the following sections:

- an outline of the purpose of the project and methodology adopted
- a review of literature outlining current/existing technologies used by the various jurisdictions
- a summary of existing and emerging technologies identified during the review that which present readability requirements, and where potential exists for future specifications to address gaps
- proposed actions, readability criteria and requirements which allow understanding and assessment of costs and efforts for implementation
- recommendations for new criteria and requirements on electronic sign readability by TSR system, based on the consultation and review of available literature.

1.5 Audience

It is understood that the audience for this work will be the Austroads' member agencies, vehicle manufacturers, suppliers of machine vision systems and local government and State road agencies.

While OEMs are not the primary audience, they will need to account for any guidance produced in the specification of future CAV products in Australia.

This document can assist all key industry and government stakeholders to better understand the latest information on the development of TSR systems.

It also aims to be a conversation starter for future collaboration on the development of a suitable definition of electronic sign readability criteria. The adoption of such a definition will aid in further developing design and test specifications supporting in-vehicle traffic sign recognition systems.

1.6 Relevant Terms

Table 1.1: List of abbreviations used in this report

Abbreviation	Expansion
ACC	Adaptive Cruise Control
ALC	Adaptive Light Control
ASR	Adaptive Speed Recommendation
ADAS	Advanced Driver-Assistance Systems
AEBS	Advanced Emergency Braking System
APGS	Advanced Parking Guidance System
FV&T	Austroads' Future Vehicles & Technology Program
ADS	Automated Driving System
AV	Automated Vehicles
ASCD	Automatic Speed Control Device
AEB	Autonomous Emergency Braking
CCD	Charge-Coupled Device
CAS	Collision Avoidance System
DDT	Dynamic Driving Task
FCW	Forward Collision Warning
GTSRB	German Traffic Sign Recognition Dataset
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HALE	HDR and LFM Engine
HDR	High Dynamic Range
ISP	Image Signal Processor
IOO	infrastructure owner and operator
IHC	Intelligent High-Beam Control
IPAS	Intelligent Parking Assist System
LC/LCA	Lane Centering / Lane Centering Assist
LDW	Lane Departure Warning
LKA/LKS	Lane Keeping Assist/System
LFM	LED Flicker Mitigation
LED	Light Emitting Diode
OEM	Original Equipment Manufacturer
PCAM	Pedestrian Crash Avoidance Mitigation
SRS	Supplemental Restraint System
TJA	Traffic Jam Assist
TSC	Traffic Sign Classification
TSD	Traffic Sign Detection
TSR	Traffic Sign Recognition
TNC	Transportation Network Company
TBT	Turn-by-turn

2. Current Electronic Traffic Signs and Technologies

This section provides an analysis of the current electronic traffic signs and technologies. This include traffic sign recognition systems, traffic signs, legacy and provides a review of current Australian Standards, New Zealand Traffic control devices, and recognition of electronic signs.

2.1 Traffic Sign Recognition (TSR) Systems

Traffic sign recognition systems are a key system used in automated driving and advanced driver assistance applications and have continued to evolve as OEMs work towards autonomous vehicles (AV). These systems are currently used to warn drivers when they exceed speed limits and, in the case of automated driving vehicles, to control speed of the vehicle in conjunction with other speed inputs.

From 1 January 2018, the Australasian New Car Assessment Program (ANCAP) safety rating process expanded to additional areas of assessment, including active safety features such as autonomous emergency braking (AEB), lane support systems (LSS) and speed assistance systems (SAS). Major OEMs are now compelled to include TSR technology in their models in order to achieve a 5-star rating.

2.2 Traffic Signs

It has been identified that there is a lack of consistency in the deployment of traffic signs in Australia, their size, angle, positioning and varied design. This can lead to this signage being unreadable by TSR systems. Additionally, it is observed that there are limitations of functionality for standard TSR systems in managing speed and lane usage. It is therefore essential that road agencies are provided with the guidelines that enable effective design, installation and maintenance of electronic traffic signs to ensure they remain compatible with in-vehicle systems.

2.2.1 Electronic/Variable Speed Limit Signs (ESLS/VSLS)

Electronic or variable speed limit signs (ESLS/VSLS) in this discussion are defined as fixed roadside installations, rather than portable devices commonly used at worksites. An example is provided in Figure 2.1.

Figure 2.1: Photograph of an ESLS

Source: Shutterstock (2019)

Like their static speed limit sign counterparts, ESLS/VSLS must comply with the specified requirements in the jurisdiction specifications and AS1742.4. The difference with ESLS/VSLS is that their displays can be changed by electronic means.

2.2.2 Integrated Speed and Lane Use Signs/ Lane Use Management Systems (ISLUS/LUMS)

Common practice is to refer to signs that can only display regulatory speed limits as ESLS/VSLS, and to refer to signs that can only display lane use designation symbols (typically arrows or crosses) as LUS. Where VSLS and LUS functions are combined in a single sign, they are often called Integrated Speed and Lane Use Signs (ISLUS) and the combined system can be referred to as a Lane Use Management System (LUMS).

For the purposes of this discussion ISLUS are defined as electronic signs capable of displaying variable speed limits along with lane closures or lane diverts, mounted overhead. An example of this signage is provided in Figure 2.2.

Figure 2.2: Photograph of an ISLUS

Source: Shutterstock (2019)

2.2.3 Variable Message Signs (VMS)

Common types of variable message signs in use by road network operators currently are electronic LED driven boards capable of displaying 2 to 3 lines of amber text against a black background. Recent installations are often capable of displaying symbols or pictograms in at least part of the display area, and latest road agency specifications tend to define multi-colour capability as well.

Variable Message Signs (VMS) in this discussion are fixed roadside installations (see Figure 2.3), rather than portable or vehicle mounted devices, which depict both text-based driver information and pictograms.

Figure 2.3: Photograph of a VMS

Source: Shutterstock (2019)

2.2.4 Electronic Message Signs (EMS)

Electronic message signs are generally installed where high visibility is required and/or the message is only required at certain times. In several States and territories these may be referred to as Internally Illuminated Message Signs (IIMS) and could encompass a wide range of devices. For the purposes of this discussion only those listed below are included, and both speed and variable message signs are excluded. Additionally, it is noted that EMS can include prismatic signs and other signs that are electronically driven and do not use LEDs (notwithstanding the flip dot displays discussed in Section 2.3.1). It is recognised that some roads still deploy these types of signs to display changeable speed limits.

2.2.5 Changeable Message Signs (CMS)

Another class of electronically driven signage is known as Changeable Message Signs (CMS). Note this term is commonly used, although these may also be referred to as Dynamic Message Signs (DMS) in other jurisdictions or transport literature. CMS can also refer to static signs with changeable portions in the sign face which operate on rotating prisms. For the purposes of this discussion CMS will refer only to electronic (LED) displays.

2.2.6 Ramp Control (RC) Signs

Ramp control (sometimes referred to as ramp metering) signs are typically used as part of a Freeway Ramp Signal installation to provide drivers with advanced information regarding the operation of ramp signals or advice regarding when a freeway ramp has been closed. In some jurisdictions, these may also include small variable message signs, capable of providing travel times to key locations or notifications of freeway incidents. For the purposes of this discussion, the focus will be on the control aspects of these devices, specifically ramp closure using messages such as ‘No Entry’, ‘No Left Turn’, ‘No Right Turn’ or ‘Freeway Closed’.

2.2.7 Portable/Trailer Signs (Portable VMS)

Portable/Trailer Signs are commonly used during road works, where portable or trailer mounted LED boards are capable of displaying several lines of text against a black background, and are often a variety symbols or pictograms, including speeds. Portable Variable Message Signs (VMS) in this discussion are defined as trailer or vehicle mounted devices, which can depict both text-based information and pictograms. Examples are provided in Figure 2.4.

Figure 2.4: Photograph of a portable VMS

Source: Shutterstock (2019)

2.3 Legacy Devices

While less common than LED, there is still the occasional legacy technology in use within some jurisdictions. This section provides a brief summary of legacy devices.

2.3.1 Flip Pixel/Dot/Disc Displays

These displays comprise of an electromechanical matrix display consisting of an array of pixels (often referred to as dots or discs) which can be energised to trigger rotation, altering the pixel orientation. This results in an alternate surface being displayed, often a highly reflective or luminous surface, which forms the message on the monochrome display.

2.3.2 Fibre Optic Displays

These include displays which commonly consist of optical fibres, illuminated by bulbs, which are arranged to form messages. These are often used where messages are required at specific times of day, or multiple messages are required in the one display. Messages, or parts of, could be altered by the illumination of specific fibres, resulting in a variety of frames or colours on the display.

2.3.3 Neon / Fluorescent Tube Illuminated Displays

These displays are often used where messages are required at specific times of day, or under specific circumstances. These displays consist of a backlit message, illuminated by the light from a lamp.

2.4 Australian Standards

2.4.1 Variable Speed Limit Signs

Variable speed limit sign displays (either mechanical, electrical or electronic) require compliance with the Australian Standards for displays that are identical in design and colour to the Speed Restriction[3] (R4-1) sign or for displays that are identical in layout, however are illuminated with white numerals within an illuminated red annulus on a black background. The sign may be rectangular or square and equipped with flashing yellow lights[4] which operate when a reduced limit is being displayed. Alternatively, the inner section of red annulus may be flashed[5] .

Australian Standard – Manual of Uniform Traffic Control Devices (AS 1742)

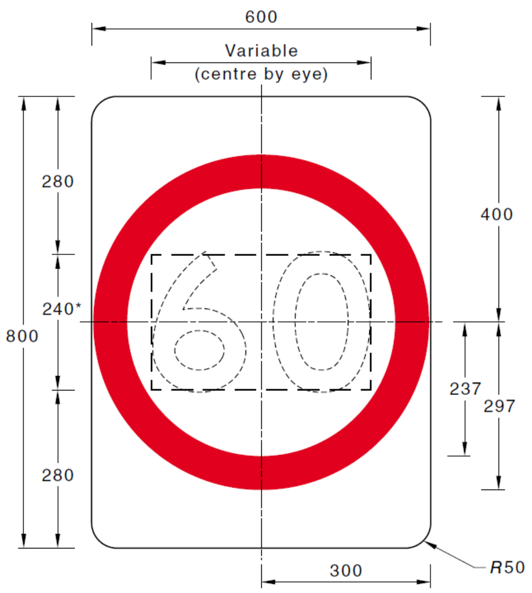
The AS 1742 series comprises fourteen individual parts specifying the sign classifications, numbering and basic design of signs including colour, shape and size. Detailed specifications for the design and manufacture of signs are provided in AS 1743 'Road Signs – Specifications' and the requirements for the letters and numerals used are included in AS 1744 'Standard alphabets for road signs'.

AS 1742.4 specifies the traffic control devices to be used for the regulatory control of traffic speed. Its objective is to provide a set of uniform requirements and guidelines for the regulatory management of traffic speeds and includes a section on the implementation of variable speed limits. Apart from the option of a square background, this section requires electronic signs to comply with the dimensions of a Speed Restriction (R4-1) sign from AS 1743, illustrated in Figure 2.5.

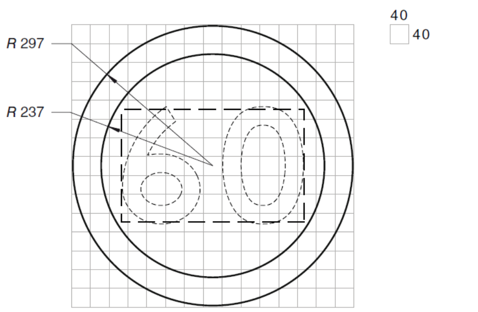
Australian Standard – Road Signs – Specifications (AS 1743)

The objective of AS 1743 is to provide a standard design or design rules for the shape and graphic content of signs. This includes regulatory signs, for which non-compliance constitutes an offence of the law. Regulatory signs include text-based signs, such as 'STOP' and 'GIVE WAY' and several symbolic signs, such as 'NO RIGHT TURN'. Speed Restriction (R4-1) signs are defined in Appendix G and detailed in Figure 2.5.

