WAKA KOTAHI
NZ TRANSPORT AGENCY

LANE AND CARRIAGEWAY SIGNALS (LCS)

ITS Delivery Specification

6 OCTOBER 2021
3.0

New Zealand Government

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More information
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More information about intelligent transport systems (ITS) is available on the Waka Kotahi website at https://www.nzta.govt.nz/its

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Template version
1.19, 27/09/2021

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1 DOCUMENT CONTROL

1.1 Document information

Document number	ITS-02-003-202110-SPEC-LCS-Interim
Previous document number/s (if applicable)	ITS-02-003-202107-SPEC-LCS ITS-02-003-202105-SPEC-LCS ITS-04-01
Document status DRAFT | PENDING | RATIFIED | RETIRED	PENDING
[IF RETIRED] New document details	
Online ISBN number	
Document availability	The controlled version of this document can be accessed from https://www.nzta.govt.nz/roads-and-rail/intelligent-transport-systems-its/its-standards-and-specifications/its-current-interim-and-legacy-standards-and-specifications/

1.2 Document owner

Role ITS Working Group

Organisation Waka Kotahi

1.3 Document approvers

This table shows a record of the approvers for this document.

Approval date	Approver	Role	Organisation
DD/MM/YYYY			

1.4 Version history – major versions

Document version control is the process of tracking and managing different versions (or drafts) of a document to easily identify the current iteration of a file.

This table shows a record of all major (published) versions of this document (for Waka Kotahi use only). To record minor versions (author updates, amendments etc), go to section 11 Full version history.

Version	Date	Author	Role and organisation	Reason
1.0	18/05/2021	ITS Working Group Kirill Yushenko Editorial services	Waka Kotahi Consultant, Resolve Group Final Word	Document issued
2.0	09/07/2021	ITS Working Group	Waka Kotahi	Reviewed internally and version 2.0 issued
3.0	06/10/2021	ITS Working Group	Waka Kotahi	Reviewed internally and version 3.0 finalised

2 TERMINOLOGY USED IN THIS DOCUMENT

Term	Definition
DRAFT	The document is being written and cannot be used outside of Waka Kotahi.
PENDING	The document has been finalised and is pending approval and ratification by Waka Kotahi. It can be used for procurement at this status.
RATIFIED	The document is an official Waka Kotahi document. Road controlling authorities are obliged to follow a document with this status.
RETIRED	The document is obsolete, and/or superseded.
AS/NZS	Australian/New Zealand standard
Aspect	Visual appearance of a signal.
ATMS	Advanced traffic management system
Beacon	An illuminated circle that flashes in order to draw a user's attention to a sign or a signal. Beacons are typically located and displayed in the corners or along the edges of a sign or signal display matrix.
Character height	Height of an upper-case character expressed in millimetres.
Character spacing	Horizontal spacing between individual characters on the same line of a message, expressed as a ratio of stroke width.
CSV	Comma Separated Values
Display matrix	Visible part of an electronic sign or signal which contains the pixels that can be activated to display the message.
EN	European standard
Enclosure	Housing for electronics systems to protect against environmental conditions.
Exception	Any unexpected or undefined state for a controller in a device.
FAT	Factory acceptance test
Frame surface	Internal and external surfaces of an electronic sign or signal enclosure.
Front screen	Screen protecting the display matrix or the parts of it against dust, water etc.
FTP	Secure File Transfer Protocol
Gantry	Support structure spanning a carriageway for the purpose of supporting electronic signs and signals.
IEC	International Electrotechnical Commission standard
IK	International numeric classification for the degrees of protection provided by enclosures for electrical equipment against external mechanical impacts.
IP code	International Protection code (sometimes interpreted as Ingress Protection code) classifies the degree of protection provided by mechanical casings and electrical enclosures against intrusion, dust, accidental contact and water.
ISO	International Organization for Standardization standard

Term	Definition
ITS	Intelligent transport systems
JSON	JavaScript Markup Language
LCS	Lane and carriageway signals
LCU	Lane control unit (see LCS)
LED	Light-emitting diode
LR	Luminance ratio
LSU	Lane signal unit (see LCS)
Message	Configuration consisting of symbols and/or text.
MTBF	Mean time between failure
MTTR	Mean time to repair
MULTI	Mark-up language for transportation information
NIWA	National Institute of Water and Atmospheric Research
NTCIP	National Transportation Communications for Intelligent Transport Systems (ITS) Protocol
NTP	Network Time Protocol
OEM	Original equipment manufacturer
Pictogram	Pictorial aspect which conveys its meaning through resemblance to a physical object.
Pixel	Smallest controllable element of a display matrix for an electronic sign or signal.
Pixel pitch	Distance between centres of adjacent pixels.
RCA	Road controlling authority
RFC	Request for Comments
RGB256	Red, green and blue can each have values from 0 to 255 using 8 bits (binary digits). This equates to the ability to display 255 x 255 x 255 (>16.5M) colour permutations.
SAT	Site acceptance test
SCADA	Supervisory control and data acquisition (system)
SIL	Safety integrity level
SSH	Secure Shell
TCD manual	Traffic control devices manual
TCDR	Traffic Control Devices Rule
TCP	Transmission Control Protocol
TOC	Traffic operations centre
TSR	Traffic sign recognition
UDP	User Datagram Protocol
UPS	Uninterruptable power supply
UTC	Coordinated Universal Time

Term	Definition
VMSS	Variable mandatory speed sign
XML	Extensible Markup Language

3 OVERVIEW AND OUTCOMES

This section defines the purpose of the equipment within the operational system.

3.1 Purpose

The purpose of this document is to specify the minimum requirements for the procurement of lane signal units and carriageway signals units by Waka Kotahi. In addition, this delivery specification will detail the system integration requirements, eg protocols, interfaces, data standards etc to ensure compliance with Waka Kotahi systems and standards.

Delivery assurance is managed through a series of delivery specifications which support procurement and systems integration. The key risks that specifications address are ensuring the correct equipment is being procured, that it will integrate with operational systems, and will deliver the correct functionality and performance requirements.

3.2 Overview

Traffic signals are very familiar to road users, making use of hierarchical positioning and universally understood colours as forms of instruction to maintain safe operation and prevent vehicle conflict.
Waka Kotahi uses a form of signal to indicate lane availability and provide variable speed limit information to road users along motorways and expressways. Although not as intuitive and ubiquitous as traffic signals, the equipment uses simple aspects to assist with safe road operation and comfortable lane changing. See section 4 Functional requirements.

This delivery specification shall be applicable to all national state highways and regional roading authorities (the latter is at their discretion).

3.2.1 Definition

Lane and carriageway signals (LCS) provide direct instruction to road users for the purposes of controlling or managing speed restrictions on a local road, motorway or expressway. Displayed aspects are subject to the Traffic Control Devices Rule (TCDR) and therefore have legal precedence.

LCS operate across a group of lanes along the length of a carriageway. In the lane management operating mode, aspects have a one-to-one direct correlation with a lane. Under the speed management operating mode, displayed aspects can apply to a lane or a whole carriageway, depending on the configuration.

The various acronyms for lane and carriageway signals have been consolidated to LCS in this delivery specification and for the purposes of this document, the following terms are no longer used:

- lane control signal (LCS)
- lane control unit (LCU)
- lane signal unit (LSU)
- variable mandatory speed sign (VMSS).

3.2.2 Waka Kotahi ITS class

003 Signals. Equipment which provides visual instructions (often legally enforceable) to the users of the transport network.
Class definitions

3.3 Scope

This delivery specification covers two similar equipment types, namely lane signal units and carriageway signal units. Both are mandatory speed-capable devices.

