Managed Freeways
Vehicle Detection System
Technical Requirements

Document No.: 12/8007-REQ-105
April 2013
1. DOCUMENT HISTORY AND PREAMBLE

This document is a draft for discussion to seek feedback from industry. It has been developed by Main Roads WA as a part of development activities for potential Managed Freeways installations in Perth, particularly on the Perth Urban Transport and Freight Corridor. This document should be read in conjunction with the other documents in this series including the Managed Freeways Acronyms and Terminology document.

<table>
<thead>
<tr>
<th>Version</th>
<th>Author</th>
<th>Reviewer</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 (draft for web release)</td>
<td>JP</td>
<td>JP</td>
<td>April 2013</td>
</tr>
</tbody>
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2. PURPOSE

2.1 Introduction

This document outlines the technical requirements for the Vehicle Detection System (VDS) to be provided for the Managed Freeways system. The VDS shall provide real time road use information, such as speed, volume and occupancy, to be used by the control system, STREAMS. The VDS are required to provide data to the following Managed Freeways services as identified in the Technology Functional Requirements (document no.: 12/6463-REQ-001):

- Ramp Signalling – Corridor Management,
- Ramp Signalling – Local Merge and Bottleneck Management,
- Travel Time Calculation,
- Freeway Performance Evaluation, and
- Incident Detection.

The services that primarily drive the requirements for VDS are the Ramp Signalling services but it is important that the VDS requirements cover the requirements of all relevant services.

This document covers the requirements of the VDS located on both the mainline carriageway and the freeway on ramps that support the operation of Ramp Signalling.

This document should be read in conjunction with the VicRoads Freeway Ramp Signals Handbook and Main Roads Jurisdictional Supplement, the Technology Functional Requirements document, the Managed Freeways Provision Guidelines and other supporting documentation.

Main Roads has entered into a negotiation process for the procurement of an ITS Control System with Transmax. This negotiation process is the extent of current commitments; however for simplicity the use of STREAMS has been included in the Managed Freeways Technical Requirement documents.

2.2 Terminology

A full list of the terms used throughout this document and other supporting documentation can be found in the Managed Freeways Acronyms and Terminology, document no.: 12/8007-GEN-001.

2.3 Acronyms

A full list of the acronyms used throughout this document and other supporting documentation can be found in the Managed Freeways Acronyms and Terminology document.

2.4 Link between Services and ITS Elements

Table 1 sets out the foundation and future ITS services with respect to those technologies that are part of the managed freeway toolkit. A dark blue box with a tick indicates that the technology is essential to the service, a light blue box with a tick means that the technology is useful to the service.
Table 1: ITS Services and ITS Elements

<table>
<thead>
<tr>
<th>ITS Service</th>
<th>Service Type</th>
<th>ITS Elements Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp Signals – Corridor Management</td>
<td>Real Time Control</td>
<td>VDS, FRS, CCTV</td>
</tr>
<tr>
<td>Ramp Signals – Local Merge and Bottleneck Management</td>
<td>Real Time Control</td>
<td>VDS, FRS, CCTV</td>
</tr>
<tr>
<td>Travel Time Calculation</td>
<td>Real Time intelligence</td>
<td></td>
</tr>
<tr>
<td>Roadside Travel Time and Other Message Display</td>
<td>Real Time Information</td>
<td></td>
</tr>
<tr>
<td>Incident Detection</td>
<td>Real Time intelligence</td>
<td></td>
</tr>
<tr>
<td>Incident Verification</td>
<td>Real Time intelligence</td>
<td></td>
</tr>
<tr>
<td>System Performance Management</td>
<td>Real Time System Management</td>
<td></td>
</tr>
<tr>
<td>Freeway Performance Evaluation</td>
<td>Historical Intelligence</td>
<td></td>
</tr>
</tbody>
</table>

This matrix is based around the example performance measurements in this document and other services and technologies may be applicable for different scenarios.
3. FUNCTIONAL REQUIREMENTS

3.1 General

All VDS technology shall be installed to meet the requirements of the user services and functionality of the ITS Control System. The VDS technology to be used shall be selected by Contractor based on the requirements of this document.

