



OTTAWA LIGHT RAIL TRANSIT
PROJECT

Testing & Commissioning Plan

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1.0 INTRODUCTION

1.1 Purpose

The Testing & Commissioning Plan/Strategy (the “T&C Plan”) describes how OLRT-C will undertake and manage test and commissioning (T&C) activities for the Confederation Line (Stage 1) Light Rail Transit (LRT) project. As per the PA Schedule 14 1.3a, this document will also show how OLRT-C will successfully demonstrate the performance and safety of the System Infrastructure [1]. This Plan is based on T&C practices employed on other successful projects including:

- Vancouver SkyTrain Expo Line and Millennium Line
- The Kuala Lumpur Kelana Jaya Line (formerly known as the PUTRA Line);
- The Kuala Lumpur Monorail System.
- Vancouver Canada Line
- Calgary West LRT

This is a living plan that will be updated as the project progress.

1.2 Scope

This T&C Plan covers activities that will start in the factory, followed by installation and unpowered Post Installation Checkout (PICO), Site Acceptance Testing (SAT), Systems Integration Testing (SIT), System-Wide Commissioning and Trial Running testing. It addresses the testing requirements of Schedule 10, Schedule 13, Schedule 14, Schedule 15 -1, 15-2 Parts 4, 5 & 6. The document explains how the Ottawa LRT systems including civil structures, trackwork, vehicles and electrical and mechanical systems will be integration tested as a revenue ready transit system. In accordance with the City’s use of ISO/IEC 15288, this document satisfies the requirement for the “Verification Process” outcome 6.4.6.2 a), “A verification strategy is defined.”

The following functional components of T&C are covered in this T&C Plan:

- Program and sequence for all T&C;
- Control and monitoring processes for the progression of the T&C program;
- Methods for reporting on completed T&C;
- T&C documentation control procedures;
- Process for managing non-conformances and re-testing;
- Management of safety during T&C and
- Transition to operation and maintenance.

The commissioning of civil structures are excluded from this document. Vehicle acceptance testing is the responsibility of Alstom, and is excluded from this document.

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1.3 Definitions and Acronyms

1.3.1 Definitions

Table 1 – Definitions

Term	Definition
Guideway	That part of the Confederation Line (Stage 1) comprising both the superstructure and substructure elements on which the Vehicles operate, whether elevated, at grade, or in the Tunnel, including all beams, slabs, columns and foundations.
Maintenance and Storage Facility	The maintenance, operation and storage facility for the Vehicles and System and includes the Maintenance Building, Operations Crew Facility, Storage Yard, the Final Vehicle Assembly Area (temporary), the Yard Control Centre, the Backup Control Centre and the Transit Services Control Centre and Vehicle Storage
Overhead Catenary or Overhead Catenary System	A system that distributes DC power from the Traction Power System to the Vehicle via a pantograph on the Vehicle. The OCS consists of a conductive messenger wire suspending a contact wire between poles and/or attachments along the Guideway to provide the DC propulsion power requirements of the Vehicle maintaining continuous contact between the pantograph and the contact wire.
Subject Matter Expert	An individual who has the highest level of expertise in performing a specialized job, task or skill within the organization or retained by the organization.
Trial Running	A twelve (12) consecutive day period that may commence upon the successful completion of T&C. Upon successful completion of Trial Running, the Integrated System will be ready for revenue service
Fixed Component	The fixed facilities and the fixed equipment, including the MSF
Vehicle Component	The Alstom vehicle and the Thales vehicle equipment

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1.3.2 Acronyms

Table 2 – Acronyms

<i>Acronym</i>	<i>Meaning</i>
ATC	Automatic Train Control
ATIS	Automatic Traveller Information System
ATO	Automatic Train Operation
BCC	Backup Control Centre
BMS	Building Management System
CBTC	Communication Based Train Control
CCTV	Closed Circuit Television
CM	Configuration Management
CTS	Communications Transmission System
DOORS	Dynamic Object Oriented Requirements System
EJV	Engineering Joint Venture
FAI	First Article Inspection
FAT	Factory Acceptance Testing
FCP	Fire Control Panel
FVA	Final Vehicle Assembly
GIDS	Guideway Intrusion Detection System
HSRS	High Speed Radio System
HVAC	Heating Ventilation and Air Conditioning
IAC	Intrusion Access Control
ITP	Inspection Test Plan
LEED	Leadership in Energy and Environmental Design
LRT	Light Rail Transit
M&E	Mechanical and Electrical
MSF	Maintenance and Storage Facility
NCR	Non Conformity Report
OCS	Overhead Catenary System
OCT	OC Transpo
OLRT-C	Ottawa Light Rail Transit Constructors
P25	Public Safety Service Radio System, Project 25
PA	Project Agreement or Public Address
PAS	Passenger Announcement System
PICO	Post Installation Check Out
PIDS	Passenger Information Display Systems
PPHPD	People Per Hour Per Direction
PS&D	Power Supply and Distribution
QA	Quality Assurance
RAM	Reliability Availability Maintainability

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<i>Acronym</i>	<i>Meaning</i>
RIO	Rail Implementation Office
ROR	Rail Operating Rules
RTG	Rideau Transit Group
RTM	Rideau Transit Maintenance
RTU	Remote Terminal Unit
SAT	Site Acceptance Testing
SCADA	Supervisory Control And Data Acquisition
SERWG	Security and Emergency Responders Working Group
SIT	System Integration Test
SOP	Standard Operating Procedures
STW	Set-To-Work
SVM	System Verification Matrix
T&C	Testing and Commissioning
TCWG	Testing and Commissioning Working Group
TMS	Test Management System
TPS	Traction Power System
TPSS	Traction Power Substation
TRR	Test Readiness Review
TSCC	Transit Services Control Centre
TVS	Tunnel Ventilation System
UPS	Uninterruptible Power Supply
UTO	Unattended Train Operation
VOBC	Vehicle On-Board Controller
WBS	Work Breakdown Structure
YCC	Yard Control Center
ZC	Zone Controller

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1.4 References

- [1] Ottawa Light Rail Transit Project Agreement Schedule 14
- [2] Ottawa Light Rail Transit Project Agreement Schedule 15-1
- [3] Ottawa Light Rail Transit Project Agreement Schedule 15-2
- [4] RTM-04-0-0000-MPL-0044 - RTM Maintenance & Rehabilitation Quality Management Plan
- [5] REJ-03-4-MEAB-REP-0228 – MSF LEED Monitoring & Verification Plan
- [6] Ottawa Light Rail Transit Project Agreement Schedule 10
- [7] Ottawa Light Rail Transit Project Agreement Schedule 13
- [8] T&C Rail Operating Rules
- [9] Alstom Vehicles Subcontract No. 507528-P001, Execution Version
- [10] Thales Automatic Train Control Systems Subcontract No. 507528-P002
- [11] OLR-50-0-0000-MPL-0002 Reliability, Availability & Maintainability Plan
- [12] Ottawa Light Rail Transit Project Agreement Schedule 20
- [13] OLR-09-0-0000-MPL-0003 Training Plan
- [14] T&C Standard Operating Procedures
- [15] OLR-05-0-0000-MPL-0002 Construction Security Plan
- [16] OLR-05-0-0000-MPL-0001 Safety Management Plan (including a T&C sub-plan)
- [17] OLR-16-0-0000-PRC-0001 T&C Turnover Procedure
- [18] OLR-16-0-0000-PRC-0002 T&C Work Authorization Procedure
- [19] OLR-04-6-0000-MPL-0017 Quality Management Plan
- [20] OLR-05-0-0000-MPL-0003 System Safety Certification Plan
- [21] OLR-05-0-0000-MPL-0005 System Security Certification Plan

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2.0 ROLES AND RESPONSIBILITIES

2.1 T&C Organization

The organization chart for the T&C program is shown in Figure 11 – T&C Organization & Interface Chart.

2.1.1 T&C Manager

The T&C Manager is responsible for all T&C activities on a T&C Site. The T&C Site is any area of the system that has been handed over to T&C. Once an area has been designated a T&C Site it becomes a controlled access area limited to authorized persons or those accompanied by an authorized person. For more details on T&C Turnover see section 5.6 - T&C Turnover.

It is the responsibility of the T&C Manager to plan access to the T&C Sites and possession of assets. The T&C Manager ensures that the necessary resources and approved documentation are available for the testing. The T&C Manager is also responsible for coordinating the overall execution of the test procedures and submission of test reports. The T&C Manager coordinates with suppliers and stakeholders (including OC Transpo) on all testing matters and ensures adequate training of all T&C staff. The T&C Manager has the final responsibility for the overall configuration of the system.

The following groups in the T&C organization support the T&C Manager:

- Deputy T&C Manager
- Commissioning Coordinator
- T&C Operations & Training Coordinator
- T&C Area Coordinators
- T&C Turnover/Possession/Test Readiness Coordinator
- Systems Integration Team (Subject Matter Experts)
- Engineering Staff

2.1.2 Deputy T&C Manager

- Prepare and manage T&C planning documents
- Prepare and manage T&C record-keeping databases
- Manage test documentation preparation, test execution and report submittal processes
- Manage T&C Drivers and T&C Turnover/Possession/Test Readiness Coordinator
- Manage the interface with the System Integration Team, T&C Safety Coordinator, RTM employees and OC Transpo employees
- Oversee procurement and distribution of test and support equipment required for T&C activities
- Implement emergency response plan as required
- Coordinate weekly meetings

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2.1.3 T&C Operations & Training Coordinator

- Develop, write, deploy and manage the T&C Operations program
- Develop, write, deploy and manage the T&C Training program

2.1.4 T&C Area Coordinators

- Responsible for securing access points to T&C Sites within their designated area
- Implement and close out all Work and Occupancy Permits
- Provide verbal clearances to Controllers for train movements through occupancy areas
- Manage all T&C activities within their assigned geographical area(s)
- Liaise with other T&C staff as required

2.1.5 T&C Turnover/Possession/Test Readiness Coordinator

- Coordinates schedule between different groups
- Issues daily and weekly possession schedule
- Manages permit application process
- Manage T&C Turnover process

2.1.6 Systems Integration Team (Subject Matter Experts)

- Maintain the T&C Schedule
- Carry out SITs
- Coordinate with engineering and supplier staff as required in preparation of test procedures
- Coordinate work between T&C and designated system group
- Coordinate test documentation preparation
- Coordinate procurement of test equipment between T&C and designated system group (i.e. test train requirement, special vehicles requirement, operating staff requirement...)
- Complete test procedure forms during tests
- Prepare test reports

2.1.7 Engineering Staff

- Prepare test plans
- Prepare test procedures
- Witness tests

2.1.8 Independent Certifier

The following roles are extracted from the PA.

- Review of test, verification and performance test forms;
- Review of commissioning progress management forms and performance testing;
- Review of the T&C Plan;
- Review of the Commissioning Schedule;
- Sample witnessing of tests and performance testing;

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- Review of the training curriculum and materials as outlined in Schedule 15 2 Part 1 Article 26 and scheduling;
- Review of the maintenance manuals;
- Sample witnessing of seasonal performance testing;
- Review of the commissioning reports;
- Attend commissioning meetings; and
- Report to the City regarding the progress of commissioning.

2.1.9 Commissioning Coordinator

- **Plan, prepare and execute**, with OLRT-C:
 - T&C Plan
 - T&C Strategy
 - T&C Process
 - T&C Procedures
- **Attend**
 - commissioning meetings
 - and audit a sample of each training session (or delegate someone)
- **Review**, with the City of Ottawa and the Independent Certifier:
 - test, verification and performance test forms
 - commissioning progress management forms and performance testing
 - T&C Plan
 - Commissioning Schedule
 - training curriculum
 - training materials (including but not limited to presentations, videos, notes, written tests, field tests, and certification guidelines)
 - training scheduling
 - maintenance manuals
 - commissioning reports
- **Sample witnessing**, with the City of Ottawa and the Independent Certifier:
 - tests and performance testing
 - seasonal performance testing
- **Coordinate**
 - with the City prior to and throughout commissioning
 - with the Independent Certifier prior to and throughout commissioning
- **Report**
 - monthly to the City regarding the progress of commissioning
- **Perform daily reviews**

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- of Trial Running with Commissioning Team

2.1.10 Quality Assurance

Members from the project Quality Assurance department provide independent review, approval and audit of the Commissioning Test Procedures as well as the test execution results.

2.1.11 Facility Commissioning Agent

The M&E facility commissioning of the MSF is being performed by an independent commissioning agent. This commissioning is following the CSA Z320 standard. The completed commissioning forms will be bundled in two: all MSF mechanical forms and all MSF electrical forms.

The M&E facility commissioning of the stations will be equivalent or better than what is done at the MSF.

2.2 TCWG & Commissioning Team

The T&C Working Group (TCWG), as a precursor to the Commissioning Team, provides the oversight necessary to allow successful execution of T&C activities. It will endeavor to ensure: necessary regulatory pre-requisites are in place, the City and RTG communicate regularly and clearly on T&C matters, City responsibilities are defined and confirmed, teamwork exists between Operations and Maintenance and other participants, and training is executed effectively.

The commissioning team, as described in Schedule 14 1.4, is an interface group which monitors T&C progress. It is comprised of:

- RTG member(s)
- City member(s)
- The Commissioning Coordinator
- The Independent Certifier
- Other individuals, as deemed necessary

2.3 Health & Safety Organization

The T&C Group has the ongoing duty to implement and maintain health and safety in accordance with the OLRT-C Safety Management Plan and in compliance to the Ontario Health & Safety Regulations. All employees, subcontractors, consultants and visitors working in the T&C designated areas have ongoing general responsibilities towards maintaining health and safety in the workplace. Specifics on T&C Safety program are detailed in the T&C Safety Plan [16].

T&C coordination personnel will follow the processes outlined in section 10.0, these personnel will be responsible for coordinating activities like train movements and traction power activation.

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System safety certification is discussed below in 2.4.1 – Safety Certification. The methodology around identifying safety critical tests is outlined in 6.1 – System Verification Matrix.

2.3.1 T&C Safety Coordinator

The T&C Safety Coordinator works together with the T&C Manager and the project Safety Manager and has the primary responsibility for ensuring the health and safety objectives set forth in this plan are implemented and maintained. Additional information on T&C Safety Coordinator can be found in the T&C Safety Plan [16].

2.4 System Safety & Security Organization

2.4.1 Safety Certification

As stated in the System Safety Certification Plan [20]:

“The safety policy for the Confederation Line is to achieve a level of safety which meets the generally accepted best practices from recent North American transit projects and that satisfies the regulatory requirements of the City of Ottawa. The System Safety Certification program contributes to the implementation of this policy by identifying these best practices, assessing if each of these is an appropriate fit, and incorporating them as appropriate.”

The project System Safety Assurance manager is responsible for this activity. System Safety Certification feeds into T&C through the issued safety certificates. Safety certificates are prerequisites for certain major T&C milestones, as are described in section 4.9 - Major T&C Milestones.

2.4.2 Security Certification

As stated in the System Security Certification Plan [21]:

“Transit Services, in cooperation with Rideau Transit Group, is committed to protect Confederation Line passengers, employees, the public as well as Confederation Line property, assets and its environment. The objectives of the Security Policy are to be met by: a) achieving a level of security which meets the generally accepted best practices from recent and comparable Canadian transit systems and satisfies the regulatory requirements of the City of Ottawa; ...”

The project Security Certification Professional is responsible for this activity. System Security Certification feeds into T&C through the issued security certificates. Security certificates are prerequisites for certain major T&C milestones, as are described in section 4.9 - Major T&C Milestones.

2.5 Maintenance Organization

Rideau Transit Maintenance (RTM) is responsible for performing the long term maintenance and rehabilitation of the Confederation Line (Stage 1) light rail transit system commencing at Revenue Service

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Availability Date. [4] This section will refer to and describe only the maintenance that will occur during the T&C phase. RTM staff occupy a dual role during T&C: first to support the T&C program, but also to learn the system to be better prepared for Revenue Service.

2.5.1 Controllers

RTM will provide controllers during the T&C period. They will coordinate yard and line operations, issue work permits (plus other authorities) and coordinate all manual operations. Details of these operations will be found in the T&C Rail Operating Rules [8] (which will be developed based on the Confederation Line Rail Operations Rules).

2.5.2 Technicians

RTM will commence hiring technicians in September of 2016. These technicians will support T&C operations and participate in the inspection and maintenance of the system to the extent that they are able, recognizing that they are largely in a familiarization and development role prior to the Revenue Service Availability Date.

2.5.3 Observers

RTM will also play an active role during T&C in observing and participating in and other commissioning activities. RTM will be informed of T&C activities and schedules as per the process described in section 5.3 (when developed).

2.6 Training Organization

The Training Plan provides details on the training program, for details see reference [13]. An outline of the training organization is provided below.

2.6.1 RTG Training Manager

To successfully complete all of the training program development and course delivery outlined in the Training Plan, it is envisioned that a training manager be hired. The importance of training to the success of the project requires a person experienced in all of the various facets of training management.

2.6.2 RTG Training Assistant

The role of the Training Assistant would be to provide administrative support to the training manager by ensuring that training resources are coordinated including the preparation of sufficient course materials when courses are delivered, that time sheets and training assessments and records are maintained and uploaded as required.

2.6.3 RTG Curriculum Development Staff

Curriculum development can be done by individuals familiar with the Competency Model as outlined in the Training Plan. [13] This may include some trainers from OC Transpo or individuals retained as

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consultants. The Training Manager should also be capable of completing some of the training program development.

2.6.4 RTG Training Instructor(s)

- Delivers T&C driver & controller training
- Delivers OCT controller training
- Delivers T&C related training (T&C Safety, T&C Rules and Procedures...)
- Delivers OC Transpo instructor training

2.6.5 OC Transpo Transit Services Instructors

- Delivers OC Transpo driver training
- 5 trained 3 months before Trial Running [Schedule 15-2 Part 1 Article 26 26.3 e)] [3]
- In practice, this will be delivered earlier than is specified in the PA

2.7 Operations Organization

Operations personnel used during T&C will be a mix of RTG personnel and OC Transpo personnel. A phased approach will be used to ensure major issues are detected early by T&C staff then provide a smooth ramp-up for OC Transpo personnel. During T&C phase 1, only RTG drivers and controllers will be required. Starting in August of 2017, OC Transpo drivers will be phased in.

The primary role of OC Transpo drivers will be to test increasingly smaller headways. In this fashion, drivers can be added to the testing program as they certified through the training program. This will also provide incremental practice for Trial Running.

2.7.1 RTG Drivers/Controllers

- RTG provided drivers and controllers for commissioning
- Trained by RTG Trainer

2.7.2 OC Transpo Drivers/Controllers

- City provided drivers and controllers for commissioning (stated in section 1.3 (h) of Schedule 14 ref [1])
- Drivers trained by OC Transpo trainer
- Controllers trained by RTG trainer

Staffing estimates for OC Transpo required for T&C are shown in Figure 1. This estimate does not include multipliers for unproductive time. For full details, see the detailed schedule in the Training Plan, reference [13]. In addition, RTG will employ approximately 4 RTG drivers and 2 RTG controllers from late 2016 to early 2018.

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As has been discussed with OC Transpo, there will be opportunity to use trained staff in the operation of the system (beyond the minimum requirements listed below), working up to the revenue service schedule.

Figure 1 – OC Transpo Staffing Required for T&C

	2017		2018				
	Nov	Dec	Jan	Feb	Mar	Apr	May
Trained Drivers	4		20	36	52	68	
Trained Controllers	4		8	12	16		
4 dedicated OCT drivers							46 drivers
2 dedicated OCT Controllers							15 ctrlrs

2.8 Thales and Alstom Testing & Commissioning Organization

As with all subcontractors, Thales and Alstom will submit testing procedures to OLRT-C for review and comment ahead of any testing activity. The OLRT-C T&C team will manage this documentation from the SAT (SAT) level and onwards. PICO testing will be managed by the OLRT-C Systems Install team. Any testing prior to PICO is managed by the OLRT-C Systems Integration team.

2.8.1 Alstom

Testing interaction between the OLRT-C T&C team and Alstom will begin when vehicle 3 is complete (January 2017). Vehicle 1 is destined for off-site qualification testing. Vehicle 2 is earmarked for climate chamber qualification testing. As Alstom will be using the 4km test track, T&C will coordinate track usage and parallel works by use of the T&C Rail Operating Rules [8] and the T&C Standard Operating Procedures.[14]

Activities prior to Alstom vehicle testing on the test track is coordinated by the Vehicle Design and Acceptance Manager.

2.8.2 Thales

Testing interaction between the OLRT-C T&C team and Thales will begin during the SAT (SAT) of CBTC wayside and server items at the MSF (likely Q2 2016). T&C should also attend the Pueblo vehicle testing.

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3.0 T&C CONTRACTUAL REQUIREMENTS

PA Schedule 14 encompass OLRT-C's primary T&C obligations, which include demonstration of system compliance with the PA.

