WAKA KOTAHI
NZ TRANSPORT AGENCY

VARIABLE MESSAGE SIGNS – FIXED

ITS Design Standard

14 SEPTEMBER 2020
2.0

New Zealand Government

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More information
If you have further queries, contact the ITS S&S Coordinator via email: itsspec@nzta.govt.nz

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

This document is available on the Waka Kotahi website at https://www.nzta.govt.nz/itsspecs

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Contents

1 DOCUMENT CONTROL

1.1 Document information

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1.2 Document owner

Role ITS Document Review Panel

Organisation Waka Kotahi

1.3 Document approvers

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

Approval date	Approver	Role	Organisation
		Design Engineer	Waka Kotahi
		Product Manager	Waka Kotahi
		Asset Manager	Waka Kotahi
		Safety Engineer	Waka Kotahi
		Security Specialist	Waka Kotahi
		Technical Specialist (Technology Operations)	Waka Kotahi
		Procurement Manager	Waka Kotahi
		Journey Manager (Transport Operations)	Waka Kotahi

1.4 Version history

This table shows a record of all changes to this document:

Version	Date	Author	Role and organisation	Reason
0.1	03/03/12	Bruce Walton	Beca	First draft Section 8 and 9 moved to ITS 01-04 Civil and structural design standard
0.2	04/03/20	Kevan Fleckney	Design Engineer, Waka Kotahi	Merge standard and notes and update
0.3	26/06/20	Final Word	Editorial services	Transfer draft document to the latest ITS design standard template
1.0	20/08/20	ITS Document Review Panel	Waka Kotahi	Check draft in new template, redirecting content, address queries Diagrams updated
1.1	31/08/20	ITS Document Review Panel	Waka Kotahi	Removed all instances of two-line regional VMS as these don't meet the operational needs of Waka Kotahi Updated Terminology used in this document section
2.0	14/09/20	ITS Document Review Panel	Waka Kotahi	Reviewed internally and version 2.0 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 approved and is pending 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RETIRED	The document is obsolete, and/or superseded
AADT	Annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating current
ADSL	Asymmetric digital subscriber line
Barrier protection	Generic term covering various roadside protective barrier systems including rails, fences and crash cushions, which are designed to restrain vehicles that are out of control
Border	Border surrounding an active display matrix on an electronic sign or signal
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
CIS	Computer and information systems
Clear zone	Area adjacent to the road that is clear of fixed or non-frangible objects and provides a recovery zone for vehicles that have left the carriageway
DC	Direct current
DTMF	Dual-tone multi-frequency, also known as touch tones
Enclosure	Housing for electronics systems to protect against environmental conditions
Expressway	High-speed roads, which may include well-spaced at-grade intersections – which means they often have accesses and driveways onto them and sometimes traffic signals or roundabouts
FAT	Factory acceptance testing
FCD	Field controller device
Flashing beacon	A circular lantern that flashes in order to draw a user's attention to a sign or a signal. Beacons are typically installed in the corners or along the edges of a sign or signal.
Frangible	Performance capability of structures, which are designed to shear or collapse when struck by a vehicle, minimising the impact hazard to the vehicle's occupants
Gantry	Support structure spanning a carriageway for the purpose of supporting electronic signs and signals

Term	Definition
GSM	Global system for mobile communication
High-voltage lines	Lines carrying electrical current greater than 1000 volts AC or 1500 volts DC
HVU	High-volume urban. Refers to non-motorway, generally high-volume roads, in urban environments
LED	Light-emitting diode
Line spacing	Vertical space between lines of text, expressed as a percentage of the upper-case font height
Low-voltage lines	Lines carrying electrical current less than 1000 volts AC or 1500 volts DC
Luminance ratio	Ratio of light emitted from the active display area, to that of the inactive display area when illuminated by an external light source
MASH	AASHTO Manual for Assessing Safety Hardware
MIB	Message information block
Motorway	Access-controlled, high-speed roads that normally have grade-separated intersections – which means they have overbridges (or underpasses) so road users don't have to stop at traffic lights
MOTSAM	Manual of traffic signs and markings
Pixel	Smallest controllable element of a display matrix for an electronic sign or signal
Pixel pitch	Distance between centres of adjacent pixels
RAMM	Road Assessment and Maintenance Management system
RCA	Road controlling authority
Road reserve	Corridor of land owned by the Crown, which is designated for roading infrastructure
Rural	In the context of ITS, rural refers to low-volume uncongested roadways in non-urban environments
SAT	Site acceptance testing
Scala penetrometer	Test equipment used to determine the penetration resistance of soil
Slip base	Shearing system for support structures involving upper and lower base plates clamped together by slip bolts in slots that are tightened to a prescribed torque
Stroke	Width of a character
TCD manual	Traffic control devices manual
TTM	Temporary traffic management
UPS	Uninterruptible power supply
VMS	Variable message sign

3 OVERVIEW AND OUTCOMES

This section defines the operational outcomes for intelligent transport systems with respect to the transport network.

3.1 ITS design standard definition

Design assurance is delivered through a series of design standards. The standards ensure road network level operational outcomes and design for safety, security and maintainability are accounted for in solutions being delivered to Waka Kotahi. Design standards address risks typically generated at the front end of roading or infrastructure projects. Their objective is to ensure solutions address the correct operational need and solutions are fit for purpose.

3.2 System overview

To be defined

3.2.1 System definition

A VMS is an electronic traffic sign used on roadways to give travellers information about special events. They warn of traffic congestion, accidents, adverse weather conditions and incidents. They may also ask vehicles to take alternative routes, limit travel speed, warn of duration and location of incidents, or just inform of traffic conditions.

3.2.2 System class

001 Signs.

3.3 Scope

This document provides design requirements for the delivery of fixed VMS.

Accordingly, the scope of this document has been defined as follows:

- site selection
- requirements for support structures
- design for road safety
- criterion for determining the visibility requirements, for example, font size and sight lines
- power and communication services
- post deployment audits.

These sign types covered are:

- motorway/expressway VMS which encompass VMS for motorways and expressways with more than one lane in the direction of travel
- regional VMS which encompass:
  - high-volume urban (HVU) VMS

- rural VMS.

3.4 Applicable legislation

To be defined

3.5 Outcomes

To be defined

3.5.1 Operational

To be defined

3.5.2 For users of the Waka Kotahi transport network

To be defined

3.5.3 For road controlling authorities

To be defined

4 DESIGN FOR OPERATION

This section defines the functionality required to achieve successful operation of the intelligent transport system.

4.1 Character height

Comprehension time will increase with a longer or more complex message.

