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1 Design guide information

1.1 Design guide purpose

The purpose of this design guide is to support Roads and Maritime Services (Roads and Maritime) Smart Motorway Technical Direction[1] and the Smart Motorway Guidelines[2].

1.2 Smart motorway document framework

This design guide is part of a suite of smart (managed) motorway documents that provide information relating to overall planning, project development, delivery and the on-going operation of smart motorways in New South Wales (NSW). This design guide is included in the group of documents highlighted in Table 1.

<table>
<thead>
<tr>
<th>Document</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical direction</td>
<td>Core overarching policy defining Roads and Maritime smart motorway implementation intentions.</td>
</tr>
<tr>
<td>Guidelines</td>
<td>A 'scene setting' document providing an overview of smart motorways, the elements and a guide for their application in NSW.</td>
</tr>
<tr>
<td>Design guides</td>
<td>A document set providing design requirement guidance for the provision, positioning and other traffic engineering considerations of smart motorway elements.</td>
</tr>
<tr>
<td>Specifications</td>
<td>Technical, construction, installation and quality specifications for smart motorway elements including the commissioning (transference to full operational mode) of smart motorway elements.</td>
</tr>
<tr>
<td>Operations</td>
<td>Operating policies and procedures, system and element administration and use documents</td>
</tr>
</tbody>
</table>

Note: The design guide group of documents also includes external primary reference documents with a Roads and Maritime supplement to define Roads and Maritime enhanced practice, complementary material or departures. This is an interim measure until a complete suite of design guides are available.

1.3 Design guide scope

This design guide provides guidance relating to smart motorway traffic monitoring and surveillance elements, including:

- Closed circuit television (CCTV) (Section 2)
- Automatic incident detection (AID) systems (Section 3)
- Emergency telephones (Section 4)
- Environmental and safety monitoring systems (Section 5)
- Enforcement systems (Section 6).

This design guide does not discuss vehicle detection, which is discussed in a separate guide[3].
This design guide focusses on the layout of traffic monitoring and surveillance devices on the motorway network. Other complementary materials should be referred to for functional, technical and performance specifications for ITS devices. Where applicable, warrants are provided to guide application of the smart motorway elements to the NSW motorway network (refer to Section 7.1 for a full definition of the term ‘warrant’).

The smart motorway elements covered in this design guide should be integrated with the motorway operations management and control system (OMCS). This will enable central control via a single operational interface for all smart motorway elements by the Transport Management Centre (TMC) and operational partners. System integration requirements are not in the scope of this guide.

1.4 Complementary material

Complementary materials are available from the Roads and Maritime website, including the other smart motorway design guides and traffic systems QA specifications covering ITS devices, communications systems, electrical power systems and centre-to-centre interface requirements. Specific complementary materials for each element discussed in this guide are identified in subsequent sections.

If there are any differences in practice between this Roads and Maritime design guide and other complementary material, this Roads and Maritime design guide will apply.

Note: some smart motorway specifications are still in development and the latest list of approved Roads and Maritime specifications should always be referred to.
2 Closed circuit television cameras

2.1 General

Closed circuit television (CCTV) cameras provide traffic operators with remote and continuous vision of motorway areas and are of fundamental importance for informed decision-making to support traffic management and planning. They allow for visual monitoring of traffic conditions in real-time and help operators with:

- Detecting and/or verifying incidents and congestion
- Determining an appropriate response for an incident
- Monitoring on-site operations during incident management, road works and special events
- Monitoring changing network conditions such as adverse weather.
- CCTV provides support for other smart motorway applications, which may include:
  - Monitoring traffic flows and operations and verifying issues with traffic flow on the motorway and strategic approaches
  - Verifying conditions identified by other detection systems prior to implementing control interventions or deploying incident management resources
  - Monitoring operation of and driver response to other motorway ITS infrastructure and traffic control devices (e.g., VSL/LCS, VMS, tunnel closure control systems)
  - Identifying the presence of vehicles and road users in emergency stopping and maintenance bays
  - Monitoring the use of emergency telephones

Where motorway shoulder or reversible lane use is applied, monitoring lane use before and during operation, i.e., to check if the lane is free of obstruction or contra-flow traffic for reversible lanes and to identify incidents.

CCTV coverage of the arterial network surrounding a motorway may assist in assessing conditions and queue lengths on the approach routes to a motorway and support operation of smart motorway elements to manage access to the motorway.

Real-time and historical images may also be used to support network operations planning and motorway performance evaluation, for example, to help determine the cause of flow breakdown at a bottleneck that produces recurrent congestion.

The TMC is the main operator of CCTV in NSW followed by monitoring offices in Roads and Maritime regions. CCTV images may be shared with external stakeholders to assist with incident and emergency management, enforcement, public transport operations and major events management.
These include:

- NSW Police
- Sydney Railways
- State Emergency Services
- Sydney Olympic Park
- City of Sydney
- Private Motorway Operators.

This may require an interface between the CCTV control systems of Roads and Maritime and other agencies. In some cases the videos may be recorded and stored for a short time.

The cameras used for the functions detailed in this section may be referred to by Roads and Maritime as ‘standard cameras’.

Cameras are also used to provide images for display on the Live Traffic NSW website and/or incorporation to third party traveller information applications and other services. These services utilise a different camera system (referred to as ‘web cameras’) that transmit JPEG snapshots of the live traffic to a server for upload to the website. Web cameras are not covered in the scope of this design guide.

### 2.2 Technology

Closed circuit television (CCTV) is a television system that transmits images on a ‘closed loop’ basis, where images are not publicly distributed but only available to those directly connected to the transmission system. They are remotely controlled either manually or automatically.

The standard cameras used for CCTV are procured commercial-off-the-shelf and may be controlled via an analogue or digitally based video control system. The video is viewed at 4CIF resolution at 25 frames per second.

There are two types of standard cameras: cameras with ‘pan, tilt and zoom’ (PTZ) functionality and fixed cameras.