3.3.1 Carriageway signal units

Carriageway signal units are gated (or paired) at the same longitudinal position to the left of the emergency shoulder (or left-hand traffic lane if absent), on either side of a carriageway or on-ramp. See figure 1 following:

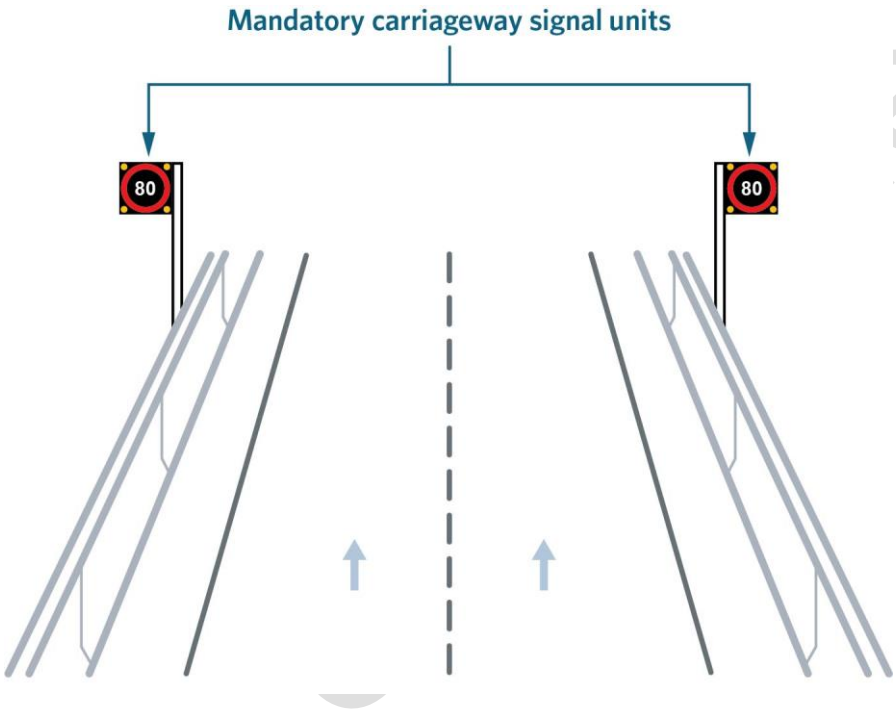

Figure 1. Carriageway signal units (typical arrangement) – front view

3.3.1.1 Carriageway signal unit aspects

Carriageway signal units can only be used to display aspects which are applicable to all traffic lanes heading in the same direction. Both devices must show the same aspect, eg mandatory 80km/h on figure 1 above.

3.3.2 Lane signal units

Lane signal units are positioned centrally above each lane to display an aspect which applies specifically to the lane below. See figure 2 following:

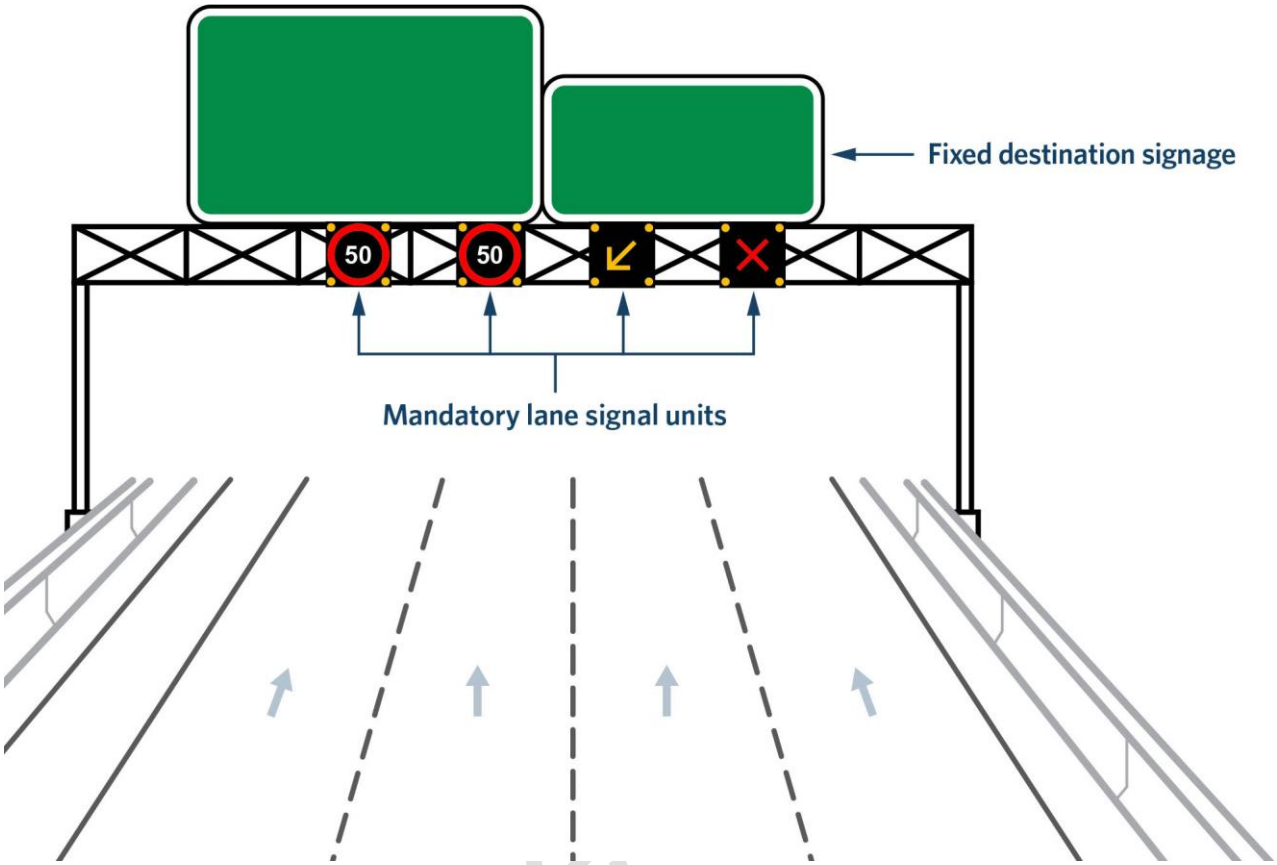

Figure 2. Lane signal units (typical arrangement) – front view

3.4 Outcomes

The critical outcomes are the ability to manage traffic speed and/or manage lanes under degraded modes (eg for incidents, events and roadworks), and to deliver consistent and unambiguous instructions to the road user across the strategic road network.

3.4.1 Operational

The intended operational outcomes of this delivery specification are to:

- control traffic flow more efficiently using dynamic speed limits
- manage lane availability by actively reconfiguring lanes
- execute traffic management plans in response to planned or unplanned events across coordinated groups of signals
- ensure the equipment is available for use and out of service for maintenance for very short periods.

3.4.2 For users of the transport network

The intended outcomes of this delivery specification for users of the transport network are to:

- have the ability to easily recognise and understand the instructions relating to lane management or speed control under all operating conditions
- cause no confusion or distraction to road users
- provide information about upcoming lane availability
- provide mandatory speed limit information.

These outcomes are aimed at ensuring road user safety and minimising the occurrence of congestion.

3.4.3 For road controlling authorities and traffic operations centres

The intended outcomes of this delivery specification for road controlling authorities (RCAs) and traffic operations centres (TOCs) are to have the ability:

- for TOCs to obtain status condition and fault logging information in real time about the performance of LCS
- to manage lane use and speed
- to support temporary traffic management (TTM) functions.

4 REQUIREMENTS

This section outlines what the equipment and systems need to do (functional), and how they need to do it (non-functional).