Figure 2.5: Speed restriction (R4-1) sign



Sign sizes, mm
R4-1A 450 × 600
R4-1B (Illust.) 600 × 800
R4-1C 900 × 1200
R4-1D 1200 × 1600



* 2 numerals (plus '110', '115')—240 D
3 numerals (other)—240C

Source: AS 1743

[3] AS 1742.1-2014 Clause 2.4.4 Speed Series – R4
[4] Often referred to as conspicuity devices
[5] AS 1742.4-2008 Clause 3.5 Variable Speed Limits

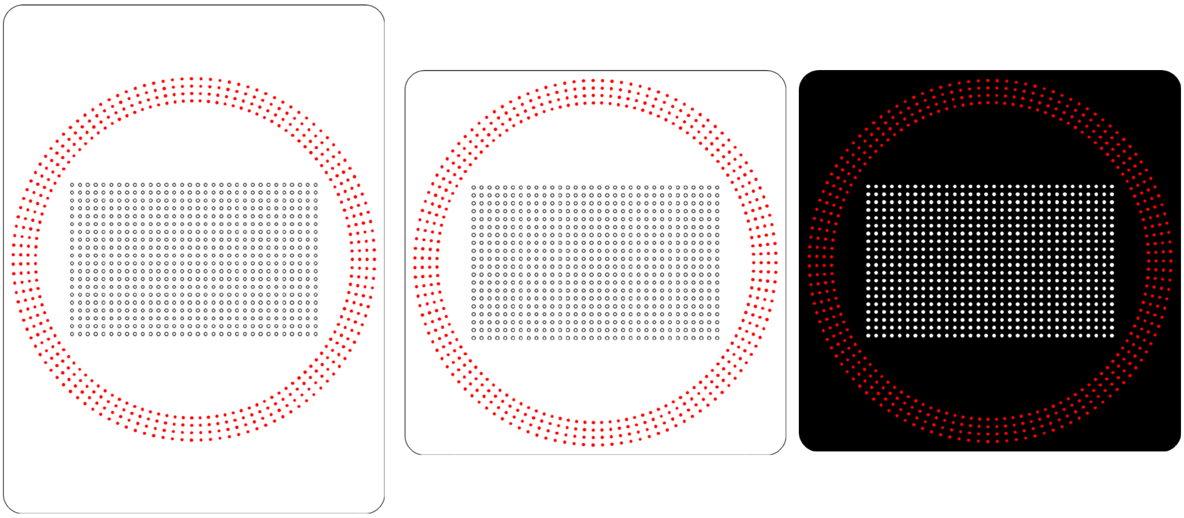
Australian Standard – Standard Alphabets for Road Signs (AS 1744)

Standard alphabets are provided in AS 1744 to establish uniformity in the forms and dimensions of letters, numerals and symbol characters. Alphabet and spacing values are based initially upon the Federal Highway Administration (FHWA) Series 2000 fonts developed by the US Department of Transportation. Both Series C and Series D are utilised in the design of Speed Restriction signs.

Australian Standard – Electronic Speed Limit Signs (AS 5156)

Electronic variable speed limit signs are speed restriction signs that are composed of discrete light-emitting elements for the purpose of communicating speed restrictions to road users. These often consist of technologies, such as light-emitting diodes (LED), either individually placed or clustered to produce pixels. These pixels are then used for generating and displaying speed limits as specified in AS 1743 for R4-1 signs. The numerals generated on the display shall, as near as practicable, comply with AS 1744 and are created by either a matrix or discrete characters[6]

Figure 2.6: Example of electronic speed restriction (R4-1)



2.4.2 Variable Message Signs

Australian Standard – Variable message signs (AS 4852)

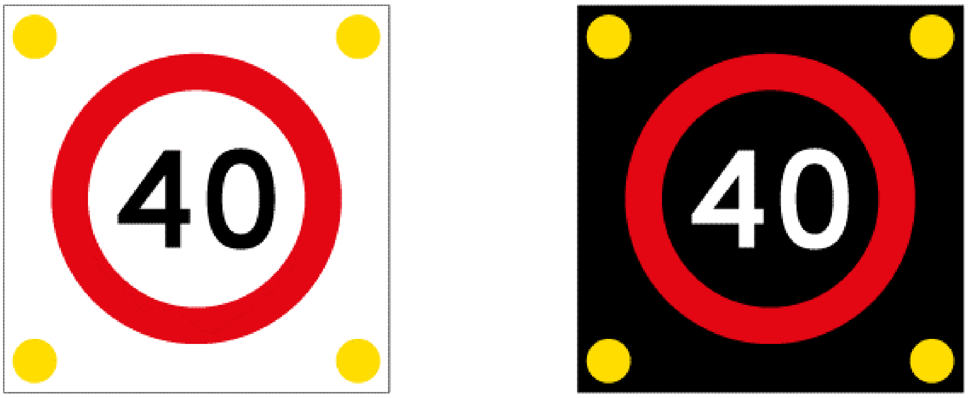
This standard covers electrically powered, on-road, variable message signs used for traffic management and/or driver information applications. Included are two parts, the first of which covers 'Fixed Signs' where the display is mounted in a permanent position and the second 'Portable Signs' where the display is mounted and deployed on a relocatable trailer. Appendix B of AS4852.1:2009 previously defined the fonts for use on these signs, the updated edition AS4852.1:2019 requires the signs be capable of supporting at least five fonts, including Font 1 and Font 2.

[6] AS 5156 Section 2.1 Display Requirements

2.5 New Zealand Traffic Control Devices

While New Zealand is not a signatory to the Vienna Convention on Road Signs and Signals, its road signs are generally similar in design. Speed limitations are displayed in black digits centred in a red circle on a white background as described above in AS 1743. Signs in New Zealand are prescribed in the Land Transport Rule: Traffic Control Devices 2004 and detailed in the Traffic Control Devices (TCD) Manual. Two options are permitted for variable speed limit signs, R1-2 and R1-2.1 shown in Figure 2.7

Figure 2.7: Variable speed limit signs R1-2 (left) and R1-2.1 (right)



In R1-2 the speed limit numerals, roundel and background are displayed in the same colours as permanent speed limit signs, namely black, red and white respectively. Mechanical elements are used to display the speed limit and the message is depicted entirely with retro-reflective material.

In R1-2.1 the speed limit numerals are displayed using yellow or white, lit pixels (e.g. light emitting diodes, fibre optics). The background is black and unlit. For signs that display only the 40km/h variable speed limit and are blank for the rest of the time, the roundel is displayed with red, lit pixels. Alternatively, for signs that display the permanent speed limit at times when the variable speed limit does not apply, the roundel may be displayed with either red, lit pixels or with red retro-reflective material (NZTA, 2011).

2.6 Recognition of Electronic Signs

When identifying these displays, TSR systems are impacted by a multitude of factors including, but not limited to:

- placement (notably the difference of detection efficiency between roadside position relative to above-road detection by TSR systems may be warranted)
- design
- contrast and adaptability to ambient light.

While drivers are able to process the sign face in microseconds and respond accordingly, TSR systems have the challenge of needing to identify the sign in an image, rank this for its intended purpose before deriving what, if any, action is required. Whilst seemingly simple, this complex task is subject to the factors above.

These challenges, which differ from device to device and between states, introduce inconsistency for OEM developed TSR systems which are deployed in the vehicle fleet across the country. These inconsistencies lead to the potential that as more TSR systems enter the market, the varying effect of their performance may degrade the safety benefits they are aiming to achieve.

‘Implications of Traffic Sign Recognition’ highlighted the need for collaboration between the vehicle industry and road operators in order to achieve TSR system reliability and encouraged further development from OEMs to ensure their TSR systems suit Australian and New Zealand practices. (Austroads 2018)

Several of the factors above were considered during the evaluation of these systems and recommendations for managing these factors were provided. Recommendations warranting further investigation included ‘Readability of VSLS’ which has been developed to include the following factors:

- design
  - size
  - display form/shape
    - equivalent area
    - pixel size and spacing
    - stroke width
  - border
  - text
  - numerals
- contrast and adaptability to ambient light
  - contrast
  - luminance ratio (reflectivity / contrast)
  - luminance intensity uniformity
  - colour consistency
  - dimming
- stability of display
  - fault scanning
  - refresh rates
  - flashing
  - multiplexed displays.

3. Literature Review

This section represents a summary of our findings on literature and specifications in Australia and internationally that guide traffic sign practices. The literature review was used as a resource to establish an understanding of the current practices for design and testing of electronic signs, applicable agency specifications and international research into readability by traffic sign recognition systems.

3.1 Evaluation Process

A range of databases and resources were researched as part of the literature review. These included:

- European ITS Platform (EUEIP) / EasyWay
- Comite Europeen de Normalisation (EN)
- US Department of Transportation (USDOT)
- Federal Highway Administration (FWHA)
- Standards Australia
- International Organization for Standardization (ISO)
- International Electrotechnical Commission (IEC)
- Institute of Electrical and Electronics Engineers (IEEE)
- International Society of Automation (ISA)
- ResearchGate
- Ingenta Connect
- Search engines e.g. Google and Google Scholar.

3.2 National and International Specifications

3.2.1 Australia

Australian Standards AS 1742 and AS 1743 provide agencies design and placement practices. When these are suitably implemented, these provide consistency and uniformity in the use of control devices. In addition to these, the Austroads *Guide to Traffic Management Part 10: Traffic Control and Communication Devices* provides guidance on the suitable use of signs, markings and devices.

Several standards are prepared by the LG-006 Road Traffic Signals Committee, representing most of the agencies listed below in Table 3.1, and are currently under review. The most notable of these include:

- AS 5156 Electronic speed limit signs
- AS 4852.1 Variable message signs, Part 1: Fixed signs
- AS 4852.2 Variable message signs, Part 2: Portable signs

Individual agencies further define their requirements for Traffic Control devices though state specifications. These often reference the Australian Standards described above, and include variations to the requirements where business needs have instigated change. Traffic sign types with state level specification and guidance are shown in Table 3.1 below and further details can be found in Appendix A.

Table 3.1: Incidence of specification/guidance document by state

Traffic Sign Type	QLD[7]	VIC[7]	NSW[7]	WA[7]	SA[7]	ACT	NT
Electronic Speed Sign Specification (ESLS/VSLS)	✓	✓	✓	✓	✓	✓	
Lane Use Specification (LUMS/ISLUS)	✓	✓	✓		✓		
Variable Message Sign Specification (VMS)	✓	✓	✓	✓	✓	✓	
Temporary ESLS/VSLS Specification (Trailer)	✓	✓		✓			
Temporary VMS Specification (Trailer)	✓				✓		
Ramp Control Specification (RAMP/RC)		✓	✓		✓		
CMS Specification (Generic & Lane Control)	✓	✓	✓		✓		
CMS Specification (NLT/NRT/No Entry)		✓	✓		✓		
CMS Specification (VAS)	✓	✓	✓		✓		

3.2.2 New Zealand

The Austroads Guide to Traffic Management Part 10 applies to both Australian agencies and New Zealand, although it is important to note the different specifications and implementation present in New Zealand. Specifically, New Zealand is not a member of the LG-006 Road Traffic Signals Committee and the standards referenced in 3.2.1 do not apply.

Several specifications apply to the use of electronic traffic signs, covering the detailed requirements for Fixed and Portable Variable Message Signs and Ramp Meter site configurations which are listed in Table 3.2.

Table 3.2: New Zealand traffic sign specifications

Traffic Sign Type	Specification
Electronic Speed Sign Specification (ESLS/VSLS)	Traffic control devices manual (Sign specification RS1V, Rule R1-2.1)
Lane Use Specification (LUMS/ISLUS)	
Variable Message Sign Specification (VMS)	ITS-06-01[8] & Traffic control devices manual (Sign specification RB2, Rule R7-10.1)
Temporary ESLS/VSLS Specification (Trailer)	
Temporary VMS Specification (Trailer)	ITS-06-04[9]
Ramp Control Specification (RAMP/RC)	ITS-05-01, ITS-05-02 & ITS-05-03
CMS Specification (Generic & Lane Control)	
CMS Specification (NLT/NRT/No Entry)	
CMS Specification (VAS)	

[7] Represented on Committee LG-006
[8] Visual performance of VMS in New Zealand are in accordance with EN 12966-1
[9] Visual performance of Mobile VMS in New Zealand are in accordance with EN 12966-1

3.2.3 International

It was identified that no evidence was found during the literature review that any international authority has implemented or planned to implement specific practices to accommodate TSR systems. The following are publications found which provide guidance on the design of Variable Message and Variable Speed Signs and the impact of automotive imaging systems.

IEEE P2020 - Automotive Image Quality Working Group

The Working Group on Automotive Imaging Standards was established in order to address the considerable ambiguity in measurement of image quality of automotive imaging systems and has commenced work on development of a new standard. Currently, there is not a consistent approach within the industry to measure automotive image quality and image quality plays a crucial role in automotive computer vision applications.

