



**Transport
for NSW**

INTELLIGENT TRANSPORT SYSTEMS

TRAFFIC SYSTEMS

SPECIFICATION NO. TSI-SP-011

INTEGRATED SPEED LIMIT AND LANE USE SIGNS

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RECORD OF AMENDMENTS

Issue	Summary	Date	Approved by
1.0	First Issue	18/03/2005	Mgr. TSI
2.0	Second Issue.	22/06/2010	A/Mgr. TSI
3.0	Major revision, in particular covers integrated speed and lane use signs, not just speed limit signs.	25/02/2014	A/Mgr. TSI
3.1	Changed to a square face. Minor other changes	1/04/2014	A/Mgr. TSI
4.0	Renumbered to whole issue number, content unchanged.	1/04/2014	A/Mgr. TSI
5.0	Multiple changes including: <ul style="list-style-type: none"> - Permits full matrix design - Permits higher resolutions - Extra ports including a dedicated output port for enforcement monitoring. - Changed display dimensions including reduced numeral height, and reduced annulus width. - Sign external dimensions less prescriptive - Text displays not required - Changed numeral shape base font. - Add "Swap Out Only" sign as maintenance option - Changes to enclosure colour, operating voltage, dimming transition time, certification, and power consumption. - Separate specs referenced for Manuals, Housings and communication interface details 	17/2/2020	Mgr. TSI
6.0	Restructure and adjust to reference AS 5156:2020 version Changed display dimensions in Table 2 and Figure 2, with min annulus width increased to 70% of static sign. Limit added for clearance of numeral to annulus. Numeral "100" spacing reduced to better fit within annulus. Measurement points defined for annulus dimensions. Percentage of annulus flashing changed to 60 to 80%, for better contrast and min. number of rings in concentric annulus for type A increased from 2 to 3 to suit. Pixel spacing requirements relaxed. Removal of 12 month clause from fault log requirements Flashing red cross frame and related message added. Multi-lane symbols not required. Addition of frame and message numbers Add requirement for method of removal of liquid water 4 inputs (switched) for external devices required. Safety in design doc. required in approval submission Approval submissions to use template/guide TSI-TG-010	05/02/2021	Director ITS Engineering

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1 SCOPE

This specification covers requirements for integrated speed limit and lane use signs (ISLUS) that are used in permanent positions above or adjacent to roadways as appropriate for speed limit and lane use management in the State of New South Wales.

This specification includes requirements for the design, performance and quality assurance of integrated speed limit and lane use signs including their associated sign controllers.

ISLUS signs described here are dedicated to a single lane, to which the display applies.

This specification uses the Australian Standard 5156 Electronic Speed Limit Signs [5] as a basis, but adds significant functionality.

1.1 System Description

The figure below shows an example ISLUS system with some of the main features and key terminology:

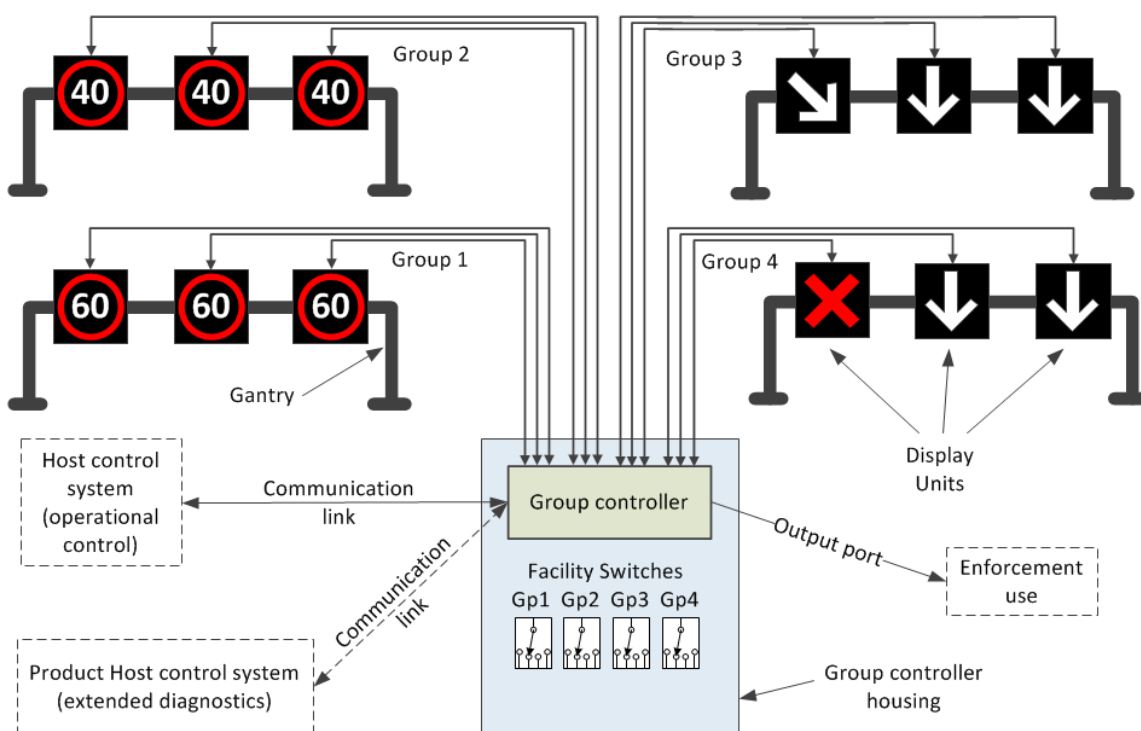


Figure 1 – Example ISLUS system schematic

Note 1: Display units may be assigned to groups in other combinations than those shown in the figure. A group may have one display unit in it, or many more. A group may include display units on several gantries. One gantry may have display units in different groups.

Note 2: The connecting lines between display units and group controller are intended as conceptual only. They do not constrain cabling methodology for communications and power supply.

For context of how this signage is typically used, the Austroads report AP-R341-09 [23] (section 9) contains information on typical usage on managed motorways, together with the TfNSW supplements 17.177 [20] and 17.168 [21].

2 REFERENCES AND APPLICABLE DOCUMENTS

2.1 Australian and International Standards

- [1] AS 1170.2 – Structural design actions - Wind actions.
- [2] AS 1744 – Standard alphabets for road signs.
- [3] AS 2700 – Colour standards for general purposes.
- [4] AS/NZS 4417.2 – Regulatory compliance mark for electrical equipment.
- [5] AS 5156 – Electronic speed limit signs.
- [6] AS 60529 – Degrees of protection provided by enclosures for electrical equipment (IP Code).
- [7] AS/NZS 61000.6.1 – Electromagnetic Compatibility (EMC) – Immunity.
- [8] AS/NZS 61000.6.3 – Electromagnetic Compatibility (EMC) – Emission.
- [9] ISO 9001 – Quality management system - Requirements.

2.2 TfNSW Documents

- [10] TS200 – Register of ITS Field Equipment
- [11] TS201 – Approval of ITS Field Equipment
- [12] TS202 – Approval of ITS Solutions for Projects
- [13] TSI-SP-003 – Communications Protocol for Roadside Devices
- [14] TSI-SP-012 – General Requirements for Roadside Equipment Housings
- [15] TSI-SP-062 – User Manual Requirements for ITS Field Equipment
- [16] TSI-SP-071 – ITS Equipment Communication Interface Requirements
- [17] TSI-TG-010 – Submission Guide for ISLUS.
- [18] TSI-TG-011 – Frame and Message numbers for ISLUS and related signage
- [19] Drawing VM005-01 – Housing Facility Key drawing
- [20] 17.177 – Smart motorway supplements.
- [21] 17.168 – Smart Motorway Design Guide Tunnel Traffic Management

2.3 Other Documents

- [22] NSW Work Health and Safety Act 2011
- [23] Austroads Report AP-R341-09: Freeway design parameters for fully managed operations

2.4 Generic Compliance

All equipment and materials, where not otherwise specified, shall be in accordance with Australian Standards/Specifications where such exist, and in their absence, with appropriate IEC or ISO Standards/Specifications.