3.1 Ottawa LRT Project

The method of verification for each functional and operational PA requirements will be defined in the System Verification Matrix (SVM) and will be stored in a DOORS database during the project. Compliance with these requirements will be verified during T&C. Suppliers will keep their own Verification and Validation matrices. System Verification Matrix will also fill in any gap between suppliers Verification and Validation matrices.

3.2 Ottawa LRT Project Agreement Schedules

Schedules 14, 15-1 and 15-2 of Ottawa LRT Project Agreement cover T&C requirements for Ottawa LRT project

The T&C Manager will perform T&C in accordance with the requirements of the Ottawa LRT Project Agreement. This will be accomplished as generally summarized below¹:

- OLRT-C will be responsible for the Integrated Systems during the Commissioning Stage
- OLRT-C will coordinate T&C activities
- The Test Plan documents will be submitted to parties outlined in Schedule 14 for review
- Stakeholders will be provided access to all T&C plans, procedures, and results.
- Stakeholders will receive notice of test schedules and will be provided access to witness tests at their discretion. Due to the fluid nature of real world testing, the Stakeholders are requested to notify the T&C Site Manager of their intention to witness tests so that they can be informed of last minute changes to the schedule.
- Periodic reviews will be held with the Stakeholders to assess the progress of T&C.

¹ This list is not intended to be exhaustive; it simply provides the reader with a general overview of how the RTG intends to address the contractual requirements.


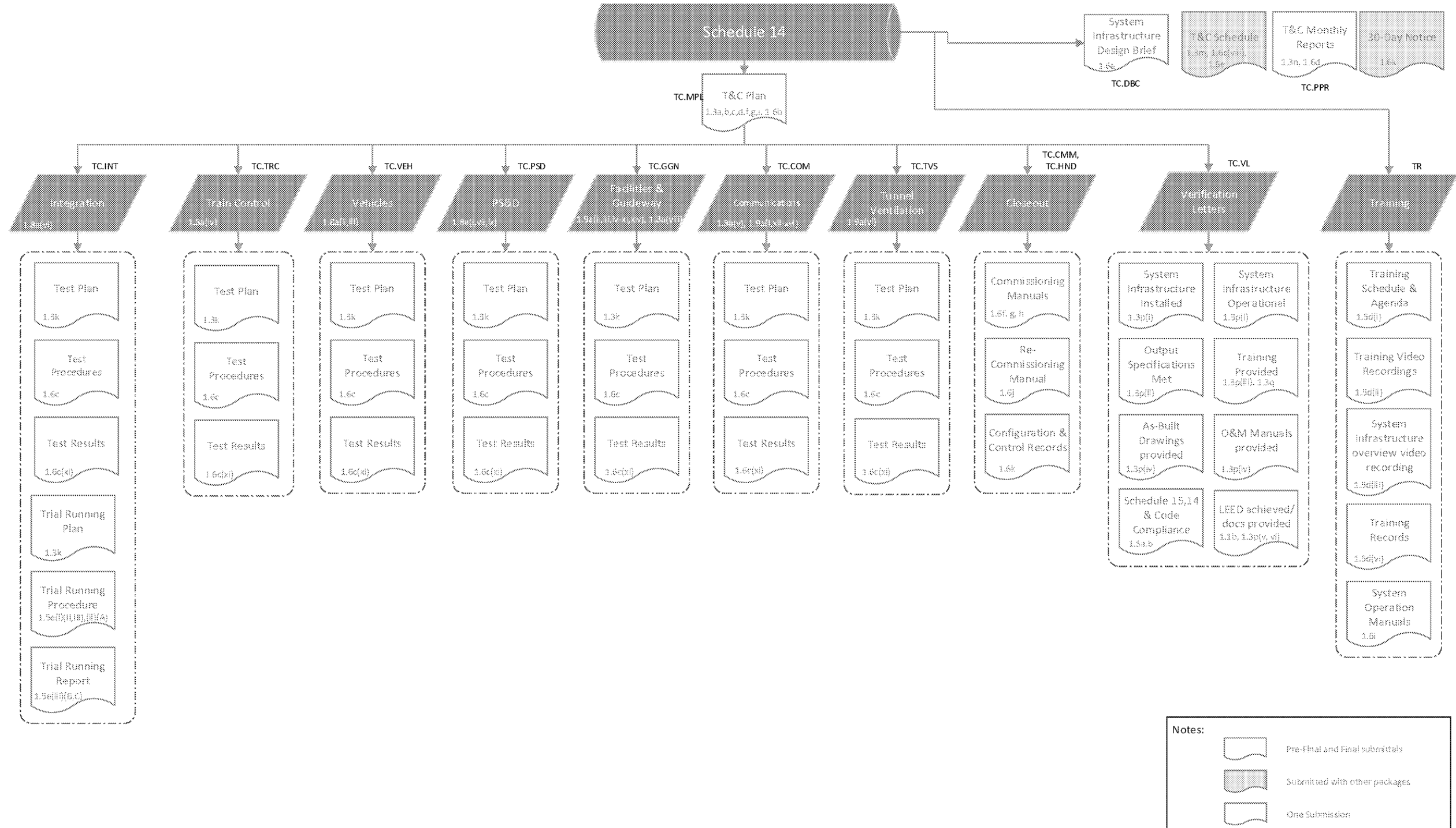
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Figure 2 – Schedule 14 Deliverables



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Table 3 – Deliverable List

<i>Title</i>	<i>PA Reference</i>	<i>Description</i>	<i>Date</i>
T&C Schedule	Schedule 14 1.3 (m) 1.6 (e), (c)(viii)	A detailed schedule of T&C activities	Detailed T&C schedule delivered 18 Dec 2015. Next revision will be integrated in project master schedule.
T&C Plan	Schedule 14 1.3 (a, b, c, d, f, g, l, p) 1.6 (b) 1.6 (c)(x) Schedule 10 Appendix A, 3.10 (o)	Overall guiding document for the T&C program	This delivery.
T&C Progress Report	Schedule 14 1.6 (d)	Monthly reports on the status of commissioning progress	Monthly, after start of commissioning
30-Day Notice	Schedule 14 1.6 (k)	Will be bundled in other packages (likely schedule and/or monthly report)	Monthly, after start of commissioning
Test Results	Schedule 14 1.6 (c)(xi)	Post-test report following each test	Following test
Trial Running Plan	Schedule 14 1.3 (k)	Overview of Trial Running.	See schedule
Trial Running Procedure	Schedule 14 1.5 (e)(iii)(A)	Scenario-level description of the Trial Running event	30 days prior practice Trial Running
Trial Running Report	Schedule 14 1.5 (e)(iii)(A)	A report following completion of Trial Running	Following test
Commissioning Manual	Schedule 14 1.6 (f, g, h)	Manual for each item of system Infrastructure, with all documentation proving the system compliance including test reports, configuration records, check sheets	Draft document will follow MSF commissioning; sequential updates. Final delivery following successful Works commissioning
Re-Commissioning Manual	Schedule 14 1.6 (j)	Clarification required.	If required, following successful Works commissioning
Configuration & Control Records	Schedule 14 1.6 (k)	Configuration records of the entire system	Following successful Works commissioning
Design Brief	Schedule 14 1.6 (a)	System overview	Complete. Delivered as SDFRs.
Verification Letter: LEED Achieved/ docs provided	Schedule 14 1.3 (p)(v, vi)	Documentation required to achieve LEED certification	Following successful Works commissioning

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<i>Title</i>	<i>PA Reference</i>	<i>Description</i>	<i>Date</i>
Verification Letter: As-Built Drawings provided	Schedule 14 1.3 (p)(iv)	Collection of system as-built drawings	Following successful Works commissioning
Verification Letter: O&M Manuals provided	Schedule 14 1.3 (iv) 1.6 (i)	Supplier / designer operation and maintenance manuals	Following successful Works commissioning
Verification Letter: Schedule 15, 14 & Code Compliance	Schedule 14 1.3 (p)(i, ii)	Compliance matrix, proving how OLRT- C is compliant with Schedule 14, Schedule 15-2 Part 1 Article 26, Schedule 15-2 Part 1 Article 2	Following successful Works commissioning
Verification Letter: System Infrastructure Installed	Schedule 14 1.3p(i)	Assurance that the system infrastructure is installed	Following successful Works commissioning
Verification Letter: System Infrastructure Operational	Schedule 14 1.3p(i)	Assurance that the system infrastructure is operational	Following successful Works commissioning
Verification Letter: Output Specifications Met	Schedule 14 1.3p(ii)	Assurance that the output specifications are met	Following successful Works commissioning
Verification Letter: Training Provided	Schedule 14 1.3p(ii), 1.3q	Assurance that training is provided	Following successful Works commissioning
Training Schedule & Agenda	Schedule 14 1.5 (d)(i)	A detailed schedule of training activities. Part of Training activities, see training plan.	Formal delivery of Training Plan Rev 0 by 18 December 2015.
Video Recording of Training	Schedule 14 1.5 (d)(ii)	One digital video recording from each training category. Part of Training activities, see training plan.	Following successful Works commissioning
System Infrastructure overview video recording	Schedule 14 1.5 (d)(iii)	One digital video recording about the System infrastructure. Part of Training activities, see training plan.	Following successful Works commissioning
Training Records	Schedule 14 1.5d(vi)	Summary of training sessions provided, what/when. Part of Training activities, see training plan.	Following successful Works commissioning
System Operation Manuals	Schedule 14 1.6i	Operation manuals for each System Part of Training activities, see training plan.	Following successful Works commissioning

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4.0 T&C STRATEGY

4.1 Work Breakdown

A work breakdown structure (WBS) of T&C activities has been created. This organizes work internal to OLRT-C T&C and deliverables to the City in a logical structure. T&C is divided into three phases: Planning, Execution & Monitoring, and Closeout. This division is reflected in the WBS (see 3), as well as the T&C Detailed Schedule.

Enclosure numbers are assigned to each deliverable package. These enclosure numbers are listed in Appendix H - Work Breakdown Enclosure Codes. The intent of this coding scheme is to provide some structure to all testing deliverables. As the T&C progresses, and the frequency of test report deliveries increases, this structure will prove to be valuable for both RTG and the City.

The T&C WBS is shown next in Figure 4 through to Figure 8. 3 is an overview, Figure 4 and Figure 5 are the T&C Planning phase, Figure 6 and Figure 7 are the T&C Execution & Monitoring phase, and Figure 8 is the T&C Closeout phase.


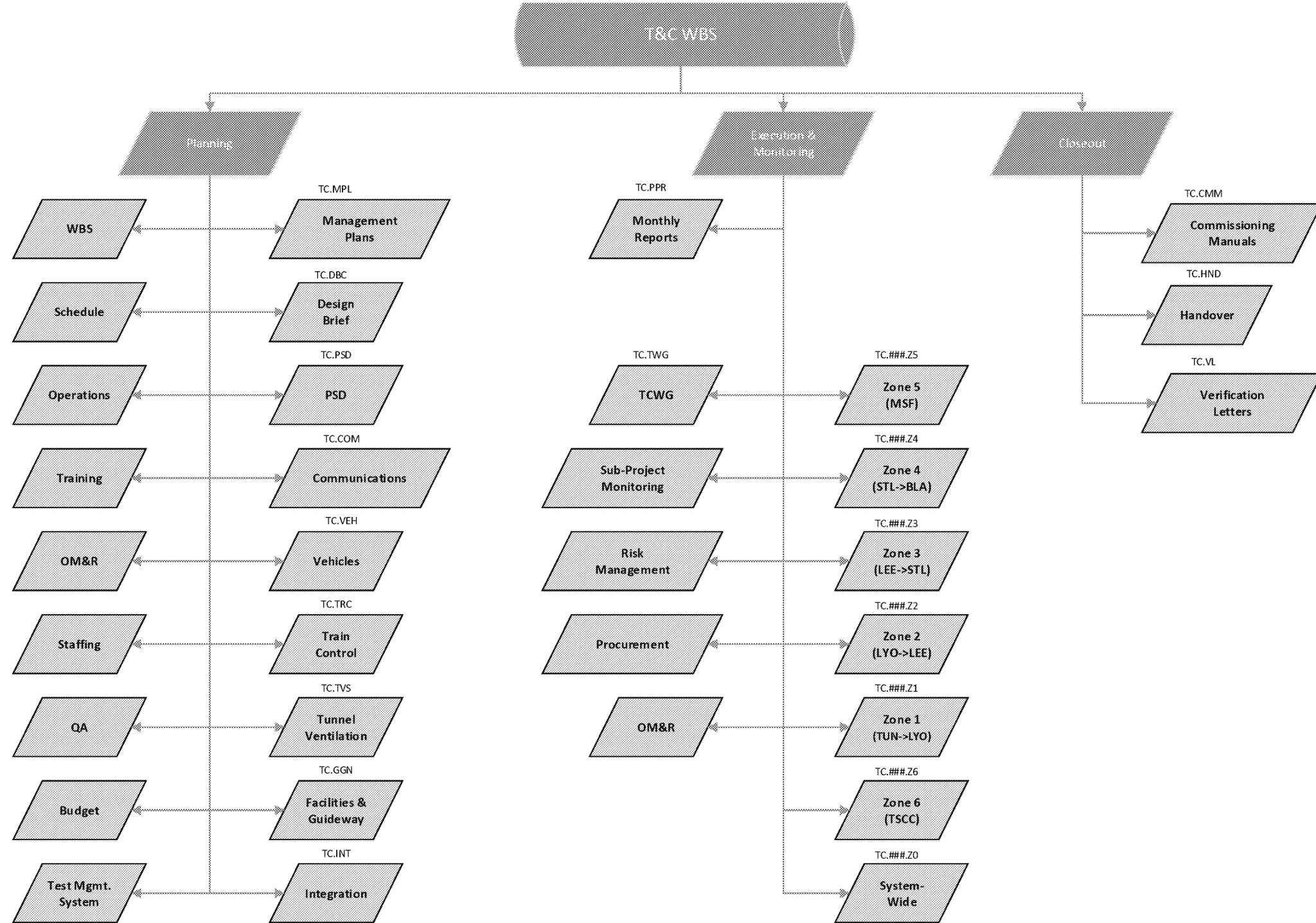
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Figure 3 – T&C Work Breakdown Structure: Overall




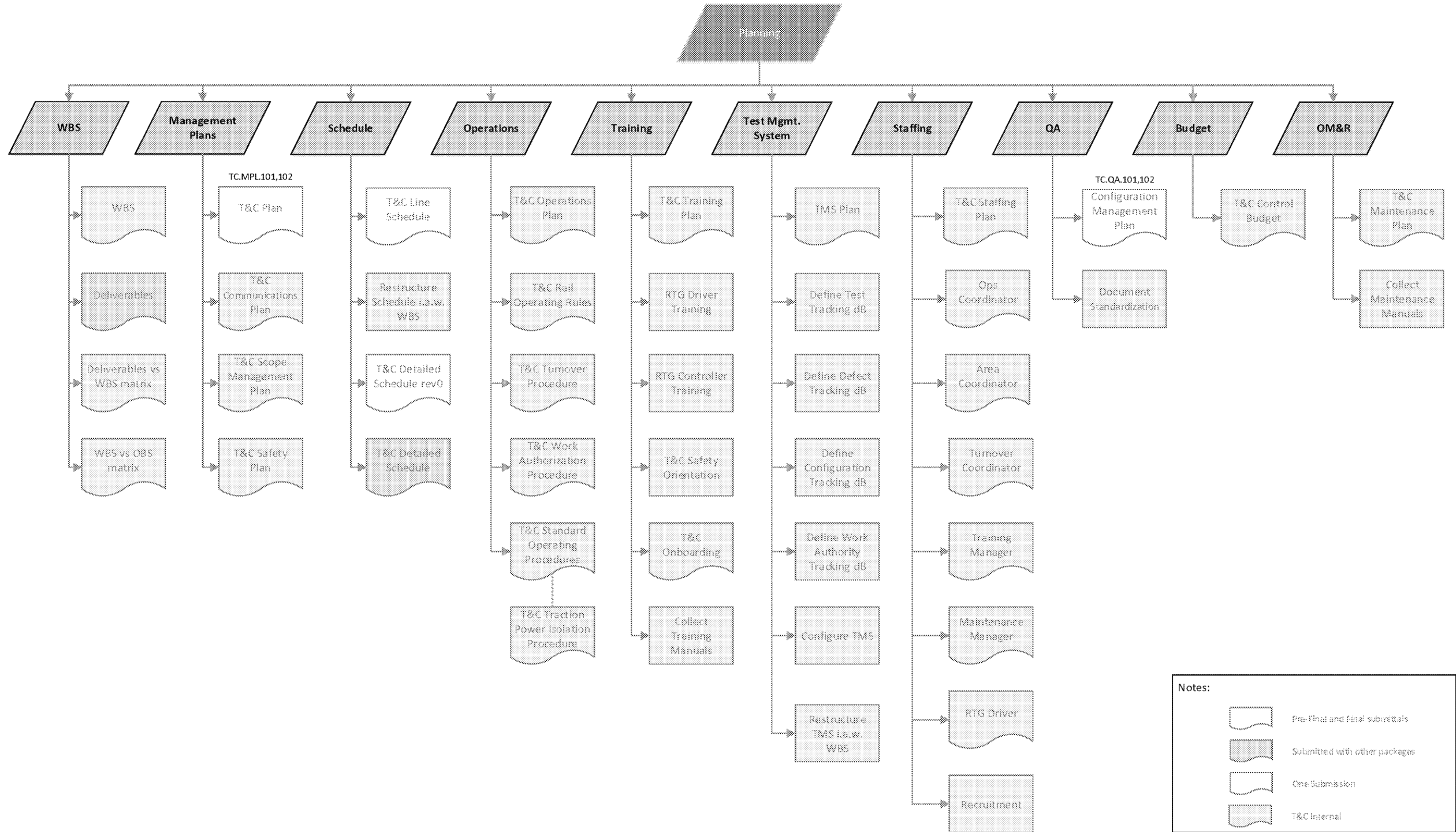
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Figure 4 – T&C Work Breakdown Structure: Planning, part 1




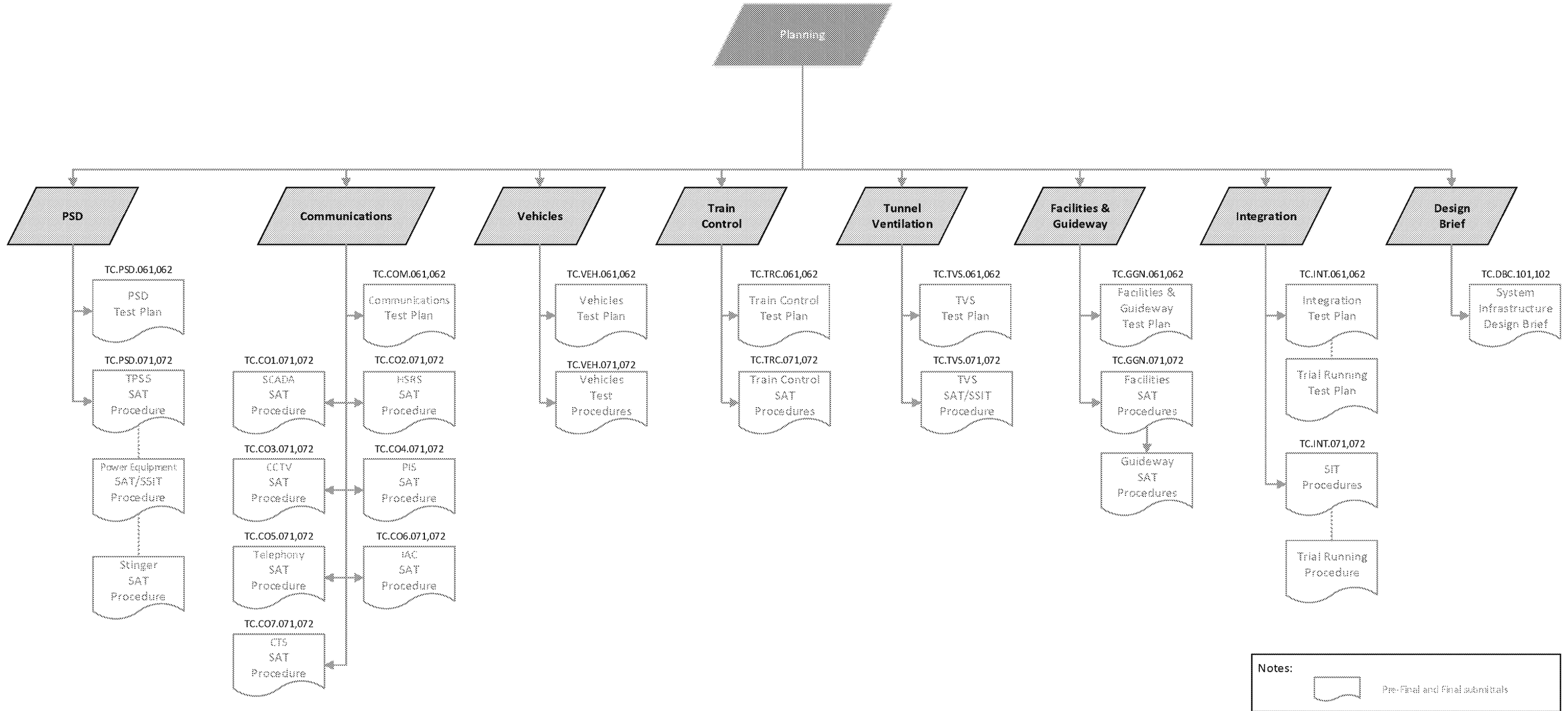
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Figure 5 – T&C Work Breakdown Structure: Planning, part 2