The selection of camera type is dependent on operational requirements and should be discussed with the CCTV operators in relation to the specific location of the network being considered. General information regarding the functionality and use of the different types is provided in the following sub-sections.

#### 2.2.1 PTZ cameras

CCTV cameras with PTZ functionality allow a single camera to cover a wider area of the road network. PTZ cameras are able to zoom into specific locations in any direction within the field of view of the camera. This enables more detailed monitoring so that the operator can follow activity and better identify issues or required actions.

The cameras may be linked to an automatic incident detection system so that the camera can automatically zoom to a location where the incident is detected. Similarly, cameras may be linked to the emergency telephone system so that the camera zooms to the telephone location when a call is placed.
2.2.2 Fixed CCTV cameras

Fixed CCTV cameras point in a single direction (set during installation) and do not have the functionality to zoom or change view. They are useful when it is important to maintain constant monitoring of an area or to monitor a very specific area of interest, particularly where immediate incident response is critical, e.g. in a tunnel or on a motorway with no emergency stopping lanes.

Fixed CCTV cameras are commonly used in tunnels as part of an automatic video incident detection (AVID) system. The camera surveillance is used in association with video image processing software for traffic monitoring, incident detection and traffic data collection. Where an image change is detected the AVID system sends an alert to the operator for verification.

2.3 Design principles

2.3.1 Warrants and coverage

CCTV must be provided on all NSW smart motorways at varying levels of coverage. The *Smart Motorway Guidelines*[^2] provides warrant recommendations for the installation of CCTV cameras. The warrants and associated levels of camera coverage are detailed in Table 2.

In general, the level of CCTV coverage is dependent on the operational risks that may apply to a section of motorway. Locations where there is a greater risk of incidents, incidents of greater severity or other areas that have a greater need for operator verification of events will have an increased level of camera coverage.

The requirements for CCTV coverage in tunnels are provided in the *Smart Motorway Design Guide for Tunnel Traffic Management*[^4].

### Table 2: Motorway areas associated with level of camera coverage

<table>
<thead>
<tr>
<th>Warrant</th>
<th>Level of coverage</th>
<th>Location(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-way AADT ≥ 60,000</td>
<td>Full motorway coverage (including interchanges) ie 100 per cent coverage</td>
<td>Motorway mainline including emergency stopping lanes (Figure 1 on p8) Entry and exit ramps and motorway-to-motorway ramps Emergency stopping lanes Emergency stopping/maintenance bays Emergency telephones (and their users) Moveable medians and surrounding roadway Under bridges or other structures Motorway approaches and intersecting roads</td>
</tr>
<tr>
<td>2-way AADT ≥ 30,000 and &lt; 60,000</td>
<td>Coverage of selected/strategic locations ie &lt;100 per cent coverage</td>
<td>Motorway mainline including emergency stopping lanes at interchange areas only (Figure 2 on p8) Entry and exit ramps and motorway-to-motorway ramps Emergency stopping/maintenance bays Emergency telephones (and their users) May also include motorway approaches and intersecting roads</td>
</tr>
</tbody>
</table>

[^2]: Smart Motorway Guidelines
[^4]: Smart Motorway Design Guide for Tunnel Traffic Management
For the purpose of this design guide, intersecting roads are defined as roads intersecting any motorway entry ramps or exit ramps. Intersecting roads must be viewable from the motorway CCTV cameras for a minimum distance of 200m from any motorway entry or exit ramp. Coverage of motorway approaches and intersecting roads includes arterial road carriageways within one km of the motorway. Additional requirements for arterial road coverage should be considered on a project-by-project basis.

To provide acceptable coverage at any location on the network the system must provide a high quality image that allows the operator to clearly discern items of interest, under all lighting and environmental conditions.

Specifically, the following viewing requirements must be met (with the camera lens at maximum zoom if applicable):

- All images must be in focus within the whole of the zoom range
- The display view must be unobstructed for the full width of the roadway
- The image must have sufficient clarity for the operator to discern:
  - all vehicles within viewable range and to categorise the vehicles by body type as either motorbikes, sedans, hatchbacks, station wagons, panel vans, light commercial vehicles or trucks of all sizes
  - carriageway delineators, the carriageway edge line marking, local static signposting and pedestrians at the side of the carriageway
  - emergency telephone numbers displayed on the outside of the phone.
- At the farthest point of the viewable range, the width of a medium size vehicle as displayed on the CCTV monitor must not be less than five per cent of the monitor screen width
- The maximum operational viewing distance from any CCTV camera location must not be greater than 1.5 km ie the camera should not be targeting a specific scene (eg stopping bay) beyond that range).

CCTV positioning should also consider any operational requirements for coverage of electronic displays of other ITS devices on the motorway network, such as VMS and variable speed limits/lane control signals.

At critical locations where CCTV coverage is provided, overlapping CCTV camera coverage (ie 200 per cent coverage with 100 per cent redundancy) should also be considered. Overlapping coverage allows more than one camera to view the same location (refer to Figure 3). This provides a number of benefits including:

- Minimising the need to change camera positions to observe conditions in the full network
- Viewing incidents from more than one direction
- Permitting simultaneous functions such as viewing the scene of an incident and observing traffic further upstream
- Improved timeliness of incident detection and verification.
Overlapping CCTV camera coverage should be considered at higher-risk locations where there may be an operational need to see multiple locations simultaneously for effective decision-making and incident management. Example locations include complex interchanges with multiple ramps/approaches, motorway-to-motorway ramps, under bridges and bottleneck locations.

Overlapping coverage may also be warranted for sections where there is all lane running/hard shoulder running or reversible lanes in operation, and for bridge and tunnel environments (refer to the *Smart Motorway Design Guide for Tunnel Traffic Management* [4] for specific CCTV requirements in tunnels).