2.5 Clause referencing of documents

Within in this document a numbered clause reference has sometimes been given to help the user to locate the relevant section of a document. Where this has been done, it respectively refers to the versions listed below:

- AS 5156 [4]: references apply to version 2020.

Note however that the most recent version of a referenced document typically applies, so if a later version is issued, the equivalent section shall be sought and applied.

3 DEFINITIONS AND GLOSSARY OF TERMS

The definitions and abbreviations given in AS 5156 [5] shall apply, unless varied by the listing below:

Term	Definition
ITS	Intelligent Transportation Systems
TfNSW	Transport for NSW, a New South Wales government agency
TSI	Traffic Systems Integration
ACMA	Australian Communications and Media Authority
Display unit	The display including its enclosure, as mounted over the lane it controls
Equipment	Sign(s) covered by this Specification unless context dictates otherwise
Host Control System	A remote computer system that communicates with the Sign to effect control of the Sign
IEC	International Electro-technical Commission
ISLUS	Integrated speed limit and lane use signs
ISO	International Standards Organisation
LED	Light emitting diode
LUS	Lane Use Sign.
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
NATA	National Association of Testing Authorities, Australia
NSW	New South Wales
Sign	Displays plus group controller plus ground level housing, unless context/statement indicates otherwise.
TIA	Telecommunications Industry Association

Table 1 – Definitions and Glossary of Terms

4 GENERAL REQUIREMENTS

4.1 Compliance with AS 5156

Signs shall comply with AS 5156 [5] except where otherwise detailed in this specification.

4.2 Work Health and Safety

- 4.2.1 The sign and its installation, including the Supplier's instructions for installation, shall comply with the requirements of the NSW Work Health and Safety Act [22].
- 4.2.2 As part of approval process, the supplier shall provide a "Safety in Design" evaluation.

4.3 General design and arrangement

Signs shall comply with section 2 of AS 5156 [5].

5 MECHANICAL REQUIREMENTS

5.1 Sign Enclosure

- 5.1.1 Signs shall comply with clause 3.1 of AS 5156 [5].
- 5.1.2 External surfaces other than the front face of the sign shall be a light colour, such as Smoke Blue (T33) in accordance with AS 2700 [3], or matt grey.
- 5.1.3 The sign shall provide a method for removal of liquid water, such that in the event of cabinet leakage, water will quickly egress the sign.
- 5.1.4 The method provided for removal of liquid water shall not permit water entry when the sign is being hose washed.
- 5.1.5 Means shall be provided to access all replaceable components of the signs for maintenance.

5.2 Sign Mounting Facilities

- 5.2.1 The mounting points on the sign display unit, and other mechanical attributes of the sign, shall meet the structural requirements as specified in AS 5156 [5] and elsewhere as relevant, including capability to withstand wind loading.
- 5.2.2 The display unit with its mounts shall be certified as able to meet the structural requirements when supported as detailed in clause 5.2.6.
- 5.2.3 The display unit shall have appropriate structural integrity and features to enable it to be lifted into position without being damaged. If use of a lifting beam is required, this shall be described.
- 5.2.4 Display units declared as "swap out only" (see clause 13.1.3) shall have a "drop and lock" type attachment arrangement that permits a rapid exchange of sign displays, and preserving the set sign alignment.
- 5.2.5 The supplier shall provide drawings as part of approval submissions, to show how the display units can be attached to a support structure to meet the required structural and alignment outcomes.
- 5.2.6 Sign support structures are not considered part of the sign itself, so are not directly subject to approvals process TS201 [10]. However, where a project requires

provision of a sign support structure, the relevant processes and standards shall be used.

5.3 Roadside Cabinet

- 5.3.1 A roadside cabinet shall be provided, as detailed in clause 3.3 of AS 5156 [5].
- 5.3.2 The roadside cabinet shall also comply with TSI-SP-012 [14].
- 5.3.3 The roadside cabinet shall be suitable for both post-mounting and ground mounting but shall be accessible by a technician standing at ground level.
- 5.3.4 The group controller and roadside cabinet shall be capable of supporting a minimum of 4 sign groups including the associated facility switches and wiring,
- 5.3.5 The group controller and roadside cabinet shall be equipped for 2 sign groups by default, unless otherwise specified by a project.
- 5.3.6 The Supplier shall supply drawings of the roadside cabinet showing the following:
 - (a) Mechanical design of the roadside cabinet including dimensions;
 - (b) General arrangement of modules, interfaces, cable terminals and main switchboard in the cabinet;
 - (c) Provisions for installation including dimensions;
 - (d) Provisions for passage and installation of cables into and out of the housing.

5.4 Facility Switches

- 5.4.1 Facility switches shall be provided on the exterior of the roadside cabinet for local (on-site) control, as detailed in clause 3.4 of AS 5156 [5].
- 5.4.2 For each sign group that the sign is required to support, one facility switch shall be provided. Accordingly, for the default (see clause 5.3.5), two switches shall be provided.
- 5.4.3 The switches shall be operable by a key complying with Drawing VM005-1 [19]. Details of this key will be provided to the prospective suppliers by request.
- 5.4.4 Operation of facility switches shall not require opening of the roadside cabinet door.
- 5.4.5 The key actuator of the facility switch shall be recessed inside a metal ferrule, such that the head of the actuator is recessed 10 mm to 12 mm from the outside surface of the control housing.
- 5.4.6 The facility switches shall be mounted within 250 mm of the top of the housing, on either the left or right side of the housing. The facility switches shall not be mounted on the rear side of the housing or the housing door.
- 5.4.7 The actuator mechanism for the facility switch shall provide sufficient spring tension such that the switch position cannot be changed without the use of the specified key. That is, it shall not be possible to change the switch position with simple tools or implements, such as screwdrivers, pliers, etc.
- 5.4.8 Each facility switch shall provide for the sign group to be switched to four (4) different display modes. The four display modes shall be, in the clockwise direction, BLANK, AUTO, MESSAGE 1 and MESSAGE 2.
- 5.4.9 Auto shall be the normal operation mode.
- 5.4.10 It shall be possible to configure displays for the two MESSAGE switch positions. The default state of MESSAGE 1 and MESSAGE 2 shall be a BLANK display.

- 5.4.11 The display units in the group shall blank if the facility switch is set to the BLANK position. It shall result in the actual removal of power from the sign display units within the group, such that they will blank regardless of the nature of fault with any of the sign display units, including an unresponsive processor in the sign display unit or group controller. This takes precedence over any competing commands from the host control system.
- 5.4.12 Means shall be provided (e.g. an electrical marshalling board) such that if sign display units are re-assigned to another group in the group controller configuration, a technician can change the connections such that the facility switch responses match the changed assignments.

6 ELECTRICAL REQUIREMENTS

6.1 General

Signs shall comply with section 4 of AS 5156 [5], except where varied below.

6.2 Operating Voltage

The sign shall comply with clause 4.2.1 of AS 5156 [5] except that the voltage range for operating correctly and reliably shall be 205 V to 264 V r.m.s. Outside of this range the sign shall either be blanked or operate correctly.

6.3 Battery Backup

- 6.3.1 The backup system shall have the capacity to maintain communication and group controller operation for a period of 12 (twelve) continuous hours.
- 6.3.2 The backup battery shall have a design service life of at least 4 years.
- 6.3.3 The battery backup system shall also provide backup for the real-time clock.

6.4 Surge Protection

In addition to the requirements for surge protection in clause 4.2.3 of AS 5156 [5], surge protection shall be provided both at the control cabinet and display for power cables and for communication lines where copper based.

