1. DOCUMENT HISTORY AND PREMABLE

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 and KP</td>
<td>AS</td>
<td>April 2013</td>
</tr>
</tbody>
</table>

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3. PURPOSE

This document captures the agreed technology functional requirements for Managed Freeways as part of the adopted Systems Engineering approach indicated below.

* The exact role of the Contractor will differ depending on the project requirements

This process above has been focused on a scenario where a project alliance has responsibilities for ITS delivery and would require some adaptation for other delivery approaches. The aim of this document is to provide the basis for the development of the Technical Requirements based on the desired operational outcomes using a Systems Engineering approach.

MRWA Function – road network outcome focus
MRWA Function – technology system performance focus
Shared Function – technology system performance focus
Contractor Function* – technology system performance focus

* The exact role of the Contractor will differ depending on the project requirements
The flow through the Systems Engineering approach is not a pure one. In keeping with Main Roads' previous analysis work and a desire to adopt as much of the Victorian approach as appropriate, some decisions that could be considered design decisions were either implied or already made early in the development process. Examples of these decisions include a preference for corridor flow and density management through the HERO/ALINEA ramp signal algorithm. Following the Systems Engineering approach set out here enables any necessary departures from Victorian practice to be identified and understood in the context of the achievement of the project objectives.

The document assumes a certain level of intervention that is required to drive the user services, and therefore the technology choices and requirements. It is important to note that there are further options available in the Managed Freeways toolkit that have not been considered here as they are not deemed appropriate at this point. The Managed Freeways Provision Guidelines provides further details on the interventions available along with when they become appropriate.
4. PROJECT OBJECTIVES AND REQUIRED PERFORMANCE OUTCOMES

The following table outlines the high level performance objectives and identifies the intended outcomes for Managed Freeways. The high level objectives centre around increased network reliability, efficiency, productivity and safety, which form the basis of Infrastructure Australia’s Managed Motorways core objectives.

Table 4.1 Managed Freeway Performance Objectives

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>Performance Objective(s): Improve efficiency (travel speed) of vehicle movements through improved operational control and optimised installation of new technology.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outcome(s): Improved average travel speeds during peak periods.</td>
</tr>
<tr>
<td>Productivity</td>
<td>Performance Objective(s): Improve productivity of the network through optimisation of speed and occupancy (density) to achieve maximum throughput (vehicles per hour).</td>
</tr>
<tr>
<td></td>
<td>Outcome(s): Increased vehicle throughput (operational capacity).</td>
</tr>
<tr>
<td>Reliability</td>
<td>Performance Objective(s): Reduce travel time variability.</td>
</tr>
<tr>
<td></td>
<td>Outcome(s): Consistent and predictable travel times.</td>
</tr>
<tr>
<td>Safety</td>
<td>Performance Objective(s): Improve safety by reducing crashes and crash severity, particularly rear-end crashes through facilitated merging, controlled and consistent travel conditions, and improved traveller information.</td>
</tr>
<tr>
<td></td>
<td>Outcome(s): Improved safety (reduction in crashes and crash severity).</td>
</tr>
<tr>
<td>Enhanced driver information services</td>
<td>Performance Objective(s): Provide enhanced information through variable message signs and other platforms, based on real-time network monitoring and intelligence.</td>
</tr>
<tr>
<td></td>
<td>Outcome(s): Enhanced road-user experience with ability to make informed travel decisions based on accurate real-time traffic and road condition information.</td>
</tr>
</tbody>
</table>
The table below sets the performance measures that are to be used as a basis to measure progress against the project outcomes.

**Table 4.2 Example Performance Targets**

<table>
<thead>
<tr>
<th>Objective</th>
<th>Performance Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Average speed above 70km/h is achieved for 90% of links and time periods during the morning and evening extended peak periods</td>
</tr>
<tr>
<td>Productivity</td>
<td>Better than 90% on the Austroads scale for 80% of the links and time periods during the morning and evening extended peak periods.</td>
</tr>
<tr>
<td>Reliability</td>
<td>Better than 1.3 on the Austroads scale is achieved for 75% of links and time periods during the morning and evening extended peak periods.</td>
</tr>
<tr>
<td>Safety</td>
<td>At least 10% reduction in casualty crashes compared to un-managed freeways</td>
</tr>
<tr>
<td>Enhance Driver Information Services</td>
<td>At least 80% of the drivers satisfied with the traveller information services provided.</td>
</tr>
<tr>
<td>Project Management</td>
<td>Completion of project on time and within budget</td>
</tr>
</tbody>
</table>
From these Managed Freeway performance objectives and measures we are able to identify the required ITS services and the relationship between these services and the Managed Freeway requirements. The table below is an example for a particular set of performance measures and services.