4.1.1 Character height for VMS

Once the number of lines has been determined, the appropriate character height must be considered. The minimum character height is determined by visibility and the ability of the motorist to read and comprehend the message. This is a function of:

- total message size
- local speed environment
- lateral position of the VMS.

Drivers approaching the sign at the maximum appropriate/legal approach speed should be able to read the message(s) for at least:

- six seconds for a sign with a single page of text
- 10 seconds for four-line signs with two pages of messaging.

Variations on VMS readability, distance and character height are acceptable to Waka Kotahi as long as they do not compromise safety. Variations shall not conflict with Waka Kotahi signage requirements or standards.

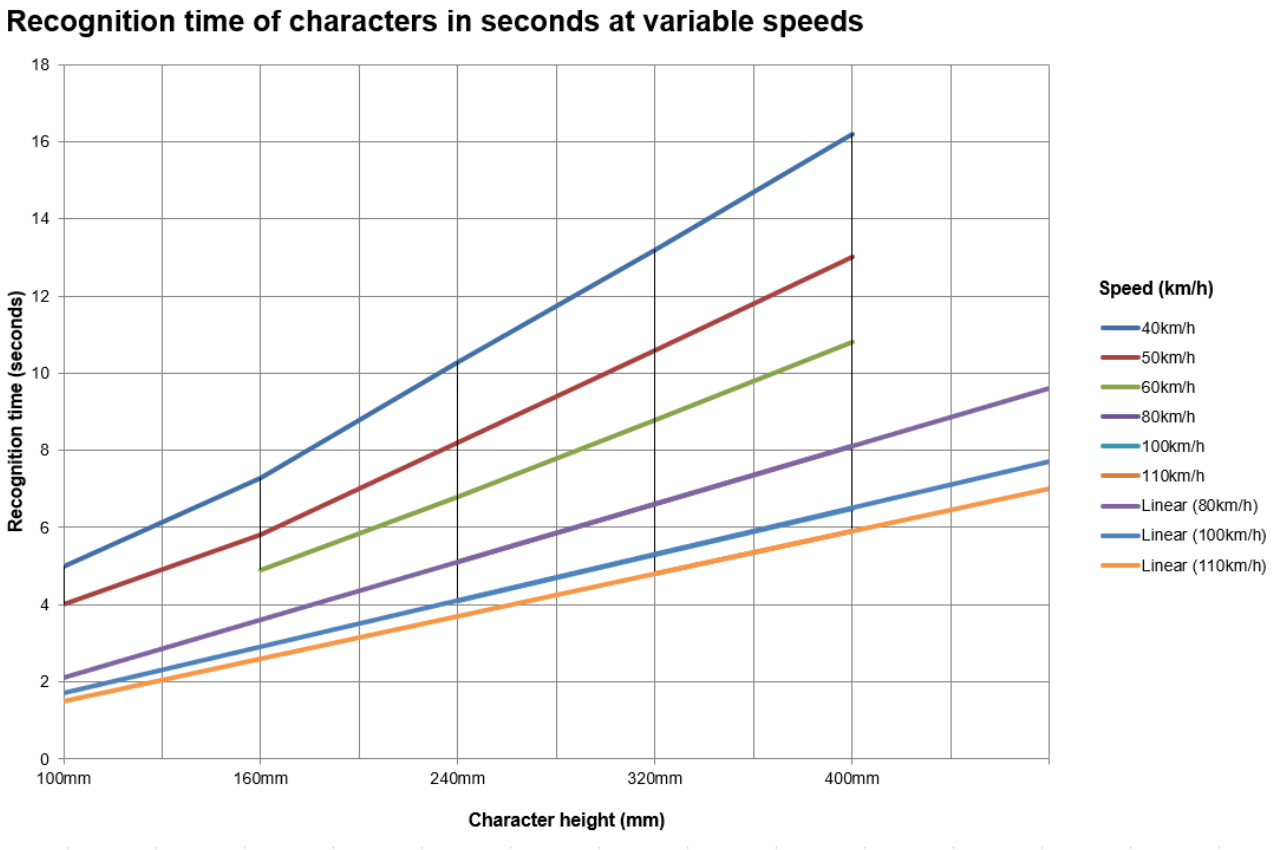

Figure 1. Relationship between character height, travelling speed and recognition (comprehension) time

The table below summarises the recommended minimum character height for HVU and rural environments for a range of speed environments, and single or dual-lane roadways.

	Minimum character height (mm)	
	Single lane in direction of travel	**Double lane in direction of travel**
Speed environment HVU and rural	**Four-line VMS**	**Four-line VMS**
Up to 50km/h	200	200
51–70km/h	200*	300
71–100km/h	300	300**

Table 1. VMS minimum character heights

*In HVU environments with a single lane in direction of travel, where:

- the annual average daily traffic (AADT) exceeds 20,000 vehicles per day, or
- 15,000 vehicles per day with pronounced peak flows,

Upgrading to a bigger font is strongly advised to improve prominence and readability in high-volume traffic.

**Sign should be mounted overhead to prevent vehicles in the left lane obscuring the message from those in the right lane.

4.1.2 How to determine character height

The legibility distance can be based on character height, multiplied by a factor. This factor is dependent on various environmental and human parameters and is typically given a value in the range between 500–620. The legibility of a font also depends heavily on its design. Standard text fonts are not always suited for a VMS, because the radiation of the light-emitting elements can easily close gaps (in letters such as ‘a’ or ‘e’ etc) that are too small.

Recognition time is calculated as the time the driver can read the message while approaching the VMS, and shall meet a range of at least four to six seconds. It is calculated from the vehicle speed and from the legibility distance. Legibility distance is the gap between maximum and minimum legibility distance (ie the distance when the text becomes readable to the distance when the reader is at a point close to the sign when the display is no longer visible). The key factors for maximum legibility distance are the character height, luminance and luminance ratio. The key factors for the minimum legibility distance are the beam width and the mounting position of the VMS.

4.1.2.1 Character height

Due to the ability of the human eye to resolve one minute of arc, typically the legibility distance can be calculated with 500–620 times character height. Text written with 300mm character height might be unreadable on distances larger than 150m. To achieve 300m legibility distance, character height of at least 500mm will be necessary.

4.1.2.2 Luminance

Due to the fact that luminance is related inverse square to the visibility distance, inter-urban systems always require the highest luminance level L3(*) of EN 12966:2014+A1:2018 Road vertical signs. Variable message traffic signs (EN 12966). This will provide visibility for 300m during normal conditions, with the consequence that from this distance it will be possible to distinguish the ON and OFF state of the sign. Please note that visibility and legibility must not be mixed in this context. In case the message is big enough (see explanations to character height in section 4.1.2.1 above), the message will be also readable, however at 300m distance the apparent luminance is already reduced significantly.