The roadside VDS controller is the device that aggregates the data from individual road sensors and interfaces with the control system and communications network and is typically installed in a roadside cabinet.

The VDS sensor is typically one of a number of sensors connected to a VDS controller that measures lane specific data. For some VDS types the VDS sensors can measure multiple lanes.

For some VDS types the VDS Controller and VDS sensor are combined. Where this is the case the combined unit should meet with the requirements of both units.

The combination of the VDS controller and VDS sensor(s) will provide the necessary data to the control system at a particular location.

There is a preference by Main Roads towards non-intrusive VDS technology, however this preference is secondary to performance and cost, and the non-intrusive technology must satisfactorily demonstrate performance and have equivalent total costs to be selected.

3.2 Placement

The VDS will be designed and installed by the Contractor to provide adequate data for the all required areas.

The data the VDS is required to provide is based on the user services required on the carriageway. There are differing requirements around VDS for Ramp Signalling, Travel Time Calculation, Incident Detection and Freeway Performance Evaluation.

Each VDS shall monitor all lanes at its installed location, with the exception of emergency lanes.

3.2.1 Main Line VDS Locations

The mainline sites have two primary functions, depending on their locations: Mainline Potential Bottleneck sites and Travel Time sites.

Mainline Potential Bottleneck sites are those sites that are located in the Ramp Signalling section of the Managed Freeway and could potentially be called upon to provide occupancy data to the Ramp Signalling algorithms.

VDS sites located outside of the Ramp Signalling area are Travel Time sites used to provide data to the travel time algorithm and will be used primarily for travel time and incident detection.

VDS immediately downstream from an on ramp should be generally installed approximately 330m after the physical nose of the on ramp median. This location is chosen to best capture the turbulence caused by road users joining the main carriageway from the on ramp.
Off ramp VDS shall be installed downstream of the physical nose on both the main carriageway and the off ramp, but not so far up the ramps as to be impacted by normal queues at traffic signals.

The remaining VDS sensors should be installed along the freeway carriageway to achieve a nominal spacing of 500m.

VDS sensors should not be located at positions that are likely to be subject to poor lane discipline, such as lane drops, immediately prior to a diverge and immediately after a merge. VDS installed in the vicinity of these potentially disruptive features should be sufficiently upstream or downstream to ensure that road users maintain good lane discipline.

The locations of the VDS shall be discussed with and agreed by Main Roads Traffic Engineering Standards Manager (TESM).

3.2.2 On Ramp VDS Locations for Ramp Signalling

The VDS shall be typically installed by the Contractor along the metered ramps as per Figure 1 below.

Figure 1: Managed Freeway Ramp Sensor Locations

As shown in Figure 1 there are five potential detection locations on the ramps: the Ramp Entry, Mid Ramp, Stop Line and Exit and the optional Extra Queue on entry. One VDS controller may be used for all five detection locations on the ramp, provided specific manufacturer specifications for the VDS technology used are not exceeded.

The Stop Line and Exit detectors are installed straddling the ramp signals stop line, with the Stop Line detectors before the stop line and the Exit detectors after.

Mid Ramp and Ramp Entry are spaced evenly along the length of the ramp. If the ramp does not have the optional Extra Queue detectors then the Ramp Entry detectors shall be located at the top of the ramp. If Extra Queue detectors are required the Ramp Entry detectors should be located at the point which provides approximately the 4 minutes of storage on the ramp. The Mid Ramp detectors should always be located approximately half way between the Ramp Entry and Stop Line detectors.
Extra Queue detectors are required at on ramps that have significantly more than the 4 minutes of storage time. The Extra Queue detection should be installed at the start of the on ramp provided it would be located at least 30m from the Ramp Entry detection.

Ramps that include a truck priority access lane shall have detectors installed in the priority lane adjacent to the other detectors in the non-priority lanes.

