**ITS Testing and Commissioning Guidelines**

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|  |  |  |  |
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| 1.0 | 21 March 2018 | Guideline creation | ALL |
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Acronyms & Abbreviations

|  |  |
| --- | --- |
| AWFS | Advanced Warning Flashing Signals |
| CCTV | Closed Circuit Television Camera |
| CSCT | Control System Compliance Testing |
| ESLS | Electronic Speed Limit Signs |
| FAT | Factory Acceptance Testing |
| FST | Final System Testing |
| HP RM | HP Records Manager (Main Roads’ document management system) |
| IAT | Installation Acceptance Testing |
| IMB | Information Management Branch |
| ISMT | ITS System Management Team |
| ISA-ES | Integrated Service Arrangement – Electrical Services |
| ITS | Intelligent Transport Systems |
| NIT | Network Integration Testing |
| PIT | Pre-Installation Testing |
| PLC | Programmable Logic Controller |
| RACI | Responsible, Accountable, Consulted, and Informed |
| REP | Resilient Ethernet Protocol |
| RTTO | Real Time Traffic Operations Branch |
| SAT | Site Acceptance Testing |
| SIAT | System Integration Acceptance Testing |
| SWTC | Scope of Works and Technical Criteria |
| TCS | Traffic Control System |
| TTO | Transition to Operations |
| VAS | Vehicle Activated Sign |
| VDS | Vehicle Detection System |
| VMS | Variable Message Sign |
|  |  |

Definitions

|  |  |
| --- | --- |
|  |  |
| FLIR | Control System for CCTV Cameras, currently FLIR Latitude V7.0 |
| ITS Contractor | Contractor or Delivery Team in charge of the procurement, installation and testing of ITS devices. For the purposes of this document Integrated Service Arrangement Electrical Services (ISA-ES) Delivery is considered equivalent to an ITS Contractor. |
|  |  |

# Purpose

The purpose of this document is to provide guidance to projects around how Testing and Commissioning of ITS devices are to be undertaken. The document outlines the various stages that are expected to be included for ITS used by Main Roads WA, although individual device types, projects and designs may require additional stages not covered in this document, or may not require all or some stages. All individual stages shall be required unless there is prior agreement between the ITS Contractor and Electrical Asset Management and the ITS System Management Team.

This document provides an overview of Testing and Commissioning of all ITS devices. For the specific variations for each ITS device type, see the device specific supplement.

The intent of Testing and Commissioning is to demonstrate/prove that the requirements of the Technical Specifications, Concept of Operations, and Scope of Works and Technical Criteria (SWTC) of the project are met, as well as validating derived requirements and the design. To ensure that the requirements are satisfied and traceable, each test shall be aligned with the SWTC, MRWA Specifications, Concept of Operations, or design documentation. It is recognized however that not all requirements will be verifiable via a test. Manufacturer’s supporting documentation shall be taken into consideration as additional proof of compliance with the requirements.

# Pre-requisite

## Pre-procurement approval of equipment

**Responsibility:** Project Manager

Prior to purchasing ITS devices, the supplier shall provide comprehensive details of the device including (where applicable) any datasheets, any prior STREAMS certifications, Type Test certificates, device firmware revisions, and other relevant information to prove compliance with the specifications. These shall be submitted for approval by the respective MRWA stakeholders, as identified in Appendix B.

## Control System Compliance Testing (CSCT)

**Responsibility:** Supplier/ITS Contractor

The ITS Contractor/Supplier shall coordinate with the Project Manager and the ITS System Management Team (ISMT) to develop specific control system device compatibility testing requirements based on required device functionalities, device driver requirements, and applicable device communications protocols, once devices and the control system that shall be used to monitor the device have been selected. While the majority of devices shall be connected into the STREAMS Control System, not all devices will be. Some, such as CCTV, are connected into other control systems. The control system selection and compliance testing shall be undertaken by the ITS Contractor/Supplier along with ISMT.

The tests will involve the devices to be tested during the Factory Acceptance Testing (FAT) located in the ITS Contractor/Supplier’s factory environment. The Control System Compliance Testing (CSCT) shall only need to be undertaken for one device of each hardware configuration and firmware combination. Subsequent devices with the same configuration and firmware shall be considered equivalent. This is the only test not undertaken on each and every device. All other tests and test stages shall be undertaken on each and every device.