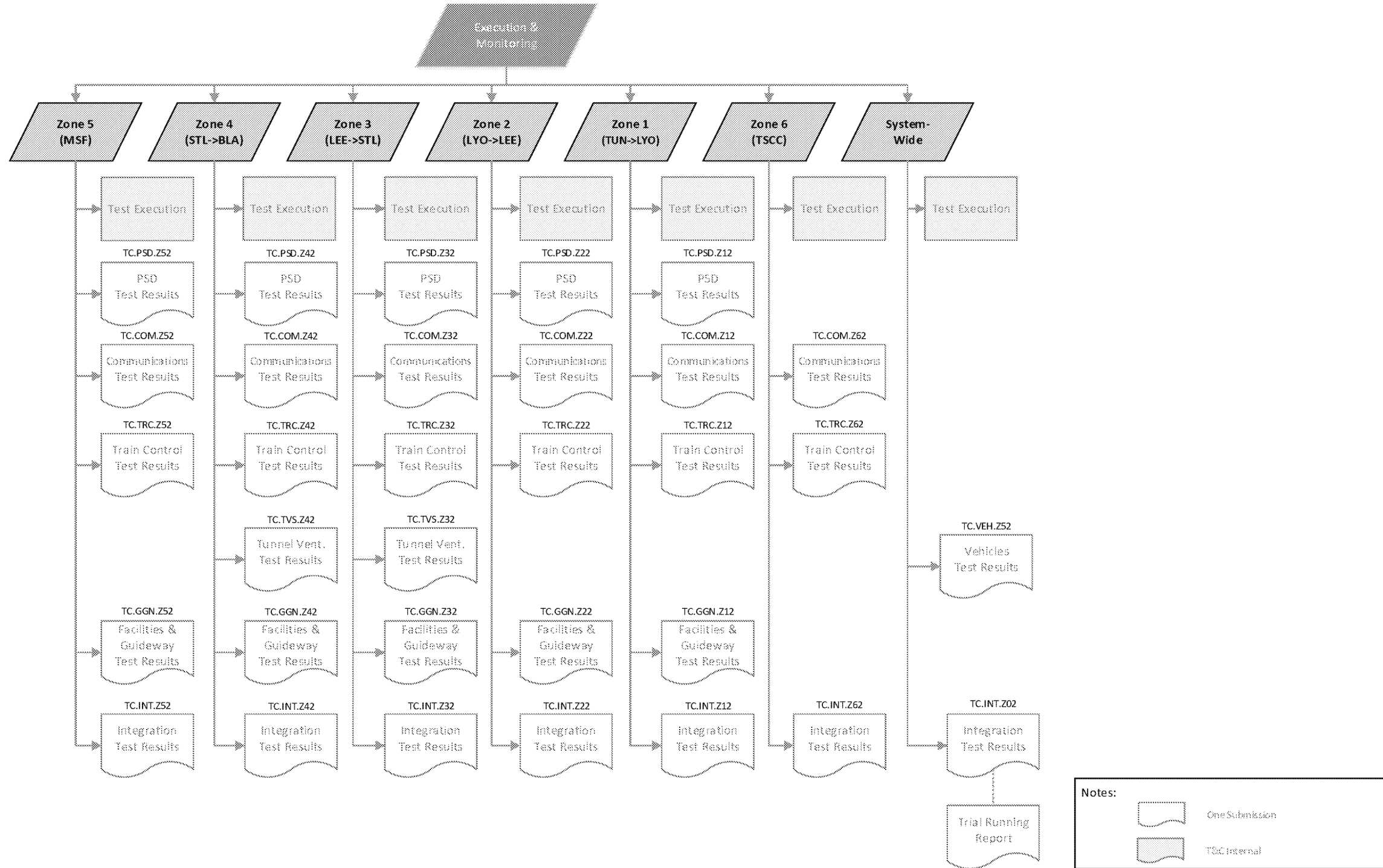
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Figure 6 – T&C Work Breakdown Structure: Execution & Monitoring, Part 1




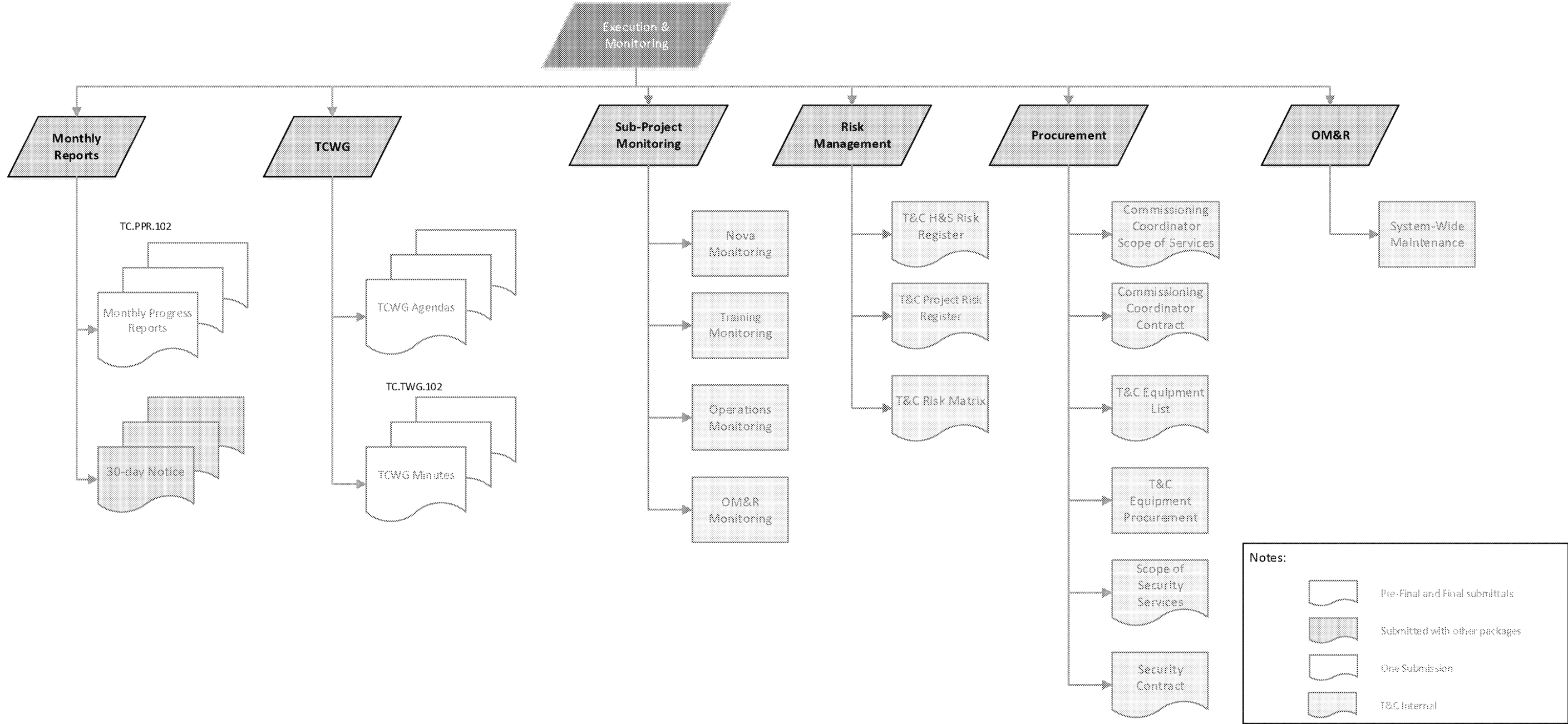
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Figure 7 – T&C Work Breakdown Structure: Execution & Monitoring, Part 2




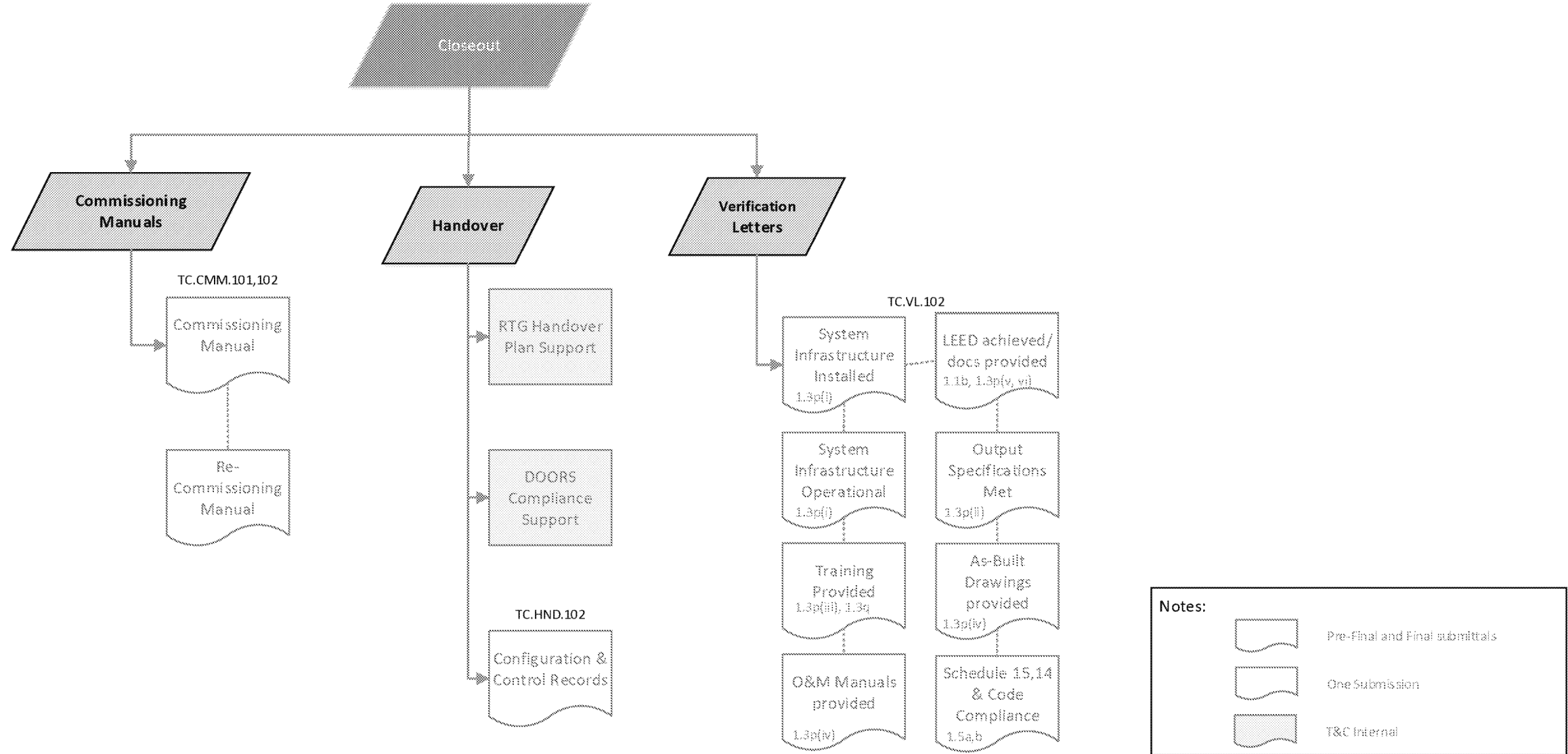
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Figure 8 – T&C Work Breakdown Structure: Closeout



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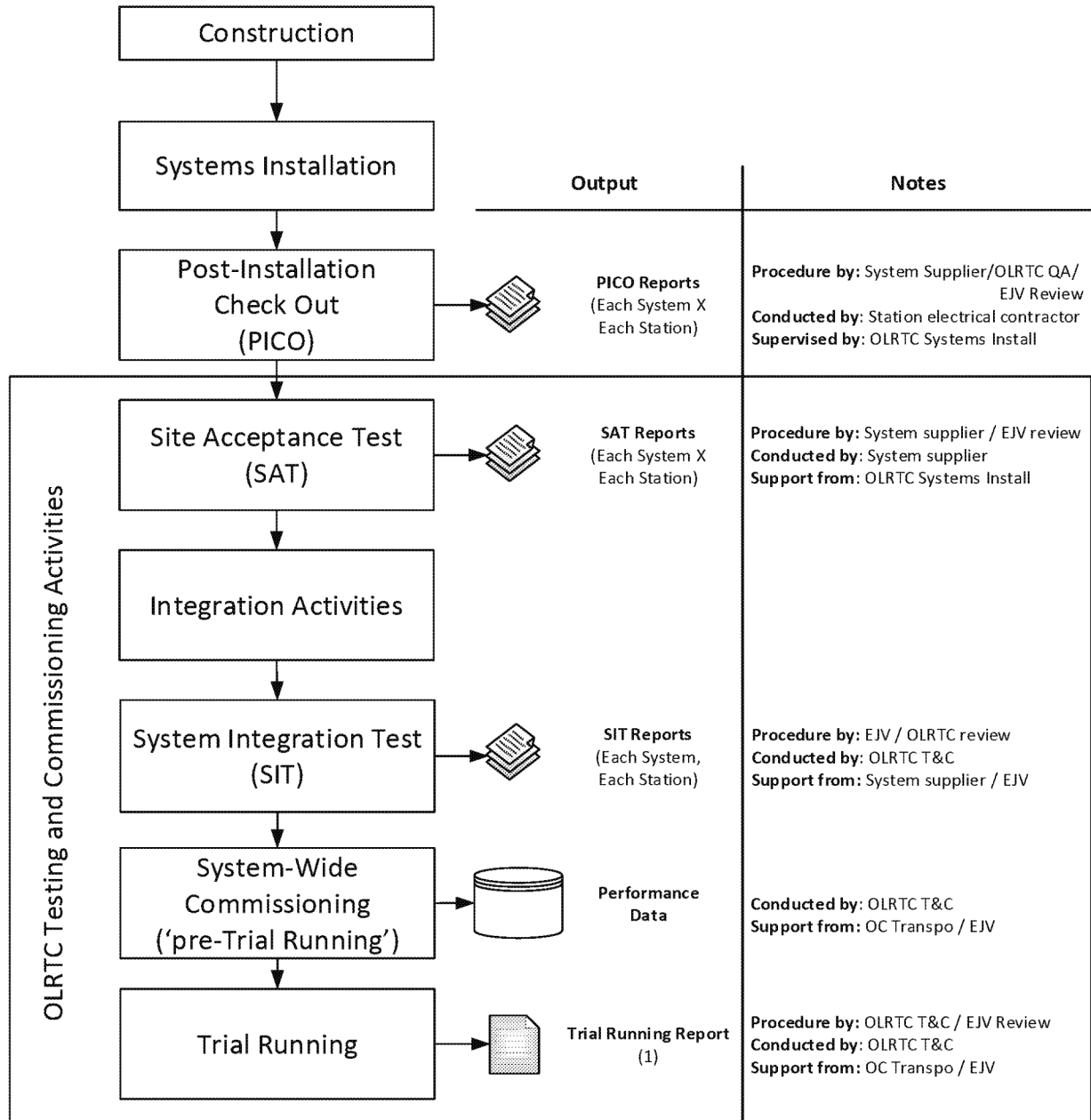
4.2 Schedule

At the time of this writing, the detailed T&C schedule has not been integrated into the project master schedule and will be a separate submittal. The integration of both schedules is due to begin in early 2016. Following integration, the T&C schedule will be reported only through the project master schedule.

The schedule follows the logical systems testing approach shown in Figure 9 – System Test Process. The pre-delivery tests shown in Figure 9 are described in the Pre-Delivery Tests section; the post-delivery tests shown in Figure 9 are described in more detail in the Post-Delivery Tests section.

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Figure 9 – System Test Process



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4.3 T&C Document Tree

This document forms part of the overall test strategy. A detailed breakdown of documents and the work can be found in the T&C project work breakdown structure, section 4.1. Other documents which make up the test strategy include:

- Planning:
 - T&C Plan (this document)
 - T&C Work Breakdown Structure
 - T&C Schedule
 - T&C Rail Operating Rules
 - T&C Standard Operating Procedures
 - OLRT-C Emergency Response Plan (part of OLRT-C Safety Management Plan)
 - Incident Call List
 - Incident Report
 - T&C Safety Plan (part of OLRT-C Safety Management Plan)
 - T&C Operating Notes and Restrictions
 - T&C Bulletin template
 - Test Plans
 - Test Procedures
- Execution & Monitoring
 - TCWG Minutes
 - T&C Monthly Look-Ahead (part of T&C Schedule and Monthly Report)
 - T&C Monthly Progress Report
- Test Results:
 - Vehicle (revenue and non-revenue)
 - PS&D (TPSS, OCS, grounding & bonding, corrosion control, stray current)
 - Guideway and Facility M&E, system-wide (including maintenance equipment)
 - Communication
 - SCADA
 - Train Control (controlled from YCC/BCC and TSCC)
 - Integration (including Trial Running and operations tests)
- Training (owned by the RTG Training Manager):
 - Training Plan
 - Training Schedule & Agenda
 - Video Recording of Selected Training Sessions
 - Training Report
 - T&C Driver's Handbook
- Close-out:
 - Verification Letter: System Infrastructure Installed
 - Verification Letter: System Infrastructure Operational
 - Verification Letter: LEED Commissioning of the MSF achieved

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- Verification Letter: As-Built Drawings provided
- Verification Letter: Requirement & Code Compliance
- Verification Letter: Operating & Maintenance Manuals provided
- Commissioning Manuals
- Configuration Control Records
- MSF monitoring and traction power monitoring verification results for energy target letter (not a T&C document)
- The Ottawa LRT Handover Plan (not a T&C document, but a project-wide plan)

This is a living list of documents that will be updated as the project progresses.

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4.4 Test Program Sequence

A generic sequence of testing activities will be followed for Systems, as described below. In general, there will be two phases to the testing program:

- Pre-Delivery Testing and
- Post-Delivery Testing

Pre-Delivery testing will include all testing activities up to the commencement of SAT such as PICO testing, FAT, First Article Tests, Component Tests, Qualification Tests or Type Tests. These activities will be undertaken by OLRT-C's subcontractors and suppliers. Oversight of these activities is done by OLRT-C QA and engineering groups.

Post-Delivery testing will include Static Tests, Start-up Tests, SATs, SITs, Set to Work Tests, Performance Verification Tests and finally Trial Running. These tests are designed to demonstrate that the system as a whole meets the technical requirements and is capable of supporting operation of the Ottawa LRT. For building M&E systems, building commissioning will be performed, building on the successful completion of the pre-delivery testing. Oversight of building commissioning will be performed by OLRT-C's commissioning agent as described in section 2.1.11 - Facility Commissioning Agent. Integration and systems commissioning will be the last T&C stage, and depends on successful pre-delivery and building commissioning.

These activities, based on the test phase, will be undertaken by OLRT-C staff or subcontractors and suppliers. The details of the test procedures are captured in other documents. The details of testing are captured in Inspection & Test Plans (ITPs) and systems test plans.

Appendix C provides the series of illustrations showing the sequence of Test & Commissioning (from PICO tests to Service Commencement) for the major systems. The list of figures is presented in Table 4.

Details of the test program will be communicated with the City through multiple means. This plan describes at a high level what tests will be performed. A preliminary list of the tests is given in Appendix F. A series of system test plans are being developed and will be delivered to the City to detail the test program. The system test plans which will be developed by OLRT-C are listed in Table 5. A template of the system test list (part of the system test plan) is given in Appendix G.

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Table 4 – T&C Sequence

<i>Figure</i>	<i>Name</i>
Figure 12	Fire Alarm
Figure 13	MSF TPSS
Figure 14	Power Distribution
Figure 15	Train Delivery
Figure 16	Signalling
Figure 17	Fibre Optic
Figure 18	Stations and BMS
Figure 20	Tunnel Ventilation
Figure 21	Radio Systems
Figure 22	Tunnel Lighting
Figure 23	Vehicle Service Equipment Delivery
Figure 24	Train Wash Delivery

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4.5 Pre-Delivery Tests

4.5.1 General

Pre-delivery tests are used as an input to T&C processes. Pre-deliver testing will begin in the factory with component, type and factory acceptance testing, all of which must occur before any equipment is delivered to site.

Successful completion of tests will be documented in the Test Management System. References to these procedures will be found in the System Verification Matrix to demonstrate compliance with the Schedule 14 requirements.

A more detailed discussion of specific Pre Delivery and Post Installation testing follows.

4.5.2 Specific Pre-Delivery Tests

Component Testing – Components will be inspected and tested in the factory. Component testing will be undertaken by all equipment suppliers. The results of all component testing will be available for inspection or audit by OLRT-C.