Truck priority access lanes shall also include an Enhanced Performance Evaluation VDS site with the primary function of providing traffic classification data. These sites are in addition to any other VDS required at the on ramp.

The Enhanced Performance Evaluation VDS shall be located 30m downstream of the stop line or whatever distance required to ensure that the typical vehicle speed at this point is in excess of the minimum speed required for the VDS to operate effectively.

3.3 Detection Requirements

Each VDS shall monitor all lanes at its installed location, with the exception of emergency lanes. To ensure that there is no traffic missed the area covered by the detector must cover as much of the lane as possible without detecting traffic in adjacent lanes. The VDS shall be able to accurately detect all vehicles that use the freeway, including motorcycles.

Any VDS that is used for freeway performance, including all VDS that are installed along the main freeway carriage way and off ramps and Enhanced Performance Evaluation sites, must be capable of accurately determining the speed, volume and occupancy of traffic.

Three measurements - speed, volume and occupancy – at any one VDS site are used to determine when to switch the ramp signals on and off. If one of these three are not available from a VDS then that VDS output cannot be used to determine when to activate or deactivate the ramp signals.

Any VDS used for ramp management, including all VDS installed along freeway on ramps, must be capable of accurately determining the volume and occupancy of traffic.

The specific detection requirements for each site on the ramp are:

- Extra Queue – Occupancy, Volume (backup);
- Ramp Entry – Volume, Occupancy;
- Mid Ramp – Occupancy, Volume (backup);
- Stop Line – Presence; and
- Exit – Volume.

Speed measurements are not required for any of the detection locations on the ramp, except for Enhanced Performance Evaluation sites.

Specific requirements for each of these measurements at each type of site are listed in Table 2 in section 3.10.
3.4 Vehicle Classification

VDS installed as mainline or ramp signal sites shall classify traffic into a simple 2 bin classification system, based on the Austroads 12 bin classification system. The 2 bin system shall classify cars as:

- Class 1 equal to Class 1 – 2 of the Austroads system
- Class 2 equal to Class 3 – 12 of the Austroads system

VDS installed as Enhanced Performance Evaluation sites shall classify vehicles to the Austroads 12 bin classification system.

3.5 Roadside Cabinet

VDS shall be supplied with a roadside cabinet when required for the housing of the VDS controller and associated communications and power equipment. The roadside cabinet may be shared with other ITS equipment installed in the immediate vicinity such as CCTV or a Ramp Signal Controller. If multiple VDS controllers are installed in one cabinet each VDS shall have its own unique identification number.

The roadside cabinet shall contain a 19” rack providing a minimum of 24RU available rack space. It shall also contain an appropriate power distribution board and have an IP55 or higher rating. All equipment associated with the VDS that is placed within the cabinet shall be either 19” rack mountable directly or on a 19” rack shelf.

The roadside cabinet shall be installed within a proximity close enough to ensure the distance between the VDS controller and VDS sensor is no greater than 75% of the maximum length quoted by the Manufacturer.

For any other elements of the VDS that are subject to maximum communications distances the above requirement of a maximum separation of 75% of the maximum length quoted by the Manufacturer shall apply.

For any location where the Contractor proposes increasing any communications distances in excess of 75% of the maximum length quoted by the Manufacturer then the prior approval of the Asset Manager Traffic Systems (AMTS) will be required.

3.6 Communications

The roadside controller shall be connected to the TCS Network in accordance with the TCS Network requirements. It is desirable that the VDS technology chosen is IP based and visible to the NMS. The VDS shall communicate to the STREAMS control system via a Field Processor.

The communications equipment associated with the VDS shall be installed within the local roadside cabinet.

The roadside controller shall include a communications port to connect an engineer’s terminal. The engineer’s terminal shall be software that can be installed on a standard laptop PC running Windows 7 or higher. The software supplied by the VDS supplier shall allow diagnostic checks to be undertaken on the detection system in the event of an error using a standard interface port (Ethernet, USB or similar). It is also highly desirable that diagnostics checks can be undertaken on the detection system remotely via the IP communications network.
3.7 **Control System**

The VDS installed by the Contractor shall be compatible with the STREAMS control system, with a strong preference for using existing drivers.