Table 4.3 ITS Services mapped to example Managed Freeway Objectives

<table>
<thead>
<tr>
<th>Managed Freeway Objective</th>
<th>ITS Services Required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ramp Signals – Coordination for Corridor Management</td>
</tr>
<tr>
<td>Efficiency</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Productivity</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Reliability</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Safety</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Enhance Driver Information Services</td>
<td>✓ ✓ ✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Project Governance</td>
<td>Need to measure and evaluate Managed Freeway outcomes</td>
</tr>
</tbody>
</table>

* System Performance Management is required to ensure appropriate operation of ITS services to achieve the required performance levels.

5. **ITS SERVICE FUNCTIONAL REQUIREMENTS**

Table 4.3 shows a many to many mapping between ITS services and Managed Freeway objectives. This section of the report draws together the high-level functional requirements for these ITS services to meet the multiple objectives required of them in a complementary manner.
5.1 Ramp Signals – Coordination for Corridor Management

This service provides a coordinated operation function for Ramp Signals.

- Monitor traffic conditions on the mainline, particularly in the bottleneck area and on ramps throughout the coordination area
- Activate ramp signalling where required to manage flow on to the freeway
- The coordinated ramps work together as a system to effectively manage the available storage across the corridor
- Incorporate the assistance of other ramps as slaves should the demand at a ramp exceed the storage capacity
- Implement a balanced system that makes best use of the available freeway capacity

**Purpose**: to monitor multiple freeway entry ramps and coordinate storage across ramps as necessary to control the ramp flow effectively to prevent flow breakdown on the main carriageway by managing the density of traffic. The system employs multiple peripheral signs at on ramps to assist with managing the flow of traffic and informing road users of current road conditions.

**Requirement**: signal and message display to drivers, and data for the local algorithm (ALINEA) and for the coordination algorithm (HERO), primarily occupancy for optimisation with speed and volume used for activation. The VDS are the sole source of this data and therefore are a key element of the system. The service requires some ability to deal with missing data through substitution as it is inevitable with so many VDS sensors deployed that at any given time a percentage will be unavailable. Each site requires the ability to operate independently on fallback mode to provide some benefits of the infrastructure should the communications link to the control system be lost.

5.2 Ramp Signals – Local Merge and Bottleneck Management

- Monitor traffic conditions on the ramp and mainline
- Implement ramp signalling where required to manage flow on to the freeway
- Provide basic traffic information to allow road users to make informed decisions

**Purpose**: to monitor a freeway on ramp and nearby freeway conditions and operate the ramp signals to improve merge safety and/or manage the storage of the ramp as necessary to attempt to help prevent or delay flow breakdown on the main carriageway by managing the occupancy. The system employs multiple peripheral signs at on ramps to assist with managing the flow of traffic and informing road users of current road conditions. This service also provides the ramp signal functionality required to support the application of coordinated ramp signal functions. The signals shall desirably have the optional ability to rest on red when there is no traffic on the ramp.

**Requirement**: signal and message display to drivers, and data for the local algorithm (ALINEA) which is primarily occupancy for optimisation with speed and volume used for activation, also provide capability for fixed-time operation. Some ability to deal with missing data through substitution. Each site requires the ability to operate independently on a fallback fixed-time mode to provide some benefits of the infrastructure should the communications link to the control system be lost.
5.3 Travel Time Calculation

- Receive inputs from roadside detection devices
- Process data to calculate live travel times
  - Definitions required to determine the travel time routes
  - Intelligence required to provide the ability to allow for gaps in information
- Provide outputs in the required format to dependant end-user services
- In terms of ‘live’ information the Roadside Travel Time Display service is the key dependant source

**Purpose**: calculate real time travel times for the freeway sections including where applicable ramp waiting times, to enable dissemination to multiple end-user services (eg. web, mobile, intellimatics, roadside) with Roadside Travel Time Display being the main end-user service for ‘live’ travel times

**Requirement**: data for travel time algorithms, primarily point speeds but also occupancy and volume to assist accurate calculations; some ability to deal with missing data through substitution

5.4 Roadside Travel Time and Other Message Display

- Displaying travel times in accordance with operational requirements
- Display messages to road users for other purposes, e.g. incident and event management
- Receives information from the Travel Time Calculation service
- Devices required to suit both the freeway and arterial network
- Deliver travel times to end display devices

**Purpose**: display travel time, incident and event messages in roadside environment to warn drivers and assist them to make informed choices; targeted at both on-freeway and prior to entry to freeway.

The purpose of this service is not to display travel time information to on any other medium such as internet, mobile or in-vehicle devices as this would be classed as a separate service as the purpose and requirements would differ making it difficult to clearly define at the technical requirements phase.