Additional coverage and viewing requirements may apply when CCTV is used as part of an automatic video incident detection system or for other specific functions. For example, it may be required for the system to identify individual vehicle registrations as well as the presence of a stopped vehicle.
Figure 1: Concept of full CCTV coverage (100% coverage)

Note: for illustrative purposes showing mainline areas only:

Figure 2: Concept of CCTV coverage of selected stratégic locations (<100% coverage)

Note: for illustrative purposes showing mainline areas only

Figure 3: Concept of overlapping CCTV camera coverage (200% coverage with 100% redundancy)

Note: for illustrative purposes showing mainline areas only
2.3.2 Mounting structures and camera positioning

Cameras should be positioned to provide full coverage while taking into account environmental considerations (e.g., impact of wind, rain, fog, etc.) and image stability. They should have a suitable outdoor camera housing that will enable high quality operator visibility under all lighting and environmental conditions. A minimum ambient illumination level is required at the site to produce an acceptable video signal without visible image processing artefacts being introduced.

Camera placement should also ensure that the risk of vandalism is minimised and adequate and safe maintenance access is provided. The co-location of CCTV with emergency stopping bays/maintenance bays may help to achieve this.

Cameras should be mounted on dedicated poles or other existing facilities with sufficient rigidity (e.g., gantries, traffic or ramp signal masts, tunnels, bridges, signs and buildings) as long as a multi-directional view can be obtained (for PTZ cameras only) and there is a secure and stable platform for the camera. Cameras with longer zooms require a more stable mounting structure to ensure the image is still clear at longer viewing distances. Tilting poles may be considered to facilitate maintenance, but should be considered against additional cost considerations.

Camera poles need to be installed either outside of the clear zone or be shielded with a safety barrier.

Camera location, positioning, and operation should consider any requirements to restrict coverage of private property, in alignment with relevant NSW and national government policy and codes of practice (refer to Section 2.4). The height of the camera poles at a particular site should consider any local community concerns in relation to privacy and visual amenity.

The CCTV system should be configured on the motorway network communication system so any single point of failure on the PTZ or fixed camera network does not lead to any loss of CCTV camera coverage of the motorway.

2.4 Complementary material

Further guidance on the detailed technical and performance requirements for CCTV systems, as well as guidance on the supply, installation, testing, commissioning and maintenance of CCTV systems, is provided in the following Roads and Maritime documents:

- ILC-ITS-TP0-002 ITS Procedural Guideline for Closed Circuit Television (CCTV) [5]
- QA Specification R300 ITS Maintenance Services – General Requirements [8]
Relevant NSW policy and codes of practice for CCTV installation are as follows:

- NSW Government Policy Statement and Guidelines for the Establishment and Implementation of Closed Circuit Television in Public Places\(^9\) – noting that roads are included in the definition of public places

- A Code for the Use of Traffic Management Closed Circuit Television (CCTV) Systems (CCTV policy\_402002a1)\(^{10}\)

Other complementary materials for CCTV, including Roads and Maritime documents and Australian Standards, are referenced in the documents mentioned above.
3 Automatic incident detection

3.1 General

Automatic incident detection (AID) systems detect the occurrence of incidents on the network and provide an alert to operators to a situation for verification. They are critical for locations with a high safety risk to improve incident detection and response times compared to manual detection.

An AID system may also be able to provide traffic data, including volume and speed, though accuracy may be limited depending on the system used.

3.2 Technology

Automatic incident response systems may utilise a number of different and complementary technologies running in roadside equipment and in the central control system. Roads and Maritime typically uses algorithmic systems using data from detectors to systemically detect traffic incidents. AID systems can use various types of detection devices, such as loops, infrared, or microwave traffic detectors.

AID systems which use analysis of video images from fixed cameras as detectors are also used under certain conditions, and these systems are known as automatic video incident detection (AVID) systems.

The selection of AID technology depends on whether it will be able to achieve the specified performance requirements at a particular location. It should be assessed against various factors including:

- Reliability of detection of incident events
- Timeliness of detection
- False alarm rate
- System redundancy.

Lighting is also an important consideration for use of AVID systems. In open air environments, AVID reliability for detection of incidents on sections with changing lighting conditions (ie areas that are regularly in shadow) may be limited. Operational measures may need to be taken to instruct the system not to detect incidents at those locations and prevent a high false alarm rate; however this will result in AID blind spots on the network.

Algorithmic systems that use detector data may also not be feasible on some sections of road such as bridges and viaducts, as metal structures can adversely interfere with detector data collection.

3.3 Design principles

3.3.1 Warrants

AID must be provided on all urban motorways. For AID requirements in tunnel environments, refer to the Smart Motorway Design Guide for Tunnel Traffic Management [4].
3.3.2 Coverage and other requirements

The AID system must provide full (100 per cent) coverage of the motorway and have the capability to immediately and accurately detect and report an incident at any location on the motorway within that section.

Full coverage includes:

- Motorway mainline including sealed shoulders
- All entry and exit ramps
- Emergency stopping bays.

The types of traffic incidents/events that should be detectable by the AID system include:

- Stopped vehicle
- Wrong way vehicle (reverse direction of travel)
- Speed change (under/over/sudden drop)
- Queuing vehicles (ie due to an incident or congestion)
- Pedestrian on the road
- Fallen objects or debris etc.

Detection of non-traffic events (eg smoke and flame detection) may also be relevant on certain sections of the network such as tunnel environments.

Where a CCTV system is used, camera coverage must comply with the viewing requirements outlined in Section 2.3.1. The cameras should also be rear-facing.
4 Emergency telephones and emergency stopping bays

4.1 General

Emergency telephones (refer to Figure 4) provide road users with a method of directly contacting motorway operators to get assistance or report incidents such as a crash or disabled vehicle. The aim of emergency telephones is to help decrease the time taken to report incidents, resulting in earlier identification of remedial action and improved motorway safety, security and efficiency.