6.5 Real-Time Clock

- 6.5.1 The sign shall comply with clause 4.5 of AS 5156 [5], except where supplemented below.
- 6.5.2 The dedicated back-up battery for the clock shall:
- (a) Be rated for operation over an extended range of temperatures up to 70°C.
 - (b) Have a design service life of at least 5 years.
 - (c) Provide not less than 60 days of support to the real-time clock after the depletion of the sign's battery backup system (clause 6.3).

6.6 Non-Volatile Memory

The Sign shall provide non-volatile memory for all of its configuration settings, logs, and other data and information that needs to be preserved when power to the Sign is off or lost.

6.7 Electromagnetic Compatibility

- 6.7.1 The sign shall meet the requirements of clause 4.6 of AS 5156 [5].
- 6.7.2 Tests shall be conducted by a NATA accredited independent test organisation, or equivalent.
- 6.7.3 A test report from that organisation, including a conclusion of compliance, shall be provided as part of approval submissions.
- 6.7.4 As part of approval submissions, the supplier shall provide a declaration of conformance of the sign to AS/NZS 61000.6.1 [7], and supporting evidence.

6.8 Mandatory Regulatory items

Either all of 6.8.1 shall be supplied, or all of 6.8.2 shall be supplied.

- 6.8.1 Evidence of valid RCM compliance as defined in AS/NZS 4417.2 [4].

Note 1: Associated details are provided on the ACMA website, such as at <https://www.acma.gov.au/Industry/Suppliers/Regulatory-arrangements/EMC-Electromagnetic-compatibility/device-compliance-levels>.

Note 2: Further associated details are provided on the NSW fair trading website such as at <https://www.fairtrading.nsw.gov.au/trades-and-businesses/business-essentials/selling-goods-and-services/electrical-articles/approval-of-electrical-articles>. The sign is classed as a 'non-declared article'.

- 6.8.2 Both of the items below:
 - (a) Certificate of Suitability issued by the NSW Office of Fair Trading.
 - (b) Declaration of Conformance of the sign to AS/NZS 61000.6.3 [8] and supporting evidence

6.9 Power Consumption

As part of approval submissions, the supplier shall provide laboratory test reports for the sign's power consumption. Measurements shall be obtained using calibrated test equipment, traceable to a national standard. Details shall be included in the reports.

The conditions of test shall be given, including what items are connected and active, and display states. If the sign has further variables that affect power consumption, such as when cooling devices are operating, then this shall be stated and data for both the low and high power demand states shall be included.

For determination of required rating of power supplies and cables, results showing:

- (a) Sign peak power during start up.
- (b) Maximum in-service power.

For comparison of running power requirements, results showing:

- (c) Power consumption when the group controller is connected to 6 signs, each showing display 100 (km/hr). These shall be at full brightness (dimming level 16), and shall display a lit, non-flashing annulus (frame number 100 as given in 10.3.1).

NOTE: Measurement may be made of fewer signs, and extrapolations provided to show the expected values for 6 signs.

7 DISPLAY REQUIREMENTS

7.1 General

7.1.1 The sign shall meet the requirements of clause 5.1.1 of AS 5156 [5]

7.2 Display Dimensions

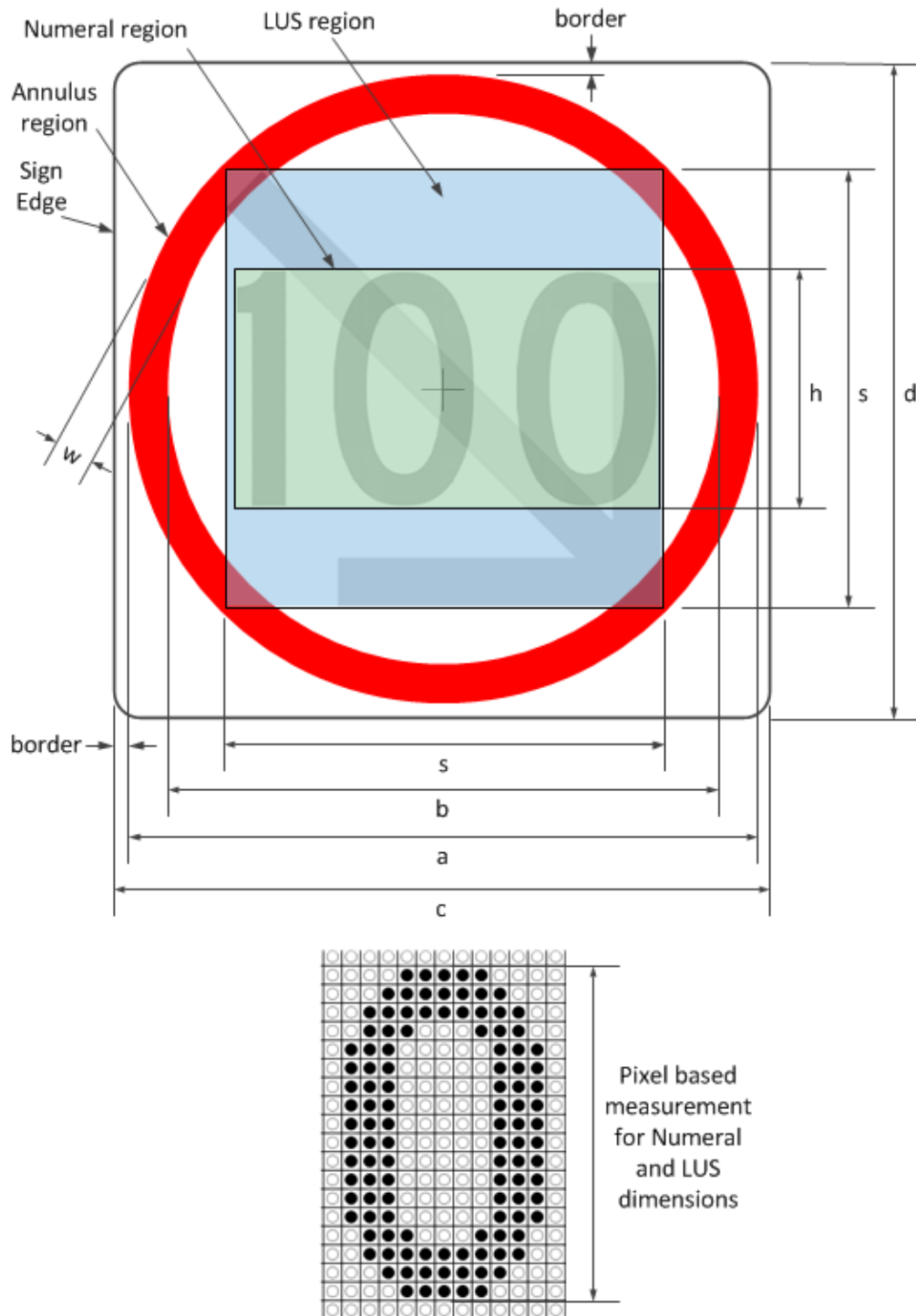


Figure 2 – Display Dimensions

Note: the colours above are not indicative of the required display colour.

7.3 Conspicuity Devices

Conspicuity devices are not required. (Flashing annulus is used instead)

7.4 Pixel arrangement

7.4.1 The sign shall meet the requirements of clause 5.1.2.1 of AS 5156 [5]

7.4.2 The requirements of clauses 5.1.2.2 to 5.1.2.6 of AS 5156 [5] do not apply.

7.5 Table of Dimensions

The dimensions referenced in AS 5156 [5] are replaced by those tabled below.