This work identifies gaps in existing standards and attempts to address these by creating a set of key performance indicators for evaluation. This has led to observations of temporal responses, namely the flicker from LED light sources. As there are no existing industry standards, it is understood that there is a need to cover the emerging use of LED light sources in road environments such as traffic signs, headlamps and tail lamps. (IEEE 2018)

United States

NEMA Standards Publication, TS 4-2016, Hardware Standards for Dynamic Message Signs (DMS)

TS-4-2016 was developed to standardise minimum performance requirements and specifications for design and implementation of dynamic traffic messaging equipment. It specifies Display Properties and Optical requirements as well as Performance Monitoring and Testing and Conformance requirements for both Fixed-Location and Portable devices.

European Union

EN 12966:2014 Road Vertical Signs - Variable Message Traffic Signs

Similarly, EN 12966 was developed to harmonise the Display Properties and Optical requirements and provide standardisation of test procedure for approvals across Member States of the European Union.

TMS-DG02 Variable Speed Limits Deployment Guideline

This document is one of a set of documents for the EasyWay project and sets clear targets, identifies the set of necessary European ITS services to deploy and is a platform that allows the European mobility stakeholders to achieve a coordinated and combined deployment of these pan-European services. Included are functional requirements, coordinated design requirements and best practices for deployment.

United Kingdom

TR 2607 Performance Specification for Electronic Motorway Display Equipment

This specification defines the generic performance requirements for Highways England Electronic Motorway Display Equipment and is to be read in conjunction with BS EN 12966. It provides extension on the European Standard, including general appearance and dimension requirements for VSLS and multiple classes of VMS.

3.3 Related Austroads Projects

The following Austroads projects have been considered during the literature review.

3.3.1 Implications of Traffic Sign Recognition

This project (Austroads 2018) investigated the potential changes required to Australian and New Zealand traffic signs to understand readability issues with TSR technology. Through stakeholder interviews, a literature review and vehicle trials the project compiled a range of observations. The most important findings included issues with the identification of electronic signs by TSR systems. Literature and stakeholder interviews indicated the refresh rate of the signs and variability of pixel illumination, as well as size, height approach angle and the sign's power source could be factors. Further research to determine the root cause of these issues and the development of readability criteria and guidelines were recommended.

3.3.2 Infrastructure Changes to Support AVs Asset Standards – Module 3

This project (Austroads 2019a) reiterates the need for updates to standards and specifications, noting that updates to asset standards and the use of parallel methods, such as C-ITS, can be utilised to assist the vehicle in understanding the applicable traffic restriction. The project notes that the recommendations of the previous project have been taken into consideration by some stakeholders, and investigations had commenced prior to updating standards and specifications.

3.3.3 Infrastructure Changes to Support AVs Asset Standards – Road Audit Module 2

Case studies conducted during a road audit (Austroads 2019b) suggested that the system often missed electronic signs using the 10m frame rate, potentially due to electronic sign refresh rates. It suggests a camera has to expose its image sensor for a short duration in order to avoid capturing a blurred image, and this high shutter speed, coupled with the rapid pulsing of the electronic sign, results in the capture of a moment when the sign may not be fully illuminated. Image capture with a higher frame rate or lower shutter speed will increase the chance of detecting electronic signs.

This may also be true of TSR technologies, where signs are flashing at a rate too quick for human eyes to perceive, yet slow enough for the camera systems on these vehicles.

3.3.4 Review of Sign Size for Electronic Regulatory Speed Signs

A review of current practice in 2015 (Austroads 2015) found that the sizes of electronic regulatory speed signs used in Australia are largely similar to those described in Australian Standard AS 1742.4. Brightness requirements and the minimum number of red annuli from jurisdictions largely followed AS 5156. However, the number of red annuli and the required number of flashing annuli during speed limit changes still vary amongst jurisdictions.

The project team members expressed strong willingness to adopt consistent and harmonised sign specifications regarding sign size, sign brightness and sign annulus flashing requirements. It was recommended agencies adopt the static sign size (and design) as outlined in AS 1742.4 and AS 1743 and adopt the following for the use of electronic regulatory speed signs in special circumstances, such as tunnels and school zones summarised in Table 3.3.

Table 3.3: Proposed electronic regulatory speed sign (ERSS) size requirements

Location	Size
School/ shopping zones	Size B (The minimum size of enhanced school zone signs can be size A.)
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

Source: Austroads (2015)

The project team further recommended the inclusion of electronic message displays in the Australian Standard 'Manual of Uniform Traffic Control Devices (AS 1742)' as these displays are of a regulatory nature.

3.4 Trials

A number of trials of connected and automated vehicles has been taking place on the Australian road network. Most notable for this project have been those conducted by Transurban of partially automated vehicles in Victoria, New South Wales and Queensland. This section summarises the key findings from these trials relevant to electronic sign recognition. Drivers and passengers in the vehicles noted how the vehicles' automated features reacted to road infrastructure and these observations were validated by video footage from temporary cameras looking inside and outside the vehicles.

3.4.1 Transurban VIC

The trial in Victoria was launched in 2016 as a partnership with the Victorian Government, VicRoads and the Royal Automotive Club of Victoria (RACV). Three phases of trials were planned, and the first phase in 2017 logged more than 6,500 observations from 12 vehicles on the Monash, CityLink and Tullamarine motorways in Melbourne.

Some of the key findings and recommendations from this trial are summarised in Table 3.4 below.

Table 3.4: Findings and recommendations from the Victorian Transurban trials

Findings	Recommendations
Electronic speed signs were more challenging for some vehicles	Share data with vehicle manufacturers to refine Traffic Sign Recognition algorithms
Signs on tunnel walls were rarely read correctly	Use different signs and change their position in future tunnels
Flashing signs were read correctly and more reliably than constantly illuminating signs	Review sign height and positioning at problem locations, and design of new road furniture
Some specific sign types, locations and positions were more challenging to read than others	Review and update electronic sign standards, if deemed necessary

Source: Transurban (2018b)

3.4.2 Transurban NSW

The findings from the trial in Melbourne that showed how partially automated vehicles interacted with urban road infrastructure formed the basis of the trial in Sydney. The first stage of the trials in New South Wales took place on Sydney's Orbital Network, a network of 12 motorways that form a loop around Sydney. In addition to the drivers' and passengers' observations and video footage from cameras, an iPad application that Transurban created specifically for these trials was also used for the observers to record the details of any interesting vehicle behaviour. From these trials, more than 4100 observations from 10 vehicles were recorded.

Some of the key findings and recommendations from this trial, some of which are common with the Victorian trials, are summarised in Table 3.5 below.

Table 3.5: Findings and recommendations from the New South Wales Transurban trials

Findings	Recommendations
Some sign types, locations and positions were more challenging to read than others	Review sign type and positioning at problem locations
	Investigate electronic sign standards, specifications and design guides (including for consistency), and consider readability criteria and guidelines
Electronic speed signs were more challenging for some vehicles	Share data with vehicle manufacturers to refine Traffic Sign Recognition algorithms
Flashing signs were read correctly more reliably than continuous signs	Review sign height and positioning at problem locations, and the design of new road furniture
	Review and update electronic sign standards

Source: Transurban (2018a)

3.4.3 Transurban QLD

The most recent round of trials was conducted in Brisbane in 2018, which built on the approach used in previous CAV trials. The iPad application developed by Transurban for CAV trials was used again here. Fewer trial iterations were required as most of the results had already been observed from the previous trials in Melbourne and Sydney. The trials were conducted on motorway-grade roads around the Brisbane and Logan areas, including six motorways operated by Transurban as well as the Centenary and Gateway Motorways. From these trials in Queensland, more than 4100 observations from 7 vehicles were recorded.

Some of the key findings and recommendations from this trial are summarised in Table 3.6 below.

Table 3.6: Findings and recommendations from the Queensland Transurban trials

Findings	Recommendations
Signs within and at the entrance to some tunnels were difficult for vehicles to identify	Further investigate electronic signs in tunnels
	Review sign type/positioning at problem locations
	Investigate electronic sign standards, specifications and design guides (including for consistency), and consider readability criteria and guidelines
	Share data with vehicle manufacturers and map providers, to refine traffic sign recognition (TSR) algorithms and digital maps

Source: Transurban (2019)

3.5 Testing

3.5.1 Australasian New Car Assessment Program (ANCAP)

The Australasian New Car Assessment Program, more commonly referred to as ANCAP SAFETY, is Australasia's independent vehicle safety authority. ANCAP safety ratings are published for a range of new vehicles entering the Australian and New Zealand markets and, as of 1999, ANCAP testing and assessment of vehicles is in accordance with the Euro NCAP protocols the latest of which includes Speed Limitation Information Function (SLIF) , a function with which the vehicle knows and communicates the speed limit including advice for identifying conditional speed limits (for example during school hours).

There are a variety of different sign types in use across Australia and New Zealand. To encourage good performance across jurisdictions systems that are able to properly identify conditions and school zones, and act accordingly, can attract additional points based on the number of advanced functions and the sign types identified, including Dynamic or Illuminated Speed Limits.

A speed limit information function (SLIF) system is not available on many vehicle variants supplied to the Australian and New Zealand market, potentially due to systems which have been designed and calibrated for international markets requiring adaption to Australia and New Zealand's unique traffic sign standards and practices (Austroads, 2018).

3.6 Research Papers

3.6.1 LED Flicker Reduction

The rise of LED lights, using pulse-width modulation (PWM) with a non-standardized pulse frequency and length for dimming, poses a new problem of flicker artefacts for the camera industry (Behmann, 2018b).

LED traffic signs emit light in a frequency in which images can be indistinct in a camera image. Because of this characteristic, many Traffic Sign Recognition (TSR) systems do not recognize LED traffic signs accurately (Jun, 2015). Due to the need to match limitations in human visual response, LED flicker mitigation (LFM) is needed to capture low duty cycle LED pulses at all light levels (Oh, 2019).

Image artefacts may be caused by objects with changing or flickering illumination in an image frame and may include missing parts of an object, edge colour artefacts, and object distortion (Silsby, 2015). Artefacts affecting the performance of camera-based traffic sign detection may require a form of flicker mitigation to compensate. Other additional causes for artefacts include multiplexed displays. Flicker can not only be variable across different sign types (manufacturer, or design), but also be out of sequence across different sections of the signs (Austroads, 2018).

In Behmann (2018a) flicker mitigation can be achieved by post processing. The affected pixels are classified using three successive motion compensated frames of a video sequence, which are then combined for a highly reduced flickering amplitude. The algorithm is parallelized and implemented on a Field Programmable Gate Array and can perform in real-time for high resolution videos with a resolution of up to 1280 x 1088 at 100MHz operating frequency making it a practical system for automotive applications.

Recent developments in CMOS image sensors include LED Flicker Mitigation (LFM) while maintaining high dynamic range (HDR) output, limiting the appearance of flicker from LED lighting. There is currently no consensus within the automotive imaging industry as to what level of mitigation is required and there are currently no standards for LED flicker metrics and measurement procedures. This is being addressed as part of the IEEE P2020 Working Group on automotive image quality standards (Deegan, 2018).

3.6.2 LED Text

Electronic road signs mostly display text as discontinuous characters as each of them are composed by a matrix of light-emitting-diode (LED) lamps with either circle or rectangular shape (other shapes are also possible, although not common), namely LED text. Unlike general text, the LED text is quite arduous to be detected and recognized due to its discontinuity. In LED text, each character consists of more than one small dot region or pixel. Consequently, these pixels need to be combined for generating characters. In order to recognize detected LED characters models are trained on LED character matrix formats (Filonenko, 2015).

3.6.3 Colour Consistency, Contrast and Adaptability to Ambient Light

Colours used for traffic signs are typically yellow, red, black and white with green occasionally in use on electronic displays. In order to reduce search areas, electronic display areas are localised based on a colour model, often resulting in failure of detection on nonuniform colour. Additionally, detection often relies on sufficient character spacing and an adequately contrasting background (Filonenko, 2015).

Similarly, TSR systems involve the detection of signage in terms of shape, colour or unique identifiable features of a detected road sign. These are relayed to an on-board processor which undertakes a series of detection techniques to extract any visual features contained in the images (López, 2017).

Colour segmentation techniques have been developed for traffic sign detection as a result of the fast processing speed and improved performance. The dominant colours of traffic signs are highly differentiated from the background scene using colour segmentation, obtaining binary colour maps based on chromaticity. Colour inconsistency may contribute to low performance of systems composing of colour/shape classification (Lim, 2010).