Any driver development required for a chosen device will be subject to the prior approval of the Asset Manager Traffic Systems (AMTS).

3.8 **Power**

Each VDS shall be provided with a power connection to a local cabinet installed by the Contractor.

The power connection to the cabinet shall be a 240vAC 50Hz single phase mains connection from a Western Power metered supply. The Contractor shall determine if an existing supply can be utilised or if a new supply is required.

Should the Contractor wish to pursue a power supply option that does not meet with the above requirement this will be subject to the prior approval of the Asset Manager Traffic Systems (AMTS).

3.9 **Environmental**

The VDS shall be designed to operate in the environmental conditions experienced in the Perth Metropolitan area with no degradation in performance.
3.10 Performance Requirements

The following table lists the proposed performance criteria for the VDS.

Table 2: VDS Performance Requirements

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mainline Sites</th>
<th>Ramp Sites</th>
<th>Enhanced Performance Evaluation Detector Sites</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mainline Potential Bottleneck Detector Sites (also used for travel time)</td>
<td>Mainline Travel Time Detector Sites</td>
<td>Ramp Queue Detectors Sites</td>
<td></td>
</tr>
<tr>
<td>Required Accuracy</td>
<td>±10 km/h</td>
<td>±5 km/h</td>
<td>±10 km/h</td>
<td>Used for performance monitoring functions.</td>
</tr>
<tr>
<td>Assessment Period Duration</td>
<td>15 min</td>
<td>15 min</td>
<td>No specific performance requirement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±5 km/h</td>
<td>±5 km/h</td>
<td>No specific performance requirement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 min</td>
<td>15 min</td>
<td>±10 km/h</td>
<td></td>
</tr>
<tr>
<td>Movement (carriageway) speed (km/h)</td>
<td>±5 km/h</td>
<td>±5 km/h</td>
<td>±10 km/h</td>
<td>Used for Real Time control (e.g. travel time and ramp signal activation)</td>
</tr>
<tr>
<td></td>
<td>5 min*</td>
<td>5 min*</td>
<td>No specific performance requirement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±5%</td>
<td>±5%</td>
<td>±5%</td>
<td></td>
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<tr>
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<tr>
<td></td>
<td>15 min</td>
<td>15 min</td>
<td>±5%</td>
<td></td>
</tr>
<tr>
<td>Movement (carriageway) volume (veh/hr) - short period</td>
<td>±5%</td>
<td>±10%</td>
<td>±5%</td>
<td>Used for Real Time control (and ramp signal activation and ramp signal management on ramps)</td>
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<tr>
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<td>5 min*</td>
<td>5 min*</td>
<td>±5%</td>
<td></td>
</tr>
<tr>
<td>Movement (carriageway) volume (veh/hr) - longer period</td>
<td>±5%</td>
<td>±10%</td>
<td>±5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 min*</td>
<td>5 min*</td>
<td>±5%</td>
<td></td>
</tr>
<tr>
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<td>2%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Measure</td>
<td>Mainline Sites</td>
<td>Ramp Sites</td>
<td>Comments</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>---------------</td>
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<tr>
<td></td>
<td>Mainline Potential Bottleneck Detector Sites (also used for travel time)</td>
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<td>Ramp Queue Detectors Sites</td>
<td>Enhanced Performance Evaluation Detector Sites</td>
</tr>
<tr>
<td>Required Accuracy</td>
<td>Assessment Period Duration</td>
<td>Required Accuracy</td>
<td>Assessment Period Duration</td>
<td>Required Accuracy</td>
</tr>
<tr>
<td>Individual vehicle in correct Austroads class</td>
<td>TBC</td>
<td>Limited 2 bin system</td>
<td>TBC</td>
<td>Limited 2 bin system</td>
</tr>
<tr>
<td>Speed Range (km/h)</td>
<td>20km/h – 110km/h</td>
<td>20km/h – 110km/h</td>
<td>5km/h – 80km/h</td>
<td>20km/h – 110km/h</td>
</tr>
<tr>
<td>Volumes at which criteria apply</td>
<td>600 – 2400 veh/ln/hr</td>
<td>600 – 2400 veh/ln/hr</td>
<td>600 – 2400 veh/ln/hr</td>
<td>600 – 2400 veh/ln/hr</td>
</tr>
</tbody>
</table>