LCS must be:

- able to present and maintain a visible and legible aspect to road users under all weather and lighting conditions and be clearly seen by road users from a significant distance (between approximately 75m and 300m)
- compliant with Waka Kotahi system interface design standards
- able to self-diagnose faults and send appropriate fault messages to the fault management system
- able to display the colour palette referred in sections 5.4.1 LED colour palette and 5.4.2 Colour.

4.1 Lane control signal unit

LCS must be able to control the display of the red (regulatory speed) roundel independently from the other features of an aspect. The display priority is included in the message content and LCS aspects are organised strictly hierarchically, where the lane closed aspect always takes priority over lane divert/merge aspects which in turn always take priority over speed aspects. The issue of contention where messages with the same priority are competing for display is not possible as each LCS aspect given has a unique priority.

4.1.1 Standard aspects

As a minimum these aspects must be supported by the LCS. Waka Kotahi may add more aspects as required for traffic management.

Figure 3. Mandatory 80km/h speed limit

Figure 4. Mandatory 100km/h speed limit

Note: 80km/h and 100km/h aspects have been shown as examples, however speed limits ranging from 10km/h to 110km/h in 10km/h increments are required.

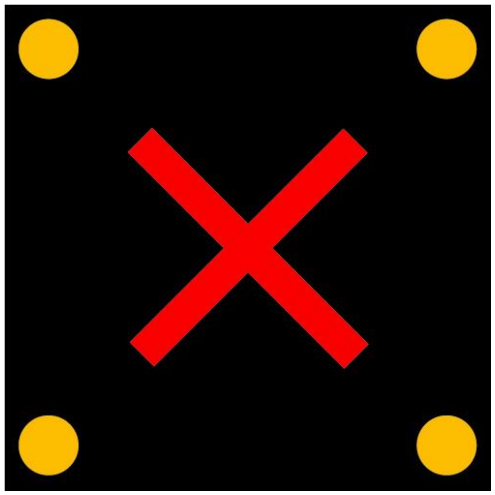

Figure 5. Lane or carriageway closed

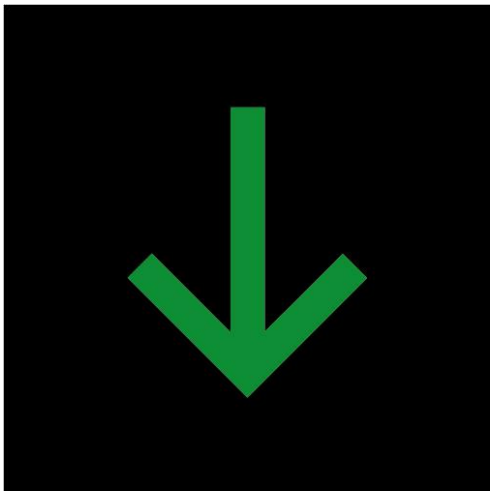

Figure 6. Lane open

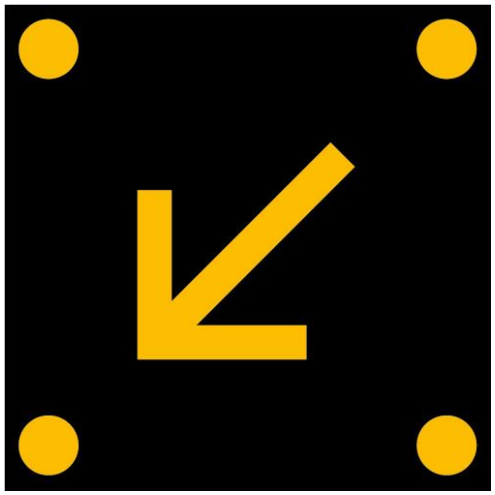

Figure 7. Divert/merge left

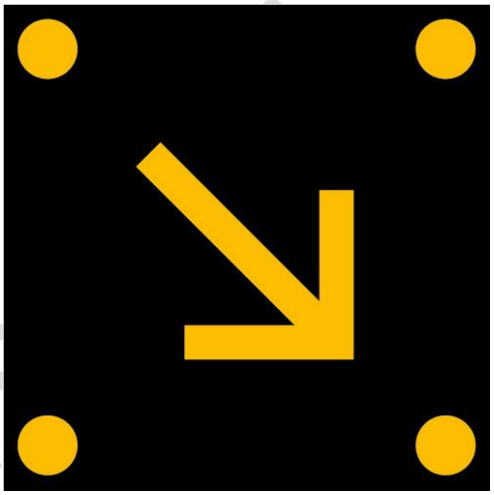

Figure 8. Divert/merge right

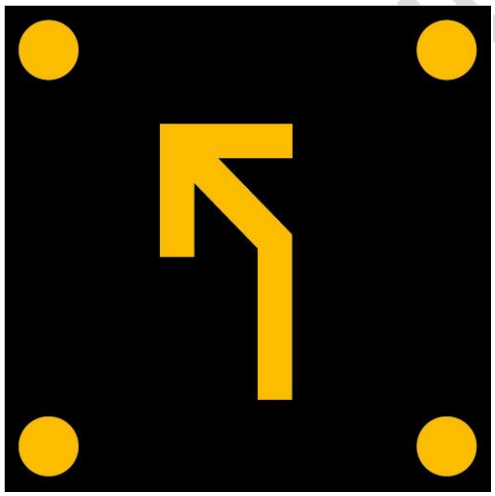

Figure 9. Lane exit left

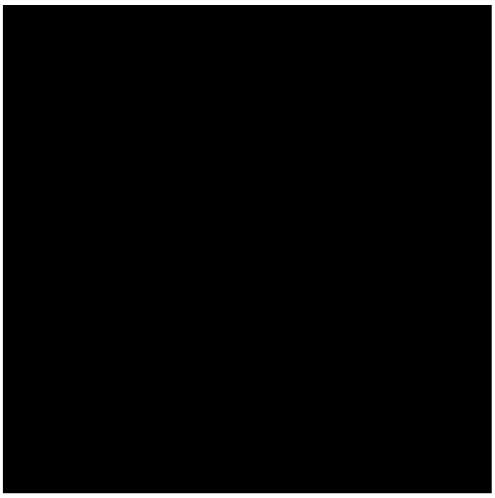

Figure 10. Blank

4.1.2 Full-colour display matrix

The functional requirement for this delivery specification is that the display must be comprised of LEDs which are mounted in a full matrix arrangement (see section 7.4 Guidance for dimensions and application, for pixel

pitch requirements) and are each capable of displaying a full-colour palette (see sections 5.4.1 LED colour palette and 5.4.2 Colour).

4.1.3 Display uniformity

The display of the LCS must appear to be uniform and consistent across the display matrix and in the following areas.

4.1.3.1 Luminous intensity (brightness)

There must be no visible variation in brightness across the display. The luminous intensity of LCS must be capable of automatically adjusting to align with ambient lighting conditions.

4.1.3.2 Colour

Optically there must be no visible variation in the colour of the light produced across the display.

4.1.4 Contrast ratio

The contrast ratio must ensure that all images displayed on the LCS are clearly legible under all conditions. See also sections 5.4.3 Luminance and 5.4.4 Luminance ratio.

4.1.5 Beacons and pulsing roundels

The LCS must be able to display circular illuminated beacon representations in each corner of the display matrix (not using separate beacon units). The two pages of flashing aspect need to be shown for 0.5 of a second each (which is the equivalent of a beacon flashing at 1 Hz) in any combination of patterns as defined in NTCIP 1203 v03 National Transportation Communications for ITS Protocol – Object Definitions for Dynamic Message Signs (DMS) (NTCIP 1203), section titled Beacon Type Parameter.

Beacon sizes are detailed in section 7 Appendix A – Indicative sizing.