Parameter (all values in mm)	Label	Limit type	Type A	Type B	Type C	Type D
Annulus outer diameter ¹	a	Maximum	510	660	960	1260
		Nominal	450	600	900	1200
		Minimum	441	588	882	1176
Annulus inner diameter ¹	b	Minimum	369	492	738	984
Annulus width ¹	w	Maximum	45	60	90	120
		Minimum	31.5	42	63	84
LUS region edge length ²	s	Minimum	315	420	630	840
Numeral height ³	h	Maximum	171	228	342	456
		Minimum	162	216	324	432
Sign Width ⁴	c	Maximum	580	730	1030	1310
		Minimum	560	710	1010	1330
Sign Height ⁴	d	Maximum	580	730	1030	1310
		Minimum	560	710	1010	1330

Note 1: Refer 7.5.1 and 7.5.2 for measurement points on the annulus.

Note 2: LUS region and numeral dimensions (s, h) are to the pixel edges as shown in Figure 2.

Note 3: Sign width and height may be re-defined by a project as described in clause 7.6.

Note 4: The annulus shall be centred between sign edges unless otherwise defined by a project.

Table 2 – Sign Dimensions

7.5.1 Matrix Annulus Measurement

For a matrix annulus, the inside diameter, outside diameter and width for measurement shall be defined by the circles touching the outermost and innermost lit LED lens edges, as below:

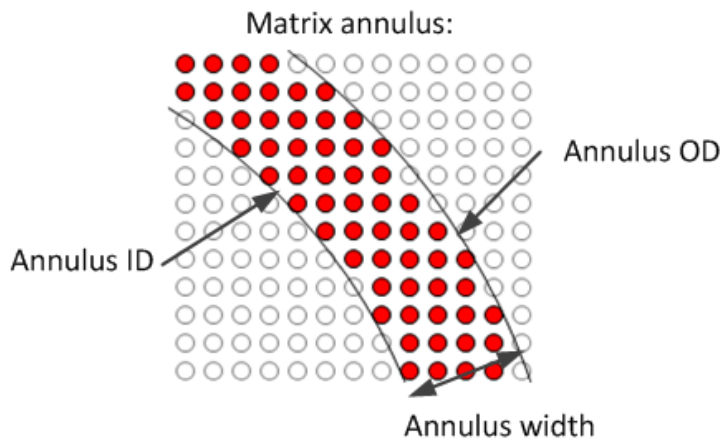


Figure 3 – matrix annulus dimension measurement

7.5.2 Concentric Ring Annulus Measurement

For a concentric ring annulus, the inside diameter, outside diameter and width for measurement shall be defined by circles through the perimeter LED lens centres, plus buffers of radial width equal to 1% of the annulus outer nominal diameter 'a' given in Table 2, as shown below. (E.g. for Type B, the buffer width is 1% of 600mm= 6mm),

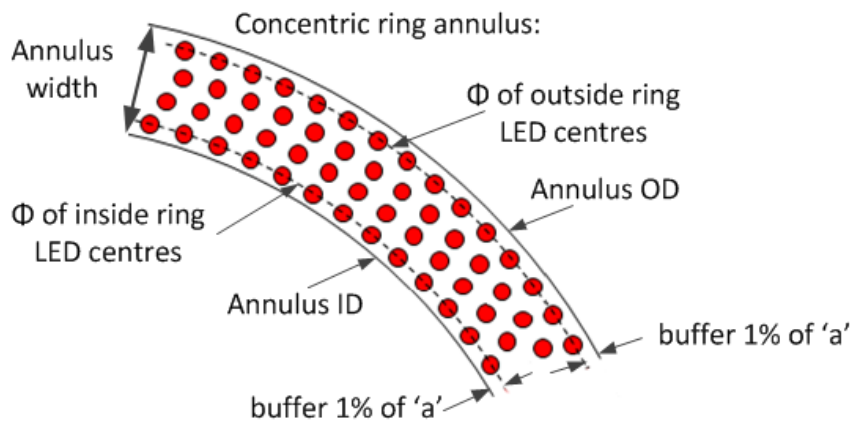


Figure 4 – concentric ring annulus dimension measurement

7.6 Sign External Dimensions

The Sign Width c and Sign Height d specified given in Table 2 may optionally be re-defined by a project specification to suit site locations and space constraints, to improve visibility for backlit signs by enlarging the border, or for other purposes. The following guidance is provided for projects seeking to follow this path:

- 7.6.1 The limits for sign width c and height d given in Table 2 fit the assumption that annulus outer diameter is 10mm more than the minimum, plus a default sign border width of 55 ± 5 mm.
- 7.6.2 Optionally a project may reduce the minimum sign width c and minimum sign height d for signs that will be minimally backlit and so have no need for borders, such as in tunnels.
- 7.6.3 Optionally a project may reduce the maximum sign height or width for sign locations with physical constraints such as narrow sites, or limited headroom.
- 7.6.4 If changed by a project, minimum sign width and height shall be specified at least 10mm larger than the minimum outer annulus diameter given in Table 2 (to preserve a practical margin).
- 7.6.5 Dimensions c and d need not be equal; the sign may be rectangular.
- 7.6.6 Optionally a project may increase the sign borders to improve legibility for signs expected to become back-lit by low sun as viewed by a driver at the site of use. For such placements it is suggested a minimum border width of 20% of the annulus outer diameter be used in at least one plane (side borders or top/bottom borders, or both). If this option is taken, sign width c and height d should be re-defined accordingly to achieve the desired border dimensions.
- 7.6.7 Optionally a project may change limits for sign width c and sign height d for other reasons, such as to enable use of a common mounting frame for ISLUS.

7.7 Display Colours

The display colours shall be as follows on a matt black background:

- (a) Speed numerals – white;
- (b) Annulus – red;
- (c) LUS cross – red;
- (d) LUS arrows – white;
- (e) Other displays – white.

7.8 LUS Region

The Lane Usage Sign (LUS) display area shall be a square region. It shall be capable of displaying white over its full area and red over sufficient area to display the LUS cross.

7.9 Numeral Region

- 7.9.1 The area used for display of numerals shall enable display of white numeral shapes as defined in AS 1744 [2], scaled to the character height.
- 7.9.2 The display “100” shall use AS 1744 [2] series C numerals and inter-character spacing of minimum 13% of the numeral height.
- 7.9.3 The clearance from displayed numerals to the annulus shall be at least that of the minimum annulus width ‘w’ given in Table 2. This is to be measured from the inside diameter of the annulus (as defined in items 7.5.1 or 7.5.2 as appropriate), to the edge of the closest lit pixel in the numeral, measured radially as shown below:

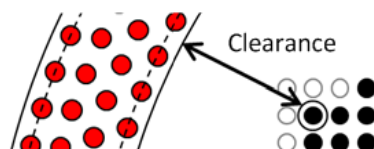


Figure 5 – Clearance of numeral to annulus

- 7.9.4 The numeral region’s width shall provide at least the horizontal pixel count needed to deliver the numeral “100”, as defined in clause 7.9.2.
- 7.9.5 Display of “110” and speed displays using 2 numerals shall use AS 1744 [2] series D numerals and the associated scaled inter-character spacing.
- 7.9.6 An example of matching illuminated pixels to the shape of numerals is given in the figure below, with the AS 1744 [2] character shape shown shaded behind the bit map, and number of pixels spacing between characters selected for closest match with the distance given in AS 1744 [2]:



Figure 6 – Character shape matching to AS 1744 [2]

Note: Resolutions may vary provided they meet the requirements of clause 7.13. Higher resolutions are preferable in terms of numeral shaping.

7.10 Sign Face Shape

The sign face shall be square or rectangular.