Figure 4: Motorway emergency telephone

The telephones provide two-way communications between people at the roadside and motorway operators. They may also be used for communication with maintenance staff.

Emergency stopping bays (ESBs) provide a space next to a motorway for accommodating vehicles clear of trafficable lanes in the event of an emergency where they may contact the designated responder by either an emergency telephone or by using a personal mobile phone.

The planning of emergency telephone systems and ESBs should be done in consultation with Roads and Maritime’s operational partners that may also use the services, including NSW Police, emergency services and automobile associations.

4.2 Technology

Motorway emergency telephones must be purpose designed and built roadside telephones that are free standing.

Smart motorways will use new style motorway emergency telephones with power and communications systems designed to minimise whole-of-life costs to reflect the low usage of these telephones in relation to personal mobile phones, particularly in urban areas.

For further technical guidance, refer to IC-QA-TS107 ITS Emergency Telephone Site [11].
4.3 Design principles

4.3.1 Warrants

Emergency telephones must be provided at appropriate locations on all motorways. They should only be installed where there is adequate storage space for a vehicle.

For future motorways, emergency telephones should always be located in an ESB. For upgrades of existing motorways this is also desirable, particularly if there is inadequate space available for storage of a vehicle along the mainline. This may occur where:

- The shoulder at a location is insufficiently wide to accommodate a vehicle and allow for safe use of a phone. Emergency telephones should not be located where a road user would be standing closer than 3.0 m to a traffic lane to use the phone and consideration should be given to providing greater safety and access for mobility-impaired people.
- All lane running/hard shoulder running is in operation (e.g. there is no shoulder or it is trafficked).
- In addition to the requirements of road users accessing emergency telephones, consideration should also be given to providing sufficient space for maintenance vehicles and workers to access emergency telephones.

4.3.2 Spacing of emergency telephones and emergency stopping bays

An emergency telephone should be within reasonable walking distance from any point on the motorway. The main consideration is to allow suitable and safe access to the telephones.

Emergency telephones and stopping bays should first be placed to serve interchanges and address other specific access and safety requirements (refer to Sections 4.3.3 and 4.3.4). They should then be regularly located on the sections of carriageway in between, in accordance with the recommended spacings below.

Emergency telephones should be provided on all motorway mainline carriageways at the following maximum spacings, at a nominal 10 per cent (refer to Smart Motorway Guidelines[2]):

- One kilometre on urban motorways (i.e. two-way AADT ≥ 30,000)
- Five kilometres on rural motorways (i.e. two-way AADT < 30,000).

Spacings are smaller for urban motorways and provide for a maximum walking distance of 500 m. These locations are more highly trafficked and therefore have higher demand for telephone use as well as greater consequences if a stationary vehicle is on the live carriageway in terms of both safety and efficiency.

Roads and Maritime preferred practice for smart motorway projects is to co-locate ESBs with maintenance bays of lane use management systems (LUMS), variable speed limits (VSL) or variable messages signs (VMS). This may lead to smaller spacings than the maximums listed above. The spacing of LUMS/VSL gantries is at a recommended desirable spacing of 500-600 metres (maximum 800 metres) on the main line between interchanges[12]. Emergency telephones must be provided in all ESBs.
Spacings of emergency telephones and ESBs in tunnels is outlined in the *Smart Motorway Design Guide for Tunnel Traffic Management* [4].

### 4.3.3 Location of emergency telephones

The location of emergency telephones should consider:

- The acceptable walking distance for motorists to safely and conveniently use the service
- The level of risk in using it
- The location of major features that may increase the need for the service at a particular site.

Pedestrian movement across motorways and high-speed roads is unacceptable from a safety point of view. Therefore, emergency telephones should generally be placed in pairs, directly opposite each other (ie not be more than 10 per cent of the nominal spacing between opposite telephones for each carriageway), as illustrated in Figure 5. The following design considerations apply:

Install telephones on the left-hand side of the carriageway for all motorways

- Consider installation of additional telephones on the right (median) side of the carriageway if there are three or more lanes, if required for safe road user access to an emergency telephone and provided that a vehicle can stand clear of traffic on the median side
- At interchanges, telephones should be placed on the departure side of the feature and therefore the distance to the next telephone may not be the same for both carriageways. In this case the desirable maximum spacing (refer to Section 4.3.2) should not be exceeded for either carriageway. The difference between the two locations should not be so great as to encourage users to cross the carriageway to use a telephone
- Approaching drivers should have adequate sight distance to the telephone
- Locations within interchanges should allow access by users of ramps as well as the main carriageway. Phones should be located so that pedestrians are not required to cross an entry or exit ramp
- Visibility of the site from a CCTV camera should be maintained (refer to Section 2.3.1).
4.3.4 Location and layout of emergency stopping bays

Provision of a new ESB should be considered based on an individual risk assessment for each application which should consider:

- The users of the route (e.g. allowance for heavy vehicles to use an ESB area and their needs including their ability to be able to enter and exit the facility safely)
- The needs and requirements of incident responders, roadside assistance services, the police and other stakeholders for using ESBs (including for enforcement/inspection purposes)
- The needs for maintenance bays (e.g. VMS and VSL/LCS gantries) and opportunities for co-location with an ESB.

As a general rule, an ESB should[^13]:

- Preferably not be located within close proximity (500 m) to an entry-ramp or exit-ramp to separate it from merge and diverge manoeuvres and to avoid the refuge area being mistaken for an exit
- Be appropriately located so that they satisfy minimum sight distance requirements
- Provide a parallel storage area no less than four metres wide measured from the edge of the ESB to the edge line and be of sufficient length to allow the maximum length vehicle (the permitted heavy vehicle) plus a response or enforcement vehicle to store clear of the trafficable lane (e.g. provide a 40 m long storage space for a B-double at 25 m plus another 15 m for another vehicle)
- Be designed to allow a vehicle to decelerate from the operating speed of the road within the length of the ESB (i.e. use of the entry taper and storage area to decelerate). For example, to decelerate from 80 kilometres per hour would require 70 metres at maximum deceleration refer to the *Guide to Road Design Part 4A*[^14]
- Be designed to allow a vehicle to safely accelerate and re-join the traffic stream (travelling up to the default speed limit).
The ESB should include:

- An emergency telephone and associated signing
- CCTV providing unobstructed coverage of the entire ESB area (refer to Section 2.3.1)
- Location signing to enable road users to better identify and advise emergency vehicle operators of their location
- Vehicle detectors to immediately alert road operators of its usage (ie when a vehicle has entered).