4. Stakeholder Consultation

4.1 Project Reference Group Consultation

Initial consultation with Project Working Group (PWG) members was undertaken to understand the relevant technical sign specifications and existing design requirements for electronic signage. These consultations aimed to identify relevant technical sign specifications, the requirements from agencies, and information relating to existing assets.

Austroads member agencies were surveyed to obtain jurisdictional information on electronic signage that may not be publicly available, with the aim of identifying relevant literature and previous research and initiating discussion on the relevance of the findings. This process helped establish an understanding current and near-future electronic sign technologies to ensure the local context and adaption of the literature review findings. Details of the stakeholder survey questions are available in Appendix B and feedback has been utilised in refining the National Practices and State Specifications above and recommendations below.

The agency stakeholders who were approached, or who participated in the survey, are listed in Table 4.1.

Table 4.1: Agency stakeholders approached for or participated in the survey

Organisation	State	Representative
Roads and Maritime Services	NSW	Raj Roychoudhry
Main Roads	WA	Chris Venables
Department of Transport (VicRoads)	VIC	Frank Costa
Department of State Growth	TAS	Ramy Gokal
Transport Canberra and City Services / Roads ACT	ACT	Gavin Leng
Department of Planning, Transport and Infrastructure	SA	Robert Kane, Yanyan Xiao
Austroads	-	David Yee
New Zealand Transport Agency	-	Russell Pinchen

4.2 External Consultation

External consultation has been undertaken with key industry stakeholders identified during the PWG consultation and literature review stages. Key parameters impacting the readability of electronic signs by TSR systems were considered during the consultation. Additionally, the questions posed which attempted to identify issues arising out of these parameters, and any information on the latest development of TSR systems and electronic signs was considered. Based on these consultations and review of available literature, requirements for electronic sign readability by TSR systems were determined and this information was used to identify gaps in the existing specifications and the impact of these emerging and near-future developments on sign readability.

4.2.1 Electronic Sign Manufacturers

In order to determine and prioritise key issues that impact the readability of electronic signs and to capture latest information on development of electronic signs a summary of electronic sign manufacturers registered for supply was prepared. Those identified were invited to participate in the survey, and their relevant products, indicated by ticks, are listed in Table 4.2 below.

Table 4.2: Electronic sign manufacturers approached to participate in the survey[10]

OEM	ESLS/ VSLS	LUMS/ ISLUS	VMS	RAMP/ RC	Generic CMS	NLT/ NRT/ No Entry	VAS	ESLS/ VSLS (Trailer)	VMS (Trailer)
A1 Roadlines									✓
A.D. Engineering International	✓	✓	✓	✓	✓			✓	✓
Aldridge Electrical Industries	✓	✓	✓		✓	✓			
Aldridge Traffic Systems	✓	✓	✓			✓	✓	✓	✓
Armitage Group	✓	✓						✓	✓
Axent Global	✓	✓	✓		✓	✓			✓
Bartco Visual Information Systems								✓	✓
Braums			✓		✓		✓		
Compusign Systems	✓	✓	✓	✓	✓				✓
Data Signs (Australia)								✓	✓
Hi-Lux Technical Services	✓	✓	✓	✓	✓	✓	✓	✓	
HMI Technologies	✓	✓	✓	✓	✓		✓		✓
J1-LED Intelligent Transport Systems	✓	✓	✓	✓	✓		✓	✓	✓
RMS Intelligent Transport Systems	✓	✓	✓						

4.2.2 Vehicle Manufacturers

During the course of the stakeholder consultation, knowledge was leveraged from internal contacts with vehicle manufacturer experience, and the project team reached out to several major OEM's directly. Unfortunately, many were unable to provide any additional information on product specifications beyond the technical data publicly available through their owner's manuals and technical specifications. This lack of success in collating tangible feedback specifically relating to these systems led to a need for direct contact with camera and traffic sign recognition systems manufacturers. Further details are included in Section 4.2.3.

4.2.3 TSR and Camera Systems

Advanced Driver Assistance Systems (ADAS) manufacturers rely upon the development of vision technology for assisted and automated driving, frequently developing hardware and software capabilities in house to deal with multiple modalities, both in the visible spectrum and alternatives such as RADAR and LiDAR.

TSR systems require extensive technical expertise to develop solutions, often in partnership with the automotive and computer industries. Generally, products are specially tailored to the needs of automotive manufacturers in order to facilitate system integration, but these many depend upon the development of automotive system on chips (SoCs) and CMOS image sensors to deliver these features.

In order to meet the evolving standards for car safety and automated vehicles, automotive cameras are performing more complex algorithms at higher speeds and in challenging lighting conditions. New technologies include LED Flicker Mitigation (LFM) while maintaining High Dynamic Range (HDR), limiting the appearance of flicker from LED lighting which is particularly important for machine vision algorithms. These image sensors are connected via image signal processors (ISPs) to the afore mentioned SoCs to produce controllable logic and actions from low-level sensor data.

[10] Products manufactured (as detailed in discussions, approvals or on manufacturer websites) are indicated with a tick.

It is identified that there is a variety of image sensors, SoCs and ISPs are available in the automotive market, and several manufacturers of these were contacted for comment on the impact of electronic signs on their products. Many were hesitant to provide any additional information on the products that went beyond the technical specifications provided online

5. Industry Challenges

This section provides an overview of the challenges to industry and includes a review of findings across vehicle manufacturers, TSR and camera systems, and electronic sign manufacturers. Additionally, it includes a gap analysis of specifications in terms of how they support or hinder readability.

5.1 Findings Review

5.1.1 Vehicle Manufacturers

Traffic sign recognition systems have been known to function incorrectly under the following conditions:

- camera conditions:
  - misalignment of the camera. (e.g. due to a strong impact)
  - the camera is covered. (e.g. by a sticker, misted over, dirty, covered in snow or mud)
- detection conditions:
  - the surrounding brightness is not sufficient or changes suddenly.
  - travelling in inclement weather conditions. (e.g. heavy fog, rain, snow, or sandstorms)
  - travelling toward bright lights. (e.g. an oncoming vehicle or the sun)
  - the sign is not in view for a sufficient period of time.
- signage conditions:
  - non-conforming road signs.
  - concealed or covered signage. e.g. all or part of the sign is hidden by the leaves, trees or a pole
  - the sign is dirty, faded, tilted or bent
  - the contrast is poor (if an electronic sign)
  - a sign resembling a system compatible sign is recognized. (e.g. stickers are attached to the rear of the preceding vehicle).

Similar factors were identified and discussed (Austroads 2018) with reference to limitations of TSR systems on all signs. Parameters such as inclement weather, insufficient/excessive light, presence of obstructions and backgrounds with similar colour schemes to the sign, the positioning of signs, deterioration and rotation of sign faces, light source flicker and pixel scanning were identified as well as light source flicker and pixel scanning.

5.1.2 TSR and Camera Systems

There were three common ways identified which address LED flicker challenges in TSR systems lateral overflow integration capacitors (LOFIC), adding components to filter the image signal (known as Chopping) and capturing images simultaneously instead of sequentially (known as Split-Pixel). Factors which contribute to the manufacturers decisions when implementing these solutions include high-temperature operation, low power consumption, high dynamic range (HDR) performance and signal-to-noise ratios.

In recent years camera sensor technology and algorithms have improved which achieve HDR in small, low temperature and low power devices capable of simultaneously capturing bright and dark scenes while retaining the capability of mitigating LED flicker. LED traffic signals and signs and LED vehicle lights can be accurately recognised with HDR enabled in high contrast situations with no highlight blowout or loss of shadow detail, such as when entering or exiting tunnels.

5.1.3 Electronic Sign Manufacturers

A common view from the stakeholder engagement process was there are numerous signs available, particularly in the portable trailer market, which do not comply with standards or individual state specifications. These are occasionally manufactured outside of Australia, and are purchased on price rather than compliance to any specification.

Of the stakeholders who responded, it was indicated that there were no specific issues in their signs with regards to Traffic Sign Recognition. Many recognised that LED technology in general poses issues for camera-based recognition, especially in products utilising pulse width modulation (PWM), multiplexed or dot-matrix displays. Several results indicated there has been consideration in the various standards and specifications for legibility and detectability using camera technology, primarily for use with road safety cameras, which works in the favour of TSR compatibility.

Manufacturers surveyed during the project had not been contacted regarding TSR system testing or sign limitations by TSR system or vehicle manufacturers. However, many considered adherence to the optical requirements dictated by the available standards and a consistent approach across different regulatory bodies, could reduce complications in recognition.

Stakeholder feedback also included concern towards inconsistencies in requirements between different regulatory bodies resulting in non-uniformity of products being deployed in the field. This is expected to complicate the readability.

There is a belief that all parties have roles to play in achieving a level of industry harmonisation. As highlighted above, regulatory bodies need to ensure compliance with standards and specifications, sign manufacturers need to consider more than human readability in designs. Additionally, TSR systems need to be capable of correctly analysing the resulting displays to ensure consistency.

Several factors were identified by industry to complicate TSR readability:

- Lack of standardisation of the requirements across the various regulatory bodies for Regulatory Speed Signs. Examples include:
  - inconsistent application of non-default speeds, for example the number of annulus rings that are flashed or the use of flashing amber lanterns (or conspicuity devices)
  - lack of adherence to font, layout and size requirements which closely mimic the equivalent static signs
  - varied display intensity from flashing aspects or annulus rings may result in erroneous display recognition
  - use of non-compliant VMS Trailers as Speed Signs in work zones.
- Lack of standardisation of the requirements across the various regulatory bodies for Variable Message Signs. Examples include:
  - use of single or multi-colour displays
  - use of red/green/blue (RGB) colour mixing vs discrete LEDs
  - use of text only, text and graphics displays, or full colour matrix displays
  - default text colours, amber or white
  - use of conspicuity devices
  - inconsistent approach to character font ratios, inter character spacing, stroke widths
  - while there are standards and specifications (such as 4852.2 & MRTS262) detailing requirements for temporary VMS displays, and suggestions for typical applications and wording, there is a lack of uniformity practical implementations and adherence to these requirements.
- There is potential, in current TSR systems, that a problem lies between the camera shutter speed and the PWM frequency used for sign dimming.

- Standards and specifications have been known to include requirements for speed cameras, such as visible displays at shutter speeds of up to 1/2000s, yet a comparable requirement is not present in all specifications.
- Many Australian manufacturers prefer not to mix colours as colour consistency can be harder to achieve, and several specifications define wavelength emission colour requirements.
- Numerous applications of electronic signage in traffic systems with limited regulation and minimal detail within standards or specifications (e.g. ramp control, heavy vehicle management, advance/flood warning systems, emergency vehicle warning).

Several suggestions from the sign manufacturing industry for improving TSR compatibility were identified. These included:

- Future electronic designs may integrate other communications means for automated systems, reducing the complexity of TSR systems or even removing their need entirely when dynamic speeds are implemented.
- TSR system designers could provide input into the sign display standards in terms of requirements specifically associated with TSRs ability to read and analyse displays, such as the use of discrete character systems rather than matrix displays in regulatory signs or greater adherence to font, layout and size.
- Further analysis of shutter speeds and technologies used in TSR cameras and the impact of PWM dimming on the consistency of captured displays.
- Reducing ‘flicker’ when utilising PWM dimming by ensuring requirements such as those in AS 5156, “pixels not continuously energised when required to be on must be pulsed at a frequency greater than 2.5 kHz”, are met
- Reducing ‘flicker’ when utilising PWM dimming by ensuring requirements such as those in AS 4852, “the frequency at which they are pulsed shall be not less than 100 Hz”, are met.
- Improved readability of regulatory signs using alternative methods to multiplexed or PWM displays (such as constant current LED drivers).
- Strict adherence to colour profiles (usually limited to Red, Amber, White, Green) based on the wavelength emission colour requirements, even when using Red/Green/Blue (RGB) systems.
- Improve colour consistency by ensuring LED colours are consistent through the batch bins used to produce signage.
- Strict adherence to optical requirements to reduce sun phantom, reflection and improve contrast and relative luminosity and uniformity.
- Equipment utilised in TSR systems to consider, and be specified appropriately, to provide the desired outcome within the constraints of varying output intensities, flashing display components and other functional requirements forming part of current and future display specifications.
- Better understanding by regulatory bodies of the benefits associated with particular features, such as TSR compatibility, as many tenders are based solely on price.
- Co-operative training of TSR systems with sign designers and collaboration with manufacturers to obtain design data of sign layouts.
- Definition of test procedures and criteria for electronic sign readability by TSR systems.
- Adherence to font, layout and size requirements which closely mimic the equivalent static signs.
- Standardisation of fonts and height-to-width ratios (such as those specified in AS 4852.1) to improve recognition of text in variable message displays.
- Improved alignment with font requirements when utilising high resolution matrix displays to improve recognition.

