Managed Freeways
Testing and Commissioning Strategy

Document No.: 12/8007-REQ-201

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.

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2. PURPOSE

2.1 Introduction

This document outlines the testing and commissioning strategy that is to be employed by the Contractor throughout the delivery stage of a Managed Freeways project in Western Australia. The Contractor is expected to develop a single, coherent Testing and Commissioning plan that covers all elements in the system building up from Factory Acceptance Testing (FAT) to the final System Operational Testing.

Throughout the testing and commissioning phase the Contractor will have to engage with other Main Roads parties to ensure that the testing is suitable for the final system.

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.
3. TESTING AND COMMISSIONING STRATEGY OVERVIEW

3.1 General

Main Roads requires the Contractor to undertake a comprehensive bottom up testing procedure that rigorously tests each element of the system throughout the installation procedure to ensure faults are identified and rectified, and future performance is optimised.

The main steps in the testing are as follows;

- Factory Acceptance Testing (Section 3)
- Pre-installation Testing (Section 4)

**HOLD POINT 1**

- Cable Testing (Section 5)
- Local Device Commissioning (Section 6)
- Local Device Site Acceptance Testing / Performance Testing (Section 7)

**HOLD POINT 2**

- Network Integration Testing (Section 8)
- Final System Testing (Section 9)

**HOLD POINT 3**

- System Operational Testing (Section 10)

Throughout the testing cycle the procedures followed shall refer back to the functional and technical requirements, where appropriate. The main aim of the testing shall be to ensure a robust system that meets the requirements set out in the project and contract documentation, and in doing so it enables the effective operation of the Managed Freeway.

All the steps listed in this document are to be developed into a Testing and Commissioning Plan with accompanying testing procedures and record sheets. All steps shall be identified explicitly on the Contractor’s program to allow interested Main Roads parties to attend where appropriate.

The documentation and processes developed for the project by the Contractor may be adopted as Main Roads corporate documentation for future schemes. Liaison with the Asset Management Traffic Systems (AMTS) team and the Integrated Service Arrangement Electrical Services (ISA ES) Contractor throughout this process is essential to ensure suitability going forward. The Main Roads Information Management (IM) branch will also be involved throughout the process but their requirements for testing are covered in the Traffic Control System Network and Asset Management Processes document. Following final system operational testing the documentation will be handed over to the relevant Main Roads parties to maintain and update for future use.
The interactions and steps highlighted in this document are summarised in the Process Map provided in Appendix A.

3.2 Key Principles

A key requirement of the Contract, and the Testing and Commissioning approach, is that the technology delivery facilitates the reliable operation of the Managed Freeway on opening. The early steps identified have the main goal of providing assurance that once installed the equipment will operate as expected. They also aim to minimise the required on site configuration and testing which will fit into tight windows that will be available for site works. The step by step testing and commissioning approach with hold points will allow the Contractor to demonstrate the effectiveness of the equipment and build confidence.

3.3 Hold Points

The steps identified in Section 3.1 also include predefined Hold Points; these are the minimum hold points that have been identified. The Contractor may choose to include additional hold points during the testing and commissioning process to satisfy themselves or internal Main Roads parties that the installed equipment meets with any requirements identified during the design phase.

The Contractor shall determine a Hold Point procedure that allows a thorough review of test results and assessment of performance before proceeding to the next step. The procedure should include certification to be signed off by the relevant internal Main Roads branches and directorates. The branches that should be included in the process shall include but not be limited to Traffic Management Services, Information Management and the Metropolitan Region.

3.3.1 Hold Point 1

Hold Point 1 is included so that the Contractor can demonstrate that the equipment selected and the configuration will perform as required whilst on site. It also demonstrates that the equipment can operate in its final environment without causing any issues to the control system or TCS Network.

3.3.2 Hold Point 2

Hold Point 2 is included so that the Contractor can demonstrate that the equipment has been satisfactorily tested and locally commissioned with no significant changes from Hold Point 1 that may affect performance prior to connection to the TCS Network and control system.