4.3.5 Other Design Principles

As outlined in *Austroads Guide to Road Design Part 6B*[^15], other principles and considerations for emergency telephone and ESB placement include:

- Avoiding conflict with location of poles/signs and the site proposed for the telephone
- Ensuring that existing or planned verge vegetation does not obscure telephones or the vision of CCTV coverage of the site (and plan for maintenance of vegetation if required to maintain visibility in the future)
- Ground topography (eg locations on steep batters are unsuitable)
- Existence of structures (eg long bridges, retaining walls) at the preferred location that may present design constraints and opportunities.
- More detailed design requirements are described below[^15].

Visibility and lighting

Emergency telephones should be readily identifiable from the road during the day and at night from a distance that enables drivers to stop safely.

Where roadway lighting is provided, location of emergency telephones should be coordinated with the location of road lighting poles. Phones should be placed within 10 m on the approach side of a lighting pole so that the spill-over lighting allows easy recognition of the telephone location and provides sufficient lighting to allow the motorist to operate the phone.

If roadside lighting is not provided, or is inadequate for identification and/or operation, special provisions may be needed to enable operating instructions to be followed ie the emergency telephone and ESB should be lit by a low-mounted pole. Lighting should be in accordance with *AS/NZS 1158-2010*[^16] and *AS 1428.2*[^17].

Audio

Ambient noise levels should not unduly affect telephone usage. The telephones must provide audible clarity for the ambient noise levels (including the reflected noise from nearby structures) at each location to ensure conversation is possible with the motorway operator under all circumstances, for example, through the use of noise cancelling microphones and other techniques.
Provision for all users

The layout of the emergency telephone area/ESB should provide easy access for all drivers, including those that have a disability and may use a wheelchair. The ESB width should be sufficient to allow drivers to access wheelchairs (refer to Section 4.3.4 and a paved surface is desirable.

Protecting the telephone user

Where no safety barrier is present, the telephone should be located just outside the bay, preferably in a location not vulnerable to an out-of-control (errant) vehicle. Isolated sections of safety barrier should not be introduced solely for the protection of a telephone. Where a continuous safety barrier is present, the telephone should be placed near the end of the barrier, or in such a position that it can easily be reached from the carriageway.

Direction of placement

It is desirable that the emergency telephone is oriented so that the user faces the oncoming traffic (ie the front face of the telephone should be oriented in the direction of traffic flow) while operating the telephone.

Telephone mounting and enclosure

Emergency telephones may be mounted on purpose-built pillars or on road lighting poles, provided that neither the use of the telephone nor the lighting is adversely affected.

When determining the position and mounting height of the telephone handset, consideration should be given to the needs of people with disabilities (as per AS 1428.2[17]), particularly where continuous safety barrier or bridge railing exists. The design of the emergency telephone should be such that no user training is required, with call initiation being made simply by lifting the telephone handset.

The telephones should be built to withstand vandalism and to protect sensitive components from malicious damage. They should be designed to operate in the extremes of weather conditions that will be experienced on the motorway.

Numbering

All emergency telephone sites should be clearly and uniquely numbered to assist callers reporting incidents, and to provide unambiguous identification of the site for the deployment of emergency services and maintenance staff.

Static signs

Static signing (refer to Figure 6) should include:

- Pedestrian indicator signs (GE7-8) erected parallel to the direction of traffic advising pedestrians of the direction forward or back along a motorway to the nearest telephone and a distance plate (GE7-9)
- Signing at the emergency telephones providing instructions for their use.
Additional static signing for an ESB includes:

- An indication of the distance to the next stopping bay downstream. Drivers should not be given information about an ESB already passed, because it may encourage drivers to reverse back
- A contact phone number for the designated responder.

GE7 signs should generally be placed at a spacing of around 200 metres on urban motorways and one kilometres on rural motorways.

**Figure 6: Static signs for emergency telephones**

Pedestrian indicator sign (GE7-8)

Distance plate (GE7-9)

Source: AS 1742.6-2004[18]

### 4.4 Complementary material

Refer to the following complementary material for more detailed guidance on the design and technical and performance requirements of motorway emergency telephones:

- QA Specification R300 ITS Maintenance Services – General Requirements[8]
- Specification D&C R152 Emergency telephones [19].
5 Environmental and safety monitoring

5.1 General

Some locations on the motorway network may be susceptible to changing environmental and road conditions that create safety hazards for road users, or have features that result in a safety hazard for a particular type of road user. At these locations it is desirable to install traffic management systems that alert road users to a safety hazard ahead and encourage safe driving behaviour.

Examples include weather-activated systems, heavy vehicle speed warning systems and over-height vehicle management systems.

5.2 Design principles

Due to the range of applications used to address differing environmental and safety issues, there is limited detailed guidance or warrants. The requirement for systems for environmental and safety monitoring should be assessed on a case-by-case basis to address the specific safety risks identified at each site.

Generally, these systems will consist of the following core components and functions:

- Detection and surveillance equipment to measure and verify changes in road conditions and/or the presence and driving characteristics of a particular type of vehicle
- Control system and algorithms to determine whether the detected condition will result in a safety hazard and whether an operational intervention is required and to control and monitor the roadside infrastructure
- Traffic management equipment used to implement an intervention which may be in the form of a warning (e.g., display)
- A message on a VMS), traffic control (e.g., speed control) or other physical interventions to help mitigate or remove the safety hazard and improve road/driving conditions.