4.1.2.3 Luminance ratio

Luminance ratio (also known as contrast) is the fundamental factor for best legibility and describes the ratio of light reflected by environmental illumination and light emitted by light dots. Best example: white text on a bright background will never be legible, even if the text is bright itself. White text on a dark background will always be legible, even if the text is not too bright. Inter-urban systems always require the highest level of luminance ratio R3 of EN 12966.

4.1.2.4 Example site

Topological background:

- one-lane road each way
- 7.6% ascending slope towards the sign
- speed 80 km/h
- mounting height 4m above ground

- sign size 4.5m x 2.4m (regional type A).

Due to the slope, the mounting height and the height of the sign, the vertical distribution angle shall be at least –10°. When using beam width classes B1 to B3, the sign should be tilted at least 10 degrees towards the road in order to achieve an acceptable recognition time. By tilting the sign that much, the sign may not be able to self-clean (with rain) and there may be a compromise to mechanical stability.

Even if the road has no slope, the minimum legibility distance will not be less than 64m, resulting in a total length of the legibility distance of only 86m for a 300mm font height. At a speed of 80km/h, the recognition time will be only 3.9 seconds.

By using B4 in the same conditions and vertical mounting position, recognition time will increase to 5.3 seconds. Considering a slope of 7.6% and tilting the VMS by 3 degrees will achieve the minimum requirements for recognition time. The wider angle of the B4 means the VMS sight lines are not as sensitive to the sight lines of the road geometry.

By using B1 to B3 classes, it will be necessary to adjust the signs carefully to the environmental conditions.

Illumination of the environment will not be a topic if the dimming algorithm of the VMS follows the requirements of EN 12966.

4.2 Selection criteria

4.2.1 Motorway and expressway VMS

- Motorway and expressway environments are characterised by high volumes, multiple lanes, limited access/egress points, and may be subject to congestion. Motorway/expressway VMS generally exhibit the following features:
- large, full matrix-displays capable of:
  - displaying three lines of at least 18 characters per line with 400mm high text
  - being read by large volumes of traffic travelling at high speed
- mounted on overhead gantries to ensure all lanes of a multi-lane environment can view the message. In many cases the gantry structures and VMS displays are provided as an integrated package
- controlled singly or in groups from a remote traffic operations centre (TOC).

4.2.2 Regional VMS

Regional VMS encompass:

- high-volume urban (HVU) VMS
- rural VMS.

Regional VMS contrast to motorway/expressway VMS in that they generally:

- have smaller display sizes with either 300mm or 200mm character height
- have four lines of text instead of three
- are mounted on roadside supports located on the left side of the highway within the road reserve, or sometimes on private land.

4.2.2.1 High-volume urban VMS

High-volume urban (HVU) VMS have similar functional applications to motorway/expressway VMS but can be in lower-speed environments that are either single or multi-lane.

The HVU VMS displays may have a smaller character size, and a correspondingly smaller display size based on road and speed environment. The signs may be positioned in the road reserve, rather than overhead on a gantry.

4.2.2.2 Rural VMS

The rural VMS application is characterised by significantly larger geographic coverage of the Waka Kotahi network, and low-volume uncongested roads.

- Located on low-volume roadways typically consisting of one lane in each direction, where motorists can slow down or pull out of the traffic flow while they consider their response to the VMS message.
- Located in advance of travel decision points.
- May be sited in isolated rural locations where there are minimal competing artificial light sources.
- May be located long distances from critical incident locations, or alternative routes (50–100km is not uncommon).
- Often have cross-regional function, in that the messages displayed may also have relevance in adjacent Waka Kotahi region(s).
- The isolated nature of some sites may mean that access to mains power, and fixed line and cellular communications systems, is not readily available.

4.2.3 Environmental impact and public consultation

Potential costs and delays arising from environmental planning and consent requirements must be considered when assessing a site, as a large VMS and its support structure may be visually intrusive on the surrounding area.

As a minimum there is a requirement to consider the need to consult with nearby residents, particularly those within the LED illumination cone, as the light emitted at night may create adverse effects.

Professional judgment must be exercised as to the likely requirement for a consultation process, and the range of likely risk to the project in terms of community sustainability, time and cost. Depending on the outcomes of these considerations, alternative sites may need to be considered.

Refer to section 4.2.4.2 Environmental planning in this document.

4.2.4 Urban design, environmental planning, site services and land issues

4.2.4.1 Urban design requirements

As a signatory to the New Zealand Urban Design Protocol, Waka Kotahi has a role to ensure that VMS respond to and enhance the environment in which they are placed.

VMS can potentially add to the visual clutter on the roadside. It is important that VMS are located in relation to other elements in the visual field of view and that the design of support elements is not neglected and unrelated to other roadscape elements.

Whilst the design of the VMS is constrained due to safety reasons etc, their size, placement, support structures and related elements, including rear surfaces, can often be modified to improve the visual quality of roads and surrounding areas without compromising the sign's purpose or road user's safety.

Key strategies and actions for VMS include:

- Design VMS as a vital element of the visual experience of the road and a possible means of reducing the number of signs.
- Ensure coordination and possible collocation of VMS with other roadscape elements.
- Ensure that the local character of an area is not adversely impacted by unnecessarily large and poorly located VMS.
- Design support structures and related signage hardware to be integrated with other elements such as lighting, bridge and guard rails, emergency phones, advertising etc.
- Where VMS are to be located on overbridges, integrate them into the design of these structures if possible so that they do not appear as add-ons.
- Explore ways to improve the appearance of the rear of the VMS.

4.2.4.2 Environmental planning

4.2.4.2.1 Outline plan

Where VMS are to be located within the boundary of a road designation, the territorial authority (city or district council) may require an outline plan for the works. It is recommended that discussions be held with the appropriate territorial authority early in the project to determine their requirements.

Where a road designation is in place, resource consent will not be required to install a VMS. Works in accordance with the designation will override the District Plan rules. An exception to this would be if there were conditions on the roading designation relevant to the VMS such as sign height, sign area, character size or illumination. If a VMS exceeded the relevant conditions, resource consent would be required. However, conditions on roading designations relating to signage are uncommon and many District Plans provide for traffic management signs on roads as permitted activities. A check should be made as to whether the sign would be a permitted activity.

Section 176A of the Resource Management Act 1991 (RMA) requires an outline plan for works that are on designated land and are in accordance with the designation, to be submitted to the territorial authority. Section 176A (3) of the RMA states:

"An outline plan must show—
(a) the height, shape, and bulk of the public work, project, or work; and
(b) the location on the site of the public work, project, or work; and
(c) the likely finished contour of the site; and
(d) the vehicular access, circulation, and the provision for parking; and
(e) the landscaping proposed; and
(f) any other matters to avoid, remedy, or mitigate any adverse effects on the environment."