3.3.3 Hold Point 3

Following installation and connection to the TCS Network it is likely that some changes will be required to the configuration of equipment and some optimisation may be undertaken to ensure that the equipment functions as required. The Final System Testing allows the Contractor to demonstrate that the system operates as required before it becomes operational.

3.4 Existing Equipment

The Contractor may become responsible for specified electrical assets on the Freeway connected to the TCS Network as identified in the Detailed Design. Any existing equipment within the project area may become the responsibility of the Contractor if the equipment is required as part of the final system, e.g. existing Vehicle Detection Stations (VDS). The Contractor will be expected to
implement the same testing and commissioning approach to the existing equipment as the new equipment as far as is practical.
4. FACTORY ACCEPTANCE TESTING

The Contractor is responsible for the procurement of all devices, cabling and infrastructure for the project with the exception of any existing devices already installed on the freeway. The Contractor is to implement a FAT schedule that covers all procured equipment. The network devices will provided by the IM Branch and are subject to separate testing and commissioning requirements as described in the Traffic Control System Network and Asset Management Processes document.

The supplier of all new equipment is expected to undertake appropriate testing to ensure quality prior to delivery to the Contractor. The Contractor shall ensure that the manufacturer’s testing procedures are appropriate to test the supplied product. The Contractor shall request the FAT documentation when placing an order so that any additional testing required can be added if necessary.

The Contractor can accept self-certification of products for the following items provided this self-certification has at least equivalent rigour the Contractor would expect:

- Pits,
- Conduits,
- FISTs,
- FOBOTs,
- Cabinets,
- Cables,
- Media Convertors,
- Terminal Servers,
- Field Processors,
- CCTV Cameras,
- Traffic Signals, and
- Mast Arms.

The Contractor shall provide a witness for the testing of the following equipment prior to delivery:

- Ramp Signal Controllers,
- RC1 Signs,
- RC2 Signs,
- Arterial Road VMS (RC3 Signs),
- Variable Message Signs,
- Vehicle Detection Stations, and
- Vehicle Detection Sensors – if loops are used then they should be treated as cables.

The Contractor is expected to determine a relevant quantity to witness based on the total quantity procured, the batch size and the equipment type.

For equipment that will be integrated with the Control System, a compatibility test will be required. The Contractor shall liaise with the TOC Control System Replacement team to determine the methodology required to effectively test this.

A copy of all FAT records is to be issued upon delivery of equipment to be provided as part of the handover file. The Contractor should cross check all FAT records upon delivery to ensure that the serial and drum numbers of equipment and cables on the FAT records match the equipment and cables supplied.

The Metro ISA ES and AMTS must be given at least 14 days’ notice of any planned witnessed FATs so they can provide an attendee if they wish. Attendance will be at the cost of Main Roads and all attendees must provide the Contractor with a minimum of 7 days’ notice of their intent to attend so this can be arranged with the manufacturer. Where the FAT is to be conducted outside of Western Australia the Contractor shall also provide suitable facilities for remote witnessing by Main Roads, if requested to do so.
5. **PRE-INSTALLATION TESTING**

5.1 **Introduction**

The Contractor will undertake pre-installation, or soak, testing prior to installation on site. This will be undertaken at a dedicated facility. This should ideally be near or part of the site/project office, referred to throughout this document as the test facility.

A functioning mock network should be set up as part of the pre-installation testing to exercise the equipment as near as possible to the final configuration. Some equipment will not be suitable for pre-installation soak testing so this equipment should undergo a delivery test to ensure that no damage has been causing during transit.

It is likely that equipment will have undergone some form of soak testing as part of the supplier’s quality system. This soak testing time should not contribute towards the minimum time required by the Contractor for soak testing.

As highlighted in Section 2.3 a Hold Point will be required following the Pre-Installation Testing step.