The LCS must be able to display illuminated circular red roundel representations. The multiple pages of pulsing need to be shown for 0.5 of a second each.

The page on time is a configurable parameter of the LCS and shall be set to 0.5 of a second.

4.1.6 Rear indicator

Where the LCS is used as advanced warning to temporarily change the speed on a section of road to a single predefined speed limit, a rear indication that can be seen clearly from 100m away must be fitted. Examples of such applications are school zone signs and intersection speed zone signs.

4.1.7 Display matrix pixel control

Each individual pixel must be able to be addressed and controlled separately. In effect, the LCS is full colour and graphics capable – it is not constrained to use alphanumeric characters or predefined aspects.

The use of fully configurable displays allows flexibility to introduce new aspects in the future should the (currently unforeseen) operational need arise. Note: the development of new aspects must be in accordance with the Waka Kotahi Traffic control devices manual (TCD manual).

4.1.8 Display matrix parameters

The LCS display must consist of a full matrix.

The key dimensions influencing the procurement of LCS are pixel pitch, internal and external roundel diameters, diameter of beacons and overall enclosure size.

4.1.9 Visible flicker – machine readability

During testing there shall be no visible light flicker, whether the LEDs of an LCS are operating at full intensity or are dimmed. Further, LCS messages must be machine readable, eg by traffic sign recognition (TSR) systems.

4.1.9.1 Frequency

The LCS must meet the frequency requirement of 100 Hz or greater.

4.1.10 Storage of text and graphics

The LCS must be able to display alphanumeric characters and graphics from an onboard library which can be commanded by sending a reference to, rather than the full configuration of, the message, eg set message 1 could translate to display the red lane closed aspect.

4.1.11 Message conflict

The LCS must be able to display aspects which resemble alphanumeric characters or pictograms, requested from approved external sources such as TOCs or as part of a local response such as from a remote tunnel supervisory control and data acquisition (SCADA) system. At least one input relay contact must be available.

4.1.12 Remote configuration

The LCS must support remote configuration by RCAs or their appointed agents such that text and graphics can be uploaded into the onboard library and modifications can be made to font files and other configurable objects.

4.1.13 Status information

The LCS must be able to communicate status information including faults, confirm receipt and read back message detail, and communicate any required performance parameters to the external source(s).

4.1.13.1 Status update in real time

Status information must be updated in real time (in less than two seconds from the point when a message is received by the LCS network interface).

4.1.14 Internal logging requirement

The LCS must maintain logs and retain performance parameters including fault conditions until they are retrieved (and removed) during the prevailing periodic maintenance cycle for resolution. Logs must be able to be retrieved remotely. Log data should be available for export analysis in non-proprietary common format, eg CSV, XML, JSON files, and recorded with a time stamp.

4.1.14.1 Internal logging retention period

Logs, including errors and performance parameters captured by the LCS, must be retained for a minimum two-year period, or until they are retrieved.

4.1.15 Communication failure

After a communication failure the LCS must blank the aspect currently being displayed on the display matrix.

Note: A communication failure is deemed to have occurred when a defined period of time from the last received communication from the associated controlling entity (such as the back-office system or local controller) has been exceeded.

4.1.15.1 Communication timer

The communication failure timer must be configurable.

4.1.15.2 Communication timeout

The default setting for the communication failure timer is a period of two minutes from the last incoming communication.

4.1.15.3 Post-communication timeout state

The LCS must blank into the lowest priority state (idle) so that asset is ready for service on recovery of communications.

4.1.16 Message queuing and prioritisation

The LCS must be able to prioritise incoming display requests from different external sources using NTCIP 1203 priorities, eg tunnel control system and advanced traffic management system (ATMS), based on the graphic image's hierarchy (lane closed, lane divert, lane exit left, mandatory speed limit). Only the highest priority messages will be displayed.

All aspects will be realised through standard NTCIP 1203 commands. All graphic and text messages will be pre-installed in the LCS and must be loaded into the same library locations or slots.

Operational priority hierarchy for standard signal aspects		
Aspect	**Priority**	**Note**
Blank	0	Reserved for putting the LCS into a known state when the LCS goes into an unknown state, or when control of the LCS is lost.
SCADA (relay contact) mission critical applications (local control)	1	
Red X	2	
Divert arrow (left and right)	3	These have equal priority. The last requested setting at this priority takes precedence.
Lane exit left arrow	4	
Straight-ahead arrow	5	
Mandatory speeds	6, 7… …17	Lower speed aspects have a higher priority than higher speed aspects. Aspects range from 10km/h to 110km/h in 10km/h increments.

Table 1. Message queuing and prioritisation

4.1.17 Fault actions

The LCS must take appropriate action when it detects faults. Under no circumstances can the LCS display to road users:

- brightness levels which are inconsistent with ambient lighting, not uniform across the LCS display, or not consistent with adjacent LCS
- partial, incomplete or otherwise potentially unintelligible messages. The LCS should be blank.

4.2 Lane control signal group

Where multiple lane signals are installed at the same longitudinal location on a gantry, or carriageway signals installed in pairs at either side of the carriageway, there is functionality which must appear consistently across every device. The grouped or system functions are as follows.

4.2.1 Display uniformity

Optically there must be no visible variation in:

- the colour of the light produced by adjacent or paired LCS
- the luminance (brightness) display by adjacent or paired LCS.

Individual unit luminance levels must be able to be calibrated to ensure consistent brightness across the group.

4.2.2 Prompt message display

The time difference between receipt and display of all messages must be such that there is no discernible lag between one device updating and updating of the adjacent LCS.

4.2.2.1 Display update time

For LCS in a group or pair, the maximum lag between sequential LCS updating is one second.

4.2.3 Handling of fault conditions

When a critical fault (see section 4.3.2 Fault reporting) occurs on any grouped or paired LCS, then the TOC operators will make the decision on what to display on the LCS.

4.2.4 Beacon synchronisation

Where LCS simulate flashing beacons to attract the attention of road users to specific graphic images, it is essential that multi-page message transition must be synchronised across all LCS in a group or pair, ie they must appear to operate in unison.

4.2.5 Manage conflicting signal settings

Conflicting signal settings on signal groups are usually managed by the central control system, eg DYNAC. In some special cases a local controller may be required, such as where the direction of travel of specific lanes can be reversed.

In cases where a local controller is used to manage LCS, the local controller must be able to resolve conflicting signal settings.

4.2.6 Roundel synchronisation

When pulsing roundels are used as a means to attract road users' attention (as an alternative to corner beacons) or to indicate a change of speed, it is essential that this action is synchronised across all LCS in a group or pair, ie they must appear to operate in unison.

4.2.7 Group management

Where a group signal controller is deployed to manage a group of signals, it must be able to execute or manage the conflict rules and signal settings, and manage fault reporting of the group.

4.3 Signal controller

4.3.1 Status reporting

The signal controller must:

- retain fault logs locally until retrieved by the Waka Kotahi authorised asset manager or logging system
- report LCS fault conditions to the central control system as soon as the communication network is available.

4.3.1.1 Retention period

Minimum of 24 months.

4.3.2 Fault reporting

The signal controller must monitor the operation and health of the LCS and communicate status with the control room. Alerts on the operators' workstations indicate whenever a problem occurs which will prevent the correct display of messages on the LCS.

There are several conditions which must be drawn to operators' attention which must be provided by the LCS supplier. There are three levels of criticality:

- Critical: detected fault results in unit outage or may have safety implications.
- Urgent: detected fault prevents designed operation to support outcomes.
- Routine: detected fault has no impact on operation to support outcomes.