First Article Testing – will be conducted on the first production unit on some Systems Equipment prior to first shipment from the factory to ensure the units are suitable in all respect for the purpose intended by OLRT-C.

Qualification Testing or Type Testing – One or more samples of critical components, which do not have a proven history, will be subject to qualification testing. This testing will be monitored by OLRT-C representatives. Qualification testing will be performed to show compliance with applicable standards as required by the contract.

Qualification testing will be performed to show compliance with applicable standards as required by the contract. In general, components that are identified for qualification or type testing will be identified in ITPs.

Factory Acceptance Testing (FAT) – Where appropriate, and reasonably practicable, components that will be brought together to provide subsystems and systems will first be tested in the factory in a representative operating environment against an agreed set of factory acceptance or factory integration test procedures. On completion of the testing a FAT review will be held between the supplier and OLRT-C representatives (Engineer of Record or delegate) to confirm that the system or subsystem is fit to be deployed to the site.

Post-Installation Checkout (PICO) Testing – Once the deployed component, system or subsystem has been installed, it will be verified against the installation drawings to ensure correct installation and that

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no damage has been sustained in the installation process. This will include the type, routing, continuity and insulation of all cables as well as location of equipment.

4.6 Post-Delivery Tests

4.6.1 General

Once equipment has been installed at site and PICO's performed, the post-delivery test phase will begin. Successful completion of PICO, or other approved tests, will trigger SAT by the equipment supplier. T&C takes responsibility for the post-delivery tests. The process by which T&C takes control of equipment is described in section 5.6 - T&C Turnover.

Once T&C is satisfied with the SAT results, that system or equipment will be accepted and incorporated into the SIT program.

The T&C team will execute the SITs and Trial Running. System and equipment suppliers will support this testing as required to ensure that any issues with their system or equipment are addressed and to complete any tests that cannot be undertaken without other systems.

Successful completion of Post-Installation testing will be documented in T&C's Test Management System. Reference will be made in OLRT-C's System Verification Matrix to the suppliers' test reports and documentation to demonstrate compliance with the Contractual requirements.

SITs will be preceded with the Test Readiness Review to insure procedures are in place and all involved parties are prepared.

The City representative will be informed via a 30-day look ahead (through T&C monthly reports and/or project master schedule) of any scheduled testing and will be able to choose to witness any of the scheduled tests.

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Table 5 – List of System Test Plans

<i>System Test Plans</i>
PS&D Test Plan
Communications Test Plan
SCADA System Test Plan
Tunnel Ventilation Test Plan
Train Control Test Plan
Vehicles Test Plan
Facilities & Guideway Test Plan
Integration Test Plan

4.6.2 Specific Post-Delivery Tests

Site Acceptance Testing (SAT) – Following PICO and static train testing, the installed components, subsystems or systems will undergo start-up tests (aka “Set To Work”) and then be tested against an agreed set of SAT procedures. These procedures will generally complement those performed in the factory, but will also focus on requirements that could not be verified in the factory. SAT testing of a system may include some level of integration with other systems but is intended to primarily test each system independently.

Power, including traction power, will be applied during SAT and therefore site safety procedures will be prepared to reflect this new hazard on the T&C site.

Systems Integration Testing (SIT) – Once two or more systems have completed SAT, they will be brought together to commence SIT. Up until this point it is expected that all testing will be led by the suppliers with an OLRT-C representative monitoring the tests. From this point it is expected testing will be led by an OLRT-C representative with supplier support.

SIT procedures will include tests prepared by the equipment supplier and an OLRT-C representative. This reflects that some system suppliers are expected to be unable to demonstrate all technical requirements without integration with other suppliers systems. SITs will therefore concentrate on intersystem functionality and performance under normal, abnormal and emergency scenarios. It is expected that simulation and test equipment will be needed to carry out some SITs as the final system will integrate into a working revenue environment which may not be available for test purposes.

Regression Testing - Regression tests may be required when a hardware or software component is to be changed and/or upgraded, where functionality or performance may be impacted by the change. A regression test shall be conducted for each new version of the Ottawa LRT Systems installed, to detect

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unexpected impact resulting from program modifications. The regression test report shall identify any variation in the results on the current revision compared to that of a previously tested revision.

4.7 T&C Phases

Due to length of the Ottawa LRT and the fact that it contains tunnel, at-grade section and MSF, the testing area will be divided in T&C phases as shown in below. However, testing may vary as necessary to address complexity of test conduct, testing environment, testing methodology, supporting test tools and interdependency with third party interfaces. A graphical representation of the T&C test phases is shown in 10.

Table 6 – Test Phases

<i>T&C Phase</i>	<i>Time</i>	<i>Name</i>	<i>Geographical Limits</i>
1	21 weeks	Alstom Test Track	MSF and at grade section to Blair Station
2	39 weeks	Mid Stage	Tunnel section and at grade section from uOttawa to Blair stations
3	25 weeks	Full Track	Tunney's Pasture to Blair Station

Integration between the vehicle and the CBTC is critically important for the success of this project. Early CBTC testing will be performed in parallel with the activities outlined below following vehicle 1 qualification testing at the Pueblo, Colorado test track.

All periods shown are subject to adjustment through the master schedule.

4.7.1 Phase 1 – Alstom Test Track – 21 weeks

SIT will commence in the MSF. Priority will be given to the construction of the facility to enable earlier integration of many of the major systems, including vehicles, power supply, track, CBTC and communications. The systems and facilities at MSF will be taken over by T&C in stages once the T&C team concludes that either facility or section of track is fit for early testing. Priority will be given to track, traction power system, trains and train shop. This will enable early testing. For example, the test track will be taken over early to facilitate testing of each train set as it becomes available. As identified in the Alstom contract, a 4km energized test track is required on 1 September 2016.

SIT will be extended to Blair station once that portion of the systems installation and PICO is complete. This testing will include Cyrville and St. Laurent stations. Testing will begin with station SATs, station SITs, integrating each station to the MSF, then single train operations and will expand to multiple trains operating under CBTC.

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The test track and MSF will be used to verify much of the Ottawa LRT functionality and performance and will be critical to the overall success of the T&C program.

4.7.2 Phase 2 – Mid Stage – 39 weeks

Following the test track, SIT will be extended to the end of the tunnelled section of the alignment. This will include operating trains in the tunnel. This will allow testing at Tremblay, Hurdman, Lees, uOttawa, Rideau, Parliament and Lyon stations to be integrated into the system. This will allow full dynamic testing to be performed with multiple trains under CBTC operation.

This alignment section will be used to verify the remaining Ottawa LRT functionality and performance relating to tunnel ventilation and Integrated Systems.

4.7.3 Phase 3 – Full Track – 25 weeks

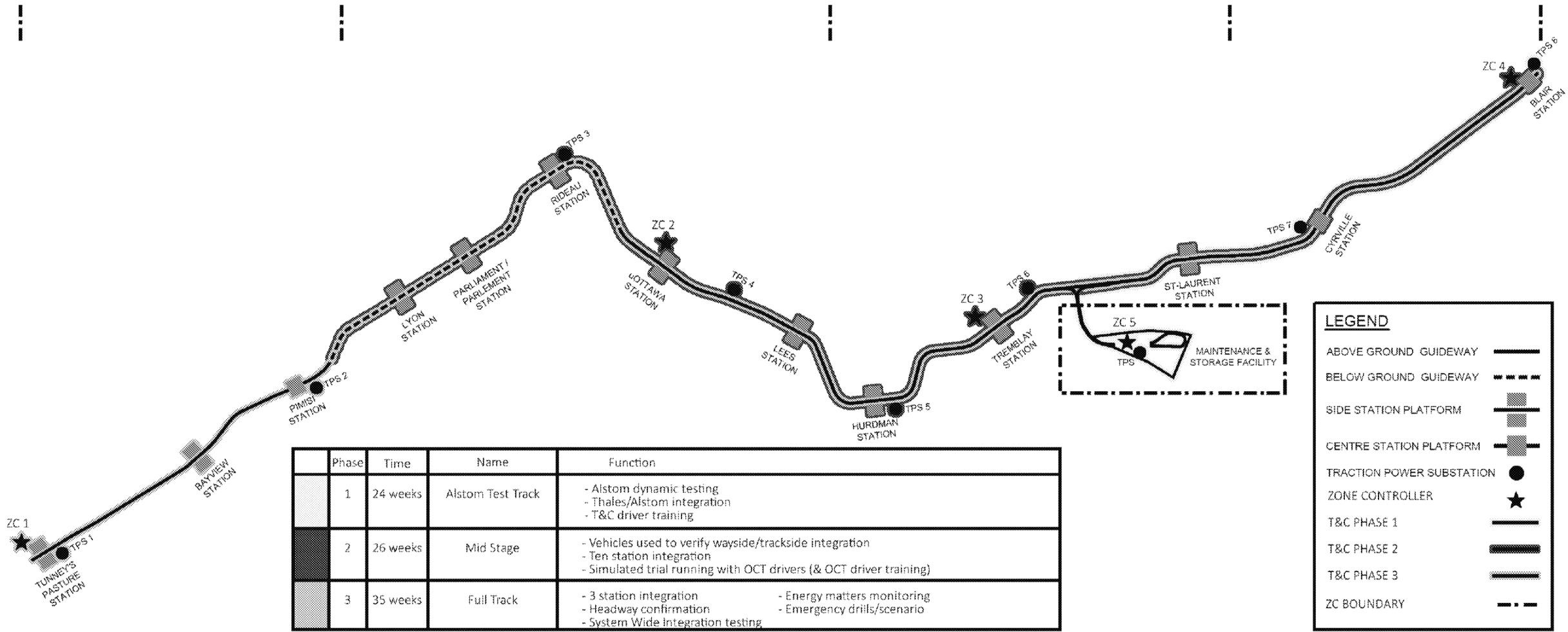
SIT will finally be extended from west tunnel portal to Tunney’s Pasture station. This will allow Pimisi, Bayview and Tunney’s Pasture stations to be integrated into the system. This will be a significant achievement for the project and will allow test running of the complete Confederation Line (Stage 1).

At this point any remaining performance testing, specifically related to abnormal and emergency response scenarios will be performed on the entire line. As each phase is accomplished there will be a need for additional train operators.

Completion of SIT will allow OLRT-C to commence Trial Running leading to Revenue Service Availability











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Figure 10 – T&C Phases



Phase	Time	Name	Function	
1	24 weeks	Alstom Test Track	- Alstom dynamic testing - Thales/Alstom integration - T&C driver training	
2	26 weeks	Mid Stage	- Vehicles used to verify wayside/trackside integration - Ten station integration - Simulated trial running with OCT drivers (& OCT driver training)	
3	35 weeks	Full Track	- 3 station integration - Headway confirmation - System Wide Integration testing	- Energy matters monitoring - Emergency drills/scenario

LEGEND

- ABOVE GROUND GUIDEWAY 
- BELOW GROUND GUIDEWAY 
- SIDE STATION PLATFORM 
- CENTRE STATION PLATFORM 
- TRACTION POWER SUBSTATION 
- ZONE CONTROLLER 
- T&C PHASE 1 
- T&C PHASE 2 
- T&C PHASE 3 
- ZC BOUNDARY 

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4.8 Sequence of SIT Activities

The strategy in undertaking SIT is to adopt a logical, low risk methodology where the number of Integrated System interfaces tested at any one time is minimised. The complexity of SIT will be built up as the functionality of specific systems is proven, and they are incorporated into the overall Ottawa LRT system. This is shown in the table below.

Table 7 – System Integration Progression

<i>TEST MODE</i>	<i>STATIC</i>	<i>SLOW SPEED DYNAMIC</i>	<i>SLOW SPEED DYNAMIC</i>	<i>FULL SPEED DYNAMIC</i>	<i>FULL SPEED DYNAMIC</i>	<i>NORMAL/ ABNORMAL/ EMERGENCY OPERATIONS</i>
# SYSTEMS	1	2	3+	3+	3+	
# TRAINS	NA	Single	Single	Single	Multiple	Multiple

The prerequisite to SIT is that all applicable systems have substantially completed SAT.

The SITs will be designed to address the specific requirements documented in the System Verification Matrix (SVM). As each SIT is successfully completed, the Test Management System will be updated.

The following list includes the tests to be performed. This is not comprehensive, and will be updated as the project progresses. The timing for the execution of these tests will be coordinated with the project schedule and resources.

4.8.1 Integration of SCADA and PS&D

- Verify wayside equipment – disconnect and transfer switches
- Verify integration of propulsion power substation with OCS
- Verify interface between SCADA and power systems
- Verify isolation between MSF and mainline OCS

4.8.2 Integration of Vehicle and Infrastructure

- Verify pantograph interface (OCS to vehicle)
- Verify gauging of vehicle on track
- Verify deflection measurements at the bridge and a typical Guideway span
- Verify vehicle noise measurement – e.g. squeaking on the rail
- Verify vehicle ride quality the length of Guideway
- Verify vehicle vibration does not affect structures / people residing along the alignment

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4.8.3 Integration of MSF and Mainline

- Verify MSF vehicle service equipment integration
- Verify MSF train wash equipment integration
- Verify MSF operation
- Verify train handoff between MSF and Mainline

4.8.4 Integration of Vehicle and CBTC

- Verify recovery of a failed train and train tracking
- Verify automatic and manual train mode transition
- Verify vehicle door control
- Verify emergency brake hold-off and emergency brake functions
- Verify interface between VOBC and CBTC
- Verify vehicle doors closed and locked status
- Verify park brake function
- Verify train integrity and coupler status
- Verify train fault monitor outputs

4.8.5 Integration of Vehicle and Communications

- Verify interface between vehicle subsystems (brakes, traction, HVAC, etc.) through CBTC and communications subsystem to control centre

4.8.6 Integration of SCADA and Tunnel Ventilation System

- Verify TVS/CCTV/BMS integration
- Verify tunnel ventilation modes for all TVS zones from TSCC
- Verify tunnel ventilation modes for all TVS zones from FCP
- Verify air-flows (after adjusting, balancing and testing fans during SAT)
- Verify Subway Environmental Simulation model with smoke test

4.8.7 Integration of BMS and Stations

- Verify integration of elevators and escalators with Control Centre
- Verify integration of station security with Control Centre
- Verify integration of station systems (HVAC, UPS, Sump Pumps,) with Control Centre
- Verify system wide Fire Alarm

4.8.8 P25 Radio

- Verify Station, Tunnel and MSF coverage
- Verify emergency services coverage

4.8.9 General Integration

- Verify time synchronization between master clock and CBTC, communications, vehicle subsystems

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- Verify failure management of interfaces between TPSS / vehicle, CBTC / communications, CBTC / vehicle, communications / vehicle and CBTC / communications / vehicle subsystems / travel time confirmation.
- Verify system wide CTS
- Verify Operational and Emergency light levels in tunnel and underground stations
- Verify operational headway
- Verify operational travel times
- Verify normal operations
- Verify abnormal operations
- Verify emergency operations
- Recover immobilized train – tunnel
- Recover immobilized train – Guideway
- Verify Maintenance of Way Equipment / Machinery on Guideway (performed by RTM)
- Verify winter operations

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4.9 Major T&C Milestones

Prerequisites and the approval process for major T&C milestones must be put in place. Additionally, the acceptance criteria (from system installation and vendor SAT) must be defined to allow these milestones to occur.

4.9.1 First Traction Power energization

- The OCS and the stinger in the MSF FVA area will be the first traction power components to be fully energized.
- This milestone will be coordinated with Alstom, as it is part of their testing program.
- Q1 2016

Table 8 – Pre-Requisites for First Traction Power energization

<i>Category</i>	<i>Pre-Requisites</i>
Section T&C Turnover (TPSS shop)	<ul style="list-style-type: none"> • PICOs & civil reports substantially complete & deficiencies documented • Inspection substantially complete & deficiencies documented • Forms substantially complete & deficiencies documented
Safety Certificates	<ul style="list-style-type: none"> • 2501 Power Supply Design
Maintenance	<ul style="list-style-type: none"> • Traction power maintenance training OR maintenance agreement signed
Training	<ul style="list-style-type: none"> • One round of Traction Power Isolation training complete
Safety Rules	<ul style="list-style-type: none"> • Confederation Line Rail Operating Rules formalized • T&C Operating Rules in place
Operational Procedures	<ul style="list-style-type: none"> • Traction Power Isolation Procedure formalized
Testing	<ul style="list-style-type: none"> • TPSS shop SAT • MSF stinger SAT • MSF PS&D SAT (for FVA area)
Approval Process	<ul style="list-style-type: none"> • OLRT-C Safety, Engineering, T&C • Alstom Safety, Testing

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4.9.2 First energized train movement

- Vehicle 2 will be the first moved in the Belfast Yard. Following the climate tests, vehicle 2 functional tests will be performed.
- This milestone will be coordinated with Alstom, as it is part of their testing program.
- Operating modes shall be ATPM and RM only.
- Q4 2016

Table 9 – Pre-Requisites for First energized train movement

<i>Category</i>	<i>Pre-Requisites</i>
Section T&C Turnover (TPSS yard, Belfast yard)	<ul style="list-style-type: none"> • PICO's & civil reports substantially complete & deficiencies documented • Inspection substantially complete & deficiencies documented • Forms substantially complete & deficiencies documented
Safety Certificates	<ul style="list-style-type: none"> • 2101 Revenue Vehicles Design • 2102 Revenue Vehicles Assembly • 2201 CBTC Design • 2708 Guideway Intrusions Outside Stations • 2802 Blue Light System • 2903 Interface Between Revenue Vehicles and CBTC
Security Certificates	<ul style="list-style-type: none"> • Se2100 MSF Design
Maintenance	<ul style="list-style-type: none"> • Maintenance training (vehicle, wayside, buildings) • Maintenance equipment (e.g. re-rail equipment)
Training	<ul style="list-style-type: none"> • One round of Traction Power Isolation training complete • 1 qualified RTG Controller • 1 qualified RTG Driver • All personnel in T&C Areas to have completed T&C training
Safety Rules	<ul style="list-style-type: none"> • Confederation Line Rail Operating Rules formalized • T&C Operating Rules in place
Operational Procedures	<ul style="list-style-type: none"> • Confederation Line Standard Operating Procedures formalized • T&C Standard Operating Procedures in place
Testing	<ul style="list-style-type: none"> • TPSS yard SAT • MSF yard OCS SAT (at least the areas to be driven) • MSF PS&D SAT (for yard) • Alstom static functional tests
Approval Process	<ul style="list-style-type: none"> • OLRT-C Safety, Engineering, T&C • Alstom Safety, Testing

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4.9.3 First train operation in ATO mode

- This milestone will be coordinated with Thales, as it is part of their testing program.
- This shall be conducted in the yard.
- 2017

Table 10 – Pre-Requisites for First train operation in ATO mode

<i>Category</i>	<i>Pre-Requisites</i>
Section T&C Turnover (wayside, comms./ PS&D/ CBTC equipment rooms)	<ul style="list-style-type: none"> • PICOs & civil reports substantially complete & deficiencies documented • Inspection substantially complete & deficiencies documented • Forms substantially complete & deficiencies documented
Safety Certificates	<ul style="list-style-type: none"> • 2202 CBTC Installation • 2203 CBTC Documentation • 2207 CBTC Systems Assurance • 2401 Communications System Design • 2402 Communications System Installation
Security Certificates	<ul style="list-style-type: none"> • Se2700 Rail Vehicle Design • Se2800 Train Control and Communication Design • Se3800 Train Control and Communication As Built
Maintenance	<ul style="list-style-type: none"> • Maintenance training (vehicle, wayside, buildings) • Maintenance equipment (e.g. re-rail equipment)
Training	<ul style="list-style-type: none"> • Minimum 2 qualified RTG Controllers (ideally 4)
Safety Rules	<ul style="list-style-type: none"> • Confederation Line Rail Operating Rules formalized • T&C Operating Rules in place
Operational Procedures	<ul style="list-style-type: none"> • Confederation Line Standard Operating Procedures formalized • T&C Standard Operating Procedures in place
Testing	<ul style="list-style-type: none"> • Qualified vehicle • Qualified VOBC • SAT of any connected PS&D, CBTC or Communications equipment
Approval Process	<ul style="list-style-type: none"> • OLRT-C Safety, Engineering, T&C • Thales Safety, Testing

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4.9.4 First Multi Train Operation

- This milestone will be coordinated with Thales, as it is part of their testing program.
- This shall be conducted in the yard.
- 2017