5.2 Gap Analysis

5.2.1 LED Flicker

A common issue identified by OEMs which appears to have the greatest impact on the readability of electronic signs by TSR systems is LED flicker. LED flicker commonly occurs when a LED light source is being powered by a pulse-width-modulated (PWM) signal. A standard camera focused on this source will produce LED letters and numbers with flickering or missing segments, resulting in a failure of machine vision or character detection under these conditions. The widespread use of LEDs for automotive and traffic lighting in applications such as front and rear LED lights and electronic traffic signs has driven the development of LED flicker mitigation (LFM) capability within cameras sensors, ensuring pulsed light sources do not appear to flicker.

Factors which impact upon LED flicker, and therefore the readability of traffic signs by TSR systems, include LED driver technologies, dimming and fault scanning. Current Australian Standards for Variable Message and Electronic Speed Limit Signs (AS 4852 and AS 5156) contain requirements which specify, at least in part, how this issue can be mitigated. Current and draft NZ specifications reference the EN12966 standard for many of the factors below, of which many align with the Australian Standard.

Table 5.1: ESLS/VSLS/ISLUS LED flicker factors

Factor	Reference	Value (if applicable)
LED Drive Current	AS 5156 2.1.3.4	"The peak magnitude of the drive current for each individual LED shall not exceed 70% of the LED manufacturer's continuous ratings"
Dimming	AS 5156 2.1.1.6	"ensure maximum legibility distances are achieved for each of the different operating conditions and under all external ambient lighting conditions"
Dimming (default level)	AS 5156 2.1.1.6.4	"50% of maximum output"
Display flicker (General)	AS 5156 2.1.1.8.1	"No discernible"
Display flicker (Refresh rate/frequency)	AS 5156 2.1.1.8.2	2.5kHz
Fault - scanning (Pixel checking)	AS 5156 2.1.1.8.3	"not produce visible flickering of the pixels"
Fault - pixel failure	AS 5156 2.1.2.1	"individual pixels of each series circuit shall be interspersed with pixels from other series circuits"
Flashing	AS 5156 2.1.2.5	"flash all pixel rings other than the outermost pixel ring"

Table 5.2: VMS LED flicker factors

Factor	Reference	Value (if applicable)
LED Drive Current		
Dimming	AS 4852.1 5.1.9.1	"ensure maximum legibility distances are achieved and avoid glare under all external ambient lighting conditions"
Dimming (default level)	AS 4852.1 5.1.9.4	Level 6 of 16
Display flicker (General)	AS 4852.1 5.1.11	"No visible"
Display flicker (Refresh rate/frequency)	AS 4852.1 5.1.11	100 Hz

Table 5.3: Portable VMS LED flicker factors

Factor	Reference	Value (if applicable)
LED Drive Current		
Dimming	AS 4852.1 5.1.6	"automatically adjust the output luminance of its display in response to external illuminance"
Dimming (default level)	AS 4852.2 5.1.7	Level 3 of 16
Display flicker (General)	AS 4852.2 5.1.7	"No visible"
Display flicker (Refresh rate/frequency)	AS 4852.2 5.1.7	100 Hz

Table 5.4: ESLS/VSLS/ISLUS changes or clarifications

Jurisdiction	Factor	Alternative
Australian Capital Territory	Display flicker (General)	RITS006 3.2 "Shall be eliminated"
New South Wales	Dimming (default level)	TSI-SP-011 6.1.4 "Where a Sign within a group cannot be dimmed in response to the scene illuminance, but one or more other signs within the group can, the Sign shall use the same or averaged target dimming level used by the latter as its own target dimming level."
Queensland	Dimming (default level)	MRTS206 5.1.1.6 "Where a sign within a group of signs connected to a same site controller cannot be dimmed due to a faulty light sensing device, the site controller shall use the target dimming level of other working sign or average of target dimming level of all working signs of the group as the target dimming level of that sign."

Table 5.5: VMS changes or clarifications[11]

Jurisdiction	Factor	Alternative
New Zealand	LED Drive Current	ITS-06-01 4.2.3 "In achieving the candela ratings no LED or group of LEDs shall be "overdriven" or supplied additional current so the stated LED life expectancy is compromised."
	Display flicker (General)	"During testing there shall be no visible light flicker, whether the LED's of a VMS are operating at full intensity or are dimmed. Further, VMS messages must be 'machine readable' (e.g. by CCTV cameras)."[12]
	Display flicker (Refresh rate/frequency)	"The VMS must meet the frequency requirement of 150Hz or greater"[13]
Queensland	Dimming	MRTS202 8.11.2 "The LED intensity shall be controlled to provide maximum legibility distances for the complete range of ambient light under which the VMS shall operate."
		MRTS202 8.11.2 "A VMS shall have a minimum of 10 and a maximum of 100 LED brightness levels. The brightness levels shall be in units of percentage of maximum brightness."
	Dimming (default level)	MRTS202 9.7.1 "In the event of failure of the light sensors, seasonally adjusted time-of-day values stored in the group controller shall be used to adjust the VMS brightness."

[11] NZTA are currently reviewing their VMS specification
[12] Based on a preliminary draft of the VMS Specification, previously ITS-06-01 requirements were for 'human eye'
[13] Based on a preliminary draft of the VMS Specification, previously ITS-06-01 requirements were for 90 Hz

Table 5.6: Portable VMS changes or clarifications

Jurisdiction	Factor	Alternative
New Zealand	LED Drive Current	ITS-06-04 4.2.3 “In achieving the candela ratings no LED or group of LEDs shall be “overdriven” or supplied additional current so the stated LED life expectancy is compromised.”
Queensland	Dimming	MRTS262 9.13.3 “The LED intensity shall be controlled to provide constant apparent brightness, and maximum legibility distance, for the complete range of ambient light under which the TVMS shall operate.”
		MRTS262 11.8.3 “The LED intensity shall be controlled to provide maximum legibility distances for the complete range of ambient light under which the TVMS shall operate.”

5.2.2 Colour, Contrast and Uniformity

As identified above in both the literature review and stakeholder consultations, colour, contrast and uniformity of both luminance levels and chromaticity are important issues for detection systems. This relies on a colour model, often resulting in failure of detection on nonuniform colour or an inadequately contrasting background.

Factors which impact upon colour, contrast and uniformity and therefore the readability of traffic signs by TSR systems, include contrast, reflectivity, luminance ratios (reflectivity/contrast), luminance intensity uniformity, colour consistency and pixel service life.

Current Australian Standards for Electronic Speed Limit and Variable Message Signs (AS 5156 and AS 4852) contain requirements which specify, at least in part, how this issue can be mitigated.

Table 5.7: ESLS/VSLS/ISLUS colour, contrast and uniformity factors

Factor	Reference	Value (if applicable)
Contrast	AS 5156 4.1.1	"The colour of the front face of the sign shall be matt black" "Where a viewing window is provided for the display, it shall be of high impact, UV resistant, anti-glare, non-polarising, polycarbonate material"
Luminance ratio (Reflectivity/Contrast)	AS 5156 2.2.1	"normalized luminance and normalized luminance ratio in accordance with Table 2.4"
Luminance intensity uniformity	AS 5156 2.2.2	"the ratio of the average of the three highest pixel outputs and the average of the three lowest pixel outputs shall be not more than 2.5:1" "The ratio of the outputs of any two pixels shall be not more than 4:1"
Consistency (colour)	AS 5156 2.2.3	"each colour present in the message shall lie within one of the regions specified by chromaticity coordinates in Table 2.5"
Pixel service life	AS 5156 2.1.3.1	"five years of continuous switching and operation" "not degraded by more than 30%"

Table 5.8: VMS colour, contrast and uniformity factors

Factor	Reference	Value (if applicable)
Contrast	AS 4852.1 3.1.2 AS 4852.1 3.1.3	"The colour of the front face of the sign shall be matt black" "The viewing area shall not be occluded, by any other part of the sign's construction from the half angles as defined in Table 5.1"
Luminance ratio (Reflectivity/Contrast)	AS 4852.1 5.2.1	"The sign's luminance and luminance ratio (LR) shall be in accordance with Table 5.5"
Luminance intensity uniformity	AS 4852.1 5.2.2 AS 4852.1 5.2.3	"Where more than one colour is displayed simultaneously, the colours should appear with similar brightness" "the ratio of the average of the three highest pixel outputs to the average of the three lowest pixel outputs shall be not more than 2.5:1" "the ratio between the outputs of any two pixels shall be not more than 4:1"
Consistency (colour)	AS 4852.1 5.2.4	"each colour present in the message shall lie within one of the regions specified by chromaticity coordinates in Table 5.6 and Figure 5.5. Monochrome displays are typically yellow."
Pixel service life	AS 4852.1 5.1.1.4	"10 years of continuous switching and operation" "output luminance shall remain within the specified permitted range over the entire service life of operation"

Table 5.9: Portable VMS colour, contrast and uniformity factors

Factor	Reference	Value (if applicable)
Contrast	AS 4852.2 3.1	"A front-viewing window of high-impact-strength, clear sheeting" "A surrounding border of not less than 100mm in width"
Luminance ratio (Reflectivity/Contrast)	AS 4852.2 5.2.1	"The sign's luminance and luminance ratio (LR) shall be in accordance with Table 5.5"
Luminance intensity uniformity	AS 4852.2 5.2.2 AS 4852.2 5.2.3	"Where more than one colour is displayed simultaneously, the colours should appear with similar brightness" "the ratio of the average of the three highest pixel outputs to the average of the three lowest pixel outputs shall be not more than 2.5:1" "the ratio between the outputs of any two pixels shall be not more than 4:1"
Consistency (colour)	AS 4852.2 5.2.4	"each colour present in the message shall lie within one of the regions specified by chromaticity coordinates in Table 5.6 and Figure 5.5. Monochrome displays are typically yellow."
Pixel service life	AS 4852.2 5.1.1.3	"10 years of continuous switching and operation" "output luminance shall remain within the specified permitted range over the entire service life of operation"

As above, where these requirements differ from those detailed above the changes or clarifications have been included in Table 5.10, Table 5.11 and Table 5.12 below.

Table 5.10: ESLS/VSLS/ISLUS changes or clarifications

Jurisdiction	Factor	Alternative
New South Wales	Pixel service life	TSI-SP-011 6.1.7 “The rated minimum service life of each pixel of the Sign shall be not less than ten (10) years of continuous switching and operation.”
	Luminance intensity uniformity	TSI-SP-011 6.2.2.2 “The Sign shall provide equalisation of the light outputs of all of its display pixels to eliminate perceivable intensity variations among the pixels. The equalisation shall be effective for all colours and output luminance levels (i.e. dimming levels) of the Sign display.”
	Consistency (colour)	TSI-SP-011 6.1.3 “Each of the required display colours shall be directly generated by LEDs for which the colour is their native output colour. The use of an RGB or similar colour mixing system to create the required colours is not permitted.”

Table 5.11: VMS changes or clarifications[14]

Jurisdiction	Factor	Alternative
New Zealand	Consistency (colour)	"All VMS must meet colour Class C2 as per EN12966:2014" which aligns with the requirements of AS 4852.1 detailed above.[15]
	Luminance ratio	"All VMS must meet luminance levels to Class L3 as per EN12966:2014" which exceeds the requirements of AS 4852.1 detailed above.[15]
		"All VMS must meet luminance ratio Class R3 as per EN12966:2014" which meets or exceeds the requirements of AS 4852.1 detailed above, with the exception of red which is defined as 4.2 in the NZ specification as opposed to 5.
	Luminance intensity uniformity	Ratio of output between highest 12% and lowest 12% of 3:1. Ratio of output between highest 4% and lowest 4% of 5:1.
	Pixel service life	"The specified design life (operational service life) of the VMS is fifteen years."
New South Wales	Luminance ratio	TSI-SP-008 6.8.2 "The conspicuity optical requirements described in clause 3.1.12 of AS4852.1 shall be met, except that the luminance requirements are defined by Table 4 of this specification."
		TSI-SP-008 7.1.2 "Luminance of different colours should be balanced when shown together on a sign, so they appear similarly bright to an observer. The relative proportions of luminance tabled below are suggested to typically achieve this."
	Consistency (colour)	TSI-SP-008 6.6 "Signs shall be able to display Yellow, Red, Green and White colours, against a matt black background. This item replaces clause 3.1.10 of AS4852.1"
		TSI-SP-008 6.6 "LEDs shall be used to generate the output colours but technology is not otherwise constrained. Signs may use RGB colour mixing, discrete LEDs, or other approaches. This item replaces clause 3.1.3 of AS4852.1"
Queensland	Luminance intensity uniformity	MRTS202 8.11.4 "The outputs of any two elements shall not vary by more than a ratio of 5:1. The luminance intensity uniformity shall be maintained at all dimming levels."
	Consistency (colour)	MRTS202 8.8.2 "Each pixel in the multicolour sign, EVMS or GDU shall be provided with by one red, one green, one white and one yellow high visibility LEDs on a matte black background. The colours for the Red, Green, White and Yellow LEDs shall conform to the colours defined by the colour coordinates in AS 4852.1-2009, Table 3.4. For each pixel, only one LED is to be displayed at a time. No other colours are to be displayed on the sign. The ability to mix pixel colours shall not be provided."