The Contractor (or Supplier, if the project is delivering from vendor direct) shall submit a list of all device type variations and firmware revisions to the Project Manager, for confirmation and approval of control system compliance by ISMT. Approval must be received prior to installation of equipment.

# Testing Requirements

All Test Plans need to be submitted to, and approved by, the Project Manager and relevant stakeholders before testing on the related stage can commence. The plans should be submitted before planned testing commences in line with the project timeline managed by the Project Manager.

Each testing stage must be successfully completed and signed off by the Project Manager and relevant parties before commencement of the subsequent stages. Relevant stakeholders for each testing stage are outlined in Appendix B.

## Factory Acceptance Testing (FAT)

**Responsibility:** Supplier/ITS Contractor

The purpose of FAT is to verify as many requirements of the Concept of Operations, SWTC, design documents, and MRWA Specifications (where applicable) as possible, and provide a level of confidence that the ITS equipment matches the design and satisfies the specified requirements. FAT should test the mechanical, electrical and functional requirements of the ITS device. CSCT shall be undertaken as a part of FAT. CSCT shall be undertaken in the STREAMS ‘Test’ environment.

FAT is to be proven or performed in the manufacturer’s workshop/factory environment to identify any design and manufacturing flaws and ensure these problems are solved at the factory.

Once complete, the Test Plan shall be witnessed and signed off by all relevant stakeholders to prove the requirements of FAT have been satisfied as a prerequisite prior to further stages of testing. The signed successful Test Plan shall be uploaded to HP RM by the relevant Main Roads’ stakeholders for record (as per the Appendix B RACI) and review by the PM. PM is to be informed via correspondence immediately upon upload of documentation.

## Pre-installation testing (PIT)

**Responsibility:** ITS Contractor/Project Manager

The purpose of PIT is to replicate the onsite installation and operation prior to the installation. Where there are multiple pieces of equipment interacting, such as a Vehicle Activated Sign (VAS) being activated by a VDS, all equipment shall be connected together to, as accurately as possible, replicate the interconnections that would occur after installation. The PIT shall be used to determine any early equipment failures or any interoperability issues with the equipment.

PIT shall include tests to:

1. Identify any equipment that may suffer an early life failure (100 hour soak test);
2. Replicate post installation conditions to ensure that equipment interoperability functions correctly; and
3. Enable any integration issues to be identified and resolved prior to roadside installation.

## Installation Acceptance Testing (IAT)

**Responsibility:** ITS Contractor/Project Manager

The purpose of IAT is to confirm that the equipment has been installed to allow correct operation and ensure that any installation errors are rectified prior to energizing the equipment, installation of subsequent equipment, or proceeding to the complete site acceptance phases.

IAT is performed progressively and as soon as practical after the installation of the various ITS equipment and devices. IAT covers each piece of the site as it installed, rather than acceptance of the site as a whole.

Installation must meet the requirements of relevant MRWA Specifications and Australian Standards.

## Site Acceptance Testing (SAT)

**Responsibility:** ITS Contractor/Electrical Asset Management

SAT is undertaken once all pieces of equipment have been installed at the site and connected together. The site is then assessed and accepted as a whole unit.

The purpose of SAT is to verify:

1. The operation of the ITS equipment and devices in their installed status and physical position (any testing completed in an earlier test phase, for example FAT that can in any way be influenced by the installed state and environment must be repeated);
2. Any requirements of the SWTC and design documents not covered by FAT, PIT or IAT.
3. Any site requirements of the MRWA Specifications.

Main Roads’ Electrical Maintenance contractor shall be engaged, at cost to the project, during SAT to review and accept the maintenance access and safety of the site.

## Network Integration Testing (NIT)

**Responsibility**: Project Manager/IMB/IMB Contractor

The purpose of NIT is to verify the operation of ITS equipment connected to the TCS Network. The test shall be coordinated with IMB. The testing of the ITS Telecommunications Network (TCS Network) shall confirm:

1. Connectivity of the network;
2. Connectivity to field equipment;
3. Remote management of switches;
4. Operation under link failure (in line with Cisco REP requirements);
5. Operation under equipment failure (in line with Cisco REP requirements).
6. Latency test, under typical load.
7. Throughput testing, under typical load.

Communications parameters need to be verified according to the information provided by IT Services.