Table 11 – Pre-Requisites for First Multi Train Operation

<i>Category</i>	<i>Pre-Requisites</i>
Section T&C Turnover (wayside, comms./ PS&D/ CBTC equipment rooms)	<ul style="list-style-type: none"> • PICO's & civil reports substantially complete & deficiencies documented • Inspection substantially complete & deficiencies documented • Forms substantially complete & deficiencies documented
Maintenance	<ul style="list-style-type: none"> • Maintenance training (vehicle, wayside, buildings) • Maintenance equipment (e.g. re-rail equipment)
Training	<ul style="list-style-type: none"> • Minimum 2 qualified RTG Controllers (ideally 4)
Safety Rules	<ul style="list-style-type: none"> • Confederation Line Rail Operating Rules formalized • T&C Operating Rules in place
Operational Procedures	<ul style="list-style-type: none"> • Confederation Line Standard Operating Procedures formalized • T&C Standard Operating Procedures in place
Testing	<ul style="list-style-type: none"> • Two qualified vehicles • Two qualified VOBCs • SAT of any connected PS&D, CBTC or Communications equipment
Approval Process	<ul style="list-style-type: none"> • OLRT-C Safety, Engineering, T&C • Thales Safety, Testing

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4.9.5 First train operation in UTO mode

- This milestone will be coordinated with Thales, as it is part of their testing program.
- This shall be conducted in the yard.
- Late 2017 / early 2018

Table 12 – Pre-Requisites for First train operation in UTO mode

<i>Category</i>	<i>Pre-Requisites</i>
Section T&C Turnover (wayside, comms./ PS&D/ CBTC equipment rooms)	<ul style="list-style-type: none"> • PICOs & civil reports substantially complete & deficiencies documented • Inspection substantially complete & deficiencies documented • Forms substantially complete & deficiencies documented
Maintenance	<ul style="list-style-type: none"> • Maintenance training (vehicle, wayside, buildings) • Maintenance equipment (e.g. re-rail equipment)
Training	<ul style="list-style-type: none"> • Minimum 2 qualified RTG Controllers (ideally 4)
Safety Rules	<ul style="list-style-type: none"> • Confederation Line Rail Operating Rules formalized • T&C Operating Rules in place
Operational Procedures	<ul style="list-style-type: none"> • Confederation Line Standard Operating Procedures formalized • T&C Standard Operating Procedures in place
Testing	<ul style="list-style-type: none"> • As directed by Thales safety program
Approval Process	<ul style="list-style-type: none"> • OLRT-C Safety, Engineering, T&C • Thales Safety, Testing

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4.9.6 Trial Running

- The final major test event, confirming PA compliance and performance.
- May 2018

Table 13 – Pre-Requisites for Trial Running

<i>Category</i>	<i>Pre-Requisites</i>
Section T&C Turnover (all)	<ul style="list-style-type: none"> • PICOs & civil reports substantially complete & deficiencies documented • Inspection substantially complete & deficiencies documented • Forms substantially complete & deficiencies documented
Safety Certificates	<ul style="list-style-type: none"> • All remaining Safety Certificates
Security Certificates	<ul style="list-style-type: none"> • All remaining Security Certificates
Maintenance	<ul style="list-style-type: none"> • Maintenance training (vehicle, wayside, buildings) • Maintenance equipment (e.g. re-rail equipment)
Training	<ul style="list-style-type: none"> • 15 qualified OCT Controllers • 46 qualified OCT Drivers • All personnel in T&C Areas to have completed T&C training or T&C orientation
Safety Rules	<ul style="list-style-type: none"> • Confederation Line Rail Operating Rules formalized • T&C Operating Rules in place
Operational Procedures	<ul style="list-style-type: none"> • Confederation Line Standard Operating Procedures formalized • T&C Standard Operating Procedures in place
Testing	<ul style="list-style-type: none"> • Follows successful completion of Ottawa LRT T&C
Approval Process	<ul style="list-style-type: none"> • OLRT-C Systems Engineering, T&C, Technical Director • Independent Certifier • City • Safety Auditor

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4.10 Energy Matters

In accordance with the Project Agreement Schedule 8 Part 1 Section 2.7, a final Energy Target Letter is to be delivered to the City. This letters outlines the actual energy performance of both the MSF and system wide Traction Power. This letter provides the baseline for painshare and gainshare calculations.

Analysis, monitoring and verification will be performed for MSF energy use as well as system-wide traction power. The results will be used to create the Energy Target Letter.

Following the monitoring period for both the MSF and system-wide traction power, the monitoring equipment will remain. RTM may use data from the monitoring equipment to generate the year-end energy summary letters for the duration of the maintenance period.

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4.11 Reliability, Availability and Maintainability

RTG's Systems Assurance Manager is in the process of developing a RAM plan. Refer to [11].

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4.12 Trial Running

4.12.1 General

Trial Running will demonstrate that the complete Ottawa LRT infrastructure together with its operator can deliver on a day-to-day basis the PA Scenario 1 performance (24,000 PPHPD). OLRT-C will prepare a Trial Running Plan and Procedure to document the test procedures and summarize the contractual requirements related to this phase of commissioning. Trial Running will incorporate the formal demonstration required under the Ottawa LRT Project Agreement to allow authorization for Service Commencement.

4.12.2 Trial Running Objectives

Trial Running will follow successful completion of SIT. The primary objective of Trial Running is to demonstrate to the stakeholders that the system is ready for revenue service commencement. Maintenance staff, OC Transpo drivers and OC Transpo controllers will be fully trained and will be familiar with the operation of the system prior to Trial Running. OLRT-C will run the complete system through several operating scenarios to:

- Familiarize operating and maintenance staff with the operation of the integrated system and Standard Operating Procedures [1]
- Demonstrate and validate the proposed service plans, operating procedures operational performance requirements [1]
- Verify system operating reliability in simulated operating scenarios [1]
- Verify failure and emergency recovery procedures
- Verify vehicle and station availability will result in a payment deduction of 0.00% [12]

4.12.3 Scope of Trial Running

Trial Running will occur over a period of 12 days following successful completion of SIT. At the successful completion of Trial Running, the Ottawa LRT System will be ready for Service Commencement.

Full regular service will be operated during Trial Running based on the proposed service plans. In addition, a number of failure management operating scenarios will be tested during Trial Running.

Prior to the Trial Running test, several weeks of full service practice will be performed. This is to ensure that Trial Running will be successful.

4.12.4 Station and Vehicle Reliability

During Trial Running, operating data will be collected and it will be verified that a process is in place for collecting, evaluating and validating this data [1]. To prove that the system is capable of achieving 0.00% payment deductions (which is 99.7% availability) during Revenue Service, vehicle availability and station availability shall be calculated for both peak and off-peak periods.

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This demonstration shall prove that the peak & off-peak Vehicle Kilometers Availability Ratio is 98.0% or higher, and that the peak & off-peak Station Availability Ratio is 99.7% or higher. Peak and off-peak availability shall be calculated separately. Calculation of vehicle availability and station availability shall be performed as set out in PA Schedule 20, but reproduced for clarity below. For the purposes of the following equations, stations are grouped as follows: [12]

Table 14 – Station Groups

<i>Group 1 Stations</i>	<i>Group 2 Stations</i>	<i>Group 3 Stations</i>
<ul style="list-style-type: none"> • Tunney's Pasture • Lyon • Parliament • Rideau Centre • Hurdman • Blair 	<ul style="list-style-type: none"> • Bayview • uOttawa • St. Laurent 	<ul style="list-style-type: none"> • Pimisi • Lees • Tremblay • Cyrville

Station Availability Ratio: [12]

$$SAR = 0.65 \times \left[\frac{SSH_1 - SAF_1}{SSH_1} \right] + 0.20 \times \left[\frac{SSH_2 - SAF_2}{SSH_2} \right] + 0.15 \times \left[\frac{SSH_3 - SAF_3}{SSH_3} \right]$$

Where:

- SAR Means the Station Availability Ratio
- SAF₁ Means the sum of group 1 Station Availability Failure Hours
- SAF₂ Means the sum of group 2 Station Availability Failure Hours
- SAF₃ Means the sum of group 3 Station Availability Failure Hours
- SSH₁ Means the sum of group 1 Scheduled Station Hours
- SSH₂ Means the sum of group 2 Scheduled Station Hours
- SSH₃ Means the sum of group 3 Scheduled Station Hours

Vehicle Availability Ratio: [12]

$$VAR = \frac{R + NPCC}{S}$$

Where:

- VAR Means the Vehicle Availability Ratio
- NPCC Means missed revenue service vehicle kilometres due to a Non-Project Co Cause
- R Means Revenue service vehicle kilometres performed

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S Means revenue service vehicle kilometres Scheduled

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5.0 PROCESSES

The T&C Manager will manage all T&C activities in accordance with this T&C Plan, and the project master schedule. The T&C Manager will report progress on a monthly basis. Any changes to the construction and turnover schedule that may affect T&C will be addressed at regular interface meetings and reflected in subsequent revisions to the project master schedule. Also, T&C will present a monthly look ahead to facilitate planning.

The System Verification Matrix (SVM), described below, will be used to document and monitor the status of testing against each project requirement.

5.1 Configuration Management

Configuration Management (CM) will be used to control all software and hardware updates before they are introduced in the testing environment. All suppliers will be responsible for defining and maintaining their own Configuration Management plans. The overall system configuration will be maintained in a central database (TMS, see section 7.0) with input from each supplier. The suppliers will be required to submit their system configuration as a prerequisite to the associated SAT. OLRT-C will develop a Configuration Management Plan where it will specify which configuration items will be tracked.

The T&C Manager (or designate) will review and accept change notices (such as new software revisions) before the change is allowed to be implemented in the field. Suppliers will be required to submit appropriate documentation for engineering changes, which will be reviewed and accepted by the chair of the Change Control Board (or designate) before forwarding to T&C for implementation. The configuration database will also be used to track non-engineering configuration changes, such as replacing a faulty component with an identical component.

The T&C Manager (or designate) is responsible for coordinating the field implementation and issuing T&C Bulletins and/or restrictions to document changes. Procedures will be employed to ensure that all personnel affected by a change are properly notified.

5.2 Coordination

Coordination with the Independent Certifier will be performed by the Commissioning Coordinator, as per Schedule 14 1.7(a) [1].

Coordination with the City of Ottawa's Emergency Services will be performed through the SERWG (Security and Emergency Responders Working Group).

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Coordination with OC Transpo will be required during fire alarm testing, due to the 3rd party monitoring of the fire alarm system. The plan for OC Transpo's MSF occupancy is to be expanded elsewhere.

5.3 Informing Witnessing Parties

The sequence of T&C testing is identified in the Test & Commissioning Plan (this document) and the work plan is specified in the project schedule. A monthly look-ahead to be distributed monthly.

A list of witnessing parties will be tailored to each test, but will draw from the list of T&C Stakeholders, Table 15.

Table 15 – T&C Stakeholders

<i>T&C Stakeholders</i>
Commissioning Coordinator
Independent Certifier
City of Ottawa – RIO
City of Ottawa – OC Transpo
Systems Safety Assurance Manager
Engineers of Record
RTM
OLRT-C Safety Team
OLRT-C Systems Installation Team
OLRT-C Quality Assurance Team
SIT Procedure Development Team

5.4 Progress Reports

Progress reports will be generated by the T&C Manager monthly, as per PA Schedule 14 1.6(d). [1] The Commissioning Coordinator will review these monthly reports which will then be delivered to the city, as per PA Schedule 14 1.3 (n) [1] and section 2.1.9 – Commissioning Coordinator.

5.5 Operations Procedural Changes

Any changes to the T&C Rail Operating Rules or the T&C Standard Operating Procedures will be communicated with the City and OC Transpo. These documents will be updated as required.

Due to the safety-critical nature of procedures in a light rail environment, changes to rules or procedures will be posted as Operating Bulletins. For more on operating bulletins, see the T&C Rail Operating Rules [8].

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5.6 T&C Turnover

As the T&C Team is the final Beneficial Occupant on the project, they are responsible for receiving systems and equipment that expose workers to new and additional hazards and/or ensure proper functioning of safety systems. These include:

- Traction power substations
- Track work and special trackwork
- Overhead Catenary
- Tunnel ventilation
- Fire and life safety systems
- Communications-based train control
- Station systems, including
 - Elevator & escalator
 - Coiling grills
 - Guideway intrusion
- Communication systems, including:
 - CCTV
 - Fiber optics
 - Building management
 - Public address
 - Intercom and telephones
 - Passenger information

As the work of T&C presents hazards such as trains and energized OCS at 1500 volts, any area of the project that is handed over to T&C becomes a test area and must be partitioned so that the test area is clearly defined and effectively marked to prevent unauthorized movement of workers, equipment and materials into the test area.

Access is allowed into a test area through the T&C Work Authorization Process [18]. Contractors will request access into a test area by completing a Work Authorization Application and submitting to the T&C Team. If the work can be accommodated the application is approved and returned to the applicant with relevant information. There are several steps to the handover process:

1. A pre-handover meeting
2. Site survey
3. Handover of the Beneficial Occupancy
4. Post-handover activities

Additional information on T&C Turnover can be found in OLR-16-0-0000-PRC-0001 reference [17], the T&C Turnover Procedure.

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6.0 REPORTING METHODS

This section describes the reporting methods that will be used during T&C. Each document type described below will be revision controlled and tracked by the project document control department.

6.1 System Verification Matrix

The System Verification Matrix (SVM) is a database used to document all project requirements. The SVM will be created using DOORS requirements management software. The SVM will be the key tool used to report requirement compliance. All project requirements contained in the Ottawa LRT Project Agreement are included in the SVM. The following information is included in the SVM for each requirement:

- Item Number
- Requirement Text
- Type
- Safety
- Compliance (Compliant, Compliant with intent, Not Compliant, Not Applicable)
- Document Name (documents like: design, studies, as-built, test results)
- Document Number
- Method (analysis, inspection, demonstration, test)
- Completion Status
- Comments

Requirement analysis will be performed on relevant technical sections of the Project Agreement (notably schedule 15). The requirement analysis will feed into the testing program. As noted above, requirements will be annotated with which test will prove compliance. During the course of the requirement analysis if it is discovered a test is required in addition to the preliminary list of tests outlined in Appendix F, a new test will be added. Requirement analysis will also identify which requirements are safety-related.

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6.2 SIT Procedures

Formal commissioning test procedures will be prepared for each test. SIT procedures will be prepared and approved by OLRT-C to verify and demonstrate system integration, functional and performance requirements are achieved.

Suppliers will be required to prepare SAT procedures in accordance with their test plan.

6.2.1 Preparation of SIT Procedures

The SIT procedures will be formulated from a series of workshops involving OLRT-CRTG EJV system Subject Matter Experts for systems such as, communications, power supply & distribution and infrastructure. SIT procedures will be written to verify the interfaces between the systems and validate the integrated functions between systems.

The individual subcontractor's test plans and procedures will be used as supporting documentation for the preparation of the SIT procedures. The SIT procedures must be used to complete the pass/fail evaluation of the individual systems, the integration between the systems and the demonstration of the Ottawa LRT System. The SIT procedures list will be found in the integration test plan, see Table 5 – List of System Test Plans.

Test procedures will be prepared in accordance with this document. A template of the SIT procedures is provided in Appendix E - Example of SIT Procedure. It is the strategy of OLRT-C to adopt one universal format for test procedures. If there is a need for additional information, the template will be changed. Test procedures will include the following:

- A. Test ID:** consists of the functional area and a counter, for example, DEM-001
- B. Revision:** current revision of the procedure
- C. Title** –describes the overall functionality to be tested
- D. Commencement Date and Time** – date and time when the execution of the procedure starts
- E. Completion Date and Time** – date and time when the execution of the procedure ends
- F. Estimated Duration** – estimated time required to execute the procedure in (days,) hours and minutes
- G. Actual Duration** – actual elapsed time to execute the procedure in (days,) hours and minutes
- H. Prepared By** – name of the author who prepared the original procedure
- I. Preparation Date** – date when the procedure was initially prepared
- J. Revised By** – name of the author who made the last modification to the procedure
- K. Revision Date** – date when the procedure was last updated
- L. Approved By** – name of the reviewer who approved the last version of the procedure
- M. Approval Date** – date when the last version of the procedure was approved
- N. Site / Area** – site or area where the procedure is performed

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- O. Prerequisites** – identifies the dependencies for the procedure to be executed, including major resources required (such as test/measurement equipment, resources outside of the OLRT-C’s authority)
- P. Tester (Name / Signature / Date and Time)** – name and signature the person responsible for completing the procedure as well as date and time when the procedure is completed
- Q. Witness (Name / Organization / Signature / Date and Time)** – name, organization and signature of person witnessing execution of the selected procedures as well as date and time when the witnessing of the procedure is completed
- R. Reviewer (Name / Signature / Date and Time)** – name and signature of reviewer who reviews and accepts the test results as well as date and time when the procedure is reviewed
- S. QA Reviewer (Name / Signature / Date and Time)** – name and signature of representative from Quality Assurance who reviews the procedure and results as well as date and time when the procedure is reviewed
- T. Supporting Documentation** – listing of formal documentation used to prepare the procedure
- U. Requirements List** – listing of requirement numbers in the Ottawa LRT Project Agreement that are satisfied by the procedure
- V. Scope** – outlines the purpose of the procedure, the system functions, desired results and lists the individual test cases included in the procedure
- W. Observations** – observations noted by the tester during or after executing the entire procedure
- X. Procedure Overview and Notes** – provides an general overview of the procedure and special instructions for executing the entire procedure
- Y. Deviations / Modifications** – notes and procedure changes required during execution of the procedure
- Z. Test Case** – individual test case within the SIT procedure complete with overview of the test case and special notes for executing the test case
- AA. Steps** – a breakdown of the test case into discrete steps, which consists of an event (action or stimulus) and expected outcome.
- BB. Expected Results** – expected results for each of the test steps with PASS / FAIL evaluation for the test step. Each step will be subject to a pass/fail evaluation. Some steps will be evaluated against a measurable numeric value. In these cases, the quantitative results of the test must be documented, in addition to the pass/fail results. Other steps will require qualitative evaluation and professional judgement to determine a pass or fail. If any step in a test procedure is failed, a defect will be raised and recorded on the procedure
- CC. PASS / FAIL / RETEST** – Overall execution results of the entire SIT procedure. A SIT procedure with a FAIL rating will have to be re-executed completely. RETEST suggests only relevant test case(s) and / or steps needs to be retested for the entire procedure to achieve the PASS status
- DD. If not PASS, Defect:** - listing of defect numbers resulting from the procedure execution when one or more of the test steps have the FAIL status

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6.2.2 SIT Approval Process

After a member of the RTG EJV engineering team prepares SIT procedures, the procedures are reviewed by the Engineer of Record (or OLRT-C system Subject Matter Expert) and system integration manager (or delegate). If updates are required to a SIT procedure, the procedures are revised, the revision number is incremented and the new revision is again reviewed and approved.

Results of SIT to be reviewed by the Engineer of Record or the OLRT-C system Subject Matter Expert. The QA department will audit the SIT process, which may include testing results.

The reviewer may change the status of a test result if he/she disagrees with the assessment of the tester. In this case a defect will be raised which will explain the reason for the change and recommend the required action to correct the problem. The defect will be forwarded to the system Subject Matter Expert for resolution as described in Section 9.0 - Defect Resolution.

The tester may discover an error in the procedure during performance of the test. If the tester judges the error to be minor then the tester will mark up the procedure and continue performing the test according to the mark-up. A tester may also mark up a procedure when real world conditions prevent a test from being performed exactly as written, but an equivalent test can be performed. The reviewer is responsible for assessing whether the marked-up test achieved the intended result and may raise a defect against the test procedure as appropriate. Mark-ups will be reviewed and approved by the Engineer of Record (or OLRT-C system Subject Matter Expert) and the systems integration manager (or delegate).

6.2.3 SIT Reports

Test reports will document the results and conclusions of a test or group of tests. Test reports will either be marked-up versions of the procedures or be produced using the TMS database described in section 7.0. All test procedures that are covered in a test report will be attached to the report.

The system will generate a report, but reports will be signed in ink, then scanned and saved. Paper originals will also be retained. As an alternative to paper reports, OLRT-C is investigating a test report database and filling in the reports on a tablet.

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7.0 TEST MANAGEMENT SYSTEM

A T&C database will be used by the T&C team to store information relevant to T&C. This forms the backend of the Test Management System (TMS). The TMS will have four parts: Test Tracking, Defect Tracking, Configuration Tracking and Work Authority Tracking. The TMS allows easy data input and generation of meaningful reports (which may be added to the T&C monthly progress reports).

7.1 Test Tracking

Detailed information about the test list (name, number, document status, test stage, results, associated defects, and others) will be entered in the database. The database will allow the T&C Manager to accurately identify which tests have passed or must be repeated.

7.2 Defect Tracking

As described in section 9.0 Defect Resolution, T&C shall track defects resulting from tests and other T&C activities. These defects will be entered, organized and managed through the TMS.

7.3 Configuration Tracking

The TMS will be used to build an asset list of hardware and software. These configuration items will include data like serial numbers, software numbers, firmware numbers and dates of installation/replacement. As described in section 5.1 - Configuration Management, this process will be governed by OLRT-C configuration management plan.

7.4 Work Authority Tracking

As operations are conducted under T&C, work authorities will be issued by rail controllers. These authorities will be logged in the TMS.

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8.0 DOCUMENT CONTROL PROCEDURES

The OLRT-C Document Control team will control all T&C documentation, in accordance with OLRT-C Document Control procedures.