5.2 **Delivery Testing**

5.2.1 **Cables**

Upon delivery all cables should undergo a drum test to ensure no damage has been caused during transit. The drum test should be defined by the Contractor but as a minimum should consist of the following;

- **Copper Cabling**:
  - Continuity
  - Insulation Resistance

- **Optic Fibre Cables**;
  - Power Meter

5.2.2 **Inspection**

For the items listed below the Contractor will be expected to undertake a visual inspection upon delivery to ensure no physical damage has occurred during transit;

- Pits,
- Conduits,
- FISTs,
- FOBOTs, and
- Mast Arms.
The Contractor shall maintain records of all delivery testing including a register of the serial numbers for each item of equipment, when it was delivered, when it was visually inspected and when it was issued for installation.

5.3 Pre-installation Soak Testing

The main aims of the pre-installation testing are to;

- Identify any equipment that may suffer an early life failure,
- Replicate post installation conditions to ensure that equipment functions correctly with the system and network, and
- Enable any integration issues to be identified and resolved prior to roadside installation.

5.3.1 TCS Network

The Contractor will be required to provide a mock TCS Network at their test facility. The mock TCS Network will be used to ensure that no clashes are experienced when connected to the live system and that the end equipment can be integrated into the network and communicate with the central system as required.

It should be noted that any FAT testing required by Information Management (IM) branch as part of the procurement process for networking equipment should be undertaken prior to soak testing. This testing should identify any issues with the equipment selected such as volume of traffic on the network, suitable SFPs etc. This is covered in the Traffic Control System Network and Asset Management Processes document.

Where possible the Contractor should use the TCS Network equipment provided by IM to undertake the soak testing. If this is not possible or additional equipment is required then the Contractor should source additional equipment to be used during the testing.

The Contractor should liaise with IM prior to the soak testing phase as IM may be able to incorporate their FAT for the network as part of the equipment soak testing.

5.3.2 Control System

The Contractor will be provided with access to a server running the current control system software in use at the TOC for the soak testing. The Contractor will be required to liaise with the TOC Control System Replacement team prior to acquiring the server to ensure it has been set up to mirror the equipment that will be installed as part of a Managed Freeways system.

This server should also be used prior to soak testing for any required integration testing to ensure that the control system can communicate with the end equipment as required. This testing should be undertaken as early as possible to identify any potential integration issues well in advance of any planned soak testing. This is not identified as a discrete step but it is essential that the Contractor is confident the end devices will function as required during the soak testing to avoid unnecessarily repeating this step in the process.
5.3.3 End Equipment

All end equipment will undergo a soak test to ensure that any early life failures are identified and mitigated accordingly. Prior to soak testing all end equipment shall undergo a visual inspection as outlined in Section 5.2.

All end equipment will be soak tested for a minimum of 100 hours by the Contractor with the exception of CCTV cameras. The test should replicate real world conditions and data loads throughout to be a true test of the end to end system.

All cabinet housed equipment will be installed into its cabinet in the final configuration prior to soak testing. This includes all ancillary equipment such as FOBOTs, power supplies, media converters, switches, patch cables, internal power cables, etc. All internal cabling, including patch cabling, shall be tested prior to the soak testing to ensure that all cabinets have been configured correctly. Once the cabinet is ready for installation it will be transported to site with only final terminations for power and communications required.

End equipment that is not cabinet mounted and is mounted on a structure, i.e. VMS, RC3, RC1, RC2, ramp signals and CCTV, are not expected to be tested in a manner that fully replicates the final installation. They should be mounted in a way that allows the equipment to be observed throughout the process with temporary cabling whilst allowing the Contractor to make best use of the space available. Any roadside cabinet mounted equipment associated with these items of equipment, e.g. a VMS roadside controller, is still expected to be cabinet mounted as part of the testing.

The Contractor should determine the most appropriate way to phase the testing of equipment based on delivery timescales, equipment availability and adequate facility space to undertake the testing. For example the Contractor may choose to test a single ramp at a time, two ramps at a time or whatever method is deemed suitable to effectively test all equipment.