An outline plan for VMS need only include the information listed above, which is relevant to the particular proposal.

Territorial authorities do not have the discretion to approve or decline an outline plan. Their sole discretion is to request changes to an outline plan prior to commencement of the work. The authority responsible for the road designation, ie Waka Kotahi, may then accept or reject the recommendation of the territorial authority in full or in part.

In the early discussion with the territorial authority it would be appropriate to enquire whether they require an outline plan of works. Section 176A (2) of the RMA lists the following exceptions to the general rule:

"An outline plan need not be submitted to the territorial authority if—
(a) the proposed public work, project, or work has been otherwise approved under this Act; or
(b) the details of the proposed public work, project, or work, as referred to in subsection (3), are incorporated into the designation; or
(c) the territorial authority waives the requirement for an outline plan."

In the past a number of territorial authorities have, upon enquiry from the road authority or its agent, not required an outline plan of works given the minor nature of the VMS.

4.2.4.2.2 Resource consents

Where VMS are to be located outside the boundary of a road designation, a land use consent may be required from the territorial authority. An assessment under the relevant rules of the District Plan will be necessary to determine whether the VMS needs a resource consent.

4.2.4.2.3 Assessments of environmental effects

Where Waka Kotahi is required to apply for a resource consent to locate a VMS, an assessment of environmental effects must be undertaken. This would require a more extensive and detailed assessment than for an outline plan.

The actual or potential effects being assessed will need to be tailored to the circumstances of the VMS proposed. In most situations, the main effects that will be considered are visual and traffic safety effects. The visual effects could include matters such as sign height, size, location or amenity. The traffic safety effects could include the benefits to traffic safety as a result of the sign or any potential driver distraction considerations. Site, location and sign design plans and information on how the sign will be operated and serviced should be included with the application. It would also be helpful to include visual imagery that demonstrates the appearance of the sign and the highly directional nature and narrow illumination cone of the display elements.

Where a VMS requires a resource consent, written approval to the proposal from the affected party, ie the landowner concerned, will be necessary. It is important to note that written approval of the VMS cannot be subject to conditions. The affected party either approves or does not approve the VMS. If the affected party has particular conditions they would like addressed, these should be incorporated into the proposal or through private contract with Waka Kotahi. If the resource consent application requires amendment due to the affected party's concerns, then the application should note that the proposal has been amended to address the

concerns of the affected party and that the affected party has provided written approval to the amended proposal.

4.2.5 Land issues

There are normally distinct advantages in having:

- the VMS site, and
- the line of clear sight to the VMS sign over the entire legibility distance, and
- trenched or overhead services to the sign

completely within the legal boundary of the road reserve or land owned by the Crown, to avoid landowner negotiations, compensation, legal issues and potential delays.

This section is intended to flag the importance of ensuring any agreements with landowners are placed on a formal legal basis if encroachment into neighbouring land is going to occur. It does not address details of such legal instruments as Easements, Land Plans, Land Entry Agreements, Full and Final Agreements, and compensation for landowners, which may be required if encroachment occurs. For specialist advice, the Waka Kotahi Property Consultant should be approached.

4.2.6 Communications to site

A communications link is required to connect the VMS to the Waka Kotahi national control system.

In urban, motorway and expressway locations, there are a range of communications options that can be utilised, including:

- use of any existing Waka Kotahi communications network
- leased lines from commercial providers (ADSL)
- mobile communications such as GSM.

For regional VMS sites, options include:

- Telecommunications copper line connecting to ADSL (broadband) – preferred option
- mobile communication such as GSM. Waka Kotahi has national communications agreements in place with a commercial provider.

Depending on the communication system selected, there may be a need to arrange cabling/trenching to the site. As with the power requirements, consideration should be given to tasking a telecommunications contractor with arranging cabling to the site. With regional VMS, this is normally arranged by the Waka Kotahi National Office.

Note that consent from Waka Kotahi is required before cabling installation is undertaken in the road reserve.

Where the VMS is connected to mains power and a copper communication cable, there must be appropriate separation. Where power and communication cables are laid in the same trench for up to 200m, separation of >200mm is required.

4.2.7 VMS site selection criteria

VMS site selection must consider many interrelated factors. There is a close relationship between site selection and selection of the sign size/display technology. Site considerations influence the selection of sign and technology, and sign constraints influence the choice of site.

The strategic location and anticipated simultaneous message suite determine the number of characters per line and lines for each sign. The character height is subsequently decided during site selection based on the speed environment and other factors at the proposed site.

4.2.7.1 Strategic locations – an introduction

VMS projects are generally justified on the benefits of establishing a sign or signs at strategic locations or nodes on the state highway network. At a macro level, the site selection process must identify all potentially suitable sections of highway for siting VMS to ensure that viable options are not excluded from subsequent consideration.

The Roadrunner tool, which provides a motorist's-eye view of the state highway system, is an extremely useful tool to identify potential sites rapidly and safely before actual site visits are undertaken.

The VMS must be positioned above or to the left of the approaching motorist. In virtually all situations, it is considered unsafe to position a VMS on the right-hand side of approaching traffic because it may confuse motorists' point of reference under night-time conditions and lead to a head-on collision.

4.2.7.2 Minimum distance from key intersections

If the VMS is intended to advise route diversions, the sign shall be located sufficiently in advance of the alternative route intersection to allow the road user to assimilate the message and react accordingly, including changing lanes if necessary.

Motorway/expressway VMS should be placed a minimum distance of 1500m prior to the exit/diversion point. This distance provides the motorist with roughly 50–60 seconds from the time they have read the message until they reach the access/diversion point. In practice, this is difficult to achieve in urban areas where interchanges are closely spaced. If the motorway/expressway has two or three lanes in the direction the VMS is indicating, this can be reduced to a minimum of 800m. Alternatively, if two exits are closely spaced, the VMS can be in advance of the first exit. No motorway/expressway VMS shall be installed within 300m of the end of an upstream merge taper.

On high-volume urban (HVU) roads, the distance is dependent on considerations such as the speed limit, local factors and right-of-way constraints.

On a rural single-lane roadway, with no need to change lanes, but acknowledging the complexity of some decisions and the route choices, a distance equating to at least 1000 metres in a 100km/h zone, or a proportionally reduced distance in lower-speed zones, is suggested.

If a rural VMS with low traffic volumes (eg 2000 AADT) may display a message advising motorists to turn back, consideration should be given to choosing a site that has a suitable pullover/turning area just after the sign for travellers to turn around.