Document Control will perform the following functions related to T&C:

- Issue document numbers, including test procedure and report numbers
- Log document numbers into Viewpoint 4P
- Track revision status of each test procedure and report
- File original paper copies of each test procedure and report (or electronic copies if not paper)
- Distribute test procedures and reports under formal transmittal as directed by T&C staff

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9.0 DEFECT RESOLUTION

All test failures will be treated as defects to be tracked and resolved in the TMS (as described in section 7.2 - Defect Tracking). Each failure and its description will be entered as a defect, usually by the T&C tester², in the database. The defect will be initially assigned to a system Subject Matter Expert for review. The system Subject Matter Expert may assign the defect to one of his or her team members or supplier for resolution. When the defect has been fixed, the defect with corrective action details will be released to T&C for verification. If the defect resolution passed the regression test of the test procedure, the defect is closed. If the resolution does not fix the problem, the defect is re-assigned to the system Subject Matter Expert.

If the system Subject Matter Expert and/or the T&C Manager decide the defect should be reported as a nonconformity, a nonconformity report (NCR) will be generated. The OLRT-C Quality Manager will keep an NCR log, and will issue NCR numbers as required. The nonconformity will be tracked and corrected by the formal NCR process. Details on nonconformities, and corrective and preventative actions are provided in Quality Management Plan [19].

² Defects may be raised by others, such as persons witnessing the test.

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10.0 SAFETY MANAGEMENT

10.1 General

These processes are detailed in the OLRT-C T&C Safety Management Plan [16], but are highlighted in this document for information. During T&C, safety will be managed in accordance with the Health and Safety Plan and the T&C Rail Operating Rules. The T&C Rail Operating Rules will be developed based on the Confederation Line Rail Operating Rules, developed by RTM. T&C site coordinators are responsible for coordinating train movements and traction power activations and will follow safety procedures developed in conjunction with the safety organization as outlined in section 2.3.

The T&C Manager will be responsible for enforcing a work permit process to manage access to the T&C site. All personnel will be required to attend a course on T&C safety and work permit procedures before being allowed to work unattended on the site.

Any work on any component of the system in an area that has been handed over to T&C (as described in section 5.6 - T&C Turnover) will require an approved work permit that must outline the work to be done, the risks that may be present and any mitigation actions that must be taken. For more information see T&C Turnover Procedure, reference [17].

At the beginning of each day, T&C Site Manager will conduct morning toolbox meeting presenting the test activity schedule for the day.

10.2 Specific Scenarios

10.2.1 Tunnel Ventilation

Before the Tunnel Ventilation System has been tested, tunnel ventilation during T&C shall be provided using the temporary construction ventilation system. The temporary system shall only be removed once the Tunnel Ventilation System is fully functional. If trains are to be used while the temporary system is installed, it will be verified that no equipment is within the dynamic envelope of the vehicle.

10.2.2 CCTV

Before Guideway intrusion and CCTV systems are operational, safety and security along the 4km test track Guideway shall be ensured in several ways. First, fencing shall be used along the entire Guideway. Second, controlled access shall be used for qualified persons to enter the T&C area. Lastly, it is planned that temporary surveillance cameras shall be installed to record the Guideway and stations 24 hours per day. Overall security measures are described in the Construction Security Plan. [15]

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10.2.3 Yard Operations

Yard operations safety during T&C will be assured by the YCC controller. Any activity in the T&C zone shall require a work permit in accordance with the T&C Rail Operating Rules and T&C Standard Operating Procedures. [8] [14] Work permits shall be coordinated by the T&C team, but ultimately issued by the YCC controller. Conflicting activities will be coordinated and resolved by the T&C manager.

The T&C area shall be controlled access, as is the Alstom Final Vehicle Assembly (FVA) area. All individuals entering the T&C area must be trained in T&C Safety (according to the Safety Management Plan [16] and the Training Plan [13]) or accompanied by a trained individual.

Security to the site will be provided. The MSF facility manager will oversee site security.

10.2.4 TSCC to BCC Transfer of Control

This will be described by the relevant Standard Operating Procedures. [8] Also tested as part of the System Operations tests.

10.2.5 CTS Network Failure

This will be described by the relevant Standard Operating Procedures. [8]

10.2.6 Traction Power Supply Failure & Start Up

This will be described by the relevant Standard Operating Procedures. [8]

10.2.7 Fallback to Line of Sight

This will be described by the relevant Standard Operating Procedures. [8]

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11.0 SYSTEM ACCEPTANCE

The TMS (Section 7.0) will be used to track defects. Some defects will be identified as related to Substantial Completion. Regular meetings will be held with the Ottawa LRT stakeholders to review and resolve any such defects. Any defects agreed to be minor in nature at the time of substantial completion must be assigned a date for corrective action. Details expanded in the Ottawa LRT handover plan.

Internal acceptance criteria will be developed to satisfy RTG stakeholders that each system is fit and capable to operate through the warrantee period through to the end of the maintenance period. Acceptance criteria will be developed for:

- T&C System acceptance from System Installation team (post-PICO)
- System acceptance following integration of every system into the overall Integrated System

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APPENDIX A. T&C HIGH-LEVEL SCHEDULE

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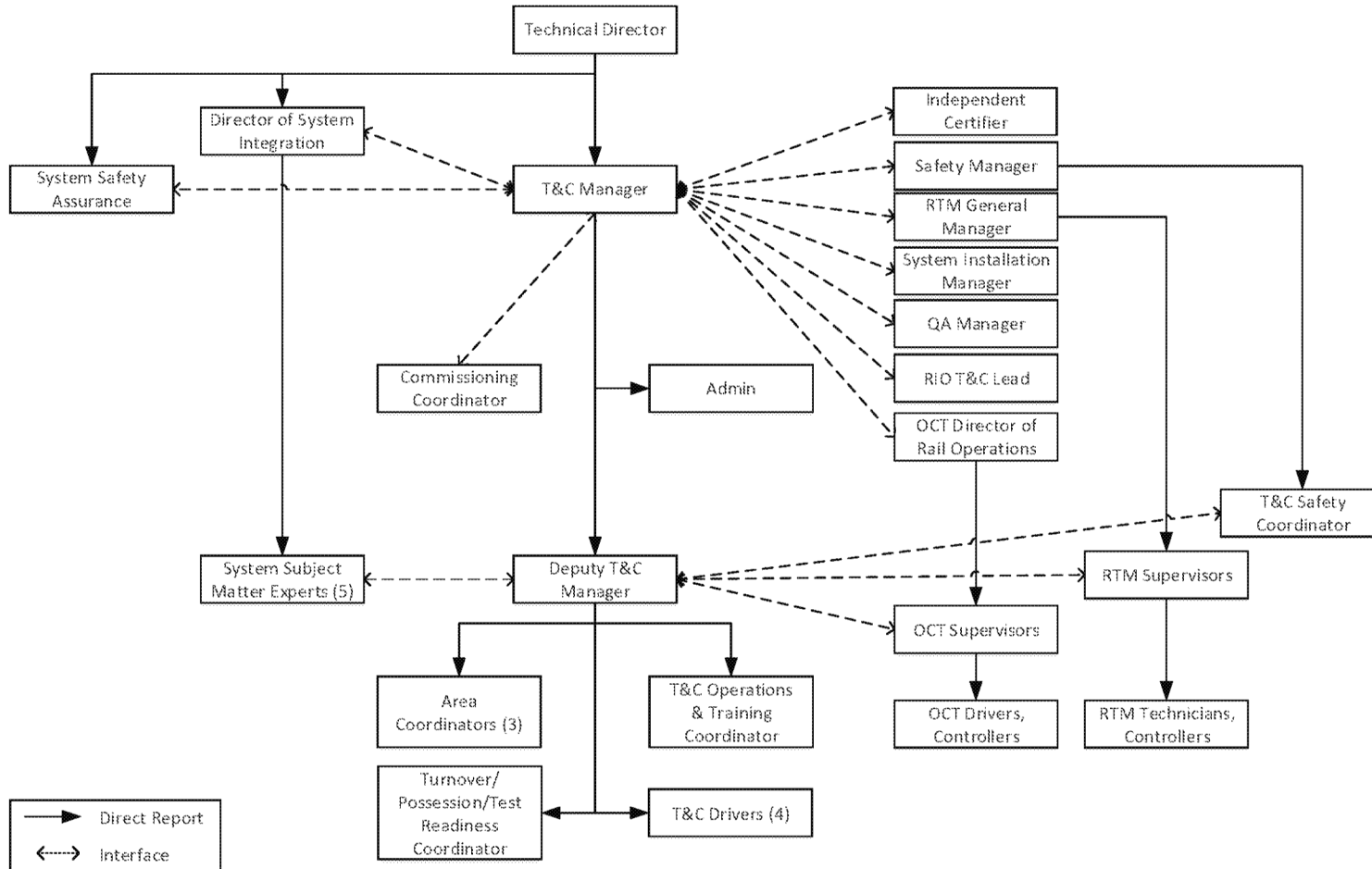
This line schedule is now outdated. Please see the T&C Detailed schedule and the project master schedule.

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Appendix B. T&C ORGANIZATION & INTERFACE CHART

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Figure 11 – T&C Organization & Interface Chart

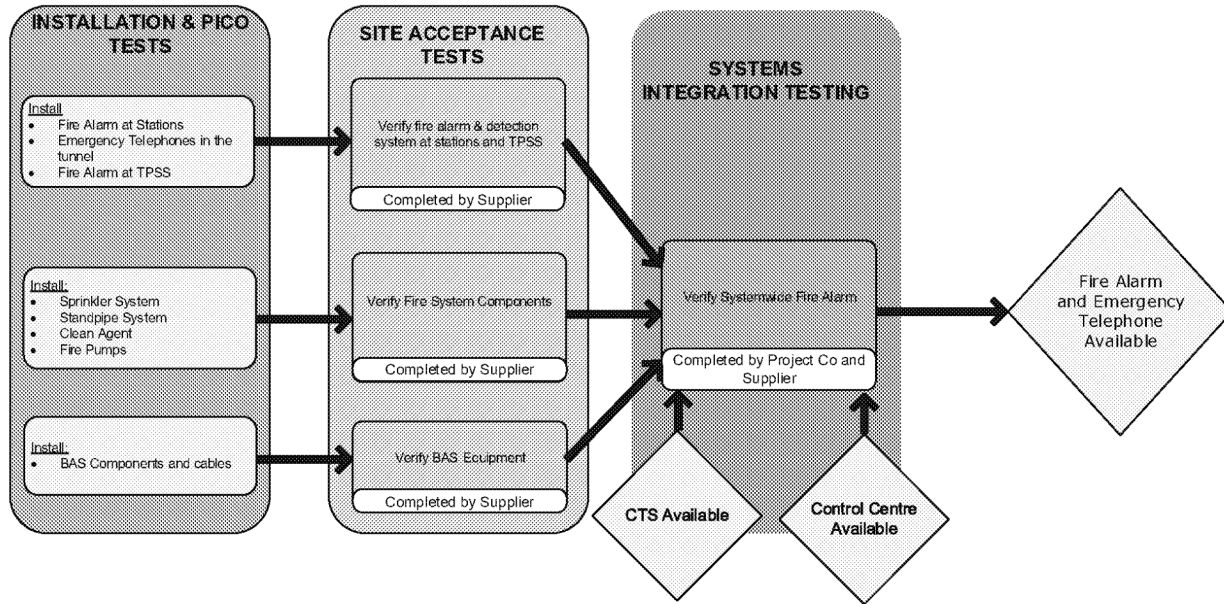


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APPENDIX C. T&C SEQUENCE, BY SUBSYSTEM

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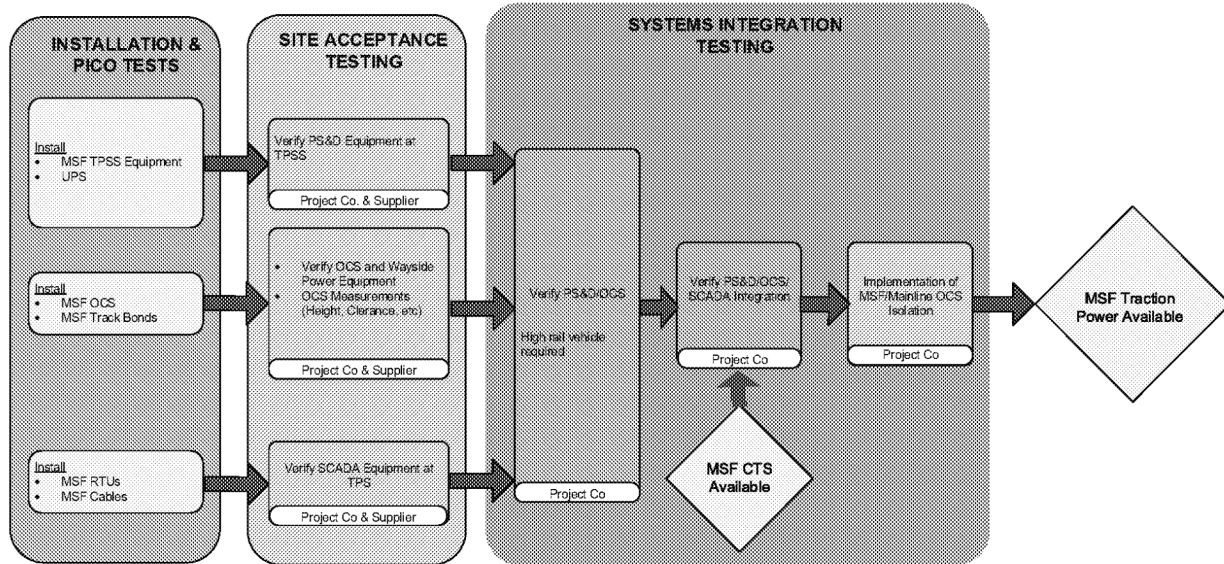
Figure 12 – Fire Alarm



Coordination to be performed with OC Transpo for fire alarm testing.

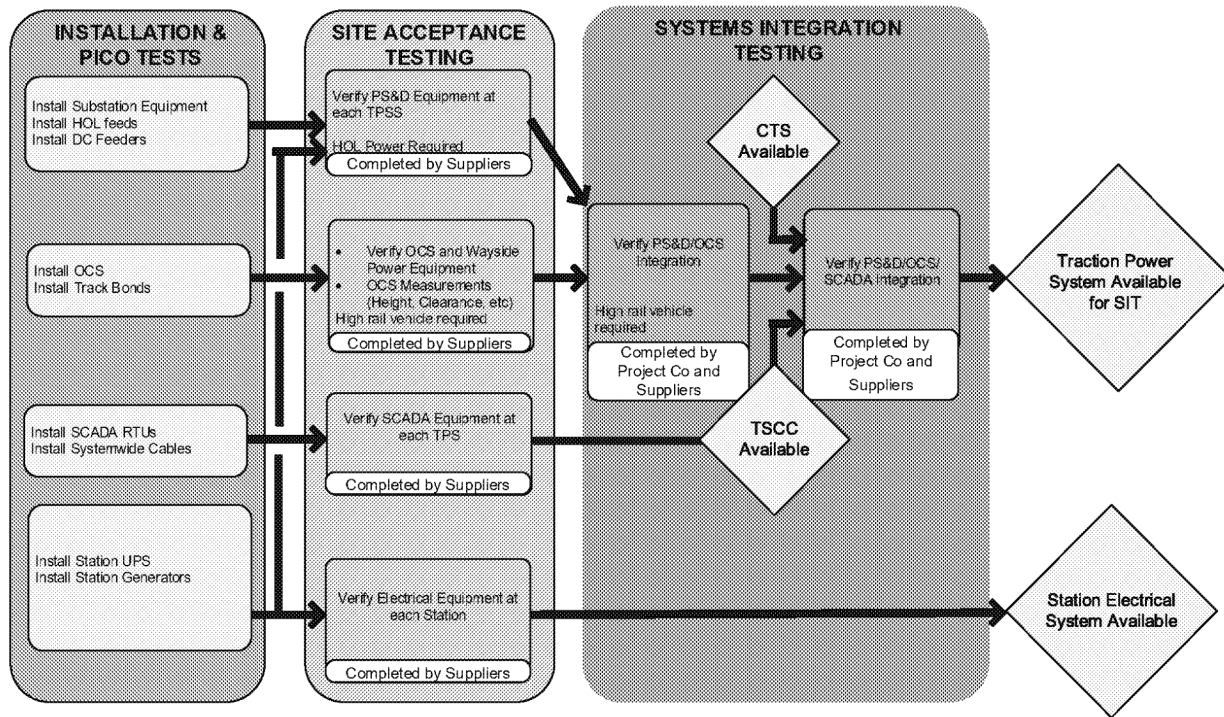
<p>OLR-16-0-0000-MPL-0001</p>	<p>Testing & Commissioning Plan</p>	
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Figure 13 – MSF Power Distribution



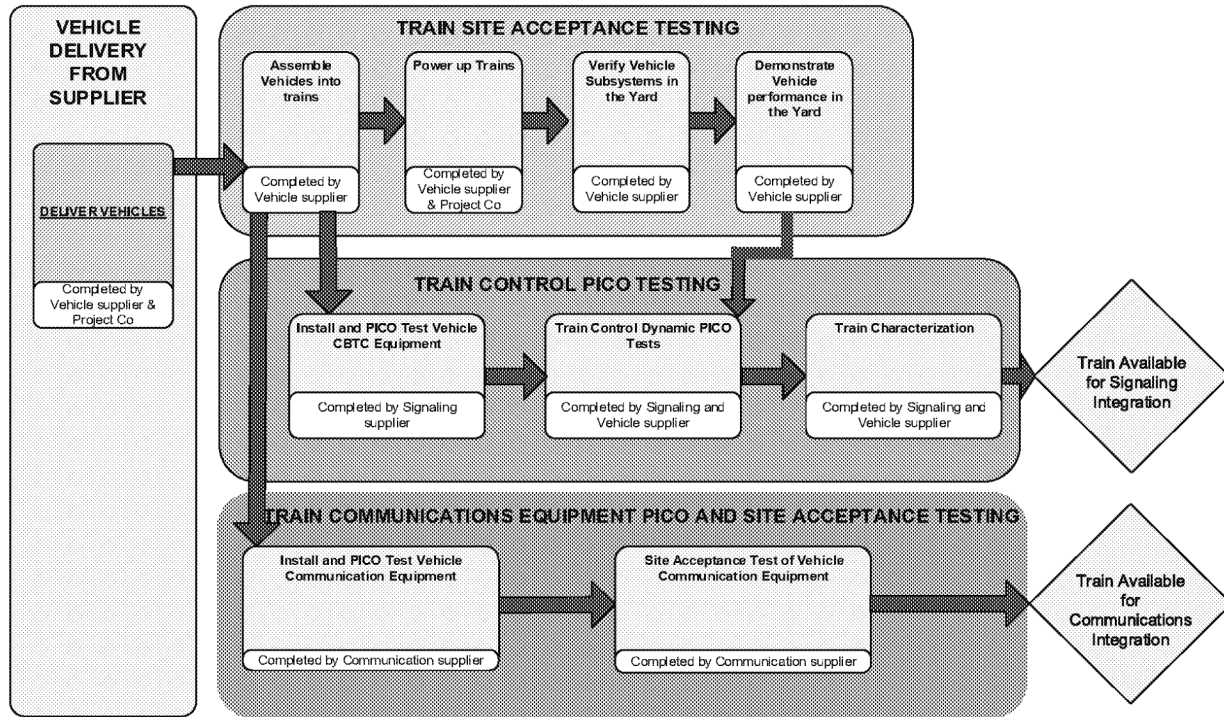
<p>OLR-16-0-0000-MPL-0001</p>	<p>Testing & Commissioning Plan</p>	
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Figure 14 – Power Distribution