7.11 Shape of Lane Usage Arrows and Crosses

7.11.1 The arrow and cross shapes shall be nominally as per the variant options shown below, subject to the constraints of LED resolution:

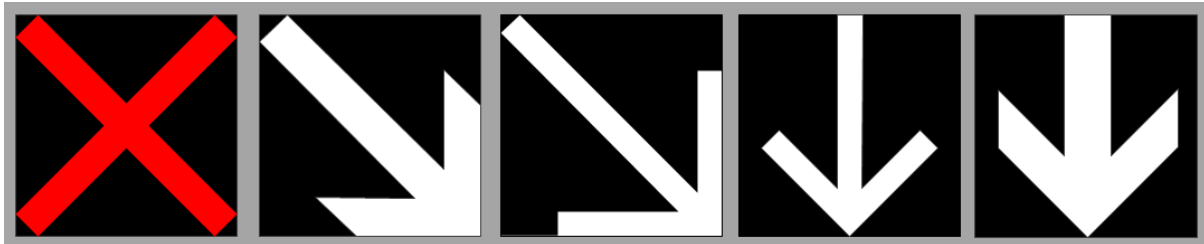


Figure 7 – Arrow and Cross shape variants

Note these are based on selected variants of table 3.3 of AS 1742.14

7.11.2 The proportions of arrows and cross shall be based on the figure below:

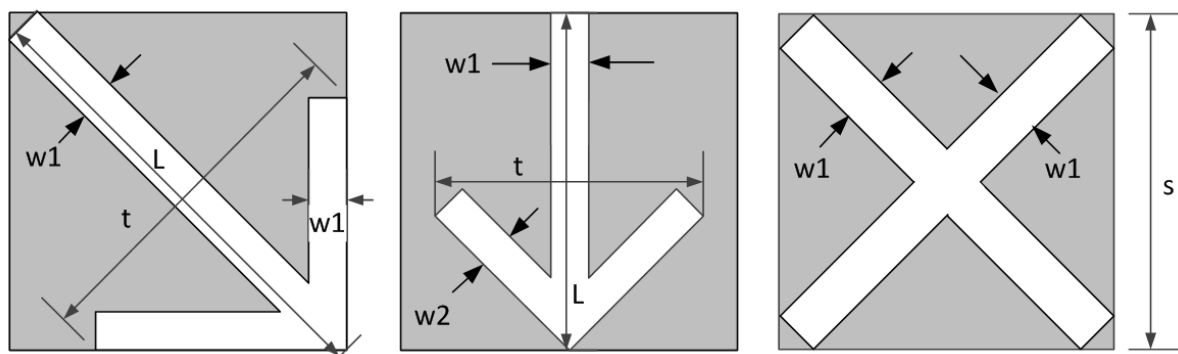


Figure 8 – Arrow and Cross dimension labels

7.11.3 The arrow head width “t” shall be between 75% and 85% of arrow shaft length ‘L’.

7.11.4 Stroke widths “w1” and “w2” shall be between 10% and 20% of distance “s”.

7.11.5 Arrow head arms shall be perpendicular to each other.

7.12 Annulus Pixel Arrangement

7.12.1 The annulus pixels may be arranged either as a matrix display, or as a set of concentric rings. Examples are given below:

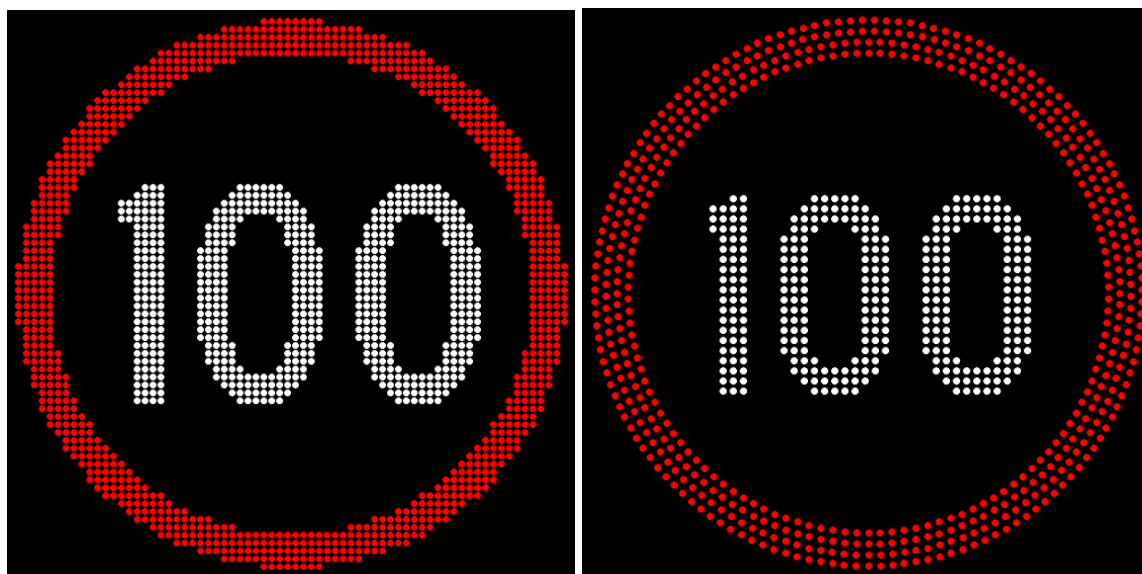


Figure 9 – Matrix Annulus and Concentric Ring Annulus

Note. These signs use different numeral pixel resolutions; 28 on the left, and 20 on the right. This is not intended to constrain, but is given to illustrate higher resolution usage.

- 7.12.2 If the annulus is arranged as a matrix display, its resolution shall be that of the numeral region, and the whole sign shall have a uniform resolution.
- 7.12.3 Pixels shall be arranged uniformly around the annulus.
- 7.12.4 An outer ring, or set, of pixels of the annulus shall remain illuminated during flashing operation of the annulus.
- 7.12.5 There shall be at least 3 rings in a concentric annulus.
- 7.12.6 During flashing operation of an annulus in a ring arrangement, the number of inner rings flashing shall be from 60% to 80% of the total number of pixel rings.
- 7.12.7 During flashing operation of an annulus in a matrix arrangement, the number of inner pixels flashing shall be from 60% to 80% of the total number of pixels in the annulus.
- 7.12.8 If the annulus is arranged as a matrix display, the whole display shall be addressable as a single matrix, and shall support graphic frame display via the protocol TSI-SP-003 [12], for alternate displays if required.

7.13 Numerals and LUS region pixel arrangement

- 7.13.1 The sign shall use a matrix display for the numerals region and LUS region.
- 7.13.2 Numerals shall have a minimum resolution of 18 pixels high.
- 7.13.3 The LUS region shall have the same pixel resolution as the numerals region.
- 7.13.4 The numeral and LUS regions shall be addressable and shall support graphic frame display via the protocol TSI-SP-003 [12].

7.14 Speed Limit Displays

- 7.14.1 The following speed numerals shall be available, pre-set in the sign: 10, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, and 110.
- 7.14.2 Appendix B of AS 5156 [5] does not apply. The bit-maps used for numerals shall meet the requirements of clause 7.9 as best suits the sign's resolution.
- 7.14.3 Speed numeral displays shall be displayed together with the speed annulus.
- 7.14.4 A flashing annulus treatment shall be available for use with speed displays. Refer 7.12.6 and 7.12.7.
- 7.14.5 Annulus flashing shall be at 1 Hz frequency ($\pm 5\%$) and 50% duty cycle ($\pm 5\%$).