## System Integration Acceptance Testing (SIAT)

**Responsibility:** ITS Contractor/ISMT

The purpose of SIAT is to verify the end-to-end system integration and operations of the device. A document with all the device configuration information needs to be provided to ISMT at least one week before starting of SIAT to configure the device in the control system. During SIAT, the data received/transmitted at the roadside should match the data received by the control system, and the device should react and report as per the protocol.

The SIAT shall be coordinated with ISMT. Should any end device not behave as intended following the connection to the TCS Network, troubleshooting shall be undertaken by ISMT in collaboration with the ITS Contractor to figure out the causes. Depending on the result of troubleshooting, ISMT is to decide what the following actions are, which may include abandoning SIAT and disconnecting the device from the TCS network.

SIAT should be testing the Concept of Operations and the Functional Requirements. It must include the following tests as a minimum:

1. Tests involving a communications connection followed by;
2. End to end integrated tests.
3. All control functions and/or simulation of critical functions and reporting of all or selected alarms and status via the network.

The intention with SIAT is to run a pre-defined sub-set of CSCT run during FAT. The whole suite of tests would not need to be run but a sufficient number would be to ensure that the installed device and backhaul network are operating as expected.

Successful completion of SIAT will result in the device being able to be transitioned into operations. In order to transition into operations, the emergency response arrangements during this time need to be clearly defined and communicated to ISMT, who is responsible for transition into operations.

Emergency Response Arrangements shall ensure that during subsequent testing stages an appropriately qualified person is available at the site to take control of the device and if needed shut it down in the case of an emergency. This should be arranged as part of the project support or through an agreement with Main Roads’ Electrical Services.

Commissioning of ITS devices, as outlined in the *Commissioning of Electrical Assets Process,* needs to be undertaken during SIAT to allow for the commencement of the FST.

## Final System Testing (FST)

**Responsibility:** ITS Contractor/ISMT

The purpose of FST is to verify the end-to-end delivery from device to control system (STREAMS) production environment via the TCS Network, and to assess the readiness of the device for ongoing operations.

STREAMS licence costs for new devices shall be paid for by the project, prior to moving the device into operations at the beginning of FST. The device configuration will be moved from ‘Test’ to ‘Production’ by ISMT, and FST will be on the STREAMS Production environment.

The requirement of FST for each device is covered in the applicable supplement, however, FST generally covers an extended period of monitoring of the ITS device to ensure correct and accurate operation.

Should the device have any issues during FST, ISMT needs to be notified immediately prior to any remediation actions (unless there is a safety risk, which requires immediate intervention). This ensures that the issue is captured and documented appropriately. ISMT will monitor the operations of the device through interrogation of the various logs, during FST and will advise of any performance issues and causes. Any issues will be discussed and assessed in terms of impact to operations and maintenance during FST.

The site cannot be considered commissioned until successful completion of FST.

The Handover of ITS devices, as outlined in the *Commissioning of Electrical Assets Process* can be undertaken after the successful completion of FST.

# Appendices

|  |  |
| --- | --- |
| **Appendix** | **Title** |
| **Appendix A** | Testing Flow Chart |
| **Appendix B** | Responsible, Accountable, Consulted, and Informed (RACI) Chart |

## Appendix A: ITS Testing Flowchart

Start Test and Commission Process

Resolve issue

No

Submit Equipment Datasheet for approval prior to purchase

Approved?

Yes

Procure equipment

Resolve non compliance

No

Submit Factory Acceptance Testing (FAT) Plan for approval

Comply?

Factory Acceptance Testing (FAT) including Control System Compliance Testing (CSCT)

Yes

Submit Pre-installation Testing (PIT) Plan for Approval

Prerequisite

Resolve non compliance

No

Comply?

Pre-installation Testing (PIT)

Yes

Resolve non compliance

No

Submit Installation Acceptance Testing (IAT) Plan for approval

Comply?

Installation Acceptance Testing (IAT)

Yes

Resolve non compliance

No

Submit Site Acceptance Testing (SAT) Plan for approval

Comply?

Site Acceptance Testing (SAT)

Yes

Submit Configuration Sheet

System Integration Acceptance Testing (SIAT) Plan developed by ISMT for PM agreement

Resolve non compliance

No

Submit Network Integration Testing Plan for approval

Comply?

Network Integration Testing (NIT)

Yes

Resolve non compliance

No

Comply?