Ramp Signals

As a minimum the Contractor will need to test each ramp as a complete site. A ramp signal site consists of the following as a minimum;

- The Ramp Signal Controller (RSC) in its cabinet with ancillaries and Field Processor (FP).
- Supporting message signs, connected to the RCS (RC1 and RC2 if appropriate).
- All traffic signal heads associated with the site.
- The Vehicle Detection Station(s) used for the on ramp sensor sites.

Each ramp site will be tested as a complete unit for 100 hours and the following activities shall be undertaken;

- The Control system will continually communicate with the FP / RSC via the mock TCS Network at the standard polling rate,
- The VDS will provide inputs to the system throughout the testing period,
- The ramp signals will activate and deactivate periodically throughout the test period,
• The support signs should activate as required when the ramp signals are in operation,

• The VDS data should result in a test cycle that constantly exercises the RSC and the supporting infrastructure, the following states are expected as a minimum;
  
  o Activated – including start up and close down sequences - with a variety of cycle times,
  
  o Ramp Closed – transitioning from both a ramp activated and ramp deactivated state,

• All RC1 And RC2 signs are expected to function in coordination with the ramp signals during each of the above conditions including at start up and close down sequences, and

• Each state should be in place for a minimum of 5 minutes and a maximum of 15 minutes before transitioning.

This test is intended to test the functionality of the equipment and not the operation of the control system or its optimisation algorithms. The criteria for this will be determined outside of the project as the operation of the Freeway Ramp Signals following successful implementation is not within the scope of the Contractor.

**RC3 / Variable Message Signs**

The signs should be connected to the control system using the mock TCS Network and cycled through a variety of aspects. The cycles should use commonly used aspects as well as a number of aspects that illuminate all possible LEDs in a variety of the available colours.

For the Variable Message Signs the connection to the mock TCS Network should be via its roadside controller which will be housed in its intended cabinet along with any ancillary equipment required for its operation.

**Vehicle Detection Stations**

All vehicle detection stations not associated with a ramp signal site should be installed within their intended cabinet along with any ancillary equipment required for their operation. The cabinet should then be connected to the control system via the mock TCS network. The Contractor should determine a method to simulate inputs to the VDS to mimic vehicle inputs to the system.

**CCTV Cameras**

All CCTV infrastructure that is to be cabinet mounted should be installed within its intended cabinet along with any ancillary equipment. The CCTV cameras and non-cabinet mounted equipment should be located within the vicinity of the cabinet for testing purposes. The cabinet should be connected to the control system via the mock TCS network.

The CCTV Cameras are not required to be soak tested for 100 hours but will be required to undergo a functionality test that will ensure the camera can be operated through the Control System. The functionality should be similar in nature to the SAT and test all the main functions of the camera; pan, tilt, zoom, auto iris, wash /wipe etc.
**Field Processors**

The FPs should be included in the ancillary equipment testing or as part of the mock TCS Network. This will be further defined as part of the detailed design phase but the final testing and commissioning plan should include for soak testing of the FPs at some point in the testing process. The FPs should be installed at a point in the system that replicates the intended final installation.

### 5.3.4 Monitoring

Throughout the testing period the control system and a network management system shall monitor the end devices to monitor faults. A fault report shall be generated following the completion of the soak testing to be assessed by the Contractor. Any faults reported shall be within the tolerances set prior to commencing any soak testing.

If during the soak testing any item of equipment under test experiences a fault that requires any sort of manual intervention the test will be deemed as a failure. Once equipment has been repaired or replaced and the testing shall be repeated in its entirety. Only when end equipment has completed a continuous period of soak testing experiencing only an acceptable number of minor faults shall it be classed as successfully completing the testing.

### 5.3.5 Fault Reporting

During the pre-installation testing the Contractor must periodically introduce some fault conditions to ensure that the system responds as expected. The successful reporting of faults should be included as part of the formal test procedure.

### 5.3.6 Documentation

All pre-installation testing shall be documented throughout with test sheets provided for all end equipment detailing the nature of testing undertaken with times and dates. This should be held on record to assist with any fault finding as part of implementation. Following the scheme completion the documentation shall form part of the handover file.