7.15 Symbol displays

- 7.15.1 The following 7 pre-set arrow and cross symbols shall be available, pre-set in the sign, to be shown filling the LUS region:

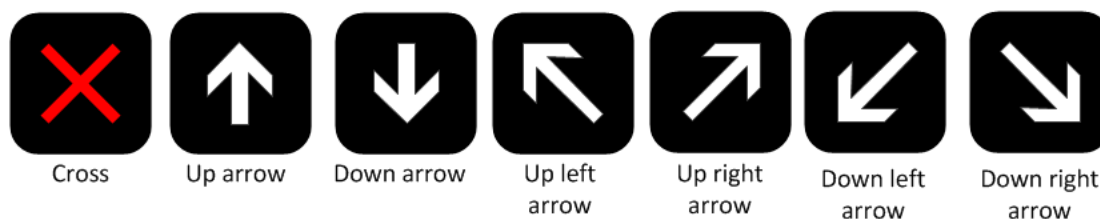


Figure 10 – Required Symbols

- 7.15.2 The cross is to be red, and the other symbols are to be white.
- 7.15.3 In addition to a static red cross, a flashing red cross shall be available. The whole symbol shall flash on and off, with 1 Hz frequency ($\pm 5\%$) and 50% duty cycle ($\pm 5\%$).
- 7.15.4 When arrows and cross symbols are being displayed, the annulus shall not be lit.

7.16 Test displays

The following test displays shall be available:

- 7.16.1 Light all pixels white that are capable of delivering white.
- 7.16.2 Light all pixels red that are capable of delivering red
- 7.16.3 Light just the pixels comprising the annulus.

7.17 Sign Dimming Control

- 7.17.1 The sign shall meet the requirements of clause 5.1.6 of AS 5156 [5].
- 7.17.2 Primary light sensors shall be present on each display enclosure.
- 7.17.3 Optionally, capability may be provided to configure to use other light sensors in the group facing in similar directions, or an average of such sensor input values, in the event of failure of primary light sensors.
- 7.17.4 For automated dimming, the following preferred sequence of fall-back shall occur in the event of a sensor fault:
- Primary light sensors on sign or integrated back-ups.
 - Alternate valid light sensors on other signs in group, individuals or average, where the optional capability exists to configure and use these.

- (c) Time of day dimming.
- (d) Fixed dimming control.

7.18 Display Flicker

The sign shall meet the requirements of clause 5.1.8 of AS 5156 [5].

8 OPTICAL REQUIREMENTS

8.1 General

- 8.1.1 The Sign shall meet the requirements of clause 5.2 of AS 5156 [5], except as varied below.
- 8.1.2 The Sign shall meet the requirements of clause 5.2.5 of AS 5156 [5], except that the percentage of annulus to be flashed shall be as defined in 7.12.
- 8.1.3 Tests to confirm compliance shall be conducted by a NATA registered laboratory or approved test organisation.
- 8.1.4 Test results shall be provided as part of approval submissions.

9 OPERATION AND CONTROL

9.1 General

The sign shall meet the requirements of section 6 of AS 5156 [5].

9.2 Product Host Control System

The Product Host Control System shall be usable under Windows® operating systems, or through a web interface/internet browser.

9.3 Display Activation

The Sign's display shall be capable of being activated by all of the methods for sign display activation listed in clause 6.1 of AS 5156 [5].

9.4 Local Control Ports

The sign's ground level control housing shall be equipped with, as a minimum, the following communication ports for in situ control, operation, configuration and diagnosis of the system:

- 9.4.1 TIA-232/485 port (one physical port supporting both protocols)
- 9.4.2 Ethernet port

These ports shall meet the requirements of specification TSI-SP-071 [16].

9.5 Remote Control Ports

In addition to the communication ports provided for local control, the ground level control housing shall be equipped with, as a minimum, the following ports for remote operation and control:

- 9.5.1 TIA-232/485 port (one physical port supporting both protocols)

9.5.2 Two x Ethernet ports

These ports shall meet the requirements of specification TSI-SP-071 [16].

9.6 Monitoring Port

9.6.1 A TIA-485 monitoring port shall be additionally provided to permit the status of displays to be verified by enforcement camera systems.

9.6.2 The monitoring port shall bear the same outgoing data as the remote control port from group controller to host control system, except that it shall be converted into TIA-485 format, if not originally in that format.

Note: Date and time values are part of the data and so shall match the source message.

9.6.3 The monitoring port shall output within 0.5 seconds of the active remote control port's output of the same data.

9.6.4 The sign shall not respond to incoming traffic on the monitoring port.

9.6.5 The monitoring port shall be labelled to distinguish it as a monitoring only port.

9.7 External inputs

9.7.1 The group controller shall provide a minimum of four inputs for external switches for interfacing with external devices.

9.7.2 Inputs shall activate on the leading edge.

9.7.3 Triggers on external inputs shall be recorded in the event log.

9.7.4 It shall be possible to configure the group controller to change the displays it controls, or trigger a timed display sequence, on receipt of these inputs.

9.7.5 External input triggers shall only change the display when the facility switch is in the "Auto" position.

9.8 Logging of Time Updates and Changes

The sign shall record time updates and changes in the event log.

10 PROGRAMMING

10.1 General

The sign shall support the range of values provided by the communications protocol for:

- (a) Number of frames;
- (b) Number of messages;
- (c) Number of plans;
- (d) Number of frames for a message;
- (e) Number of messages for a plan;
- (f) Frame on times and transition times within a message;
- (g) Other frame, message and plan related parameters.

10.2 Frames, Message and Plans

- 10.2.1 A plan which is enabled by the host control centre shall override the plan currently enabled by the group controller.
- 10.2.2 When the overriding plan expires/completes, the group controller shall revert to the appropriate plan based on the previous plan, its schedule and any plans which are scheduled to activate.
- 10.2.3 The controller shall activate one plan at a time.
- 10.2.4 A plan shall be active until its completion, except where overridden (clause 10.2.1).
- 10.2.5 Prior to completion of a plan the group controller shall establish which plan will be activated next, to minimise delays. If no plan is available to be activated next, the sign shall blank on completion of the running plan.
- 10.2.6 Frames, messages and plans shall reside in the Sign controller.
- 10.2.7 Execution of any display shall be via the local “display” library.

10.3 Frame and message numbers

- 10.3.1 The following frame numbers and sign message responses shall be used for control of speed displays of the sign for use with TfNSW host control systems:

Speed Display	Frame number		Message in TSI-SP-003 protocol	
	without flashing	flashing annulus	message number	Sign Response to message
10	010	011	011	“011” for 15s, then “010” indefinitely
20	020	021	021	“021” for 15s, then “020” indefinitely
25	025	026	026	“026” for 15s, then “025” indefinitely
30	030	031	031	“031” for 15s, then “030” indefinitely
40	040	041	041	“041” for 15s, then “040” indefinitely
50	050	051	051	“051” for 15s, then “050” indefinitely
60	060	061	061	“061” for 15s, then “060” indefinitely
70	070	071	071	“071” for 15s, then “070” indefinitely
80	080	081	081	“081” for 15s, then “080” indefinitely
90	090	091	091	“091” for 15s, then “090” indefinitely
100	100	101	101	“101” for 15s, then “100” indefinitely
110	110	111	111	“111” for 15s, then “110” indefinitely

NOTE: Numbering is based on TSI-TG-011 [18].

Table 3 – Frame and message numbers for speed displays

10.3.2 The following frame numbers and sign message responses shall be assigned to the other displays of the sign, for use with TfNSW host control systems

Display	Frame Number	Message number	Sign Response to message in TSI-SP-003 protocol
Up Arrow	180	-	-
Down arrow	181	-	-
Up-left arrow	182	-	-
Up-right arrow	183	-	-
Down-left arrow	184	-	-
Down-right arrow	185	-	-
Red Cross (static)	189	-	-
Red Cross (flashing)	199	199	"199" for 15s, then "189" indefinitely
All white pixels lit	250	-	-
All red pixels lit	251	-	-
Only Annulus lit	252	-	-

NOTE: Numbering is based on TSI-TG-011[18], plus an extra for the red flashing cross.

Table 4 – Frame and message numbers for other displays

10.3.3 For a default sign, 10.3.1 and 10.3.2 cover all required displays. However, if a supplementary display is provided to meet a special project need, it shall have frame and message numbering as described in TSI-TG-011 [18].