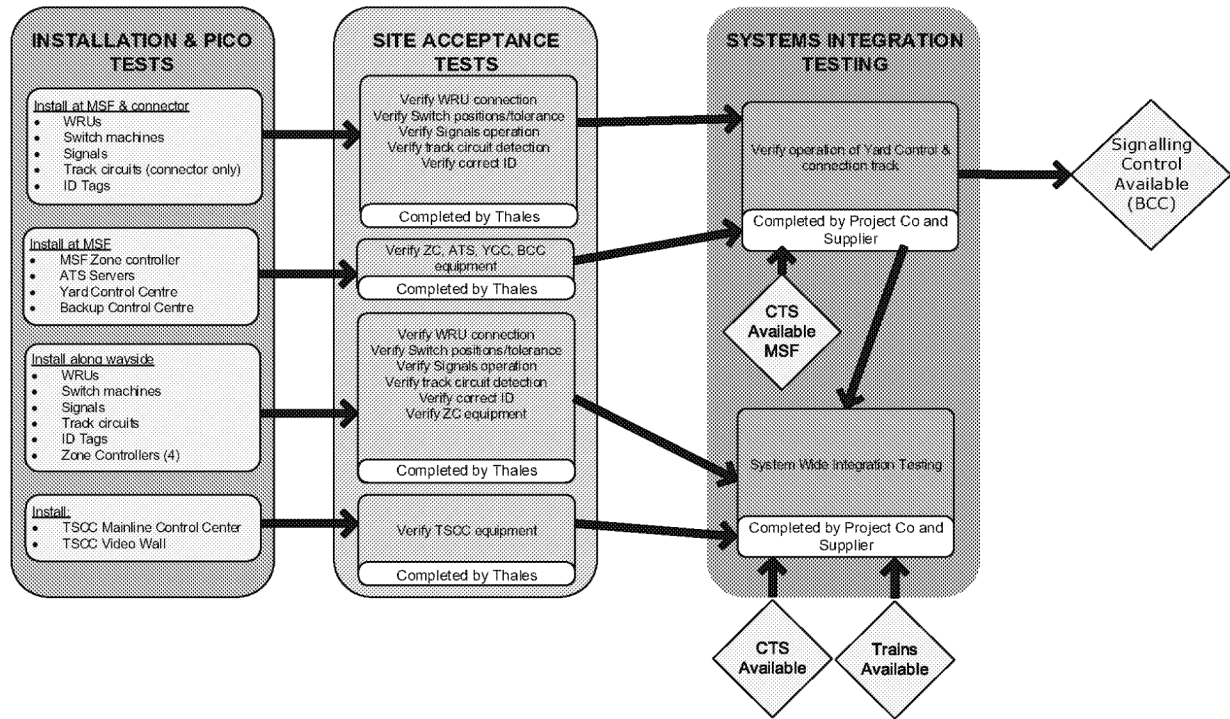
<p>OLR-16-0-0000-MPL-0001</p>	<p>Testing & Commissioning Plan</p>	
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Figure 15 – Vehicle Delivery



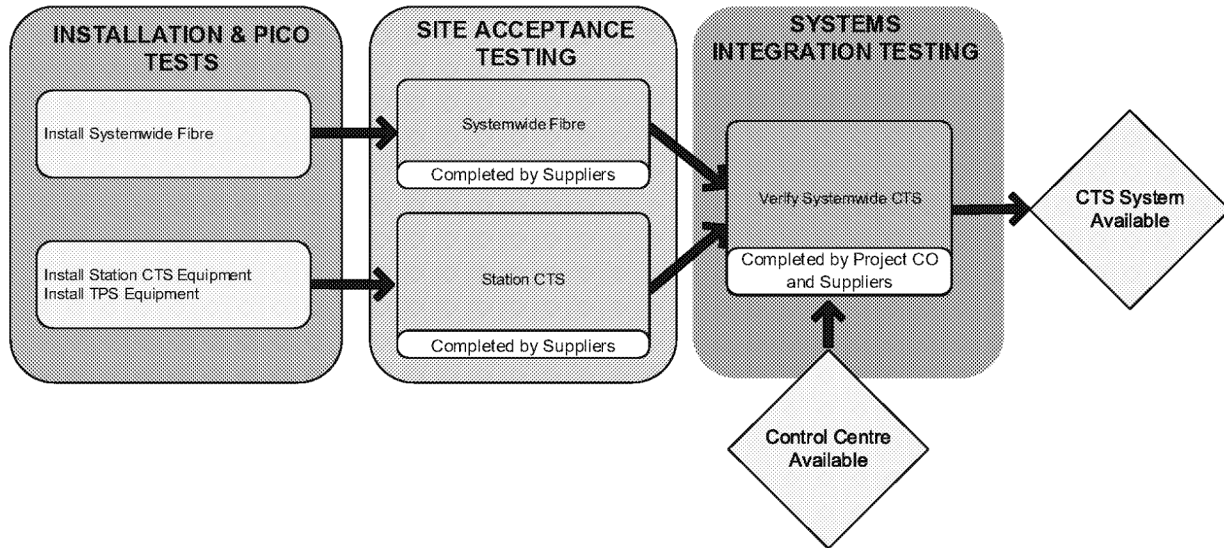
<p>OLR-16-0-0000-MPL-0001</p>	<p>Testing & Commissioning Plan</p>	
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Figure 16 – Signalling



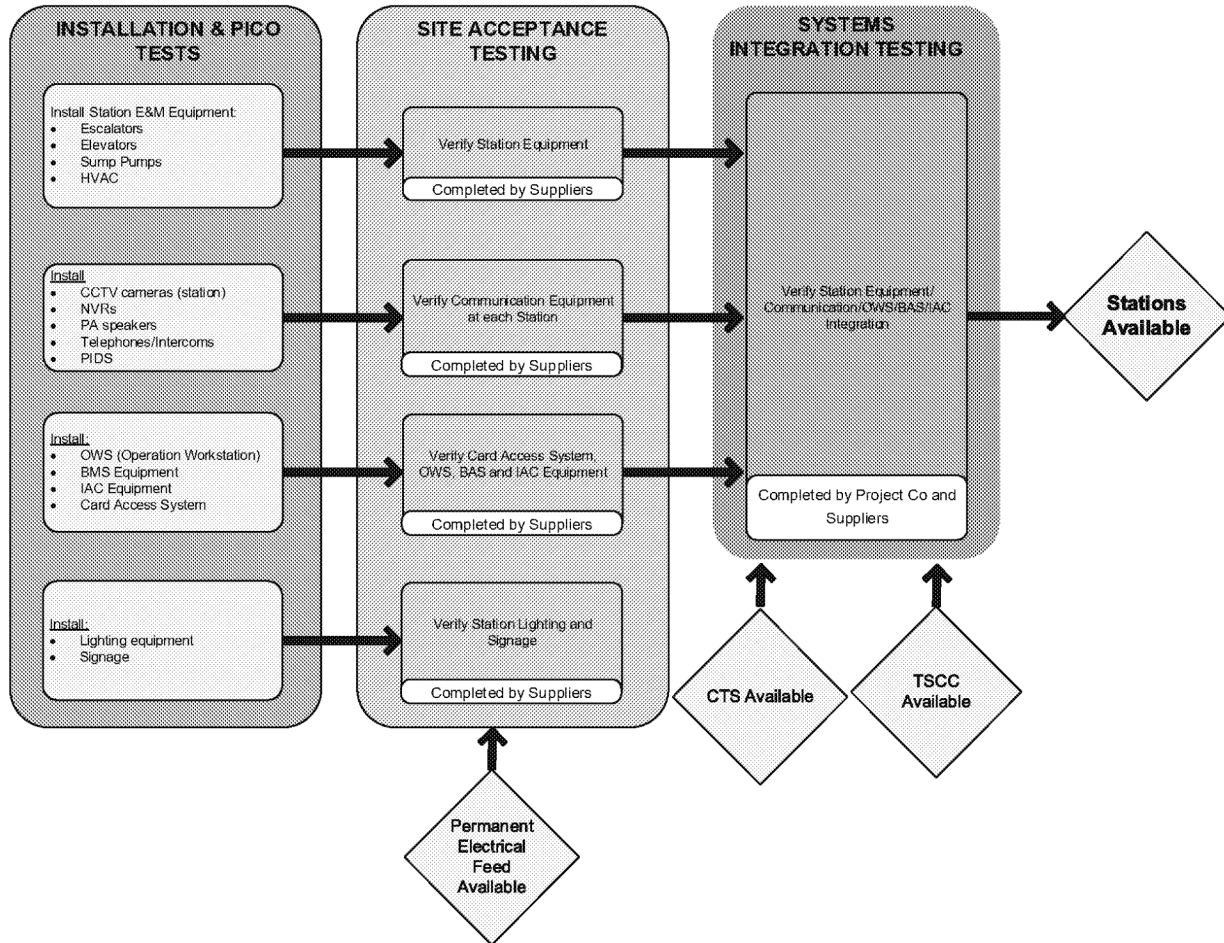
<p>OLR-16-0-0000-MPL-0001</p>	<p>Testing & Commissioning Plan</p>	
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Figure 17 – System Wide Fibre



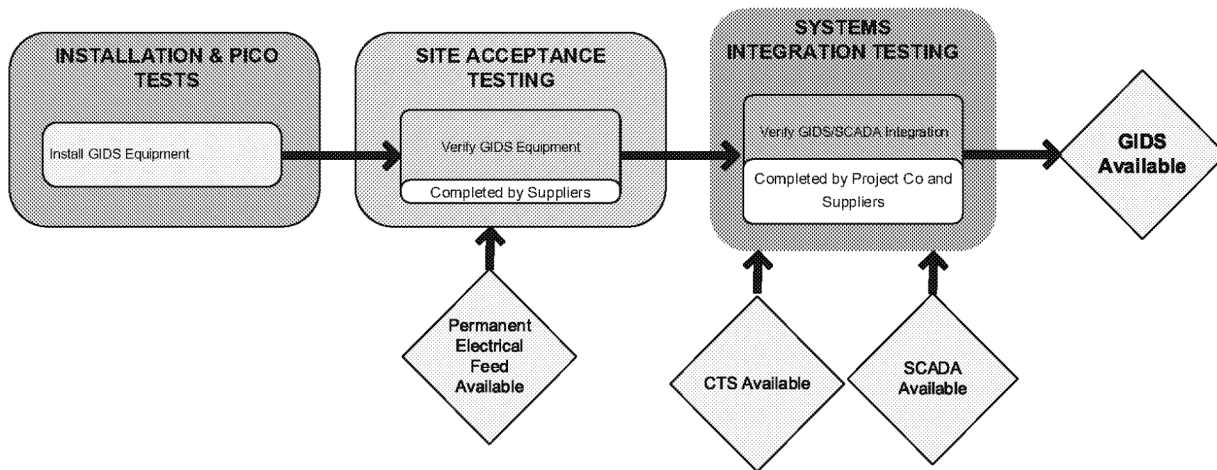
<p>OLR-16-0-0000-MPL-0001</p>	<p>Testing & Commissioning Plan</p>	
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Figure 18 – Stations and BMS



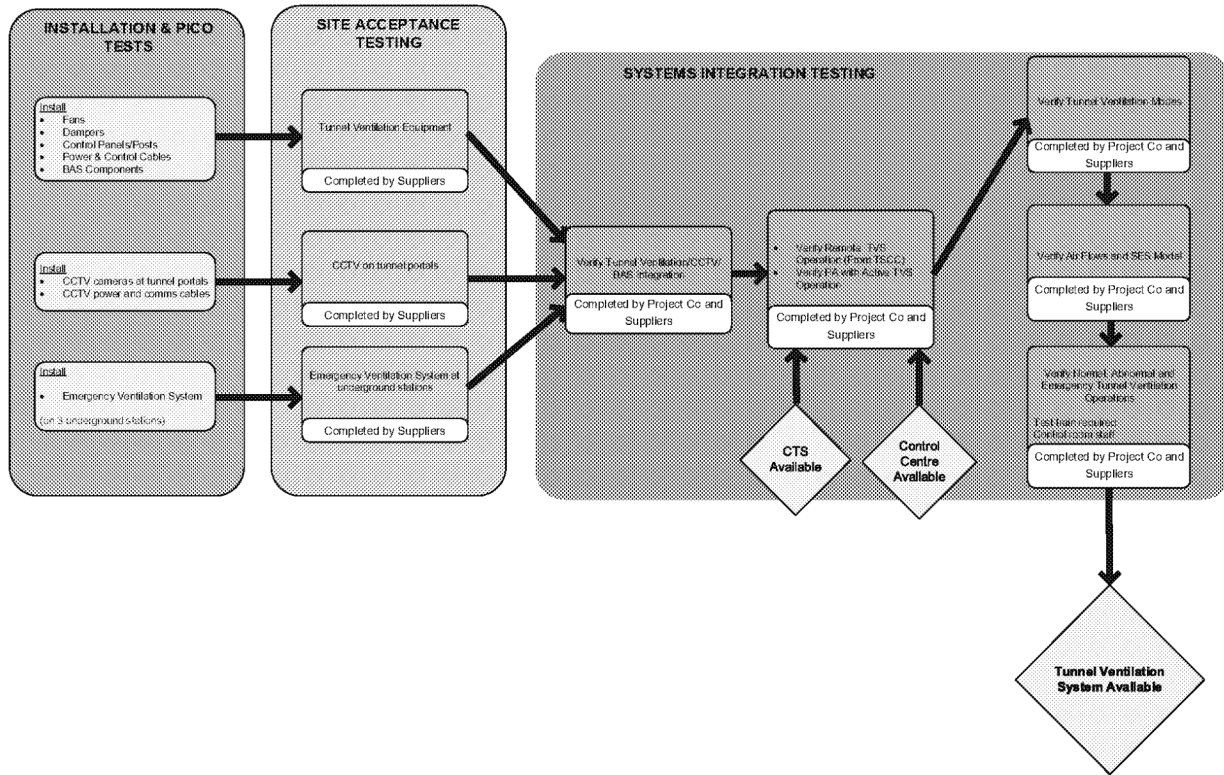
<p>OLR-16-0-0000-MPL-0001</p>	<p>Testing & Commissioning Plan</p>	
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Figure 19 – GIDS



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Figure 20 – Tunnel Ventilation




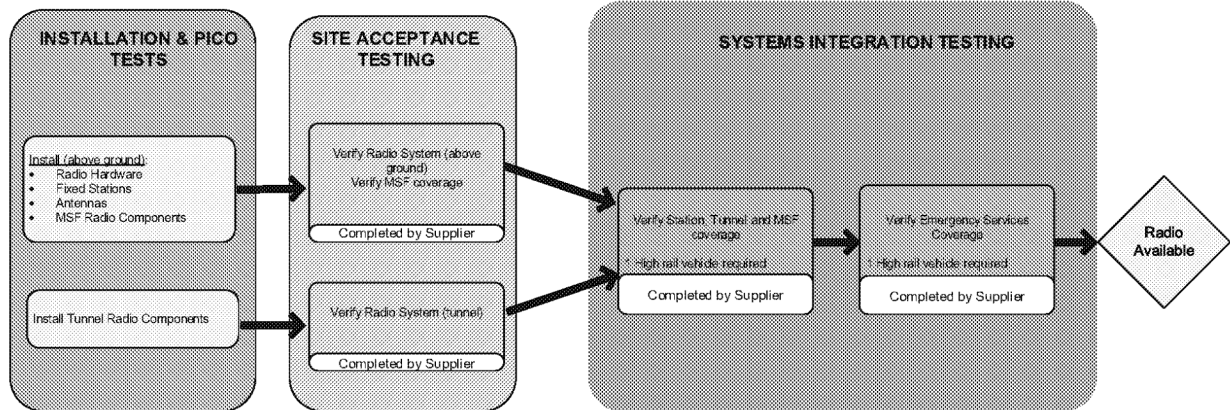
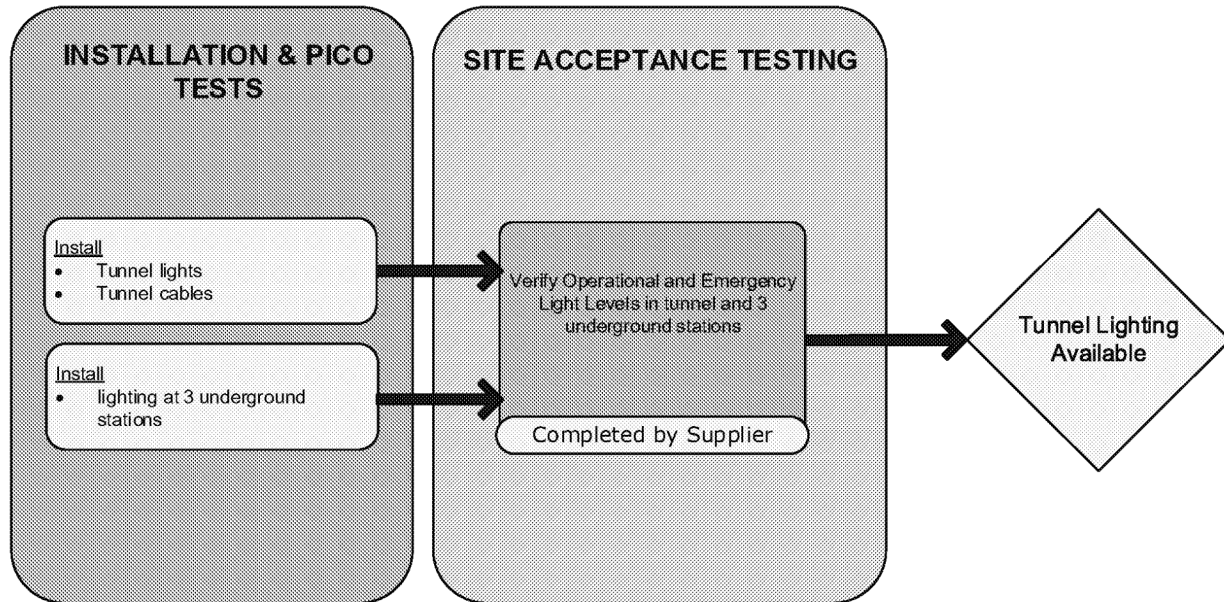
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Figure 21 – P25 Radio System



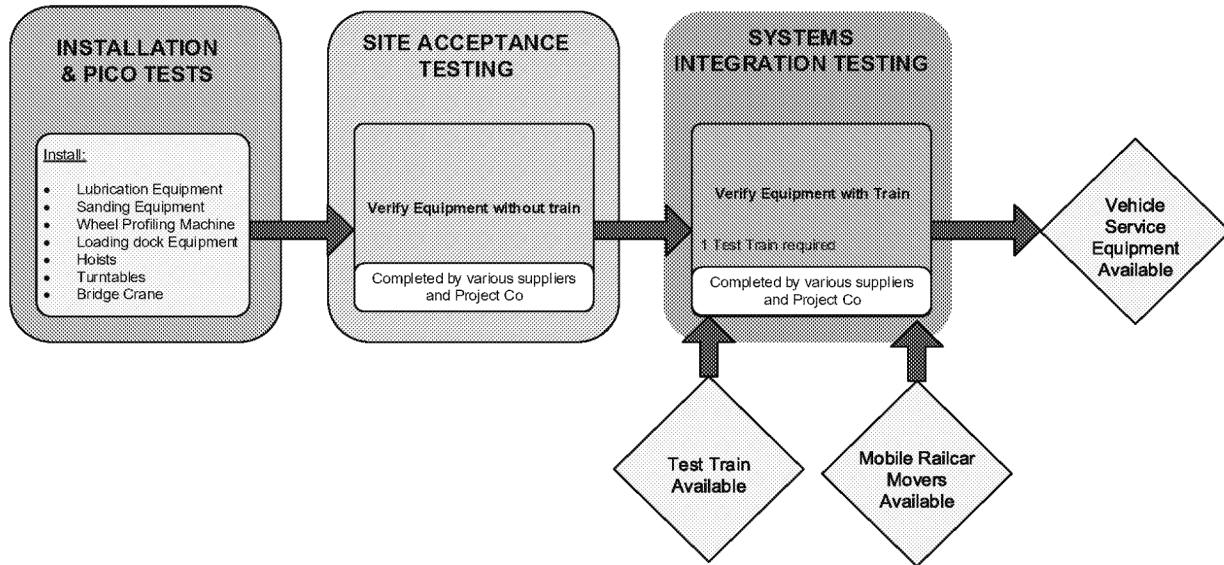
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Figure 22 – Tunnel Lighting



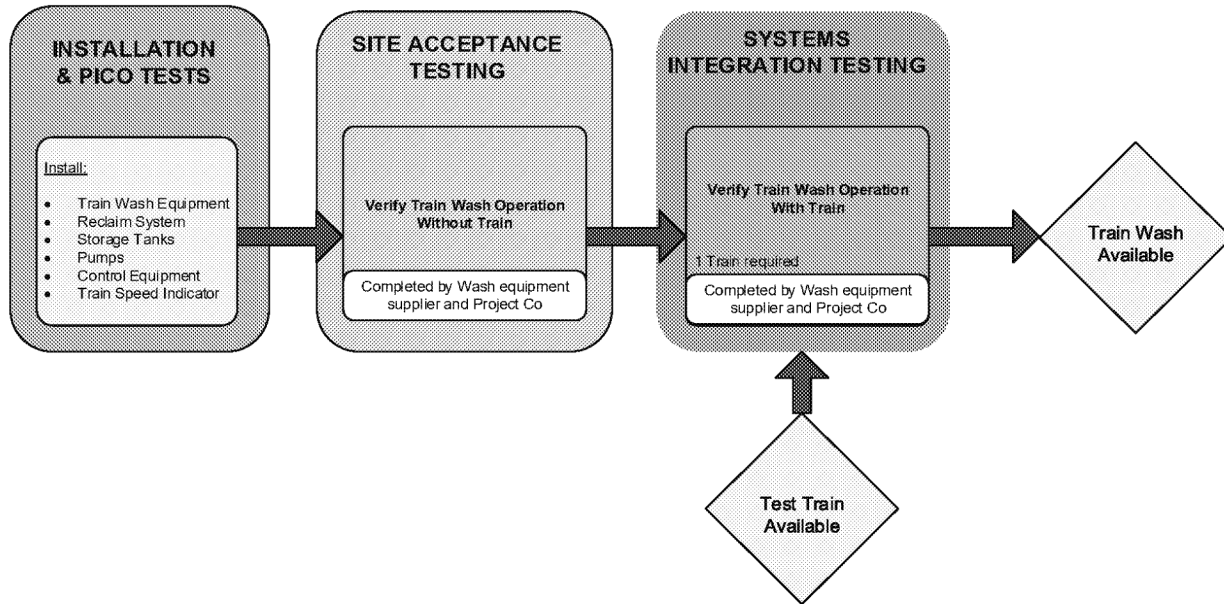
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Figure 23 – Vehicle Service Equipment