System Integration Acceptance Testing (SIAT)

Yes

Resolve non compliance

No

Accepted?

Requirements for Emergency Response

Yes

Note: Requirements for Emergency Response is outside the scope of this document.

This is “Commissioning” as per the Main Roads’ *Commissioning of Electrical Assets Process.*

Handover of Electrical Assets

Resolve non compliance

No

Submit Final System Testing (FST) Plan for approval

30 days error free

Final System Testing (FST)

Yes

**NOTE:** Although “Submit Testing Plans” is split throughout the flowchart, they should all be submitted at once at the beginning. The plans are subject to change when the situation and requirement of the testing changes as the testing progresses.

Note: Handover of Electrical Assets is outside the scope of this document.

This is as per the Main Roads’ *Commissioning of Electrical Assets Process.*

## Appendix B: RACI

| Key Tasks | Suppliers | ITS Contractor | MRWA Project Manager\* | Electrical Asset Management | ITS System Management Team (ISMT) | IMB/ IMB Contractor | Electrical Services Maintenance | RTTO |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Factory Acceptance Testing (FAT) | **R** | **RA** | **C** | **C** | **R** |  |  |  |
| Develop FAT Test Plan.  Perform testing. | Attend testing and ensure it is undertaken correctly. | Approve FAT Plan.  Arrange/assess testing. | Attend and review FAT. Involvement based on level of risk for each item. | Responsible for developing and undertaking CSCT. |  |  |  |
| Pre-Installation Testing (PIT) | **I** | **R** | **A** | **C** | **I** | **C** |  |  |
| Inform only. | Develop PIT Plan.  Perform testing. | Provide oversight for testing.  Sign off on completion. | Provide oversight for testing. | Inform only. | Provide network equipment support. |  |  |
| Installation |  | **R** | **A** | **I** | **I** | **I** | **C** | **C** |
|  | Install devices in accordance with design. | Provide management and oversight to installation. Sign off on installation. | Inform only. | Inform only. | Inform only. | Supply Surveillance Officer (at project cost). | Provide operational support (traffic notifications etc.) to installation. |
| Installation Acceptance Testing (IAT) |  | **R** | **A** | **C** | **I** | **I** | **C** | **I** |
|  | Develop IAT Plan.  Perform testing. | Approve IAT Plan  Provide management and oversight for testing.  Sign off on completion. | Consult in installation requirements of individual parts | Inform only. | Inform Only. | Supply Surveillance Officer (at project cost). | Inform Only. |
| Site Acceptance Testing (SAT) |  | **R** | **R** | **AR** | **I** |  | **R** |  |
|  | Develop SAT Plan.  Perform testing. | Provide management and oversight for testing. | Review and Accept SAT Plan.  Sign off on SAT completion. | Inform only. |  | Review site installation to ensure maintenance access and safety. |  |
| Network Integration Testing (NIT) |  | **R** | **A** | **C** | **C** | **R** | **I** |  |
|  | Work from site testing NIT. | Provide management and oversight for testing.  Sign off on completion. |  |  | Develop NIT Plan.  Perform testing. | Inform upon completion |  |
| System Integration Acceptance Testing (SIAT) |  | **R** | **A** | **C** | **R** | **C** | **I** | **C** |
|  | Work from site testing functions in Control System. | Provide management and oversight for testing.  Sign off on completion |  | Develop SIAT Plan.  Undertake testing functions in Control System. |  | Formally inform upon completion to begin Commissioning | Support ISMT in function testing. |
| Transition to Operation (TTO) |  |  | **R** | **C** | **A** |  | **I** | **R** |
|  |  | Provide support and information to ISMT, for TTO. | Support ISMT as required. | Lead definitions of TTO process and ensure process is followed. |  | Inform only. | Provide TTO requirements.  Accept assets into operation. |
| Final System Testing (FST) | **C** | **C** |  | **C** | **RA** |  | **I** | **C** |
| Remediate any identified defects with the device. | Remediate any identified defects with the installation. |  | Provide support for FST activities. | Lead FST activities.  Coordinate any remediation needed. |  | Formal inform upon completion for readiness for Handover | Provide support to FST activities. |
| Handover (Transition to Maintenance) |  |  | **R** | **A** | **I** |  | **R** | **I** |
|  |  | Ensuring devices meeting Handover requirements | Accept ownership of assets | Inform only. |  | Provide Handover requirements.  Accept assets into maintenance. | Inform only. |
| Defects Liability | **C** | **R** | **A** | **C** | **C** |  |  | **C** |
| Assist with defects repair/replacement. | Undertake defects repair/replacement. | Ensure defects are addressed in expected time. | Provide information on asset functions and availability. | Some defects may require testing with ITS control system. |  |  | Provide information on asset functions and availability. |
| Ongoing Maintenance | **C** |  |  | **A** | **R** |  | **R** | **C** |
| Provide maintenance information and support as required. |  |  | Plan maintenance programmes and procure maintenance funding. | Define use of STREAMS for asset performance monitoring.  Oversee asset performance monitoring. |  | Maintain and support devices. | Provide operational support to maintenance. |
| Ongoing Operations |  |  |  | **C** | **C** |  |  | **RA** |
|  |  |  | Consult regarding device types for future development and planning | Assess use of STREAMS.  Provide support for operations optimisation.  Plan enhancement of STREAMS functionalities. |  |  | Operate ITS asset. |