4.3.2.1 Fault reporting error types

The minimum error types are:

Error type	Definition
Pixel	Pixels can fail from time to time. A pixel error must be raised when pixels fail. Should multiple failures occur on any display matrix, this may affect message interpretation, however as LCS fulfil a safety critical role they will continue to display a (potentially partial or incomplete) aspect. The LCS will generate a pixel error. The threshold at which a critical pixel error is raised must be configurable and will occur on any display matrix when either: • the number of pixels which have failed has exceeded a certain percentage, the default for this shall be set at 2%, or • the number of failed pixels in any 3 x 3 square matrix has exceeded a certain number, the default for this shall be set at 7. NOTE: Any LED pixel shall be deemed failed if it does not behave as expected. Such behaviour shall include pixels remaining in the wrong state (on or off), pixels which flicker, and pixels which exhibit reduced or increased brightness compared to properly functioning pixels. The display module(s) where faults have occurred must have a visible fault indicator to facilitate efficient maintenance removal and replacement.
Message	This error is raised when the LCS is not able to display any message either because of internal device failure(s) or because the LCS is unable to resolve a message in the format in which it is presented.
Power	This error is raised when one or more power supplies becomes faulty or the mains power supply fails. The LCS must log the fault.

Error type	Definition
Temperature	If the temperature inside the enclosure exceeds a critical threshold level, the LCS must report the temperature and log it. The sign must be turned off to protect the sensitive electronic components from damage.
Photocell	A pair of photocells is used to measure the ambient light at the sign and adjust the brightness of the LEDs to suit. If a photocell fails, the sign could become either too dim or too bright to be legible.
Internal communication	This error advises a communication failure within the LCS unit.
External communication	The LCS must log when external communication failure has occurred and must report this error as soon as external communication is restored.

Table 2. Fault reporting error types

4.3.3 Error handling

Incorporate an error handler to detect out-of-program conditions and reset the controller.

The error handler must put the LCS into a known state, eg clear the message automatically and immediately in the event of internal or external critical failures such as a communications failure.

All errors must be logged.

The controller must be able to deal with unexpected events (exceptions) and faults.

The error handler must place the equipment into a known state so that it is easily able to transition back to normal operation when the error condition has been resolved.

4.3.3.1 Exceptions

Error type	Aspect displayed	Action
Partial, incomplete or otherwise potentially unintelligible messages	Speed	Blank sign
	Lane closed Divert left/right	Continue displaying aspect
Brightness levels which are inconsistent with ambient lighting, not uniform across the LCS display, or not consistent with adjacent LCS	All	Continue displaying aspect

Table 3. Error handling exceptions

4.3.4 Configuration and administration

The signal controller must:

- provide an interface in the LCS for a device to be connected to upload and download graphics and facilitate diagnostic testing. The LCS must support both local and remote access for the manufacturer's

proprietary software. Associated software must be provided by the manufacturer for use by Waka Kotahi or their agents
- store, as a minimum, 500 aspects for immediate display
- be able to upload and download the aspect on demand.

4.3.5 Command and control

The signal controller must:

- be able to operate the LCS in both local-control mode (ie no external communications) and remote-control mode (ie communicating with an external central control system)
- in both local and remote modes, support technician/operator selection of all NTCIP 1203 functions (such as manually changing dimming level, commanding display of pre-stored messages, and running diagnostic routines capable of testing full LCS operation)
- display a message on the LCS within one second of receiving the message.

4.3.6 Remote management interface

The LCS must be able to have remote management and configuration functionality through a standard interface, eg a web browser. If propriety software is required to administer the signal, then the manufacturer must make this available to Waka Kotahi at no additional cost.

4.3.7 Security and access

Access to all management reporting and command functions as detailed in sections 4.3.4 Configuration and administration, 4.3.5 Command and control and 4.3.6 Remote management interface must be done through a single communications port.

The LCS shall:

- support user authentication remotely and locally
- comply with Waka Kotahi or local authority (if applicable) cyber security requirements.

5 PERFORMANCE REQUIREMENTS

This section outlines the reliability and availability requirements of equipment which may require independent certification and/or declarations of conformity.

5.1 Resistance to the effects of external conditions

The operating environment of LCS can be relatively harsh. Equipment that is deemed fit for purpose is expected to continue to operate effectively exposed to the New Zealand environment as per the National Institute of Water and Atmospheric Research (NIWA), for a minimum of 15 years. It is essential that materials and manufacturing processes take this into account.

LCS shall be capable of continuous, normal operation (24/7 day and night) and maintaining performance criteria in the conditions described below:

- installed and operated in direct sunlight
- ambient temperature range between –25ºC and +55ºC (class T2 as per EN 12966:2014+A1:2018 Road vertical signs – Variable message traffic signs [EN 12966])
- enclosure air temperature between –10ºC and +75ºC
- maximum wind conditions likely to occur at the installation site as per AS/NZS 1170.2:2011 Structural design actions – Part 2: Wind actions
- solar radiation with value of up to 2000W/m^2 at direct sunlight, incident at an angle of 30º from the vertical
- humidity between 10% and 95% non-condensing
- conditions, both permanent and temporary, that may be unique to the specified location, eg instances of thick smoke or electromagnetic interference
- marine environment
- road surface reflection.

5.2 Display matrix finish

The finish of all LCS surfaces should not result in specular (mirror) reflection that distracts road users.

5.2.1 Display matrix surfaces

The display matrix must:

- not reflect light back to the user in order to maintain contrast of the message being displayed
- be finished as per BS4800:2011 colour chart (matt black 00 E 53)
- be powder-coated
- not use smooth, monolithic front screens (such as polycarbonate panels).

5.2.2 Frame surfaces

Frame surfaces (internal and external) must be powder-coated as per AS 4506-2005 Metal finishing – Thermoset powder coatings.

The colour of the frame coating is to be as per BS4800:2011 colour chart (matt black 00 E 53).

The coating must facilitate the removal of graffiti.

5.3 Mechanical

LCS shall be designed to ensure reliable transfer of all static and dynamic forces to the fixing and mounting structures.

LCS must meet class TBD6 as per EN 12966 for temporary bending deflection. See EN 12966 section titled Mechanical performance requirements.

5.3.1 Resistance of electrical/electronic components to the effects of pollution

The manufacturer shall declare the degree of resistance in accordance with EN 12966 section titled Resistance of electrical/electronic components to the effects of pollution.

5.3.2 Resistance to surface corrosion

The surface protection of LCS enclosures against corrosion shall meet the requirements of EN 12966 section titled Resistance to corrosion of discontinuous VMS.

5.3.3 Enclosure: ingress protection against water and dust

LCS enclosures shall be protected against water and dust ingress in accordance with EN 12966 section titled Ingress protection against water and dust (IP) provided by enclosure. All LCS enclosures must meet a minimum IP rating of IP56 (P3 as per EN 12966).

5.3.4 Enclosure: protection against external mechanical impacts

The sensitive electrical equipment inside LCS shall be given adequate protection against mechanical impacts such that the enclosure does not deform, delaminate, lose its structural integrity, or suffer a reduction in ingress protection if struck. The LCS must meet a rating of IK8 (as per EN 62262:2002 Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts [IK code]).

5.3.5 Vibration resistance

The LCS shall be capable of withstanding vibration in accordance with table 19 of EN 12966 section titled Environmental and mechanical tests.

5.4 Visual performance

5.4.1 LED colour palette

When observing the whole LCS display matrix from all viewing angles within the specified beam width, colours shall not be discernible as individual red, green and blue light sources.

Each individual red, green and blue LED must be capable of displaying 256 shades of corresponding colours equating to 255 x 255 x 255 colour permutations (>16M colours).

5.4.2 Colour

All LCS must meet colour class C2 as per EN 12966. The chromaticity coordinates of the required colour parameters are defined in table 3 and figure 1 of EN 12966 section titled Colour.