10.4 Control of Multiple Signs

- 10.4.1 The group controller shall be capable of controlling twelve sign display units.
- 10.4.2 The displays shall be able to be grouped, for the purposes of control. The group controller shall be able to support four groups of displays.
- 10.4.3 The number of displays assigned to each group shall be configurable, from none up to twelve displays.
- 10.4.4 The sign group controller shall be able to support a poll rate of 1 heartbeat poll command per second, such that a sign status reply for all connected signs can be delivered in less than this interval, including when equipped 12 signs, however grouped.

Note: The heartbeat poll command and sign status reply are as defined in specification TSI-SP-003 [12] with MI codes respectively 05h and 06h.

- 10.4.5 Signs in a group shall be monitored on an individual basis. This shall include both fault and display monitoring. Refer to Clause 10.5 for monitoring and response.
- 10.4.6 The Signs shall be capable of being programmed, monitored and controlled from both a local and remote location via the sign group controller.
- 10.4.7 All displays and the group controller shall be individually addressable.
- 10.4.8 Displays within the same group shall change their displays simultaneously in response to a demanded change.
- 10.4.9 In the event that the group controller determines that there is a critical fault on one or more displays, the group controller shall force all displays within the same group to blank.
- 10.4.10 The group controller shall limit displays within the same group to one of the following combinations of displays:
 - (a) All displays showing the same speed limit; or
 - (b) Some displays showing the same speed limit, and other displays showing lane use signals;
 - (c) Displays showing lane use signals.

10.5 Monitoring and Response

10.5.1 The group controller shall monitor the display at all times for the following conditions:

- (a) A Sign display unit not responding to the control signals from the group controller;
- (b) One or more Sign display units within a group displaying a blank display when other sign display units in the group are not blank;
- (c) A Sign display unit within a group displaying a different speed limit display to other display units of the group; Differential speeds shall not be shown on the same gantry for signs facing the same carriageway and travel direction;
- (d) A Sign display unit within a group displaying a lane use signal that directs traffic to merge with an adjacent lane that does not exist or is closed;

NOTE: The lane use signals for lane merge are the Down-Left LUS Arrow and Down-Right LUS Arrow. NOTE: An adjacent lane is closed if the lane use signal of that lane is displaying the lane closed signal (a red cross).

- (e) A Sign display unit within a group displaying a lane closed signal, e.g. a red cross, whereas a Sign display unit of an immediately adjacent lane is directing traffic (i.e. displaying a merge arrow) on to the closing/closed lane;
- (f) Sign display units within a group on adjacent lanes displaying lane use signals that direct traffic toward each other;
- (g) A Sign display unit on a lane that is not the furthest left lane of the road displaying a lane use signal that directs traffic to exit the road from its left, but the left adjacent lane is not an exit lane;
NOTE: The lane use signals for exit are the Up-Left LUS Arrow and Up-Right LUS Arrow.
- (h) A Sign display unit on a lane that is not the furthest right lane of the road displaying a lane use signal that directs traffic to exit the road from its right, but the right adjacent lane is not an exit lane.

10.5.2 The Sign group controller shall detect any of the above conditions (clause 10.5.1) and respond to such a condition by blanking the displays of all sign display units within the same group, within 0.3 seconds of the occurrence of that trigger condition.

10.5.3 The group controller shall check all incoming commands that attempt to display stored frame(s), for the conditions specified in clause 10.5.1. The group controller shall reject all such commands where any of these conditions are detected.

10.5.4 For the purpose of clause 10.5, the Sign group controller shall provide a configuration facility for the user to define the relative locations and orientations of all signs, entry lanes, exit lanes and road kerbs.

10.6 Communications

10.6.1 The sign shall use the protocol specified in TSI-SP-003 [12] for communication with the host control system.

10.6.2 For the TSI-SP-003 protocol, the MI codes listed as applicable to ISLUS in the summary table of TSI-SP-003 [12] shall be implemented.

10.6.3 For the message “Sign Set Text Frame” (MI code 0A), the sign shall respond with the reject response.

NOTE: Character font sets are not to be used for ISLUS. Any text representation, if required, is to be loaded and managed as a graphic frame.

10.6.4 The Sign shall not initiate communication connection with the host control system.

10.6.5 The Sign shall not initiate transmission of unsolicited messages to the host control system.

10.7 Configuration Mode

10.7.1 The Sign shall provide a configuration mode to allow for changes to be made to configuration values and settings of the Sign.

10.7.2 Changes to configuration values and settings of the Sign shall be possible only when the Sign is in the configuration mode.

10.7.3 The normal operation of the Sign display shall not be affected while in configuration mode.

10.8 Fall-Back Operation

10.8.1 The sign shall meet the requirements of clause 6.7 of AS 5156 [5].

10.8.2 When mains power is lost the group controller shall:

- (a) Maintain its operation and normal sign operation (except for pixel lighting) on battery back-up whilst stored power remains to do so;
- (b) If the group controller has been able to maintain operation during the mains power outage, then on mains power restoration, the group controller shall resume the current scheduled plan and/or frame or message display commanded prior to or during the mains failure.
- (c) If the group controller has not been able to maintain operation during the mains power outage, then on resumption of mains power the group controller shall leave sign displays blank until it receives confirmation from the host control system of the latest required displays, and only then shall it begin display of those.

10.8.3 When communication is lost or adversely affected the sign shall maintain normal sign operation, continuing to operate from local control and current plan sequence. (but log a communications time-out).

10.8.4 Where the processor is affected – completely blank the display area (by default).

10.8.5 Where display drivers, or other items, are affected to the extent that the resultant displays may be confusing to the public the sign shall completely blank the display area.

10.8.6 Where one or more Signs in the same sign group experiences a fault causing it to blank, all signs in the group shall blank and remain blanked, until all critical faults are rectified (i.e. cleared).

10.8.7 In each case, the Sign shall correctly report and log the fault, as well as report the currently active display.

10.8.8 Upon clearance of the fault, the Sign shall correctly report and log the clearance.

10.8.9 Upon clearance of the fault, the Sign shall resume normal operation, displaying according to its plans and schedules, as stored or subsequently received.

NOTE: Communications faults (see 10.8.3 above) cannot be reported as they occur, but should be logged as specified in this clause. Clearance of communications faults is to be reported and logged as specified above.

10.8.10 In any case, where communication is available, the remote operator shall be able to blank the Sign, or group of signs. For the purpose of this requirement, the Sign Controller shall support the "Power ON/OFF" command in Specification TSI-SP-003 for turning ON or OFF the power for the specified groups of sign display units. If the facility switch is in the Auto, Message 1 or Message 2 position, the sign (or group of signs) shall blank on receipt of this command.

NOTE: Turning OFF the power for a group shall result in the actual removal of power from the sign display units within the group, such that they will blank regardless of the nature of fault with any of the sign displays or sign display units, including an unresponsive processor in the sign display.

10.8.11 If communication between the sign controller and the host control system is lost and not resumed within a communications threshold time, the Sign controller shall end the communications session (i.e. go "offline").

- (a) The communications threshold time shall be configurable ranging from 0 (infinite) to 65535 seconds.
- (b) A default communications threshold time of 30 seconds shall be pre-set.
- (c) For Sign controllers on dial-up links, in addition to performing a virtual end session and logging a communications time-out, the Sign controller shall ensure that the modem is returned to the on-hook state whether online or not.
- (d) The communications time-out fault shall be cleared on the next successful communications message.

10.8.12 Where communication between the sign controller and the host control system is lost, and not resumed within a display threshold time, the Sign controller shall blank all signs it controls, and log a display time-out.

- (a) The display threshold time shall be configurable ranging from 0 (infinite) to 10080 minutes.
- (b) A default display threshold time of 2 minutes shall be pre-set.
- (c) The display time-out fault shall be cleared on the next successful communications message.