[14] NZTA are currently reviewing their VMS specification
[15] Based on a preliminary draft of the VMS Specification

Table 5.12: Portable VMS changes or clarifications

Jurisdiction	Factor	Alternative
New Zealand	Contrast	ITS-06-04 5.1.1 "The bezel surrounding the primary display elements should have a minimum width of at least 200mm."
	Luminance ratio	ITS-06-04 4.2.5 "The display shall meet the L3 class for Luminance, and the R3 class for Luminance Ratio, described in EN 12966-1."
	Consistency (colour)	ITS-06-04 4.2.4 "The colour of all LED's shall be yellow and co-ordinates shall meet the C1 class for Colour, described in the European Standard EN 12966-1."
	Pixel service life	ITS-06-04 5.1 "The design life of the Mobile VMS is ten (10) years."

5.2.3 Display Form, Shape and Fonts

TSR systems may also involve the detection of signage in terms of shape, colour or other unique identifiable features, undertaking a series of detection techniques to extract any visual features contained in camera images. A lack of adherence to font, layout and size requirements which closely mimic the equivalent regulatory signs could lead to issues with readability by TSR systems.

Factors which impact upon font, layout and size and therefore the readability of traffic signs by TSR systems, can vary between Variable Message and Discrete displays.

Discrete displays are impacted by display size, display form or shape, display borders, text format or font, pixel size, equivalent pixel area, pixel spacing and stroke width. The current Australian Standard for Electronic Speed Limit Signs (AS 5156) contains requirements which specify, at least in part, how these issues can be mitigated and references the Manual of uniform traffic control devices (AS 1742) which details the use of variable speed limits, including electronic signs.

Table 5.13: ESLS/VSLS display form, shape and fonts

Factor	Reference	Value (if applicable)
Display Size	AS 5156 Preface AS 1742.4 3.5	"The use of any signs, including electronic speed limit signs, for road traffic management is subject to regulation by traffic control authorities. Guidance and requirements on their use is provided in the series of Standards AS 1742" "The sign enclosure may be rectangular or square. A square sign housing may be used, provided the width of the sign, character height and annulus size is retained." "Variable message speed limit sign displays shall be limited to the following: 1) A display that is identical in design and colour to the Speed Restriction (R4-1) sign. 2) A display that is identical in layout to the Speed Restriction (R4-1) sign but has illuminated white numerals within an illuminated red annulus on a black background" "The sign may be rectangular or square"
Display Form/Shape	AS 1742.4-2008 AS 5156 2.1.1.1 AS 5156 2.1.2.3 AS 5156 2.1.2.4 AS 5156 2.1.2.5 AS 1743 (R4-1)	"A display that is identical in layout to the Speed Restriction (R4-1) sign but has illuminated white numerals within an illuminated red annulus on a black background" "as defined in AS 1743 for R4-1" "The display matrix shall be centrally located within the annulus of the sign" "The red annulus shall consist of evenly spaced pixel rings in accordance with Table 2.3." (Type A=2, B=3, C=4, D=6) "The display shall be centrally located within the annulus of the sign"

Factor	Reference	Value (if applicable)
Display Border	AS 5156 4.1.1	"The height and width dimensions of the sign face shall not be greater than 150 mm more than the equivalent static sign excluding requirements for conspicuity devices."
Numerals	AS 1744 AS 5156 2.1.1.1	"numerals generated on the sign shall, as near as practicable, comply with AS 1744"
Equivalent area (Pixel form / shape / points)	AS 5156 2.1.2.3	"Figure 2.1 shows the relationship between pixel diameter, pitch, spacing and equivalent area."
Pixel Size		
Pixel spacing - Text - Discrete	AS 5156 2.1.2.4	"maximum of 1.5 times the diameter of the pixel"
Pixel spacing - Annulus	AS 5156 2.1.2.2	"maximum of 2 times the diameter of the pixel"
Stroke width		

Table 5.14: ISLUS/LUMS display form, shape and fonts

Factor	Reference	Value (if applicable)
Display Size	AS 5156 Preface AS 1742.4 3.5	"The use of any signs, including electronic speed limit signs, for road traffic management is subject to regulation by traffic control authorities. Guidance and requirements on their use is provided in the series of Standards AS 1742" "The sign enclosure may be rectangular or square. A square sign housing may be used, provided the width of the sign, character height and annulus size is retained." "Variable message speed limit sign displays shall be limited to the following: 1) A display that is identical in design and colour to the Speed Restriction (R4-1) sign. 2) A display that is identical in layout to the Speed Restriction (R4-1) sign but has illuminated white numerals within an illuminated red annulus on a black background" "The sign may be rectangular or square"
Display Form/Shape	AS 1742.4-2008 AS 5156 2.1.1.1 AS 5156 2.1.2.3 AS 1743 (R4-1)	"A display that is identical in layout to the Speed Restriction (R4-1) sign but has illuminated white numerals within an illuminated red annulus on a black background" "as defined in AS 1743 for R4-1" "The display matrix shall be centrally located within the annulus of the sign"
Display Border	AS 5156 4.1.1	"The height and width dimensions of the sign face shall not be greater than 150 mm more than the equivalent static sign excluding requirements for conspicuity devices."
Text	AS 5156 2.1.1.1	"Where other displays are specified by the purchaser (e.g. arrows, text), they shall comply with Appendix B"[16]
Numerals	AS 1744 AS 5156 2.1.1.1	"numerals generated on the sign shall, as near as practicable, comply with AS 1744"
Equivalent area (Pixel form / shape / points)	AS 5156 2.1.2.3	"Figure 2.1 shows the relationship between pixel diameter, pitch, spacing and equivalent area."
Pixel Size		
Pixel spacing - Text - Matrix	AS 5156 2.1.1.1	"Where other displays are specified by the purchaser (e.g. arrows, text), they shall comply with Appendix B"[17]
Pixel spacing - Annulus	AS 5156 2.1.2.2	"maximum of 2 times the diameter of the pixel"
Stroke width		

[16] Appendix B of AS 5156
[17] Appendix B of AS 5156

Similarly, Variable Message displays are impacted by display size, display borders, text format or font, pixel size, equivalent pixel area, pixel spacing and stroke width, with several of these factors having a greater impact due to the inconsistency between implementations. The current Australian Standards for Variable Message Signs (AS 4852) contains requirements which specify, at least in part, how these issues can be mitigated.

Table 5.15: VMS display form, shape and fonts

Factor	Reference	Value (if applicable)
Display Size	AS 4852.1 5.1.2	"Minimum proportions shall be observed and scaled against the minimum character height (H) as defined in Table 5.3" "Signs shall have sufficient vertical pixels to permit lower case text to be shown concurrently on all three lines"
Display Border	AS 4852.1 3.1.7	"The width of the border shall be at least 80% of the minimum character height. Conspicuity devices may be incorporated in the border"
Text	AS 4852.1 5.1.2.1 AS 4852.1 5.1.4	"For alphanumeric characters, the parameters set out in Tables 5.2 and 5.3 shall apply. " "The sign shall be capable of supporting at least five fonts"
Equivalent area (Pixel form / shape / points)	AS 4852.1 5.1.2	"Minimum proportions shall be observed and scaled against the minimum character height (H) as defined in Table 5.3" "Figure 5.2 shows how character heights are to be measured and the relationship between pixel width or diameter and pixel equivalent area"
Pixel Size		
Pixel spacing - Text - Matrix	AS 4852.1 5.1.2.1	"Figure 5.2 shows how character heights are to be measured and the relationship between pixel width or diameter and pixel equivalent area"
Stroke width	AS 4852.1 5.1.2.1	"10% of H" where H is the minimum character height

Table 5.16: Portable VMS display form, shape and fonts

Factor	Reference	Value (if applicable)
Display Size	AS 4852.2 5.1.1.1	"The message display shall be a full matrix LED display conforming to Table 5.1"
Display Border	AS 4852.2 3.1	"A surrounding border of not less than 100 mm in width"
Text	AS 4852.1 5.1.2.1 AS 4852.1 5.1.4	"For alphanumeric characters, the parameters set out in Tables 5.2 and 5.3 shall apply. " "The sign shall be capable of supporting at least five fonts"
Equivalent area (Pixel form / shape / points)	AS 4852.2 5.1.2	(Minimum 47 pixels wide x 25 pixels high) "Minimum proportions shall be observed and scaled against the minimum character height (H) as defined in Table 5.3" "Figure 5.2 shows how character heights are to be measured and the relationship between pixel width or diameter and pixel equivalent area"
Pixel Size		
Pixel spacing - Text - Matrix	AS 4852.2 5.1.2.1	"Figure 5.2 shows how character heights are to be measured and the relationship between pixel width or diameter and pixel equivalent area"
Stroke width	AS 4852.2 5.1.2.1	"10% of H" where H is the minimum character height

As above, where these requirements differ from those detailed above the changes or clarifications have been included in Table 5.17, Table 5.18 and Table 5.19 below.

Table 5.17: ESLS/VSLS/ISLUS changes or clarifications

Jurisdiction	Factor	Alternative
New Zealand	Display Size	Code RS1V Rule R1-2.1 “800mm x 800mm”
	Display Form/Shape	Traffic Note 37 Revision 2 “R1-2.1: the speed limit numerals are displayed using yellow or white, lit pixels (e.g. light emitting diodes, fibre optics). The background is black and unlit. For signs that display only the 40km/h variable speed limit and are blank for the rest of the time, the roundel is displayed with red, lit pixels. Alternatively, for signs that display the permanent speed limit at times when the variable speed limit does not apply, the roundel may be displayed with either red, lit pixels or with red retro-reflective material.”
	Display Border	Code RS1V Rule R1-2.1 “100mm”
	Text / Numerals	Code RS1V Rule R1-2.1 200D
Queensland	Display Size	MRTS206 5.1.4 “Type A – Square 450 mm (h) x 450 mm (d) *Only to be used in tunnels where size constraints prohibit the use of Type B, refer to drawing TC1785_1&2”
	Display Form/Shape	MRTS206 5.1.2.5 “The red annulus shall consist of suitably constructed, evenly spaced pixel rings in accordance with Table 5.1.2.5 Red annulus display characteristics. (Type A=3, B=3, C=4, D=6)
	Text / Numerals	MRTS206 5.1.1.1 “The display of numerals for speed regulation and information must comply as much as practicable with the fonts defined in MUTCD. Numerals must meet the fonts defined for use on a Regulatory Sign R4-1.”
Victoria	Display Size	TCS037 4.1.6 “The height and width dimensions of the sign face shall not exceed 100 mm difference compared with the equivalent static sign (R4-1).”
	Display Form/Shape	TCS037 5.1.11 “The design of the sign display shall ensure that there is an adequate space between the inner ring of the annulus and any numeral adjacent to the annulus. This is to prevent ‘bleeding’ of the LED’s into adjacent LED’s and provide a clear display.”
		TCS037 5.5.1 “The number of pixel rings used for the annulus shall be as specified in Table 5.2 below. (Annulus diameter - Type A=~375 to ~425mm, B=~495 to ~575mm, C=~730 to 870mm)
	Display Border	TCS037 4.1.7 “The height and width of the sign enclosure shall be designed so that no part of the annulus is closer than 40mm to the outside edge of the enclosure.”
	Text / Numerals	TCS037 5.3.3 “The total size of the stroke width (i.e. outside to outside of the LED’s) will typically be slightly less than the requirement of AS 1743 due to flaring of LED’s.” TCS037 5.3.2 “Numerals shall be configured in accordance with Table 5.1 below, for the respective R4-1 sign sizes specified in AS 1743” (Type A=2 rows, B=2 rows)
	Equivalent area	TCS037 5.4.5 “Where the pixel spacing would be greater than 1.5 times the diameter of the pixel, the display resolution or pixel diameter shall be increased to ensure suitable spacing.”