The selection of traffic management treatments will depend on various factors including the level of risk and type of hazard. In some cases, multiple systems may be required to provide operators with the ability to implement progressive levels of warning and control as vehicles approach the hazard location. Supporting systems may also be required, such as enforcement systems that can help improve driver compliance and thereby improve safety outcomes for road users.

Both automated and manual systems may be used to activate traffic control interventions. In the case of manual systems, the detectors may trigger an alert to the operator to activate a particular response plan. For automated systems, the operator should be able to override the system response if required.

The following sub-sections provide more detailed guidance in relation to some of the more common applications. Specific applications for tunnel environments are discussed in the *Smart Motorway Design Guide for Tunnel Traffic Management* [4].
5.2.1 Weather-activated warning systems

Weather-activated warning systems are used to detect adverse weather conditions and provide warning and/or information to drivers on how to alter their behaviour to improve road safety. Adverse weather conditions include fog, heavy rain, strong winds and ice on the road.

Systems should generally be installed where there is a history of weather-related incidents on existing roads, or where analysis indicates a higher safety risk on new roads. Road sections such as bridges that are more vulnerable to adverse weather conditions may particularly benefit from such systems.

Table 3 outlines the potential components of weather-activated warning systems, the selection of which will depend on the type of weather hazard experienced at a particular location.

<table>
<thead>
<tr>
<th>Detection and surveillance</th>
<th>Intervention</th>
<th>Supporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fog detectors</td>
<td>Warning via variable message sign (VMS)</td>
<td>Static signing (to note start of scheme and reinforce default speed limits if relevant)</td>
</tr>
<tr>
<td>Water level/ pavement moisture detectors</td>
<td>Variable speed limit (VSL) system</td>
<td>Speed enforcement (if VSL are used)</td>
</tr>
<tr>
<td>Precipitation detectors/rain gauges</td>
<td>Water pump</td>
<td>Operator alert (for manual intervention) in control system</td>
</tr>
<tr>
<td>Wind speed detectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature detectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle detectors – to measure vehicle speed</td>
<td></td>
<td></td>
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<tr>
<td>CCTV</td>
<td></td>
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</tr>
</tbody>
</table>

Where adverse weather conditions are localised the detection and warning system should be placed upstream of the affected area. This will allow sufficient time for motorists to modify their behaviour ahead of the hazard.

All ITS should be designed to ensure the desired level of reliability during adverse weather conditions.

The design of weather-activated systems should consider if VMS and/or VSL are already installed (or planned) for the carriageway for other purposes and whether they can be used for multiple functions to minimise the need for additional roadside devices.

Where VSL is installed, it is advisable to have static signing and/or a VMS installed upstream of the VSL section to alert road users to the fact they are entering a VSL environment and to provide advance warning of adverse weather/road conditions ahead.

An example of a weather-activated warning system in NSW is the wet weather speed limit system on the M1 Sydney to Newcastle motorway north of the Hawkesbury River Bridge to Mount White. The system utilises VSL signs, weather stations (with tipping bucket rain gauges), pavement moisture detectors, static signs and a fixed speed camera enforcement system to reduce the speed limit to 90 km/h when it is raining.
Another example is a fog warning system installed on the M1 Sydney-Wollongong motorway between Bulli and Waterfall. The system incorporates fog and speed detection equipment and is capable of providing motorists with individual warning messages relative to their speed and the weather conditions.

Motorways that regularly experience black ice, such as in the Blue Mountains region, may also warrant use of weather-activated detection and warning systems.

5.2.2 Heavy vehicle curve warning systems

Due to the curvature of some motorway entry ramps, heavy vehicles entering the curve at excessive speeds can be subject to reduced stability, resulting in possible overturning. Since the critical speed at which loss of wheel contact with the road surface varies with the vehicle’s centre of gravity, the driver is not always aware of what the critical speed is or how close to that speed the vehicle is travelling, even on familiar curves \[^{13}\]. Reducing these incidents can minimise the safety risk and the extent of congestion resulting from an incident.

A heavy vehicle warning system should generally only be installed on existing roads where there is a history of heavy vehicle instability and where other general traffic warning signs have been installed and have been ineffective. New motorways and major upgrades should preferably be designed so that heavy vehicle stability is not an issue.

A heavy vehicle speed warning system can be installed on or in advance of curved ramps to detect and warn drivers who are at risk of rolling over, of excessive speed. The critical speed depends on vehicle type and other site specific factors. The warning system is capable of assessing whether each vehicle’s operation is likely to enable it to safely enter the ramp curve (referred to as the rollover decision threshold) and if required, display a timely warning message to drivers whose vehicle speed may be deemed unsafe for the ramp curve.

Table 4 outlines the potential components of a heavy vehicle speed warning system, the selection of which may depend on the level of safety risk at a particular location.

<table>
<thead>
<tr>
<th>Detection and surveillance</th>
<th>Intervention</th>
<th>Supporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum:</td>
<td>Warning via:</td>
<td>Static signing</td>
</tr>
<tr>
<td>Vehicle detectors – to measure classification and speed</td>
<td>VMS (Figure 7)</td>
<td>Speed enforcement systems</td>
</tr>
<tr>
<td>of approaching heavy vehicles</td>
<td>static sign with flashing lights/wig wags</td>
<td>Operator alert (for manual intervention) in control system</td>
</tr>
<tr>
<td>For improved functionality/accuracy of rollover decision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>threshold [^{13}].</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weigh-in-motion to measure vehicle weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detection of non-live load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle height detectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle configuration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCTV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Vehicle detection equipment should provide coverage of all lanes used by heavy vehicles on the entry ramp.

The mounting structure of the VMS used in a heavy vehicle warning system should be located so that it is in clear view of the approaching truck driver and is either outside of the clear zone of the curve or so that errant vehicles are satisfactorily protected from striking the base.