\*MRWA Project Manager may include IDD Project Manager/Project Director, Metro Project Manager/Project Director, RNO, RNP ITS Project Development Manager, ISA Electrical Services Project Manager or the selected ITS Contractor by any of the above.

[R]esponsible: Those who do the work to complete a task. There is typically one Responsible, although others can be delegated to assist in the work required.

[A]ccountable: Those who are ultimately accountable for the correct and thorough completion of the deliverable or task, and the one to whom Responsible is accountable. In other words, an Accountable must sign off (Approve) on work that Responsible provides. There must be only one Accountable specified for each task or deliverable.

[C]onsulted: Those whose opinions are sought; and with whom there is two-way communication.

[I]nformed: Those who are kept up-to-date on progress, often only on completion of the task or deliverable; and with whom there is just one-way communication.

## Appendix C: Example Individual Test Plan Template

Contained within is guidance on how an Individual Test Plan shall be set up, with the minimum elements Main Roads WA expects to be contained.

The document should contain a list of all individuals witnessing or attending the tests. The details for each person should include, as a minimum:

* Name
* Organisation
* Title
* Signature

An example table for the test witnesses / attendees is shown below in Table C.1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Witnessed by (Name)** | **Organisation** | **Designation** | **Signature** | **Date** |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Table C.1: Example Witness List

Where any tools or equipment is used for testing the details of that equipment should be contained within the ITP. An example of the expected details of the equipment is shown below in Table C.2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Manufacturer** | **Model/Serial No** | **Description** | **Last Calibration Date** | **Next Calibration Date** | **Comments** |
|  |  | PC, with STREAMS compliant protocol software |  |  |  |
|  |  | DMM Digital Multimeter (Volts/Ohms) |  |  |  |
|  |  | AC/DC Clamp meter for current measurements |  |  |  |
|  |  | Mains Socket Polarity Tester |  |  |  |

Table C.2: Example Equipment List

The details of each test to be undertaken should be clearly defined in the ITP. Each test should contain, as a minimum,

* a test number,
* a title / item to be checked
* a reference of a requirements document,
* a methodology for the testing,
* an expected result,
* an observed result
* a pass/fail, and
* a section for comments

The tests to be undertaken shall be set out in a table similar to the table C.3 below

| **#** | **Item to Check** | **Requirement Reference (where applicable)** | **Test Procedure/Methodology** | **Expected Result** | **Measured / Observed Result** | **Pass /Fail** | **Comments** |
| --- | --- | --- | --- | --- | --- | --- | --- |
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Table C.3: Example Tests and Methodology

Where faults or failed tests are identified during the testing these shall be entered into a Punch List for rectification. An example of the expected details in the punch list are contained in Table C.4 below

| **No.** | **Test Number** | **Description of fault** | **Level of Importance** | **Remedial Action to be undertaken by Supplier/Contractor** | **Remedial Action Date to be Completed** | **Remedial Action performed Date** | **Sign-Off by SUPPLIER** | **Witnessed by CLIENT** | **Date Closed** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |

Table C.4 Example Punch List

The ITP should contain a final sign-off with space for signatures by the supplier, the contractor and relevant Main Roads WA stakeholders. The acceptance signatures should also be dated.