In addition to the tests the documentation will form a major part of the certification that will allow the Contractor to progress through the hold point that follows the Pre-Installation Testing step in the testing and commissioning process.
6. CABLE TESTING

The Contractor shall prepare an inspection and testing plan for all cables installed as part of a Managed Freeways implementation. The Contractor shall consider what testing and measures could be implemented throughout installation to minimise the risk of a fault being discovered at final testing.

The Contractor should follow the guidance of the cable supplier during installation to avoid any undue stress or damage to the cable.

6.1 Power Cables

As a minimum all power cables and protective devices shall be tested to the requirements of AS3000 and all other specifications referenced as part of the wiring rules.

The exact test method and pass criteria shall be agreed prior to testing with the ATMS team and the ISA – ES.

6.2 Optic Fibre Cables

The Contractor shall test the fibre cores to ensure in accordance with the guidance provided in AS/NZS ISO/IEC 14763.3:2012 for single mode fibre to ensure that the installation and splicing has been undertaken successfully.

The exact test method and pass criteria shall be agreed prior to testing with the ATMS team and the ISA – ES.
7. LOCAL DEVICE COMMISSIONING

Local device commissioning is the process that is to be undertaken prior to the Site Acceptance Test (SAT) to prepare the end device for testing. This process is to determine any variables that cannot be set as part of the pre-installation testing. All details from the site including but not limited to the following should be recorded and signed off at this stage on a data sheet;

- Device Type,
- Asset Number,
- IP Address,
- Access Node,
- Site Variables – e.g. loop sensitivities,
- Dependant device information,
- Power Source,
- Installation Date, and
- Installer.

All commissioning shall be undertaken in accordance with the guidance provided by the manufacturer or supplier along with the requirements developed by the Contractor.

The Contractor shall agree the content of the commissioning records with the TOC Control System Replacement team. Any variables that need to be captured to allow devices to be configured correctly in the Control System should be captured at this stage. Upon connection to the Control System some device configuration data may be lost so it is important that this is recorded accurately.

Copies of the commissioning sheets shall be held as records to form part of the handover documentation. A copy shall also be kept in the end device’s local cabinet to assist with trouble shooting or device replacement in the future. If at any point following local device commissioning any changes are made to the setup of a device these changes shall be recorded with the relevant data sheet being updated.
8. SITE ACCEPTANCE TESTING

The Site Acceptance Testing (SAT) is a discrete set of tests to be performed sequentially to prove that the end device has been installed and commissioned successfully prior to connection to the TCS Network. The Contractor can perform a number of pre-SAT tests to ensure correct operation prior to the formal SAT. AMTS and ISA ES should be given the opportunity to attend all SATs and a minimum of 14 days notice should be provided.

All end devices are to pass a SAT within any predefined tolerances before they can be connected to the TCS Network. As part of the SAT end devices should be connected to the Control System using 3G remote connection to the test environment.

In parallel to the end device SATs the TCS Network should also undergo a SAT to ensure that it is ready for the connection of devices. The SAT is to be performed in conjunction with Main Roads’ IM branch as detailed in the Traffic Control System Network and Asset Management Processes document.

8.1 End Devices

8.1.1 Ramp Signals

Each element of a ramp signal site shall be individually commissioned and undergo a standalone SAT prior to the SAT for the site. The SAT must test the functionality of the individual end device as far as practical prior to connection to the RSC. The VDS and VDS sensors are to be tested as per Section 7.1.3 prior to the operation of the ramp signal site.

Once all elements have been individually tested the ramp signal site must undergo a SAT to ensure that all the elements function correctly as a ramp signal site.

8.1.2 RC3 / Variable Message Signs

The SAT for the message signs shall involve displaying a number of the standard messages to ensure that the sign has been installed and commissioned correctly.

As well as testing the ability of the sign to display the messages the SAT shall ensure that the sign has been orientated correctly in order to be viewed as intended by the road user.