**Requirement**: for travel times, VMS with a capability for colour display (white, green, yellow, red); for other messages desirable to be able to use symbol, pictogram to reduce reading times; need ability to drive situation-relevant messaging out of control system, not just rely on manual text entry
5.5 Incident Detection

- Receive inputs from various sources to flag incidents
  - Provide incoming call facility to allow notification of incidents with some ability to locate origin of call
    - Roadside Help Phones
    - Mobile Telephones
  - Automatically detect unusual traffic movements that may have been caused by an incident
    - Flag incidents into likely categories; Congestion, Accident etc

**Purpose:** detect traffic disturbances that are likely to have been caused by incidents and flag to operators for verification.

**Requirement:** for most managed freeways, this is not at tunnel level criticality; need to factor in multiple means of detection – phone calls, detector based algorithms, etc.

5.6 Incident Verification

- To provide the ability to independently verify reported incidents
- Near 100% CCTV coverage required
- Ability to control CCTV surveillance cameras to provide maximum coverage with assets

**Purpose:** verify nature of incident to enable more rapid and targeted response

**Requirement:** almost always visual verification – therefore good, but perhaps not perfect visual coverage

5.7 System Performance Management

**Purpose:** monitor and improve system availability/reliability and reduce fault detection resolution times to ensure that systems perform to required levels

**Requirements:** monitoring and management systems, business processes and resources

5.8 Freeway Performance Evaluation

**Purpose:** measure freeway performance for operational performance tuning and ongoing strategic reporting

**Requirement:** measure, record and enable analysis of freeway performance
6. LINK BETWEEN SERVICES AND ITS ELEMENTS

The matrix below sets out foundation and future ITS services with respect to Managed Freeways and 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 6.1 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></td>
<td>Control System</td>
<td>Comms</td>
</tr>
<tr>
<td>Ramp Signals – Corridor Management</td>
<td>Real Time Control</td>
<td>☑</td>
</tr>
<tr>
<td>Ramp Signals – Local Merge and Bottleneck Management</td>
<td>Real Time Control</td>
<td>☑</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.
6.1 **Description of ITS Technology Elements**

This section provides some commentary about special requirements for technology arising from these functional requirements. It is not intended to provide comprehensive descriptions as these can be found in individual technical requirement documents.

6.1.1 **Control System**

For the Managed Freeway System to operate as an integral part of the road network, the control system needs to be an integral part of Main Roads overall traffic management control system.

6.1.2 **Communications System**

The advantages of IP networks enable us to focus on building an efficient robust network across the metropolitan area – not just fibre but multiple/resilient IP routes. Physical redundancy will provide a strong benefit to the scheme when assessing the overall availability of the system. Projects will be required to make use of existing infrastructure and augment as necessary.

6.1.3 **Power**

Fit for purpose including appropriate reliability level as part of overall availability calculations. UPS units to be provided where required on key items of equipment, as determined by availability requirements.

6.1.4 **Vehicle Detection Stations**

Essential source of real time and historical intelligence required for freeway management.

6.1.5 **Freeway Ramp Signals**

These provide the basis of the planned operational regime for the Managed Freeways in Western Australia so are an integral part of the system. It should be noted that the Ramp Signals reply on a number of other items of equipment in order to operate effectively including the RC1/2 signs, VDS and other Ramp Signal sites in order to allow coordination.

6.1.6 **CCTV Cameras**

The operational preference is to extend and augment current arrangements. AID (automatic incident detection) and VIP (video image processing) have not yet been identified as necessary for Main Roads’ operations outside of tunnels.
6.1.7 Variable Message Signs

Note that colour for travel times and symbol/pictogram for simplifying messages are both parts of the MRWA VMS traveller information plan.

6.1.8 Arterial Road VMS (RC3 variant)

These are small VMS on the arterial road on the approach to freeway entries – about 200m prior. They provide travel condition information (including colour travel times) prior to drivers committing to enter the freeway. They are often associated with ramp signalling but also provide other functions and aren’t an essential item for successful operation.

6.1.9 Ramp Control Signs (RC1 and RC2)

These are primarily used in association with ramp signalling, but can also be used to support freeway closures for incident management reasons.

6.1.10 Network Management System (NMS)

Monitoring of network and connected devices for asset management – proactive maintenance, capacity planning, security, etc. This is probably best seen as part of an overall Main Roads NMS but has some relationship also with the particular maintenance arrangements adopted for Managed Freeways and will assist with improving the overall availability figure for the scheme.

7. NEXT STEPS

This documented set of functional requirements informs the next stage of the Systems Engineering process – technical requirements. These technical requirements will be based on this current version of the functional requirements and hence any change in the functional requirements needs to be reflected in consequential changes in technical requirements.

These functional requirements will also inform the commissioning, monitoring and evaluation of projects.