5.4.3 Luminance

All LCS must meet luminance levels to class L3 as per tables 4 to 9 of EN 12966 section titled Luminance.

5.4.4 Luminance ratio

All LCS must meet luminance ratio (LR) class R3 as per table 10 of EN 12966 section titled Luminance ratio.

5.4.5 Uniformity of luminous intensity

There are two requirements around luminous intensity for which each colour (as specified in section 5.4.2 Colour) must be tested as follows:

Luminous intensity		Ratio of output
Highest 12%	Lowest 12%	3:1
Highest 4%	Lowest 4%	5:1

Table 4. Uniformity of luminous intensity

5.4.6 Design life

The specified design life (operational service life) of the LCS is 15 years.

5.4.7 Degradation of visual performance

LCS design solutions must consider the impact to visual performance (ie colour, luminance and LR) caused by ageing effects. The visual performance requirements are minimum requirements and must be achieved during the entire operational lifetime of the LCS (see section 6 Technical requirements).

5.5 Maintainability

LCS shall be designed:

- so all the internal components can be easily and quickly replaced in the field (see mean time to repair (MTTR) in section 6.4.15 General)
- to be installed and maintained by local technicians following the manufacturer's supplied documentation
- to have a standard access from the rear
- for easy cleaning
- to minimise onsite cyclic maintenance
- so that no specialist tools are required.

6 TECHNICAL REQUIREMENTS

This section outlines specific technical and physical constraints for the equipment.

6.1 Electrical safety

All ITS equipment must comply with and be installed in accordance with Electricity (Safety) Regulations 2010 (SR 2010/36).

6.1.1 Equipment declaration of conformity

The vendor shall supply a declaration of conformity for the LCS in accordance with SR 2010/36, sections 80 (2), and 81.

6.1.2 Installation of electrical equipment

The installer is required to supply a certificate to confirm the equipment has been installed correctly and is complaint with AS/NZS 3000:2018 Electrical installations – Known as the Australian/New Zealand Wiring Rules. The electrician/electrical engineer who installs the equipment must provide the required certification. This includes acceptance of the declaration of conformity.

6.2 Electrical

6.2.1 Power supply

LCS must be supplied with reticulated mains power 230V AC.

The LCS shall have the necessary termination equipment to cater for reticulated mains power supply or other type(s) (specified during the procurement). Earthing/equipotential bonding connection point must be provided within the LCS.

The LCS enclosure must not contain uninterruptable power supply (UPS) or batteries. If required, an alternative power source should be housed separately near to the enclosure.

6.2.2 Power consumption

Power consumption can be a significant operational cost factor.

Waka Kotahi wishes to act sustainably and responsibly, minimising power usage and carbon footprint. Value for money, total cost of ownership and quality are important factors in the procurement of LCS:

- Manufacturers must state typical and maximum power consumption figures throughout the expected design life for consideration in procurement evaluation.
- The maximum power consumption figure quoted must be with all LEDs illuminated at maximum brightness.

6.2.3 Nominal voltages

The standard nominal voltage for connection to the public supply shall be taken to be 230V AC RMS single phase.

6.2.4 AC operating voltage range

Variations in the nominal supply voltage defined in EN 12966 section titled Operating voltage range shall not affect the LCS functions. This shall be tested in accordance with tables 16 and 17 of EN 12966 section titled Electrical tests, and shall meet the requirements given therein.

6.2.5 Mains frequency

Variations within the frequency range of 50 ± 1 Hz shall not affect the LCS functions.

6.2.6 Power-up activation

The LCS shall be ready for activation when the supply voltage reaches a value within its operating voltage range. At no time during power-up activation shall partial, incomplete or false messages be displayed.

6.2.7 Low voltage – switch-off voltage response

A drop in the nominal voltage of more than 13% shall not cause:

- partial, incomplete or false messages to be displayed
- damage to the LCS.

6.2.8 Low voltage – voltage interruption

The device always needs to be in a known state and the default after a reboot must be blank.

The effect of voltage interruption shall be as per EN 12966 section titled Voltage interruption.

6.2.9 Low voltage – temporary over-voltage

When protection for temporary (not transient) over-voltage is incorporated, the operating voltage range of the protective device shall be stated and shall be tested in accordance with table 16 of EN 12966 section titled Electrical tests, and shall meet the requirements given therein.

6.2.10 Electromagnetic emission and immunity

For all types of environment, the LCS shall conform to EN 50293:2012 Road traffic signal systems. Electromagnetic compatibility.

The performance of any external equipment must not be interrupted by any radio frequency or electromagnetic interference generated by the LCS or vice versa.

6.2.11 Electrical surge protection

All equipment shall be internally protected against damage resulting from:

- lightning strikes near the LCS or gantry
- electrical transients on power cabling
- electrical transients on internal and external signal wiring
- electromagnetic interference
- static electrical discharge.

6.3 Signal controller

The embedded controller must:

- support both local and remote access through the same RJ45 Ethernet port
- support a fully featured, industry standard, embedded operating system
- be able to support as a minimum the following communication interface standards:
  - TCP as per RFC 793
  - UDP as per RFC 768
  - IP as per RFC 791
- as a minimum provide two communication ports, one for a local connection and one to connect to the ATMS.

The controller must:

- support NTCIP 1203 including mark-up language for transportation information (MULTI) and as a minimum support the LCS-applicable aspects defined in section 4.1.1 Standard aspects
- comply with Waka Kotahi or local authority (if applicable) cyber security requirements
- support user authentication remotely and locally
- support time synchronisation from an external clock, eg UTC, NTP.

6.4 Physical characteristics

6.4.1 Front panels

LCS front panels should be designed in such a way that no part of the message displayed is obscured when observed from the required viewing positions. They should be designed in such a way as to minimise the effects of ice and snow.

6.4.2 Front screens

Front screens adversely impact the intensity of light being transmitted from the LCS and can be prone to degradation caused by weathering and exposure to intense direct sunlight. Consequently, monolithic screens such as polycarbonate panels or louvres are not permitted.

LCS which allow portions of the front screen to be removed (modular) may risk weather tightness of the enclosure and are not permitted.

6.4.3 Display matrix

6.4.3.1 Physical layout

The display must be formed using a regular matrix, ie the spacing between individual light sources in both the x and y axes is uniform.

6.4.3.2 Display technology options

LED technologies are the default choice for the displays for all LCS applications. This technology provides good visibility under most viewing conditions, high reliability and low optical degradation, and has low maintenance requirements.

6.4.3.3 Pixel pitch

The pixel pitch of LCS should facilitate the display of smooth graphics and numerals which closely resemble fixed speed limit signage. The LCS pixel pitch should be as per the table in section 7.4 Guidance for dimensions and application.

6.4.3.4 Beam width

Depending on application, the beam width shall be in accordance with EN 12966 section titled Beam width.

Beam width class	Beam angles			
	Horizontal			Vertical
B3	–10°	0°	+10°	0°
				0°
				–5°
B4	–10°	0°	+10°	0°
				0°
				–10°
B5	–15°	0°	+15°	0°
				0°
				–5°
B6	–15°	0°	+15°	0°
				0°
				–10°

Table 5. Beam width class

Carriageway signal units are installed at heights corresponding to road users' eye levels where the vertical beam width can be narrow. Conversely, lane signal units mounted above each lane require a wider vertical beam width.

Detailed information about which beam widths are applicable for specific road types can be found in the latest version of ITS design standard: Lane and carriageway signals.

6.4.3.5 LEDs

LCS suppliers are required to provide evidence that LEDs supplied as part of any LCS meet the quality, luminous intensity ratings, batch requirements and life expectancy (refer to section 5.4.6 Design life).

Details of the current rating of the proposed LEDs to be used, and what actual current they will be driven at to meet the luminous intensity requirements, must be provided.