8.1.3 Vehicle Detection Stations

The SAT for the VDS must prove that the data being received from the sensors is accurate and within the tolerances of the Technical Requirements. The Contractor shall demonstrate that the sensors have been installed and connected to the VDS correctly so the right lane information is mapped to the relevant VDS input.

8.1.4 CCTV Cameras

The SAT for the CCTV cameras must prove the functionality of each device. The visual output from the camera should be tested on a laptop or other display device to confirm that the camera is operating satisfactory.

The SAT shall also confirm that the camera can view the road network and major features as intended by the Detailed Design.
8.1.5 Documentation

Every SAT shall be documented on a SAT sheet and signed and dated by the Contractor. Any representative from a Main Roads internal party attending a SAT shall also countersign the SAT sheet to confirm attendance and the results of the SAT.

A SAT sheet for every end device shall be provided as part of the handover file along with a copy to be stored in the local cabinet.
9. NETWORK INTEGRATION TESTING

Following a successful SAT, each end device can be connected to the TCS Network. Immediately following the connection to the TCS Network the Contractor shall undertake a Network Integration Test (NIT). The NIT shall determine that the control system can communicate to the end device through the TCS Network. The data received / transmitted at the roadside should match the data received by the control system. As the end device is required to be tested immediately following the connection to the TCS Network the Contractor shall make all necessary arrangements with the TOC and any other required parties prior to connection to allow this.

The Contractor shall ensure that the functionality of the device is as expected and that the control system and TCS Network can report on faults as expected.

The Main Roads AMTS team must be given the opportunity to witness any NIT. IM will also be involved in accordance with the requirements of their own processes outlined in the Traffic Control System Network and Asset Management Processes document.

Should any end device not behave as intended following the connection to the TCS Network the NIT must be abandoned and the device disconnected from the TCS Network. Prior to Final System Testing the Contractor shall look to proactively monitor equipment connected to the TCS Network to ensure no faults occur and the equipment is behaving as expected.
10. **FINAL SYSTEM TESTING**

Once all end devices have been connected to the control system and have successfully passed a NIT the final system testing can be undertaken. This is to test that the entire system works as expected with information transmitted and received within the defined timescales. This testing could take a number of days and may have to parallel the initial set up of the ramp signalling algorithms.

The Hold Point following final system testing will form part of the handover to operations. Although some work will be undertaken to look at optimising the ramp signalling algorithms, operational handover of the system will not be allowed until the final system testing has been completed and signed off. This also provides the Contractor the opportunity to demonstrate the system functionality prior to operations.

As part of the initial installation the ramp signals are required to be configured so that the algorithms perform within set criteria. This can be done initially using simulated data but prior to going live some optimisation will be performed to ensure the correct operational outcomes are achieved. The Contractor is only to provide the system that allows this process as the optimisation and ramp configuration will be undertaken outside the Contract.
11. SYSTEM OPERATIONAL TESTING

The System Operational Testing is a repeat of the Final System Testing after 30 days of successful operation. This test is to prove that the system can operate as expected for an extended period with only limited interaction with the system for maintenance. At the end of the 30 days the repeated Final System Testing, the fault log from the previous 30 days and feedback from the operators must be compiled to form a report on the system’s operation. The Contractor shall demonstrate that the system operates within the expected tolerances with limited interaction.

Following the sign off after Final System Testing the Contractor will be responsible for the maintenance of the system throughout the system operational testing. In order for a complete assessment of the system to be undertaken any changes to the setup of the system or changes to the configuration of end devices must be subject to a change control process. Any changes made must be recorded and only undertaken where required and with the approval of the TOC.

Should any significant faults or issue occur the Contractor must extend the time period of the system operational testing sufficiently so that enough data is gathered to demonstrate that the implementation has been successful.

This testing is not intended to demonstrate that the system operates effectively to manage congestion or to prove any other operational outcome.

Where applicable, the results and subsequent assessment of the System Operational Testing may feature in contract performance incentives and penalty arrangements.
Appendix A – Process Map for Managed Freeways Testing and Commissioning