10.9 Software

- 10.9.1 The sign shall meet the requirements of clause 6.8 of AS 5156 [5].
- 10.9.2 The sign manufacturer/Supplier shall control the issue of firmware/software versions for the group controller / sign according to their quality plan for this activity.
- 10.9.3 The supplier shall provide a local means to upgrade the group controller / sign's software/firmware, should this be needed post deployment. Preferably, most activity of this type shall be achievable at ground level via the control housing. Details shall be described in maintenance manuals.
- 10.9.4 The group controller / sign shall revert to the previous version if the new version fails to validate or install correctly.
- 10.9.5 The group controller / sign shall not be rendered inoperable in the event of an interruption during the software/firmware upgrade process, for example a power failure.
- 10.9.6 The supplier shall provide a means to perform a remote firmware/software upgrade. The process shall be described in the manual.
- 10.9.7 It shall be necessary to enter the device's individual password to enact a remote access firmware upgrade.
- 10.9.8 It shall be possible to disable the remote upgrade capability.

11 MANUALS

The sign shall meet the requirements of clause 6.9 of AS 5156 [5].

11.1 Sign Generic Manuals

- 11.1.1 The Supplier shall provide generic manuals compliant with TSI-SP-062 [15] as part of the approval process.
- 11.1.2 Manuals shall include a list of relevant spare parts for anticipated maintenance, and include instructions for related diagnosis for when spare parts should be used.
- 11.1.3 Maintenance manuals shall include arrangement drawings or photographs to illustrate activity required for replaceable items. This shall include pixel module replacement, as well as other replaceable items.

11.2 Project Specific Manuals

- 11.2.1 The Supplier may be required to provide project specific manuals; if so these shall be similar to approved generic manuals, with additional items, or approved variations, as appropriate to the project.
- 11.2.2 Project specific manuals are not required as part of the TS201 [10] approval process. Instead, they relate to the project, and shall be sent to the project's TfNSW Representative for their review, prior to the delivery of the sign(s) under order.

12 ENVIRONMENTAL REQUIREMENTS

12.1 Temperature and Humidity

- 12.1.1 The sign shall meet the requirements of clause 7.1 of AS 5156 [5].
- 12.1.2 The sign shall be tested as defined by clause 7.1 of AS 5156 [5] by a NATA registered laboratory or approved test organisation.
- 12.1.3 Test results confirming compliance shall be provided as part of approval submissions.

12.2 Enclosure Protection

- 12.2.1 The sign enclosure shall provide at least protection level IP55, in accordance with AS60529 [6]. This clause replaces clause 7.2(a) of AS 5156 [5].
- 12.2.2 The roadside cabinet shall provide at least protection level IP45.
- 12.2.3 The complete sign enclosure and the roadside cabinet housing shall each be tested for compliance with the level of enclosure protection specified by a NATA registered laboratory or approved test organisation.
- 12.2.4 Test results confirming compliance shall be provided as part of approval submissions.

12.3 Wind Loading

- 12.3.1 The sign shall meet the requirements of clause 7.3 of AS 5156 [5], except that the applicable wind loading conditions shall be for Region B, Terrain Category 2, in accordance with AS/NZS 1170.2 [1].
- 12.3.2 The sign shall (itself) be designed to meet the wind loading requirements for Region B, Terrain Category 2, including internal bracing and mounting brackets that are part of the sign.
- 12.3.3 The Supplier shall provide certified calculations by a qualified structural engineer as proof of sign compliance with clause 12.3.2.

12.4 Vibration

- 12.4.1 The sign shall meet the requirements of clause 7.4 of AS 5156 [5].
- 12.4.2 The sign shall be tested as defined by clause 7.4 of AS 5156 [5] by a NATA registered laboratory or approved test organisation.
- 12.4.3 Test results confirming compliance shall be provided as part of approval submissions.

13 SUPPORTABILITY

13.1 Design for Maintenance

- 13.1.1 The equipment design and construction shall take account of ergonomic factors relating to operation and maintenance safety (clause 4.2) irrespective of the maintenance strategy chosen (“in-situ” or “swap out”).
- 13.1.2 Where signs are required to be maintained in situ, doors shall be provided that give the access described in clause 5.1.5 when the sign is mounted on the expected support structure. Signs lacking this capability shall be declared by the supplier as “Swap out only”.
- 13.1.3 “Swap out only” signs shall provide facilities to be swapped out as the maintenance strategy, such signs shall provide a means to access the internal components, but are not required to provide such access whilst the sign is mounted.
- 13.1.4 A modular approach should be used in designing the equipment to facilitate maintainability, ease of installation and commissioning.
- 13.1.5 Equipment layout within housings shall be designed for ease of access during operation, maintenance and service. Access to individual modules shall be provided for replacement of the module without the need for removing other components or wiring. The access to and replacement of modules shall not require the removal of fasteners that are not reusable. Preference shall be given to fasteners which are held captive when loosened.
- 13.1.6 Preference shall be given to only requiring standard tools for preventive and repair maintenance activities. A standard tool in this context is considered one that is readily available from common hardware retailers, as distinct from one that has very restricted supply sources, such as only available from the ISLUS manufacturer.
- 13.1.7 The Supplier shall provide the following information as part of approval submissions, to help evaluation of maintainability:
- (a) Mean Time between Failures (MTBF) for the Sign;
 - (b) Mean Time between Failures (MTBF) for the sign display system;
 - (c) Mean Time to Repair (MTTR) for the Sign;
 - (d) Mean Time to Repair (MTTR) for the sign display system.

13.2 Reliability

- 13.2.1 All Signs shall have a mean-time-between-failure of not less than 45,000 hours in operation.
- A failure for the purpose of the above MTBF limit is defined as any defect (hardware or software) which causes the display to be blanked or the display to be stuck ‘ON’. It also includes failures where the actual display differs from the intended display to the extent that viewers are unlikely to comprehend the intended message.
- 13.2.2 As part of approval submissions, the supplier shall provide the MTBF of the sign display system, and information and calculations supporting the MTBF value provided.

14 QUALITY ASSURANCE

14.1 Quality System

The Supplier and the manufacturer shall operate a quality management system complying with ISO 9001 [9] and certified by an accredited quality management system certification body.

14.2 Quality Plan

The manufacturer shall document a quality plan. A copy of this quality plan shall be provided to TfNSW as part of the TS201 [10] approval process. Acceptance of this quality plan by TfNSW is a prerequisite to gaining overall approval.

The quality plan shall include details of model numbers, traceability of key components, in process and release inspections and records, and control of software/firmware release associated with update/rework of deployed ISLUS.

14.3 Quality Audits

TfNSW reserves the right to examine the Manufacturer's quality records pertaining to an order. TfNSW also reserves the right to arrange for an independent quality audit concerning items in contract.

15 APPROVAL

15.1 Approval Process

Manufacturers and Suppliers seeking approval of their signs shall follow the process defined in TS201 [10].

Projects shall either use signs listed in the ITS Register of Approved Equipment TS200 [10] or follow process TS202 [12] to seek project based approval for a sign not listed in the Register.

The spreadsheet TSI-TG-010 [17] titled "Submission guide for ISLUS" shall be used, when issued, as a form to submit the compliance claim part of a TS201 [11] or TS202 [12] submission for ISLUS.

When issued, TSI-TG-010 [17] can be downloaded via the web-page below, under technical guides. <https://www.rms.nsw.gov.au/business-industry/partners-suppliers/document-types/specifications/intelligent-transport-systems/index.html>

15.2 Changes

If a design, material or manufacturing method change is made to an approved ISLUS, the Supplier shall notify the ITS Helpdesk at itshelpdesk@rms.nsw.gov.au, and the requirements of TS201 [10] regarding changes shall be followed.