* Test Parameters: 2 Lanes for traffic movement + 80% of 5 minute intervals must comply with 60 minute assessment period

This requirement is predominantly for Enhanced Performance Evaluation sites

Ramp detection needs also to be accurate at very low speeds for rolling queue, at least for measurements for algorithm control purposes
4. OTHER REQUIREMENTS

4.1 Asset Manager Traffic Systems

The Contractor shall liaise with the Asset Manager Traffic Systems (AMTS) team during the process of determining a suitable VDS technology to ensure wider Main Roads interests are considered.

Engagement with AMTS is required throughout the design, implementation and commissioning phases and the process involved are outline in the Traffic Control System Network and Asset Management Processes (document no.: 12/8007-RI-002).

4.2 High Risk Technology Elements

Main Roads has identified a number of technology elements that have an elevated risk level for technology selection with ramifications extending beyond the life of the Contract.

Main Roads has determined that the VDS technology selection is one of these elements that has an elevated risk level.

As a result the Contractor will require endorsement of the Asset Manager Traffic Systems (AMTS) for activities including:

- the proposed procurement approach
- for the technology/product selection

4.3 Reliability

The Contractor shall review the existing network in the project area and determine the availability requirements of end equipment in order to meet the overall availability requirements of each user service as defined in the Managed Freeway Technology Functional Requirements (document no.: 12/8007-REQ-001). The availability requirements of end equipment should be agreed with the Main Roads Asset Manager for Traffic Systems.

The VDS shall have a minimum design life of 10 years.

4.4 Maintenance

The VDS must not require routine maintenance visits at an interval shorter than 12 months, unless agreed to by the AMTS.
5. INSTALLATION

5.1 Schedule

The VDS detectors, roadside cabinet or any other supporting infrastructure should not be installed until a power supply is available at the site.

5.2 Testing and Commissioning

The Contractor shall test the VDS rigorously prior, during and following installation in accordance with the Testing and Commissioning Strategy (document no.: 12/8007-REQ-201).

All test results should be captured on an appropriate pro-forma and provided as part of the Operation & Maintenance handover documentation.

The AMTS and the Metro Integrated Service Arrangement Electrical Service Senior Project Manager shall be provided with a minimum of 7 days notice prior to installation of each VDS to provide witness at the installation and testing if desired.
6. DOCUMENTATION

6.1 Drawings

The Contractor shall supply for each VDS site a full suite of As Constructed drawings that detail the following as a minimum:

- The specific site layout,
- Lane configuration details for each VDS and detector,
- The VDS housing construction and mounting arrangements (if applicable),
- The VDS internal component arrangement, and
- The VDS external wiring arrangement.

6.2 Manuals and Datasheets

An O&M manual shall be supplied with the VDS that detail all elements of VDS and roadside controller.

A quick reference troubleshooting guide shall also be provided with the documentation.

The Contractor shall also provide documentation that details the following as a minimum:

- Serial numbers for all equipment installed, including the controller and detectors (where applicable),
- Detector installation details including lane number, leading or trailing details, and distance in millimetres between leading and trailing detectors,
- Sensitivity settings for each detector (if applicable),
- Minimum signal strength for each detector (if applicable),
- Battery numbers, size and date of installation (if applicable),
- Communications configuration including IP and gateway addresses, and fibre allocations, and
- Installation date of each detector.

All test results as detailed in Section 5 shall be supplied as part of the VDS documentation.