The VMS should be designed and installed so that a driver has time to read and respond to the message before arriving at the curve. This requires consideration of sign size, message legibility and number of lines etc. Sign placement will also be influenced by local factors, including the reasonable maximum speed of entering vehicles, a reaction time travel distance and the vehicle deceleration distance in order to negotiate the curve without rolling. Sign design should also consider the type of warning message to be displayed (eg text, speed roundel and/or pictogram).

The placement of the sign should consider the relative positioning of other VMS (as part of the motorway traveller information system) as well as the ramp signalling metering system and associated devices, if also used on the entry ramp. The sign should be placed so as not to interfere with the effective operation of other traffic management systems.

### 5.2.3 Over-height vehicle management systems

Over-height vehicles (in excess of 4.3 metres) pose a risk to low-clearance structures including bridges and tunnels on NSW motorways. Over-height vehicle collisions with these structures have significant consequences and impacts for road users, road managers and transport providers in relation to road safety, vehicle and infrastructure damage and associated costs.
Over-height vehicle management systems have been developed that can detect the presence of an over-height vehicle upstream of a low-clearance infrastructure and initiate an advance vehicle warning (eg via advisory signing, see Figure 8) to drivers so that they know to exit the motorway or stop in advance of the structure. They may also be installed on entry ramps to prevent over-height vehicles from entering the motorway upstream of the structure.

Figure 8: Example of a VMS message used in an over-height vehicle management system

In practice, signing and warning measures alone do not always deter drivers of over-height vehicles from entering low clearance structures. Over-height detectors may also be used to notify operators that an over-height vehicle is located on the approach to a low-clearance structure to facilitate incident management in the case of a non-compliant vehicle. Additional vehicle control systems may therefore also be required in front of major structures to stop non-compliant vehicles from damaging the structure and creating a safety hazard for other road users.

Generally, the system design should try in the first instance to minimise the probability of non-compliance (eg through signing and warning systems, good sight distance and visibility of structures) and then secondly minimise the impact of non-compliant over-height vehicles on traffic flow and safety.

Roads and Maritime currently employs over-height vehicle management systems for a number of routes and tunnels in NSW.

The requirement for an over-height vehicle detection and warning system should be considered on a case-by-case basis. They should generally be considered for:

- Existing or planned freight priority routes and/or routes with significant freight movements that have low clearance structures (ie under 4.6 m)
- Routes where historically over-dimension incidents have been an issue
- New motorway routes should be designed to minimise the risk of over-height vehicle collisions with structures, subject to the agreed access restrictions for the route.

Table 5 outlines the potential components of an over-height vehicle warning system, the selection of which will depend on the type of weather hazard experienced at a particular location. Effective over-height vehicle management is likely to require a combination of mitigation measures that are considered on a site-by-site basis.
### Table 5: Potential components of an over-height vehicle warning system

<table>
<thead>
<tr>
<th>Detection / surveillance</th>
<th>Intervention</th>
<th>Supporting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum:</strong> Vehicle detectors – to measure classification</td>
<td>Warning via VMS (Figure 8) or static sign with flashing lights/wig wags</td>
<td>Static signing</td>
</tr>
<tr>
<td>Over-height detectors (eg dangles, infra-red, laser beams and photoelectric sensors, ANPR)</td>
<td>Traffic control such as via physical barrier (eg boom barrier/swing gate), traffic signals, LUMS and/or flashing lights and Roads and Maritime Other innovative measures to encourage vehicles to stop before the front of a structure</td>
<td>Enforcement systems</td>
</tr>
<tr>
<td>CCTV</td>
<td></td>
<td>Physical barrier or sacrificial structure (eg detachable protection beams to protect front of low clearance structure and minimise vehicle damage)</td>
</tr>
<tr>
<td><strong>Additional:</strong> Impact detectors – to measure degree and level of impact to structure</td>
<td></td>
<td>Reflective surfaces/markings to improve structure visibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measures to support diversion of non-compliant over-height vehicles (eg parking bay/moveable median)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operator alert (for manual intervention) in control system</td>
</tr>
</tbody>
</table>

In NSW, dynamic systems that enable individual vehicle detection and warning are most commonly utilised in advance of motorway tunnel environments. The *Smart Motorway Design Guide for Tunnel Traffic Management*[^1] should be referred to for more detailed guidance on the design of over-height vehicle detection and warning systems.

As a minimum, the motorway design must include regulatory static signing required for reinforcement of restricted access heavy vehicle routes and warnings on approaches to all low clearance structures as appropriate. This includes R6-11 and W4-8 warning signs (refer to AS 1742.2-2009[^2] and AS 1742.3-2009[^3]) as illustrated in Figure 9). Clear detour signs must also be provided as appropriate.

**Figure 9: Static signs for over-height vehicles**

![Figure 9: Static signs for over-height vehicles](image)

Source: Roads and Maritime Traffic Signs Database
5.2.4 Other systems

Systems that incorporate pollution or noise monitoring devices and VSL may also be used to achieve local environmental benefits, such as improved air quality or reduced noise levels. Depending on traffic volumes and prevailing environmental conditions, vehicle speed limits may be set to optimum levels to reduce emissions, fuel consumption and noise as required to keep environmental conditions within defined thresholds. These systems also require a detection and traffic control component, similar to weather-activated systems discussed in Section 5.2.1.


5.3 Complementary material

Complementary design guidance on the use of VSL and VMS on smart motorways is provided in the following Roads and Maritime supplements:

- Smart Motorway Supplement for Traveller Information [23]
- Smart Motorway Supplement for LUMS including VSL [12].

Complementary information in relation to over-height vehicle management is provided in the following documents:

- Static and Active Signposting to Divert Overheight Vehicles Around Low Clearance Structures – Literature Review [24]
- Static and Active Signposting to Divert Overheight Vehicles Around Low Clearance Structures – Best Practice Methodologies [25].