Jurisdiction	Factor	Alternative
Victoria (cont)	Pixel spacing - Text - Matrix	TCS037 “Where the pixel spacing would be greater than 1.5 times the diameter of the pixel, the display resolution or pixel diameter shall be increased to ensure suitable spacing.”
	Pixel spacing - Annulus	TCS037 5.5.1 “The number of pixel rings used for the annulus shall be as specified in Table 5.2 below. “ (Type A=2, B=4, C=5)
	Stroke width	TCS037 5.3.2 “Numerals shall be configured in accordance with Table 5.1 below, for the respective R4-1 sign sizes specified in AS 1743” (Type A=~25mm stroke width, B=~35mm, C=~55mm) TCS037 5.3.3 “The total size of the stroke width (i.e. outside to outside of the LED’s) will typically be slightly less than the requirement of AS 1743 due to flaring of LED’s”
New South Wales	Display Size	TSI-SP-011 8.1 “In addition to the requirements for sign enclosure in AS 5156, the following requirements shall apply: (a) The height and width dimensions of the sign shall be in accordance with Appendix A;” (Type A=570x570mm, B=720x720mm, C=1020x1020mm, D=1320x1320mm)
	Display Form/Shape	TSI-SP-011 8.1 “In addition to the requirements for sign enclosure in AS 5156, the following requirements shall apply: (a) The height and width dimensions of the sign shall be in accordance with Appendix A;” (Annulus diameter - Type A=356 to 446mm, B=474 to 594mm, C=712 to 892mm, D=948 to 1188mm)
	Display Border	TSI-SP-011 8.1 “In addition to the requirements for sign enclosure in AS 5156, the following requirements shall apply: (a) The height and width dimensions of the sign shall be in accordance with Appendix A;” (Type A=60mm, B=60mm, C=60mm, D=60mm)
	Pixel spacing - Annulus	TSI-SP-011 6.1.6.1 “The requirements for red annulus pixel configuration in AS 5156 shall be replaced by those shown in Table 6.1.6.1.” (Type A=4, B=5, C=7, D=10)
Western Australia	Display Form/Shape	Specification 709 709.08.03 “The sign enclosure shall be made of marine grade aluminium (minimum of 2.5mm thick) and be Golden Yellow Y14 colour powder coated.”

Table 5.18: VMS changes or clarifications[18]

Jurisdiction	Factor	Alternative
New Zealand	Display Size	ITS-06-01 4.1.1 “The choice of display is dictated by the intended ITS application and message requirements. For the previously described applications, the NZTA utilises the following standard VMS display types: ATMS Motorway - 400mm Text (Standard) Regional 4 Line – 200/300mm Text Regional 2 Line – 200/300mm Text”
	Display Border	ITS-06-01 5.1.1 “The bezel surrounding the primary display elements should have a width minimum of at least 300mm for Motorway VMS, and 200mm for regional VMS.”
	Text	ITS-06-01 4.2.7 “The VMS controller shall be capable of generating the following display fonts and text layout: - Font: The NZTA’s Motorway or Regional VMS font respectively - Character spacing: Blank pixel(s) total must equal or exceed stroke - Line spacing: 3 or 4 blank pixels – configurable - Word spacing: 5 blank pixels The VMS shall also be able to generate the following fonts: - Double stroke”
	Equivalent area	ITS-06-01 4.1.1 ATMS Motorway 124 wide by 30 high (Standard) Regional 96-100 wide by 38 high Regional 96-100 wide by 18 high
	Pixel Size	ITS-06-01 4.2.3 “Where a pixel is comprised of more than one LED, the LEDs shall be grouped to form a symmetrical circular, square or diamond shaped pixel in the display matrix.”[19]
	Pixel spacing - Text - Matrix	N/A
	Stroke width	ITS-06-01 “Stroke may be illustrated using the letter “T”: In single stroke the cross arm and the down leg are one lit pixel in thickness. In double stroke the cross arm and the down leg are two lit pixels in thickness”[20]
Queensland	Display Border	MRTS202 8.5.1 Type A – 125mm border Type B – 260mm border Type C – 260mm border
	Text	MRTS202 8.6 “As a minimum, the variable message display shall generate single stroke alphanumeric character fonts generally to the requirements of AS 1744. The characters shall be arranged so as to have a minimum of two pixels between characters and two pixels between lines.”
	Equivalent area	MRTS202 8.5.2 “The Graphics display unit (GDU) shall be formed by a matrix arrangement of a minimum of 64 horizontal pixels and a minimum of 64 vertical pixels”
	Pixel Size	MRTS202 8.2 “The variable message display technology shall be light emitting diode (LED). The display pixels may be formed by arranging one or more LEDs in a cluster to achieve the required luminance levels.”

[18] NZTA are currently reviewing their VMS specification
[19] Pixel pitch and dimensions are defined in the preliminary draft of the VMS Specification
[20] Pixel pitch and dimensions are defined in the preliminary draft of the VMS Specification

Jurisdiction	Factor	Alternative
Queensland (cont)	Pixel spacing - Text - Matrix	MRTS202 8.6 “The characters shall be arranged so as to have a minimum of two pixels between characters and two pixels between lines.”
Victoria	Display Size	TCS015 5.2.4 “The dimension of the housing shall be the minimum practical required to house the display. The dimensions of the entire VMS assembly, including the pictogram section, shall not exceed: Height: 2.3m. Width: 10m. Depth 0.35m.”
	Text	TCS015 5.4.2 “Standard operation of the sign shall permit the generation of default Font 2 characters.” TCS015 5.4.4 “In addition to the standard operation, the sign shall be capable of generating: • double stroke characters; • two lines of Font 4 characters; • one line of Font 5 characters, and • various fonts and proportional spacings.”
	Equivalent area	TCS015 5.2.1 “The VMS text display dimensions shall be 30 x 124 (vertical x horizontal) pixels.” TCS015 5.2.2 “If a pictogram display is required, the display dimensions shall be 64x64 pixels.”
	Pixel Size	TCS015 5.4.3 “To enhance the graphical qualities of the display, the individual pixel (element) dimensions shall not be greater than 40mm”
New South Wales	Text	TSI-SP-008 6.2.6 “The upper case text character shall be at least 14 pixels high”
	Equivalent area	TSI-SP-008 6.2.7 “The display vertical resolution shall be at least 58 pixels high”
	Stroke width	TSI-SP-008 6.2.5 Type A = 20mm, Type B = 32mm, Type C= 40mm
South Australia	Display Size	Operational Instruction 2.36 Section 2.2 - Minimum size of a small VMS sign shall be 1660 X 800. - Minimum 10 characters per row.
	Text	Operational Instruction 2.36 Section 2.2 - Font size equivalent to 180mm (minimum). - Font type equivalent to Arial. - 50 mm character spacing. - 50 mm row spacing. - 100mm word spacing.

Table 5.19: Portable VMS changes or clarifications

Jurisdiction	Factor	Alternative
New Zealand	Display Size	ITS-06-04 4.1 "For general use, a three line Mobile VMS with 300-350mm character height is specified."
	Display Border	ITS-06-04 5.1.1 "The bezel surrounding the primary display elements should have a minimum width of at least 200mm"
	Text	ITS-06-04 4.3 "The Mobile VMS must be able to display the following fonts and text layout: - Font NZTA approved font (Refer Appendix A - The slightly compressed alpha and numeric fonts approved by NZTA for use in Mobile VMS, is illustrated in the following graphics. These fonts must be used in all NZTA Mobile VMS.) - Character spacing Equal to or greater than width of down stroke (pitch) - Line spacing 3 pixels"
	Equivalent area	ITS-06-04 4.1 "Stipulating a minimum 56 pixels per line is designed to provide at least 9 characters per line. Up to 12 characters per line may be possible in conjunction with the approved compressed font. To provide 3 blank rows between lines of text, the display shall be at least 27 pixels high."
	Pixel Size	ITS-06-04 4.2.3 "Where a pixel is comprised of more than one LED, the LEDs shall be grouped to form a symmetrical circular, square or diamond shaped pixel in the display matrix."
	Pixel spacing - Text - Matrix	N/A
	Stroke width	N/A
South Australia	Text	Operational Instruction 2.36 Appendix E "Standard Alphabet (5x7 Matrix)"
	Equivalent area	Operational Instruction 2.36 Section 3.4 "To achieve adequate definition of pictorial messages it is recommended that there be a pixel matrix of 35 pixels square. As many of the existing VMS have only 28 pixels vertically or less, pictograms and network diagrams should not be used"
Queensland	Text	MRTS262 11.5 "As a minimum, the variable message display shall generate single stroke alphanumeric character fonts generally to the requirements of AS 1744. The characters shall be arranged so as to have a minimum of two pixels between characters and two pixels between lines."
	Equivalent area	MRTS262 11.4.2 "The GDU shall be formed by a matrix arrangement of a minimum of 64 horizontal pixels and a minimum of 64 vertical pixels. The pixels in the GDU shall be evenly spaced to match the overall vertical dimension of the TDU."
	Pixel Size	MRTS262 11.1 "The variable message display technology shall be light emitting diode (LED). The display pixels may be formed by arranging one or more LEDs in a cluster to achieve the required luminance levels."

6. Conclusion and Recommendations

On-road and off-road testing during prior Austroads projects identified problematic areas with TSR technology in Australia and New Zealand when attempting to identify electronic signage. Inconsistent identification of Electronic Variable Speed Limit Signs can result in incorrect speeds being displayed by the TSR systems, generally 30 or 60 for 80 and vice versa, or the system defaulting to another source for speed restrictions. Additionally, identification of text and pictogram displays on variable and changeable message displays can be challenging for advanced driver assistance systems as the Australian and New Zealand standards do not contain criteria specifically for readability by TSR technology.

The Australian Standards Road Traffic Signals Committee (LG006), having discussed Traffic Sign Recognition systems during the recent revisions to AS 4852.1, AS 4852.2 and AS 5156, has addressed some of the TSR readability issues with a series of new requirements such as pixel arrangement, dimming and uniformity. Further discussion with representatives of LG006 indicated TSR technology was not considered a major issue that would require drastic amendments to the current standards.

Consultation also indicated New Zealand are in the process of revising specifications for electronic signage which address some of the identified factors for recognition. This review of the Australian Standards and New Zealand specifications creates a potential risk whereby any recent readability requirements may not be rapidly adopted. Additionally, as a result of these revisions, many of these changes have not been included in the current versions of individual specifications requiring future revisions by jurisdictions.

6.1 Harmonisation Challenges

For fixed Variable Message Signs and Variable Speed Limit Signs, most of the jurisdictions have already referenced Australian Standards AS4852 and AS5156 for sign compliance. An opportunity exists for Standards Australia to review the standards relating to Traffic Sign Recognition systems, and for New Zealand to adopt the same requirements for improved harmonisation across jurisdictions.

Technologies in vehicles will evolve faster than the roadway infrastructure, and this is demonstrated in the new developments for LED flicker mitigation and high dynamic range discussed above. There still exists some discrepancy across states, with the greatest variation being in the application of fonts, both in the variable message and variable speed signs when utilising a matrix display. Individual specifications adopt and exclude clauses from the standards where deemed necessary or preferable by the jurisdictions resulting in variation in design, construction and operation of electronic signs. Harmonisation of standards, testing and certification is potentially a long journey, especially where ITS management platforms and communication protocols are involved, however if jurisdictions are prepared to adopt stricter compliance to the design form, colour and operation of the signs a reduction in effort for TSR compatibility is anticipated.

6.2 TSR Readability Criteria

Through the consultation process, a review was undertaken of the range of devices managed by each jurisdiction, their respective specifications and alignment with the relevant standards. The standards and specifications do not currently consider TSR systems, and therefore the assets currently deployed are not specifically designed for TSR readability.

Consistency of TSR readability criteria across all Australia jurisdictions and New Zealand provides a common standard for original equipment manufacturers, increasing availability in the Australian and New Zealand market and improving performance levels of TSR. The requirements for readability are based on the research and consultation outlined in Section 3 and Section 4 of this report.

While there is no immediate requirement to change signs as technology developments have the potential to mitigate the aforementioned issues there are several factors which can address gaps and improve the readability of electronic signs. These are further discussed in Table 7.1 below.