LEDs must be sourced from the same batch/bin in order to mitigate the risk of minor variations in colour output.

The latest high-quality manufacturing techniques must be used to ensure that:

- exposure of components to mechanical or thermal stress is minimised
- manual handling of sensitive componentry is minimised
- conformal coatings are consistently applied to circuit boards to minimise exposure to condensation.

Whilst there is no standard size prescribed for the modules forming the display, they should be of a size that is easy to replace with the LCS in situ in the field and without the need to dismantle any part of the LCS. No soldering or heat-based bonding is permitted to be undertaken as part of LCS maintenance.

6.4.4 Heating and forced ventilation

The provision of heaters and fans for supplementary environmental control within the enclosure is not generally permitted.

In areas that are prone to snow build-up on the display matrix, provisions for internal heating may be permitted. Seek clarification from Waka Kotahi via email: itsspec@nzta.govt.nz

6.4.5 Doors and maintenance access

All covers, doors, protective screens, plates, glands, external connectors etc shall be provided with rubber seals or equivalent materials which are maintenance free and shall remain effective for the design life of the equipment.

Where access doors are provided, they shall all be fitted with a suitable retention stay to hold the door in the open position for the safety of maintenance personnel working inside the enclosure. The LCS shall have a mechanism to restrict the door opening from left to right and from right to left at a 90 or 120 degree angle. They must include physical security against unauthorised access and have a door-open alarm capability to remotely report that any of the doors were opened.

For security, access doors and panels shall be fitted with suitable locks (one lock per door/panel), designed for outside conditions. Unless specified otherwise, all access door locks shall have an identical key and the supplier shall provide at least four copies of the key.

6.4.6 Cable entries

All power supply, control and communication cabling shall enter the LCS enclosure through appropriately constructed, sealed and glanded entry holes. All the cable entry points must be through the bottom of the LCS frame as standard.

6.4.7 Electrolytic compatibility

Components shall comprise of materials that when assembled into the LCS are electrolytically compatible and environmentally stable.

6.4.8 Lifting eyes

The enclosure shall be provided with at least two lifting eyes which enable the LCS to remain vertical and upright when lifting the enclosure onto the support structure.

The lifting eyes shall be appropriately located ensuring sufficient structural strength to allow the LCS to be lifted or moved without causing any damage or deformation to any part of the LCS.

6.4.9 Mounting to support structure

The LCS must be designed to be mounted to the structure on which it will be supported. Modifications to the LCS enclosure are not permitted once it has left the place of manufacture.

The LCS enclosure mounting points must be agreed with the design engineer. The mounting points are specified in the site or gantry design.

Penetration through the enclosure for mounting is not permitted. Captive nuts in the LCS must be used to attach the structure to the LCS with appropriately sized fixings (bolts or screws).

6.4.10 Speed environment and character height

Guidance for LCS dimensions and application is available in section 7.4 Guidance for dimensions and application.

Site layout commensurate with operating environment (high-speed, high-volume urban motorways for Waka Kotahi) is provided in the ITS design standard: Lane and carriageway signals.

6.4.11 Labelling

All LED modules, signal controller boards and other similar serviceable parts shall have unique serial numbers permanently marked, which cannot be removed and shall not ever be modified.

6.4.12 Transportation

LCS should be shipped in containers that protect their contents from damage in transit including extreme temperature, humidity, impact/shock etc. The LCS must be wrapped to prevent contamination and the

packaging should be fitted with a device (shock indicator) to show whether the unit has been subjected to rough treatment during its journey. If the shock indicator has been triggered, then Waka Kotahi may reject the LCS.

6.4.13 Certification and declarations of conformity

The manufacturer shall request LCS test certificates from the Waka Kotahi list of accredited test houses.

All LCS supplied to Waka Kotahi must include:

- certification from an accredited independent testing facility demonstrating compliance with EN 12966
- a declaration of conformity from the manufacturer.

The supplier must provide supplementary report information from the testing facility stating all the tests performed, including, but not limited to, the LED colour(s), pixel pitch, beam width, luminance, LR and IP rating of the specific LCS type being supplied under the Waka Kotahi contract.

6.4.14 Documentation, software and licensing

6.4.14.1 Documentation

LCS vendors must supply original equipment manufacturer (OEM) maintenance, service and operations guidelines and manuals which will include maintenance schedules and procedures, handling and storage, and spares list.

6.4.14.2 Software and licensing

LCS vendors must supply all software and licensing required to configure and manage the LCS to Waka Kotahi or its agent's use.

6.4.15 General

Item	Requirement
Reliability	99.99% excluding mains power or external communications failures.
Failure modes (power or communications failures)	• Display or enter default mode. • Shutdown in safe manner where specified. • Automatic restart in safe manner upon restoration of power or communications.
Privacy/security of data	Comply with: • ISO/IEC 27002:2013 Information technology – Security techniques – Code of practice for information security controls • ISO/IEC 27001:2013 Information technology – Security techniques – Information security management systems – Requirements. Note: Compliance from January 2024 will be enforced.

Item	Requirement
Functional safety	• Comply with the IEC 61508 series. • Functional safety study in conjunction with Waka Kotahi to determine any safety integrity level (SIL) requirements.
Alarms, events and status	Configurable and monitored from TOC.
Communications	Interface to the Waka Kotahi communications network.
Mean time between failure (MTBF)	All LCS equipment shall have a specified MTBF of 55,000 hours or greater, unless otherwise approved in writing by Waka Kotahi.
Mean time to repair (MTTR)	Ability to readily replace modules or components from when the maintenance contractor turns off the power supply to the unit, until the unit is powered back on and working. The default MTTR is 10 minutes which applies to LCS components for onsite repair only. Replacing the whole LCS is outside of this delivery specification.
Disposal	LCS should utilise materials where possible which are recyclable to minimise the adverse environmental effect of disposal.

Table 6. General requirements

6.4.16 FAT, SAT, commissioning, spare parts, servicing manuals, warranty, defects liability period

Further requirements including, but not limited to, factory acceptance testing (FAT), site acceptance testing (SAT), spare parts inventory, service manuals, warranty, defects liability period and terms of payment must be specified by Waka Kotahi in the procurement of the LCS but are outside the scope of this delivery specification.

7 APPENDIX A – INDICATIVE SIZING

7.1 Speed limit character height

The numeral height of LCS speed displays is shown in section 7.4 Guidance for dimensions and application. TCDR permits the numeral height to be increased to 125% of the nominal height if required.

7.2 Roundel internal and external diameters, thickness

LCS are required to have roundels in which the difference between the external diameter and internal diameter (thickness) are larger than their fixed sign equivalents, eg the roundels of static mandatory speed signs have an external diameter of 600mm and an internal diameter of 450mm (a thickness of 75mm). Dynamic signage with 600mm external diameter has an internal diameter of 420mm (a thickness of 90mm).

7.3 Roundels formed from concentric rings

For dynamic signage Waka Kotahi requires the roundel to be comprised of two or more concentric rings of LEDs. For such functionality, TCDR (Schedule 1 Signs, R1 Speed limit signs: R1-2 Variable speed) requires that the outer ring must be continuously illuminated while the other rings may flash with a frequency of 1 Hz.

For signs with an external diameter of 600mm the total thickness of the roundel (all rings) must be 90mm.

Figure 10. The two states of an oscillating red roundel

7.4 Guidance for dimensions and application

Speed limit numerals will use proportional character spacing. Refer to section 8 Appendix B – LCS display matrix and aspect dimensions.