With higher traffic volumes in a high-speed environment, a level (~10,000 AADT) is reached where pulling over or turning around is unsafe. Under normal circumstances, the VMS will be placed in advance of the decision/alternative route point, so turning around will be unnecessary, but professional judgement should be exercised as to whether pullover or turning areas are appropriate.

4.2.7.3 Influence of message suite on sign configuration

The number of locations or routes covered by the sign, and range of messages required to be displayed at any one time, influence the selection of sign. This is particularly true in the rural context where a choice is made between two- or four-line signs. The interaction between likely message complexity, speed environment and character height must reach a mutually compatible solution. Character height in turn determines sign width. It is therefore necessary to establish the maximum likely range of messages to be displayed at any one time and understand sign type options before undertaking detailed site selection. Refer to section 4.1 Character height in this document.

4.2.7.4 Speed environment and character height

Refer to section 4.1 Character height in this document. The minimum character heights are based on table 1 of TD 33/05 UK Design manual (TD 33/05).

The standard categories of character height for Waka Kotahi VMS are:

- 400mm for motorways and expressways
- 300mm and 200mm for HVU and rural, dependent on message size and speed environment.

The character height determines the width of regional signs, and hence influences site selection, ie:

- standard regional VMS with 300mm character height is ~5m overall width
- standard regional VMS with 200mm character height is ~3.3m overall width.

4.2.7.5 Clear sight distance

In motorway/expressway and HVU settings there are typically many other signs and distractions that compete for motorists' attention. Visibility and impact, proportional to the environmental context, are particularly important considerations of site selection.

For rural VMS, the designer should look for sites that allow motorists clear sight distance to the sign of at least 375m for 300mm character height, and at least 250m for 200mm character height, when travelling at 100km/h. In lower-speed environments the distances can be reduced proportionally.

Ensure that roadside trees or other structures will not obscure the sign. Ensure that requirements for trimming or other activities to maintain clear line of sight in the foreseeable future can be legally enforced.

4.2.7.6 Sign orientation requirements

The VMS shall be orientated such that it complies with the relevant beam-width class specified in EN 12966.

4.2.7.7 Road angle vertical plane

The designer must take into account the viewing angle of the LEDs when considering a site.

Correct alignment is important to ensure approaching motorists will remain within the cone of illumination for as long as possible. The ability to optimally align the VMS in the vertical plane must be considered when the approach is up a steep hill, or if the VMS is unusually high above the road.

4.2.7.8 Road angle horizontal plane

If possible, avoid positioning the VMS directly in front of a rising or setting sun as this may significantly reduce its effective visibility. Similarly, reflections of the sun on the display face may reduce its legibility even with an anti-phantom display. Note the seasonal variation between the intersection of the arcs of the (higher) summer sun and the (lower) winter sun, and the horizon.

Where these display visibility factors cannot be mitigated, eg by taking advantage of a natural backdrop of a hill or trees, or a downhill slope, then the use of a hood or louvres should be considered to shield the display.

In certain situations, eg where traffic is angling across, rather than directly approaching the sign, it may be necessary to specify LEDs with a wider non-standard illumination cone.

Regional VMS are normally mounted to the side of the roadway on the left-hand side of approaching traffic where there is a single approaching lane. For a straight approach, the right edge of the cone of visibility should be aligned down the road reserve parallel with the road, as illustrated in figure 2 below.

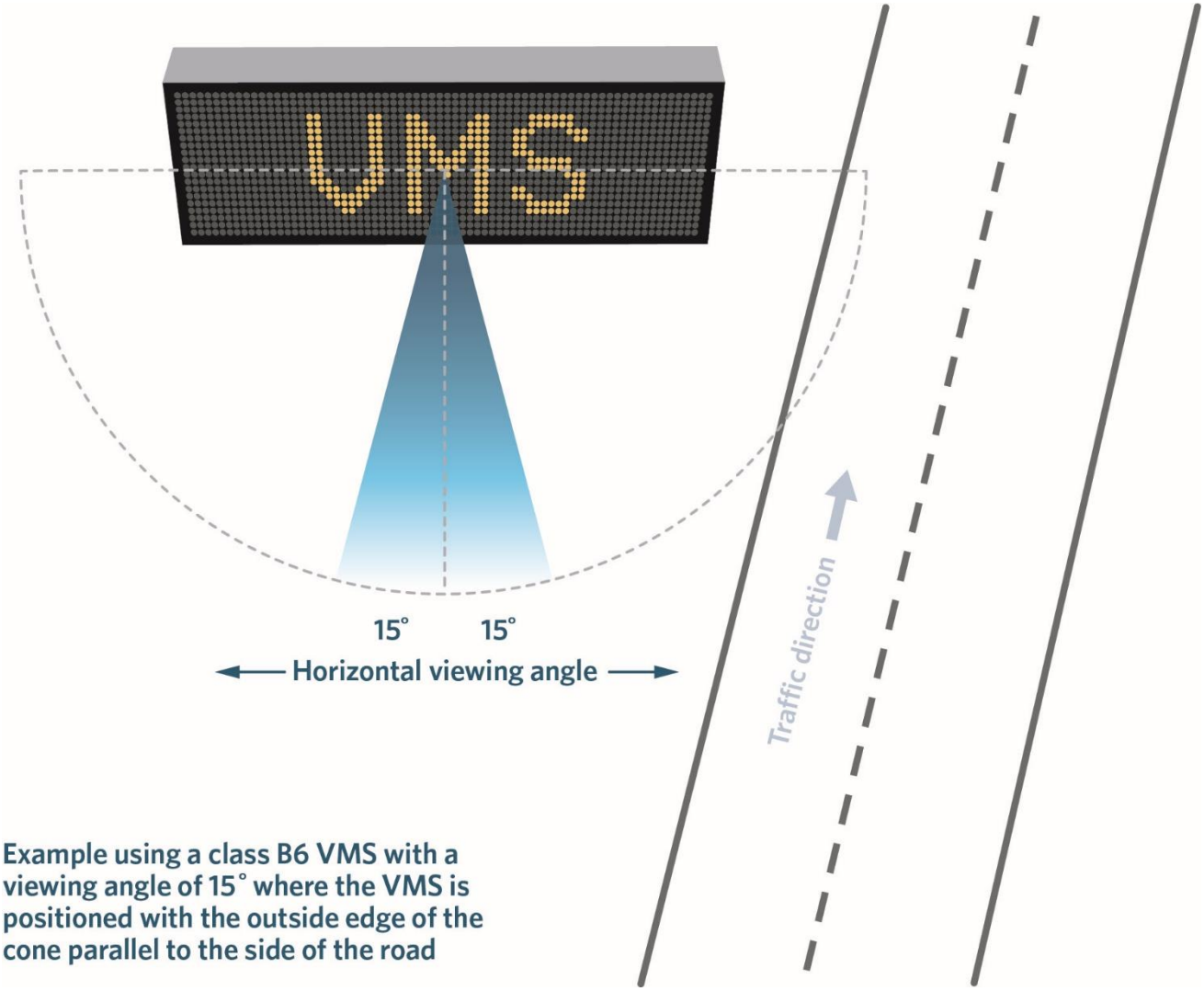

Figure 2: Cone of visibility alignment for a straight approach to a roadside sign

For VMS mounted some distance beyond a left or right-hand curve, alignment should maximise the time that travellers remain within the cone of visibility, as illustrated in figure 2 and detailed in the latest version of ITS design standard: Civil and structural requirements.