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Figure 24 – Train Wash



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APPENDIX D. T&C SEQUENCE, ALL SYSTEMS


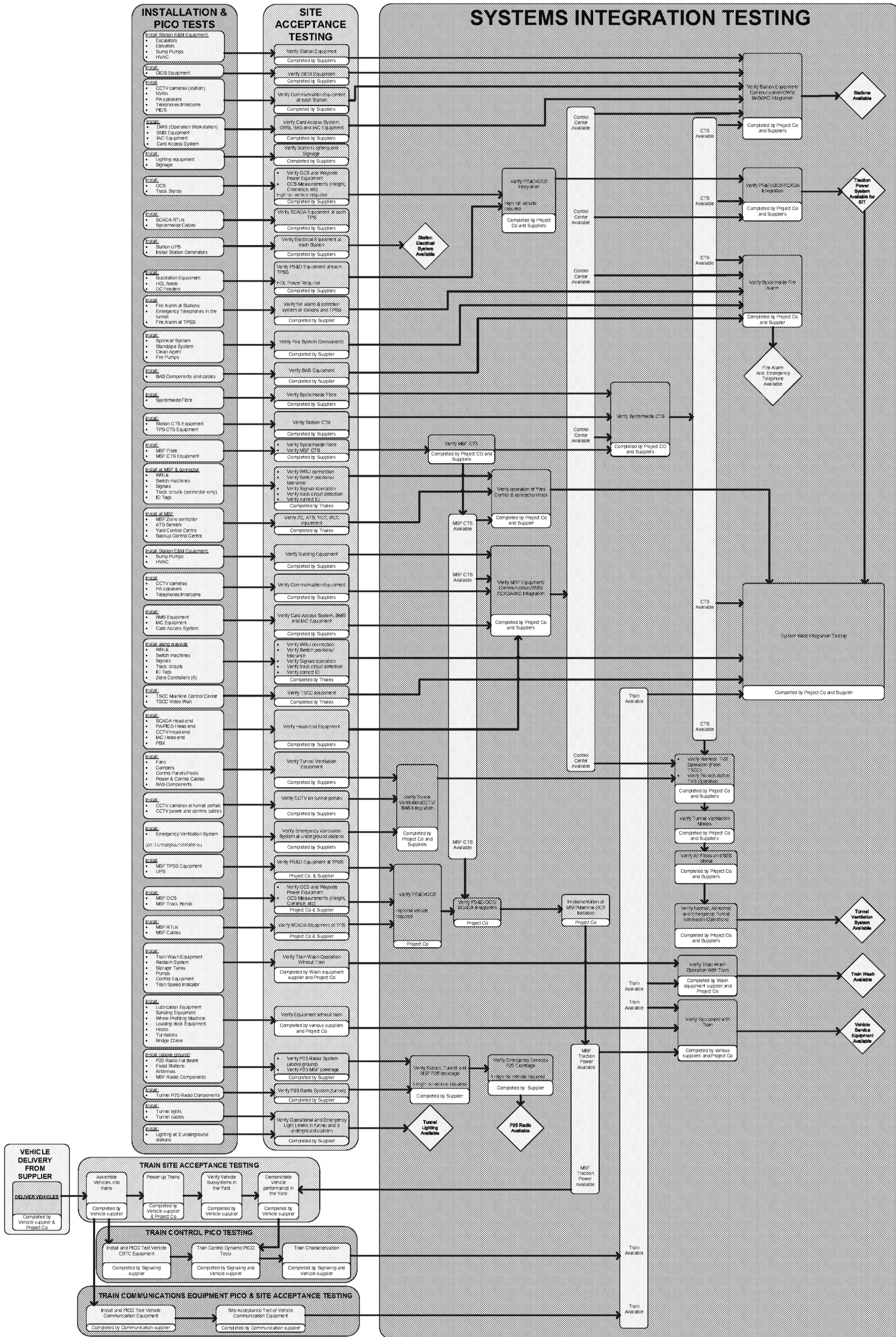
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Figure 25 – T&C Sequence, all Systems



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APPENDIX E. EXAMPLE OF SIT PROCEDURE

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PASS <input type="checkbox"/> FAIL <input type="checkbox"/> RETEST <input type="checkbox"/>					
Test ID:		If not PASS, Defect: Revision: Page __ of __			
Title:					
Commencement Date and Time:			Completion Date and Time:		
Estimated Duration:			Actual Duration:		
Prepared By:	Preparation Date:	Revised By:	Revision Date:	Approved By:	Approval Date:
Site / Area:					
Prerequisites:					
Test equipment used (trains, special vehicles, measuring equipment) including serial/model number, calibration status/date and software version if applicable:					
I certify that this procedure has been performed according to the procedures detailed herein except as noted, and that the results recorded are accurate and complete.					
Tester:	_____	_____	_____		
	Name	Signature	Date and Time		
Witness:	_____	_____	_____		
	Name/Organization	Signature	Date and Time		
I certify that the results recorded against the test procedure with the noted deviations are correct					
Reviewer:	_____	_____	_____		
	Name	Signature	Date and Time		
Quality Assurance Reviewer:	_____	_____	_____		
	Name	Signature	Date and Time		

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Supporting Documentation:

Requirements List:

Scope:

Observations:

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Test Objectives:

Notes:

Deviations / Modifications:

Test Case A:**Overview:****Notes and specific prerequisites:**

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Steps**Expected Results**

1)

PASS () / FAIL ()

2)

PASS () / FAIL ()

.
.
.
.

Deviations / Modifications:

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APPENDIX F. PRELIMINARY LIST OF TESTS

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Table 16 – Preliminary List of Tests

Type	Name
PS&D	
Pre-functional	Stray current baseline survey (prior to energization)
	OLR-04-0-0000-ITP-0076 (covers DC ground potential)
SAT	TPSS 01 - SAT
	TPSS 02 - SAT
	TPSS 03 - SAT
	TPSS 04 - SAT
	TPSS 05 - SAT
	TPSS 06 - SAT
	TPSS 07 - SAT
	TPSS 08 - SAT
	TPSS SHOP - SAT
	TPSS YARD - SAT
	BELFAST - OCS SAT (including Acceptance Measurements [Stagger, Trolley Wire Heights, Pole Horizontal Offset and Wire Stringing Tensions]; Visual Inspection; Clearance Envelope; Electrical Tests [Megger Test, Circuit Continuity (or Loop) Test, Hi-Pot Tests and Ground Resistance Measurement at Lightning Arrestors])
	Segment 5 - OCS SAT (including Acceptance Measurements [Stagger, Trolley Wire Heights, Pole Horizontal Offset and Wire Stringing Tensions]; Visual Inspection; Clearance Envelope; Electrical Tests [Megger Test, Circuit Continuity (or Loop) Test, Hi-Pot Tests and Ground Resistance Measurement at Lightning Arrestors])
	Segment 4 - OCS SAT (including Acceptance Measurements [Stagger, Trolley Wire Heights, Pole Horizontal Offset and Wire Stringing Tensions]; Visual Inspection; Clearance Envelope; Electrical Tests [Megger Test, Circuit Continuity (or Loop) Test, Hi-Pot Tests and Ground Resistance Measurement at Lightning Arrestors])
	Segment 3 - OCS SAT (including Acceptance Measurements [Stagger, Trolley Wire Heights, Pole Horizontal Offset and Wire Stringing Tensions]; Visual Inspection; Clearance Envelope; Electrical Tests [Megger Test, Circuit Continuity (or Loop) Test, Hi-Pot Tests and Ground Resistance Measurement at Lightning Arrestors])

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	Segment 2 - OCS SAT (including Acceptance Measurements [Stagger, Trolley Wire Heights, Pole Horizontal Offset and Wire Stringing Tensions]; Visual Inspection; Clearance Envelope; Electrical Tests [Megger Test, Circuit Continuity (or Loop) Test, Hi-Pot Tests and Ground Resistance Measurement at Lightning Arrestors])
	Segment 1 - OCS SAT (including Acceptance Measurements [Stagger, Trolley Wire Heights, Pole Horizontal Offset and Wire Stringing Tensions]; Visual Inspection; Clearance Envelope; Electrical Tests [Megger Test, Circuit Continuity (or Loop) Test, Hi-Pot Tests and Ground Resistance Measurement at Lightning Arrestors])
	BELFAST - PS&D Functional (including OCS Sectioning and DC Short Circuit)
	Segment 5 - PS&D Functional (including OCS Sectioning and DC Short Circuit)
	Segment 4 - PS&D Functional (including OCS Sectioning and DC Short Circuit)
	Segment 3 - PS&D Functional (including OCS Sectioning and DC Short Circuit)
	Segment 2 - PS&D Functional (including OCS Sectioning and DC Short Circuit)
	Segment 1 - PS&D Functional (including OCS Sectioning and DC Short Circuit)
	Filtering and harmonics
SIT	
	BELFAST - OCS + Vehicle Commissioning
	Segment 5 - OCS + Vehicle Commissioning
	Segment 4 - OCS + Vehicle Commissioning
	Segment 3 - OCS + Vehicle Commissioning
	Segment 2 - OCS + Vehicle Commissioning
	Segment 1 - OCS + Vehicle Commissioning
	UPS Operation in Power Failure
	Verify wayside disconnect & transfer switches, and mass trip
	Verify MSF/Mainline Isolation

Communications	
SAT	
	TUN - CTS SAT
	BAY - CTS SAT
	PIM - CTS SAT
	LYO - CTS SAT
	PAR - CTS SAT
	RID - CTS SAT
	UOT - CTS SAT
	LEE - CTS SAT
	HUR - CTS SAT

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TRE - CTS SAT
STL - CTS SAT
CYR - CTS SAT
BLA - CTS SAT
TUN - CTS SAT
TPSS 01 - CTS SAT
TPSS 02 - CTS SAT
TPSS 03 - CTS SAT
TPSS 04 - CTS SAT
TPSS 05 - CTS SAT
TPSS 06 - CTS SAT
TPSS 07 - CTS SAT
TPSS 08 - CTS SAT
TPSS SHOP - CTS SAT
TPSS YARD - CTS SAT
BELFAST - CTS SAT
CENTRAL - CTS SAT (including NMS, network link failure 50ms auto convergence, network failure auto root cause analysis) (YCC, BCC, TSCC, server)
BAY - CCTV SAT
PIM - CCTV SAT
LYO - CCTV SAT
PAR - CCTV SAT
RID - CCTV SAT
UOT - CCTV SAT
LEE - CCTV SAT
HUR - CCTV SAT
TRE - CCTV SAT
STL - CCTV SAT
CYR - CCTV SAT
BLA - CCTV SAT
BELFAST - CCTV SAT
CENTRAL - CCTV SAT (YCC, BCC, TSCC, server)
TUN - IAC SAT
BAY - IAC SAT
PIM - IAC SAT
LYO - IAC SAT
PAR - IAC SAT

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	RID - IAC SAT
	UOT - IAC SAT
	LEE - IAC SAT
	HUR - IAC SAT
	TRE - IAC SAT
	STL - IAC SAT
	CYR - IAC SAT
	BLA - IAC SAT
	TPSS 01 - IAC SAT
	TPSS 02 - IAC SAT
	TPSS 03 - IAC SAT
	TPSS 04 - IAC SAT
	TPSS 05 - IAC SAT
	TPSS 06 - IAC SAT
	TPSS 07 - IAC SAT
	TPSS 08 - IAC SAT
	TPSS SHOP - IAC SAT
	TPSS YARD - IAC SAT
	BELFAST - IAC SAT
	CENTRAL - IAC SAT (server)
	TUN - PIS (PA/PIDS) SAT
	BAY - PIS (PA/PIDS) SAT
	PIM - PIS (PA/PIDS) SAT
	LYO - PIS (PA/PIDS) SAT
	PAR - PIS (PA/PIDS) SAT
	RID - PIS (PA/PIDS) SAT
	UOT - PIS (PA/PIDS) SAT
	LEE - PIS (PA/PIDS) SAT
	HUR - PIS (PA/PIDS) SAT
	TRE - PIS (PA/PIDS) SAT
	STL - PIS (PA/PIDS) SAT
	CYR - PIS (PA/PIDS) SAT
	BLA - PIS (PA/PIDS) SAT
	BELFAST - PIS (PA/PIDS) SAT
	CENTRAL - PIS (PA/PIDS) SAT (server)
	TUN - Telephony SAT
	BAY - Telephony SAT

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PIM - Telephony SAT
LYO - Telephony SAT
PAR - Telephony SAT
RID - Telephony SAT
UOT - Telephony SAT
LEE - Telephony SAT
HUR - Telephony SAT
TRE - Telephony SAT
STL - Telephony SAT
CYR - Telephony SAT
BLA - Telephony SAT
BELFAST - Telephony SAT
CENTRAL - Telephony SAT (YCC, BCC, TSCC, PBX)
TUN - FDAS SAT
BAY - FDAS SAT
PIM - FDAS SAT
LYO - FDAS SAT
PAR - FDAS SAT
RID - FDAS SAT
UOT - FDAS SAT
LEE - FDAS SAT
HUR - FDAS SAT
TRE - FDAS SAT
STL - FDAS SAT
CYR - FDAS SAT
BLA - FDAS SAT
TPSS 01 - FDAS SAT
TPSS 02 - FDAS SAT
TPSS 03 - FDAS SAT
TPSS 04 - FDAS SAT
TPSS 05 - FDAS SAT
TPSS 06 - FDAS SAT
TPSS 07 - FDAS SAT
TPSS 08 - FDAS SAT
TPSS SHOP - FDAS SAT
TPSS YARD - FDAS SAT
CENTRAL - FDAS SAT (server)

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	TUN - GIDS SAT
	BAY - GIDS SAT
	PIM - GIDS SAT
	LYO - GIDS SAT
	PAR - GIDS SAT
	RID - GIDS SAT
	UOT - GIDS SAT
	LEE - GIDS SAT
	HUR - GIDS SAT
	TRE - GIDS SAT
	STL - GIDS SAT
	CYR - GIDS SAT
	BLA - GIDS SAT
	EPORTAL - GIDS SAT
	WPORTAL - GIDS SAT
	CENTRAL - GIDS SAT
	TUN - HSDR SAT
	BAY - HSDR SAT
	PIM - HSDR SAT
	LYO - HSDR SAT
	PAR - HSDR SAT
	RID - HSDR SAT
	UOT - HSDR SAT
	LEE - HSDR SAT
	HUR - HSDR SAT
	TRE - HSDR SAT
	STL - HSDR SAT
	CYR - HSDR SAT
	BLA - HSDR SAT
	BELFAST - HSDR SAT
	CENTRAL - Master Clock SAT (server)
	CENTRAL - ATIS SAT
	P25 SAT (each segment + MSF/TSCC)
	CENTRAL - P25 SAT [by others]
SIT	
	FDAS / PIS Integration Test
	CCTV / HSDR / Vehicle Integration Test

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	P25 / Vehicle Integration Test (including silent alarm)
	Time Change Integration Test

SCADA	
SAT	
	TUN - SCADA SAT (local)
	BAY - SCADA SAT (local)
	PIM - SCADA SAT (local)
	LYO - SCADA SAT (local)
	PAR - SCADA SAT (local)
	RID - SCADA SAT (local)
	UOT - SCADA SAT (local)
	LEE - SCADA SAT (local)
	HUR - SCADA SAT (local)
	TRE - SCADA SAT (local)
	STL - SCADA SAT (local)
	CYR - SCADA SAT (local)
	BLA - SCADA SAT (local)
	CENTRAL - SCADA SAT
SIT	
	TPSS 01 - SCADA / TPSS - Local Integration Test
	TPSS 02 - SCADA / TPSS - Local Integration Test
	TPSS 03 - SCADA / TPSS - Local Integration Test
	TPSS 04 - SCADA / TPSS - Local Integration Test
	TPSS 05 - SCADA / TPSS - Local Integration Test
	TPSS 06 - SCADA / TPSS - Local Integration Test
	TPSS 07 - SCADA / TPSS - Local Integration Test
	TPSS 08 - SCADA / TPSS - Local Integration Test
	TPSS SHOP - SCADA / TPSS - Local Integration Test
	TPSS YARD - SCADA / TPSS - Local Integration Test
	CENTRAL - SCADA / TPSS - Remote Integration Test for each TPSS
	SCADA / CBTC Integration Test
	PIS / SCADA / CBTC Integration Test
	ATIS / SCADA Integration Test (open data output validation)
	Telephony / SCADA / CCTV Integration Test
	IAC / SCADA / CCTV Integration Test
	GIDS / SCADA / CCTV Integration Test

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TVS	
SAT	
	LYO - TVS SAT
	PAR - TVS SAT
	RID - TVS SAT
	STL - TVS SAT
SIT	
	TVS / FDAS SIT
	Verify Air Flows (after adjusting, balancing, and testing fans)
	Verify Subway Environmental Simulation with SMOKE TEST
	CENTRAL - Remote TVS Operation
	Normal, Abnormal and Emergency TVS Operations

Operations	
SIT	
	Verify TSCC Integration
	Operational Headway/ Service Level 1
	Verify normal Operations (MSF departure / arrival handoff, winter, travel times, mainline handoff for maintenance)
	Verify abnormal & failure Operations (vehicle recovery, re-rail)
	TSCC communications failure (includes TSCC to BCC transfer)
	Trial Running
	Maintenance of Way Equipment
	CCTV to Transit Police Integration Test
	Energy Matters (traction power & MSF)
	Hand off of Trains
	Major Service Change
	Medium Service Change
	Minor Service Change
	Baseline EMC/EMI Survey
	Final EMC/EMI survey
	Vehicle Endurance


CBTC	
Thales V&V Plan (3CU_05018_0043_VCZZA)	
Vehicle	
Alstom Acceptance Test Plan (ADD0000938987)	

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APPENDIX G. SYSTEM TEST LIST DRAFT TEMPLATE

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Table 17 – System Test List Draft Template

													SYSTEM TEST PLAN													For System Test Plan No. OLR-XX-0-0000-XXX-XXXX												
System Test Plan Title:													XXXX SYSTEM TEST LIST													Date: XX-XXX-2015 Revision: A												
General Information										Test Specification & Procedure			Comments																									
Test #	Test Description	Subsystem	Responsible Engineer	Duration	Testing Party	Test Location	Operations Staff	Vehicles Required	Document ID	REV	Author																											
			<i>name</i>	<i>business days</i>	<i>OLRT-C Entity, Supplier or Sub</i>	<i>factory, station, segment</i>	<i>role</i>	<i>#</i>			<i>name or supplier</i>																											
Qualification Tests																																						
Factory Acceptance Tests																																						
Post-Installation Check Out Tests																																						
Site Acceptance Tests																																						
Subsystem Integration Tests																																						
System Integration Tests																																						

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APPENDIX H. WORK BREAKDOWN ENCLOSURE CODES

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The enclosure codes take the form of AA.BBB.CCD.

Table 18 – Work Breakdown Enclosure Codes

AA	Description
TC	Testing & Commissioning
TR	Training
BB	Description
GGN	Facilities & Guideway, System-Wide
TRC	Train Control Systems
TVS	Tunnel Ventilation System
VEH	Light Rail Vehicle
INT	Integration, System-Wide
DBC	Design Brief
COM	Communications and Signals (VSS-COM)
CO1	Communications and Signals (VSS-COM) - SCADA
CO2	Communications and Signals (VSS-COM) - High Speed Radio System
CO3	Communications and Signals (VSS-COM) - CCTV
CO4	Communications and Signals (VSS-COM) - Passenger Information System (PIS)
CO5	Communications and Signals (VSS-COM) - Telephony System
CO6	Communications and Signals (VSS-COM) - Intrusion & Access Control System
CO7	Communications and Signals (VSS-COM) - Communication Transmission System
CO8	Traction Power Supply & Communication Interface
PSD	Power Supply & Distribution / TPSS (VSS-PSD)
MPL	Management Plans
PPR	Monthly Reports
TWG	T&C Working Group
CMM	Commissioning Manuals
HND	Handover
VL	Verification Letters
QA	Quality Assurance
CC	Description
10	General / System-Wide
06	Test Plans
07	Test Procedures
Z0	System-Wide
Z1	Zone 1 (TUN->LYO)
Z2	Zone 2 (LYO->LEE)
Z3	Zone 3 (LEE->STL)
Z4	Zone 4 (STL->BLA)
Z5	Zone 5 (MSF)
Z6	Zone 6 (TSCC)
D	Description
1	Pre-Final Report
2	Final Report

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