• **All dimensions are in millimetres unless otherwise stated.** • **Consider selecting a larger signal size on roads where operating speeds are high.**				
				
Environment	Local urban roads	Rural roads	Tunnels and gated carriageways	Motorway and expressway overhead lane signals
Enclosure dimensions* (W x H)	800 x 800 (minimum)		The maximum border size is 15% of the display matrix height or width. The border must be equal along every edge, eg 1200 x 1200 has a maximum border size of 180mm on each edge.	
Display matrix dimension* (W x H, minimum)	600 x 600	750 x 750	900 x 900	1200 x 1200
Roundel external diameter	600	750	900	1200
Roundel thickness	90	95	110	150
Numeral height (may be increased by up to 25%)	200	250	300	400
Beacon diameter	90	95	110	150
Pixel pitch (maximum)	16	16	16	16
Weight (kg, maximum)	35	60	80	100
Power consumption (W, maximum)	200	300	400	700

*Display matrix and enclosure face must be square.

Table 7. LCS standard sizes

8 APPENDIX B – LCS DISPLAY MATRIX AND ASPECT DIMENSIONS

It is expected that the display matrix area is fully populated with LEDs.

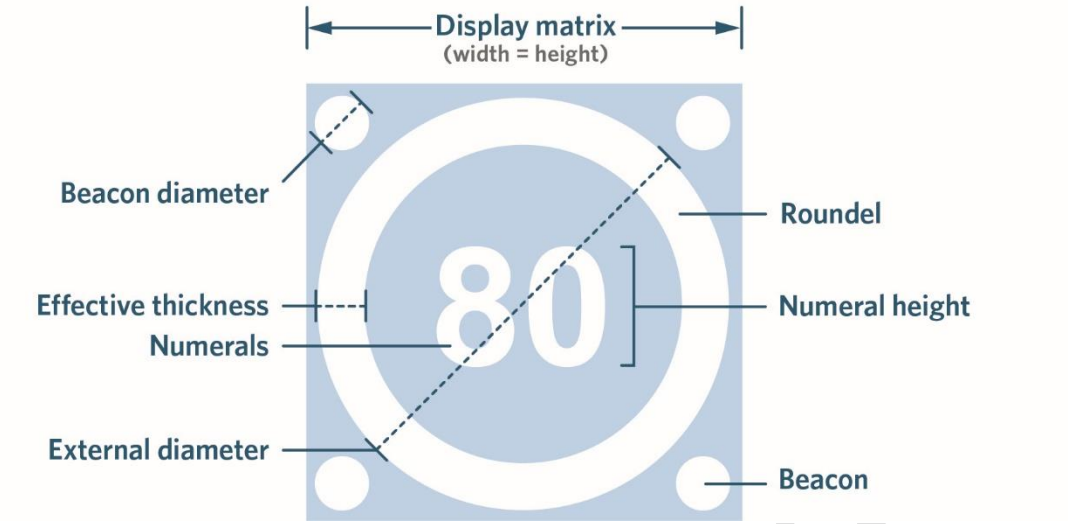

Figure 11. LCS aspect for variable mandatory speed limit dimensions

9 REFERENCES

This section lists all external and Waka Kotahi references included in this document.

9.1 Industry standards

Standard number / name	Source	Licence type and conditions
AS 4506-2005 Metal finishing – Thermoset powder coatings	Standards Australia website	Available for purchase
AS/NZS 1170.2:2011 Structural design actions – Part 2: Wind actions	Standards NZ website	Available for purchase
AS/NZS 3000:2018 Electrical installations – Known as the Australian/New Zealand Wiring Rules	Standards NZ website	Available for purchase
ISO/IEC 27001:2013 Information technology – Security techniques – Information security management systems – Requirements	ISO website	Available for purchase
ISO/IEC 27002:2013 Information technology – Security techniques – Code of practice for information security controls	ISO website	Available for purchase
BS4800:2011 colour chart (matt black 00 E 53)	e-paint.co.uk website	Publicly available
EN 12966:2014+A1:2018 Road vertical signs. Variable message traffic signs	Standards NZ website	Available for purchase
EN 50293:2012 Road traffic signal systems. Electromagnetic compatibility	Standards NZ website	Available for purchase
EN 62262:2002 Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)	Standards NZ website	Available for purchase
IEC 61508 series (for functional safety)	IEC webstore	Available for purchase
NTCIP 1203 v03 National Transportation Communications for ITS Protocol – Object Definitions for Dynamic Message Signs (DMS)	NTCIP website	Available for purchase
SR 2010/36 Electricity (Safety) Regulations 2010	NZ Legislation website	Available for purchase
IP as per RFC 791	RFC Editor website	Publicly available
TCP as per RFC 793	RFC Editor website	Publicly available
UDP as per RFC 768	RFC Editor website	Publicly available

9.2 Waka Kotahi standards, specifications and resources

9.2.1 Standards and specifications

See the Waka Kotahi website for the latest versions of the ITS design standards, delivery specifications and core requirements listed below.

Document name
ITS design standard: Lane and carriageway signals

9.2.2 Resources

Document name / code	Waka Kotahi website link
Traffic Control Devices Rule (TCDR)	https://www.nzta.govt.nz/resources/rules/traffic-control-devices-2004/
Traffic control devices manual (TCD manual)	https://www.nzta.govt.nz/resources/traffic-control-devices-manual/

9.3 ITS standard drawings

See the Waka Kotahi website for the latest versions of the ITS standard drawings listed below.

Drawing number

10 CONTENT TO BE REDIRECTED

This section records any circumstances where content from this document will be reclassified and moved into future documents. This table is then updated with a reference to the new location.

Section reference	Section name	Future document title	Class
4	Introduction, part only of first bulleted point: • and be clearly seen by road users from a significant distance (between approximately 75m and 300m)	Lane and carriageway signals design standard	003 Signals
5.1	Resistance to the effects of external conditions	Environmental core requirements specification	000 Core requirements
5.3	Mechanical	Environmental core requirements standard	000 Core requirements
6.1.2	Installation of electrical equipment	Electrical core requirements standard	000 Core requirements
6.2	Electrical	Electrical core requirements specification	000 Core requirements
6.3	Signal controller, second-to-last bullet only The controller must: • support user authentication remotely and locally	Security core requirements standard	000 Core requirements
6.3	Signal controller, last bullet only The controller must: • support time synchronisation from an external clock, eg UTC, NTP.	Network time protocol design standard	012 System interfaces
6.4.6	Cable entries	Electrical core requirements specification	000 Core requirements
6.4.7	Electrolytic compatibility	Environmental core requirements specification	000 Core requirements
6.4.16	FAT, SAT, commissioning, spare parts, servicing manuals, warranty, defects liability period	Commissioning and handover core requirements standard	000 Core requirements

11 FULL VERSION HISTORY

This table shows the full history of changes made to this document, both minor and major, in chronological order, since the document was first authored.

Minor versions are numbered 0.1, 0.2 etc until such point as the document is approved and published, then it becomes 1.0 (major version). Subsequent edited versions become 1.1, 1.2 etc, or if it's a major update 2.0, and so on.

Version	Date	Author	Role and organisation	Reason
1.0	18/05/2021	ITS Working Group Kirill Yushenko Editorial services	Waka Kotahi Consultant, Resolve Group Final Word	Document issued
1.1	05/07/2021	ITS Working Group	Waka Kotahi	Updated to align with VMS delivery specification
2.0	09/07/2021	ITS Working Group	Waka Kotahi	Reviewed internally and version 2.0 issued
2.1	04/10/2021	ITS Working Group	Waka Kotahi	Updated section 4.1.15 Message currency (and subsections) to Communication failure (and subsections) Updated to latest template version 1.19 Updated URL links for industry standards sources and ITS S&S new web pages Added interim watermark and file name extension
3.0	06/10/2021	ITS Working Group	Waka Kotahi	Reviewed internally and version 3.0 finalised