The horizontal alignments for straight and curved approaches are illustrated in figure 2 and detailed in the latest version of ITS design standard: Civil and structural requirements.

For curved approaches, the VMS must be aligned to ensure:

- at the maximum reading distance, the inside edge of the curve is within the cone of visibility
- approaching the VMS, the outside edge of the curve remains within the cone of visibility for as long as possible.

For further guidance, refer to EN 12966 section N.4.3.

See the latest version of ITS design standard: Civil and structural, for these diagrams:

- Optimum alignment for regional VMS on roadside support structure
- Optimum alignment for motorway VMS on overhead gantry.

4.2.7.9 Road geometry

Avoid positioning a VMS immediately before a sharp bend, blind crest or intersection, where the VMS may distract attention at a critical moment and could lead to loss of driver control.

Also, the VMS must not be positioned where the display may be seen from a neighbouring road if this will result in motorists receiving confusing or conflicting information.

4.2.7.10 Presence of other signage

VMS should not compete with other existing signs and/or strong light-emitting sources or interfere with traffic control devices. The designer must make an inventory of all signs and traffic control devices both proceeding and beyond the potential site. Based on this inventory, existing signs may need to be moved to accommodate the VMS placement.

VMS and static signage may be co-located on a gantry structure.

MOTSAM requires different signs to be located a minimum of ($0.6V_{85}$) apart, where V_{85} is the 85^{th} percentile speed of traffic, in km/h, at the sign location.

4.2.7.11 Width and boundary of road reserve

Having established the space requirements for the VMS and any barrier protection, it is essential to identify the position of the legal boundary in relation to the boundary fence or other indication of the edge of the road reserve. The position of the boundary fence and the legal boundary of the road reserve may not coincide. It may be enough to overlay boundary plans on an aerial photo, or a survey may be required to establish the legal boundary.

4.2.7.12 Access to mains power

Assuming the VMS will be mains powered, it is necessary to estimate the cost of supplying power to the site. If there is not an existing power supply nearby, or if a line must be run over private property, the cost and delay factors can be significant.

If the power supply must come from the other side of the roadway, trenching across the state highway is not acceptable, an aerial cable may also not be acceptable, and thrust boring may be the only option.

4.2.7.13 Communications coverage

Depending on the communications options being considered, it may be necessary to establish the location of the nearest suitable hardwiring, or the strength of the cellular coverage at the proposed sites.

The installation (capital) cost, operating cost and fitness for purpose of the communications options must be established.

4.3 Main attributes

4.3.1 Summary table of motorway and expressway VMS

The main attributes of Waka Kotahi motorway/expressway VMS are summarised in the following table.

Note: This table is intended as a quick reference only.

Attribute	Specification
Character height	400mm for overhead mount or side mount with <6m offset (450mm is required for side mount with >6m offset)
Equivalent number of lines of characters	400mm character height – three lines 300mm character height – four lines
Display font / pixel spacing	As close as practicable to AS 1744:2015 Standard alphabets for road signs (AS 1744) series D upper-case font. Spacing in section 4.2.7
Flashing beacons	Required

Table 2. Motorway/expressway VMS main standard attributes summary

4.3.2 Summary table of regional VMS

Note: This table is intended as a quick reference only.

Attribute	Specification
Character height and number of lines of characters	Type A: 300mm x 4 lines Type C: 200mm x 4 lines
Display font / pixel spacing	As close as practicable to AS 1744 series D upper-case font. Spacing in section 4.2.7
Flashing beacons	Required

Table 3. Regional VMS main standard attributes summary

4.4 Display attributes

4.4.1 Display size

The choice of display is dictated by the intended operational application and message requirements. For the previously described applications, Waka Kotahi utilises the following standard VMS display types.

	Number of lines of characters	Minimum character height (mm)
Application	**Standard**	
Motorway/expressway	3 (4 permitted for journey time information)	400 (300)
Regional x 4 lines	4	200/300
Regional x 2 lines	2	200/300

Table 4. Standard display types

Both vertical and horizontal spacing of pixels must be the same across the entire display.

Full matrix signs are standard for all Waka Kotahi applications where flexibility to support text heights greater than the standard line height and/or graphics in the future is required.

4.4.2 Font display

These character, word and line spacing requirements provide a proportionally correct text appearance that allows the sign to be more easily read from a distance. Along with other parameters such as font height and word count per line, they help the designer to determine sign size and therefore the requirements for space at the roadside/on a gantry for the sign.

The VMS controller shall be capable of generating the following display fonts and text layout:

Attribute	Specification
Font	As near as practicable to AS 1477 series Dd upper case
Character height	Measured in millimetres
Character width	Proportional font is required, measured in millimetres
Character spacing	Must equal or exceed stroke
Word spacing	0.7 of font height
Line spacing	0.4 to 0.6 of font height, configurable
Proportional spacing	

Table 5. Font and text format display parameters

The VMS shall also be able to generate the following fonts:

- double stroke
- variable height up to triple height
- capable of displaying any combination of text and numerals, including standard punctuation and arrow display.

The associated controller software functionality shall allow:

- centre, left or right justification by word, numeral and/or line
- any colour combination

- transmission of live data (such as time/temperature etc)
- insertion of single or multiple pictograms anywhere in the display area, configurable.

4.5 Vertical alignment

For a sign designed to meet the beam angle requirements contained within EN 12966, the face angle will be set by the required beam depth below and above the horizontal plane in relation to the topography of the site. A vertical sign face will be the norm, but it is permitted to be up to 5 degrees down for sites with steep approach gradients to the sign.

The design of sign enclosure doors, door stays, weep holes and all other equipment shall ensure satisfactory operation with the sign enclosure in its design position.

4.6 Mounting to the support structure

The VMS enclosure shall include structural attachment points, bolts and clamps to mount the VMS on the support structure.