Table 6.1: Recommendations for TSR readability

Criteria	Recommendation
LED Driver	Improved readability of regulatory signs using alternative methods to multiplexed or pulse width modulated displays, such as constant current LED drivers.
Dimming	Standardisation of input/output luminance ratios and operation methods for dimming to ensure correct display intensity under all lighting conditions.
Display flicker	Sign refresh rate or pulse frequency should by synchronised across the entire display to reduce the presence of artefacts in captured images. Reducing ‘flicker’ when utilising PWM dimming by ensuring requirements such as those in AS 5156 are met.
Fault – scanning	Definition of maximum fault scanning duration rather than the current ‘not produce visible flickering of the pixels’ to reduce captured image artefacts during fault scan.
Fault - pixel failure	Improved requirements for deactivation of illegible displays to prevent incorrect speeds being displayed by TSR systems
Flashing	Limit the use of flashing annuli which may result in problems identifying displays, either through changes in the intensity of the display or changes in the width of the stroke as the inner rings flash.
Contrast	Harmonisation of contrast by standardisation of border/bezel width and colour and adherence to the use of anti-glare, non-polarising, polycarbonate material where viewing windows are required.
Luminance ratio (Reflectivity/Contrast)	Adherence to the luminance ratios defined in the relevant Australian Standards (or equivalent New Zealand specifications)
Luminance intensity uniformity	Further definition of requirements for displays utilising more than one simultaneous colour to ensure uniformity.
Consistency (colour)	Harmonisation of colour requirements between jurisdictions to improve uniformity in design and recognition by TSR systems
Display Size	Deployment of electronic speed control signs based on recommended sizes defined in AS 1742.4 Table 3.2. Consideration to be given to increased size where visible duration is limited, such as overhead gantries.
Display Form/Shape	Harmonisation of annuli requirements between jurisdictions to improve uniformity in design and recognition by TSR systems. Harmonisation of font requirements between jurisdictions to improve uniformity in design and recognition by TSR systems.
Display Border	Adherence to border requirements to improve uniformity in design and recognition by TSR systems.
Numerals	Adherence to font requirements, especially when utilising LED matrix displays, to improve uniformity in design and recognition by TSR systems.
Pixel Size	Improved definition of pixel design and testing to enhance matrix displays
Stroke width	Improved definition of stroke width to enhance discrete displays

6.3 Further Work with Standards Australia

Further work is recommended following this project. This includes the integration of Traffic Sign Recognition systems into existing standards AS 4852.1, AS 4852.2 and AS 5156, which can be submitted to Standards Australia for consideration.

6.4 Project Recommendations

As indicated in Section 5, this project has resulted in a series of key criteria relating readability criteria that are suitable for consideration and adoption by the jurisdictions. The project team engaged with project working group members and original equipment manufacturers to achieve these outcomes and the results are outlined in this report.

While undertaking this project, the harmonisation of standards across jurisdictions was considered. This is recommended in the future following the release of updated Standards.

It is not intended that road agencies immediately begin implementing changes to road assets to support Traffic Sign Recognition systems. As with any other change in standards, a transition process is required during which road agencies will begin to implement these changes in a manner which is determined by their priorities and resources. It should be noted that some road agencies have already begun to implement some of the recommendations of the report. The discretion of each road agency is required, to develop a program for the implementation and funding for these changes to occur. It is most likely that this will be done under existing maintenance programs.

Cost to Implement

Jurisdictions were approached to provide detail on assets and renewal plans, unfortunately the level of detail disclosed by jurisdictions and stakeholders does not allow a detailed assessment of the current costs and efforts. The potential enhancements that may be deployed are variable and subject to a scalable implementation to increase compatibility with TSR systems. This could range from simple firmware updates in assets to more complex replacements of hardware. As such, these costs could be millions to tens of millions and costs to be incurred variable dependant on manufacturer, model and quantity of devices deployed by each jurisdiction.

It is anticipated that the next steps will be to:

- revise specifications to align with updated AS 4852.1, AS 4852.2 and AS 5156
- harmonise testing and certification
- consider incremental retrofit of existing assets where feasible or deemed necessary as part of renewal plans.

6.5 Further Work

Anecdotally, the flashing annulus on many variable speed limit signs may result in problems identifying displays, either through changes in the intensity of the display or changes in the width of the stroke as the inner rings flash. Additional analysis with the co-operation of TSR manufacturers to determine the validity of this factor is recommended.

In order to produce improved definitions of test procedures and standards, additional evaluation and alignment with standards for Automotive Vision Systems being developed by the IEEE P2020 Working Group is recommended.

An investigation into the feasibility and effectiveness of Cooperative Intelligent Transport Systems (C-ITS) to supplement electronic variable speed limits signs is recommended. The deployment of these systems could reduce the reliance on automotive vision systems in situations where dynamic speed limits are in place.

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Appendix A Transport Agency Specifications

A.1 Department of Transport (formerly VicRoads)

Table A.1: Victorian specifications

Specification	
Electronic Speed Sign Specification (ESLS/VSLS)	TCS037
Lane Use Specification (LUMS/ISLUS)	TCS056
Variable Message Sign Specification (VMS)	TCS015[21] / TCS034[22]
Temporary ESLS/VSLS Specification (Trailer)	TCS062
Temporary VMS Specification (Trailer)	
Ramp Control Specification (RAMP/RC)	TCS003
CMS Specification (Generic & Lane Control)	TCS042[23]
CMS Specification (NLT/NRT/No Entry)	TCS032
CMS Specification (VAS)	TCS057

A.2 Department of Transport and Main Roads

Table A.2: Queensland specifications

Specification	
Electronic Speed Sign Specification (ESLS/VSLS)	MRTS222 / MRTS206
Lane Use Specification (LUMS/ISLUS)	MRTS206
Variable Message Sign Specification (VMS)	MRTS202
Temporary ESLS/VSLS Specification (Trailer)	MRTS260
Temporary VMS Specification (Trailer)	MRTS262
Ramp Control Specification (RAMP/RC)	
CMS Specification (Generic & Lane Control)	MRTS227
CMS Specification (NLT/NRT/No Entry)	
CMS Specification (VAS)	MRTS218

[21] TCS 015-2016 Specification for Variable Message Signs (Fixed freeway applications)
[22] TCS 034-2-2013 The Supply of Variable Message Signs for Arterial Roads
[23] TCS 042-2-2005 Generic Specification for the Supply and Installation of Internally Illuminated Message Signs (IIMS)

A.3 Transport for New South Wales (formerly Roads and Maritime Services)

Table A.3: New South Wales specifications

Specification	
Electronic Speed Sign Specification (ESLS/VSLS)	TTD 2014/006[24], TS105[25]
Lane Use Specification (LUMS/ISLUS)	TSI-SP-011, TS105[26]
Variable Message Sign Specification (VMS)	TSI-SP-008, TS105[27]
Temporary ESLS/VSLS Specification (Trailer)	
Temporary VMS Specification (Trailer)	
Ramp Control Specification (RAMP/RC)	TSI-SP-051
CMS Specification (Generic & Lane Control)	TSI-SP-067[28]
CMS Specification (NLT/NRT/No Entry)	TSI-SP-072
CMS Specification (VAS)	TSI-SP-066

A.4 Main Roads Western Australia

Table A.4: Western Australian specifications

Specification	
Electronic Speed Sign Specification (ESLS/VSLS)	SPECIFICATION 709
Lane Use Specification (LUMS/ISLUS)	
Variable Message Sign Specification (VMS)	SPECIFICATION 707
Temporary ESLS/VSLS Specification (Trailer)	SPECIFICATION 202[29]
Temporary VMS Specification (Trailer)	
Ramp Control Specification (RAMP/RC)	
CMS Specification (Generic & Lane Control)	
CMS Specification (NLT/NRT/No Entry)	
CMS Specification (VAS)	

[24] Technical Direction for Variable Speed Limit Signs referencing TSI-SP-011
[25] Specification for ITS Electronic Message Sign Site (covering standard and specialised VMS, ISLUS)
[26] Specification for ITS Electronic Message Sign Site (covering standard and specialised VMS, ISLUS)
[27] Specification for ITS Electronic Message Sign Site (covering standard and specialised VMS, ISLUS)
[28] Specification for Changeable Message Signs - Electronic
[29] Traffic Control Devices in accordance with AS1742.3

A.5 Department of Planning, Transport and Infrastructure

Table A.5: South Australian specifications

Specification	
Electronic Speed Sign Specification (ESLS/VSLS)	RD-ITS-S4 (Section 5) & OI 20.26
Lane Use Specification (LUMS/ISLUS)	RD-ITS-S4 (Section 5) & OI 20.26
Variable Message Sign Specification (VMS)	RD-ITS-S4 (Section 5) & OI 2.36
Temporary ESLS/VSLS Specification (Trailer)	
Temporary VMS Specification (Trailer)	OI 2.36 & OI 3.14
Ramp Control Specification (RAMP/RC)	RD-ITS-S4 (Section 5) & OI 2.36
CMS Specification (Generic & Lane Control)	RD-ITS-S4 (Section 5 & 6) & OI 2.36
CMS Specification (NLT/NRT/No Entry)	RD-ITS-S4 (Section 5)
CMS Specification (VAS)	RD-ITS-S4 (Section 5)

A.6 Transport Canberra and City Services

Table A.6: Australian Capital Territory specifications

Specification	
Electronic Speed Sign Specification (ESLS/VSLS)	MIS13 & RITS006
Lane Use Specification (LUMS/ISLUS)	
Variable Message Sign Specification (VMS)	MIS13 & RITS001
Temporary ESLS/VSLS Specification (Trailer)	
Temporary VMS Specification (Trailer)	
Ramp Control Specification (RAMP/RC)	
CMS Specification (Generic & Lane Control)	
CMS Specification (NLT/NRT/No Entry)	
CMS Specification (VAS)	

A.7 New Zealand Transport Agency

Table A.7: New Zealand specifications

Specification	
Electronic Speed Sign Specification (ESLS/VSLS)	Traffic control devices manual (Sign specification RS1V, Rule R1-2.1) and P32
Lane Use Specification (LUMS/ISLUS)	
Variable Message Sign Specification (VMS)	ITS-06-01 (2013) Traffic control devices manual (Sign specification RB2, Rule R7-10.1)
Temporary ESLS/VSLS Specification (Trailer)	
Temporary VMS Specification (Trailer)	ITS-06-04
Ramp Control Specification (RAMP/RC)	ITS-05-01, ITS-05-02, ITS-05-03
CMS Specification (Generic & Lane Control)	
CMS Specification (NLT/NRT/No Entry)	
CMS Specification (VAS)	

Appendix B Stakeholder Consultation

B.1 PWG Survey Questions

- Have you had any feedback or discussion in relation to traffic sign recognition from manufacturers (TSR systems or OEM's)?
- Are you able to advise either in the box below or via email the outcomes of the discussion?
- Have you had any feedback or discussion in relation to traffic sign recognition with sign manufacturers?
- Are you able to advise either in the box below or via email the outcomes of the discussion?
- In review we have noted the following specifications (included in separate email), are there any others we are missing?
- Are you currently planning to update your specifications in the near future (within 6mths)?
- Within your specifications, do you have variations to the requirements of the respective AS/NZ standards?
- Are you able to highlight the variation and where possible the supporting business need which has instigated the change?
- Do you have a policy or guide for trailer mounted VMS/VSLS and the use of such portable VMS as VSLS?
- Are you able to email a copy of this to the project team?
- Are there any sign recognition related electronic signs that this list does not encompass?
  - VMS
  - VSLS
  - LUMS/ISLUS
  - RAMP/RC
  - VAS (Vehicle Activated)
  - ESLS/Stand Alone VSL
  - CMS
  - Trailer VMS
  - NLT/NRT/No Entry Signs
  - Advanced Warning Signs (Fog/Overheight etc)
- Are there any relevant testing specifications or performance requirements not covered by the standards identified earlier?

B.2 PWG Request for Asset Data

If possible, please provide a list of existing and planned VMS and 'School Zone'/ESLS/LUMS with the following details (any additional asset data, such as CMS or Ramp control would also be appreciated):

- age (installation date)
- manufacturer/model
- obsolescence or upgrade date (if available).

B.3 Sign OEM Survey Questions

- Are you currently aware of any limitations in your signs with regards to TSR?
- Has TSR been highlighted as an issue or requirement on any of your projects?
- Do you consider any remedy lies with TSR systems more so than sign design/manufacture?

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