The Austroads technical report Reviewing ITS Technologies and Road Safety Opportunities [26] also provides an overview of a number of different environmental and safety monitoring systems.
6 Enforcement Systems

6.1 General

Driver compliance with smart motorway treatments such as lane use management systems (LUMS) and variable speed limits (VSL) is critical to their effectiveness in achieving traffic flow and safety benefits.

As a key principle, a smart motorway should be designed as a self-explaining and intuitive road environment with clear signing that promotes compliant driver behaviour. It is a highly controlled road environment which in itself can improve compliance.

Also important in achieving good compliance is the education of road users. This includes raising awareness of how they are expected to behave within a smart motorway environment as well as the benefits to their journey if they do comply (e.g. improved travel time, reliability and safety).

Enforcement should therefore be considered as a supplementary option to improve driver compliance in addition to good motorway design and educational initiatives. Requirements for enforcement systems including integration with smart motorway control systems should be discussed with Roads and Maritime and the NSW Police. The level of driver compliance with existing traffic control systems on the Sydney motorway network, such as LUMS, VSL and traffic lights, should be considered.

Enforcement systems may include speed enforcement systems (e.g., spot speed or average speed enforcement), lane closure (‘Red X’) enforcement systems, red light infringement systems for ramp metering signals and heavy vehicle inspection and compliance systems (including inspection bays).

6.2 Design principles

If enforcement systems are not installed at project opening, the design of the motorway should allow for cost-effective retrofitting of enforcement systems if driver compliance is proven to be poor following the initial ‘settling in’ period.

The design of dynamic smart motorway elements should consider additional functionalities required for enforcement. Any devices displaying a mandatory (enforceable) traffic control signal must have a mechanism for monitoring the electrical and optical performance of the signal display in order to verify what was on display to drivers at the time/location of an offence. This will ensure that the display of the signal can be enforced without risk of legal challenge.
### Glossary

<table>
<thead>
<tr>
<th>Term / sign</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AADT</td>
<td>Annual Average Daily Traffic. The total yearly traffic volume in both directions at a road location, divided by the number of days in the year. In NSW, AADT is measured as either the number of vehicles or the number of axle pair passes during a 24 hour period averaged over a year.</td>
</tr>
<tr>
<td>AID</td>
<td>Automatic Incident Detection</td>
</tr>
<tr>
<td>AS</td>
<td>Australian Standard</td>
</tr>
<tr>
<td>AVID</td>
<td>Automatic Video Incident Detection</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed Circuit Television. CCTV uses video cameras to transmit a signal to the motorway control centres where operators monitor traffic conditions and incidents. A separate system of web cameras is used to display images on the Roads and Maritime Livetraffic website.</td>
</tr>
<tr>
<td>CIF</td>
<td>Common Interface Format</td>
</tr>
<tr>
<td>Element</td>
<td>Technology or other design feature that delivers a smart motorway function.</td>
</tr>
<tr>
<td>Emergency telephone</td>
<td>A roadside telephone providing road users with a method of directly contacting an operator/designated responder to organise assistance.</td>
</tr>
<tr>
<td>ESB</td>
<td>Emergency Stopping Bay. A space provided to store vehicles clear of trafficable lanes.</td>
</tr>
<tr>
<td>ESL</td>
<td>Emergency Shoulder Lane. Also referred to as hard shoulder.</td>
</tr>
<tr>
<td>Full coverage</td>
<td>Where CCTV provides 100 per cent coverage of the carriageway including the mainline, interchanges, emergency stopping lanes and emergency stopping/maintenance bays, emergency telephones, bridges and other structures, arterial and intersecting routes.</td>
</tr>
<tr>
<td>Intersecting roads</td>
<td>Roads intersecting any motorway entry ramps or exit ramps.</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transport System</td>
</tr>
<tr>
<td>LCS</td>
<td>Lane Control Signal</td>
</tr>
<tr>
<td>Low-clearance structure</td>
<td>A roadway structure with a clearance of less than 4.6 m.</td>
</tr>
<tr>
<td>LUMS</td>
<td>Lane Use Management System</td>
</tr>
<tr>
<td>Motorway approaches</td>
<td>Arterial road carriageways that connect with a motorway interchange</td>
</tr>
<tr>
<td>NZS</td>
<td>New Zealand Standard</td>
</tr>
<tr>
<td>NSW</td>
<td>New South Wales</td>
</tr>
<tr>
<td>Operations management and control system (OMCS)</td>
<td>Integrated control system for all motorway control, monitoring and communication systems required for traffic and incident management on the motorway network including approach roads and ramps. Includes monitoring and control of motorway plant and equipment.</td>
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</tbody>
</table>
# References

The resources shown in the table are directly referenced in this design guideline. Some of these sources may have limited access for non-subscribers.

<table>
<thead>
<tr>
<th>Ref #</th>
<th>Resource Name</th>
<th>Version / date</th>
<th>Author</th>
<th>Location</th>
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<tr>
<td>[12]</td>
<td>Smart Motorway Supplement for LUMS including VSL</td>
<td>2016</td>
<td>Roads and Maritime</td>
<td>Roads and Maritime</td>
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<td>[16]</td>
<td>AS/NZS 1158-2010 Lighting for Roads and Public Spaces</td>
<td>2010</td>
<td>Standards Australia</td>
<td>Online</td>
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<td>[17]</td>
<td>AS 1428 Design for Access and Mobility</td>
<td>2003</td>
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<td>[25]</td>
<td>Static and Active Signposting to Divert Overheight Vehicles Around Low Clearance Structures - Best Practice Methodologies</td>
<td>2013</td>
<td>ARRB Group</td>
<td>Roads and Maritime</td>
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<tr>
<td>[26]</td>
<td>Reviewing ITS Technologies and Road Safety Opportunities</td>
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<td>Austroads</td>
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### Revision history

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<tbody>
<tr>
<td>1.0</td>
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