4.7 Installation

4.7.1 Interface between VMS and the support structure

Where the VMS and the civil works are procured through separate contracts, the interface or integration between the VMS enclosure and the support structure must be closely managed by Waka Kotahi or our appointed representatives.

The appointed Project Manager is responsible for ensuring the design requirements for the VMS contract are met, including:

- determining the VMS dimensions, weight and method of attachment to the support structure with the contractor supplying the VMS. A clear distinction must be made between the dimensions of the enclosure plus tolerance that are required for connection to the support structure, and the dimensions of the enclosure plus the surrounding border (which may be bolted to the enclosure) that are relevant for wind-loading calculations
- coordinating design for attachment of the VMS to the support structure
- communicating this information to the appointed Engineer(s) responsible for the VMS and for the civil works.

4.7.2 Foundation conditions

The foundations for large motorway, single pole, cantilevered and other VMS structures outside the standard rural type designs require a detailed geotechnical assessment of the ground conditions.

The regional VMS two-post support structure standard designs, and the single-post centre-mounted support structure standard designs, include foundation designs for a specified envelope of wind and ground conditions. To reduce the risk to Waka Kotahi from the contractor encountering unforeseen ground conditions, the designer shall carry out appropriate investigations before a site is recommended. The results of these investigations shall be used to determine whether the standard designs may be adopted. If ground conditions

are poorer than the specified criteria at any site, then either an alternative foundation design must be provided in the tender, or enough information must be included to enable tenderers to submit foundation designs for approval.

For more information on foundations, see the latest version of ITS design standard: Civil and structural.

4.7.3 Site acceptance testing (SAT)

The contractor shall undertake SAT as required by the appointed Engineer on the VMS display, controller, communications and site condition following installation and prior to commissioning. This SAT may include, but is not limited to:

- any repeat factory acceptance testing (FAT) as deemed appropriate
- testing of the power supply and back-up power supply
- testing of the communications link(s)
- testing of the central VMS control software application
- inspection of the site.

In all cases, the contractor shall provide full details of testing and acceptance criteria for the above SAT for the appointed Engineer's approval at least two weeks prior to commissioning.

The appointed Engineer shall appoint a competent person from Waka Kotahi, or from the maintenance provider, to conduct the test.

4.8 Power supply

4.8.1 Motorway and expressway VMS uninterruptible power supply (UPS)

All motorway and expressway VMS shall be equipped with UPS facility, which shall maintain operation of the controller and communications equipment for a minimum period of four hours in the event of mains power failure.

Power to the VMS controller and communications equipment shall be routed via the UPS to ensure a clean and stable power supply.

Batteries shall be of a deep discharge, low-maintenance gel type and automatically charged from the mains power supply.

4.8.2 Regional VMS UPS

All regional VMS shall be equipped with a UPS facility, which shall maintain operation of the VMS, communications and ancillary equipment for a minimum of seven hours in the event of mains power failure.

Options include:

- battery banks
- back-up generator.

Power to the VMS shall be routed via the UPS to ensure a clean and stable power supply.

Batteries shall be of a deep discharge, low-maintenance gel type and automatically charged from the mains power supply.

The back-up power facility shall be capable of providing a minimum of seven hours of full VMS operation including pixel lighting in normal daytime mode, communications and controller under normal operational conditions.

4.8.3 Remote reboot and upload capability

The ability to remotely reboot a sign and remotely upload new protocols and software is required.

The VMS shall be supplied with remote reboot and upload functionality, involving a temporary power cut to the modem, field controller device (FCD), and all other sign electronics for 10 seconds.

4.8.4 Electrical surge protection

All display equipment shall be internally protected against damage resulting from:

- lightning strikes near the VMS/gantry/roadside cabinet
- electrical transients on power cabling
- electrical transients on internal and external signal wiring
- electromagnetic interference
- static electrical discharge.

A lightning protection system shall be installed in accordance with AS/NZS 1768:2007 Lightning protection (AS/NZS 1768). The system shall consist of:

- an air termination to intercept lightning discharges directly
- down conductors to connect the air terminal to earth terminals. Note that it is possible that these down conductors can be formed from reinforcing steel that may be used in concrete support structures (as applicable)
- earth terminations to discharge the lightning currents into the general mass of earth. Note that this may in part, or in full, consist of the foundations for the support structure, depending on the calculated required maximum earthing resistance
- equipotential bonding between the lightning earthing system and any other earthing systems for personal and equipment protection.

Multi-stage surge diversion shall also be provided on the incoming power circuits and communication circuits. Surge diverters shall be field replaceable without the need to disconnect wiring and they shall have integral indicators to show when they have blown (as applicable). A preferred option is to have an auto-reset function which negates the need for an actual site visit.

5 DESIGN FOR SAFETY

This section defines the requirements to ensure the intelligent transport system can be operated and serviced safely.

5.1 Health and safety

All ITS equipment must be designed to ensure installation and maintenance in accordance with the Health and Safety at Work Act 2015.

5.2 Safety outcomes

5.2.1 Space to ensure safety conformance

In the motorway and expressway context, gantry support structures will normally require barrier protection.

For regional VMS, the width of the left-hand road reserve is a crucial determinant in the decision process. The space must accommodate the width of the proposed sign, space for barrier protection if required, and allow a further distance to the edge of the live lane dependent on speed environment.

Regional VMS support structures should be sited outside the clear zone where practicable, refer to Clear Zones, Barriers and Driving Lines – Mitigating the Effects of Crashes on Corners (Horizontal Curves) (Report 12-529B33). Consideration should be given to natural protection afforded by positioning signs on top of cuttings or beyond culverts, providing the other site selection requirements can be met.

For speed environments at or above 70km/h, structures in the clear zone must be frangible or protected, refer to Report 12-529B33.

Below 70 km/h there is no requirement to protect non-frangible signs, but the supports should be located as far from the road edge as practicable. Where a barrier is possible this should be considered especially when pedestrians and cyclists are using roadway or footpath.

5.2.2 Site access

The site must allow reasonable vehicle access for erection, and for reactive and routine maintenance. The site shall be accessible, and the sign shall be maintainable, without the need for temporary traffic management (TTM). The design should:

- allow safe access to the sign for maintenance vehicles
- minimise the exposure to hazards posed between maintenance vehicles and personnel, and traffic in the live lane(s)
- facilitate effective traffic control for any maintenance work above the carriageway.

5.2.3 Safety issues – above and below ground

The top of the sign shall not be located any closer than 2m to overhead low-voltage power lines, and not closer than 4.5m for high-voltage lines. However, some power companies may require slightly greater separation distances.

Note should be made if the site is under power lines low enough to interfere with erection of the support structure and this information should appear in the tender documents.

Note that a check must also be made for the presence of underground services before digging or testing with a Scala penetrometer.

5.2.4 Road safety

5.2.4.1 Motorway and expressway

In the motorway and expressway context, gantry support structures will normally require barrier protection.

5.2.4.2 HVU and rural

In the HVU and rural context, support structures should be sited outside the clear zone where practicable (refer to Report 12-529B33). Consideration should be given to natural protection afforded by positioning signs on top of cuttings or beyond culverts, providing the other site selection requirements can be met.

For speed environments at or above 70km/h, structures in the clear zone must be either frangible or protected to MASH test level 3. Please refer to Report 12-529B33 and Specifications and notes for road safety barrier systems on state highways (NZTA M23).

Where a barrier is being considered, the needs of pedestrians and cyclists shall be considered.

5.2.4.3 Barrier protection

Where safety barriers or guardrails are provided to protect the VMS support structure and any associated equipment, refer to the latest version of ITS design standard: Civil and structural requirements.

Urban design, environmental planning, site services and land issues.

5.3 Site assessment

To be defined

5.4 Site audit

To be defined

5.5 System-specific safety requirements

To be defined

6 DESIGN FOR MAINTAINABILITY

This section defines the requirements to ensure the intelligent transport system can be maintained.

6.1 Maintenance outcomes

6.1.1 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.

Door seals are considered essential to protect against ingress of dust/insects and to meet the ingress requirements of EN 12966. In addition, they may form part of the water and pollutant ingress protection systems.

Where access doors are provided, they shall be fitted with a suitable retention stay or gas strut to hold the door in the open position for the safety of maintenance personnel working inside the enclosure. For security, access doors and panels shall be fitted with suitable locks, 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.

Regional VMS located alongside roads where there is a single approaching traffic lane are generally located so that the bottom of the enclosure is located 3m above the ground. The design should ensure ease of access to components for ladder-based access or facilitate use of portable access equipment (eg scissor lift or cherry picker). If the sign is located on a 4m monopole, a safe ladder rest and secure platform on the back of the sign cage shall be provided.

Access doors at the rear of gantry-mounted sign enclosures shall be designed to be fully openable without coming into contact with the gantry structure.

The design shall eliminate or minimise:

- the need for a lane closure during maintenance
- exposure to errant vehicles.

6.1.2 Extreme weather or other environmental conditions

Avoid sites prone to flooding where possible. If necessary, use a tall traffic signal-type roadside cabinet ensuring its position does not offer vandals a platform to reach the VMS. Consideration must be given to extreme or unusual conditions at each site that will require upgrading of part of the design.

Obvious examples include:

- extreme winds that are more likely >500m altitude, on a ridge or cutting, or in a lee effect multiplier zone, affecting foundations and structural support design
- corrosive environments requiring enhanced coating systems.

Another less obvious example is the need to protect exposed equipment in alpine locations from wildlife.

6.1.3 As-built documentation

As-built drawings shall be supplied by sign vendors and contractors and will include:

- site layout
- support structures
- installation elevations/plans
- cabinet drawings
- power supply arrangements
- electrical compliance certificates
- RAMM data.

6.1.4 VMS structures inspection and maintenance

6.1.4.1 Inspection

Inspection of VMS structures shall be undertaken in accordance with Waka Kotahi policies, specifications and guidelines.

The scope of the inspection shall include:

- damage (accident or vandalism)
- condition of the corrosion protection system
- the connection between support structure and cabinet
- weather tightness and security of cabinet
- security of power cable and conduit
- adhesion of the mask to the polycarbonate panel
- obstruction to the motorist's clear line of sight.

6.1.4.2 Maintenance

Maintenance shall be undertaken following the identification of defects, in accordance with Waka Kotahi requirements. For VMS structures with frangible slip bases, regular maintenance of bolt tightness is required.

6.1.5 Roadside cabinets

Where an external roadside cabinet is required, the cabinet shall be:

- sized to house all communications equipment, comms termination, power supply, batteries/UPS and power meter. The cabinet shall include two empty 19-inch rack unit spaces to allow for the addition of future technology
- compliant with the requirements of the latest version of ITS delivery specification: Roadside cabinets
- lockable and with a different key to the sign enclosure – see the latest version of ITS delivery specification: Roadside cabinets for equipment cabinet locking requirements
- fitted with a minimum of two single-phase switched 10A-rated power outlet sockets for portable maintenance equipment
- fully equipped to withstand class T1 environmental conditions

- fully equipped to maintain the required operation conditions for the equipment which is to be enclosed within the cabinet.

6.1.6 Operational life

The operational life of motorway/expressway and regional VMS is 15 years.

7 DESIGN FOR SECURITY

This section defines the requirements to ensure the intelligent transport system can be secured and maintain integrity.

7.1 Security outcomes

To be defined

8 APPENDIX A – <TITLE>

9 APPENDIX B – <TITLE>

10 REFERENCES

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

10.1 Industry standards

Standard number / name	Source	Licence type and conditions
Health and Safety at Work Act 2015	NZ Legislation website	Public
AASHTO Manual for Assessing Safety of Hardware (MASH)	AASHTO Store website	
RS-232/485 Standard for serial connections		
AS 1744:2015 Standard alphabets for road signs		
EN 12966:2014+A1:2018 Road vertical signs. Variable message traffic signs		
TD 33/05 UK Design manual		
AS/NZS 1768:2007 Lightning protection		
Resource Management Act 1991 (RMA)	NZ Legislation website	Public

10.2 Waka Kotahi standards, specifications and resources

10.2.1 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 delivery specification: Roadside cabinets
ITS design standard: Civil and structural requirements

10.2.2 Resources

Document name / code	Waka Kotahi website link
Specifications and notes for road safety barrier systems on state highways (NZTA M23)	https://www.nzta.govt.nz/resources/road-safety-barrier-systems/index.html
Traffic control devices manual (TCD manual)	https://www.nzta.govt.nz/resources/traffic-control-devices-manual/
Manual of traffic signs and markings (MOTSAM)	https://www.nzta.govt.nz/resources/motsam/part-1/

Document name / code	Waka Kotahi website link
Clear Zones, Barriers and Driving Lines – Mitigating the Effects of Crashes on Corners (Horizontal Curves) (Report 12-529B33)	https://www.nzta.govt.nz/resources/clear-zones-barriers-and-driving-lines/
Safety and geometric design	https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/safety-and-geometric-design/

10.3 Drawings

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

Drawing number

11 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	Class
4.2.6	Communications to site	Communications infrastructure core requirements standard	000 Core requirements
4.8	Power supply	Electrical core requirements specification	000 Core requirements